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Unlocking Climate Finance to Accelerate Energy Access in Uganda

November 2, 2021

Developed in partnership with:

Shell Foundation

The ROCKEFELLER FOUNDATION

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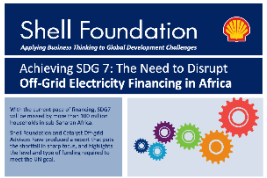
Research Context

This research is part of a series of reports from Catalyst Off-Grid Advisors and partners

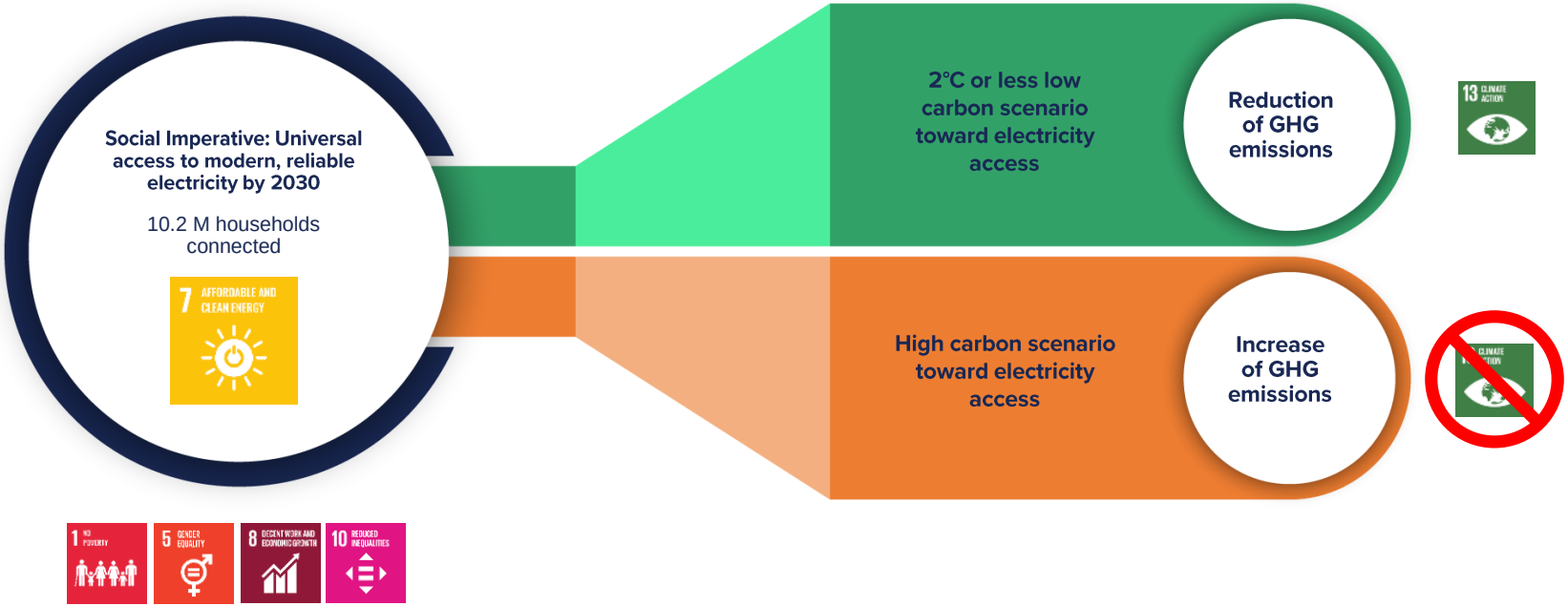
They demonstrate the business opportunity to unlock billions in climate finance and deliver on multiple SDG goals

- Our 2018 research demonstrated the financing opportunity to achieve universal household electrification in Africa (SDG 7) via off-grid solutions
- First launched on **Earth Day 2021**, and covering all of Sub-Saharan Africa, this research shows off-grid solar's social dividends, which cut across numerous SDGs1
- Alongside the **climate dividends** attributable to low-carbon SDG 7 scenarios
- It forecasts the **climate finance opportunity** associated with these low-carbon SDG 7 scenarios
- Illustrating the **multi-billion-dollar climate finance opportunity** associated with the low-carbon scenarios



Modeling illustrates Uganda's low-carbon scenarios and the impact they will have on SDG 13

SDG 7 – Ensure access to affordable, reliable, sustainable and modern energy for all
SDG 13 – Take urgent action to combat climate change and its impacts



Low-carbon scenarios accelerate Uganda's achievement of SDG 7 and SDG 13 via 3 pillars

Predictive modeling forecasts three scenarios for each thematic pillar: business-as-usual, high-carbon, and low-carbon, shows the avoided emissions between the latter two, and then provides the investment costs associated with the low-carbon scenario

Electricity Access

Electricity access
Providing first-time electricity access

What will it take to provide first time electricity access in Uganda via a low-carbon trajectory that avoids millions of tons of CO_2 emissions?

+

Unreliable grid

Greening back-up generation
Solving the unreliable grid challenge

What's required to get enterprises and households to transition off back-up generators and onto distributed renewable sources of power?

+

Cleaner cooking

Modern cooking access
Moving households onto modern cooking solutions

What is a credible scenario to move a portion of Uganda's households onto modern cooking solutions?

=

Uganda's Climate Finance Opportunity

Improving access and reducing emissions across the continent

What level of CO_2 emissions are avoided via each pillars' low-carbon scenario? What is the associated climate finance opportunity?

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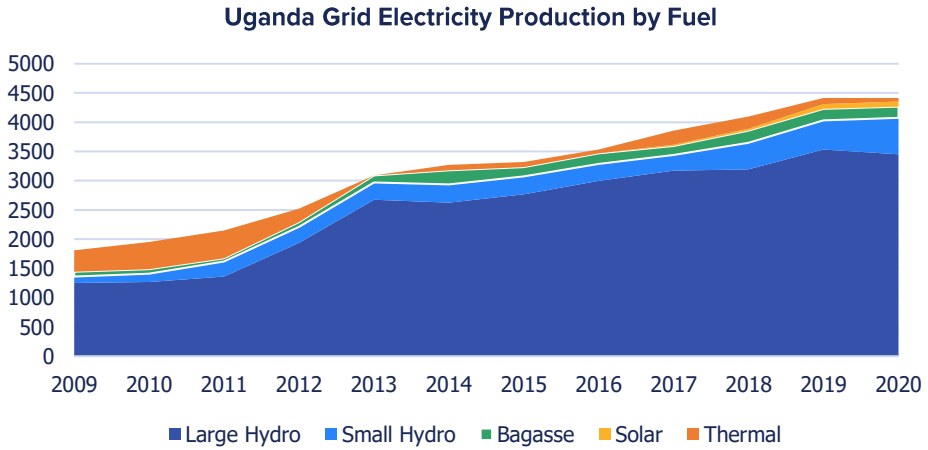
Setting the Scene

Uganda's grid generation mix relies heavily on hydroelectricity

The country also has significant untapped renewable potential, including geothermal

- **143% increase in generation** since 2009, averaging 13%% increase per annum
- **92% of generation from hydropower** in 2019, up from 75% in 2010
- **2% of generation from solar**, with a total solar potential of 5000 MW
- **1500 MW of geothermal** power potential

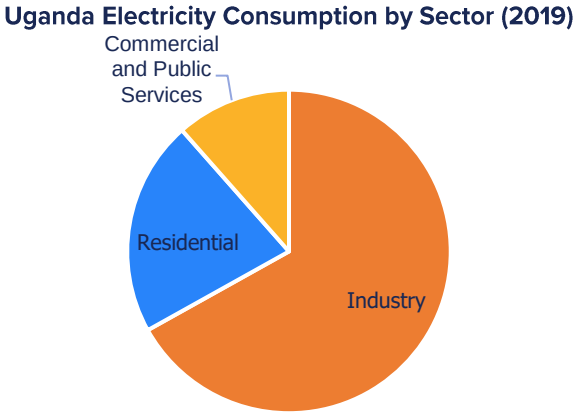


Source: Uganda Electricity Regulatory Authority; Uganda Vision 2040

Uganda's industrial sector accounts for the majority of electricity demand

Residential consumption is strikingly low in Uganda on a per household basis, underscoring affordability challenges, and bolstering industry's level of consumption in comparison

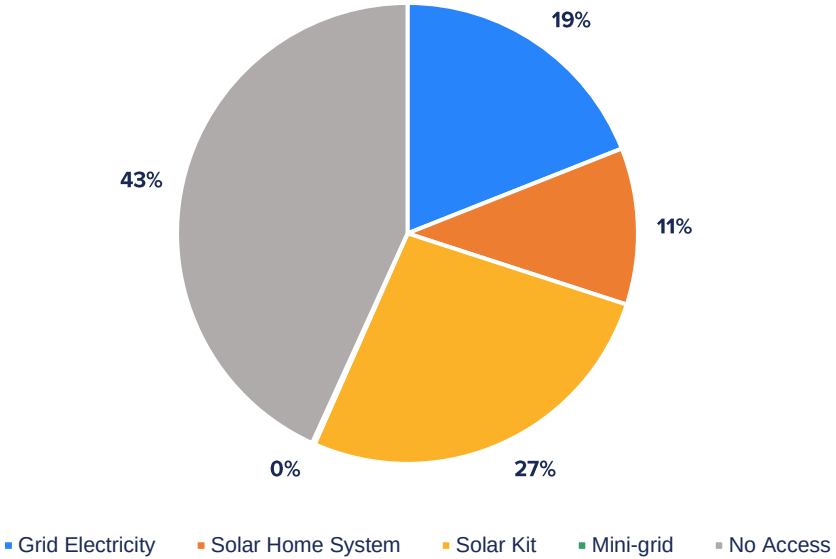
- **69% of global electricity demand** driven by industrial and commercial off-takers
- **78% of Uganda's electricity demand** driven by industrial and commercial off-takers
  - Tariffs range from an **average of $0.17 / kWh** for small commercial customers to US$0.08 / kWh for large industrial customers
- **27% of global electricity** demand originates from households
- 22% of Uganda's electricity demand originates from households. Tariffs are $0.07 / kWh for the first 15 kWh and $0.21 / kWh thereafter



All $in this deck refer to United States Dollars (USD)
Source: International Energy Agency – *World Energy Balances 2020*;; *Uganda Annual Energy Sector Report 2019;* UMEME

Ugandan households are electrified by diverse sources

This includes a surprisingly high level of standalone solar uptake in unelectrified areas



- **43%** of households had no source of electrification
- **19%** of households got their power from the grid
- **38%** of households got their power from solar home systems or solar kits
- **0.2%** of households got their power from mini-grid connection

Source: Uganda Bureau of Statistics *Household Survey 2019 / 2020*

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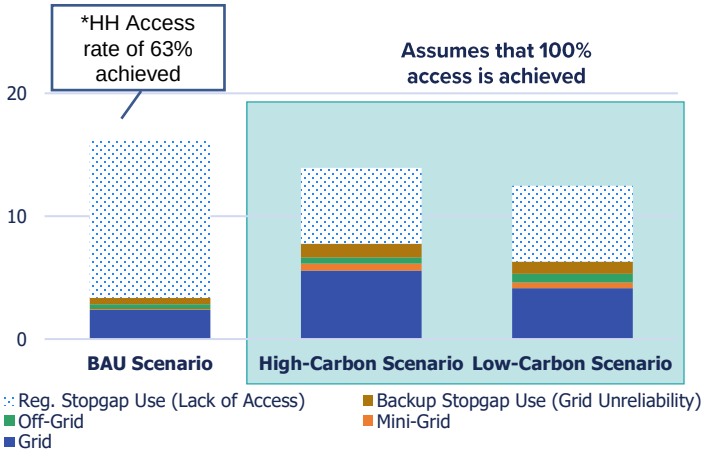
Electricity Access: Pathways and Gamechangers

Tier 1* Pathway: this low-carbon scenario enables Uganda to avoid 1.4 million tons of CO_2 emissions

BAU only achieves 63% access in 2030; a low-carbon scenario envisages significant scale up of grid (38%), off-grid (59%) and mini-grid (8 times) connections to deliver universal access



Scenario	Connections	Climate Finance Opportunity
BAU 	**Total Access Rate: 63%** • No Access: 5.5M HH (37%) • Grid: 4.7M HH (32%) • Mini-grid: 0.1M HH (1%) • Off-grid: 4.4M HH (37%)	**Total: $436 Million** • Mini-grid: $58M • Off-grid Solar: $378M
High Carbon 	**Total Access Rate: 100%** • Grid: 8.5M HH (58%) • Mini-grid: 0.6M HH (4%) • Off-grid: 5.6M HH (38%)	**Total: $902 Million** • Mini-grid: $379M • Off-grid Solar: $524M
Low Carbon[1] 	**Total Access Rate: 100%** • Grid: 6.8M HH (46%) • Mini-grid: 0.9M HH (6%) • Off-grid: 7.0M HH (48%)	**Total: $1.36 Billion** • Mini-grid: $652M • Off-grid Solar: $706M

Impact 10.2 million households get first-time access

Financing opportunity $1.36 B (Low-Carbon)

No Access | Grid | Off-grid | Mini-grid

[1]The low-carbon scenario has lower estimated emissions than the BAU scenario since emissions from electrification activities are more than offset by reductions in stopgap emissions.

* Tier 1 access is the minimum threshold for these scenarios and is defined as at least 4.3 kWh of electricity consumption per household per year – supporting basic lighting and device charging

Gamechanger 1: Specialized vehicle to underwrite off-grid financing risk

Financing improvements for off-grid solar PAYG sales in underserved areas of Uganda

The Challenge

- OGS needs to **serve areas where it is not feasible to connect households to the grid** or mini-grids
- Low-carbon scenario forecasts **4.5 million new connections** from OGS
- These underserved areas are often difficult to access; households **have lower willingness and ability to pay for solar**
- **Extending credit** to these households is considered particularly risky, and building credit risk management capabilities within solar companies is a complex, costly undertaking
- Many incumbent solar companies do not target these market segments
- Though solar lighting penetration is quite high in Uganda (**37% of HHs report solar as their primary lighting source**), over 75% of these products are non-VeraSol* quality verified

The Opportunity

- **Develop a pooled risk sharing facility** of PAYG loans that originate in underserved areas
- In addition to scaling sales of incumbent solar retailers in Uganda, **leverage existing last mile distribution** businesses to expand availability of quality verified products
- **Blended finance structure** for the facility, crowding in varied risk/reward appetites among climate financiers
- Facility will seek **net capital preservation**, creating value creation opportunities for more commercially-minded investors
- Retailers could **manage customer acquisition** (including basic creditworthiness screening), technical servicing, and payment recovery escalations. In the event of default, claims could be made on the facility

Source: Catalyst estimates; GOGLA Sales Data; USAID; UOMA; *Uganda Household Electrification Survey*; Access Insights Platform (AIP); GOGLA
**VeraSol is the evolved quality assurance program for off-grid solar products and appliances*

Gamechanger 1: Impact and key design considerations

If 30% of new OGS connections were underwritten by the facility, this could make a meaningful contribution toward achieving Uganda's low-carbon SDG 7 scenario and crowd in significant climate finance

Key Design Considerations

- **Facility structure and capitalization:** Separate windows for inventory financing and receivables underwriting, each capitalized with blended finance and set up as revolving windows
- **Inventory:** available to retailers on a consignment basis via the Facility
- **Product Quality:** All products VeraSol Quality Verified
- **Household Eligibility:** Geographic targeting to be done based on poverty mapping, ability to pay or other quantifiable metrics
- **Management:** Competitively selected manager with extensive credit risk and collections management experience; could be done in partnership with local financial institutions to leverage existing infrastructure
- **Distributor Eligibility:** Solar distribution experience, logistics and supply chain robust enough to reach targeted areas, and sound collections practices
- **Technical assistance:** For distributors, focused on customer screening, after sales management and servicing, and collections

Gamechanger 1 Impact

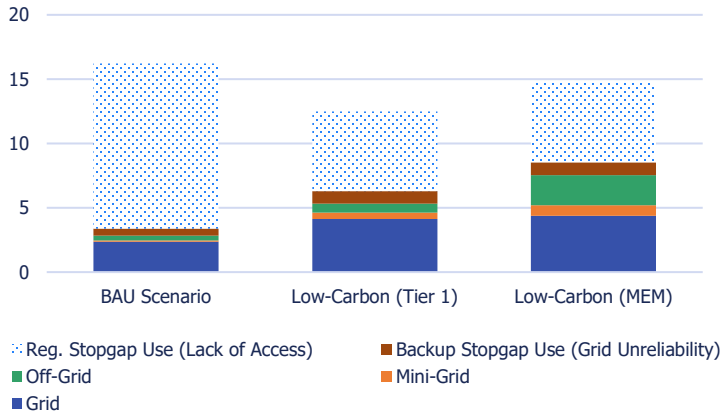
- **1.35 million HHs** would benefit from Tier 1 connections*
- Avoided household stopgap emissions of **880,000 tons of CO_2**
- **~$132 million** in receivables that would need to be underwritten

Sources: Catalyst estimates

*Currently this is modeled to focus solely on Tier 1 access as those households are expected to be the most difficult to reach and the group who would benefit most from the envisioned facility. In practice, it will likely need to cover larger Tier 2 and Tier 3 systems as well

MEM: Targeting the Modern Energy Minimum (MEM)* in Uganda generates additional 2.2MTCO_2 emissions, unlock higher levels of household consumption

To achieve 300 kWh/capita/year by 2040, per capita consumption must exceed 136 kWh by 2030; generating 2.2 MT of addition CO_2 emissions compared to Tier 1



Scenario	Connections	Climate Finance Opportunity
Low Carbon (Tier 1)	**Average consumption: 72 kWh/pp/yr** Connection mix: • Grid: 6.8M HH • Mini-grid: 0.9M HH • Off-grid: 7.0M HH	**Total: $1.36 Billion** • Mini-grid: $652M • Off-grid Solar: $706M
MEM	**Average consumption: 136 kWh/pp/yr** Change in connections compared to Tier 1 • Grid: Same • Mini-grid: 300k additional • Off-grid: 300k fewer	**Total: $2.92 Billion** • Mini-grid: 1.11B • Off-grid Solar: 1.81B
OGS Mix[1]	**MEM, OGS mix of system sizes** • Tier 1: 2.11 million HHs • Tier 2: 3.05 million HHs • Tier 3: 1.41 million HHs • In LC Tier 1 scenario, 76% of HHs had Tier 1, 21%, Tier 2, 3% Tier 3	**OGS financing mix:** Tier 1: 140 million Tier 2: 626 million Tier 3: 1.05 billion

Tier 3 Tier 2 Tier 1

Sources: Catalyst estimates.

[1]The MEM calls for a higher, more inclusive level of electricity consumption as a better access metric to raise global energy ambitions; Energy for Growth Hub, 2020.

Gamechanger 2: Catalyzing use of productive use appliances

Leverage partnerships with grid and off-grid operators to spur power consumption by small enterprises

The Challenge

- Need to accelerate both on-grid and mini-grid demand via productive use applications (in the Low-Carbon **Tier 1 Scenario Uganda only reaches 72 kWh / capita** well short of the 2030 MEM Interim Target (130 kWh / capita)
- This will **help Uganda target the MEM**, tackling energy poverty and spurring local economic development
- **Low affordability, limited access to capital**, and low willingness to pay constrain household and enterprise investment in PUE opportunities
- **Lack of awareness and fit-for-purpose technologies**, particularly in agricultural value chains
- Promising pilot initiatives ongoing in Uganda, but these need to be scaled quickly

The Opportunity

- Leverage Uganda's ongoing **pay-as-you-save, on-bill financing, asset-based financing, and other utility financing pilots** to support household and commercial uptake of productive use applications (e.g., Twaake, Nyenje, EnerGrow)
- Partner with UMEME, other distribution provides, and mini-grid operators, helping **to stimulate customer demand and utility and business revenues**
- **Boost demand (and utility/mini-grid revenue)** via increased roll out of more established and tested technologies like carpentry, cold storage, tailoring. and pumps
- Help power providers and other parties to **offer end-user financing for productive use assets** (e.g. EnerGrow, Utilities 2.0)

Sources: Power for All / Rockefeller Foundation; Catalyst estimates

Gamechanger 2: Impact and key design considerations

Scaling Utilities 2.0 and other new utility frameworks to support downstream PUE, improve consumption, and grow utility revenue

Key Design Considerations

- Partner with UMEME, other distribution companies, and mini-grid developers to identify prospective customers
- Develop a **menu of productive use technologies**, including supporting local manufacturing and assembly when possible
- **Mobilize productive use asset financing** via specialized and existing local financial institutions
- Partner with power providers to **deploy innovative mechanisms** to manage repayment of PUE loans
- **Provide catalytic concessionary capital** for power providers to test new ideas, including emerging PUE technologies and business model innovations
- Create **favorable market and regulatory conditions for PUEs** to flourish in Uganda
- Customer **engagement and outreach campaigns** to foster awareness of PUE programs

Gamechanger 2 Impact

- Boost power consumption **an average of 38-50%** via PUEs
- **Average 135%** increase business revenues thanks to PUEs
- **De-risking of investment** and enhanced bankability of power providers thanks to increased revenue
- **Lower connection costs** (average 50% reduction), due to integrated energy approaches including distributed energy, smart metering, asset-based financing, open data, etc.
- **Mobilize ~$50 million** in climate finance to scale these initiatives

Sources: Utilities 2.0 Power for All / Rockefeller Foundation; Power for All *Appliance Finance and Demand Stimulation Report*; Catalyst estimates

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Unreliable Grid: Pathways and Gamechangers

Uganda's grid, managed by UMEME, is reliable compared to neighboring markets

However, enterprises still invest heavily in back-up gensets

Unreliable grid connections

- In developing countries, unreliable grids are the primary driver for genset use
- About **75% of sites** using fossil-fuel powered gensets are "grid connected"

In Uganda alone:

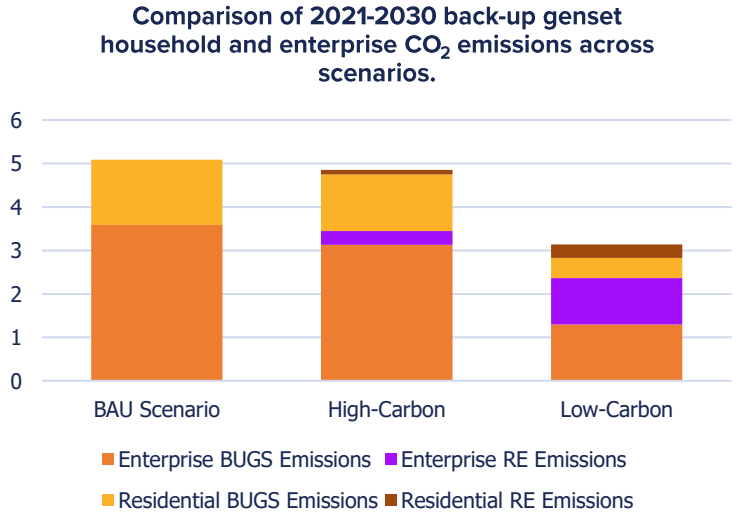
- About **81.5% of firms** experience outages
- **6.3 outages** in a typical month for total downtime of about 64 hours (About **8.6% downtime**)
- Unreliable grid connections result in an average **11.2% loss in business revenues**

Use of backup gensets

- Backup fossil-fueled generators are used by households and enterprises
- Powered with fossil fuels, typically diesel or gasoline
- Significant source of air pollutants
- Uganda's current fleet is **32,000 gensets and 1.5 GW**
- Uganda's genset fleet spends over **$150 million per year on fuel**
- Off-grid enterprises often resort to using gensets for power, particularly for productive use applications
- In Uganda, **14.8k gensets** are deployed for commercial use (99% are on-grid businesses), while **17.2k gensets** are deployed for residential use (45% are grid connected residences)

[1] An unreliable grid is defined as one in which local enterprises, on average, report 12 or more hours of electrical outages in a typical month;
Source: World Bank Enterprise Surveys; IFC *Dirty Footprint of Broken Grid*; SERC estimates; Catalyst estimates
*Based on US$1.046 / liter

Replacing Uganda's gensets with DREs can reduce emissions by 1.8 million tons of CO_2



- Emissions reductions are driven by the growth rate in back-up genset fleets and the rate at which back-up gensets are replaced by renewables; replacement rates are varied across scenarios[1]
- In the low-carbon scenario displacing over **50,100 assets with a total generation capacity of 2.6 gigawatts by 2030** would yield a **$2.1 billion** climate finance opportunity

[1] The modeling assumes that average capacity factors of back-up generators remain fixed over time, in line with historical averages (i.e., assumes no improvement or deterioration in grid reliability).
Sources: IFC *Dirty Footprint of Broken Grid*; SERC estimates; Catalyst estimates

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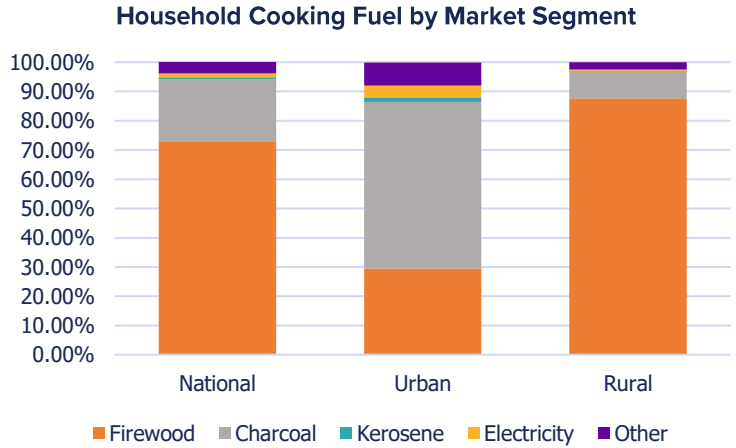
Cleaner Cooking: Pathways and Gamechangers

Uganda's clean cooking sector is strikingly underdeveloped

Charcoal and wood fuels dominate household cooking practices

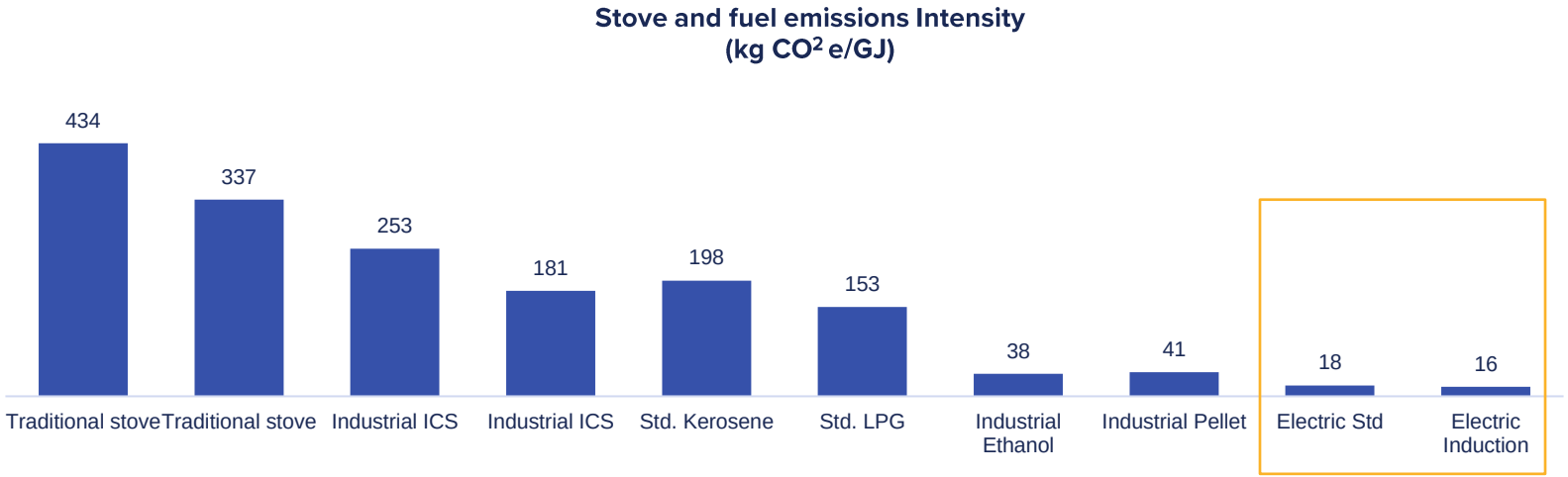


- 94.8% of households utilize **solid fuel or kerosene** fuels
- **23,360 people killed annually** from household air pollution
- 1.4% of households cook **primarily with electricity**
- 18.8% of households utilize **multiple stove types**

Source: Uganda Bureau of Statistics *Household Survey 2019 / 2020*; WHO *Global Health Observatory*

Uganda's clean grid power presents an opportunity for electric cooking, though affordability presents a challenge

Electric cooking represents the cleanest path for those connected to the grid or to a DRE powered mini-grid, though the cost to cook may be a barrier to uptake

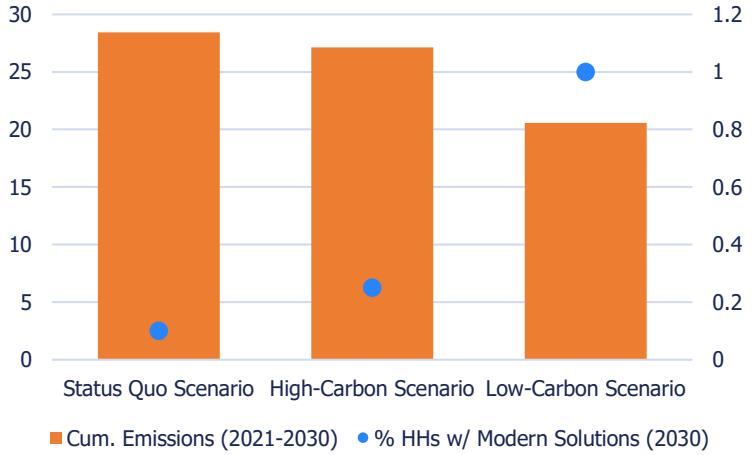


*Each fuel has a GHG emissions intensity factor ($kgCO_2e$ per gigajoule of fuel burned) which illustrates the carbon-intensity of the fuel when burned. When used in a particular stove, only a percentage of the burned fuel is converted into useful energy, resulting in a higher GHG emissions intensity in practice.

Source: Authors' analysis based on multiple sources including Penisse et al, Bailis et al; Clean Cooking Alliance's Clean Cooking Catalog, inter alia.

Shifting households from charcoal to modern fuels could avoid 6.5M tons of CO_2 emissions

Households cooking with charcoal are likely to be able to afford to switch to a modern fuel; they're also often close to infrastructure and supply chains that could be used for modern fuels



- In the low-carbon scenario, **2.1 million households that cook with charcoal** would transition to modern fuels
- **1.3M HHs** cooking with electricity
- **700k HHs** cooking with LPG
- **100k HHs** cooking with ethanol
- **$392 million** investment required to primarily produce and distribute electric and LPG stoves as well as to support infrastructure development
- Significant health benefits, thanks to reduced household air pollution from charcoal combustion

[1] In a household, the primary fuel is the one which accounts for the majority of cooking needs.
Sources: Catalyst estimates

Gamechanger 3: Catalyzing all urban charcoal users to switch to electric cooking

The Challenge

- Modern fuels are more expensive than charcoal on a per meal basis
- Electric pressure cookers (EPCs) can compete on some meals like matooke ($0.13 / meal for charcoal and $0.07 for EPC), but on shorter cook time dishes costs are less favorable
- Transitioning to electric cooking means buying electric cooking appliances (EPCs, induction stoves, etc.), with high upfront capital costs and behavior change challenges
- The market for efficient domestic electric cooking technologies is not well developed, so availability is limited, and costs are high

The Opportunity

- Power provider-led financing programs to foster end-user electricity demand and create new revenue streams
- Locally manufactured electric cooking solutions, particularly PAYGO enabled
- Results-based financing could support power providers to pre-finance appliances; households pay back via monthly deductions from electric bills
- Emissions savings (average of 5.4 kg CO_2e avoided / meal) can be tracked and monetized as carbon credits; proceeds can help subsidize upfront capital costs of the appliances and/or finance consumer awareness campaigns

Sources: Catalyst estimates; MECS *Cooking with Electricity in Uganda: Barriers and Opport*unities

Gamechanger 3: Impact and key design considerations

Transitioning Uganda's 1.4 million urban charcoal users to electric cooking unlocks huge climate impacts and financing opportunities

Key Design Considerations

- Electric cooking **necessitates a robust electric grid**, which needs to be included in integrated electrification planning; grid-strengthening ancillary investments will need to be financed
- **Leverage existing pilots** (e.g. MECs) to track and certify emission reductions from electric cooking
- **Customer financing options like PAYGO or Pay-as-you-save** approaches to make appliances affordable
- **Support local manufacturing** of electric cookstoves, particularly electric pressure cookers, to help scale up the electric cooking sector in Uganda
- Explore potential for **commercial electric cooking schemes**, particularly for injera bread as a starting point for electric cooking acceptance and predictable planning for electricity demand

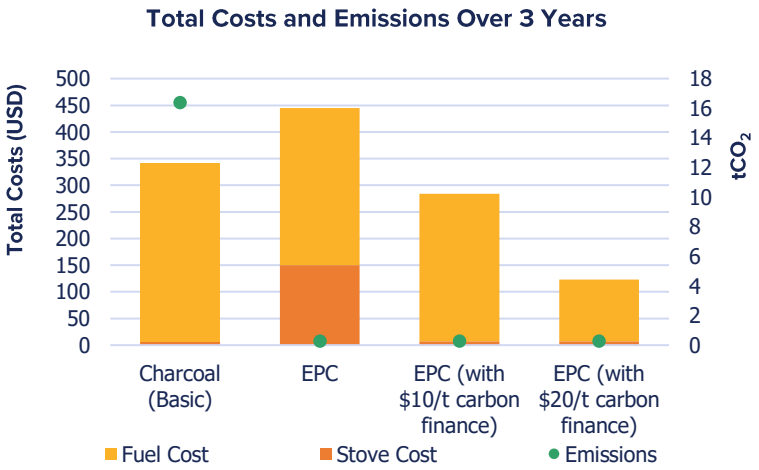
Gamechanger 3 Impact

- **9 MT CO_2** avoided compared to status quo
- **$234** in investment for electric cooking infrastructure and stoves
- **1.4 million households** with improved household health from avoided charcoal combustion and household air pollution
- **$100.8 million** in avoided fuel costs
- At a conservative $20 / ton, **$180 million of carbon finance could be mobilized** to support the capital costs for cooking devices
- **30-51% time savings** for staple meals with EPCs instead of charcoal

Sources: Modern Energy Cooking Services (MECS): *Uganda cooking transitions*; Catalyst estimates

Gamechanger 3: Climate finance should significantly lower costs

Climate finance can help lower upfront capital costs for consumers, and enable UMEME and other providers to offer special pricing on power used for electric cooking



- **High upfront capital costs** for EPCs make switching to electric cooking very difficult for most households
- At current prices households would **save an average $13 per year in fuel costs** using EPCs compared to charcoal and **would avoid ~5.4 tons of CO_2 per year**
- If a small portion of potential carbon finance revenue was used to buy down the cost of EPCs to be equal to the cost of charcoal stoves (and then subsidize electricity costs), households could **save an average of $58 – $219** over the 3-year warrantied lifetime of the EPCs
- Local manufacturing and partnerships could also lower the cost of electric pressure cookers
- To help with adoption, **utility programs could be designed with specialized tariffs** to incentivize use of electric cooking over charcoal
- Other **results-based financing for health outcomes** could also be stacked with carbon finance to help support cost competitiveness of electric cooking

Source: Catalyst estimates; MECS *Cooking with Electricity in Uganda: Barriers and Opportunities*

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Summary

Uganda's energy sector: setting the scene

Key energy trends and their climate impacts illustrate the scope of the SDG 7 and SDG 13 challenges

Electricity access

- **43% of Ugandan households** are unelectrified
- **38% use small solar solutions** to meet basic needs
- **19%** are connected to the grid
- Uganda's grid power is extremely clean; **98% of generation** comes from renewable sources

Unreliable grid

- Ugandan enterprises experiencing an average of **8.6% downtime**, and **11.2% revenue losses**
- **> 32,100 backup gensets** deployed in the country, with an installed capacity of 1.54 GW.
- These gensets consume **155.5 million** liters / year of petrol and diesel fuels

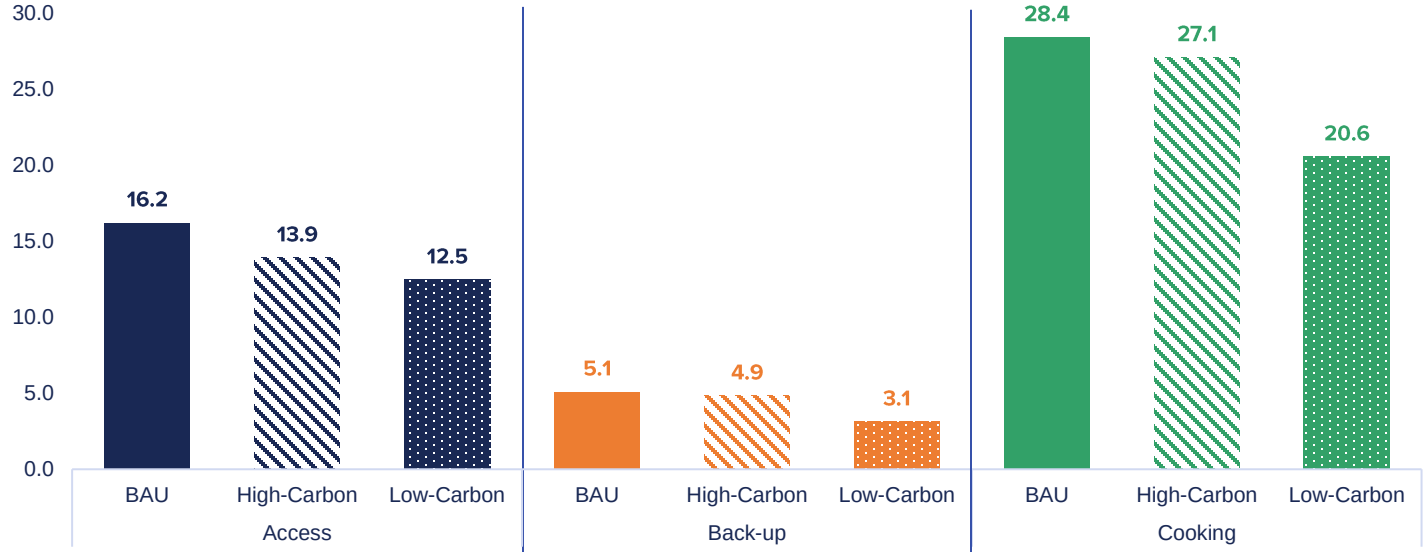
Cleaner cooking

- **>95% of Uganda's population** use solid fuels for primary cooking needs
- **~24,000 people** in Uganda die annually from household air pollution
- **1.4% of households** have transitioned to electric cooking

Source: Uganda Bureau of Statistics *Household Survey 2019 / 2020*; IFC *Dirty Footprint of Broken Grid*; SERC estimates; Catalyst estimates

The low-carbon scenarios avoid 9.7 million tons of CO_2 through 2030, deliver SDG 7 impacts, requiring substantial climate finance

Emissions from Uganda's low-carbon scenarios are benchmarked against high-carbon counterfactuals for avoided emissions



Summing up: Uganda's low-carbon path

Uganda could unlock a **$3.85 billion climate finance** imperative

A low-carbon scenario contributes massively toward universal access

10.2 million new connections for energy access delivered

More than **50,100 gensets** used by enterprises and households replaced

More than **2.1 million households** with new modern cooking access

A low-carbon scenario benchmarked vs. a high-carbon scenario yields

9.7 million tons of avoided CO_2 emissions over the next decade

A low-carbon scenario requires substantial volumes of new capital

$1.36 billion climate finance opportunity for first time access

$2.1 billion climate finance opportunity to green back-up generation for enterprises and households

$392 million climate finance opportunity for clean cooking

Potential gamechangers to accelerate energy access and development in Uganda

Risk-sharing facility for PAYG solar

- Off-grid solar (OGS) is not accessing underserved areas where there is also lower willingness and ability to pay;
- Underwrite consumer receivables for new OGS connections via a blended finance risk-sharing facility; could support 1.35 million households and avoid almost **900 thousand tons of CO_2**

Scaling productive use of energy

- Accelerate both on-grid and mini-grid demand via end-user financing of productive use applications in partnership with UMEME, other distribution providers, and mini-grid operators
- Early pilots show this could boost power demand **38-50%** per customer, increase business revenues **135%,** and bolster bankability of electricity service providers.

Electric cooking

- Uganda's clean power grid could be used to scale uptake of electric cooking, with electric cooking appliances being financed by third parties and administered by electricity service providers
- This could avoid **9 MT CO_2** emissions and **$100 million** in charcoal fuel costs for **1.4 million urban households** cooking with charcoal, while also creating significant health and time savings.

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