The Socioeconomic Impact of Standalone Solar on Households and Businesses in Nigeria



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The Socioeconomic Impact of Standalone Solar on Households and Businesses in Nigeria

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Acronyms and Abbreviations

CBN	Central Bank of Nigeria
DARES	Distributed Access through Renewable Energy Scale-up
DRE	Distributed renewable energy
GEAPP	Global Energy Alliance for People and Planet
GHS	General Household Survey
GOGLA	Global Off-Grid Lighting Association
JICA	Japan International Cooperation Agency
MICS	Multiple Indicator Cluster Survey
MTF	Multi-Tier Framework
NBS	Nigeria's National Bureau of Statistics
PAYGo	Pay-as-you-go credit
PPP	Purchasing Power Parity
REA	Rural Electrification Agency
RESIP	Rural Electrification Strategy and Implementation Plan
SHS	Solar Home System
UNSD	United Nations Statistics Division

EXECUTIVE SUMMARY

Nigeria has the largest unelectrified population in the world, and unreliable supply for many of those who are connected. Between 85 and 90 million Nigerians, around 40% of the population, have no access to electricity, and households and firms fill the gaps in grid supply with petrol and diesel generators that are costly, polluting and increasingly hard to afford.

Standalone solar is a central pillar of Nigeria's response, anchored by the World Bank's USD 750 million DARES programme and by significant private investment by homes and businesses. Yet decisions about public support, private investment and product design still rest on thin Nigeria-specific evidence of what standalone solar delivers.

This report helps to fill that gap. Commissioned by Sun King and LeapFrog Investments, and independently designed and analysed by Genesis Analytics, this report draws on a survey of 2,277 Sun King customers across all six geopolitical zones to examine the socioeconomic value associated with standalone solar for households and businesses in Nigeria. The report identifies where the benefits are clear, where they remain limited, and what should be investigated next.

FOUR MESSAGES STAND OUT

1. **For customers, solar is not simply about electricity. Solar can reduce the cost of living and of doing business, free up resources for other priorities, and protect livelihoods against energy-price shocks and unreliable power.** In this study, surveyed households reported real monthly energy spending 76% lower than before adoption, and 89% of customers said their product kept them running through power outages.

2. **45% of surveyed household customers run a business from home, and for 53% of them it is the main source of household income.** The usual distinction between household consumption and productive energy use is, for these customers, largely artificial: a light that lets a market trader work after dark, or a charged phone that connects an entrepreneur to suppliers and customers, is being put to productive use.

3. **Small systems already do productive work.** Four in five surveyed standalone businesses use an entry-level Tier 1 system, yet those with Tier 1-or-smaller systems reported 69 more minutes of trading a day and 59% reported improved profitability, through longer hours, visible premises and charged phones rather than machinery. Productive use in Nigeria includes lighting and charging, not only refrigeration, pumping or milling.

4. **Impact and economics, and purpose and profit, can reinforce each other.** For investors, the proposition is that converting expensive, unreliable and often polluting energy expenditure into affordable solar power can generate benefits for people and the planet while supporting a commercially sustainable business. This study speaks to the customer side of that proposition.

ABOUT THIS STUDY

At a glance

WHO

The sample consists of 2,277 Sun King customers, including households (48%), home-based businesses (38%) (i.e. households where a home-based business is also run) and standalone businesses (14%).

WHERE AND WHEN

All six geopolitical zones in Nigeria. A stratified random sample drawn from Sun King's customer records, limited to customers who had owned their product for up to three years, **interviewed by telephone in June and July 2026 through Sun King's call centre.**

HOW

Genesis Analytics designed the questionnaire, sampling and analytical methodology, trained the Sun King call-centre agents, and independently cleaned, validated and analysed the data. **The study was commissioned by Sun King and LeapFrog Investments.**

STUDY DESIGN

After a detailed review of available evaluation methodologies and consultation with experts, a retrospective before-and-after design was adopted for the study, in which each customer serves as their own point of comparison.

The design rationale is set out in Section 1.4 and Annexure 1.



The analysis is structured around an explicit *theory of change* linking adoption to outcomes through five links. Household and business pathways are modelled separately but overlap for home-based businesses, which the survey captured as a distinct third group. Home-based businesses are an important part of Nigeria's informal economy that is easily obscured when surveys treat "households" and "businesses" as separate categories: nearly half of surveyed household customers (45%) run a business from their home, and for over half of them it is the main source of household income. Capturing them as their own group allows their household and productive uses of electricity to be considered together. PAYGo is part of the input: it enables customers to acquire their system and so gain access to energy, and it separately produces financial outcomes of its own, such as improved money management and wider access to finance. *The full theory of change is set out in Section 2.*

The evidence is strongest where the pathway is shortest. Lower energy costs, resilience to outages and fuel-price shocks, and productive use through longer trading hours and connectivity follow directly from what a solar system delivers, and the findings on them are broadly consistent across customer groups, regions and product types. Prosperity outcomes, meaning higher real income, employment and wealth, sit at the end of the pathway and depend on energy access combined with productive assets, finance, skills and market access. Over a recall period of severe inflation, the study did not establish gains in these, which is consistent with the wider literature and is explained in the body of the report.

HIGH-LEVEL FINDINGS

Sun King customers and their energy context

Sun King products serve both customers gaining electricity for the first time and those seeking more reliable or affordable supply.

One in five respondents (20%, 460/2,277) reported no previous use of grid electricity, a generator or another solar product. For 81% (371/460) of these first-time-access customers, solar is now their only source of electricity. A broader 25% (561/2,277) had no prior grid or generator access, but some of these had previously

used another solar product. Most customers, however, use solar to improve an existing supply: 57% (1,109/1,954) of household respondents have a grid connection, and 93% of them use solar because the grid is unreliable. Generator use before adoption was also widespread, reported by 34% (674/1,954) of household respondents, including 35% of those with grid access. Solar therefore plays a dual role: it extends access, and it supplements unreliable grid electricity while replacing or reducing reliance on polluting and costly generators.

Entry-level Tier 1 solar home systems account for around two-thirds of products used.

68% (1,539/2,277) of respondents use an entry-level system on the World Bank's Multi-Tier Framework, with most of the remainder using larger Tier 2 systems; lanterns and inverters together account for only 4%. The findings therefore predominantly describe the experience of solar home system customers, particularly those using entry-level systems.

The sample is geographically diverse and dominated by small-scale enterprises.

Among household respondents who disclosed their income, 88% fell below LeapFrog Investments' Emerging Consumer threshold of USD 11.20 per day (2017 PPP), although 61% did not disclose it. Surveyed businesses were mostly retail and trading enterprises averaging 2.4 employees, and women headed 54% of standalone and 41% of home-based businesses. Most therefore need reliable lighting, phone charging and customer-facing electricity rather than power-intensive machinery.



Household pathway: more light, lower energy costs and greater resilience

Households report more usable light and much lower energy bills.

Household customers report 3.2 more hours of usable light per evening (a 57% increase) after adopting their Sun King product, and a 76% decline in real monthly energy spending (from ~₦25,318 to ~₦5,997, or USD 18 to USD 4). This saving is equivalent to 28% of the national minimum wage. Among household-only respondents, real monthly energy expenditure declined by 76% for Tier 1-or-smaller systems and 80% for Tier 2 systems. Savings were larger in absolute terms among customers using higher-capacity systems, although the inverter sample was too small for reliable conclusions. The precise magnitude of these reductions remains subject to the limitations of recalled, banded expenditure data.

Savings are particularly large where solar replaces generator use.

Prior generator-adopting households reported an average real monthly reduction of approximately ₦36,400, compared with ₦10,800 among households that had not used a generator. Reduced generator fuel spending was also the most commonly reported reason for lower energy costs, cited by 55% of respondents whose nominal energy-cost band fell. These findings suggest that reducing reliance on costly generator backup is an important mechanism through which solar generates financial value in Nigeria. The same mechanism may apply in other generator-dependent electricity systems. Displacing generators also means less fossil fuel burned close to where people live and work. Together with the 70% of former kerosene and generator users who report less indoor smoke, this points to local environmental and health benefits, although emissions were not measured in this study.

Additional electricity supports household free time, connectivity and welfare.

Specifically, 44% of household respondents (855 of 1,954) reported having more free time since acquiring their Sun King product. Around a third of them used some of this time for paid work (31%) or business activity (5%), while others used it for rest and leisure (33%), household chores (30%), childcare (19%) and study or learning (8%). *Respondents could give more than one answer.* Among households owning a phone, 66% (1,141/1,726) reported using it more frequently, overwhelmingly because it was more reliably charged. Among respondents who had previously relied on kerosene lamps or generators, 70% (615/882) reported less indoor smoke. This time saving came through a different route from the one the electrification literature usually emphasises: rather than less time spent collecting or buying fuel, 88% (753/855) attributed it to having reliable lighting and electricity at home, with far fewer citing less time buying or handling fuel (16%) or travelling to charge devices (13%).

Households likewise report positive perceived and nominal income movement, although inflation-adjusted income fell over the recall period.

43% of household respondents (843 of 1,954) said their Sun King product had contributed to higher household income. In real terms, however, average household income fell. Given the absence of a comparison group, these real-terms declines describe the economic period customers lived through and cannot show whether Sun King customers fared better or worse than otherwise similar non-customers facing the same inflationary pressures (which were substantial during the recall period). This is also consistent with the wider literature showing that electrification is necessary but not sufficient for income gains, which also depend on market access, access to productive assets, finance, and skills.

Households are also better insulated from shocks.

87% of household-only respondents completing the resilience module (870/1,000) said their product left them less affected by rising fuel prices, over a period in which the pump price of petrol rose more than ninefold (May 2022 to May 2026). For a household, a fixed PAYGo instalment in place of a volatile fuel bill is a cost that no longer moves with the pump price.



Business pathway: longer trading hours, reported profitability gains and greater resilience

For businesses, more light after dark is associated with longer trading hours and stronger profitability.

Among 1,014 businesses with matched operating-hours observations, daily operating time increased by 38 minutes on average. Standalone businesses also reported real monthly energy costs 67% lower (from ~₦26,008 to ~₦8,478). 43% of home-based and standalone business respondents (518 of 1,196) reported that profitability had increased since acquiring their Sun King product. Businesses whose operating hours increased were twice as likely to report higher profitability as those whose hours did not (76% against 38%).

This matters because consistent power is a precondition for firm productivity.

The literature shows the inverse clearly: across Sub-Saharan Africa, a 1% increase in outage frequency reduces firm output by 3.3% and revenues by 2.7%, and in Nigeria over 80% of SMEs rely on costly diesel generation. The businesses surveyed are overwhelmingly micro-enterprises, the segment the literature identifies as most exposed to outages.

Small systems already support commercially meaningful productive use.

Of the 323 standalone businesses surveyed, 82% used Tier 1 or smaller systems, including 79% using an entry-level Tier 1 solar home system. Among these Tier 1-or-smaller businesses, the 241 with matched before-and-current operating-hours data reported an average increase of 69 minutes per day, while 59% reported improved profitability. These descriptive findings are consistent with reliable lighting, charging and connectivity acting as productive inputs for micro-enterprises.

Solar helps households and businesses keep operating through power outages and fuel-price shocks.

Of customers completing the resilience module of the survey, 89% say their product kept them running through power outages, and 83% also report it made them less exposed to rising fuel prices, 74% "a lot less". These benefits to household and firm stability matter for productivity in a currency and fuel-subsidy environment as volatile as Nigeria's. For a business, an outage absorbed is a trading hour kept.

Gains in hours and profitability have not yet translated into job creation.

Employment was unchanged for 76% of businesses, and average real employee pay fell by 23% over the recall period, consistent with evidence that electrification is necessary but not sufficient for employment and wage gains.

Home-based businesses follow the same pathway as standalone businesses, but with smaller reported gains.

38% reported higher profitability, against 59% of standalone businesses, and they gained 26 extra

minutes of operating time a day against 69 minutes. Neither sector nor system size appears to explain the gap, although the survey cannot establish its cause. Among home-based businesses whose hours increased, 63% reported higher combined household and business income, against 36% of those whose hours did not. Further research should identify what holds home-based businesses back.



PAYGo: an input that opens access to energy and to finance

PAYGo financing is the input through which many customers gain access to energy, and it also builds financial inclusion.

For over half of the surveyed respondents who used PAYGo credit to purchase their Sun King product (54%, 766/1,430), this was their first experience with any form of credit, and 30% (433) say they could not have afforded the product without it. 59% (839) also report better money management, most attributing this at least partly to paying in instalments.

WHERE NEXT: RESEARCH, INVESTMENT AND POLICY PRIORITIES

The findings point to five priorities for the standalone solar industry, funders, and policymakers, *further outlined in Section 5.*

1. Invest in longitudinal evidence: follow a cohort of new customers from a pre-purchase baseline, track a consistent core set of metrics (useful light-hours, energy spending by source, operating hours, income, employment, resilience, and PAYGo repayment and credit outcomes), and extend the approach to schools, clinics and other institutions;
2. Explore how last-mile PAYGo distribution networks, agent relationships and payment infrastructure can connect customers to business support, skills training and opportunities to use solar products for income-generating activities;
3. Prioritise home-based businesses, which gain less than standalone businesses, with productive-use bundles, tier-upgrade financing and first access to training;
4. Build on PAYGo as a route to financial inclusion, using repayment histories (with customer consent) to link customers to further credit, savings and insurance; and
5. Value resilience and cost-avoidance in result-based financing metrics, target support where solar displaces generators, and create a productive-use window for home-based businesses.



1 INTRODUCTION & CONTEXT

Between 85 and 90 million Nigerians - around 40% of the population - have no access to electricity at all

1.1 Nigeria's electrification gap is large, costly, and getting more expensive to ignore

Nigeria has the largest unelectrified population in the world. Between 85 and 90 million Nigerians - around 40% of the population - have no access to electricity at all.[1,2] Even those who are connected to the national grid cannot always rely on it, as Nigeria's installed generation capacity of 13,000 to 14,000 MW has historically delivered less than 6,000 MW of power to a population of over 200 million. For comparison, South Africa - with roughly 60 million people, less than a third of Nigeria's population - operates around 32,000 MW of its 48,500 MW installed capacity.

The result is that households and businesses rely heavily on self-generation, primarily petrol and diesel generators. National Bureau of Statistics estimates suggest that over 48% of electricity consumed in Nigeria is powered by generators - at significantly higher per-unit cost and with substantial local air pollution and greenhouse gas emissions.[3] For businesses, the effect is direct and severe: unreliable electricity is consistently cited as the biggest constraint to doing business in Nigeria,[4] and more than 80% of Nigerian small and medium-size enterprises (SMEs) rely on diesel generators to keep operating.[5] That dependence has become markedly more expensive. Between May 2022 and May 2026 the national average retail price of petrol rose by more than 800% and diesel by nearly 400%, far outpacing general inflation over the same period.[6] Self-generation in Nigeria is therefore not only costly in absolute terms but has become progressively harder to afford.

This is not a uniquely Nigerian problem. **Across Sub-Saharan Africa, a 1% increase in the frequency of power outages reduces firm output by 3.3% and firm revenue by 2.7%.[7]** Globally, outages are estimated to cause USD 82 billion in lost sales annually and force a further USD 65 billion in defensive spending on self-generation.[8] At a macro level, eliminating outages entirely could raise output per worker by around 25% across five African countries,[9] and shortages are estimated to shave 2-4% off Sub-Saharan African GDP each year - a loss that also shows up in government revenue, with resolved shortages projected to generate more than USD 9.5 billion in additional tax revenue annually across 36 African countries, equivalent to roughly 4.3% of current collections.[10]

In short, Nigeria's electricity challenge has two dimensions: millions of people remain without electricity access at all, while many of those who are connected receive unreliable supply and rely on expensive self-generation. Both of these dimensions impose a direct tax on firm productivity, household income and welfare, and government revenue **- which is precisely why closing the gap, and closing it in a way that is fiscally sound, has become a national policy priority**.

1.2 Why standalone solar's evidence gap matters right now

The Federal Government of Nigeria has formally recognised decentralised renewable energy (DRE) as central to closing the access gap, prioritising mini-grids and standalone solar under the Rural Electrification Strategy and Implementation Plan (RESIP), led by the Federal Ministry of Power and the Rural Electrification Agency (REA).[11]

The clearest expression of this strategy is the World Bank's USD 750 million Distributed Access through Renewable Energy Scale-up (DARES) programme, approved in December 2023: Component 1 funds mini-grid deployment, Component 2 - the component most relevant to this study - uses results-based financing to scale standalone household and productive-use solar through providers such as Sun King, and Component 3 funds technical assistance. DARES also draws in co-financing from the Global Energy Alliance for People and Planet (GEAPP) and the Japan International Cooperation Agency (JICA), alongside more than USD 1 billion in anticipated private capital.[12]

Whether standalone solar secures a sustained share of DARES and future concessional finance largely depends on whether policymakers have credible, Nigeria-specific evidence that standalone solar delivers real socioeconomic returns.

1.3 Purpose and scope of this report

This report presents an independent, evidence-based assessment of the socioeconomic value of standalone solar in Nigeria, commissioned by Sun King and LeapFrog Investments. The findings are designed to contribute to the evidence informing how resources are allocated towards standalone solar, and to help shape the design of future results-based financing and scale-up decisions.

Section 2 sets out the theory of change - how, in principle, energy access (and standalone solar adoption specifically) is expected to translate into socioeconomic value for households, home-based businesses, and standalone businesses, and what conditions that translation depends on. **Section 1.4** and **Annex 1** describe the survey of Sun King customers and the empirical approach used to test the theory of change against real data. **Section 4** presents the resulting impact findings. **Section 5** sets out recommendations for the standalone solar industry and relevant funders and policymakers: how to build on this evidence through future research, how to help customers turn energy access into productive use, and policy implications to take forward.

1.4 Methodology and how to read this report

This report draws on a structured telephone survey of 2,277 Sun King customers across all six of Nigeria's geopolitical zones, carried out by Sun King's call centre in June and July 2026. Genesis Analytics designed the questionnaire and sampling approach, trained the call centre agents on question wording, routing and the neutral delivery of sensitive questions, piloted the instrument for a week before fieldwork, and independently cleaned, validated and analysed the data. The survey covered customers' energy sources and use, household and business outcomes, financial inclusion and resilience, with modules tailored to each respondent's circumstances. Customers reported on their circumstances both before and after adopting their Sun King product, so that each customer's own experience provides the point of comparison.

WHY WE USED A RECALL DESIGN, WITH EACH CUSTOMER AS THEIR OWN CONTROL

A recall design was the most feasible robust approach available for a commercial product at this scale. Randomised trials are usually not suitable for products that customers choose and pay for, since withholding them from a control group is often difficult. A quasi-experimental design, comparing customers with a matched group of non-customers, would have been difficult given that Sun King holds no data on non-customers, and so collecting data from a separate control group would have required a much larger survey going to respondents outside of Sun King's customer base, which was not reasonable within the study constraints and timelines. A quasi-experimental design would also have faced its own methodological challenges: people who buy solar are likely to differ from those who do not in income, location and grid access, and these differences are hard to control for fully.

Using each customer as their own control has real strengths. This approach holds constant everything about a customer that does not change over time, such as where they live, their household make-up and the type of business they run, which a comparison between different groups of people cannot do. It allowed a large, geographically diverse sample to be surveyed quickly and at modest cost, giving strong statistical power for the comparisons that matter most, such as by gender, customer type, product and region. And it captures customers' own explanations of why things changed, not just whether they did. Customer-reported change of this kind is the standard basis for impact measurement in the standalone solar sector, including the 60 Decibels and GOGLA studies cited in Section 2.

The survey was designed to make recall as accurate as possible. Each respondent's adoption date was taken from Sun King's records and confirmed at the start of the interview, anchoring all "before" questions. For seasonal measures such as income and energy spending, respondents recalled the same calendar month in the year before adoption, and could answer "don't recall" rather than guess. Money values were collected in bands to avoid false precision, and the sample was limited to customers who had owned their product for up to three years, limiting the recall window to around four years at most. Effects that build over longer periods, such as business growth and asset accumulation, may still be developing, so the findings are best read as early- to medium-term impacts.

WHO THE FINDINGS REPRESENT

The sample was drawn at random from Sun King's customer records, stratified by region, customer type and gender, so that it reflects Sun King's Nigerian customer base rather than whichever customers were easiest to reach. The findings therefore describe Sun King customers, rather than Nigerian households and businesses as a whole.

The achieved sample is broadly representative of that customer base. The 2,277 completed interviews equal 43% of the 5,290 call records, but this figure mainly reflects calls that did not reach a customer, rather than customers choosing not to take part. Of the 3,013 call records that did not produce a completed interview, 1,197 (40%) did not connect (busy, hung up, unreachable or out of service) and 345 (11%) reached someone other than the customer, or a customer who could not talk at that time. Only 102 (3%) were refusals: 97% of customers who were available to take part agreed to do so. The rest were customers screened out as ineligible (340, 11%), mainly because they no longer used their product or could not verify their purchase, and respondents who stopped part-way through the 25-minute interview (1,029, 34%). Among consenting, eligible customers, 69% completed the core modules. Whether a call connects is unlikely to be closely related to customers' outcomes, and the achieved sample's distribution by region and product tier is broadly similar to Sun King's administrative records.

HOW TO READ THE RESULTS

The direction of reported changes is more robust than their precise size. The results are based on customers' own reports. Because interviews were conducted by Sun King's call centre, some upward bias is possible, for example if customers wish to affirm a product they chose. The safeguards described above reduce this risk but cannot eliminate it. Where customers explain why an outcome changed, or how much of a change they attribute to their product, these are their own perceptions and complement the before/after comparisons.

Before/after comparisons show what changed after customers adopted solar. When the report says an outcome improved, it means it improved among surveyed customers after adoption. Where the report links a change to the product, this rests on the before/after comparison, on customers' own attribution, and on how closely the pattern of changes matches the mechanisms in the theory of change. For example, the largest energy savings are concentrated among households that previously relied on costly generators, exactly where the theory of change predicts them. Wider economic changes over the same period are discussed alongside the results so that readers can distinguish the two.

Further details on sampling, survey modules, recall design, statistical power and the analytical approach are set out in Annexure 1.



2 OUR THEORY OF CHANGE

How energy access, and standalone solar in particular, creates economic value

Access to reliable energy has long been recognised as a foundational infrastructure component for economic development, evidenced most strongly by literature showing the counterfactual, i.e. the economic losses in countries facing limited energy access and/or outages.[13] For instance, across Sub-Saharan Africa, Blimpo and Cosgrove-Davies (2019) show that a 1% increase in outage frequency reduces firm output by 3.3% and revenues by 2.7%,[14] while globally Rentschler et al. (2019) estimate USD 82 billion in annual sales losses and USD 65 billion in self-generation spending due to power outages, highlighting the scale of additional costs economies face due to unreliable power.[15] Firm-level evidence from Asia reinforces these magnitudes: Zhang (2019) finds that a 10% power shortage reduced total factor productivity by 3.1% to 4.1% in Bangladesh and that each additional hour of daily outages in Pakistan cut value-added and revenues by about 1.3%.[16] In Indonesia, Poczter (2016) shows smaller firms are disproportionately harmed, implying effects on market structure,[17] while in Nigeria over 80% of SMEs rely on costly diesel generation.[18] At the macro level, Fried and Lagakos (2020) estimate that eliminating outages could raise output per worker by around 25% across five African countries, reflecting a broader "lock-in" dynamic whereby unreliable electricity pushes firms toward inefficient, power-insensitive technologies and constrains capital deepening and structural transformation.[19]

The productivity losses associated with unreliable electricity also aggregate into broader macroeconomic costs. Across Sub-Saharan Africa, electricity shortages are estimated to reduce GDP by between 2% and 4% annually.[20,21,22] These losses translate into reduced fiscal capacity, as weaker firm performance constrains taxable economic activity. Simulations suggest that resolving electricity shortages could generate more than USD 9.5 billion in additional tax revenues annually across 36 African countries, equivalent to approximately 4.3% of current tax revenue collections.

At a household level, access to reliable energy allows households to (i) use lights and appliances needed for productive tasks, such as studying, and (ii) can free up time previously spent on tasks like fuel collection. However, the latter effect is mainly relevant in contexts where electricity leads to shifts in cooking practices, such as in South Africa or other Southern African countries. In many other settings, including Nigeria, cooking continues to rely largely on traditional fuels, so time savings from electrification are limited until appliances such as washing machines or dishwashers become more common. Nevertheless, evidence from other contexts illustrates the potential productivity gains: Barron and Torero (2014) report a 78% increase in children's participation in educational activities in electrified Salvadoran households,[23] while Zhang (2019) documents that electricity access in Bangladesh increased girls' study time, contributing to gender parity in educational attainment.[24] Where fuel collection is reduced, this can also create opportunities for economic activity: Zhang (2019) finds that Indian women reduced fuel collection time by 44% following electrification,[25] and Barron and Torero (2014) show that Salvadoran women in electrified households were 46 percentage points more likely to engage in non-farm employment.[26] Similarly, Grogan (2018) finds that Guatemalan women increased time spent working for money by 2 to 3 hours daily.[27]

Through these mechanisms, electricity access can support both improved educational outcomes and expanded labour market participation. This is particularly relevant in Nigeria, where unemployment stood at 5.3% in Q1 2024 and where a large share of employment remains concentrated in informal or low-productivity sectors.[28] For instance, Nano (2022) finds that in Nigeria, electricity access increased male employment probability by 3.3%.[29] The study suggests that electricity access enables small-scale enterprises, such as barber shops or vendors selling cold beverages, to operate and expand, often shifting labour from



agriculture (typically household farming) toward non-agricultural activities. Particularly noteworthy are the wage effects documented by Djoumessi et al. (2021), who report that Ugandan households with electricity access earned wages more than 100% higher than non-electrified households in some specifications.[30] Winther, T et al. (2017) identify a qualitative shift in employment types in India, where electricity access facilitated transitions from casual to regular wage work for men.[31]

Beyond economic indicators, Lee et al. (2020a) note that increased access to electricity may enable greater access to news media and other information that in turn may spur greater participation in "public life and generate improvements in the political system or public policy".[32] While their study in Kenya does not reveal such an impact after 36 months of grid connection, the authors nonetheless note that evidence of these kinds of socio-political impacts may take longer to materialise. This highlights a key evidence gap: the lack of long-run impact studies on socio-political outcomes of electrification. Hence they suggest that "further long-run impact studies will thus be useful."[33]

While there is a well-established macroeconomic correlation between energy consumption and development, the assumption that household electrification automatically drives economic growth in the Global South is contested, revealing significant gaps in the sufficiency of evidence for broad, untargeted interventions.[34,35] Broad systematic reviews, such as those catalogued in the SEforALL Evidence Gap Map and Systematic Review, reveal that the empirical evidence on the impacts of electrification remains starkly divided, largely due to variations in baseline economic conditions and a concentration of research in only a few intervention categories and geographies, despite major energy access deficits elsewhere.[36] Some of the literature notes that historical electrification success stories typically occurred in regions that were already experiencing an upward economic growth trajectory.[37] Conversely, extending grid infrastructure to remote communities that are barely integrated into broader economic processes often fails to independently catalyse development. Access to energy alone does not produce economic growth; rather, there are crucial moderating variables that determine the impact that access to energy will have on a business or household.

Randomised and quasi-experimental studies illustrate these limitations. Experimental trials in rural Kenya, for example, find little evidence of meaningful medium-term impacts on household income, employment, or living standards following grid connection.[38] Similar findings have emerged in Rwanda, where even a decade after electrification, income and employment effects remained limited in many rural communities.[39] In these contexts, electricity consumption and appliance ownership remain low, reflecting affordability constraints and limited productive opportunities.[40]

While electrification improves service delivery in public facilities such as schools and health centres through better lighting, reduced energy costs, and improved administrative functioning, these improvements alone have often proven insufficient to catalyse broader local economic transformation.

Off-grid solar systems - including Pico solar products, Solar Home Systems (SHS), solar water pumps/ irrigation systems, solar systems for small businesses, and institutional solar systems - offer the fastest deployment pathway, particularly for remote or low-income households. Without the need for distribution infrastructure, comparative studies in rural Nigeria find significantly shorter time-to-access relative to grid connection.[41]

Most socioeconomic impact studies of standalone solar systems in particular are concentrated at the household level, demonstrating:[42,43,44,45,46,47]

- Immediate expenditure savings from replacing kerosene and phone-charging fees;
- Improvements in indoor air quality and associated health outcomes;
- Increased study time due to high-quality LED lighting; and
- Time savings, particularly for women and girls.

Insights from 60 Decibels' standalone impact studies show that of all standalone products, solar lanterns produce the greatest reported improvements in quality of life and customer satisfaction across standalone products, with 94% of surveyed customers reporting improvements overall and 64% saying their quality of life had improved significantly because of the light.[48] Additionally, the Global Off-Grid Lighting Association (GOGLA) reports that millions of systems are sold annually under Pay-As-You-Go (PAYGo) models, reflecting strong demand when upfront costs are amortised.[49]

In West Africa, GOGLA also found that SHS generates clear economic benefits, but these are concentrated among specific subsets of users: many households report increased savings or disposable income (e.g. 75% in West Africa say they have more money available after adopting SHS), largely driven by reduced spending on fuels like kerosene, while a smaller subset directly engages in income-generating activities.[50] For example, around 1 in 7 households earn additional income (about USD 31/month on average) and multiple household members may increase working hours or start small enterprises. GOGLA also found that standalone solar supports climate resilience by enabling vulnerable households and communities to better anticipate, withstand, and recover from climate shocks, primarily through improved access to electricity services that power critical infrastructure, support climate-resilient livelihoods, and provide access to information and early warning systems.[51]

Drawing on the literature, this study sets out to test the "theory of change" or "impact pathways" in Figure 1. Figure 1 distinguishes between service tier, user characteristics, and complementary factors as mediating variables. We also acknowledge that the impact pathways for households and businesses are different. Public institutions are not included in this study, but would, in reality, be a third user category with broader economic impacts based on enabling education and health services to be provided.

Read from top to bottom, the theory of change has five links:

1. **Inputs:** A household or business (or home-based business) acquires a standalone solar system – anything from a small pico-solar lantern to a larger productive-use system. Most customers finance their system through pay-as-you-go (PAYGo) instalments rather than paying upfront, so PAYGo forms part of the input: for many customers, it is what makes access to energy possible in the first place. The size and capability of the system determines what outputs the system can deliver.

2. **Outputs**: The system delivers reliable and usable electricity for reliable lighting and greater ability to run appliances or equipment. These are the benefits that are easiest to observe and that most existing studies measure well.

3. **Intermediate outcomes:** Households and businesses then decide what to do with those outputs, such as study or work longer hours after dark, reallocate time previously spent on fuel collection or generator management, adopt new appliances, or extend business operating hours.

4. **Final outcomes:** Sustained productive use may, in principle, feed through into income, savings, asset accumulation, better educational and health outcomes, job creation, or firm growth. In practice, however, there is no strong *a priori* reason to expect standalone solar adoption on its own to move these final outcomes by a large or reliably measurable amount: access to electricity is rarely the binding constraint on things like household income or business profitability, which depend at least as much on market access, finance, skills and the wider macroeconomic environment. We nonetheless measure these outcomes, both because they matter to policymakers and because doing so lets us test, rather than assume, the strength of this link.

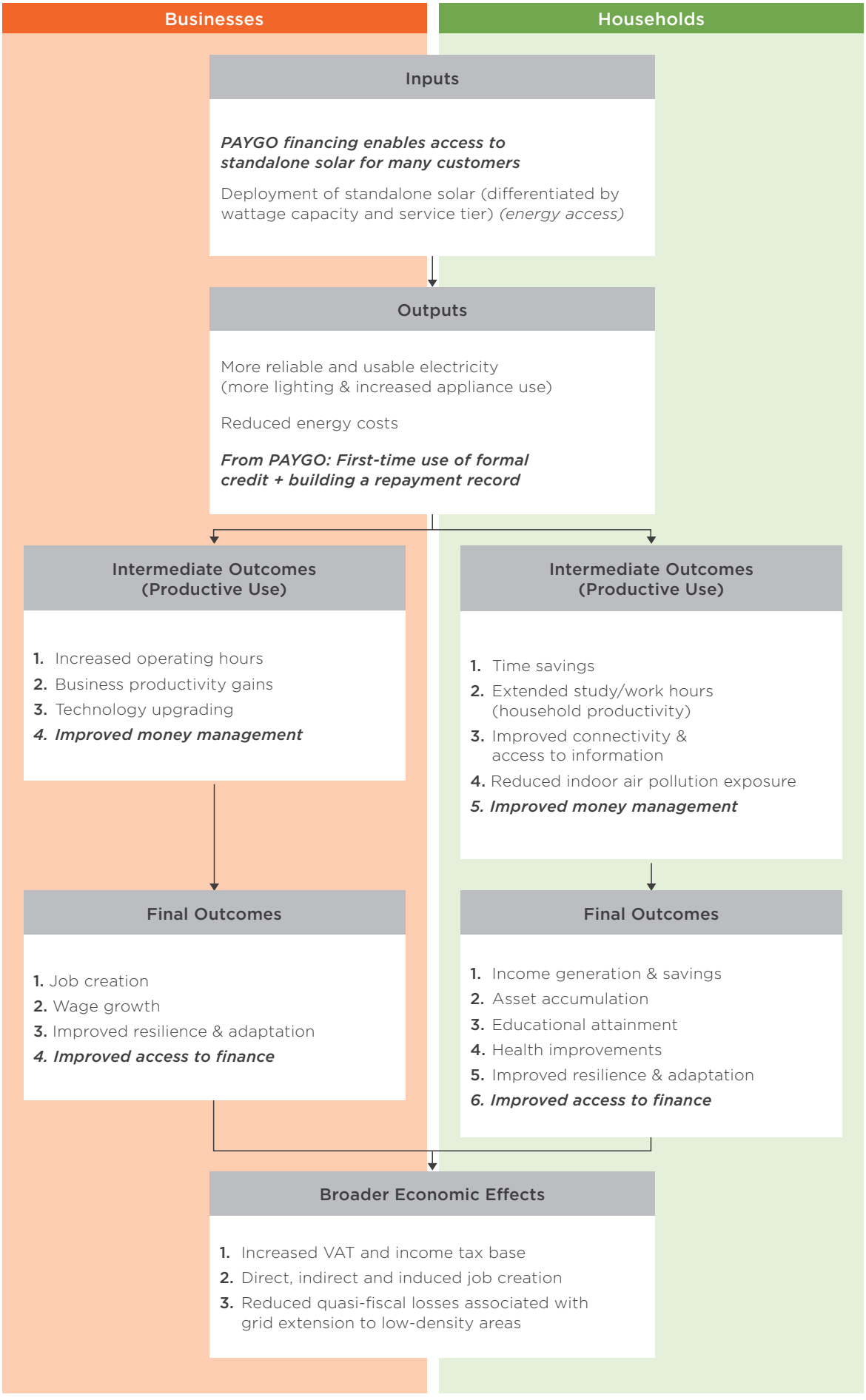
5. **Broader economic effects:** At sufficient scale, these household- and business-level changes can also feed through into broader fiscal and policy outcomes, such as a larger tax base, direct and indirect job creation, and reduced quasi-fiscal losses associated with extending the grid to low-density areas. As with final outcomes, this link is plausible in principle but is the most indirect and hardest to evidence with this survey. We thus rely on the literature review above, rather than an extrapolation of the survey results, to illustrate these broader economic effects.

PAYGo also produces outcomes of its own. Paying for a system in small, regular instalments can change customers' financial lives independently of the electricity the system delivers. For many customers it is their first experience of formal credit and builds a record of regular repayments (outputs); this may encourage more structured budgeting and money management (intermediate outcome), and open the door to further credit, savings or insurance (final outcome). Figure 1 therefore shows PAYGo as an input with two roles: enabling access to energy, which feeds both the household and business pathways, and driving a separate financial-inclusion pathway. The evidence on both roles is summarised in Section 4.3.1.

The diagram shows two parallel tracks because household and business outcomes are genuinely different: a household mainly converts light and power into study and work time, fuel savings, and more free time, while a business converts the same inputs into longer trading hours and productivity gains. However, a large share of Nigerian economic activity does not sit neatly in either track. Where someone runs a business from home (such as, a salon, a phone-charging stand, or provisions shop), the same system is simultaneously a household and a productive asset, and the tracks overlap. The survey and the results that follow capture this overlap by splitting respondents into three categories: households, home-based businesses (the overlap), and standalone businesses.

These impacts are conditional on: (i) baseline wealth and asset ownership, baseline SHS and LED usage, market access, access to finance, gender and intra-household dynamics and local grid reliability conditions; **(ii)** whether SHS is providing primary energy access or backup support to the user; and **(iii)** how much time has passed since the user first acquired SHS.

Figure 1 Impact Pathways for energy access (particularly standalone solar usage) by households and businesses, with PAYGo financing as an input





3 SUN KING CUSTOMERS & THEIR ENERGY CONTEXT

3.1 Who we spoke to: survey overview

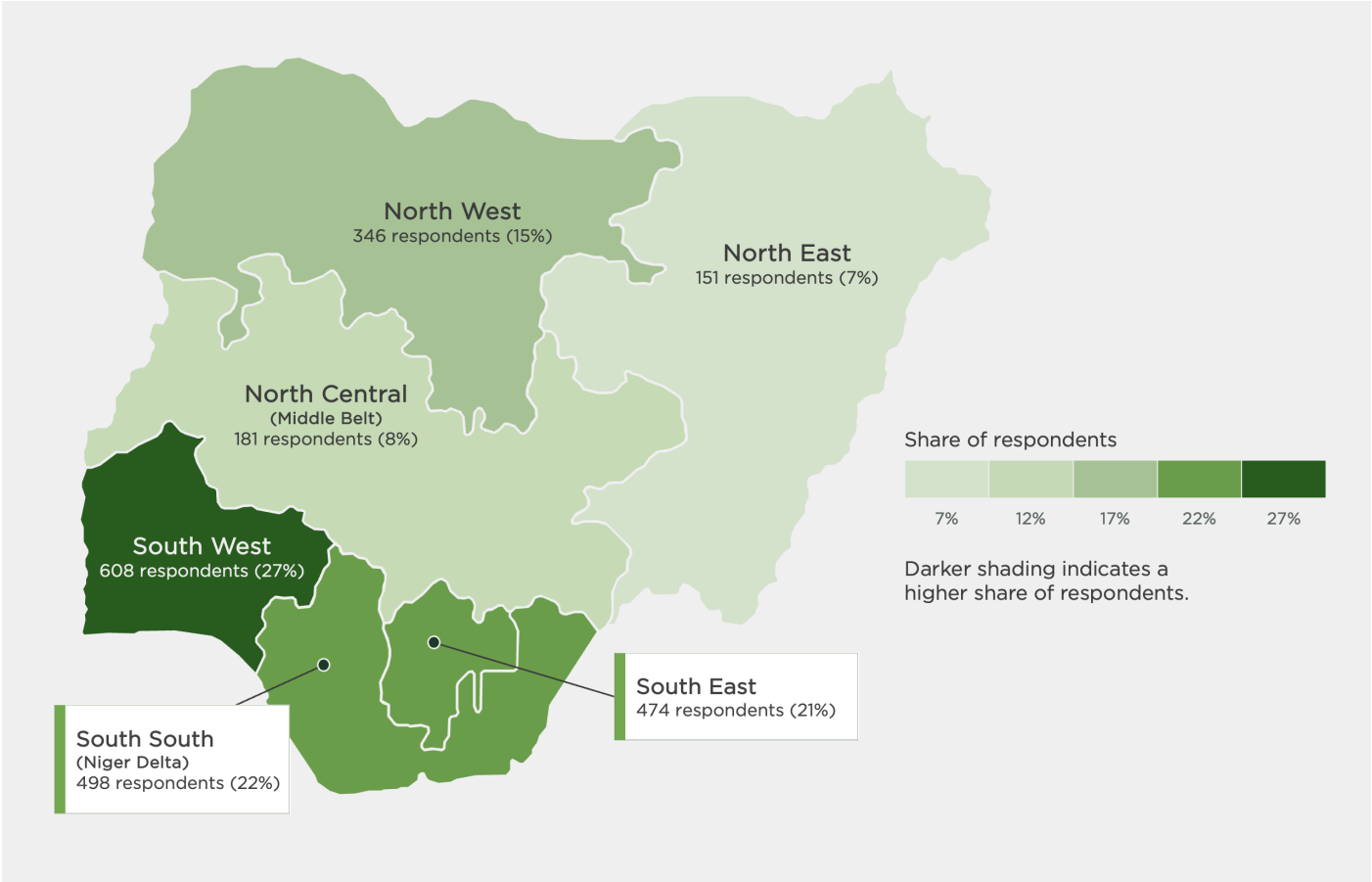
The survey yielded 2,277 materially complete responses, i.e. respondents who completed the modules on electricity sources and household and/or business impacts: 1,081 (48%) household-only respondents, 323 (14%) business-only respondents, and 873 (38%) home-based business respondents. Of those, only 1,430 completed the financial inclusion module (as this was asked only of respondents who had used credit to purchase their solar product), and 2,006 completed the supplementary module on resilience.

1,081 (48%) household-only respondents,
323 (14%) business-only respondents, and
873 (38%) home-based business respondents.

RESPONDENTS WERE DRAWN FROM EVERY REGION IN NIGERIA.

The largest share of respondents came from the South West (27%) and the smallest from North Central (8%), as shown in Figure 2,[52] which reflects the geographic distribution of Sun King's customer base which was intentionally sampled to be representative.

Figure 2 Geographic spread of surveyed Sun King customers across geopolitical zones in Nigeria



A MAJORITY OF BUSINESS-ONLY RESPONDENTS CAME FROM FEMALE-HEADED BUSINESSES.

Table 1 outlines the gender and age demographics of respondents, disaggregated by household-only, business-only, and home-based business respondents. Household respondents (including household-only and home-based business respondents) reported an average of 5.3 individuals per household.[53]

Table 1 Gender and age demographics of respondents, disaggregated by segment

	Households	Business-only	Home-based business
Female household or business head	306 (**16%**)	174 (**54%**)	353 (**41%**)
*Household or business head <35 years (or <30 years)**	468 (**25%**) *199 (11%)*	88 (**28%**) *31 (10%)*	205 (**25%**) *64 (8%)*

Notes: *1. International Guidelines, such as the Africa Youth Charter, define youth as individuals aged 15-35 years. However, Nigeria's revised National Youth Policy (2019) defines youth as individuals aged 18-29 years. 2. Household category includes household module respondents and home-based business module respondents where the household head was separate from the business head. In this table, percentages are based on valid responses, excluding missing and non-substantive answers. Gender sample sizes are 1,906 (households), 322 (standalone businesses) and 859 (home-based businesses); age sample sizes are 1,848, 320 and 832, respectively.*

Surveyed households reported relatively high levels of educational attainment, with significant variation across regions. Overall, 39% (758 of 1,954) reported university/college education as the highest level achieved within the household, 9% (178) vocational/technical education, 28% (539) secondary education, 5% (93) primary and 8% (154) no formal education. A further 12% (232) did not know or chose not to respond.[54] The distribution of educational attainment differed significantly across Nigeria's six geopolitical zones, particularly in the prevalence of no formal education, which was highest in the North East (25%, compared with 4% in the South West).[55] For national context, Nigeria's 2021 Multiple Indicator Cluster Survey found that 21% of household heads had attained higher/tertiary education, compared with 39% of surveyed Sun King households reporting university/college education as the highest level achieved by any household member.[56]

Higher household educational attainment was also associated with greater grid access. Among surveyed households, 63% of those reporting university/college education had a grid connection, compared with 30% of those reporting no formal education.[57]

MOST HOUSEHOLD RESPONDENTS WHO REPORTED THEIR HOUSEHOLD INCOME CAN BE CONSIDERED "EMERGING CONSUMERS".

Among household respondents who provided a classifiable income response, 88% met LeapFrog Investments' Emerging Consumer threshold of earning less than USD 11.20 per day in 2017 Purchasing Power Parity (PPP) US dollars.[58] Of the 1,954 household respondents, 666 (34%) were classified as Emerging Consumer based on their self-reported household income for June 2026. A further 89 (5%) were above the Emerging Consumer threshold, while 1,199 (61%) selected "don't know/prefer not to answer". Given the sensitivity of income questions and the high level of non-response, the 34% figure should therefore be interpreted as the minimum observed share of the full household sample, rather than as an estimate of the overall prevalence of Emerging Consumers.

Business respondents represented both standalone and home-based enterprises, predominantly operating at a small scale. Retail and trading were the most commonly reported activities in both segments. Both groups reported an average of 2.4 employees. Women

headed 54% (174/323) of standalone businesses and 41% (353/873) of home-based businesses. The survey did not assess whether businesses were formally registered, so their formal or informal status cannot be determined, although their small scale and characteristics are consistent with those of Nigeria's informal enterprise sector. Further detail on the characteristics and economic importance of these businesses is provided in Section 3.3.

3.2 How customers access and use electricity

Respondents use Sun King products within diverse electricity environments, ranging from households without a grid connection to grid-connected customers who rely on solar and generators as backup. Understanding this energy mix is important for interpreting the impacts reported in Section 4. Below we describe the different products respondents use, their grid access and reliability, and their use of alternative electricity sources before and after acquiring Sun King.

TWO-THIRDS OF RESPONDENTS USE ENTRY-LEVEL SHS PRODUCTS.

The World Bank's Multi-Tier Framework (MTF) for energy access provides a useful basis for categorising solar products according to the level of electricity service they provide, rather than treating energy access as binary.[59] By considering factors such as capacity, availability, reliability and quality, the MTF enables products such as solar lanterns, SHS and solar inverters to be differentiated by the level of energy service they provide. This is important for assessing socioeconomic impacts, as different levels of energy access enable different household and productive uses and may therefore have different effects on outcomes such as income, expenditure, education, time use and business activity.

Table 2 summarises the different solar products used by respondents in the survey and their corresponding MTF tier.

Table 2 Sun King products used by survey respondents, with associated tier from the Multi-Tier Framework for energy access

Sun King product (example)	Product category & Sun King product examples	MTF Tier	No. of respondents (*n* = 2,277)	Household only (*n* = 1,081)	Home-based business (*n* = 873)	Standalone business (*n* = 323)
	**Entry-level SHS** Small standalone solar home systems designed primarily to provide basic household electricity services: several lighting points, mobile-phone charging and, depending on the configuration, a radio or other very small DC appliance. These systems are intended to provide a household with a first meaningful level of electricity access. *E.g., Home 200x, Home 200x Plus, HomePlus, HomePlus Pro SHS 200X Plus*	Tier 1	1,539 (68%)	691 (64%)	594 (68%)	254 (79%)

Sun King product (example)	Product category & Sun King product examples	MTF Tier	No. of respondents (*n* = 2,277)	Household only (*n* = 1,081)	Home-based business (*n* = 873)	Standalone business (*n* = 323)
	**Large SHS without TV** Higher-capacity standalone solar home systems designed to provide substantially more electricity than entry-level systems. They typically provide multiple household lighting points, phone charging and enough capacity for appliances such as fans, radios and other small DC appliances. *E.g., Home 500x, HomePlus Max, SHS 500X, SHS 600*	Tier 2	428 (19%)	239 (22%)	151 (17%)	38 (12%)
	**Large SHS with TV** Higher-capacity standalone solar home systems that combine household lighting and phone charging with the ability to operate a television and other small appliances. The TV configuration represents an expanded household electricity service compared with entry-level SHS. ***E.g., Large SHS products with 32-inch TV***	Tier 2	204 (9%)	119 (11%)	81 (9%)	4 (1%)
	**Lanterns** Portable, single-light solar products, generally designed for basic lighting and, in many models, mobile-phone charging. *E.g., Sun King Boom, Sun King Pro 400*	Total Tier 1[60] Tier 0	46 (2%) 2 (<1%) 44 (2%)	18 (2%) 1 (<1%) 17 (2%)	18 (2%) 1 (<1%) 17 (2%)	10 (3%) 0 (0%) 10 (3%)
	**Solar inverters** Larger solar power systems that convert solar-generated DC electricity to AC electricity and store energy in batteries, allowing households or businesses to operate conventional AC appliances such as TVs, refrigerators, fans, computers and other equipment. *E.g., PowerPlay Pro, Home 8000, PowerHub 2.0*	Tier 3-5	41 (2%)	7 (1%)	18 (2%)	16 (5%)

Product information was unavailable for 19 respondents, 0.8% of the full sample (7 household-only, 11 home-based businesses and 1 standalone business) who could not be assigned to a product category or MTF tier. Percentages use the sample sizes shown in each column heading and are rounded to the nearest percentage point.

Entry-level (Tier 1) SHS are the predominant product across all customer segments, used by 691/1,081 (63.9%) household-only respondents, 594/873 (68.0%) home-based businesses and 254/323 (78.6%) standalone businesses. Once lanterns are included, 264/323 (81.7%) standalone businesses use Tier 1 or smaller systems. Larger Tier 2 SHS are more common among household-only respondents and home-based businesses, while solar inverters, although uncommon overall, are relatively more prevalent among standalone businesses. Lanterns and solar inverters together account for only 4% (87/2,277) of the full sample, meaning that the findings primarily reflect the experiences of SHS customers.

The product mix varies by region. Tier 1 or smaller systems account for around three-quarters of surveyed customers in the North West, South South and South West (74–76%), against around three in five in North Central, the North East and the South East (60–63%), where larger Tier 2 systems are more common. Grid-connected customers were slightly more likely to use a Tier 1 or smaller system than those without a connection (73% against 67%), while prior grid use made no difference. These figures describe the product mix of the surveyed sample, not outcomes.

GRID CONNECTION DOES NOT MEAN RELIABLE ELECTRICITY ACCESS.

Grid unreliability helps explain why solar remains valuable even for grid-connected households. Across the full household sample of 1,954 respondents, 57% (1,109) reported having a grid connection, while 43% (839) did not.[61] Among the 1,109 respondents with a grid connection, 93% (1,027) continued using solar because the grid was unreliable, while a further 4% (47) cited both unreliability and high grid costs. Only 2% (26) cited high costs alone and 1% (9) another reason.[62]

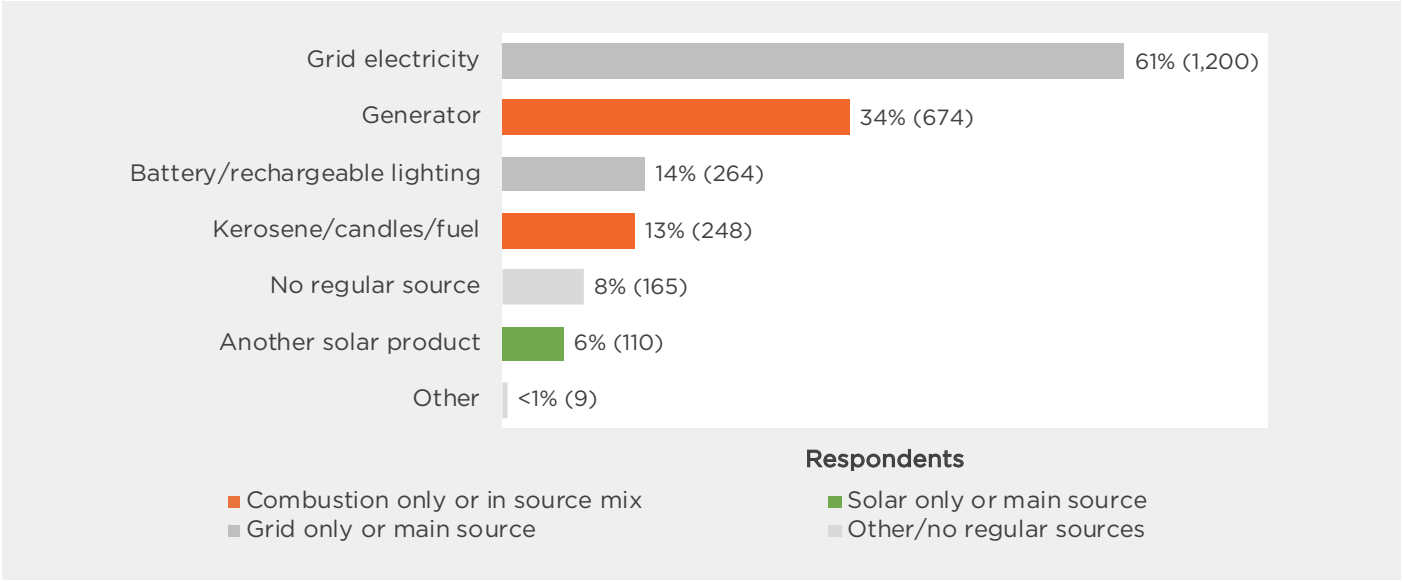
57% of all households surveyed reported having a grid connection, and 93% of these grid-connected customers cited grid unreliability as the main reason they continued using solar.

CUSTOMERS COMMONLY COMBINE MULTIPLE ELECTRICITY SOURCES.

A household with a grid connection may still rely on solar and other backup sources when grid supply is unavailable, rather than relying on any one source exclusively. Before acquiring their Sun King product, 631 households (32%) reported regularly using at least two different lighting or electricity sources, and 104/1,954 (5%) used three or more.[63] Grid access in particular did not imply reliance on the grid alone. Although 1,200 households (61%) reported using grid electricity before Sun King, 572 of these grid users (48%) also used at least one other source. Generator backup was especially common with 416 of 1,200 grid users (35%) also using a generator. This is equivalent to 21% (416) of the full household sample. Sun King products frequently complement grid access by providing a more reliable source of electricity during outages.

Figure 3 shows sources of lighting respondents reported using prior to their Sun King product. For almost half of the 882 household respondents that reported using these combustion based sources prior to owning their Sun King product, one of these sources was also their *main* source prior to their Sun King product (48%, 422). 146 (7%) of the full household sample relied *mainly* on kerosene/candles and 276 (14%) mainly on a generator, while only 2% (46) reported using any form of solar as their main source.[64]

Figure 3 Lighting and electricity sources used by households prior to their Sun King product

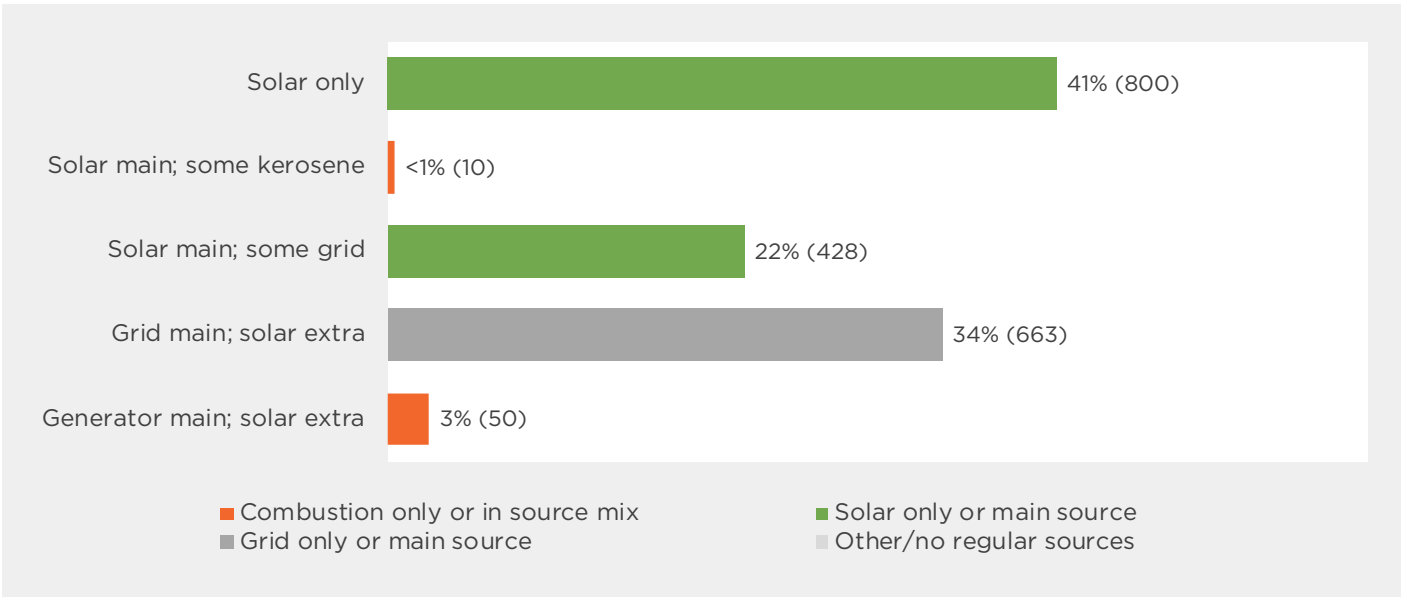


Notes: *n = 1,954 household respondents. Respondents could report multiple sources used before acquiring their Sun King product, so percentages do not sum to 100%.*

Prior to obtaining their Sun King product 45% (882) household respondents report previously using kerosene/candles or a generator.

Customers' current energy mix is substantially more solar-led, as shown in Figure 4. Specifically, 63% (1,238) now report solar as their main source, including 41% (800) who use solar alone, while 34% (663) use grid electricity as their main source with solar as backup and 3% (50) mainly use a generator with solar as backup.

Figure 4 Reported main source of lighting and electricity at the time of the survey



Note: *n = 1,954 household respondents. 3 respondents answered "Don't know / prefer not to answer".*

63% of households (1,238) now report using solar as their main source of electricity.

FOR ONE IN FIVE CUSTOMERS, THEIR SUN KING PRODUCT REPRESENTED FIRST-TIME ACCESS TO ELECTRICITY.

For one in five surveyed customers, their Sun King product represented first-time access to electricity.[65] Overall, 20% (460/2,277) reported having used neither grid electricity, a generator nor another solar product before acquiring their Sun King product. Instead, these customers had relied only on sources such as kerosene or candles, battery or rechargeable lighting, or had no regular source of lighting or electricity. The share was similar across customer segments as seen in Table 3 below. A broader 25% (561/2,277) had no prior grid or generator access, although some of these customers had previously used or owned another solar product.

Table 3 Energy access before Sun King, by customer segment

Prior access group	Household-only (*n* = 1,081)	Home-based business (*n* = 873)	Standalone business (*n* = 323)	All respondents (*N* = 2,277)
First-time access (no grid, generator or solar)	20% (221)	19% (166)	23% (73)	20% (460)
Prior solar only (no grid or generator)	4% (38)	5% (48)	5% (15)	4% (101)
Prior grid and/or generator	75% (813)	74% (645)	71% (230)	74% (1,688)
Don't know	1% (9)	2% (14)	2% (5)	1% (28)

For these first-time access customers, solar has become their whole electricity supply rather than a backup. 81% (371/460) now use solar as their only source of electricity, against 30% (535/1,789) of customers who had other sources before.

One in five Sun King customers surveyed had no grid, generator or solar before their Sun King product. For four in five of them, solar is now their only source of electricity.

Sun King is therefore serving two distinct groups: a majority who use solar to make an existing, often unreliable supply more reliable or cheaper; and a substantial minority for whom it provides electricity for the first time.

3.3 Businesses in the sample and Nigeria's informal economy

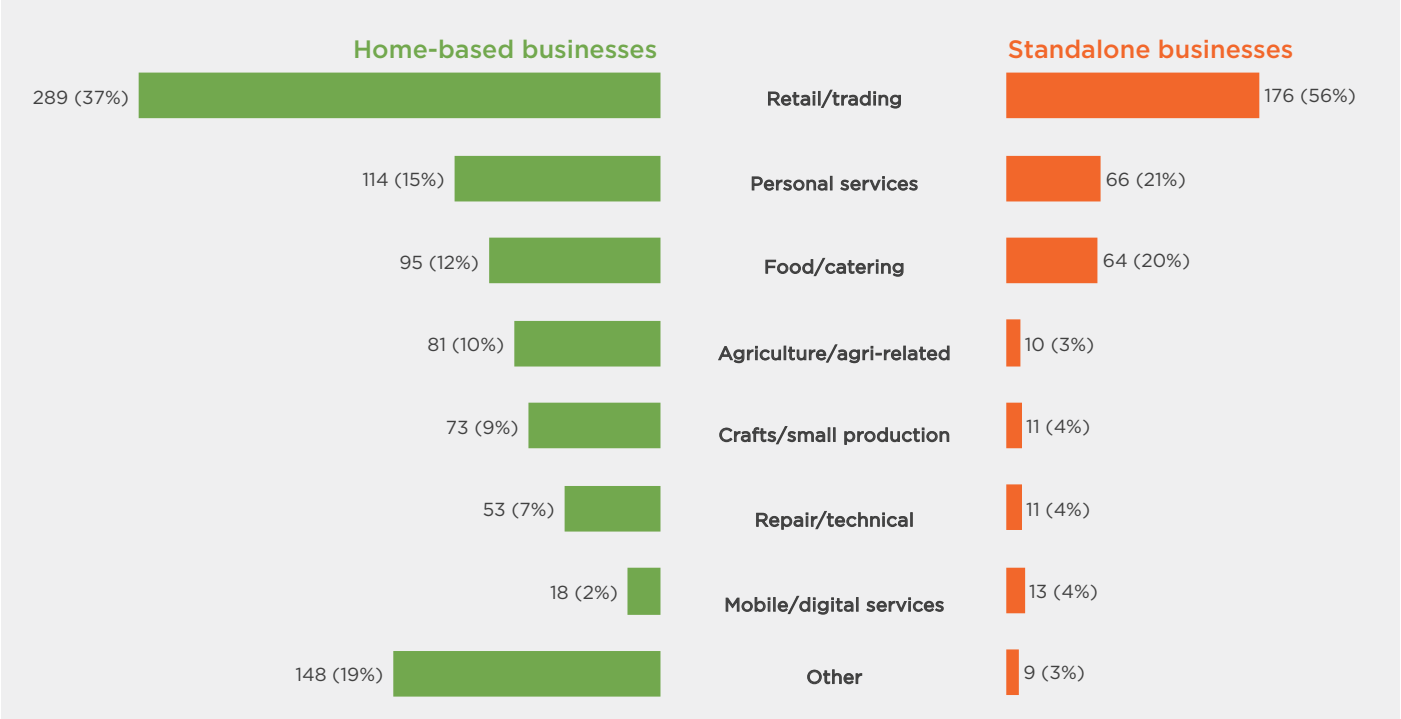
Informality isn't a niche segment of the Nigerian economy - it *is* the Nigerian economy for most workers. With informal employment at 93% in the latest published Nigeria Labour Force Survey (for Q2 2024),[66] Nigeria sits well above even the already-high Sub-Saharan African average of 87.6% informal employment.[67] This isn't a transitional phenomenon expected to fade with growth: the World Bank's 2015 "Profile of Work and Workers" concluded that "informal is normal, and will continue to be so" in Nigeria,[68] and a decade of near-flat informality rates bears that out. **Any assessment of economic impact in Nigeria that only counts formally registered firms is, by construction, missing the activity of more than nine in ten workers.**

This matters for SHS impact measurement because a large share of that informal activity happens inside the home. Nigeria's latest General Household Survey (GHS) (2023-2024) reported that only 13.1% of non-farm enterprises are formally registered, with over half operating in or around the home.[69] Critically, electricity access is the single most-cited constraint on these enterprises' operations and growth by 20.3% of GHS respondents. Put together, this is precisely the population an SHS kit is most likely to affect: a household-based, electricity-constrained, informal enterprise that a standard household impact survey may not register as a "business."

Home-based enterprises were widespread among surveyed customers. Of the 1,954 household-type respondents in the survey (household and home-based business respondents), 873 (45%) run a non-farm home-based business. While some of these home-based businesses may be registered, we assume based on national statistics that a large proportion of these are informal businesses, not nationally registered; however, this was not asked in the survey. Similarly, some businesses not based out of the home that completed the business module of the survey may also be unregistered, informal businesses. This is consistent with the broader importance of household enterprise in Nigeria: the nationally representative 2023/24 General Household Survey found that 59.2% of households operated a non-farm enterprise.[70]

These businesses also represented an important source of household livelihoods. Of the 873 home-based business respondents, 465 (53%) said their home-based business was their main source of household income, 211 (24%) said it was an important source but not the main source of household income, 63 (7%) said it provided small or occasional income only, and 75 (9%) said it was kept separate from their household income. The remaining 59 (7%) did not give one of these answers. The nationally representative Multiple Indicator Cluster Survey (MICS) Plus survey conducted in July–August 2024, similarly reports that 42% of all Nigerian households identified their own business or trade as their main source of income.[71]

Figure 5 Sector snapshot of home-based and standalone businesses surveyed



Note: *Percentages are based on respondents with valid business-sector information (n = 787 home-based businesses; n = 315 standalone businesses), excluding 86 and 8 respondents with missing information, respectively. Multiple sectors could be selected, so percentages do not sum to 100%.*

With informal employment at 93% in the latest published Nigeria Labour Force Survey (for Q2 2024), Nigeria sits well above even the already-high Sub-Saharan African average of 87.6% informal employment.

On average, most home-based businesses run by respondents are over ten years old, with the mean business start date being 2013 for home-based businesses and 2014 for standalone businesses. Both home-based and non-home-based reported an average employee count of 2.4.

Most businesses across both segments are retail/trading businesses, per Figure 5. This profile provides important context for interpreting productive use: many of the businesses in the sample require reliable lighting, phone charging and customer-facing electricity services rather than power-intensive machinery.

Standalone businesses were predominantly very small enterprises, consistent with the wider structure of Nigeria's MSME sector. Among business-only respondents who provided classifiable revenue data, reported revenues were heavily concentrated at the lower end of the monthly equivalents of IFC-aligned MSME bands based only on revenue.[72] Of the 323 business-only respondents, 21 (7%) reported monthly revenue below ₦70,000, 62 (19%) fell within the IFC Micro enterprise band (₦70,000 - ₦11.3 million per month), and 3 (1%) within the Small enterprise band (₦11.3 million - ₦340 million per month). A further 236 respondents (73%) selected "don't know/ prefer not to answer". Among the 86 respondents who provided revenue information that could be placed within these bands, 72% were classified as Micro enterprises.

This concentration of small-scale businesses is consistent with national evidence. PwC's 2024 MSME survey estimated that micro enterprises constituted 96.9% of Nigeria's approximately 39.7 million MSMEs in 2020.[73] The study also found that MSMEs contributed about 46% to the national GDP, accounted for 6% of gross exports and employed over 84% of total workforce as of 2020. Although the national and survey classifications are not directly comparable, both indicate the economic importance and numerical dominance of very small enterprises.

53% of home-based business respondents said their home-based business was their main source of household income.



4 HOW SUN KING PRODUCTS AFFECT CUSTOMERS

Two impact pathways

This section of the report outlines the results from the survey, showing evidence of the links within the theory of change outlined in section 2 of this report. Following the two tracks in Figure 1, the findings are organised into two pathways, each traced from outputs, through intermediate outcomes, to final outcomes:

1. **Household pathway (Section 4.1):** more usable light, more reliable electricity and lower energy bills (outputs) free up time and money and improve connectivity and indoor air (intermediate outcomes), which feed through to income, resilience to shocks and overall welfare (final outcomes);
2. **Business pathway (Section 4.2): (including standalone and home-based businesses)** more light after dark and lower energy bills (outputs) extend operating hours and raise profitability (intermediate outcomes), with implications for resilience, employment, wages and growth plans (final outcomes).

Section 4.3 brings together cross-cutting findings, most notably PAYGo financing, which the theory of change treats as an input to both pathways. PAYGo enables many customers to acquire their system in the first place, and separately supports financial inclusion through first-time credit use and better money management.

This section separates impacts by household segment (household-only and home-based business household impacts where *n* = 1,954), and impacts by business segment (business-only and home-based business impacts where *n* = 1,196). The full sets of results tables are included in Annexure 2.

4.1 Household pathway: from more light and lower energy bills to welfare and resilience

Households

Inputs	Outputs	Intermediate Outcomes (Productive Use)	Final Outcomes	Broader Economic Effects
Deployment of standalone solar *(energy access)* **(Section 3.2)**	More reliable and usable electricity (more lighting & increased appliance use **(Section 4.1.1)** Reduced energy costs **(Section 4.1.2)**	1. Time savings **(Section 4.1.3)** 2. Extended study/ work hours (household productivity) **(Section 4.1.3)** 3. Improved connectivity & access to information **(Section 4.1.3)** 4. Reduced indoor air pollution exposure **(Section 4.1.4)**	1. Income generation & savings **(Section 4.1.4)** 2. Asset accumulation **(Section 4.1.4)** 3. Educational attainment *Not measured directly in this survey* 4. Health improvements **(Section 4.1.4)** 5. Improved resilience & adaptation **(Sections 4.1.4, 4.3.2)**	1. Increased VAT and income tax base 2. Direct, indirect and induced job creation 3. Reduced quasi-fiscal losses associated with grid extension to lowdensity areas *Not measured directly in this survey.* *The report relies on the literature for this link.*

The household pathway runs from what the system delivers, to what households do with it, to whether they end up better off. Sun King products give households more hours of usable light and a more reliable electricity supply, and in most cases sharply cut what they spend on energy (outputs). Households put the extra light, time and money into study, chores, rest, communication and, for around a third of those with more free time, paid work, while swapping combustion lighting for solar reduces indoor smoke (intermediate outcomes). These changes are associated with perceived income gains, lower exposure to fuel-price shocks and power cuts, and a strong sense that households would be worse off without their product, even though real household incomes fell over a highly inflationary recall period (final outcomes). PAYGo is an important input to the whole pathway: 37% of household-only customers who bought on credit say they could not have afforded their product without it (Section 4.3.1).

4.1.1 More usable light and more reliable electricity

SUN KING CUSTOMERS REPORT SUBSTANTIALLY MORE USABLE LIGHT AFTER DARK.

Sun King customers report substantially more useful lighting after dark than they recalled having before adoption. Among the 1,736 household respondents with matched before/current responses, average useful lighting reportedly increased from 5.6 hours to 8.8 hours per evening - an average increase of 3.2 hours (57%) that is statistically significant. Respondents were asked specifically about hours after dark with sufficient artificial light to read, cook, study, work, or move around safely.

Useful lighting increased substantially for households both with and without a grid connection. Households with a current grid connection reported an average increase of 3.38 hours per evening, compared with 2.96 hours among those without one. This is about a 25 minute difference per evening.[74] Both groups began from a similar baseline, at 5.65 and 5.55 hours respectively. The result is consistent with the wider energy-access picture described in Section 3.2: having a grid connection did not necessarily mean having reliable electricity.

First-time access households reported smaller gains in useful light than other households, although both groups ended at similar levels. These are the 1 in 5 households that had no grid, generator or solar before their Sun King product. Their useful lighting rose by 2.4 hours per evening (from 6.1 to 8.5 hours),[75] compared to an additional 3.4 hours for households that had used a grid/generator/solar before (5.5 to 8.9 hours per evening). Interestingly, first-time access households recalled *more* useful light before adoption. One likely explanation for this result lies in the two groups' starting points. For first-time access households, solar more often replaced kerosene lamps, candles and torches that respondents may already have counted as "useful" light. However, for households that used a grid or a generator, solar mainly filled the gaps left by outages and fuel shortages, which would show up directly as extra hours.

Lighting features most prominently in the household findings because it is the main service most customers' systems provide. Two-thirds of household respondents (68%, 1,321/1,954) use an entry-level SHS or lantern, designed mainly for lighting and phone charging. Of those asked, 92% (1,062/1,157) use their system for lighting and 83% (964/1,157) to charge a phone or other device. Few households with entry-level SHS use them to power a fan (3%, 31/1,121), compared with 41% (199/490) of households with larger Tier 2 SHS. The survey asked about higher-load appliances such as televisions and fridges only of customers whose systems can power them: 31% (153/490) of households with Tier 2 SHS use theirs for a television, and 16 of the 25 households with solar inverters use theirs for a fridge or cold storage.

Lighting hours gained were larger in the North West, South South and South East than in North Central. Gains were smaller among households that ran home-based businesses (+2.3 hours) than household-only respondents (+4.0 hours). The size of the lighting gain did not differ significantly by system tier. The substantial increase in usable light was therefore not confined to customers using higher-capacity systems.

SOLAR FREQUENTLY BECOMES A PRIMARY OR RELIABLE BACKUP SOURCE.

Sun King products increase the quantity and reliability of usable electricity, including for customers already connected to an unreliable grid. As shown in Figure 4, 63% (1,238/1,954) of household respondents now use solar as their main source of lighting or electricity, including 41% (800/1,954) who use solar alone. A further 34% (663/1,954) use grid electricity as their main source with solar as backup. This helps explain why customers can gain substantial usable electricity even where they already have a grid connection and mirrors a consistent finding in the electrification literature: that reliability, rather than nominal connection status, is the binding constraint on the productivity and income gains electrification is expected to deliver.[76]

The importance of this distinction becomes clearer in the energy-cost findings below, which show that grid-connected households were also more likely to have previously relied on generator backup and that the largest reported energy-cost reductions were concentrated among prior generator users.

4.1.2 Lower energy spending and reduced generator dependence

HOUSEHOLDS REPORT SUBSTANTIALLY LOWER MONTHLY ENERGY SPENDING AFTER ADOPTING THEIR SUN KING PRODUCT.

Household energy expenditure (including PAYGo repayments where relevant) was markedly lower in the matched before/current comparison. Among the 1,267 household respondents with matched expenditure data, mean real monthly energy expenditure fell from ~₦25,300 (~USD 18) before adoption to ~₦5,997 (~USD 4) in June/July 2026 at the time of the survey. This represents an average reduction of 76% or ~₦19,320 (~USD 14) per month. The reduction was statistically significant and was observed among both female- and male-headed households. The fact that this figure compares a recalled "before" amount, and is deflated to constant naira across a period of high inflation, means that it is likely to overstate the real decline.

Respondents' direct assessments reinforce this finding. When asked how their Sun King product had affected monthly energy costs, 63% (1,223) reported that their product had helped to lower energy costs, compared with 23% (458) reporting no change and only 1% (20) reporting higher costs. A further 13% (253) were unable to say.

1,223 (63%) household respondents reported that their Sun King product had helped to lower household energy costs.

To put the magnitude of these savings in context, Nigeria's National Minimum Wage (Amendment) Act 2024 raised the statutory national minimum wage to ₦70,000 per month.[77] The estimated ₦19,320 monthly household energy saving is equivalent to 28% of this amount. For further policy context, in October 2023 the Federal Government committed to pay ₦25,000 per month for three months to 15 million households, including vulnerable pensioners, as part of measures responding to the withdrawal of the fuel subsidy.[78] The estimated real monthly household saving is equivalent to 77% of the face value of that monthly transfer.

SAVINGS DEPEND MORE ON WHAT SOLAR REPLACES THAN ON SYSTEM TIER.

Savings varied considerably according to households' previous energy arrangements. First-time electricity access households (households with no prior grid, generator or solar) saved less in naira than their counterparts, but still cut energy spending by around two-thirds.[79] Average real monthly energy expenditure for these newly connected households fell from ~₦10,700 (~USD 8) before adoption to ~₦3,700 (~USD 3) at the time of the survey, a decline of 65% or ~₦7,013 (~USD 5) per month.[80] Among other households, expenditure fell from ~₦29,700 (~USD 21) to ~₦6,600 (~USD 5), a decline of 78% or ~₦23,045 (~USD 16) per month.[81] The smaller absolute saving among first-time access households likely reflects their substantially lower energy expenditure before adopting Sun King; in proportional terms, they still reduced their spending by around two-thirds.

Reported expenditure reductions were broadly similar in proportional terms among household-only Tier 1-or-smaller and Tier 2 users. Among the 498 Tier 1-or-smaller household-only customers with matched expenditure data, average real monthly expenditure fell from approximately ₦24,700 (~USD 18) before adoption to ₦5,900 (~USD 4) at the time of the survey, a reduction of approximately ₦18,800 (~USD 14), or 76%. Among the 263 Tier 2 household-only customers with matched data, expenditure fell from approximately ₦31,000 (~USD 22) to ₦6,100 (~USD 4), a reduction of approximately ₦24,900 (~USD 18), or 80%. The five household-only customers using Tier 3–5 systems reported a larger reduction, from approximately ₦69,900 (~USD 50) to ₦1,500 (~USD 1), but this estimate is based on too few observations to interpret reliably and the change was not statistically significant.

The larger absolute reductions reported by higher-tier customers partly reflect their higher expenditure before adoption and should not be interpreted as an independent effect of system capacity.[82] Households' previous energy arrangements, particularly whether they had relied on a generator, provide a clearer explanation of variation in reported savings.

SAVINGS WERE LARGEST WHERE SOLAR DISPLACED GENERATOR USE.

Generator use was widespread before customers adopted their Sun King products, including among grid-connected households. Overall, 34% (674/1,954) of household respondents reported using a generator prior to their Sun King product. This generator use was not confined to households without grid access: 416 of the 1,200 respondents with previous grid access (35%) also reported using a generator. This reflects the widespread use of generators as a backup during outages and periods of poor-quality grid supply.

Previous generator use provides the clearest explanation of variation in household savings. Among the 1,256 households with matched expenditure and prior-energy-source data, the 422 respondents (34%) who had previously used a generator reported an average monthly reduction of approximately ₦36,400 (~USD 27). By contrast, the 66% of households (834/1,256) that had not used a generator reported a substantially smaller reduction of approximately ₦10,800 (~USD 8).[83] The mean difference was statistically significant.

Households with a current grid access also reported larger reductions than those without grid access, but the generator distinction was considerably more pronounced. Matched real energy expenditure fell by an average of ~₦22,640 (~USD 17) per month among grid-connected households, compared with ~₦15,854 (~USD 12) among those without a connection.[84] Within both the grid-connected and non-grid-connected groups, households that had previously used a generator reported substantially larger reductions than those that had not.[85] This indicates that generator displacement, rather than grid connection on its own, is the clearest distinguishing factor.

Respondents' explanations of their savings support this interpretation. Among the 548 respondents whose reported energy-cost band declined in nominal terms, reduced generator-fuel expenditure was the most commonly cited reason, reported by 55% (301/548). This was followed by reduced grid electricity spending, reported by 39% (214); reduced spending on batteries or torches, 22% (118); reduced spending on paid charging, 17% (95); and lower kerosene spending reported by 8% (44). Among the smaller group of 81 respondents whose nominal energy cost band rose, 48% (39) attributed this to using more electricity, and 12% (10) attributed this to continued spending on other energy sources. A further 19% (15) could not identify a reason.[86]

> Sun King products appear to create particular value where customers would otherwise purchase expensive backup energy, especially generator fuel during outages.

There is also evidence of households moving away from generators as their principal electricity source. Of the 276 respondents who identified a generator as their main source before adopting their Sun King product, 78% (215/276) reported that solar was now their main or only source. Only 18 respondents (7%) continued to identify a generator as their main source. These findings suggest that solar creates particular value where it replaces expensive backup generation. The wider Nigerian energy context helps explain the scale of the reported savings.

BOX 1 THE HIGH COST OF GENERATOR DEPENDENCE IN NIGERIA

Generator fuel can represent a particularly expensive part of the energy mix in Nigeria. The 2024 Nigeria Residential Energy Demand-Side Survey found average grid-electricity expenditure of approximately ₦4,156 (~USD 3) per month across the nine states surveyed.[87] By contrast, households purchasing petrol or diesel for captive generation bought an average of 61.2 litres per month and spent approximately ₦44,752 (~USD 34) per month on generator fuel. Prior-generator households in this survey similarly report baseline total real energy expenditure of approximately ₦45,000 (~USD 34) per month. These figures are not directly comparable because they cover different populations, reference periods and price bases, but they illustrate the potentially high monetary cost of generator dependence.

Fuel costs rose far faster than consumer prices generally over the period respondents were recalling. NBS Price Watch data show that between May 2022 and May 2026, the national average retail price of petrol increased from ₦173.08 to ₦1,596.25 per litre, an increase of 822%; diesel rose from ₦671.08 to ₦3,277.47 per litre, an increase of 388%; and household kerosene rose from ₦679.54 to ₦2,971.94 per litre, an increase of 337%.[88] These increases were considerably faster than general consumer-price growth over comparable portions of the recall period. For example, between May 2022 and May 2024, petrol prices rose by 345% and diesel by 109%, compared with an approximately 64% cumulative increase in headline consumer prices on the then-consistent NBS CPI series.[89] The particularly sharp increase in petrol followed the removal of the petrol subsidy in May 2023, while diesel had already been deregulated well before this period.

The price of petrol and diesel significantly outpaced inflation during the study recall period. According to NBS Price Watch Data, the price of petrol rose by over 800% between May 2022 and May 2026.

These high and rapidly rising fuel costs help explain why replacing generator use can produce substantial savings, even where a solar system supports relatively modest loads. Where a household would otherwise run a generator during a grid outage to meet relatively modest needs such as lighting or phone charging, solar may allow it to avoid that period of generator operation altogether rather than merely reduce the generator's load.

This interpretation is consistent with wider evidence that cost savings from standalone solar products arise primarily from displacing other, often costlier, energy sources. Samad et al. (2013) and Lemaire (2018) similarly identify reduced kerosene and paid-charging expenditure as an early and consistent benefit of standalone solar, while GOGLA's 2024 survey evidence from West Africa links greater disposable income after solar-home-system adoption primarily to lower spending on other fuels.[90,91,92] Nigeria's combination of unreliable grid electricity, widespread generator use and high fuel costs creates a particularly strong scope for solar to avoid costly self-generation. More broadly, the findings show that the financial value of standalone solar depends partly on what it replaces, helping to explain why even smaller systems can generate meaningful savings. This may be relevant in other markets where unreliable grid supply leads households to rely heavily on small generators for basic electricity services.

Moving away from generators is also likely to bring environmental benefits. Where solar displaces generator use, less petrol and diesel is burned in and around homes and businesses, reducing exposure to exhaust fumes and noise. The study did not measure fuel volumes or emissions, so it cannot put a figure on these benefits. Even so, the shift away from generators points to environmental and local air-quality gains alongside the cost savings.

4.1.3 How households use additional electricity and time

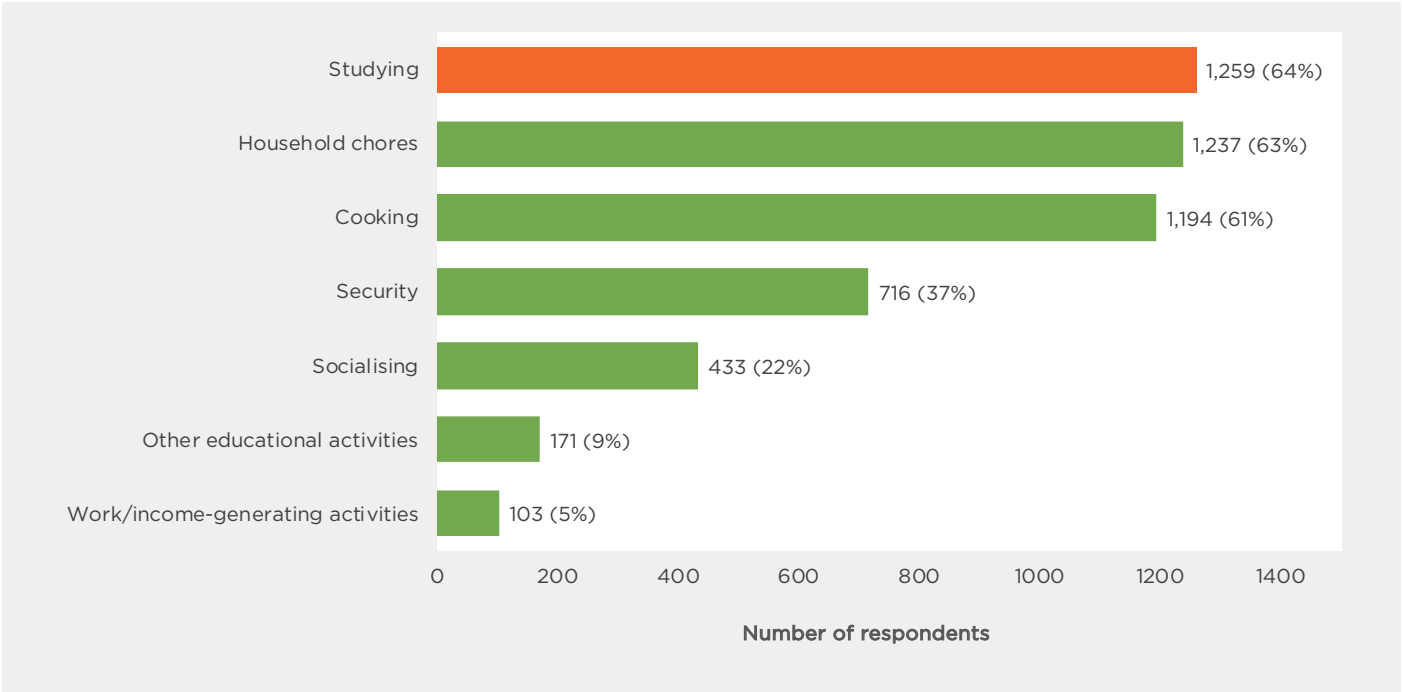
ADDITIONAL ELECTRICITY ENABLES ACTIVITIES THAT WERE PREVIOUSLY CONSTRAINED.

Respondents report using additional lighting for a mix of educational and everyday activities, with children's study and household chores being the most commonly reported uses. Across all 1,954 household respondents, where more than one option could be selected, 64.4% (1,259) said that any additional lighting was mainly used for children's studying or homework, and a further 8.8% (171) cited adult education or learning. This is consistent with wider literature where increased study time is considered a well-established household benefit of standalone solar.[93,94,95,96] Income-generating uses of standalone solar are less consistently reported in the literature, with some studies finding increased activities like retail, hairdressing and other small businesses, while others report little or no increase in income-generating use following SHS adoption.[97,98]

64% of households reported using the additional lighting provided by their Sun King product for children's studying or homework.

Other common uses were household chores (63.3%, 1,237), cooking or food preparation (61.1%, 1,194), and improved safety or security around the home (36.6%, 716). A smaller share, 5.3% (103), used the extra light for income-generating work, and 4% (74) selected none of the listed uses. The lower share reporting income-generating use is also consistent with that literature, though the measures are not directly comparable. GOGLA's West Africa study found that while most solar home system owners report having more money available after adoption (largely through reduced fuel spending) only around one in seven households report earning additional income as a result.[99] Results are summarised in Figure 6.

Figure 6 How surveyed respondents report using additional lighting from their Sun King product



Notes: *Multiple responses were permitted. Percentages are based on all 1,954 household and home-based business respondents. These are reported uses of increased lighting, not measured changes in time allocation. "Other" and "None" are omitted from the chart.*

SUN KING PRODUCT USAGE IS ASSOCIATED WITH INCREASED FREE TIME, WHICH ENABLES HOUSEHOLDS TO BE MORE PRODUCTIVE.

Beyond extra light for study and chores, a second way households use these outputs is through the time they free up.

A sizable share of Sun King customers report that their product increased the time available to them during the day or evening. Across the full household sample of 1,954 respondents, 44% (855) reported more free time because of their solar product, compared with 30% (593) reporting no change and 2% (38) reporting less free time. The remaining 24% (468) did not know or preferred not to answer.

Use of a Sun King product appears to free up time through a somewhat different pathway from that commonly emphasised in the electrification literature. Existing studies often link time savings to reduced fuel collection (for improved cookstoves) or time spent buying petrol or batteries, particularly for women and girls, with some of that time subsequently shifting into paid work.[100,101] Among surveyed Sun King customers, fuel-related savings are a secondary factor: of the 855 respondents reporting more free time, 88% (753) cited time savings from accessing electricity,[102] compared with 16% (136) cited less time spent on purchasing/handling kerosene or other fuels, 13% (113) reporting less travel for charging or accessing electricity, and 11% (90) reporting fewer disruptions from power cuts.

More free time was reported most often by first-time access households and least often by households that previously used the grid. 52% (202/387) of first-time access households reported more free time, against 42% (649/1,545) of other households. Among households that had used grid electricity before, the share was 39% (466/1,200), against 53% (385/732) of those that had not. This fits the pathway described above. Time is saved mainly by removing the everyday hassle of getting electricity, and that hassle is likely to be greatest for households without a prior connection.

Crucially for the theory of change, a substantial share of this freed time is reallocated to productive activity, alongside important welfare uses. Among the 855 respondents reporting more free time, 31% (269) used some of it for income-generating work, and 5% (43) for business activities. At the same time, 33% (278) used the time for rest or leisure, 30% (254) for household chores, 19% (162) for childcare and 8% (66) for learning or study.



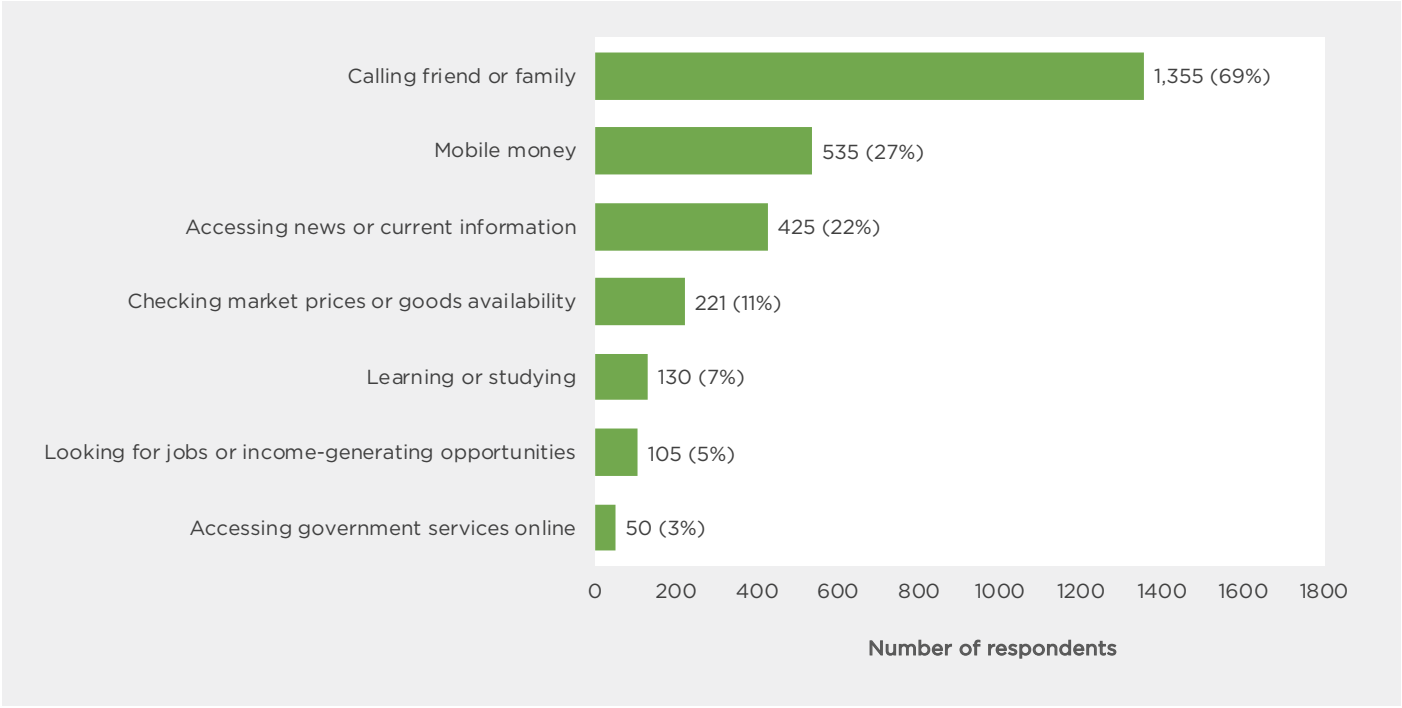
SUN KING PRODUCT USAGE IS ASSOCIATED WITH INCREASED PHONE USAGE AND CONNECTIVITY BY HOUSEHOLDS.

Sun King product usage also appears to make mobile phones more reliably usable, primarily by easing charging constraints. Among 1,726 household respondents whose households own a smartphone or feature phone, 66% (1,141) reported using their phone more often than before acquiring their Sun King product. This increase was overwhelmingly attributed to more reliable charging: 98% (1,113) said they used their phone more often because it was more regularly charged, compared with 1% (12) citing greater internet access, <1% (5) citing both, and 1% (11) citing another reason.

Among 1,726 household respondents whose households own a smartphone or feature phone, 66% reported using their phone more often than before acquiring their Sun King product, with 98% attributing this to their phone being more regularly charged.

Alongside greater phone usability, respondents reported increased communication and access to digital services and information. Across the full household sample of 1,954 respondents, 69% (1,355) reported calling family or friends more often since acquiring their Sun King product, as shown in Figure 7. A number of respondents reported more frequent use of mobile money (27%, 535) and news or current information (22%, 425), while 11% (221) reported checking market prices or goods availability more often. Smaller shares reported increased learning or study (7%, 130), looking for jobs or income-generating opportunities (5%, 105), or accessing government services online (3%, 50). The literature identifies improved access to information as one potential benefit of electrification and standalone solar, including for resilience and early-warning information, although evidence on whether this translates into broader socioeconomic outcomes remains mixed.

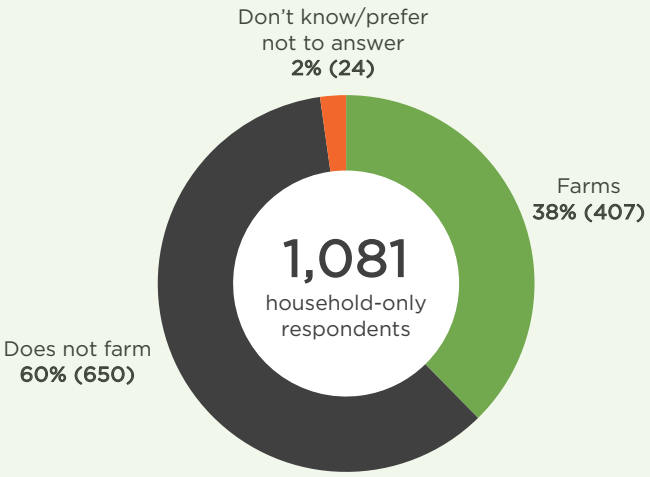
Figure 7 Activities respondents report doing more often since acquiring their Sun King product



Notes: *Multiple responses were permitted. Percentages are based on the full sample of 1,954 household and home-based-business respondents, including "don't know/prefer not to answer" responses in the denominator. The question was not restricted to respondents reporting increased phone use and did not specify that activities had to be undertaken using a phone. These are self-reported changes since acquiring a Sun King product, not measured changes or causal effects. "None of these" (n = 401) and "don't know/prefer not to answer" (n = 127) are omitted from the chart.*

BOX 2 FROM HOUSEHOLD ENERGY TO FARMING ACTIVITY: PRODUCTIVE USE BEYOND THE HOME

Figure 8 Share of household respondents engaged in farming activity

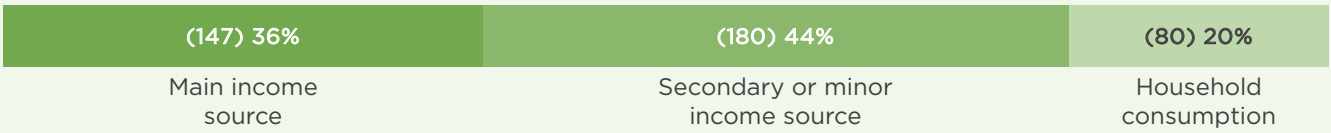


Sun King products also support the productive activities of some farming households, principally by improving access to phone charging and lighting. Among the 1,081 household-route respondents asked about farming, 407 (38%) reported that their household farmed either for income or consumption.

Farming is the main source of income for only 36% (147) of the 1,081 household-only respondents. Farming is a secondary source or minor source of income for 180 respondents (16.7%), and 80 (7.4%) that farm for household consumption only. A further 650 households (60.1%) reported that they do not farm, and 24 (2.2%) did not know or preferred not to answer.

Figure 9 Contribution to household income from farming activities

Of the 38% of household respondents that farm (*n* = 407):



Notes: *Farming status was asked only of the 1,081 household-only respondents. Whether and how their Sun King product helped with farming was asked only of households reporting farming as their main income source. The assistance categories were multiple-response.*

Where farming was the household's main income source, around two in five customers said their Sun King product helped with it, mainly by keeping phones charged and providing light. Of the 147 main-income farming households, 58 (40%) said their product helped their farming or agricultural activities, including 51 (35%) who said it helped "a lot" and 7 (5%) "a little"; 88 (60%) said it did not help. Among the 58 households reporting assistance, the dominant use was charging phones used for farming activities (84%, 49), followed by lighting or security for agricultural activities (22%, 13) and communicating with buyers, suppliers or workers (16%, 9). Smaller numbers cited crop or livestock processing (5%, 3), accessing market prices (2%, 1) and other uses (2%, 1). No respondent reported using the product for water pumping or irrigation.

This is consistent with the product categories these customers own. Solar water pumping and irrigation systems are a distinct, higher-capacity product class of 200W and above, while two-thirds of respondents use entry-level systems rated at Tier 1 on the Multi-Tier Framework. Agro-processing, milling and irrigation are more commonly associated in the literature with mini-grids or dedicated productive-use systems than with household solar.[103]

4.1.4 Income, assets, resilience and welfare

The final link in the household pathway asks whether more light, time and money leave households better off. The evidence is strongest for resilience and welfare, and weakest for real income, which is shaped as much by Nigeria's macroeconomic conditions over the recall period as by energy access.



SWITCHING FROM KEROSENE LAMPS AND/OR GENERATORS TO STANDALONE SOLAR IS ASSOCIATED WITH REPORTED REDUCTIONS IN INDOOR SMOKE.

Seven in ten (70%, 615 of 882) household-only and home-based business respondents who previously relied on kerosene lamps or generators reported less indoor smoke since owning their Sun King product, including 63% who reported "much less".[104] Additionally, 92% reported that their household did not experience any breathing problems, eye irritation, or burns from fire incidents. While we cannot say with certainty that Sun King product usage has caused these health improvements, switching from kerosene lamps or generators to solar removes one source of combustion-related pollution in and around the home, so it is plausible that this would reduce indoor smoke exposure, related respiratory and eye irritation, and burn/fire risk. This is consistent with what has been found elsewhere in the literature - improved indoor air quality and associated health benefits as a consequence of replacing combustion-based lighting and energy sources with solar.[105,106,107] Other sources of household air pollution, particularly biomass fuels used for cooking, may remain and were not measured in this survey.

Seven in ten (70%) household respondents who previously relied on kerosene lamps or generators reported less indoor smoke since owning their Sun King product.

HOUSEHOLDS REPORT LOWER EXPOSURE TO FUEL-PRICE SHOCKS.

Among household-only respondents completing the resilience module, 87% reported being "a lot less affected" or "somewhat less affected" by rising fuel prices because of their Sun King product. Lower reliance on purchased fuels can reduce households' exposure to price increases, alongside the direct energy savings discussed in Section 4.1.2. For customers substituting PAYGo-financed solar for fuel purchases, instalment payments may also make this part of their energy spending more predictable - this is further discussed in Section 4.3.

BOX 3 PRODUCTIVITY GAINS DO NOT AUTOMATICALLY TRANSLATE INTO HIGHER REAL HOUSEHOLD INCOME

The positive intermediate productivity findings did not translate into improvements across every downstream economic outcome measured by the survey. The results above show gains in usable light and time, alongside perceived income and profitability gains and upward movement in some nominal monetary measures. However, the inflation-adjusted income and asset results provide a more mixed picture and are important for interpreting the limits of what improved electricity access achieved over the recall period.

Perceived income gains were widespread: 43% of household respondents (843/1,954) said their Sun King product had contributed to higher household income. They were reported more often by former generator users (48%, 322/674, against 41%, 516/1,258), consistent with their larger energy savings, but did not differ significantly by other prior-access groups.

Real household income fell, despite the increase in nominal income recorded in the matched sample. Among the 657 respondents with comparable before/current household income, estimated mean household income per month, in real terms, fell from ~₦443,143 (~USD 323) before adoption to ~₦277,355 (~USD 202) at the time of the survey (June/July 2026). This is a statistically significant decline of ~₦165,788 (~USD 121). Reported real household income fell significantly for both female-headed and male-headed households, and there isn't evidence that this change differed by household-head gender. Holding other characteristics constant, the decline was larger in the North West but did not differ by product type.

Income is also one of the harder outcomes to measure in a retrospective survey (covering, at most, May 2022 to July 2026), particularly in Nigeria's recent inflationary environment. Respondents were asked to recall income before acquiring their Sun King product, using fixed nominal bands (to reduce false precision). However, even income bands cannot eliminate all recall or measurement errors. Additionally, consumer prices in Nigeria rose rapidly over much of the period respondents were recalling: headline inflation reached 34.2% in June 2024.[108] Over the full recall period, general prices more than doubled, so a household's naira income would have needed to rise by around 130% just to stand still in real terms. The World Bank similarly found that high inflation and weak growth over this period eroded purchasing power, with average household consumption falling by 6.7% between 2019 and 2023.[109] By April 2026, the World Bank reported that household incomes had still not fully recovered.

Households reported only a very small increase in durable asset ownership after acquiring their Sun King product. The survey asked about before and after ownership of common household assets, including radios, televisions, refrigerators, electric fans, smartphones, and feature phones. Among the 1,885 households with matched before/after asset ownership responses, the average number of assets owned rose only marginally, from 4.23 to 4.29 of the listed items. There was no evidence that asset accumulation differed by the gender of the household head nor, holding other characteristics constant, by product type, region or other baseline characteristics (Annexure 3). At the asset level, there were statistically significant but very minor increases in radio ownership (48% to 50%), television ownership (78% to 80%) and feature-phone ownership (39% to 40%) across the surveyed households. Baseline reported ownership was already high for several of these items - 78% of surveyed households owned a television before adoption - so there was limited scope for further increases, and the flat result reflects the profile of customers who purchase solar as much as any absence of effect.

These final outcomes (the last link in the household pathway) are often both the most policy-relevant, and the hardest to establish with confidence. The wider evidence base suggests that higher household income as a result of standalone solar usage is possible, but far from automatic. For instance, GOGLA found that many solar-home-system users in West Africa report having more money available after standalone solar adoption, largely through lower energy spending, while only around one in seven report earning additional income.[110] Evidence on income itself is mixed: for instance, Lee et al. (2020a) find little evidence of meaningful medium-term income gains in rural Kenya,[111] and Masselus et al. (2025) similarly find limited income effects from electrification in Rwanda.[112] This supports the theory of change set out earlier in the report: reliable electricity can enable productive use, but whether it ultimately becomes "more money" depends on market opportunities, access to productive assets, access to finance, skills and other factors beyond energy access itself.

4.2 Business pathway: from more light after dark to longer trading hours and higher profitability

	Inputs	Outputs	Intermediate Outcomes (Productive Use)	Final Outcomes	Broader Economic Effects
Businesses	Deployment of standalone solar *(energy access)* **(Sections 3.2, 3.3)**	More reliable and usable electricity (more lighting & increased appliance use) **(Section 4.2.1)** Reduced energy costs **(Section 4.2.2)**	**1.** Increased operating hours **(Section 4.2.3)** **2.** Business productivity gains **(Section 4.2.3)** **3.** Technology upgrading **(Sections 4.2.1, 4.2.4)**	**1.** Job creation **(Section 4.2.4)** **2.** Wage growth **(Section 4.2.4)** **3.** Improved resilience & adaptation **(Sections 4.2.4, 4.3.2)**	**1.** Increased VAT and income tax base **2.** Direct, indirect and induced job creation **3.** Reduced quasi-fiscal losses associated with grid extension to lowdensity areas *Not measured directly in this survey.* *The report relies on the literature for this link.*

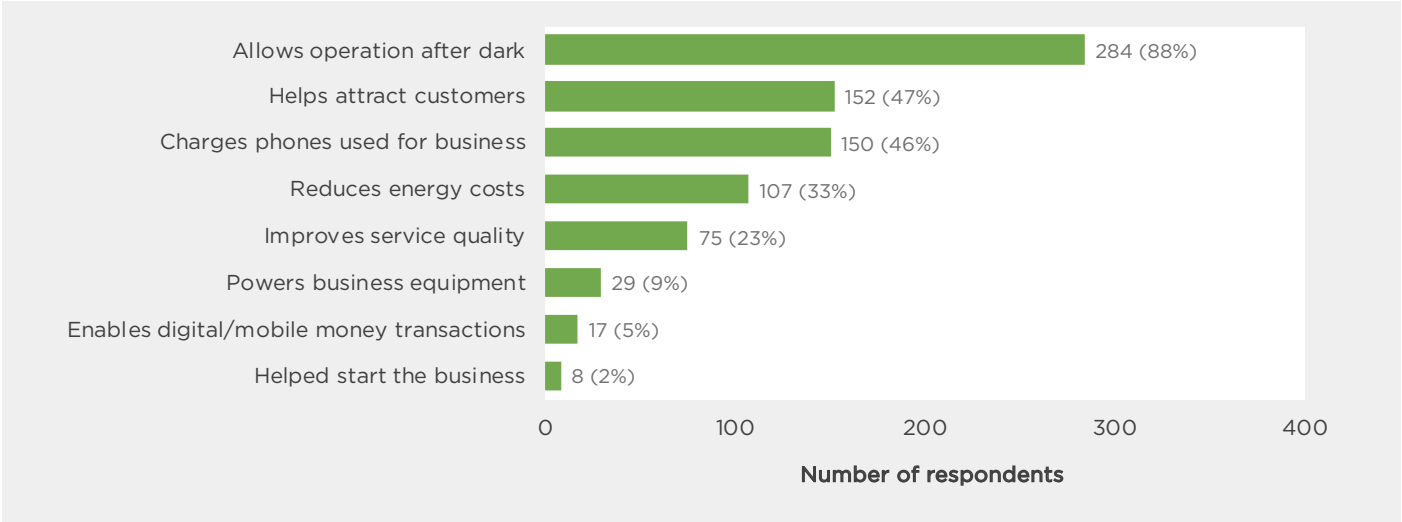
For businesses, the pathway runs from more light and power after dark, to longer operating hours, to higher profitability. Most businesses use their Sun King product mainly to light their premises so they can keep trading after dark, and standalone businesses also report substantially lower energy bills (outputs). Operating hours rise, and businesses whose hours increased are twice as likely to report higher profitability (intermediate outcomes). This matters because the literature consistently shows the inverse: unreliable power reduces firm output, revenue and productivity. Whether these gains flow through to jobs, wages and growth is less clear (final outcomes). The pathway covers standalone businesses (*n* = 323) and home-based businesses (*n* = 873). Home-based businesses report smaller gains, and are discussed in Box 4. PAYGo again matters for access: 39% of female-owned standalone businesses that bought on credit say they could not have afforded their product without it (Section 4.3.1).

4.2.1 Productive use through lighting and charging

BUSINESSES MAINLY USE THEIR SUN KING PRODUCT TO KEEP TRADING AFTER DARK.

Most businesses mainly use their Sun King product to keep trading after dark. Most standalone-business respondents reported using the product for additional light that allows their business to operate for longer after dark, as shown in Figure 10. Other reported uses include charging phones, attracting customers, reducing energy costs and powering equipment.

Figure 10 Reported ways Sun King products have affected standalone businesses



Notes: *Multiple responses were permitted. Percentages are based on all 323 standalone-business respondents, including "don't know/prefer not to answer" responses in the denominator. "Other" (n = 3; 0.9%), "does not support the business" (n = 7; 2.2%) and "don't know/prefer not to answer" (n = 5; 1.5%) are omitted from the figure.*

SMALL SYSTEMS ARE MOST COMMONLY USED BY STANDALONE BUSINESSES.

Most standalone businesses use Tier 1-or-smaller systems, and these customers report substantial productive-use gains. Overall, 82% (264/323) of surveyed standalone businesses used a lantern or entry-level solar home system, grouped as Tier 1 or below. This includes 79% (254/323) using an entry-level Tier 1 solar home system. Among the 241 Tier 1-or-smaller standalone businesses with matched operating-hours data, average daily operating time increased from 9.96 to 11.10 hours after acquiring their Sun King product, equivalent to an additional 69 minutes per day. Across all 264 Tier 1-or-smaller standalone businesses, 59% (155) reported improved profitability.

The reported mechanisms show how relatively small systems can support productive activity. Among Tier 1-or-smaller standalone businesses, 88% (233/264) reported using their Sun King product to operate after dark, 45% (120/264) to attract customers, 43% (114/264) to charge business phones and 31% (81/264) to reduce energy costs. Only 6% (16/264) reported using the system to power business equipment (see Figure 10). The dominant pathway for these businesses is therefore the ability to trade for longer, remain visible and accessible to customers, keep phones connected and avoid part of the cost of less reliable energy sources.

These findings expand the productive-use framing commonly applied to off-grid solar. Policy and market discussions frequently foreground refrigeration, water pumping, milling and mechanised processing because these applications require greater capacity and can transform what a business produces. However, the 2024 *Off-Grid Solar Market Trends Report* also identifies lanterns and smaller solar home systems as productive inputs for street vendors, small shops and phone-charging businesses.[113] These Sun King findings provide further evidence that lower-load services can be economically meaningful.

4.2.2 Lower energy expenditure for standalone businesses

BUSINESSES ALSO REPORT SUBSTANTIALLY LOWER MONTHLY ENERGY SPENDING AFTER ADOPTING THEIR SUN KING PRODUCT.

Standalone businesses report substantially lower energy expenditure after Sun King product usage. Among the 165 standalone businesses with before/after matched expenditure information, mean monthly energy expenditure fell from ~₦26,008 (~USD 19) to ₦8,478 (~USD 6) in real terms (constant June 2026 naira), a statistically significant decline of ~₦17,530 (~USD 13). In the broader standalone business sample (n = 323), 63% (202) reported a perception of lower energy costs since acquiring their Sun King product, compared with 23% (75) reporting no change, 1% (3) an increase, and 13% (43) not knowing. When asked how their Sun King product contributed to their perceived change in energy expenditure, 33% (107) cited lower generator-fuel use and 15% (49) lower grid-electricity spending. Business-only energy expenditure is not separately available for home-based businesses because their survey measure combines household and business energy use. Home-based business results are therefore reported in the household analysis rather than pooled with standalone businesses.

Standalone businesses reported lower real monthly energy expenditure across all three system tiers. Among the 133 Tier 1-or-smaller businesses with matched expenditure data, mean monthly spending fell from approximately ₦23,800 (~USD 17) before adoption to ₦8,900 (~USD 6) at the time of the survey, a reduction of approximately ₦15,000 (~USD 11), or 63%. Among the 21 Tier 2 businesses with matched data, spending fell from approximately ₦24,900 (~USD 18) to ₦5,600 (~USD 4), a reduction of approximately ₦19,200 (~USD 14), or 77%. The 11 Tier 3–5 businesses reported a decline from approximately ₦54,700 (~USD 40) to ₦9,400 (~USD 7), a reduction of approximately ₦45,300 (~USD 33), or 83%.[114]

While the within-tier reductions were significant, there isn't a clear and consistent association between system capacity and the size of expenditure reduction. A change-score regression takes each standalone business's change in real monthly energy expenditure as its outcome and tests whether the size of that change varied across owner gender and age, business sector and age, prior solar use, system capability, length of ownership and region. Of these characteristics, only length of ownership was statistically significant - suggesting that larger reductions in monthly business energy expenditure are also associated with longer ownership. Among standalone businesses, each additional year since adoption was associated with an additional ~₦5,200 (~USD 4) reduction in monthly real energy expenditure.[115] This may show how the shift from more costly sources of energy into greater solar reliance is a gradual process, with benefits increasingly accruing over time, although, as for households, part of this association may reflect the longer inflation-adjustment period for earlier adopters.

4.2.3 Longer operating hours and reported profitability gains

SUN KING PRODUCT USAGE IS ASSOCIATED WITH LONGER BUSINESS OPERATING HOURS.

Across the 1,014 home-based and standalone businesses with matched before/after survey data on operating hours, average operating hours increased from 9.12 to 9.76 hours per day, equivalent to a statistically significant additional 0.64 hours/38 minutes per day. The increase was smaller among home-based businesses, from 8.80 to 9.23 hours (+0.43 hours/26 minutes; *n* = 715), and larger among standalone businesses, from 9.90 to 11.05 hours (+1.15 hours/69 minutes; *n* = 299). All three changes are statistically significant. Gains did not differ significantly by product type or region. As with other self-reported attribution measures in this report, these figures may be affected by the upward bias and should be read accordingly.

Sun King product usage is associated with 38 extra minutes of business operations on average per day.

Operating-hour gains depended on what solar replaced. Businesses that had previously used grid electricity added 0.80 hours a day (*n* = 602), against 0.38 hours for those that had not (*n* = 398). Businesses with no prior grid, generator or solar showed no significant change in operating hours. This is consistent with solar extending trading time mainly where it fills gaps in an existing but unreliable supply.

BUSINESSES REPORT STRONGER PROFITABILITY.

Improved profitability was widely reported across the business sample. Of 1,196 business respondents, including both home-based and standalone businesses, 43% (518) reported that profitability had increased since acquiring their Sun King product, compared with 32% (378) reporting no change, 3% (36) reporting a decrease and 22% (264) who did not know. Among the 474 businesses reporting improved profitability that answered a follow-up attribution question, 57% (269) attributed all of the improvement to their Sun King product and a further 16% (78) attributed most of it.

The perceived profitability gain was particularly pronounced among standalone businesses. Among the 323 standalone businesses surveyed, 59% (191) reported higher profitability, compared with 23% (74) reporting no change, 3% (9) reporting a decline and 15% (49) who did not know. Among HBBs, by comparison, 38% (327/873) reported higher profitability. This segment difference is descriptive rather than a causal or formally tested difference in impact, but it is consistent with the larger increase in operating hours observed among standalone businesses.[116]

Businesses reporting longer operating hours were substantially more likely to report higher profitability. Of the 1,014 businesses with matched operating-hours data, 23% (232) recorded longer hours after adopting their Sun King product. Among these, 76% (176/232) reported higher profitability, compared with 38% (299/782) of businesses whose hours did not increase. The pattern held in both segments: 77% (87/113) of standalone businesses with longer hours reported higher profitability against 52% (97/186) of those without, and 75% (89/119) of home-based businesses against 34% (202/596).

First-time electricity access was not associated with larger business gains in this sample. Businesses that had used no grid, generator or solar before their Sun King product showed no significant change in operating hours. Businesses with prior electricity access added 0.74 hours a day (*n* = 796), and the difference is statistically significant.[117] The share reporting increased profitability was similar in both groups (41% against 43%). Improved profitability did not differ significantly between Tier 1-or-smaller systems and larger systems as a group, although the small group of Tier 3-5 (inverter) users reported markedly higher rates (85% - see Annexure 2).

BOX 4 HOME-BASED BUSINESSES: THE SAME PATHWAY, WITH SMALLER GAINS

Home-based businesses sit at the intersection of the household and business pathways. They account for 45% (873/1,954) of household-route respondents, and for 53% (465/873) of these respondents the business is the main source of household income (Section 3.3). Electricity serves domestic and productive purposes within the same setting, and the survey combines household and business energy spending and income for these customers.

Additional lighting also supported longer operating hours for nearly one-third of home-based businesses. Among the 873 home-based businesses, 32% (276) reported using the additional light provided by their Sun King product to operate their business for longer after dark.

Home-based businesses experience measurable productivity gains, but these are more modest on operating hours and perceived profitability than those of standalone businesses. Among 715 HBBs with matched operating-hours data, average daily operating hours increased from 8.80 to 9.23 hours, an increase of 0.43 hours, or approximately 26 minutes per day. By comparison, standalone businesses gained 1.15 operating hours per day. Among 873 HBBs, 38% (327) reported that profitability had increased since acquiring their Sun King product, compared with 35% (304) reporting no change, 3% (27) reporting a decline and 25% (215) who did not know. This is lower than the 59% (191/323) of standalone businesses reporting improved profitability.

The segment gap also persists within broad sectors. In every sector with a usable standalone sample, a higher share of standalone businesses reported increased profitability than home-based businesses; for example 62% (109/176) against 43% (123/289) in retail and trading, and 69% (44/64) against 56% (53/95) in food and catering. The same pattern holds for operating-hour increases.

The smaller reported gains do not appear to be a simple consequence of smaller systems. Entry-level SHS are more common among standalone businesses, at 79% (254/323), than among HBBs, at 68% (594/873). HBBs also reported smaller gains in useful household light than household-only respondents, although they started from a higher baseline (Section 4.1.1). The survey cannot establish the cause of these differences, but the product mix and broad sector comparisons do not suggest that system capacity alone accounts for them.

Home-based business respondents also report positive nominal movement in their combined household and business income, and the matched nominal income data show a similar positive direction. The HBB income measure deliberately combines household and home-based-business income and is therefore not directly equivalent to the household-only measure, nor the standalone business measure. Among 873 HBB respondents, 38% (334) reported that their Sun King product had contributed to higher combined income, while 31% (266) reported no change, 6% (53) reported a reduction and 25% (220) could not say. Among 242 HBB respondents with matched before/current data, estimated average combined household and business income increased from ~₦291,000 (~USD 208) to ~₦336,500 (~USD 240), an increase of ~₦45,500 (~USD 32), or 16%.

As with the household results, the nominal rise did not translate into higher real combined income over the recall period. In real terms, estimated average combined household and business income fell from ~₦537,796 (~USD 392) to ~₦339,776 (~USD 248), a decline of ~₦198,020 (~USD 144), or 37%. This reflects changes in purchasing power over an inflationary period and cannot show how these customers would have fared without their solar product.

Taken together, the results suggest that HBBs benefit from improved electricity access, but the scale of their productive-use gains is smaller than for standalone businesses on operating hours and perceived profitability. This raises an important question on the constraints facing home-based businesses.

4.2.4 Employment, wages and business prospects

EMPLOYMENT REMAINED BROADLY STABLE AND REAL WAGES FELL.

For businesses, employment remained broadly stable, while employee pay declined in real terms. Among 968 businesses with matched worker counts, 735/968 (76%) reported no change in employment, while 137/968 (14%) increased their workforce and 96/968 (10%) reduced it. Employee pay was broadly stable in nominal terms, but fell once adjusted for inflation: among 216 businesses with matched data, average real monthly employee pay declined by around ₦31,416 (23%). As with household income pointed out in the household findings, nominal salaries can rise while real purchasing power falls when consumer prices increase faster than wages[118]. As in the household pathway, reliable electricity can enable productive use, but whether that becomes additional jobs or higher real wages depends on demand, finance and the wider macroeconomic environment.

Business revenue was asked only of standalone businesses given the blurred nature of business revenue and household income for home-based business respondents. Of the 83 standalone businesses that had before/after matches for monthly revenue data, 16% (13) reported moving to a higher nominal revenue band, 82% (68) remained in the same band, and 2% (2) moved to a lower band.[119]

BOX 5 FUTURE PLANS: EXPANSION INTENTIONS

Many respondents linked their Sun King product to changed plans for the future, most commonly business expansion. Across all 1,954 household and home-based business respondents, 37% (729) reported planning to expand a business, while 6% (113) planned to start a new business, 3% (60) to invest in education and 3% (49) to buy productive assets. However, 25% (493) reported no change in their plans because of the product and 31% (610) did not know or preferred not to answer.

The emphasis on expansion was stronger among the 323 standalone business respondents. Almost half, 49% (158), reported plans to expand their business, while 6% (19) planned to start a new business, 4% (12) to buy productive assets and 2% (6) to invest in education or training. A further 22% (72) reported no change in their business plans and 25% (80) did not know or preferred not to answer. These findings capture respondents' intentions rather than investments or business growth that have already occurred.

49% (158) of standalone business respondents reported plans to expand their business that they attributed to having their Sun King product.

BUSINESSES KEEP TRADING THROUGH OUTAGES AND ARE LESS EXPOSED TO FUEL-PRICE SHOCKS.

Resilience is where the business pathway's final outcomes are clearest. As reported in Section 4.3.2, 89% of respondents completing the resilience module, across all segments, said their Sun King product helped their household or business keep running during power outages. Among business-only respondents, 81% reported being less affected by rising fuel prices, and for business-only respondents who completed the resilience module (n = 283), improved business performance was the single most important benefit of their product for 15%, after better lighting (39%) and more reliable electricity (30%). For a business, an outage absorbed is a trading hour kept.

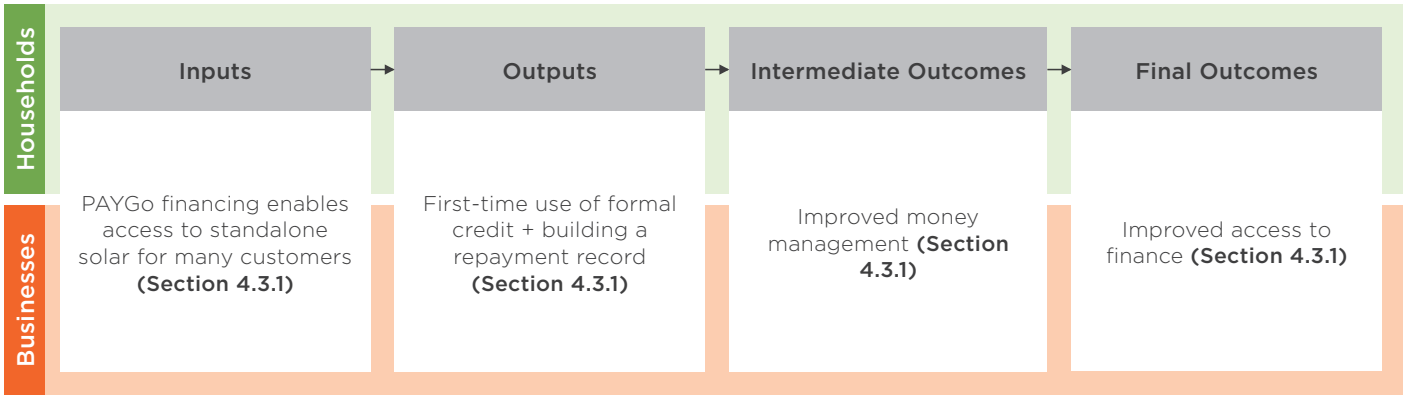
WHY THIS MATTERS: CONSISTENT POWER ENABLES FIRM PRODUCTIVITY.

The association between longer operating hours and higher profitability mirrors, in reverse, one of the most robust findings in the electrification literature. Most of that evidence measures what firms lose when power fails; the corollary is that businesses able to keep lights and equipment running after dark and through outages should be more productive.

4.3 Across both pathways: PAYGo, resilience and wider effects

Some findings span both the household and business pathways. PAYGo can enable customers to acquire their systems and has financial outcomes of its own. The shared resilience module captures continuity and perceived value across household-only, home-based businesses and standalone-business respondents. Electricity sharing and product limitations also concern customers across these groups.

4.3.1 PAYGo financing: the input that opens access to energy, and a route to financial inclusion



PAYGo financing is an input to both pathways: it enables many customers to acquire a system acquire a system, and has financial-inclusion outcomes of its own (Section 4.3.1). Adapted from Figure 1.

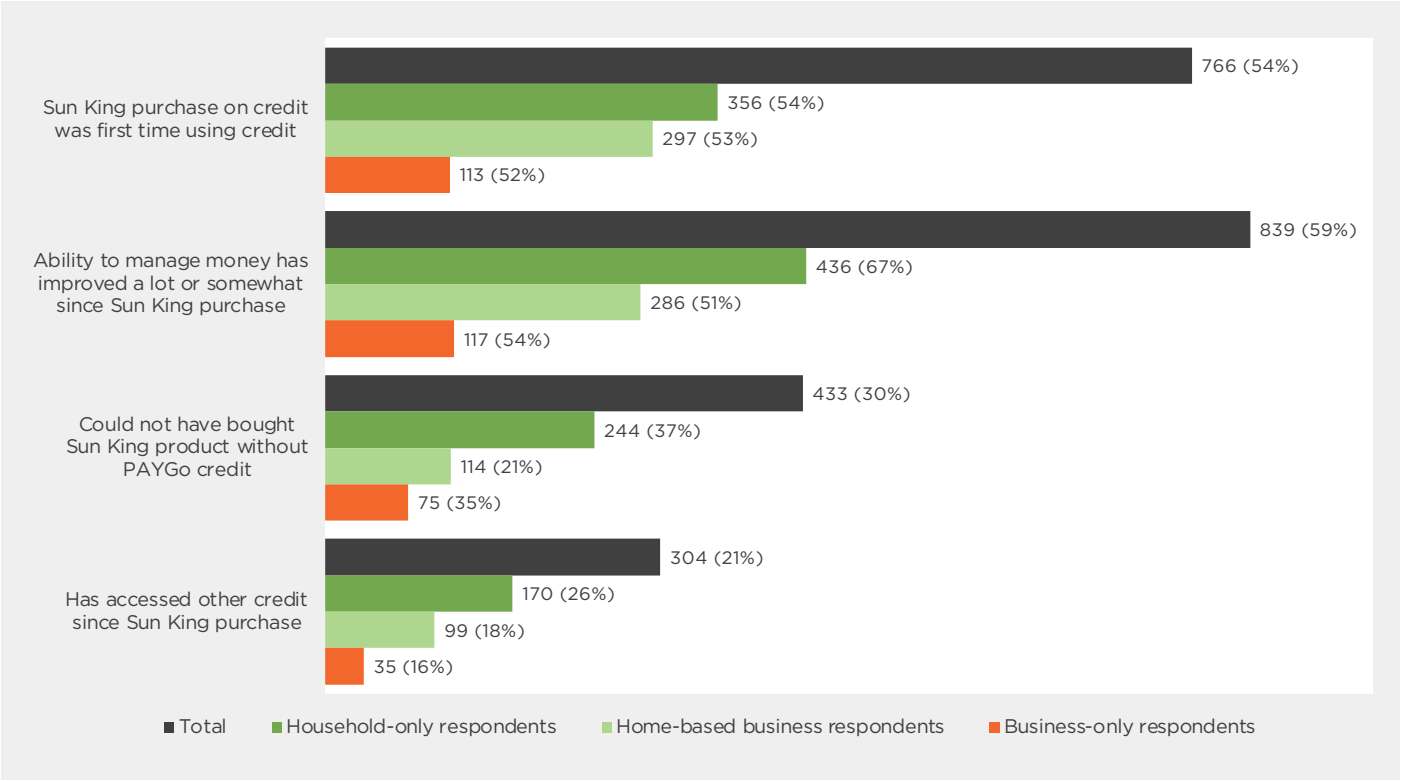
In the theory of change (Figure 1), PAYGo is part of the input rather than a separate pathway. It is how many customers acquire their system in the first place, so it sits upstream of both the household and business pathways in Sections 4.1 and 4.2. It also produces financial outcomes of its own, independent of the electricity the system delivers. The figures below come from the 1,430 customers who bought on credit and completed the survey's financial-inclusion module; they are customers' own accounts and may carry upward bias.

PAYGo enables access to energy. 30% (433) said they could not have bought their product without PAYGo credit, rising to 37% (244/656) of household-only customers and 39% (45/114) of female-owned standalone businesses, against 29% (30/102) of male-owned standalone businesses. Most of the rest (64%, 913) said they could have paid upfront. This is customers' own judgement rather than a measured counterfactual, but it suggests that for a substantial minority, PAYGo was the difference between gaining access to solar and going without.

PAYGo is an entry point into formal credit. For 54% (766), buying their Sun King product on credit was their first use of any credit. This share was consistent across households (54%), home-based businesses (53%) and standalone businesses (52%), and between female- and male-owned standalone businesses (52% each). Formal credit is otherwise scarce in Nigeria: only 9% of non-farm household enterprises reported requesting credit in the past 12 months,[120] and only 6% of adults had borrowed through a regulated financial institution.[121]

PAYGo is associated with better money management. 59% (839) said their ability to manage money had improved since buying their product, including 51% (736) who said it had improved "a lot". Of these, 83% (696) attributed the improvement fully or partly to paying in instalments, as summarised in Figure 11. These reported money-management gains were strongest among household-only customers. Improvement was reported by 67% (436/656) of household-only customers, compared with 51% (286/557) of home-based businesses and 54% (117/217) of standalone businesses. Household-only customers were significantly more likely to report improvement than either business group, while the two business groups did not differ significantly.

Figure 11 How PAYGo financing of Sun King products has helped to expand financial inclusion for customers



Note: *Results are restricted to the 1,430 respondents who responded to the financial-inclusion module.*

Two caveats apply. The survey only reached customers who completed a purchase, so it cannot speak to households for whom the product remained unaffordable even with PAYGo, a concern raised in parts of the literature.[122,123] And 231 respondents reported payment-related difficulties, a reminder that instalment credit carries risks as well as benefits for low-income customers.

4.3.2 Resilience, perceived value and spillovers

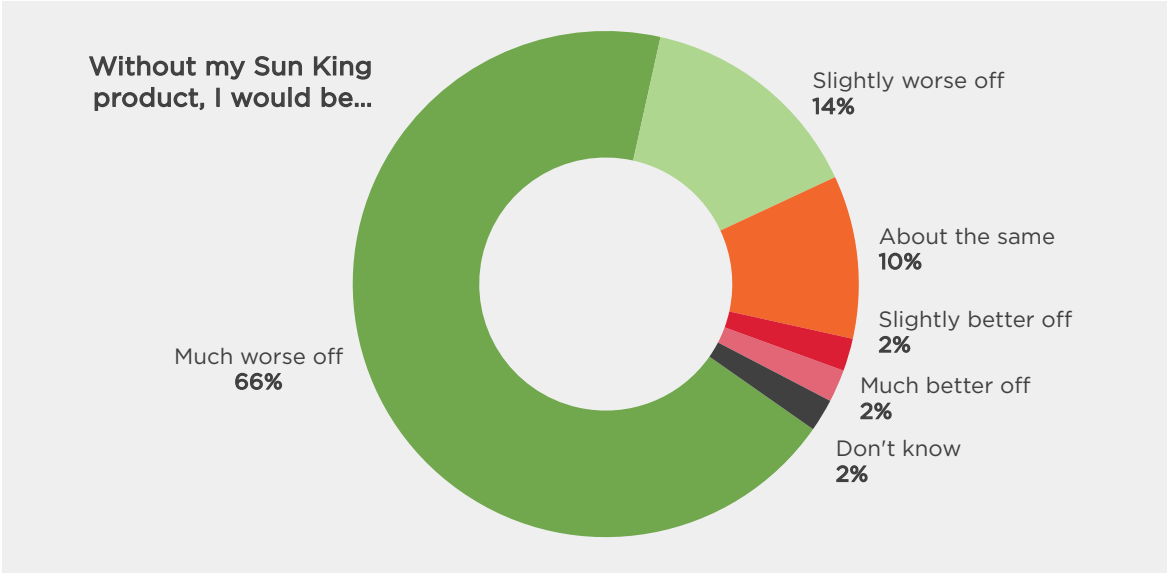
CUSTOMERS ACROSS THE SURVEY REPORTED THAT THEIR SUN KING PRODUCTS HELPED THEM CONTINUE DURING OUTAGES AND REDUCED EXPOSURE TO RISING FUEL PRICES.

Respondents reported strong resilience to both of the shocks the survey asked about, most of all to power outages. Out of the 2,006 respondents who completed the final resilience module of the survey, 1,790 (89%) reported that their Sun King product has helped their household and/or business to carry on running during power outages, and 108 (5%) said it helped "a little". Additionally, 1,486 (74%) respondents reported that they were "a lot less affected" by rising fuel prices because of their Sun King product, and 182 (9%) reported being "somewhat less affected". Resilience to rising fuel prices was reported most strongly by household-only respondents, with 87% reporting being "a lot less affected" or "somewhat less affected", compared to 81% of business-only respondents, and 79% of home-based business respondents.[124] The scale of what customers report being insulated from is set out in Box 1: petrol prices rose by more than 800% between May 2022 and May 2026, far outpacing general inflation.

MOST MODULE RESPONDENTS SAID THEY WOULD BE WORSE OFF WITHOUT THEIR SUN KING PRODUCT.

Out of 2,006 respondents who completed the resilience module in the survey, 80% reported that they would be "much worse off" or "slightly worse off" without their Sun King product, as shown in **Figure 12**. The "single most important benefit" of the Sun King product was better lighting for 51% of respondents, and reliable electricity for 32% of respondents (n = 2,006). For business-only respondents who completed the resilience module (n = 283), improved business performance was reported as the single most important benefit of the Sun King product by 15% of respondents, after better lighting (39%) and more reliable electricity (30%).

Figure 12 Self-reported well-being in the absence of their Sun King product (n = 2,006)



Nonetheless, a minority of respondents did report challenges with their Sun King product. Weather was by far the most commonly reported: 31% (696) of respondents said that on cloudy days or in certain seasons their product does not charge fully or work as well. This was followed by payment-related difficulties (10%, 231), repairs or product failure since acquisition (8%, 177), and insufficient capacity to power everything the respondent needs (6%, 137). Theft or security concerns were rare (2%).[125] These patterns are consistent with the structural limitations of standalone solar identified in the literature, which notes both that lower-capacity products cannot support higher-load activities and that the viability of pay-as-you-go models depends on household purchasing power.[126]

ELECTRICITY SHARING SUGGESTS POTENTIAL BENEFITS BEYOND CUSTOMERS.

By sharing their solar electricity, respondents also showed that there may be spillover impacts to non-customers. Out of the 2,006 respondents who completed the resilience module of the survey, 24% reported "frequently" sharing solar electricity with others outside the household/business, and 19% reported "sometimes" doing so. This combined percentage was highest among household-only respondents (46%), followed by business-only respondents (41%) and home-based business respondents (39%).

CONCLUSION & RECOMMENDATIONS

The findings in this report support treating standalone solar as a credible, evidence-backed component of Nigeria's electrification strategy. The evidence shows that standalone ownership is associated with large, statistically significant reductions in energy costs and meaningful gains in useful time and business operating hours for Sun King's Nigerian customers; and standalone solar appears to play a partial but real role in relieving the cost and resilience pressures customers face created by Nigeria's large and persistent electricity access gap. The findings also show where value is still being left on the table: income and employment gains have been modest, home-based businesses gain less than standalone businesses, and because the evidence comes from a single survey round that relies on recall, it cannot yet show whether gains persist or grow over time, or separate the product's effects from the wider economic changes of the period.

The report therefore supports the following research, investment and policy priorities for the sector, and its funders and policymakers:

BUILD ON THIS EVIDENCE THROUGH FUTURE RESEARCH:

1. **Move from recall to a longitudinal panel.** Recruit a cohort of new customers at the point of sale, record a baseline before installation, and re-survey the same customers at regular intervals (for example at 6, 12, 24 and 36 months). This removes the reliance on recall, captures slower-building effects such as business growth and asset accumulation that the three-year window may understate, and shows whether early gains persist, grow or fade. Where feasible, prospective customers who have registered interest but not yet bought could serve as a comparison group, allowing a difference-in-differences estimate at modest additional cost.
2. **Track a small, consistent set of core metrics.** Building on the indicators that proved most informative in this study, a core set could cover: useful light-hours after dark; monthly energy spending by source, especially generator fuel; time use, including hours of paid work and study; business operating hours, revenue and profit; employment and wages; household income and assets; resilience to outages and fuel-price shocks; and PAYGo outcomes such as repayment performance, first-time credit use, subsequent access to other finance and money management.
3. **Expand beyond households and businesses.** Institutions are a third user category with potentially wider economic effects, which are not studied here. Extending the approach to schools, primary health clinics, places of worship and community or farmer organisations served by standalone solar would show whether solar improves the services they provide.

HELP CUSTOMERS TURN ENERGY ACCESS INTO PRODUCTIVE USE:

1. **Leverage PAYGo last-mile distribution networks to promote productive use of solar energy.** PAYGo providers could explore ways to use their distribution networks, agent relationships and payment infrastructure to encourage productive uses of solar energy. This could include connecting customers with practical business training, enterprise support and opportunities to adopt solar-powered activities, helping translate improved energy access into sustainable business growth and livelihood opportunities.
2. **Prioritise home-based businesses.** Nearly half of household customers (45%) run a business from home, yet they gain less than standalone businesses (26 against 69 extra minutes of trading a day; 38% against 59% reporting higher profitability), and neither sector nor system appears to explain the gap. Sun King and other solar providers could identify these customers at the point of sale, offer them productive-use bundles and tier-upgrade PAYGo financing rather than the standard household offer, and target them first for training. Future research should test what is holding them back.

BUILD ON PAYGO AS A ROUTE TO FINANCIAL INCLUSION:

1. **Use PAYGo repayment histories to open up further finance.** For 54% of credit customers, their Sun King product was their first experience of formal credit, and 59% report better money management. With customer consent and appropriate data protection, Sun King and other solar providers could share positive repayment data with credit bureaus or partner lenders, offer graduated credit for upgrades and productive-use assets, and link customers to savings and insurance products. Because 10% of customers reported payment difficulties, this should go hand in hand with responsible-lending safeguards and close monitoring of repayment stress.

ENSURE THAT OFF-GRID SOLAR PROGRAMMES, SUBSIDIES AND FINANCING MECHANISMS REFLECT THE FULL VALUE SOLAR DELIVERS TO HOUSEHOLDS AND BUSINESSES BY:

1. **Valuing resilience and cost-avoidance, not only income.** 89% of respondents said their product kept them running through power outages and 83% said it made them less exposed to rising fuel prices. DARES and other results-based financing could weigh these benefits explicitly when assessing returns.
2. **Targeting affordability support where solar displaces costly generators.** Households that previously used generators reported much larger savings, so customers' baseline energy mix could contribute to the evidence base informing how subsidies are targeted under DARES. *Because prior generator users may be better off and grid-connected, such targeting should be weighed against DARES' objective of reaching unserved and poorer households.*
3. **Creating a productive-use window for home-based businesses.** Dedicated tier-upgrade financing or productive-use bundles within DARES would avoid defaulting these customers into the standard household offer.

ANNEXURE 1
Methodology

A. STUDY DESIGN AND RATIONALE

This study uses a retrospective before/after design. Each customer serves as their own point of comparison, recalling their circumstances before adoption in a once-off telephone survey conducted through Sun King's call centres. A randomised controlled trial was not feasible for a commercial product that customers choose and pay for. A matched comparison of non-customers (e.g. via propensity-score matching) would have required a separate survey of people outside Sun King's records, which was beyond the time and budget available, and would still have faced confounding because buyers and non-buyers differ systematically in income, location and grid access. The before/after design holds constant characteristics that do not change over time, at the cost of relying on recall and being unable to separate the effect of the product from other changes over the period (see E | Limitations).

B. SAMPLING AND DATA COLLECTION

We used Sun King's administrative customer database as our sampling frame, and used a stratified random sampling approach, stratifying by region, usage type (residential vs. commercial), and gender, to reflect the underlying customer base rather than whichever customers were easiest to reach. Eligibility was further restricted to customers who had owned their product for up to three years, applied as a recall accuracy safeguard.

We aimed to target 2,000 completed interviews, informed by a power analysis and a fieldwork feasibility assessment. The achieved sample was **2,277 materially complete responses** (1,081 household-only, 323 standalone businesses, and 873 home-based business respondents). A materially complete response required the respondent to reach the end of the energy component and complete an assignable household, home-based business or standalone business socioeconomic route.

Call centre agents recorded 5,290 call records, of which 4,093 (77.4%) were recorded as available. The remaining 1,197 initial calls were recorded as busy (611), hung up (485), unreachable (62), or not in service (39). Among customers successfully contacted, 57 calls reached someone other than the customer and 288 customers were unable to speak at that time. Of the 3,748 confirmed customers who were available to participate, 3,646 consented and 102 declined, corresponding to a **97.3% consent rate and 2.7% refusal rate** among customers available to participate.

Of the 3,646 consenting respondents, 3,306 passed the study's eligibility screening, after which further attrition occurred as respondents progressed through the questionnaire. Eligibility required respondents to be continuing users of the Sun King product and to be either its main user or sufficiently knowledgeable about how it was used, alongside the preceding consent and customer-record verification requirements. Of the 340 respondents who did not meet or complete eligibility screening, 155 reported that the product was no longer regularly in use, 76 could not sufficiently recall or verify the product or purchase-period information, 73 were not the main or a sufficiently knowledgeable user or did not recall owning the product, and 36 had incomplete eligibility information. Of the 3,306 respondents who passed screening, 2,939 reached the energy stage; the other 367 comprised 217 explicit drop-offs and 150 whose continuation status was not recorded. A further 562 stopped at the energy-module exit check, leaving 2,377 respondents who continued into the socioeconomic modules. Of these, 100 could not be assigned a final socioeconomic route, leaving the **2,277 core analytical responses** used in the report.

Overall, the 2,277 core responses represent **43% of the 5,290 recorded calls**. Most of the shortfall reflects calls that did not reach an available customer (1,542 call records, 51% of the 3,013 that did not produce a completed interview), rather than refusals (102, 3%). A further 340 (11%) were screened out as ineligible and 1,029 (34%) stopped part-way through the interview. Among consenting, eligible customers, 69% (2,277 of 3,306) completed the core modules. Because respondents were told at the outset that the survey was conducted on behalf of Sun King, customers willing to complete a 25-minute interview on this basis may be somewhat more satisfied with their product than non-respondents, which would tend to bias the findings in this report toward the more favourable end of the true range. The findings also describe continuing users only: the 155 customers who no longer regularly used their product were screened out, and their experience is likely to have been less favourable.

The design gives strong power for the comparisons that matter most for policy, namely gender, residential vs. commercial, major product types, and the largest regions. Some smaller segments (niche product types, the youngest age group, the smallest regions) are underpowered. Targeted oversampling in future waves would address this where strategically relevant.

The achieved sample was broadly aligned with Sun King's administrative customer distributions across geography and product type. A comparison of the survey with Sun King's administrative records found that the geographic distribution was similar across all six geopolitical zones, with differences ranging from approximately −3.0 to +2.2 percentage points. The product distribution was also closely aligned when restricted to the five solar product categories included in the survey. Entry-level solar home systems accounted for approximately 68% of surveyed customers, compared with 66% in the comparable administrative product records.

C. EMPIRICAL STRATEGY

Two harmonised populations are used throughout the report: the ***household population*** (n = 1,954), combining household-only and home-based business respondents, and the ***business population*** (n = 1,196), combining home-based business and standalone business respondents.

For quantitative outcomes (income, expenditure and employee salary, which were collected in bands and converted to band midpoints (Annexure 2), and operating hours and number of people working), we report matched before/after pairs from the same respondent, tested with a paired t-test (primary) and a Wilcoxon signed-rank test as a non-parametric robustness check. Where the two tests disagree, as for business employment and nominal employee salary, this is reported explicitly. Respondents were also asked directly whether an outcome had improved, stayed the same or worsened; an exact binomial test assesses whether favourable and unfavourable changes are equally likely among respondents who reported a change in either direction.

Banded outcomes are also analysed in their original nominal bands using the Stuart-Maxwell test of marginal homogeneity and a sign test, changes in ownership of individual assets use McNemar's test, and 95% confidence intervals for proportions are Wilson score intervals. Unless otherwise stated, "statistically significant" in the report means $p < 0.05$; results significant only at the 10% level are marked as such in the annex tables. P-values are not adjusted for multiple comparisons, so isolated significant results among the many subgroup comparisons should be interpreted with caution.

The change-score regressions in Annexure 3 relate the size of each respondent's change to baseline household, business and product characteristics. These estimates are conditional on observed characteristics and should be read as associations rather than causal estimates, given the absence of a comparison group.

D. IDENTIFYING HOME-BASED BUSINESSES

Respondents identified themselves as household-only, standalone business, or home-based-business respondents early in the survey and were routed to the corresponding module accordingly. We did not verify this against administrative records. Where a home-based-business respondent's household head and business head are different people, the household demographic table treats these as separate individuals. Energy expenditure and income measures for home-based-business respondents were collected on a combined household and business basis, so these respondents are included in the household population but always shown as a separate route sub-row, rather than being assumed equivalent to either a household-only or a standalone-business figure. Because the routes are mutually exclusive, harmonised figures stack the route sub-samples rather than averaging them. Where no genuinely comparable combined measure exists (e.g., for standalone business revenue, which has no household-income equivalent), no harmonised figure was constructed, and the measure is reported for its own analytical population only.

E. LIMITATIONS

No comparison group. The before/after design cannot separate the effect of the product from other changes over the same period, most importantly high inflation, the removal of the petrol subsidy and exchange-rate depreciation. The results describe what changed for customers, not what would have happened to them without the product.

Recall. "Before" values rely on respondents' recollection of circumstances up to around four years earlier, reported in fixed bands. Recall error is likely to be larger for monetary values than for simpler measures such as lighting hours or asset ownership.

Social desirability and sponsor effects. The survey was introduced as being conducted on behalf of Sun King, was administered by Sun King call-centre agents, and asked respondents directly whether the product had improved outcomes. Each of these is likely to bias reported effects upwards, which is why the report places more weight on the direction of changes than on their precise magnitude.

Selection of respondents. The sample comprises current customers who could be reached by phone, agreed to take part, still used their product and completed the interview. Customers who had stopped using their product or who dropped out during the interview may have had less favourable experiences, so results are likely to sit at the favourable end of the range for all purchasers.

Inflation adjustment. Real values depend on the CPI series, the reference month assigned to each recalled value and band midpoints (Annexure 2). Because earlier adopters' "before" values are deflated over a longer period, real-terms changes, and their association with years since adoption, are sensitive to these choices.

Time horizon and generalisability. The three-year ownership cap needed to protect recall accuracy means that slower-building effects, such as business growth or asset accumulation, may be understated. Findings are specific to Sun King customers in Nigeria under the macroeconomic conditions of 2022–2026 and should not be assumed to generalise to other providers, countries or periods.

F. ETHICS AND DATA QUALITY

The survey was administered by Sun King call centre agents. This made it possible to reach a large, verified sample of existing customers, since contact details and product adoption dates were held in Sun King's own customer records. Genesis Analytics retained independent control of the instrument and the analysis throughout: Genesis designed the questionnaire, trained the agents, ran the pilot, and conducted all data cleaning, validation and analysis. The trade-off is a recognised risk of social-desirability bias, which is why the report treats the direction of reported changes as more reliable than their precise magnitude. Agents identified themselves and Sun King as the survey sponsor upfront, stated the survey's purpose (understanding the impact of standalone solar on households and businesses in Nigeria), and its approximate length (25 minutes), and gave an explicit assurance that responses were confidential and to be used for research purposes only. Agents reiterated that participation was voluntary with the right to skip any question or stop at any time, and asked for **informed consent** as a discrete survey question prior to proceeding with the substantive questionnaire.

Completed interviews were checked against the sampling frame for duplicate or invalid contact records, implausible or inconsistent response patterns were flagged for review, and Genesis Analytics cleaned and validated the data in Stata using the missing-data taxonomy in Annexure 2.

Personal data were handled in line with the Nigeria Data Protection Act 2023. Survey responses were collected by Sun King and shared with Genesis Analytics under a data-sharing agreement between the two organisations. All data were anonymised before being shared, so Genesis Analytics received no information that could identify individual respondents, and results are reported only in aggregate.

ANNEXURE 2

Before/after and reported-effect tables

A. HOUSEHOLD RESULTS

Table A1 Paired changes in key household outcomes

Outcome	Paired *N*	Before	Current	Mean change	95% CI for change	Paired t-test p-value	Wilcoxon p-value
Useful light-hours after dark	**1,736**	**5.60**	**8.80**	**+3.20**	**[2.99, 3.41]**	**<0.001**	**<0.001**
Female (household head)	271	5.20	8.08	+2.88	[2.42, 3.34]	<0.001	<0.001
Male (household head)	1,423	5.67	8.95	+3.27	[3.04, 3.51]	<0.001	<0.001
Emerging consumer (<₦740k)	597	4.85	8.68	+3.83	[3.51, 4.15]	<0.001	<0.001
→ Household-only route	948	5.08	9.06	+3.98	[3.70, 4.25]	<0.001	<0.001
→ HBB route	788	6.23	8.49	+2.26	[1.96, 2.56]	<0.001	<0.001
Durable asset count (9-item)	**1,885**	**4.23**	**4.29**	**+0.07**	**[0.03, 0.10]**	**<0.001**	**0.015**
Female (household head)	286	3.63	3.74	+0.11	[0.01, 0.22]	0.037	0.160
Male (household head)	1,556	4.36	4.42	+0.06	[0.02, 0.10]	0.005	0.052
Emerging consumer (<₦740k)	663	4.00	4.01	+0.01	[−0.05, 0.07]	0.726	0.985
→ Household-only route	1,054	4.21	4.27	+0.06	[0.01, 0.11]	0.016	0.091
→ HBB route	831	4.25	4.32	+0.07	[0.02, 0.12]	0.010	0.079
Household income, nominal	**661**	**₦240,680**	**₦276,295**	**+₦35,615**	**[₦24,291, ₦46,939]**	**<0.001**	**<0.001**
Female (household head)	94	₦193,191	₦206,473	+₦13,282	[−₦8,435, ₦34,999]	0.228	0.028
Male (household head)	545	₦251,554	₦291,661	+₦40,106	[₦26,927, ₦53,286]	<0.001	<0.001
Emerging consumer (<₦740k)	596	₦164,457	₦185,371	+₦20,914	[₦12,256, ₦29,571]	<0.001	<0.001
→ Household-only route	419	₦211,611	₦241,555	+₦29,944	[₦16,473, ₦43,414]	<0.001	<0.001
→ HBB route	242	₦291,010	₦336,444	+₦45,434	[₦25,044, ₦65,824]	<0.001	<0.001
Household income, real	**657**	**₦443,143**	**₦277,355**	**−₦165,788**	**[−₦192,667, −₦138,909]**	**<0.001**	**<0.001**
Female (household head)	94	₦368,151	₦207,992	−₦160,159	[−₦235,983, −₦84,335]	<0.001	<0.001
Male (household head)	541	₦461,925	₦292,729	−₦169,196	[−₦198,982, −₦139,410]	<0.001	<0.001
Emerging consumer (<₦740k)	593	₦300,232	₦186,512	−₦113,720	[−₦131,406, −₦96,034]	<0.001	<0.001
→ Household-only route	417	₦388,667	₦241,430	−₦147,237	[−₦177,546, −₦116,927]	<0.001	<0.001
→ HBB route (includes business income)	240	₦537,796	₦339,776	−₦198,020	[−₦249,467, −₦146,572]	<0.001	<0.001
Household energy expenditure, nominal	**1,276**	**₦13,526**	**₦5,918**	**−₦7,607**	**[−₦8,503, −₦6,712]**	**<0.001**	**<0.001**
Female (household head)	206	₦7,818	₦3,456	−₦4,362	[−₦6,060, −₦2,663]	<0.001	<0.001
Male (household head)	1,039	₦14,881	₦6,468	−₦8,412	[−₦9,451, −₦7,373]	<0.001	<0.001
Emerging consumer (<₦740k)	586	₦13,466	₦6,305	−₦7,160	[−₦8,361, −₦5,959]	<0.001	<0.001
→ Household-only route	772	₦14,456	₦5,904	−₦8,552	[−₦9,706, −₦7,398]	<0.001	<0.001

→ HBB combined household + business route	504	₦12,101	₦5,940	−₦6,161	[−₦7,577, −₦4,744]	<0.001	<0.001
Household energy expenditure, real	**1,267**	**₦25,318**	**₦5,997**	**−₦19,320**	**[−₦21,151, −₦17,489]**	**<0.001**	**<0.001**
Female (household head)	206	₦13,797	₦3,490	−₦10,307	[−₦13,649, −₦6,965]	<0.001	<0.001
Male (household head)	1,030	₦28,070	₦6,563	−₦21,507	[−₦23,633, −₦19,381]	<0.001	<0.001
Emerging consumer (<₦740k)	582	₦25,037	₦6,398	−₦18,639	[−₦21,118, −₦16,160]	<0.001	<0.001
→ Household-only route	766	₦27,166	₦5,975	−₦21,191	[−₦23,633, −₦18,750]	<0.001	<0.001
→ HBB combined household + business route	501	₦22,492	₦6,032	−₦16,460	[−₦19,190, −₦13,729]	<0.001	<0.001

Notes: *Change is defined as the current value (month before the interview) minus the before value (the same calendar month in the year before adoption). The income and energy-expenditure figures labelled real are inflation-adjusted midpoint estimates expressed in constant June 2026 naira. Paired Ns for real values can be slightly smaller than for nominal values because a few records lacked the adoption date needed for inflation adjustment. Changes are calculated before rounding, so displayed before and current values may not difference exactly to the displayed change.*

Household income is harmonised across household-only and HBB (households with home-based businesses) routes. The HBB concept includes business income, so the harmonised headline should be read as an analytical household/HBB income measure rather than a perfectly identical income concept across routes. Household energy expenditure similarly pools mutually exclusive household-only and HBB route measures. For HBB respondents, this figure includes energy used by the home-based business; separate-premises standalone-business energy expenditure is excluded. The household-only and HBB route estimates are retained immediately below the harmonised headline for transparency.

Subgroup rows show household-head gender (female and male only; a small "other/not stated" group is not shown) and Emerging Consumer status (current monthly household income below ₦740,000; the "not Emerging Consumer" and "income not stated" groups are not shown). Subgroup Ns therefore do not sum to the paired N.

Table A2 Nominal ordinal movement in banded household outcomes

Outcome	Paired N	Favourable band movement, n (%)	Same band, n (%)	Unfavourable band movement, n (%)	Stuart-Maxwell p-value	Sign-test p-value
Household income band, all households	**661**	**179 (27.1%)**	**431 (65.2%)**	**51 (7.7%)**	**<0.001**	**<0.001**
Female (household head)	94	23.4%	67.0%	9.6%	0.504	0.029
Male (household head)	545	27.9%	65.0%	7.2%	<0.001	<0.001
Emerging consumer (<₦740k)	596	27.3%	64.1%	8.6%	<0.001	<0.001
→ Household-only route	419	114 (27.2%)	272 (64.9%)	33 (7.9%)	<0.001	<0.001
→ HBB route (includes business income)	242	65 (26.9%)	159 (65.7%)	18 (7.4%)	0.002	<0.001
Household energy-cost band, all households	**1,276**	**548 (42.9%)**	**647 (50.7%)**	**81 (6.3%)**	**<0.001**	**<0.001**
Female (household head)	206	31.1%	62.1%	6.8%	<0.001	<0.001
Male (household head)	1,039	45.6%	48.3%	6.1%	<0.001	<0.001
Emerging consumer (<₦740k)	586	45.6%	47.1%	7.3%	<0.001	<0.001
→ Household-only route	772	362 (46.9%)	369 (47.8%)	41 (5.3%)	<0.001	<0.001
→ HBB route (includes business energy use)	504	186 (36.9%)	278 (55.2%)	40 (7.9%)	<0.001	<0.001

Notes: *These analyses use the original fixed **nominal** survey bands and are not inflation-adjusted. For income, movement to a higher band is treated as favourable. For energy costs, movement to a lower band is treated as favourable. The Stuart-Maxwell test assesses whether the paired marginal distribution changed; the sign test assesses whether favourable and unfavourable movements are balanced among respondents whose band changed.*

*Because the real monetary estimates in Table A1 are CPI-adjusted, these ordinal rows should be treated as **nominal companion analyses rather than robustness checks of the real estimates**. A respondent can move to a higher nominal income band while experiencing lower real purchasing power after inflation.*

Table A3 Paired changes in household asset ownership

Asset	Paired N	Owned before, n (%)	Owned currently, n (%)	No → yes, n (%)	Yes → no, n (%)	McNemar p-value
Radio	1,885	910 (48.3%)	934 (49.5%)	67 (3.6%)	43 (2.3%)	0.022
TV	1,885	1,470 (78.0%)	1,515 (80.4%)	85 (4.5%)	40 (2.1%)	<0.001
Fridge	1,885	1,146 (60.8%)	1,137 (60.3%)	62 (3.3%)	71 (3.8%)	0.435
Fan	1,885	1,351 (71.7%)	1,365 (72.4%)	86 (4.6%)	72 (3.8%)	0.265
Smartphone	1,885	1,594 (84.6%)	1,610 (85.4%)	87 (4.6%)	71 (3.8%)	0.203
Feature phone	1,885	729 (38.7%)	752 (39.9%)	75 (4.0%)	52 (2.8%)	0.041
Bicycle	1,885	78 (4.1%)	76 (4.0%)	14 (0.7%)	16 (0.8%)	0.715
Motorcycle	1,885	426 (22.6%)	432 (22.9%)	46 (2.4%)	40 (2.1%)	0.518
Car	1,885	265 (14.1%)	272 (14.4%)	35 (1.9%)	28 (1.5%)	0.378

Notes: *McNemar's test compares the two discordant transitions within the matched sample. It asks whether movement from non-ownership to ownership is systematically more common than movement in the opposite direction. The aggregate 9-item asset count is reported separately in Table A1.*

Table A4 Directly reported household changes since acquiring Sun King

Outcome	Answered N (incl. DK)	Favourable direction, n (%)	No change, n (%)	Unfavourable direction, n (%)	Don't know / can't recall, n (%)	95% CI for favourable share	Net favourable (pp)	Directional p-value
Phone use	**1,726**	**1,141 (66.1%)**	**469 (27.2%)**	**85 (4.9%)**	**31 (1.8%)**	**[63.8%, 68.3%]**	**+61.2**	**<0.001**
Female (household head)	250	75.2%	15.6%	6.0%	3.2%	[69.5%, 80.1%]	+69.2	<0.001
Male (household head)	1,443	64.6%	29.1%	4.8%	1.5%	[62.1%, 67.0%]	+59.8	<0.001
Emerging consumer (<₦740k)	597	83.4%	13.4%	2.7%	0.5%	[80.2%, 86.2%]	+80.7	<0.001
Available free time	**1,954**	**855 (43.8%)**	**593 (30.3%)**	**38 (1.9%)**	**468 (24.0%)**	**[41.6%, 46.0%]**	**+41.8**	**<0.001**
Female (household head)	306	46.7%	23.5%	1.3%	28.4%	[41.2%, 52.3%]	+45.4	<0.001
Male (household head)	1,600	43.5%	31.4%	2.0%	23.1%	[41.1%, 45.9%]	+41.5	<0.001
Emerging consumer (<₦740k)	666	64.1%	25.4%	2.3%	8.3%	[60.4%, 67.7%]	+61.9	<0.001
Household smoke / indoor air	**882**	**615 (69.8%)**	**198 (22.5%)**	**68 (7.7%)**	**1 (0.1%)**	**[66.7%, 72.7%]**	**+62.1**	**<0.001**
Female (household head)	130	56.9%	27.7%	15.4%	0.0%	[48.3%, 65.1%]	+41.5	<0.001
Male (household head)	735	71.7%	21.9%	6.4%	0.1%	[68.3%, 74.8%]	+65.3	<0.001
Emerging consumer (<₦740k)	287	74.6%	16.7%	8.7%	0.0%	[69.2%, 79.3%]	+65.9	<0.001
Household income, all households	**1,954**	**843 (43.1%)**	**526 (26.9%)**	**132 (6.8%)**	**453 (23.2%)**	**[41.0%, 45.3%]**	**+36.4**	**<0.001**
Female (household head)	306	37.6%	20.6%	8.8%	33.0%	[32.3%, 43.1%]	+28.8	<0.001
Male (household head)	1,600	44.4%	28.2%	6.3%	21.1%	[42.0%, 46.8%]	+38.1	<0.001
Emerging consumer (<₦740k)	666	61.6%	28.2%	7.1%	3.2%	[57.8%, 65.2%]	+54.5	<0.001

→ Household-only route	1,081	509 (47.1%)	260 (24.1%)	79 (7.3%)	233 (21.6%)	[44.1%, 50.1%]	+39.8	<0.001
→ HBB route (includes business income)	873	334 (38.3%)	266 (30.5%)	53 (6.1%)	220 (25.2%)	[35.1%, 41.5%]	+32.2	<0.001
Household energy costs, all households	**1,954**	**1,223 (62.6%)**	**458 (23.4%)**	**20 (1.0%)**	**253 (12.9%)**	**[60.4%, 64.7%]**	**+61.6**	**<0.001**
Female (household head)	306	55.9%	24.8%	1.6%	17.6%	[50.3%, 61.3%]	+54.2	<0.001
Male (household head)	1,600	64.2%	23.0%	0.9%	11.9%	[61.8%, 66.5%]	+63.2	<0.001
Emerging consumer (<₦740k)	666	73.7%	21.5%	1.1%	3.8%	[70.3%, 76.9%]	+72.7	<0.001
→ Household-only route	1,081	752 (69.6%)	204 (18.9%)	6 (0.6%)	119 (11.0%)	[66.8%, 72.2%]	+69.0	<0.001
→ HBB route (includes business energy costs)	873	471 (54.0%)	254 (29.1%)	14 (1.6%)	134 (15.3%)	[50.6%, 57.2%]	+52.3	<0.001

Notes: *These are direct self-reported change questions rather than paired measurements. Don't-know responses remain in the denominator (Annexure 2, D4).*

For home-based businesses, income includes business income and the energy-cost question includes business energy costs. These direct reported-change questions are not CPI-adjusted, so perceived or nominal directional change may differ from the real purchasing-power changes reported in Table A1. The indoor-smoke question was asked only of respondents who previously used kerosene lamps or a generator.

Table A5 Tests of subgroup gaps in key household outcomes

Outcome	Comparison	Group 1 (n)	Mean change, group 1	Group 2 (n)	Mean change, group 2	Gap (1 minus 2)	p-value
Useful light-hours after dark	Household head gender	Household head: Female (271)	+2.88	Household head: Male (1,423)	+3.27	−0.40	0.175
Useful light-hours after dark	Emerging Consumer status	Emerging consumer (597)	+3.83	Not emerging consumer (83)	+3.31	+0.52	0.271
Durable asset count (9-item)	Household head gender	Household head: Female (286)	+0.11	Household head: Male (1,556)	+0.06	+0.06	0.287
Durable asset count (9-item)	Emerging Consumer status	Emerging consumer (663)	+0.01	Not emerging consumer (88)	+0.23	−0.22	0.019
Household income (nominal)	Household head gender	Household head: Female (94)	+₦13,282	Household head: Male (545)	+₦40,106	−₦26,825	0.111
Household income (real)	Household head gender	Household head: Female (94)	−₦160,159	Household head: Male (541)	−₦169,196	+₦9,037	0.820
Household energy expenditure (nominal)	Household head gender	Household head: Female (206)	−₦4,362	Household head: Male (1,039)	−₦8,412	+₦4,051	0.001
Household energy expenditure (real)	Household head gender	Household head: Female (206)	−₦10,307	Household head: Male (1,030)	−₦21,507	+₦11,200	<0.001
Household energy expenditure (real)	Emerging Consumer status	Emerging consumer (582)	−₦18,639	Not emerging consumer (69)	−₦29,069	+₦10,430	0.011

Real income and expenditure are inflation-adjusted (constant June 2026 naira). Emerging Consumer status is defined from current household income, which is also the endline value of the income outcome. Income changes are therefore not compared by Emerging Consumer status, because the gap would be partly mechanical; comparisons of other outcomes by Emerging Consumer status should be read as descriptive.

Group sample sizes (n1, n2) do not sum to the paired N reported in Table A1 because "other/not stated" household-head gender and "not emerging consumer"/"income not stated" respondents are excluded from both comparison groups, consistent with the subgroup convention used in Tables A1–A4.

Table A6 Real household energy expenditure by prior grid and generator use

Panel A. Four-way prior energy mix

Prior mix before Sun King	N	Mean before	Mean current	Mean change	95% CI for change	% change
Grid + generator	259	₦49,120	₦9,447	−₦39,673	[−₦44,619, −₦34,727]	−80.8%
Generator, no grid	163	₦37,490	₦6,363	−₦31,127	[−₦37,934, −₦24,320]	−83.0%
Grid, no generator	489	₦18,594	₦5,471	−₦13,124	[−₦15,299, −₦10,948]	−70.6%
Neither grid nor generator	345	₦11,200	₦3,797	−₦7,402	[−₦9,618, −₦5,187]	−66.1%

Panel B. Collapsed generator comparison

Prior generator use	N	Mean before	Mean current	Mean change	95% CI for change	% change
Generator	422	₦44,628	₦8,256	−₦36,372	[−₦40,391, −₦32,353]	−81.5%
No generator	834	₦15,535	₦4,779	−₦10,757	[−₦12,336, −₦9,178]	−69.2%

Panel C. Tests of differences in mean expenditure change

Comparison	N1	N2	Mean change 1	Mean change 2	Difference (1 − 2)	95% CI	t (Welch df)	p-value
Any generator vs no generator	422	834	−₦36,372	−₦10,757	−₦25,615	[−₦29,931, −₦21,299]	−11.66 (554.8)	<0.001
Grid+generator vs grid, no generator	259	489	−₦39,673	−₦13,124	−₦26,549	[−₦31,947, −₦21,151]	−9.67 (360.8)	<0.001
Generator, no grid vs neither	163	345	−₦31,127	−₦7,402	−₦23,725	[−₦30,876, −₦16,573]	−6.54 (197.4)	<0.001
Four-group omnibus	—	—	—	—	—	—	Welch F=54.52 (3, 478.2)	<0.001

Table A7 Single most important benefit of the Sun King product

Population: *All respondents who reached the resilience module.*

Response	n	%	95% CI
All respondents (H + HBB + B) (Answered *n* = 2,006)			
1. Better lighting	1,025	51.1%	[48.9%, 53.3%]
2. Lower energy costs	77	3.8%	[3.1%, 4.8%]
3. More reliable electricity	636	31.7%	[29.7%, 33.8%]
4. Increased income	12	0.6%	[0.3%, 1.0%]
5. Improved business performance	55	2.7%	[2.1%, 3.6%]
6. Phone charging/connectivity	99	4.9%	[4.1%, 6.0%]
7. Children's education	31	1.5%	[1.1%, 2.2%]
8. Health benefits	7	0.3%	[0.2%, 0.7%]
9. Safety/security	18	0.9%	[0.6%, 1.4%]
10. Other	16	0.8%	[0.5%, 1.3%]
Don't know / can't recall	30	1.5%	[1.0%, 2.1%]
Household-only (Answered *n* = 1,000)			
1. Better lighting	551	55.1%	[52.0%, 58.2%]
2. Lower energy costs	29	2.9%	[2.0%, 4.1%]
3. More reliable electricity	291	29.1%	[26.4%, 32.0%]
4. Increased income	7	0.7%	[0.3%, 1.4%]
5. Improved business performance	1	0.1%	[0.0%, 0.6%]
6. Phone charging/connectivity	62	6.2%	[4.9%, 7.9%]
7. Children's education	22	2.2%	[1.5%, 3.3%]

8. Health benefits	4	0.4%	[0.2%, 1.0%]
9. Safety/security	9	0.9%	[0.5%, 1.7%]
10. Other	10	1.0%	[0.5%, 1.8%]
Don't know / can't recall	14	1.4%	[0.8%, 2.3%]
Home-based business (Answered *n* = 723)			
1. Better lighting	364	50.3%	[46.7%, 54.0%]
2. Lower energy costs	29	4.0%	[2.8%, 5.7%]
3. More reliable electricity	259	35.8%	[32.4%, 39.4%]
4. Increased income	1	0.1%	[0.0%, 0.8%]
5. Improved business performance	11	1.5%	[0.9%, 2.7%]
6. Phone charging/connectivity	24	3.3%	[2.2%, 4.9%]
7. Children's education	9	1.2%	[0.7%, 2.3%]
8. Health benefits	3	0.4%	[0.1%, 1.2%]
9. Safety/security	7	1.0%	[0.5%, 2.0%]
10. Other	6	0.8%	[0.4%, 1.8%]
Don't know / can't recall	10	1.4%	[0.8%, 2.5%]
Standalone business (Answered *n* = 283)			
1. Better lighting	110	38.9%	[33.4%, 44.7%]
2. Lower energy costs	19	6.7%	[4.3%, 10.2%]
3. More reliable electricity	86	30.4%	[25.3%, 36.0%]
4. Increased income	4	1.4%	[0.6%, 3.6%]
5. Improved business performance	43	15.2%	[11.5%, 19.8%]
6. Phone charging/connectivity	13	4.6%	[2.7%, 7.7%]
7. Children's education	0	0.0%	[0.0%, 1.3%]
8. Health benefits	0	0.0%	[0.0%, 1.3%]
9. Safety/security	2	0.7%	[0.2%, 2.5%]
10. Other	0	0.0%	[0.0%, 1.3%]
Don't know / can't recall	6	2.1%	[1.0%, 4.5%]

Table A8 Reported reasons for a lower household energy-cost band

Answered denominator n = 548.

Response	n	%	95% CI
Reduced kerosene	44	8.0%	[6.0%, 10.6%]
Reduced candles	14	2.6%	[1.5%, 4.2%]
Reduced batteries/torches	118	21.5%	[18.3%, 25.2%]
Reduced paid charging	95	17.3%	[14.4%, 20.7%]
Reduced generator fuel	301	54.9%	[50.7%, 59.0%]
Reduced grid electricity	214	39.1%	[35.1%, 43.2%]
Reduced other energy	33	6.0%	[4.3%, 8.3%]
Don't know / can't recall	8	1.5%	[0.7%, 2.9%]

Notes: *This question is harmonised across household-only and HBB routes. Asked of respondents whose current nominal energy-cost band was lower than their before band. Multiple responses were permitted.*

Table A9 Reported reasons for a higher household energy-cost band

Answered denominator n = 81.

Response	*n*	%	95% CI
Using more electricity	39	48.1%	[37.6%, 58.9%]

New appliances	2	2.5%	[0.7%, 8.6%]
Larger/additional solar system	3	3.7%	[1.3%, 10.3%]
Still using/paying for other sources	10	12.3%	[6.8%, 21.3%]
Other	14	17.3%	[10.6%, 26.9%]
Don't know / can't recall	15	18.5%	[11.6%, 28.3%]

Notes: *This question is harmonised across household-only and HBB routes. Asked of respondents whose current nominal energy-cost band was higher than their before band. Multiple responses were permitted.*

B. BUSINESS RESULTS

Table B1 Paired changes in key business outcomes

Outcome / analytical population	Paired N	Before	Current	Mean change	95% CI for change	Paired t-test p-value	Wilcoxon p-value
Business operating hours/day, all businesses	**1,014**	**9.12**	**9.76**	**+0.64**	**[0.49, 0.79]**	**<0.001**	**<0.001**
Female (business owner)	452	9.21	9.85	+0.64	[0.43, 0.849]	<0.001	<0.001
Male (business owner)	555	9.12	9.76	+0.64	[0.43, 0.854]	<0.001	<0.001
Home-based businesses	715	8.80	9.23	+0.43	[0.28, 0.58]	<0.001	<0.001
Standalone businesses	299	9.90	11.05	+1.15	[0.79, 1.51]	<0.001	<0.001
People working in the business, all businesses	**968**	**2.52**	**2.43**	**−0.09**	**[−0.23, 0.05]**	**0.226**	**0.019**
Female (business owner)	433	1.73	1.67	−0.05	[−0.28, 0.17]	0.642	0.026
Male (business owner)	527	3.17	3.06	−0.11	[−0.30, 0.07]	0.233	0.175
Home-based businesses	698	2.47	2.43	−0.05	[−0.18, 0.09]	0.506	0.195
Standalone businesses	270	2.63	2.44	−0.20	[−0.57, 0.18]	0.302	0.027
Average monthly employee salary, all businesses (nominal)	**221**	**₦96,796**	**₦102,968**	**+₦6,172**	**[−₦635, ₦12,979]**	**0.075**	**<0.001**
Female (business owner)	55	₦105,573	₦119,055	+₦13,482	[−₦2,738, ₦29,702]	0.101	0.006
Male (business owner)	163	₦93,552	₦97,371	+₦3,819	[−₦3,689, ₦11,327]	0.317	<0.001
Home-based businesses	162	₦105,571	₦111,725	+₦6,154	[−₦2,480, ₦14,789]	0.161	0.001
Standalone businesses	59	₦72,703	₦78,924	+₦6,220	[−₦3,545, ₦15,986]	0.207	<0.001
Average monthly employee salary, all businesses (real)	**216**	**₦135,541**	**₦104,125**	**−₦31,416**	**[−₦42,728, −₦20,104]**	**<0.001**	**<0.001**
Female (business owner)	53	₦148,785	₦122,406	−₦26,378	[−₦51,711, −₦1,046]	0.042	<0.001
Male (business owner)	160	₦130,568	₦97,923	−₦32,645	[−₦45,496, −₦19,794]	<0.001	<0.001
Home-based businesses	158	₦147,907	₦113,243	−₦34,664	[−₦49,034, −₦20,295]	<0.001	<0.001
Standalone businesses	58	₦101,855	₦79,287	−₦22,568	[−₦38,544, −₦6,591]	0.006	0.004
Business energy expenditure, standalone businesses only (nominal)	**166**	**₦18,409**	**₦8,418**	**−₦9,991**	**[−₦12,874, −₦7,108]**	**<0.001**	**<0.001**
Female (business owner)	91	₦12,533	₦5,478	−₦7,055	[−₦10,097, −₦4,013]	<0.001	<0.001
Male (business owner)	75	₦25,540	₦11,986	−₦13,553	[−₦18,730, −₦8,376]	<0.001	<0.001
Business energy expenditure, standalone businesses only (real)	**165**	**₦26,008**	**₦8,478**	**−₦17,530**	**[−₦21,827, −₦13,233]**	**<0.001**	**<0.001**
Female (business owner)	90	₦18,041	₦5,496	−₦12,546	[−₦17,461, −₦7,631]	<0.001	<0.001
Male (business owner)	75	₦35,569	₦12,058	−₦23,511	[−₦30,798, −₦16,224]	<0.001	<0.001

Notes: *Where a comparable measure exists for both home-based and standalone businesses, the all-businesses result is the headline, followed by home-based business (HBB) and standalone-business sub-rows. Real values for sub-rows use the same inflation-adjustment method as the headline.*

Operating hours and employment are not monetary and are unchanged by the CPI adjustment. Employee salary is reported in real, constant June 2026 naira. The current salary value is assigned to the interview month; the retrospective salary value is assigned to the month immediately before adoption because the questionnaire asks about salary "before" Sun King without a more precise historical month. This retrospective reference month is therefore an explicit approximation.

Standalone-business energy expenditure is also inflation-adjusted and remains standalone-only because the HBB energy-cost measure is combined household + business expenditure and is not comparable to a separate-premises business-only measure.

For employee salary, the t-test and Wilcoxon test disagree in nominal terms ($p = 0.075$ and $p < 0.001$) but agree in real terms, where both show a statistically significant decline. For the number of people working, the all-business t-test is not significant ($p = 0.226$) while the Wilcoxon test is ($p = 0.019$); the divergence is concentrated in standalone businesses ($p = 0.302$ and $p = 0.027$), and home-based business results are not significant under either test. Given the right-skew in this outcome, the Wilcoxon result is the more reliable guide and points to a small net decline in the number of people working rather than no change.

Table B2 Nominal ordinal movement in business salary, revenue and energy-cost bands

Outcome / analytical population	Paired N	Favourable band movement, n (%)	Same band, n (%)	Unfavourable band movement, n (%)	Stuart-Maxwell p-value	Sign-test p-value
Employee salary band, all businesses	**221**	**52 (23.5%)**	**156 (70.6%)**	**13 (5.9%)**	**0.005**	**<0.001**
Female (business owner)	55	29.1%	63.6%	7.3%	0.370	0.012
Male (business owner)	163	22.1%	72.4%	5.5%	0.038	<0.001
Home-based businesses	162	33 (20.4%)	118 (72.8%)	11 (6.8%)	0.222	0.001
Standalone businesses	59	19 (32.2%)	38 (64.4%)	2 (3.4%)	0.056	<0.001
Business revenue band, standalone businesses only	**83**	**13 (15.7%)**	**68 (81.9%)**	**2 (2.4%)**	**0.009**	**0.007**
Female (business owner)	41	12.2%	85.4%	2.4%	0.102	0.219
Male (business owner)	42	19.0%	78.6%	2.4%	0.030	0.039
Business energy-cost band, standalone businesses only	**166**	**72 (43.4%)**	**84 (50.6%)**	**10 (6.0%)**	**<0.001**	**<0.001**
Female (business owner)	91	45.1%	52.7%	2.2%	<0.001	<0.001
Male (business owner)	75	41.3%	48.0%	10.7%	0.001	<0.001

Notes: *These are analyses of the original fixed nominal bands. They are not inflation-adjusted and should not be described as robustness checks of the real monetary results in Table B1.*

For salary, the inflation-adjusted analysis has a smaller sample ($n = 216$ versus $n = 221$) because administrative adoption dates were missing for five businesses, preventing adjustment to constant June 2026 naira.

Higher salary and revenue bands are treated as favourable; lower business energy-cost bands are treated as favourable.

Standalone-business revenue remains ordinal only. No continuous midpoint estimate was created because the revenue bands are very wide, so no CPI-adjusted real revenue estimate is reported. HBB respondents report combined household/business income rather than a comparable standalone business-revenue measure.

Table B3 Directly reported business changes since acquiring Sun King

Outcome / analytical population	Answered N (incl. DK)	Favourable direction, n (%)	No change, n (%)	Unfavourable direction, n (%)	Don't know / can't recall, n (%)	95% CI for favourable share	Net favourable (pp)	Directional p-value
Business profitability, all businesses	**1,196**	**518 (43.3%)**	**378 (31.6%)**	**36 (3.0%)**	**264 (22.1%)**	**[40.5%, 46.1%]**	**+40.3**	**<0.001**

Female (business owner)	527	42.3%	32.6%	1.5%	23.5%	[38.2%, 46.6%]	+40.8	<0.001
Male (business owner)	654	44.2%	31.3%	4.1%	20.3%	[40.4%, 48.0%]	+40.1	<0.001
Home-based businesses	873	327 (37.5%)	304 (34.8%)	27 (3.1%)	215 (24.6%)	[34.3%, 40.7%]	+34.4	<0.001
Standalone businesses	323	191 (59.1%)	74 (22.9%)	9 (2.8%)	49 (15.2%)	[53.7%, 64.4%]	+56.3	<0.001
Business energy costs, standalone businesses only	**323**	**202 (62.5%)**	**75 (23.2%)**	**3 (0.9%)**	**43 (13.3%)**	**[57.1%, 67.6%]**	**+61.6**	**<0.001**
Female (business owner)	174	58.0%	24.1%	1.1%	16.7%	[50.6%, 65.1%]	+56.9	<0.001
Male (business owner)	148	68.2%	22.3%	0.7%	8.8%	[60.4%, 75.2%]	+67.6	<0.001

Notes: *Business profitability is a harmonised HBB/standalone-business measure, so the all-businesses headline is followed by HBB and standalone-business subrows. Business energy-cost impact remains standalone-business-only because the HBB question refers to combined household + HBB energy costs and is already captured under the household analysis.*

Table B4 Tests of subgroup gaps in key business outcomes

This tests whether the size of the paired change differs between business-owner gender groups, not whether either group's change is itself significant (see Table B1 for that).

Outcome	Group 1 (n)	Mean change, group 1	Group 2 (n)	Mean change, group 2	Gap (1 minus 2)	p-value
Business hours/day, all businesses	Business owner: Female (452)	+0.64	Business owner: Male (555)	+0.64	0.00	0.999
People working in the business, all businesses	Business owner: Female (433)	−0.05	Business owner: Male (527)	−0.11	+0.06	0.688 [1]
Average monthly employee salary, all businesses (nominal)	Business owner: Female (55)	+₦13,482	Business owner: Male (163)	+₦3,819	+₦9,663	0.232
Average monthly employee salary, all businesses (real)	Business owner: Female (53)	−₦26,378	Business owner: Male (160)	−₦32,645	+₦6,267	0.641 [2]
Business energy expenditure, standalone businesses only (nominal)	Business owner: Female (91)	−₦7,055	Business owner: Male (75)	−₦13,553	+₦6,498	0.026
Business energy expenditure, standalone businesses only (real)	Business owner: Female (90)	−₦12,546	Business owner: Male (75)	−₦23,511	+₦10,965	0.012 [3]

Notes: *[1] The number of people working is right-skewed with some large outliers; results for small subgroups should be read with caution. [2] Inflation-adjusted (constant June 2026 naira). Excludes businesses with no paid employees. [3] Standalone businesses only. Inflation-adjusted (constant June 2026 naira). Group sample sizes do not sum to the paired N reported in Table B1 because a small "other/not stated" business-owner-gender group is excluded from both comparison groups, consistent with the gender-subgroup convention used in Tables B1–B3.*

C. RESULTS BY PRIOR ENERGY ACCESS AND SYSTEM TIER

Table C1 Tests of differences in key outcomes by prior energy access

Outcome	Analytical population	Group 1 (n)	Mean change / %, group 1	Group 2 (n)	Mean change / %, group 2	Gap (1 minus 2)	p-value	BH-adjusted q
Panel A. First-time electricity access								
Useful light-hours after dark	Households (H + HBB)	First-time access (348)	+2.37	Had grid, generator or solar before (1,370)	+3.44	−1.07	<0.001	<0.001
Household energy expenditure, real (₦/month)	Households (H + HBB)	First-time access (287)	−₦7,013	Had grid, generator or solar before (968)	−₦23,045	+₦16,032	<0.001	<0.001
Durable asset count (9-item)	Households (H + HBB)	First-time access (378)	+0.06	Had grid, generator or solar before (1,487)	+0.07	−0.01	0.839	0.915
More free time since Sun King	Households (H + HBB)	First-time access (387)	52.2%	Had grid, generator or solar before (1,545)	42.0%	+10.2 pp	<0.001	0.001
Household income increased (self-reported)	Households (H + HBB)	First-time access (387)	43.4%	Had grid, generator or solar before (1,545)	43.3%	+0.1 pp	0.969	0.988
Product helped a lot during power cuts	Resilience-module completers	First-time access (418)	92.6%	Had grid, generator or solar before (1,568)	88.5%	+4.1 pp	0.017	0.036
Would be worse off without product	Resilience-module completers	First-time access (418)	78.5%	Had grid, generator or solar before (1,568)	81.0%	−2.5 pp	0.247	0.371
Business operating hours/day	Businesses (HBB + standalone)	First-time access (203)	+0.23	Had grid, generator or solar before (796)	+0.74	−0.50	0.017	0.036
Business more profitable since Sun King	Businesses (HBB + standalone)	First-time access (239)	41.4%	Had grid, generator or solar before (938)	43.3%	−1.9 pp	0.604	0.767
Panel B. Prior grid use								
Useful light-hours after dark	Households (H + HBB)	Used grid before (1,057)	+3.65	No grid before (661)	+2.53	+1.12	<0.001	<0.001
Household energy expenditure, real (₦/month)	Households (H + HBB)	Used grid before (748)	−₦22,317	No grid before (508)	−₦15,015	−₦7,302	<0.001	<0.001
Durable asset count (9-item)	Households (H + HBB)	Used grid before (1,148)	+0.06	No grid before (717)	+0.07	−0.01	0.759	0.854
More free time since Sun King	Households (H + HBB)	Used grid before (1,200)	38.8%	No grid before (732)	52.6%	−13.8 pp	<0.001	<0.001
Household income increased (self-reported)	Households (H + HBB)	Used grid before (1,200)	42.3%	No grid before (732)	45.1%	−2.7 pp	0.237	0.371
Product helped a lot during power cuts	Resilience-module completers	Used grid before (1,212)	87.9%	No grid before (775)	91.7%	−3.9 pp	0.006	0.016

Outcome	Analytical population	Group 1 (n)	Mean change / %, group 1	Group 2 (n)	Mean change / %, group 2	Gap (1 minus 2)	p-value	BH-adjusted q
Would be worse off without product	Resilience-module completers	Used grid before (1,212)	83.4%	No grid before (775)	75.9%	+7.5 pp	<0.001	<0.001
Business operating hours/day	Businesses (HBB + standalone)	Used grid before (602)	+0.80	No grid before (398)	+0.38	+0.41	0.008	0.019
Business more profitable since Sun King	Businesses (HBB + standalone)	Used grid before (718)	38.9%	No grid before (460)	49.1%	−10.3 pp	<0.001	0.002

Panel C. Prior generator use

Useful light-hours after dark	Households (H + HBB)	Used generator before (599)	+4.45	No generator before (1,119)	+2.56	+1.89	<0.001	<0.001
Household energy expenditure, real (₦/month)	Households (H + HBB)	Used generator before (422)	−₦36,372	No generator before (834)	−₦10,757	−₦25,615	<0.001	<0.001
Durable asset count (9-item)	Households (H + HBB)	Used generator before (650)	+0.06	No generator before (1,215)	+0.06	−0.01	0.886	0.938
More free time since Sun King	Households (H + HBB)	Used generator before (674)	46.1%	No generator before (1,258)	42.9%	+3.2 pp	0.175	0.299
Household income increased (self-reported)	Households (H + HBB)	Used generator before (674)	47.8%	No generator before (1,258)	41.0%	+6.8 pp	0.004	0.012
Product helped a lot during power cuts	Resilience-module completers	Used generator before (690)	91.6%	No generator before (1,297)	88.2%	+3.4 pp	0.020	0.039
Would be worse off without product	Resilience-module completers	Used generator before (690)	79.1%	No generator before (1,297)	81.2%	−2.1 pp	0.271	0.390
Business operating hours/day	Businesses (HBB + standalone)	Used generator before (293)	+0.63	No generator before (707)	+0.63	−0.00	0.988	0.988
Business more profitable since Sun King	Businesses (HBB + standalone)	Used generator before (360)	53.3%	No generator before (818)	38.3%	+15.1 pp	<0.001	<0.001

Panel D. Prior solar use

Useful light-hours after dark	Households (H + HBB)	Used solar before (210)	+3.43	First-time solar user (1,506)	+3.20	+0.24	0.451	0.624
Household energy expenditure, real (₦/month)	Households (H + HBB)	Used solar before (155)	−₦22,772	First-time solar user (1,099)	−₦18,839	−₦3,934	0.186	0.305

Outcome	Analytical population	Group 1 (n)	Mean change / %, group 1	Group 2 (n)	Mean change / %, group 2	Gap (1 minus 2)	p-value	BH-adjusted q
Durable asset count (9-item)	Households (H + HBB)	Used solar before (232)	+0.04	First-time solar user (1,632)	+0.07	−0.03	0.639	0.767
More free time since Sun King	Households (H + HBB)	Used solar before (239)	43.1%	First-time solar user (1,691)	44.2%	−1.1 pp	0.753	0.854
Household income increased (self-reported)	Households (H + HBB)	Used solar before (239)	49.8%	First-time solar user (1,691)	42.5%	+7.3 pp	0.032	0.061
Product helped a lot during power cuts	Resilience-module completers	Used solar before (256)	90.2%	First-time solar user (1,729)	89.2%	+1.0 pp	0.631	0.767
Would be worse off without product	Resilience-module completers	Used solar before (256)	84.0%	First-time solar user (1,729)	79.9%	+4.1 pp	0.127	0.228
Business operating hours/day	Businesses (HBB + standalone)	Used solar before (135)	+0.72	First-time solar user (863)	+0.62	+0.10	0.620	0.767
Business more profitable since Sun King	Businesses (HBB + standalone)	Used solar before (156)	54.5%	First-time solar user (1,020)	41.2%	+13.3 pp	0.002	0.005

Table C2 Real monthly energy expenditure by tier (constant June 2026 NGN)

Segment	Tier	Matched n	Before mean	Current mean	Mean change	Change (%)	95% CI	Paired-test p
Household-only	Tier 1 or below	498	24,721	5,949	-18,772	-75.9%	-21589.43 to -15953.92	<0.0001
Household-only	Tier 2	263	30,983	6,109	-24,874	-80.3%	-29393.87 to -20354.80	<0.0001
Household-only	Tier 3–5	5	69,918	1,500	-68,418	-97.9%	-148688.90 to 11852.63	0.0771
Home-based business	Tier 1 or below	355	18,418	5,830	-12,587	-68.3%	-15190.76 to -9983.67	<0.0001
Home-based business	Tier 2	135	30,700	6,550	-24,150	-78.7%	-30949.28 to -17351.05	<0.0001
Home-based business	Tier 3–5	11	53,229	6,168	-47,061	-88.4%	-81438.91 to -12683.21	0.0122
Full household module	Tier 1 or below	853	22,097	5,900	-16,198	-73.3%	-18174.69 to -14220.99	<0.0001
Full household module	Tier 2	398	30,887	6,258	-24,629	-79.7%	-28385.05 to -20872.35	<0.0001
Full household module	Tier 3–5	16	58,444	4,709	-53,735	-91.9%	-82749.17 to -24721.12	0.0013
Standalone business	Tier 1 or below	133	23,817	8,852	-14,964	-62.8%	-19356.77 to -10572.04	<0.0001
Standalone business	Tier 2	21	24,856	5,641	-19,215	-77.3%	-33884.02 to -4545.61	0.0128
Standalone business	Tier 3–5	11	54,708	9,375	-45,334	-82.9%	-67994.68 to -22672.92	0.0012

Table C3 Reporting improved profitability, by tier

Segment	Tier	Main: more profitable/all	Sensitivity: more profitable/substantive	Non-response
Standalone business	Tier 1 or below	155/264 (58.7%)	155/221 (70.1%)	43
Standalone business	Tier 2	21/42 (50.0%)	21/36 (58.3%)	6
Standalone business	Tier 3–5	14/16 (87.5%)	14/16 (87.5%)	0
Standalone business	Missing	1/1 (100.0%)	1/1 (100.0%)	0
Home-based business	Tier 1 or below	216/612 (35.3%)	216/456 (47.4%)	156
Home-based business	Tier 2	90/232 (38.8%)	90/177 (50.8%)	55
Home-based business	Tier 3–5	15/18 (83.3%)	15/16 (93.8%)	2
Home-based business	Missing	6/11 (54.5%)	6/9 (66.7%)	2
All businesses	Tier 1 or below	371/876 (42.4%)	371/677 (54.8%)	199
All businesses	Tier 2	111/274 (40.5%)	111/213 (52.1%)	61
All businesses	Tier 3–5	29/34 (85.3%)	29/32 (90.6%)	2
All businesses	Missing	7/12 (58.3%)	7/10 (70.0%)	2

Denominators: *The main result retains all businesses, treating no change, less profitable and don't know/non-response as not reporting improvement. The sensitivity denominator retains only substantive answers (more, same or less profitable).*

Table C4 Profitability association tests

Segment	Comparison	N	Test	Statistic	p-value
Standalone business	Three tiers; all denominator	322	Pearson chi-squared	chi2=6.79 (2 df)	0.0336
Standalone business	Higher vs lower; all denominator	322	Fisher exact, two-sided	OR (higher/lower)=1.070	0.8833
Standalone business	Three tiers; substantive answers	273	Pearson chi-squared; permutation p (10,000 shuffles)	chi2=4.61 (2 df)	0.0998
Home-based business	Three tiers; all denominator	862	Pearson chi-squared	chi2=17.59 (2 df)	0.0002
Home-based business	Higher vs lower; all denominator	862	Fisher exact, two-sided	OR (higher/lower)=1.328	0.0741
Home-based business	Three tiers; substantive answers	649	Pearson chi-squared	chi2=13.49 (2 df)	0.0012
All businesses	Three tiers; all denominator	1184	Pearson chi-squared	chi2=25.62 (2 df)	<0.0001
All businesses	Higher vs lower; all denominator	1184	Fisher exact, two-sided	OR (higher/lower)=1.134	0.3499
All businesses	Three tiers; substantive answers	922	Pearson chi-squared	chi2=17.10 (2 df)	0.0002
All businesses	Capacity × standalone interaction	1184	HC1 linear-probability model	-5.1 pp (95% CI -20.8 to 10.6)	0.5265

Notes: *The three-tier tests assess whether reported profitability differs across Tier 1 or smaller, Tier 2 and Tier 3–5 systems. The higher-versus-lower comparison groups Tier 2–5 systems together and reports odds for higher-capacity relative to lower-capacity systems. The main analysis retains all businesses, including non-response in the denominator, while the sensitivity analysis includes only substantive responses. The capacity-by-standalone interaction tests whether the association differs between standalone and home-based businesses. Tier 3–5 samples are small, and all results are unadjusted and associational.*

D. TABLE NOTES

D1. Analytical populations and route decomposition

Harmonised headline figures combine the mutually exclusive household-only and HBB routes (household population, *n* = 1,954) or HBB and standalone-business routes (business population, *n* = 1,196), with route sub-rows shown beneath. Measures that are not comparable across routes, notably standalone-business revenue and business-only energy expenditure, are reported for standalone businesses only.

D2. CPI data and inflation adjustment

Monetary before-and-after outcomes are converted to constant June 2026 naira using Nigeria's national headline All-Items Consumer Price Index (CPI). From January 2025 the rebased NBS index is used (2023 expenditure weights; 2024 average = 100). For 2021–2024 the pre-rebasing NBS index, as disseminated by the UN Statistics Division, is re-referenced to its own 2024 average = 100 and linked to the rebased series, following the annual-overlap approach in the IMF Consumer Price Index Manual (IMF, 2020, Chapter 9) and NBS's revised linkage (CBN, 2025). The linked series matches NBS's official re-referenced index to within rounding for every month from January 2021 to December 2025 (NBS, 2026); re-referencing changes only the scale of the historical index, not its price movements. The June 2026 index used as the common price month is 143. Each nominal value is converted using the CPI for its questionnaire reference month.

The CPI adjustment removes general consumer-price inflation only. It does not address other limitations such as recall error, imperfect historical reference dates, seasonality, other time-varying household/business changes and macroeconomic conditions. Nor does use of the national headline CPI imply that every individual expenditure category, especially energy, experienced the same price movement as the aggregate consumption basket. The real figures should therefore be read as changes in purchasing power over the general consumption basket, not as changes in the quantity of energy consumed. Additionally, because the historical series is rescaled rather than recalculated, price movements before 2025 reflect the pre-rebasing basket and weights which may differ from the rebased CPI.

D3. Midpoint estimates and open-ended bands

The monetary variables were originally collected in bands rather than as exact continuous values. Inflation adjustment is applied after converting each reported band to its established nominal midpoint. The real figures therefore remain midpoint-based approximations. They should not be interpreted as exact respondent monetary values within each band. For employee salary, the open-ended top band above ₦740,000 uses the midpoint convention of ₦1,110,000 (1.5 times the lower bound) before inflation adjustment.

Only very wide ordinal bands were available for **standalone-business revenue** and no continuous midpoint estimate was constructed.

D4. Missing values and don't-know/can't-recall responses

The cleaned survey data distinguish four types of non-substantive value: system or routing missingness; "don't know", "can't recall" and "prefer not to answer" responses; structurally not-applicable responses (e.g. the business did not yet exist at the retrospective reference date); and data errors.

Treatment differs according to analysis type:

1. **Paired before/current analyses:** both values must be non-missing, so all missing types are excluded.
2. **Direct self-reported change questions:** "don't know / prefer not to answer" is retained as a valid answered category. It contributes to the displayed N and is reported as its own percentage, but does not enter the favourable/unchanged/unfavourable classification or the exact directional test.
3. **Categorical and multi-response questions:** "don't know / prefer not to answer" is retained in the answered denominator and reported as an explicit "Don't know / can't recall" row. Routing missingness, structural not-applicable and data-error codes are excluded.

ANNEXURE 3

Change-score regressions

The paired tests in Annexure 2 estimate the average within-respondent change between the recalled pre-Sun King period and the current period. Because each respondent is compared with themselves, fixed differences between households/businesses do not explain the before/current difference. The paired tests do not, however, show whether the **size of that change varies systematically across different types of households or customers**. The regressions below examine this heterogeneity.

Each column in Table E1 is a **change-score regression**: the relevant outcome change (current minus before) is regressed on observed household and customer characteristics, including baseline asset ownership, prior solar use, market access, gender, household size, education, system capability, duration of ownership, household type, and region. The coefficients indicate whether households with a particular characteristic experienced larger or smaller reported changes, holding the other included characteristics constant.

The **mean change in the regression estimation sample** is not a separately adjusted estimate. In a linear regression with a constant, the average fitted change equals the observed mean change for the households included in that regression. It is shown alongside the full paired-sample mean to indicate whether the smaller complete-case regression sample has a materially different average outcome.

Table E1 Change-score regressions on baseline characteristics, four household outcomes

Baseline characteristic	(1) Light-hours (hrs/evening)	(2) Energy spend (real ₦/month)	(3) Durable assets (0–9)	(4) Income (real ₦/month)
Baseline wealth and prior solar				
Durable assets before Sun King (0–9)	0.111 (0.100)	−1,390** (0.022)	–	−13,044 (0.135)
Owned any solar product before	0.346 (0.419)	−4,978 (0.232)	−0.063 (0.504)	6,534 (0.907)
Solar was main prior lighting source	−0.554 (0.275)	9,735** (0.017)	0.027 (0.804)	109,589* (0.057)
Market access (ref. under 15 min)				
Travel to town: 15–30 min	−0.031 (0.909)	−1,781 (0.447)	0.075 (0.165)	41,899 (0.188)
Travel to town: 30–60 min	0.154 (0.695)	1,458 (0.616)	0.058 (0.342)	59,955 (0.206)
Travel to town: over 60 min	1.337* (0.056)	−6,597 (0.307)	0.129 (0.228)	16,155 (0.893)
Household head gender (ref. male)				
Female	−0.398 (0.201)	8,391*** (<0.001)	0.067 (0.315)	−13,851 (0.740)
Other	−0.962 (0.606)	35,192** (0.028)	−0.106 (0.190)	−1,884 (0.985)
Household size				
Number of people in household	0.012 (0.787)	−115 (0.702)	0.009 (0.210)	−7,601 (0.274)
Highest education in household (ref. none)				
Primary	−1.080* (0.073)	−1,801 (0.538)	−0.013 (0.907)	44,081 (0.359)
Secondary	−0.135 (0.762)	−10,644*** (<0.001)	0.064 (0.358)	−32,853 (0.500)
Vocational / technical	−0.074 (0.895)	−17,021*** (<0.001)	0.093 (0.320)	4,787 (0.924)
University / college	0.345 (0.425)	−15,243*** (<0.001)	0.125* (0.061)	−50,851 (0.307)
System capability tier (ref. lanterns)				
SHS entry-level	0.043 (0.967)	−237 (0.970)	0.393 (0.102)	−55,711 (0.118)
SHS large, without TV	0.537 (0.613)	−1,911 (0.771)	0.472* (0.052)	−57,718 (0.197)
SHS large, with TV	0.442 (0.686)	−15,341** (0.041)	0.385 (0.121)	−110,977* (0.088)
Solar inverter	0.477 (0.735)	−43,267*** (0.004)	0.398 (0.128)	−352,061* (0.056)
Duration of ownership				
Years since adoption	−0.050 (0.710)	−8,235*** (<0.001)	0.015 (0.572)	−108,214*** (<0.001)
Region (ref. North Central)				
North West	1.400*** (0.004)	−7,609* (0.060)	−0.114 (0.212)	−178,618*** (0.004)

Baseline characteristic	(1) Light-hours (hrs/evening)	(2) Energy spend (real ₦/month)	(3) Durable assets (0–9)	(4) Income (real ₦/month)
North East	0.672 (0.203)	−2,523 (0.505)	−0.009 (0.914)	−83,675* (0.094)
South West	0.846* (0.066)	−4,049 (0.269)	−0.114 (0.158)	−104,818* (0.056)
South South	1.319*** (0.004)	−2,943 (0.381)	−0.032 (0.697)	−99,668* (0.064)
South East	1.151** (0.012)	−10,022*** (0.006)	−0.123 (0.128)	−84,898 (0.102)
Household type (ref. household-only)				
Has Home-based business	−1.248*** (<0.001)	3,604* (0.080)	0.036 (0.447)	−22,123 (0.484)
Model summary				
Observations	1,266	1,040	1,401	605
R-squared	0.049	0.187	0.017	0.154
F-statistic	2.98	8.46	1.07	4.26
Prob > F	<0.001	<0.001	0.368	<0.001
Mean change, regression estimation sample	**3.651*** (<0.001)**	**−20,653*** (<0.001)**	**0.058** (0.011)**	**−167,331*** (<0.001)**
Mean change, full paired sample	3.199*** (<0.001)	−19,320*** (<0.001)	0.066*** (<0.001)	−165,788*** (<0.001)
Paired N, full sample	1,736	1,267	1,885	657

Notes: *Each cell reports the coefficient followed by its p-value in parentheses. Ordinary least squares with heteroskedasticity-robust standard errors throughout. Significance: * p<0.10, ** p<0.05, *** p<0.01. Population: household-only and home-based business respondents (1,954 before listwise deletion).*

Table E2 Change-score regressions on baseline characteristics, four business outcomes

Baseline characteristic	(1) Operating hours (hrs/day)	(2) People working (count)	(3) Employee salary (real ₦/month)	(4) Energy spend, standalone only (real ₦/month)
Owner demographics				
Owner gender: female (ref. male)	−0.300 (0.103)	0.165 (0.352)	−11,291 (0.449)	7,802 (0.215)
Owner gender: other	−1.841** (0.014)	−4.503*** (<0.001)	52,684 (0.166)	–
Owner age: 30–35 (ref. under 30)	0.210 (0.594)	−0.119 (0.655)	8,261 (0.649)	−180 (0.983)
Owner age: over 35	−0.335 (0.314)	−0.274 (0.299)	7,433 (0.647)	1,564 (0.837)
Sector (multi-select; no reference category)				
Retail	0.308 (0.338)	0.276 (0.393)	37,233** (0.039)	−4,600 (0.528)
Food	0.301 (0.300)	0.090 (0.731)	12,860 (0.555)	−6,241 (0.421)
Services	0.365 (0.270)	0.203 (0.637)	35,304* (0.070)	−2,062 (0.790)
Repair	0.340 (0.460)	0.028 (0.937)	53,627** (0.048)	−26,343 (0.141)
Crafts	0.257 (0.575)	−0.042 (0.931)	35,861 (0.164)	2,193 (0.856)
Digital	1.091* (0.074)	0.241 (0.608)	16,680 (0.653)	−12,774 (0.405)
Agriculture	0.247 (0.652)	0.249 (0.488)	62,895*** (0.001)	−6,335 (0.507)
Other	−0.129 (0.780)	0.467 (0.165)	39,019* (0.065)	–
Business maturity				
Business age (years)	−0.019* (0.087)	−0.008 (0.340)	−1,240** (0.048)	−311 (0.244)
Prior solar history				
Owned any solar product before	0.132 (0.525)	−0.231 (0.293)	3,068 (0.916)	4,054 (0.556)
Solar was main prior lighting source	−0.180 (0.589)	0.089 (0.846)	−32,290 (0.317)	2,771 (0.787)
System capability tier (ref. lanterns)				
SHS entry-level	−0.241 (0.615)	0.105 (0.671)	−14,692 (0.411)	−7,299 (0.253)
SHS large, without TV	0.048 (0.927)	0.349 (0.229)	−26,134 (0.191)	−5,124 (0.578)
SHS large, with TV	−0.127 (0.812)	−0.308 (0.500)	−21,040 (0.383)	−60,025* (0.065)
Solar inverter	0.604 (0.405)	0.397 (0.271)	−57,550 (0.162)	−29,197* (0.057)
Duration of ownership				

Baseline characteristic	(1) Operating hours (hrs/day)	(2) People working (count)	(3) Employee salary (real ₦/month)	(4) Energy spend, standalone only (real ₦/month)
Years since adoption	0.062 (0.502)	0.025 (0.772)	−20,726*** (<0.001)	−5,176** (0.044)
Region (ref. North Central)				
North West	−0.453 (0.397)	−0.206 (0.598)	−29,074 (0.152)	11,872 (0.326)
North East	−0.704 (0.289)	−0.012 (0.979)	−30,106 (0.220)	19,537 (0.107)
South West	−0.908* (0.080)	−0.255 (0.484)	−3,177 (0.876)	7,245 (0.543)
South South	−0.404 (0.453)	−0.111 (0.772)	−3,766 (0.845)	20,113* (0.089)
South East	−0.873* (0.095)	−0.045 (0.902)	−395 (0.983)	3,210 (0.804)
Analytical route (ref. home-based business)				
Standalone business	0.693*** (0.004)	−0.075 (0.687)	19,477 (0.124)	–
Constant	1.414* (0.075)	−0.041 (0.939)	134 (0.996)	−7,919 (0.606)
Model summary				
Population	HBB + standalone	HBB + standalone	HBB + standalone	Standalone only
Observations	815	774	193	148
R-squared	0.074	0.025	0.189	0.284
Mean change, regression estimation sample	0.702*** (<0.001)	−0.061 (0.415)	−32,853*** (<0.001)	−18,157*** (<0.001)
Mean change, full paired sample	0.640*** (<0.001)	−0.088 (0.226)	−31,416*** (<0.001)	−17,530*** (<0.001)
Paired N, full sample	1,014	968	216	165

*Each cell reports the coefficient followed by its p-value in parentheses. Ordinary least squares with heteroskedasticity-robust standard errors throughout. Significance: * p<0.10, ** p<0.05, *** p<0.01. Columns (1)–(3) cover home-based and standalone businesses; column (4) covers standalone businesses only. A dash marks a control excluded or dropped from that model.*

Table E3 Generator-displacement heterogeneity in real household energy expenditure

Dependent variable: current − before real household energy expenditure (₦/month). Coefficients with robust standard errors in parentheses.

Baseline characteristic	(1) + prior generator	(2) + generator + grid	(3) generator × grid
Baseline wealth and prior solar			
Durable assets before Sun King (0–9)	−452 (589)	−313 (589)	−319 (591)
Owned any solar product before	−4,771 (3,899)	−4,503 (3,885)	−4,561 (3,878)
Solar was main prior lighting source	6,151 (3,857)	4,908 (3,897)	5,090 (3,855)
Prior grid/generator use			
Used generator before Sun King	−17,814*** (2,337)	−17,988*** (2,330)	−16,745*** (3,712)
Used grid electricity before Sun King	—	−4,528** (2,023)	−3,803** (1,900)
Generator × grid	—	—	−2,063 (4,704)
Market access (ref. under 15 min)			
Travel to town: 15–30 min	−1,787 (2,268)	−1,552 (2,269)	−1,558 (2,270)
Travel to town: 30–60 min	844 (2,834)	490 (2,836)	481 (2,840)
Travel to town: over 60 min	−6,095 (6,120)	−5,769 (6,091)	−5,704 (6,105)
Household head gender (ref. male)			
Female	6,614*** (2,189)	6,515*** (2,153)	6,499*** (2,149)
Other	27,390* (15,099)	28,896* (14,798)	28,735* (14,851)
Household size			
Number of people in household	−147 (295)	−174 (293)	−177 (294)
Highest education in household (ref. none)			
Primary	−926 (2,766)	−1,396 (2,741)	−1,321 (2,730)
Secondary	−8,362*** (2,473)	−8,324*** (2,450)	−8,270*** (2,457)
Vocational / technical	−14,306*** (3,826)	−13,862*** (3,836)	−13,833*** (3,843)
University / college	−12,857*** (2,670)	−12,351*** (2,686)	−12,272*** (2,711)

Baseline characteristic	(1) + prior generator	(2) + generator + grid	(3) generator × grid
System capability tier (ref. lanterns)			
SHS entry-level	5,062 (6,142)	4,494 (6,149)	4,578 (6,145)
SHS large, without TV	4,248 (6,470)	3,880 (6,463)	3,891 (6,465)
SHS large, with TV	−7,578 (7,306)	−8,022 (7,312)	−7,954 (7,318)
Solar inverter	−33,919** (14,242)	−34,336** (14,112)	−34,503** (14,072)
Duration of ownership			
Years since adoption	−7,433*** (1,068)	−7,330*** (1,075)	−7,350*** (1,073)
Region (ref. North Central)			
North West	−4,094 (3,883)	−4,124 (3,843)	−4,119 (3,845)
North East	−1,588 (3,618)	−1,777 (3,612)	−1,723 (3,624)
South West	305 (3,549)	−50 (3,501)	−106 (3,513)
South South	1,485 (3,306)	1,154 (3,262)	1,201 (3,258)
South East	−6,009* (3,575)	−6,222* (3,537)	−6,178* (3,538)
Household type (ref. household-only)			
Has home-based business	2,676 (1,993)	2,885 (1,996)	2,775 (1,992)
Constant	7,143 (7,139)	9,685 (7,162)	9,243 (7,108)
Model summary			
Observations	1,040	1,040	1,040
R-squared	0.239	0.243	0.243
F-statistic	9.81	10.23	9.91
Prob > F	<0.001	<0.001	<0.001
Mean change, estimation sample	−₦20,653	−₦20,653	−₦20,653
Mean change, full paired sample	−₦19,320	−₦19,320	−₦19,320

Notes: *OLS with heteroskedasticity-robust (HC1) standard errors. Significance markers: one star = p<0.10, two = p<0.05, three = p<0.01. Reference categories and the estimation sample (n = 1,040) match Table E1, column (2); column (1) adds prior generator use to that specification. Unlike Tables E1 and E2, cells report standard errors rather than p-values.*

Endnotes

1 **World Bank Group (2023).** Nigeria to Expand Access to Clean Energy for 17.5 Million People. Available here.

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6 Based on NBS Price Watch Data. See Box 1.

7 **Blimpo, M.P. and Cosgrove-Davies, M. (2019).** Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact. Available here.

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12 **World Bank Group (2023).** Nigeria - Distributed Access Through Renewable Energy Scale-Up Project (English). Available here.

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14 **Ibid.**

15 **Rentschler, J et al. (2019).** Underutilized Potential The Business Costs of Unreliable Infrastructure in Developing Countries. Available here.

16 **Zhang, F. (2019).** In the Dark: How Much Do Power Sector Distortions Cost South Asia?. Available here.

17 **Poczter, S. (2016).** You Can't Count on Me: The Impact of Electricity Unreliability on Productivity. Available here.

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30 **Djoumessi, Y.F et al. (2021).** Modelling the Impact of Electricity Access on Labour Market Outcomes in Uganda. Available here.

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32 **Lee, K. et al. (2020a).** Experimental evidence on the economics of rural electrification. Journal of Political Economy 128(4): 1523-1565.

33 **Ibid.**

34 **Ibid.**

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37 **Lee, K. et al. (2020b).** Does household electrification supercharge economic development? Journal of Economic Perspectives, 34(1): 122-144. Available here. https://doi.org/10.1257/jep.34.1.122

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48 **60 Decibels (2024).** Why Off-Grid Energy Matters 2024. Available here.

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51 **Global Off-Grid Lighting Association (2024).** Powering Climate Adaptation and Justice: The Critical Role of Off-Grid Solar Technologies. Available here.

52 Location information was not available for 19 respondents (1%).

53 n = 1,740, which excludes 214 "don't know" or "prefer not to say" responses.

54 n = 1,954, which includes all household-only and home-based business respondents.

55 Pearson chi-squared test of independence across six geopolitical zones and five education categories: $x^2(20) = 108.58$, $p < 0.001$ (n = 1,704). Regional differences in the prevalence of no formal education were also significant: $x^2(5) = 61.19$, $p < 0.001$.

56 Note that the Cluster Survey asks about household head attainment while this survey asks about any member of the household. National Bureau of Statistics (NBS) and UNICEF (2022). 2021 Nigeria Multiple Indicator Cluster Survey (MICS): Statistical Snapshots Report, p. 4. Available here. https://www.nigerianstat.gov.ng/pdfuploads/2021%20MICS%20Statistical%20Snapshots%20Report.pdf;

57 Pearson chi-squared test of independence between educational attainment and current grid connection: $x^2(4) = 72.67$, $p < 0.001$ (n = 1,718).

58 LeapFrog Investments defines low-income Emerging Consumers as those earning less than USD 11.20 per day in 2017 PPP dollars for investments made since February 2022. The ₦740,000 monthly household-income threshold is the corresponding threshold provided by LeapFrog Investments for application in this study.

59 **Angelus, N., Kersey, J., Koo, B. B., Padam, G., Zaman, F. and Park, J. (2026).** The Multi-Tier Framework for Energy Access: Insights and Impact from a Decade of Surveys. ESMAP and World Bank Group. Available here. https://openknowledge.worldbank.org/entities/publication/b0042d1a-eb42-4f4f-83a6-9b0c355abd0a

60 Under the MTF, lanterns do not generally provide full household Tier 1 access; they provide partial Tier 1 access (and some products may fall below Tier 1). Only the Sun King Pro series meets Tier 1 requirements.

61 Six respondents (<1%) did not know whether they had a grid connection.

62 The follow-up question on reasons for using solar was applicable only to the 1,109 respondents with a grid connection

63 *n* = 1,954

64 *n* = 1,954, other main sources reported were grid electricity (1,021, 52%), battery/rechargeable (94, 5%), no regular source (141, 7%), other (19, 1%), don't know/prefer not to answer (14, 1%) and missing responses (197, 10%)

65 We define first-time electricity access as respondents who reported no prior use of grid electricity, generators or solar before acquiring their Sun King product. This is an operational definition based on customers' reported baseline energy sources, rather than a formal Multi-Tier Framework (MTF) classification.

66 **National Bureau of Statistics (2024).** Nigeria Labour Force Survey (NLFS) Report Q2 2024. Available here.

67 **International Labour Organisation (2026).** The world of work and the 2030 Agenda: a ten-year review. Available here.

68 **World Bank Group (2015).** More, and More Productive, Jobs for Nigeria: Profile of Work and Workers. Available here.

69 **Nigerian National Bureau of Statistics (2024).** Nigeria General Household Survey-Panel (Wave 5) 2023/2024. Available here.

70 **National Bureau of Statistics (NBS),** with support from World Bank Living Standards Measurement Study, Nigeria General Household Survey-Panel (Wave 5), 2023/2024. Available here.

71 **UNICEF Nigeria and National Bureau of Statistics, Nigeria MICS Plus: Nigeria Analytical Report, Waves 1, 2 and 3, November 2025.** Available here.

72 The International Finance Corporation (IFC) defines MSMEs using three criteria: employees, total assets and annual sales. Under the revenue criterion, a micro enterprise has annual sales below USD 100,000, a small enterprise USD 100,000 to below USD 3 million, and a medium enterprise USD 3 million to USD 15 million. An enterprise ordinarily needs to meet two of the three criteria to qualify under the IFC MSME definition. The survey bands used in this report are monthly equivalents of these annual thresholds, and classify businesses on revenue alone.

73 **PwC (2024).** Building Resilience: Strategies for MSME Success in a Changing Landscape. PwC's MSME Survey 2024, p. 7, citing the NBS/SMEDAN 2021 MSME Survey. Available here.

74 Based on the 970 grid-connected and 762 non-grid-connected household respondents with matched before/current lighting data. The 0.42-hour difference between the two change scores is statistically significant at the 5% level (p = 0.048). The grid-connected base was 5.65 hours of useful light per evening and the non-grid connected base was 5.55 hours.

75 *n* = 348

76 **Blimpo, M.P. and Cosgrove-Davies, M. (2019).** Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact. World Bank. Available here.

77 **National Salaries, Incomes and Wages Commission (2024).** Consequential Adjustment in Pensions Arising From the Implementation of the National Minimum Wage (Amendment) Act, 2024. Available here.

78 **The State House (2023).** Press Statement on the Meeting Between Federal Government and the Leadership of Nigeria Labour Congress (NLC), and Trade Union Congress (TUC). Available here.

79 See Section 3.2 for more on first-time access statistics in this sample.

80 *n* = 287

81 *n* = 968

82 These figures are restricted to household-only respondents because home-based businesses reported combined household and business energy expenditure. The paired Tier 3–5 change was not statistically significant (*n* = 5; *p* = 0.077). See Annexure 2.

83 Adding prior generator use to the report's existing change-score specification also produces a large and statistically significant association. In the preferred augmented change-score model, prior-generator use is associated with an additional statistically significant ₦17,988 reduction per month, compared to prior non-generator users, holding other household characteristics and prior grid use constant. See Annexure 3. As previously mentioned, the precise magnitude of the reported expenditure reduction should be interpreted cautiously. Nevertheless, the descriptive, transition, attribution and regression evidence all point in the same direction.

84 Grid-connected *n* = 653; without a grid connection *n* = 611. The difference between the two change scores is statistically significant ($p<0.001$). In nominal terms the corresponding reductions were ~₦8,893 (*n* = 657) and ~₦6,265 (*n* = 616; *p* = 0.004).

85 See Annexure 3.

86 In these questions, respondents could select more than one reason.

87 **National Bureau of Statistics (2024).** Nigeria Residential Energy Demand-Side Survey Report 2024. Available here.

88 **National Bureau of Statistics (NBS).** Price Watch data for petrol, diesel and household kerosene in May 2022 and May 2026. See full references.

89 NBS Price Watch and CPI data for May 2022 to May 2024. Cumulative CPI growth is calculated from the NBS-reported year-on-year headline inflation rates for May 2023 and May 2024. See full references.

90 **Samad, H.A., Khandker, S. R., Asaduzzaman, M. & Yunus, M. (2013).** The Benefits of Solar Home Systems: An Analysis from Bangladesh. World Bank Policy Research Working Paper No. 6724. Available here.

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96 **Zhang, F. (2019).** In the Dark: How Much Do Power Sector Distortions Cost South Asia? Available here.

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99 **Global Off-Grid Lighting Association (2024).** Powering Opportunity in West Africa. Available here.

100 **Ibid.**

101 **Barron, M. & Torero, M. (2014).** Electrification and Time Allocation: Experimental Evidence from Northern El Salvador. Available here.

102 In the survey, "electricity-related time savings" corresponds specifically to respondents selecting "Provides reliable lighting/electricity at home" when asked how their Sun King product had increased their free time. Other potential mechanisms, including reduced travel for charging or electricity access, less time spent on kerosene, candles, fuel or generator use, fewer disruptions from power cuts, being able to undertake activities at home, and greater efficiency, were offered as separate response options.

103 **Carabajal, A.T., Moudio, M.P.E., Haggai, T., Okonkwo, C.J., Jarrard, G.T. and Selby, S.N. (2024).** Social and economic impact analysis of solar mini-grids in rural Africa: a cohort study from Kenya and Nigeria. Environmental Research: Infrastructure and Sustainability, 4(2). Available here.

104 *n* = 882 household-only and home-based business respondents who reported using kerosene lamps and/or a generator before owning their Sun King product (Annexure 2, Table A4).

105 **Samad, H.A., Khandker, S.R., Asaduzzaman, M. & Yunus, M. (2013).** The Benefits of Solar Home Systems: An Analysis from Bangladesh. World Bank Policy Research Working Paper No. 6724. Available here.

106 **Harun, M.A. (2015).** The Role of Solar Home System (SHS) in Socio-economic Development of Rural Bangladesh. Available here.

107 **Lemaire, X. (2018).** Solar Home Systems and Solar Lanterns in Rural Areas of the Global South: What Impact? Available here.

108 **National Bureau of Statistics (2024).** CPI and Inflation Report June 2024. Available here.

109 **World Bank Group (2025).** Nigeria Development Update: From Policy to People: Bringing the Reform Gains Home. Available here.

110 **Global Off-Grid Lighting Association (2024).** Powering Opportunity in West Africa. Available here.

111 **Lee, K. et al. (2020a).** Experimental evidence on the economics of rural electrification. Journal of Political Economy 128(4): 1523-1565.

112 **Masselus, L. et al. (2025),** Adoption of Electricity in Rural Rwanda 10 Years after Connection. Nature Communications, 16(1): 10942.

113 **Energy Sector Management Assistance Program (ESMAP), GOGLA and Dalberg (2024).** Off-Grid Solar Market Trends Report 2024. Available here.

114 All three within-tier reductions were statistically significant. The larger absolute and proportional reductions among higher-capacity users should be interpreted cautiously. The Tier 2 and Tier 3–5 matched samples are small, and Tier 3–5 businesses reported substantially higher expenditure before adoption.

115 $p = 0.044$.

116 Both measures are reported by the same respondent, so this association cannot establish that longer hours produced higher profitability.

117 Welch t-test on change scores, $p = 0.017$ ($q = 0.036$; Annexure 2).

118 Employee salaries are midpoint estimates from reported salary bands, adjusted for inflation. The real estimates therefore remain approximations rather than exact payroll observations.

119 To align with the International Finance Corporation's (IFC) classifications of micro, small and medium-sized enterprises, the monthly revenue bands used in the survey were: <₦70,000, between ₦70,000 and ₦11.3 million (micro), ₦11.3 million to ₦340m (small), ₦340 million to ₦1.7 billion (medium), or more than ₦1.7 billion (large). The IFC classifications can be found here: IFC (n.d.). IFC's Definitions of Targeted Sectors. Available here.

120 **National Bureau of Statistics (2024).** Nigeria General Household Survey-Panel (Wave 5) 2023/2024. Available here.

121 **Eromosele, O., Nwaiwu, C., Igwe, N., Khumalo, J. and Chamboko, T. (2023).** Access to Financial Services in Nigeria Survey 2023. Available here.

122 **Grimm, M. & Peters, J. (2016).** Solar off-grid markets in Africa. Recent dynamics and the role of branded products. Field Actions Science Reports, Special Issue 15. Available here.

123 **Ankel-Peters, J., Bensch, G., Kongeter, A., Rauschenbach, M. and Sievert, M. (2025).** Are rural energy access programs pro-poor? Some are, many are not. Energy Research & Social Science, 120. Available here.

124 Reported resilience was widespread across system tiers. The recorded response distributions did not differ significantly by tier for help during power cuts or reduced exposure to fuel-price increases.

125 *N* = 2,277, respondents could select more than one challenge, so percentages don't sum to 100.

126 **Boyer, A., Dunoyer, J.C., Corbyn, D., McGrath, L.K., Tonui, P. and Wainaina, F. (2024).** Pricing Quality: Cost drivers and value add in the off-grid solar sector. Available here.



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