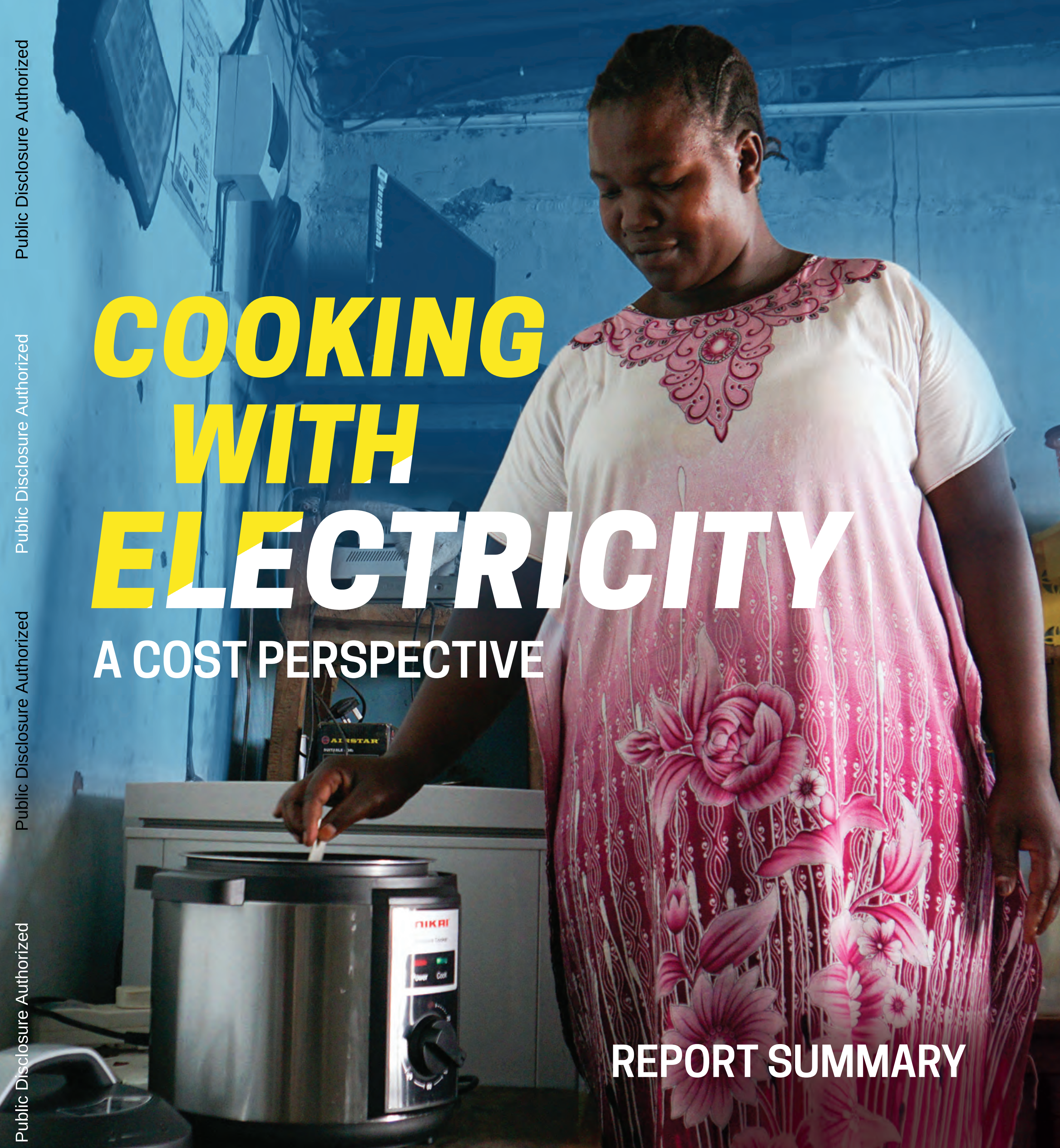

COOKING WITH ELECTRICITY

A COST PERSPECTIVE

REPORT SUMMARY

ESMAP
MECS Modern Energy Cooking Services
WORLD BANK GROUP

The MECS program is funded by UK aid from the UK government; however, the views expressed do not necessarily reflect the UK government's official policies.

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About ESMAP

ESMAP is a partnership between the World Bank and 21 development partners and private non-profits to help low- and middle-income countries reduce poverty and boost prosperity through environmentally sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated into the World Bank Group's strategies, country financing and policy dialogue in the energy sector, through which it works to accelerate the energy transition required to achieve Sustainable Development Goal 7 and the Paris Agreement targets.

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About MECS

Modern Energy Cooking Services (MECS) is a five-year programme funded by UK Aid (DFID). Led by Loughborough University and ESMAP, the program aims to bring together the clean cooking and electrification sectors to take advantage of emerging opportunities for collaboration and co-investment.

By integrating modern energy cooking services into the planning for electricity access, quality, reliability and sustainability, MECS hopes to leverage investment in renewable energies (both grid and off-grid) to address the clean cooking challenge. MECS is implementing a strategy focused on including the cooking needs of households into the investment and action on "access to affordable, reliable, sustainable modern energy for all."

A hybrid clean cooking system pairing LPG with a DC EPC powered from a solar home system in Kenya (case study 5).

EXECUTIVE SUMMARY

Through five case studies, this report compares the current and projected costs to the consumer of a range of electric cooking (eCooking) solutions with the costs of cooking with currently widely-used fuels in each context. The use of energy-efficient electric cooking appliances challenges the widespread perception that electricity is too expensive for cooking. The analysis shows that eCooking can already be a cost-effective option in a variety of settings and is likely to become increasingly effective in the near future.

2.8 billion people globally are still cooking with solid biomass, however, just 789 million are now without access to electricity (ESMAP 2020). This implies that approximately 2 billion people now have access to some form of electricity, but continue to cook with biomass. The case studies show that in some settings, using modern energy-efficient appliances to cook with reliable grid electricity already offers a cost-effective opportunity to enable clean cooking. For people with unreliable electricity access, as well as people who are still not connected to the grid, a suite of new clean cooking technologies and business models is emerging. The results indicate that there is a growing potential to enable modern energy-efficient electric cooking with grid and off-grid electricity, enhancing both reliability and access.

Taking the case studies as a baseline, the report extrapolates the results to illustrate the wider application of eCooking for a range of costs and fuel prices and carries out sensitivity analyses to explore emerging trends. The results highlight the cost thresholds that can be used to identify the markets where the levelized costs[1] of eCooking systems are already lower than current expenditures on cooking fuels. When the models are projected to include 2025 costs and expenditures, the comparison looks even more favorable, meaning that eCooking is likely to become cost-effective in a broader range of markets.

The uptake of eCooking will depend substantially on the willingness of the private sector—in particular solar companies, mini-grid operators and utilities—to adopt the technology as part of the suite of services it offers its customers. Utilities with excess generating capacity could stimulate demand by developing an on-bill financing mechanism for energy-efficient cooking appliances. Financial institutions also have an important role to play, as financing will be needed across the value chain to offset the high upfront costs of eCooking solutions, especially battery-supported models. End-users will require credit to allow them to pay for the high upfront cost of eCooking devices in affordable installments or reframe them as eCooking services, where the provider retains ownership of the assets, leasing or renting them to the user.

1 The net present value of investment and operating costs per month of cooking service delivered.

The report seeks to build the evidence base to assess whether cooking with electricity could make a significant contribution to the Sustainable Development Goals (SDGs) by simultaneously enabling cost-effective access to modern energy and clean cooking. The results suggest that integrating planning and action on electrification with the need to transition away from biomass cooking could add momentum to the quest to achieve SDG7 in particular (ensuring access to affordable, reliable, sustainable, and modern energy). Commercial and political interest in eCooking is growing. With appropriate support from governments, adoption of eCooking can be accelerated, yielding substantial environmental, gender equity, and health benefits to some of the world's most disadvantaged people.

Experimenting by cooking ugali in a rice cooker at a workshop in East Africa (case study 1).

REPORT OVERVIEW

Modern energy-efficient electric cooking (eCooking) has the potential to achieve a broad range of developmental goals—for energy access, the environment, gender equity, and health—by enabling access to clean cooking and reliable electricity. Battery-supported cooking devices can make cooking with electricity more reliable and offer the co-benefit of also making low power energy services (such as LED lighting or phone charging) more reliable. This emerging opportunity leverages rapid progress in the electricity sector to drive the clean cooking sector toward achieving the seventh Sustainable Development Goal (SDG7) of universal access to affordable, reliable, sustainable, and modern energy by 2030.

A new generation of highly efficient eCooking appliances is now available that can drastically lower costs by reducing the amount of electricity required to cook (Zubi and others 2017; Leary, Serenje, Mwila and others 2019; Couture and Jacobs 2019). The electric pressure cooker (EPC) is the most energy-efficient appliance for cooking the most energy-intensive foods. Recent field trials[2] have shown that it is also attractive to cooks, as it cooks more quickly and includes automatic controls that allow for multitasking (Leary, Fodio Todd, Batchelor, Chepkurui and others 2019). IMARC (2019) reports that worldwide sales of EPCs totaled 8 million units or $578 million in 2018. It reports that convenience and speed are primary drivers of sales. Awareness of the energy efficiency potential of EPCs is still low among consumers, but it is growing within the development community, who are searching for cost-effective solutions to the clean cooking challenge.

The prices of lithium-ion batteries and solar photovoltaic (PV) power have dropped significantly in recent years, and the cost of biomass fuels is rising rapidly in many heavily degraded or deforested areas (Batchelor 2015; Couture and Jacobs 2019). This trend is opening the door to a range of potentially transformative solutions for cooking with both alternating current (AC) electricity and battery-supported direct current (DC) devices that can enable cooking on weak grids, mini-grids, and stand-alone systems. As a result, mini-grid developers, solar home system companies, and utilities are starting to take a closer look at eCooking.

In many developing countries, electricity grids are expanding their coverage and becoming more reliable (Power Africa 2015, 2018), while battery-supported appliances can support weaker grids and enable off-grid access. This development is important, as energy-efficient eCooking appliances can also be powered by batteries, as they draw much less power than conventional electric hotplates. Advancements in energy storage can shift electricity demand away from peak times and allow users to cook during blackouts or brownouts. Advancements in battery storage and solar PV also have the potential to provide electricity access in even the most remote parts of the world (Batchelor and others 2018).

[2] Cooking diary studies with 80 households and 13 focus groups across Kenya, Tanzania, Zambia and Myanmar (Batchelor et al. 2019; Scott et al. 2019; Leary, Scott, Serenje, Mwila, et al. 2019b; Leary et al. 2019).

Case Study Methodology and Modeling

This report compares the costs to the consumer of cooking with electricity versus other fuels based on detailed empirical data on cooking energy demand. Five case study sites were selected to represent a cross section of contexts in the countries where cooking energy demand data is available, including both urban and rural areas and for households with access to reliable grids, unreliable grids, and no grid access. The report identifies settings where eCooking is likely to be as affordable as (if not cheaper than) current practice by comparing typical expenditures on cooking fuels in the study sites with the levelized costs of a range of eCooking solutions. As further cost reductions of key components are expected, the report compares actual costs in 2020 with projections for 2025.

The affordability of cooking is usually assessed based on the proportion of household income spent on cooking fuel, suggesting that even existing expenditures may not be considered "affordable" for households that are already spending a large proportion of their income on cooking fuels. However, this report does not seek to compare cooking fuel expenditures to household incomes. It highlights opportunities where eCooking is already, or will soon be, cost-competitive with current practice. In addition to offering benefits to individual households, eCooking could provide an opportunity to redirect expenditures away from polluting fuels,[3] especially where they are used inefficiently, to support the roll-out of modern energy infrastructure.

A model was constructed to simulate the monthly costs of cooking on a range of eCooking systems and compare them with typical expenditures on other fuels (Leach and others 2019). The modeling considers cooking using AC appliances and battery-supported DC appliances, connected to national grid, mini-grid, and stand-alone systems. It also compares two business models: (a) the private sector pay-as-you-go (PAYG) model, with a 5-year financing horizon and (b) the utility (or energy service) model, with a 20-year horizon.

The study team collected data on energy consumption, cooking practices, and user experiences from households in four countries: Kenya, Myanmar, Tanzania, and Zambia (Leary, Scott, Sago and others 2019; Leary, Scott, Serenje and others 2019a; Leary, Scott, Numi and others 2019; Leary, Scott, Hlaing and others 2019). Data were collected using cooking diary studies, which included assessment of the acceptability and desirability of appliances and electricity usage based on preparation of typical dishes. The data reveal that using a mixture of conventional and energy-efficient appliances, the average household (assumed to include 4.2 people) in these countries can perform its daily cooking with 0.88–2.06 kilowatt hours (kWh) of electricity. Under a "fuel-stacking scenario" (in which half the menu is cooked using an EPC and the other half is cooked with another fuel), daily electricity consumption is projected to be just 0.30–0.67 kWh per household.

3 According to the World Health Organization (WHO 2016, 31), polluting fuels include "biomass (wood, dung, crop residues and charcoal), coal (including coal dust and lignite) and kerosene."

TABLE ES.1 Comparison of the five case studies and rationale for selection

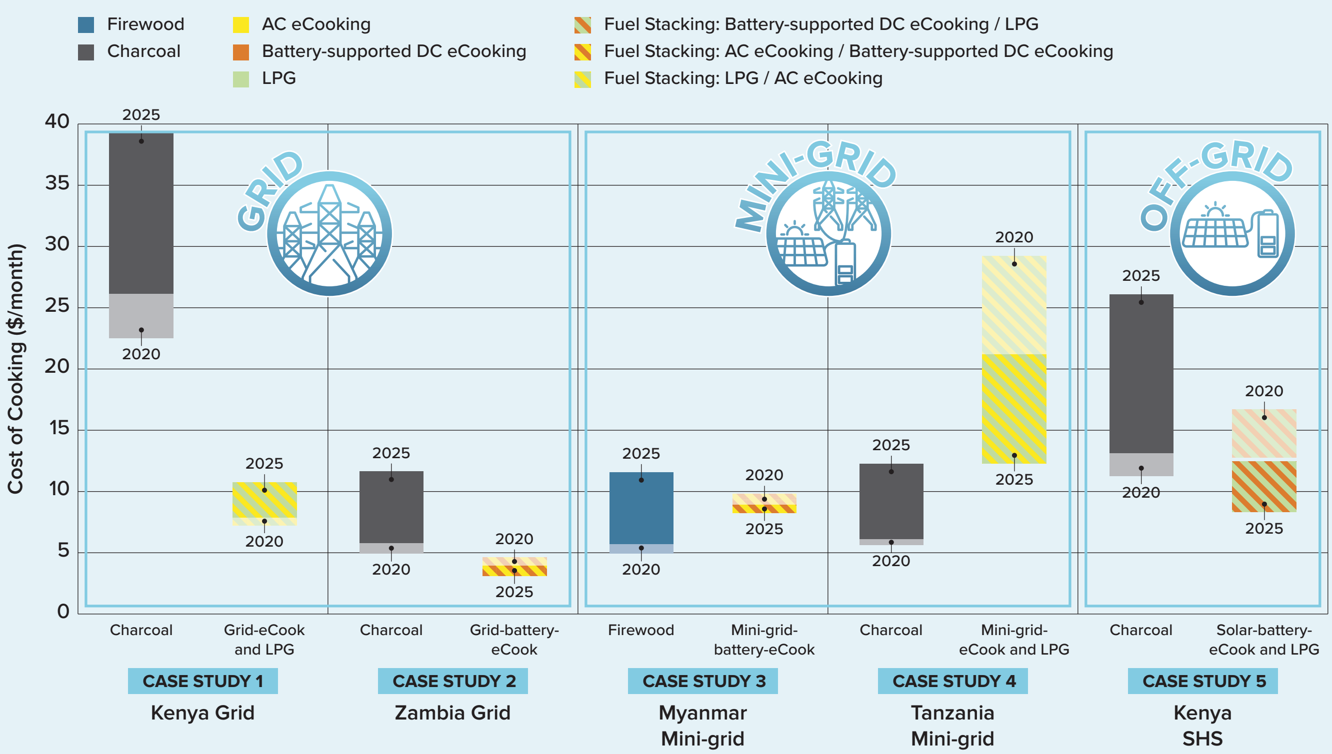
CASE LOCATION	CONTEXT	SUPPLY SIDE	DEMAND SIDE: BASELINE FUELS/ APPLIANCES	KEY OPPORTUNITY TO ENABLE 100% CLEAN COOKING	ENERGY STORAGE CONSIDERED
1 Nairobi, Kenya	Urban, national grid	Stimulate demand for surplus national grid electricity	LPG, charcoal and kerosene	Clean fuel stack: LPG and most efficient electric appliances (EPCs)	None
2 Lusaka, Zambia	Urban, national grid	Mitigate load shedding on national grids with energy storage	Inefficient electric appliances (hotplates, oven) and charcoal	Most efficient (EPCs) and minimal use of less efficient appliances (hotplates, oven)	Household battery
3 Shan State, Myanmar	Rural, micro-hydro mini-grid	Mitigate peak loading constraints on micro hydro mini-grids with energy storage	Firewood and efficient electric appliances (induction stove, rice cooker and insulated electric frying pan)	Only efficient electric appliances (induction stove, rice cooker and insulated electric frying pan)	Household battery
4 Kibindu village, Tanzania	Rural, solar hybrid mini-grid	Stimulate demand for electricity in rapidly growing solar-hybrid mini-grid sector	Charcoal and firewood	Clean fuel stack: LPG and most efficient electric appliances (EPCs)	Centralized battery bank
5 Echariria village, Kenya	Rural, off-grid	Enable electricity access and clean cooking with solar systems	Charcoal, kerosene LPG and firewood	Clean fuel stack: LPG and most efficient electric appliances (EPCs)	Household battery

CASE STUDY MODELING RESULTS

The case studies illustrate real-world contexts where the levelized cost of eCooking solutions can be lower than existing expenditures on biomass. A range of system architectures and fuel-stacking scenarios was modelled, using actual costs. Figure ES.1 shows the most viable clean cooking solution in each setting. Except for the Tanzania minigrid case, modern energy cooking services are already cost-competitive with the dominant biomass fuel, including electric solutions as well as clean fuel stacking with liquefied petroleum gas (LPG). In some cases, eCooking can be more cost-effective than biomass even if the appliance must be supported by a battery.

The **first case study** explores an opportunity for urban East Africans to transition completely away from biomass by fuel stacking LPG with an EPC. Kenya Power has surplus generation capacity and is looking to increase demand for electricity, which is currently barely used for cooking. LPG is currently the aspirational fuel across most of East Africa, yet many households with an LPG stove still purchase charcoal to cook "heavy foods". Case study 1 illustrates an urban context with high charcoal prices ($0.49/kg), low LPG prices ($1.08/kg), and average electricity prices (lifeline tariff of 100kWh/month at 0.17/kWh). It shows that a clean fuel stack of LPG and an AC EPC ($7–$10/month) is already one of the lowest-cost cooking solutions and substantially cheaper than charcoal ($23–$34/month).

FIGURE ES.1 Cost of cooking with biomass (charcoal/firewood) versus cost of cooking with the most cost-effective technically viable eCooking solution in each of the five case study contexts



Note: Case study 1, Kenya grid: Fuel stack of 50 percent liquefied petroleum gas (LPG) and 50 percent AC electric pressure cooker (EPC); private sector model (five-year financing horizon). Case study 2, Zambia grid: Hybrid AC/DC appliances with battery sized for 50 percent of cooking; utility model (20-year financing horizon). Case study 3, Myanmar mini-grid: Hybrid AC/DC appliances with battery sized to power 50 percent of cooking; utility model (20-year financing horizon). Case study 4, Tanzania mini-grid: Fuel stack of 50 percent LPG and 50 percent AC EPC; private sector model (five-year financing horizon). Case study 5, Kenya solar home system: Fuel stack of 50 percent LPG and 50 percent solar home system with DC EPC and battery sized to power 50 percent of household cooking; private sector model (five-year financing horizon).

The **second case study** illustrates an opportunity for countries with significant populations already cooking with electricity but using inefficient appliances, to optimize loading on their grids. Although electricity is already the aspirational cooking fuel in Zambia, the national utility (ZESCO) has repeatedly been forced to carry out load shedding over the past few years, as late rainfall has severely limited generation capacity on its hydropower-dominated grid. Case study 2 illustrates an urban context with lower charcoal prices ($0.21/kg) and low electricity prices (lifeline tariff of 200kWh/month at $0.01/kWh). The findings show that by 2025, a hybrid AC/DC eCooking system with a battery sized for half the day's cooking using energy-efficient appliances and practices will be the cheapest option ($7–$8/month), substantially cheaper than charcoal ($6–$12/month)

The **third case study** highlights the opportunity for micro-hydro minigrid developers that have already enabled cooking on their systems to allow their customers to do all of their cooking with electricity. At peak times, grids often reach capacity and the voltage dips. This case study explores the potential role of battery storage in overcoming the supply constraints on micro-hydro minigrids in Myanmar. Case study 3 shows a rural area, with moderate firewood prices ($0.12/kg) and electricity access from a micro-hydro minigrid with a low tariff ($0.16/kWh). By 2025, a battery sized to support half the day's cooking load could enable 24-hour eCooking ($9–$10/month), the cost of which would be on a par with firewood ($6–$11/month).

The **fourth case study** explores how the rapidly falling prices of batteries and solar PV are opening up new opportunities for integrating energy-efficient eCooking into solar-hybrid minigrids. Urbanization is causing many people who used to collect fuel to start paying for it, creating an opportunity to translate expenditures on biomass fuels into electricity units, which could drive down the tariff for the minigrid as a whole. Case study 4 depicts a rural area with low-cost biomass fuels available (firewood: $0.04/kg, charcoal: $0.13/kg) and access to electricity via a minigrid with a very high tariff ($1.35/kWh). By 2025, tariffs in the solar hybrid minigrid sector are expected to have fallen considerably (to $0.25–$0.38/kWh), enabling eCooking at marginal extra cost by fuel stacking an EPC. The most cost-effective clean cooking solution is a clean fuel stack of LPG and an EPC ($12–$21/month).

A participant in an EPC trial on a solar-hybrid mini-grid in Tanzania (case study 4).

The **fifth case study** describes a Kenyan village, where cooking was previously dominated by collected firewood, but dwindling forest resources and increasing livelihood opportunities have led many residents to start paying for firewood (or adopt charcoal, kerosene, or LPG). It explores whether pairing a DC EPC with lithium-ion battery storage and a suitably sized solar panel may be able to offer a cost-effective off-grid eCooking solution. Case study 5 illustrates an off-grid rural area with moderate fuel prices (charcoal: $0.30/kg; LPG: $1.33/kg). In 2025, the cheapest option is expected to be LPG ($8–$12/month). However, a clean fuel stack of LPG with a solar home system powering a DC EPC ($11–$14/month) can offer valuable co-benefits by enabling access to electricity for other purposes at marginal extra cost.

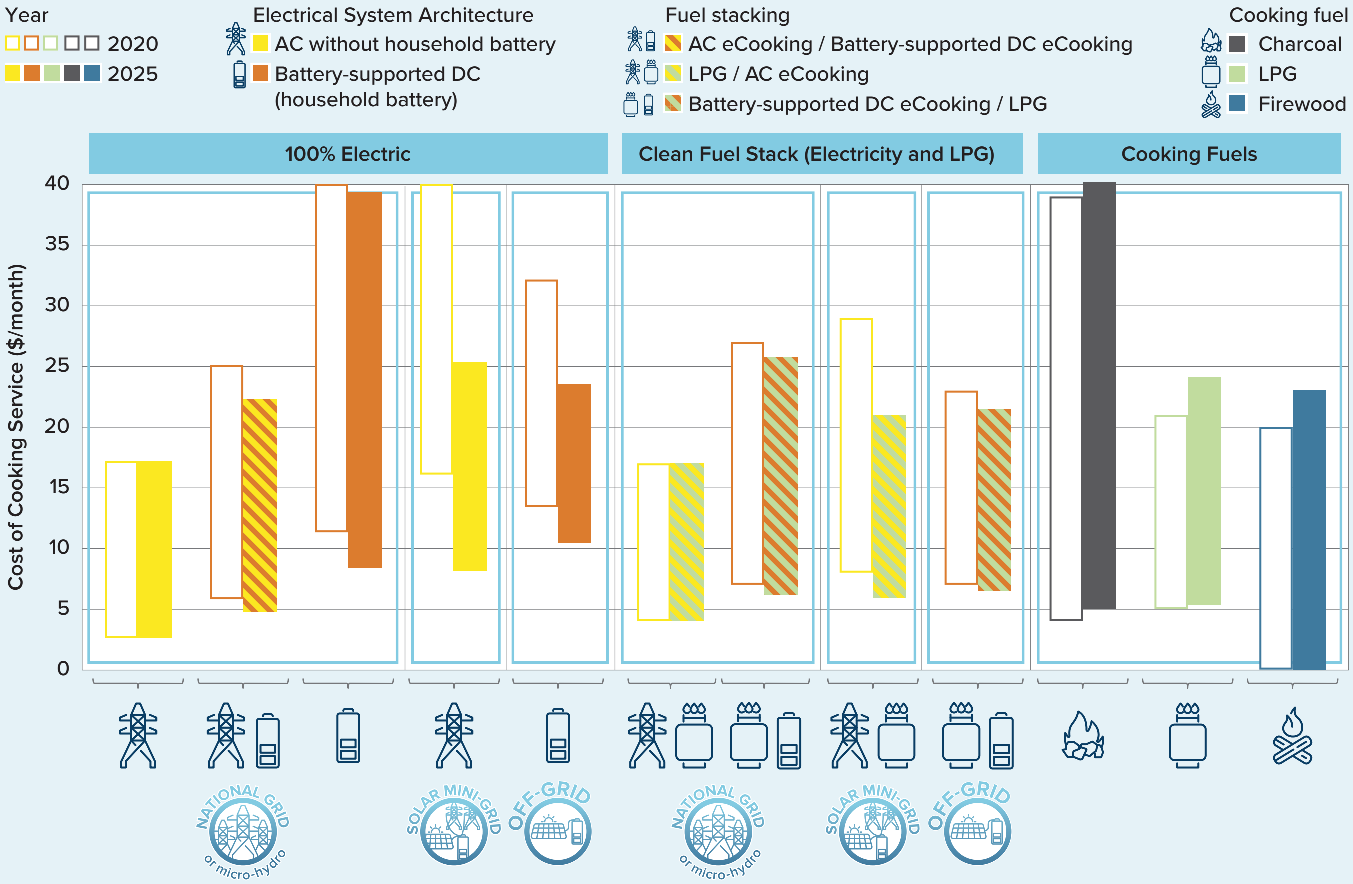
The global perspective

Figure ES.2 shows the outlook for eCooking at a global level by comparing the range of costs of the eCooking technologies explored in this paper with those of the most widely used cooking fuels. Input data were drawn from across the four case study countries (Kenya, Zambia, Tanzania, and Myanmar) and the three system architectures (grid, mini-grid, solar home system).

The results show that AC eCooking on national grids or mini-/micro-hydropower is already cost-effective for many people today and that battery-supported DC eCooking and solar-hybrid minigrids become cost-effective in 2025, although clean fuel stacks with LPG can make all of these technologies cost-effective today. Cooking with AC grid electricity can be the cheapest option for many people ($3–$17/month), but it is not always possible due to access and grid stability challenges. Supporting 50 percent of cooking loads with a battery increases the cost of cooking ($5–$22/month in 2025) but is still competitive with LPG, charcoal, and firewood ($6–$24/month, $5–$41/month, and $0–$23/month, respectively in 2025). Supporting 100 percent of the cooking loads increases the cost substantially (to $8–$39/month in 2025) but may still be competitive in contexts with low tariffs and low energy demand. By 2025, the costs of cooking with AC appliances connected to solar hybrid mini-grids ($8–$25/month) and with DC appliances powered by solar home systems ($11–$24/month) become competitive. LPG can play an important role as a transition fuel since a clean fuel stack of electricity and LPG can make battery-supported eCooking cost-competitive for some households today ($6–$29/month).

Training a cooking diary participant on cooking beans in an EPC in Kenya (case study 1).

FIGURE ES.2 Comparison of system architectures using aggregated data from all case studies



Note: The cost of cooking service is calculated over a five-year financing period for all system architectures. The range on each bar represents sensitivities to energy demand, to the grid tariff or solar resource and to key system performance and cost parameters. The ranges for energy demand are derived from the range of median values from the four country cooking diary studies for 100 percent eCooking (0.87–2.06kWh/household/day). The ratios of energy demand for cooking fuels: electricity calculated from the cooking diaries were used to model demand for LPG (2: 1), charcoal (10: 1) and firewood (10: 1). Grid-connected system architectures use a tariff range encompassing 90 percent of Sub-Saharan African utilities from AFREA and ESMAP (2016): \$0.04–\$0.25/kWh. National grids and mini-/micro-hydropower are grouped together, as tariff ranges are almost identical (\$0.05–\$0.25/kWh for mini-/micro-hydropower) (Skat 2019). Solar hybrid mini grid system architectures use a current tariff range of \$0.55–\$0.85/kWh and a range of \$0.25–\$0.38/kWh in 2025. The solar resource range is the range of average monthly solar irradiation in the least sunny months in each of the four case study countries (3.68–4.30kWh/kW$_{peak}$). eCook system performance and cost ranges are as reported in Table 2.3. Batteries are $LiFePO_4$, sized to meet 100 percent and 50 percent of daily cooking loads, at 1–3kWh and 0.34–0.98kWh, respectively. PV is 300–700W for 100 percent and 100–200W for 50 percent. For full details of modelling input and output parameters, see appendix F.

The critical role of energy-efficient appliances

Both energy-efficient appliances and fuel stacking can substantially reduce the costs of electric cooking, with or without a battery (figure ES.3). An uninsulated four-plate cooker and oven may be cost-effective for households with reliable grid electricity and low tariffs (\$7/month at \$0.04/kWh). It is unlikely that anyone would consider supporting it with a battery, which would need 4.56kWh capacity (\$28/month even at \$0.04/kWh). In contrast, the appliance stack of uninsulated (hotplate, induction, infra-red cooker, or kettle) and insulated (EPC, rice cooker, electric frying pan, or thermo-pot) appliances can offer a much more affordable solution that is capable of covering 100 percent of a household's everyday cooking needs. It would cost \$4–\$13/month for AC (where the grid is reliable enough) and \$13–\$29/month for battery-supported DC. Simply cooking with a single uninsulated appliance will be cheaper for some AC users as the upfront cost of appliances is lower but cooking may be less convenient. For the DC systems, the cost of the battery dominates, so spending more on an additional

A community solar hub acts as a demonstration, distribution and after-sales service centre for solar electric cooking systems in a Kenyan village (case study 5).

energy-efficient appliance actually reduces overall costs (from \$16–\$37/month to \$13–\$29/month), as the battery capacity is reduced (from 2.85kWh to 2.14kWh).

Although it cannot cook all food types, the EPC is likely to be an attractive first step into eCooking for many, as it can deliver the cheapest cooking service by some considerable margin. Systems could be designed to cook 50 percent of the menu (at a cost of \$2–\$5/month for AC or \$5–\$11/month for battery-supported DC) or simply what the EPC does most efficiently, which is boil heavy foods (at a cost of \$2–\$3/month for AC and \$3–\$4/month for battery-supported DC).

MAIN FINDINGS

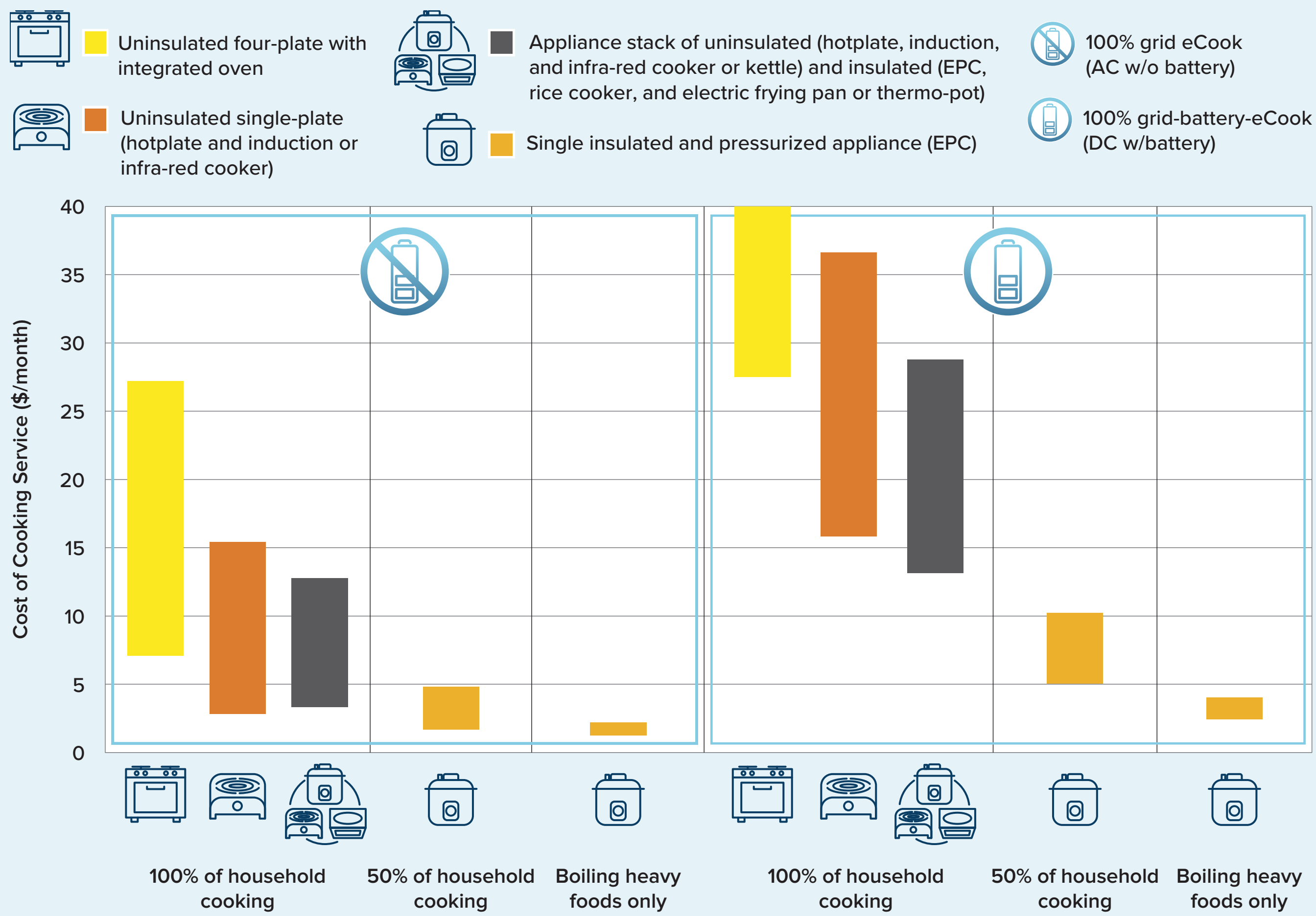
Several key findings emerge from this report:

- Field trials with 80 households show that modern energy-efficient eCooking appliances (notably EPCs) are highly attractive to consumers and can substantially lower the cost of eCooking by reducing energy demand. Compared with electric hotplates, EPCs can reduce energy demand by 80 percent for “heavy foods” (foods that require boiling for more than an hour) and by 50 percent across the entire range of foods that they are able to cook.[4]
- The cost of cooking with energy-efficient appliances is significantly lower than the cost of cooking with electric hotplates, but the upfront cost is higher (typically \$50–\$80 for an EPC, compared with \$10–\$30 for a hotplate).
- eCooking with AC grid electricity is already cheaper than cooking with charcoal in some of the urban centers studied, where charcoal costs more than \$0.40/kg and electricity tariffs are below \$0.35/kWh.
- Using a clean fuel stack of LPG and a highly efficient eCooking appliance is often the most cost-effective way to cook.[5]

4 Analysis of the menu recorded during these trials showed that participants cooked 50 percent of their meals on an energy-efficient appliance and that with additional training this share could increase to up to 90 percent.

5 LPG is a good complementary fuel to eCooking since it is popular for frying and preparing quick meals

FIGURE ES.3 Impact of energy-efficient appliances and fuel stacking on cost of AC and battery-supported DC eCooking



Note: The cost of the cooking service is calculated over a five-year financing period for all system architectures. Component costs are from 2025. The range on each bar encompasses 90 percent of Sub-Saharan African utility tariffs from AFREA and ESMAP (2016) ($0.04–$0.25/kWh). Daily household energy demand values are from Figure 2.2 (100 percent eCooking: uninsulated plate with oven, 3kWh; uninsulated single plate, 2kWh; appliance stack, 1.5kWh; 0.5kWh. 50 percent eCooking: EPC, 0.5kWh. Boiling heavy foods only: EPC, 0.15kWh). Fuel-stacking scenarios model only the eCooking service, not the cost of the cooking fuel.

- Battery-supported eCooking is already cost-effective for charcoal users in urban centers with electricity tariffs below $0.15/kWh.
- By 2025, expected increases in charcoal prices and the falling costs of battery-supported solutions suggest that the cost of eCooking will likely be comparable to the cost of cooking with charcoal in weak-grid and off-grid contexts ($8–39/month vs. $5–41/month respectively).
- Battery-supported cooking devices can also provide access to other low power energy services such as lighting and mobile phone charging.
- Stand-alone solar systems start to become competitive with their grid-connected counterparts at tariffs of $0.15–$0.35/kWh (see main report figure 3.34).
- Lifeline tariffs of 100kWh/month at $0.10/kWh would be sufficient to allow most consumers to cook all their food with electricity, even if the cooking appliances had to be supported by a battery. 50kWh/month would be sufficient for cooking half the menu with a highly efficient appliance such as an EPC.

Comparing energy-efficiency and service delivery amongst popular electric cooking appliances in Myanmar (case study 3).

HOW CAN ECOOKING BE DELIVERED AND FINANCED?

Innovative delivery and financing models will be needed to support the roll-out of eCooking since even where it is cost-competitive, challenges remain, especially if energy storage is required. In markets that do not require energy storage, supply chains for energy-efficient appliances are emerging but are not yet strong and the high upfront cost prevents many poorer households from accessing them. For example, private sector retail supply of EPCs is increasing in Asia, but is not yet common in Sub-Saharan Africa (IMARC 2019), where awareness among consumers remains low. In markets where energy storage will be needed, batteries further increase the upfront cost, which will require financing with longer repayment horizons, additional supply chain development, consumer awareness, and after-sales support.

End-users will require credit options to break down the high upfront cost of eCooking devices into affordable installments or reframe them as eCooking services, where the provider retains ownership of the assets and rents them to the user. For example, pay-as-you-go for lease-to-own solutions and on-bill financing for energy service models.[6] The uptake of eCooking will depend substantially on the willingness of energy service companies to integrate it into the suite of services they offer. For example, utilities with excess generating capacity could stimulate demand by developing an on-bill financing mechanism for EPCs and support women entrepreneurs to leverage their social networks to demonstrate new cooking technologies and practices.

Grant funding could support an initial feasibility study and piloting, with results-based financing and other instruments accelerating scale up. Distributors and retailers will require working capital to finance the appliances and roll out supporting services over longer repayment periods. Financing instruments—including debt and equity finance, social impact investment, and results-based financing tied to environmental, gender equity, and/or health goals—will need to be combined to close the initial cost–viability gaps.

[6] Pay-as-you-go systems rely on a "lock-out" mechanism to prevent the device from functioning if the user does not keep up with regular repayments. On-bill financing allows installments to be repaid automatically when topping up electricity units on prepaid meters or adding to the monthly bill on post-paid meters.

A “single investment strategy” that incorporates clean cooking into electrification and renewable energy investments could enable the existing mechanisms for mobilizing finance from the electricity sector to address the problem of cooking with polluting fuels. These include long-term loans, guarantees, and project bonds, which can offer the clean cooking sector an opportunity to leverage much larger investments. Such a strategy could synergistically position eCooking as an opportunity to improve delivery infrastructure and stimulate demand.

Conclusions and Recommendations

The case studies examined in this report show that in specific contexts, cooking with energy-efficient electric appliances is already a cost-effective option. As prices of key components continue to fall, the range of contexts in which eCooking can offer a cost-effective alternative to polluting fuels is expected to broaden, challenging the widespread perception that electricity is too expensive for cooking in developing regions.

Commercial and development partners’ interest in eCooking is growing. With appropriate support, adoption of eCooking can be accelerated and attention focused on achieving pro-poor outcomes. Integrating planning and action on electrification with the need to transition away from biomass cooking can accelerate progress toward SDG7 and yield environmental, gender equity, and health benefits to some of the world’s most disadvantaged people.

However, even in places where energy-efficient electric appliances are cost-effective, challenges exist. They include the lack of supply chains, high upfront costs for consumers, lack of awareness, the need for changes in the way people cook, and uncertainty about the impacts of scaled uptake on grid systems.

Working together, governments, donors, and private sector can address most of these challenges—recommended actions to support the roll-out of eCooking solutions include:

1. **Support policy makers to create an enabling environment that crosses the division between the electrification and clean cooking sectors**
   - Reduce the lifetime cost of eCooking by bringing down the upfront cost of quality-assured energy-efficient appliances by streamlining supply chains (through, for example, the Global LEAP awards program for EPCs).[7]
   - Create interministerial spaces (committees, working groups, and so forth) to develop single investment strategies that align with existing political objectives.
   - Create a space for dialogue between stakeholders in the clean cooking and electrification sectors.
   - Reduce the relative cost of cooking with electricity by diverting fossil fuel subsidies to energy access programs.
   - Strengthen the case for the poor through strategic use of lifeline tariffs financed by cross-subsidies or targeted subsidy programs.

[7] The Global LEAP Awards is an international competition to drive innovation and performance in early-stage product markets. Awards provide market intelligence for investors, donors, policymakers, solar distributors, and other off-grid market stakeholders.

2. **Conduct strategic, evidence-based research to inform decision makers, private sector players, and consumers of emerging opportunities**
   - Identify and popularize culturally appropriate energy-efficient eCooking appliances.
   - Gain a deeper understanding of target market segments, particularly of their existing expenditures on cooking fuels.
   - Enhance techno-economic models by including the expected costs of marketing, selling and supporting solar battery–powered eCooking devices in rural areas.
   - Model the implications of encouraging eCooking for load management on national grids and mini-grids, in order to establish the likely impact on overall costs and the integrity of the systems.

3. **Support private sector efforts to develop appropriate products and services tailored to the needs and aspirations of the poor**
   - Enable utilities and minigrid developers to pilot, and scale up eCooking services that are compatible with their existing business models.
   - Enable solar home system companies to develop, pilot, and scale up innovative new eCooking products and services.
   - Incentivize appliance manufacturers to develop products targeted at the bottom of the pyramid, in particular DC– and battery-supported eCooking products.
   - Enable players in the existing clean cooking value chain to expand their product range to include eCooking appliances.
   - Empower women entrepreneurs to lead the development and dissemination of innovative eCooking solutions.
   - Identify viable business models that will both unlock consumer responses and meet private sector financing needs.
   - Bridge initial cost–viability gaps in new markets by combining financing instruments, including including grants, social impact investment and results-based financing tied to environmental, gender equity, and health outcomes.

4. **Help consumers understand the benefits of adopting modern eCooking solutions, and reduce barriers to behavioral change**
   - Help consumers determine how much it would really cost them to cook with electricity.
   - Make it possible for consumers to explore eCooking through participatory eCooking demonstrations and trial periods with limited financial risk to the consumer.
   - Encourage consumers to cook as much of their typical menu on energy-efficient appliances as possible.
   - Translate evidence-based research into easy-to-understand content that can be shared on popular media (by, for example, creating targeted content on EPCs for social media groups on cooking).
   - Develop “pay-as-you-cook” financing (flexible repayment schemes that are based on how consumers currently pay for biomass).

The Modern Energy Cooking Services (MECS) program is supporting strategic interventions in each of the five case study contexts featured in this report (plus many more). Over the next decade, the relative price points of key technologies will continue to change, which will likely open the door to an even broader range of cost-effective eCooking solutions. The program intends to keep close track of these developments, create a range of market-ready innovations, and shape enabling environments to make a valuable contribution toward SDG7.

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