EFFICIENCY FOR ACCESS

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SYNTHESIS REPORT

Solar Appliance Technology Briefs

AUGUST 2021

EFFICIENCY FOR ACCESS COALITION

CONTEXT

This synthesis report is the final output in the Solar Appliance Technology Brief series. They summarise the latest market intelligence and chart the pathway to commercialisation for 11 off- and weak-grid appropriate technologies most relevant to catalysing energy access and achieving the Sustainable Development Goals.

This report was developed by CLASP and Energy Saving Trust as part of the Low Energy Inclusive Appliances (LEIA) programme, a flagship initiative of the Efficiency for Access (EforA) Coalition. EforA and LEIA are a catalyst for change, accelerating the growth of off-grid appliance markets to boost incomes, reduce carbon emissions, improve quality of life and support sustainable development.

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Introduction

The first Low-Energy Inclusive Appliance (LEIA) Technology Summaries were published in 2017 to help the newly established Efficiency for Access Coalition navigate a nascent market and identify technologies with the most potential to scale with support from its flagship LEIA programme. At the time, there was limited data and reliable research available on the market trends and performance characteristics of appliances and enabling technologies suitable for resource-constrained settings.

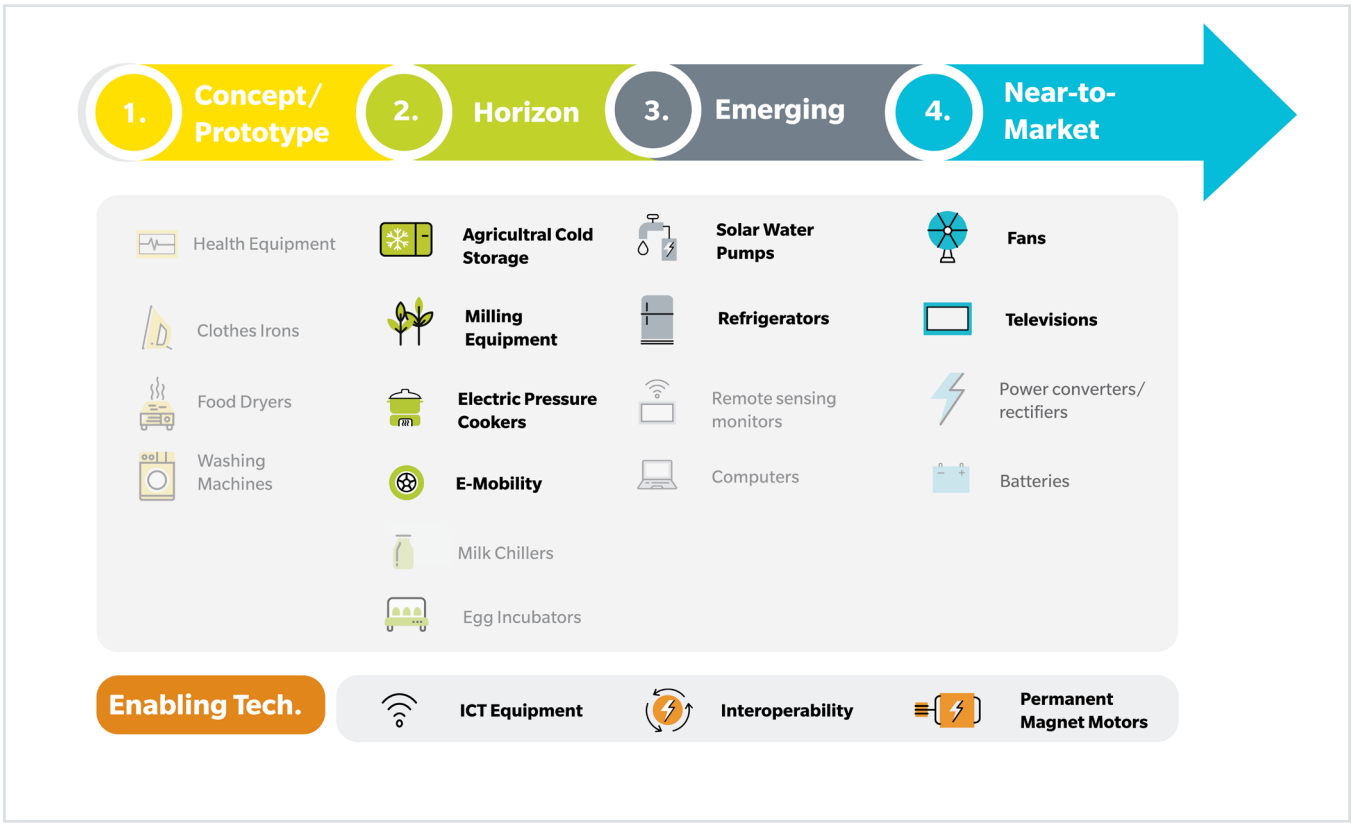
Since then, the off-grid appliances market has matured, bringing concepts like "productive uses of energy" to the forefront of the energy access dialogue. The sector continues to push towards bigger, bolder innovations to enable appliances with higher power requirements to be used with stand-alone solar systems. At the same time, new business innovations such as pay-as-you-pump are also helping to make prohibitively costly appliances like solar water pumps affordable to more people.

Interest in the off-grid appliances market is growing, particularly as the market and product offerings expand. For example, the Efficiency for Access Donor Coalition has collectively invested over £278 million in the high-performing appliances space, and seeks to move existing off- and weak-grid appropriate solutions further along the market development continuum. To support this continued knowledge sharing effort, Efficiency for Access and partners have assembled a wealth of information on relevant appliances and enabling technologies.

Our Solar Appliance Technology Briefs synthesise this latest market intelligence and chart the pathway to commercialisation for the technologies most likely to catalyse energy access and achieve the UN Sustainable Development Goals (SDGs). The Briefs have been released in groupings based on our assessment of their relative market maturity: near to market (fans, TVs); emerging (solar water pumps; refrigerators); horizon (walk-in cold rooms, electric pressure cookers, milling, e-mobility); and enabling technologies (interoperability, information communications technology (ICT), permanent magnet (PM) motors).

The categorisation of these technologies (Figure 1) is broadly based on best-available quantitative data (e.g., number of companies in the marketplace, global sales volumes, product performance data, and investment capital) and qualitative data (e.g., stakeholder interviews and on-the-ground learnings). We recognise that this grouping is somewhat subjective and may overly simplify national or regional nuances. However, grouping by relative maturity can help better characterise the market for similar product classes and identify common next steps.

Figure 1. Market maturity assessment of solar appliance technologies included in the series



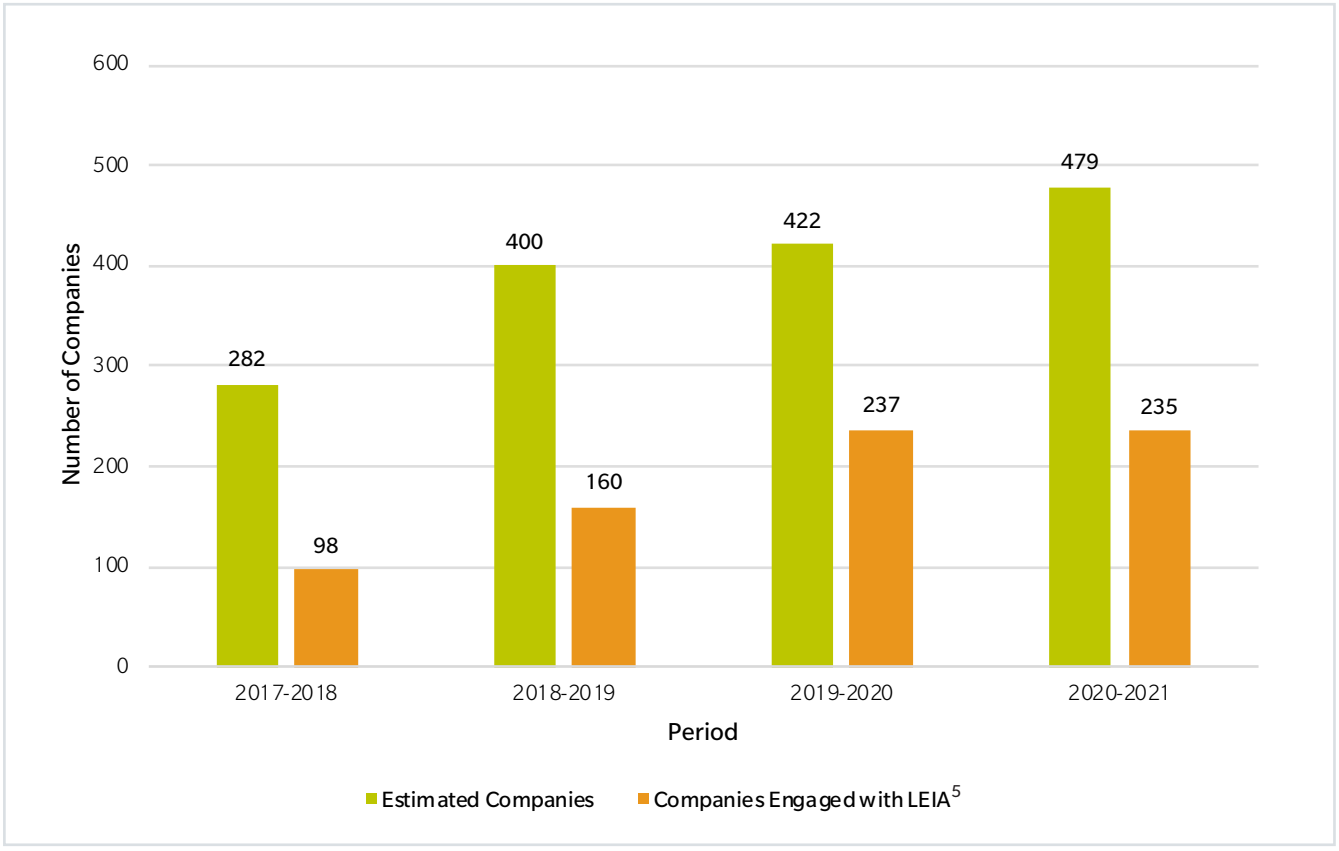
Successes & Progress to Date

The market for solar-compatible appliances and technologies has developed rapidly since the first iteration of the LEIA technology summaries. Some of the predictions we made came true: the 2017 solar water pump technology summary identified advances in brushless direct current (DC) motors, pay-as-you go (PAYGo) firmware and GSM-enabled systems as innovations that would improve performance and affordability for small hold farmers. The solar water pumps in today's market incorporate them all.

Some unforeseen successes – new trends and technologies alike – have emerged as shining examples of the sector's capacity to innovate and scale. Electric pressure cookers (EPCs)—a technology not considered an off- or weak-grid appropriate advanced cooking solution in 2017—demonstrate the most surprising uptick in innovation and demand. Consumer feedback from mains-connected homes to mini-grid users has been overwhelmingly positive, with convenience cited as the greatest benefit. Global LEAP Awards financing catalysed the procurement of 4,806 EPCs by six early mover distributors in Kenya from May 2020 to October 2020. For comparison, total EPC sales were estimated at 7,100 in 2018.[1]

The number of companies selling off-grid appliances provides the most telling proof that the market is blossoming. There is evidence that the diversity of brands and models available on the market for more mainstream products has also increased. In 2018, only 34 GOGLA members (44% of membership) sold appliances or productive use technologies. In 2020, this number jumped up to 72 (65% of membership).[2] The adoption and integration of appliances in SHS bundles offered by distributed energy service companies (DESCOs) has helped to lower prices, enabling energy access and driving demand for quality products. The estimated number of companies that are active in the solar appliance sector is 479, up from 282 from four years ago.[4] This growth in brands and models alike means increased competition, innovation and most importantly, greater consumer choice.

Figure 2. Estimated Number of Companies Operating in the Solar-Compatible Appliances Market (2017-2021)



1. ESMAP, The State of Access to Modern Energy Cooking Services. Washington, D.C.: World Bank Group. 2020, 85, http://documents.worldbank.org/curated/en/937141600195758792/The-State-of-Access-to-Modern-Energy-Cooking-Services.

2. GOGLA is the global association for the off-grid solar energy industry. Established in 2012, GOGLA now represents over 180 members as a neutral, independent, not-for-profit industry association. Their services assist the industry to build sustainable markets and profitable businesses delivering quality, affordable off-grid electricity products and services to as many customers as possible across the developing world.

3. This estimate includes all manufacturers, distributors, technology developers and service providers for off-grid fans, televisions, refrigerators, solar water pumps, agricultural processing technologies, electric cookers, plus IoT and interoperability solution providers targeting those appliances, within the LEIA database.

4. The number of companies active in LEIA appliances in the baseline included both manufacturers and distributors of off-grid fans, televisions, refrigerators, and solar water pumps. This included companies which had participated in Global LEAP Awards competitions, companies whose products were identified from market scoping, and via information received from GOGLA on their members that manufacture and/or distribute appliances. No work was done in the baseline to distinguish companies that manufacture low energy appliances from standard appliances.

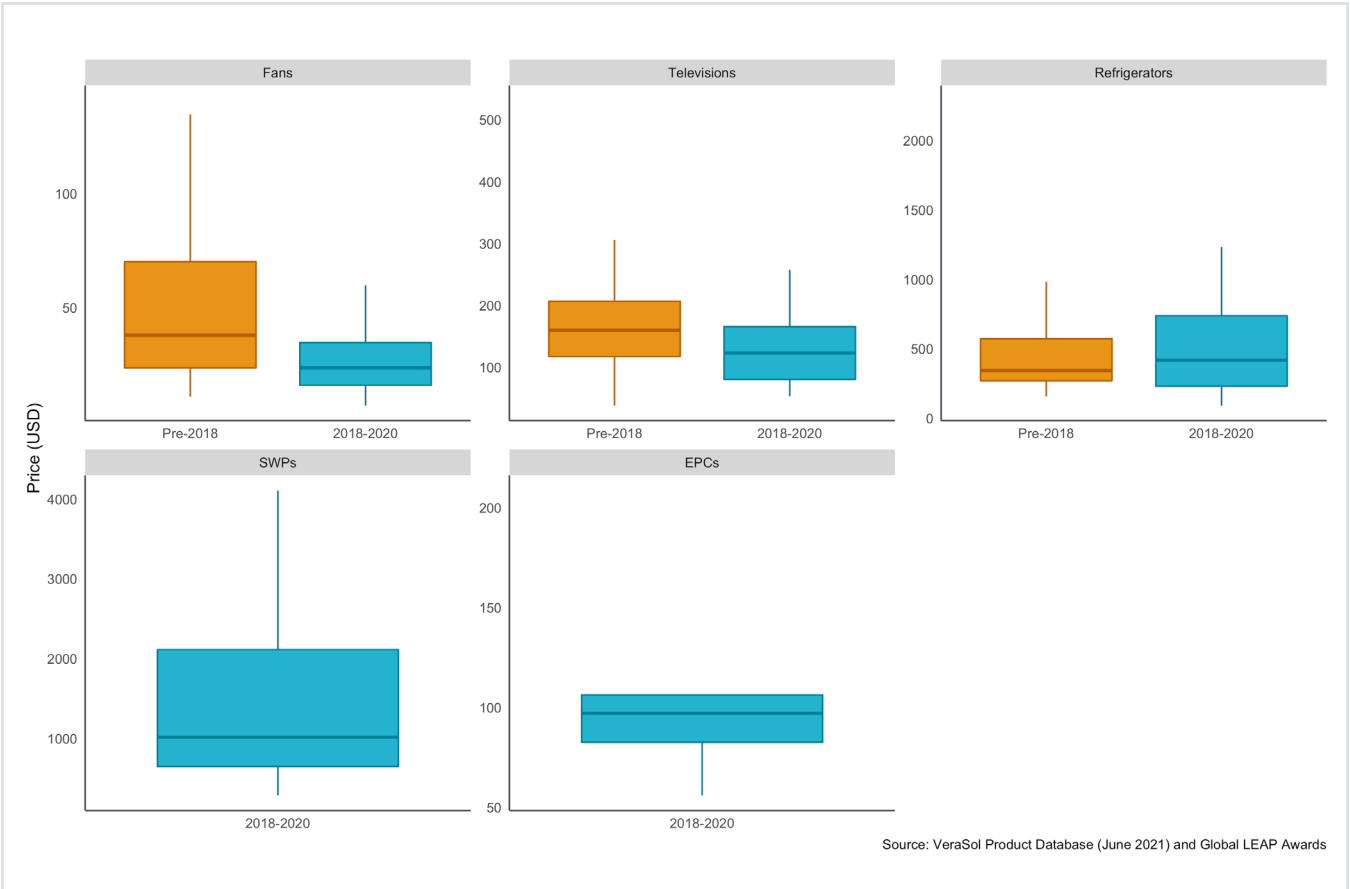
5. Based on the number of companies responding to the GOGLA annual survey.

Declining prices have helped move smaller, more mature household products to full commercialisation. Average fan prices dropped 47% over a two-year period, becoming even more affordable for off-grid consumers, and signifying that the off-grid fan market has become highly commoditised and competitive (Figure 3). As anticipated in the 2017 technology summaries, improvements in price and efficiency unlocked further demand for fans. In 2019 alone, GOGLA affiliates reported selling 670,000 off-grid fans globally, with the majority sold in Bangladesh India and Pakistan. TVs show a similarly positive trend – GOGLA affiliates sold an estimated 475,000 TVs in 2020, compared to just 8,500 refrigerators. However, relatively low prices and high efficiency do not necessarily result in mass adoption: estimated TV penetration in 2019 stood at 66% in India and 35% in Sub-Saharan Africa (SSA); in rural SSA, it falls to just 18%.[6]

Without financing improvements, the mismatch between sales and market potential for less mature technologies will persist. Current solar water pump sales, 11,400 units in 2020,[7] pale in comparison to the estimated serviceable market of 700,000 African households.[8] Kenya, a flourishing off-grid market, is leading the pack, but solar water pump penetration is still low. There are 9 million small hold farmers in Kenya. However, only 12% of Kenyans own a solar appliance, and only 1.5% of this group (35,000) own a solar water pump.[9]

The cumulative global market potential for off-grid refrigerators is expected to grow by 10% each year as affordability and efficiency improve.[10] In East and West Africa, regions with strong latent demand, refrigerators were the only appliance that did not see a decline in sales in 2020, even amid the COVID-19 pandemic.[11] However, only 68 million households, 15% of all off- and weak-grid households, are currently able to afford a typical off-grid refrigerator.[12] Inclusive finance options could help make products more accessible to families in need of reliable cooling technologies and drive greater market growth.

Figure 3. Appliance Price (Retail and Estimated) for Five Appliances Discussed in the Briefs (2014-2020)



6. Efficiency for Access, State of the Off-Grid Appliance Market Report. (2019, 9): https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report.
7. See GOGLA, Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data H1 2020. 2020, 15: https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2020-sales-and-impact-data and GOGLA, Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data H1 2020. 2020, 9: https://www.gogla.org/global-off-grid-solar-market-report
8.. Efficiency for Access, Solar Water Pump Outlook 2019: Global Trends and Market Opportunities. 2019, https://efficiencyforaccess.org/publications/solar-water-pump-outlook-2019-global-trends-and-market-opportunities.
9. Data from a forthcoming Efficiency for Access on consumer perspectives on product quality in Kenya.
10. Efficiency for Access, State of the Off-Grid Appliance Market Report 2019, pg. 34.
11. GOGLA, Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data, H1 2020. 2020, https://www.gogla.org/global-off-grid-solar-market-report.
12. Efficiency for Access, State of the Off-Grid Appliance Market Report. 2019, https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report.

BOX 1

Energy Efficiency

THE KEY TO CONTINUED MARKET GROWTH & SUSTAINABILITY

High performing, energy efficient appliances minimise costs to the consumer. Efficiency for Access has documented impressive efficiency improvements over the last four years, primarily in near-to-market appliances. According to market samples:

- Average off-grid TVs efficiency has improved by 149% since 2018.[13]
- Fan efficiency improved by 49% over a one-year period, likely driven by the adoption of energy-efficient permanent magnet (PM) motors.[14]

As the markets for TVs and fans mature, manufacturers can take advantage of increasing economies of scale. Some companies are now integrating once costlier, more efficient improvements like LED screens into their product line.

Emerging appliances have also demonstrated efficiency improvements in recent years. 2019 Global LEAP Awards Refrigerators Competition winners were 18% more energy-efficient than the 2017 winners. Refrigerators sampled from local retail markets improved by 36% over the same period.[15] Despite these promising trends, a 64% gap in efficiency remains between high performing Global LEAP Awards products and market samples, meaning access to affordable, good-quality products is a bottleneck for many customers.

Improving energy efficiency is a major focus for many horizon technologies. These products can be technically complex and have higher power requirements than the first wave of off-grid appropriate appliances. However, innovations like PM motors and direct drive mechanisms with variable speed inverters can increase efficiency. The price of these efficiency improving components will likely continue to decline due to technological innovation, market development and targeted support. For example, the higher upfront cost for PM motors can be mitigated through standardisation of appliance architecture and manufacturing processes.[16]

13. Efficiency for Access, 2021 Appliance Data Trends. 2019: https://efficiencyforaccess.org/publications/2021-appliance-data-trends.
14. Efficiency for Access, 2021. Solar Appliance Technology Briefs: Fans. 2021: https://efficiencyforaccess.org/publications/2021-solar-appliance-technology-briefs
15. Efficiency for Access, 2021. Solar Appliance Technology Briefs: Refrigerators. 2021: https://efficiencyforaccess.org/publications/2021-solar-appliance-technology-briefs.
16. Efficiency for Access, The Benefits of Permanent Magnet Motors: Efficiency Opportunities in Off- and Weak-Grid Markets. 2020: https://efficiencyforaccess.org/publications/2019-state-of-the-off-grid-appliance-market-report.

Larger, more complex productive use appliances have arrived, but are they ready to take off? New technologies and business models have emerged since LEIA launched in 2017. With greater diversity, the sector can now tailor an ideal off-grid configuration for a variety of resource and geographic settings. However, the landscape for larger productive use equipment, such as cold chain technologies, remains complicated. The 2017 summaries explored advanced refrigeration solutions as a whole. In this iteration, we singled out walk-in cold rooms as a crucial part of a cold chain. Cold chains complicated and involve multiple stakeholders like farmers, aggregators, transportation companies, warehouses and processing centres. Solar powered cold room technology and business models are showing promise, but the market remains nascent with estimated sales of fewer than 1,000 units across South Asia and SSA.[17]

Some technologies that seemed far away in 2017 are now ready for adoption—none more than PM motors, which are gaining traction in different applications. The 2017 Summaries estimated that brushless direct current (BLDC) motors (a subset of PM motors) comprised less than 1% of the total market for motors by the end of 2017. The off-grid solar market is poised to grow significantly in the coming years. Appliance manufacturers are soon expected to adopt PM motor technology in higher value products. For example, as of June 2021, 32 out of the 34 solar water pumps listed in the VeraSol Product Database use BLDC motors. In SSA, the penetration rate ranges from 4% for fans (expected to reach 6% by 2025) to 60% for solar water pumps (expected to reach 100% by 2025).[18]

Interoperability is still a nascent concept, but investments now could yield large gains for the sector. There is an ongoing digital transformation of off-grid energy systems as a result of R&D, including smart meters, energy management systems and PAYGo with parallel supportive and enabling technologies such as internet of things (IoT). Interoperability enables energy systems and devices to operate in harmony in the same environment (e.g., on the same energy supply). Interoperability also unlocks a number of environmental and social benefits. By reducing the risk of technology obsolescence, it drives reduction in e-waste and appliance dumping. It can also improve repair and maintenance networks. High levels of interoperability across systems can greatly increase the value of trained skills by making them more "portable" across a wide range of equipment and systems. Together, these benefits coupled with consumer protection measures create a more equitable and sustainable ecosystem.

Standards will gradually improve the overall performance and cost of interoperable devices. Bespoke components add to manufacturing costs. Standardisation allows systems providers to benefit from economies of scale. Consumers benefit from increased flexibility and a market where competition is based on the best value proposition, determined by quality and price. Whilst specific standards for distributed energy systems are few in number, they continue to be developed. The Institute of Electrical and Electronics (IEEE) standard 1547 and P2030 provide technical specifications on interoperability in smart grids. A white paper developed by Efficiency for Access and GOGLA recommends a starting point, The Connect Initiative, to develop a suite of interoperability standards for 12V DC connectors and PAYGo communication protocols.[19]

Increasing use of ICT technology, including IoT, can play a significant role in improving efficiency, productivity and sustainability. The expansion of the associated brief's scope from IoT in 2017 to ICT allows for a more holistic overview of technologies that enable off- and weak-grid communications, including relevant sector contexts such as health and education. ICT equipment in healthcare (e.g., telemedicine and e-health) can improve access to care and medical information, improve diagnosis (e.g., using mobile technologies as low-cost diagnostic tools) and provide remote health worker training. Solar water pumps (SWPs) paired with sensors and IoT can predict weather and schedule pump run times—reducing labour inputs, optimising pump performance, improving farm production and enhancing water management.

The horizon for off-grid appropriate appliances, equipment and enabling technologies is expanding. A number of the technologies included in this series were not included in the previous iteration. This trend is reflected by the growing support from the Efficiency for Access Coalition donors – and beyond – for a wider range of off-grid technologies. In 2018, just over half of Coalition members had agricultural processing in their portfolio; this figured has jumped to 87% in 2021. Milling, for example, represents the largest single use of stationary energy in off-grid areas. Several new companies have entered the electric milling market developing solutions at all scales from grinders to micro-mills and community level mills. Likewise, e-mobility was not supported by Coalition members until 2020, but now a third of members focus on e-mobility and transport. Given the lack of transportation infrastructure to support growing productive use applications in off- and weak-grid contexts, the soaring lithium-ion (Li-ion) battery market is finally making it possible to grow the micro-e-mobility sector, with innovative business models allowing for lower consumer fees and flexible PAYGo options helping to translate these technologies to rural areas.

17. India has over 7,000 cold storage installations estimated to be in place, but the majority of these are on-grid applications, and it remains difficult to estimate how many might be in an off- or weak-grid setting.
18. Efficiency for Access, State of the Off-Grid Appliance Market Report 2019.
19. GOGLA, The Connect White Paper. 2020: https://www.gogla.org/resources/the-connect-white-paper.

Current Challenges & Opportunities

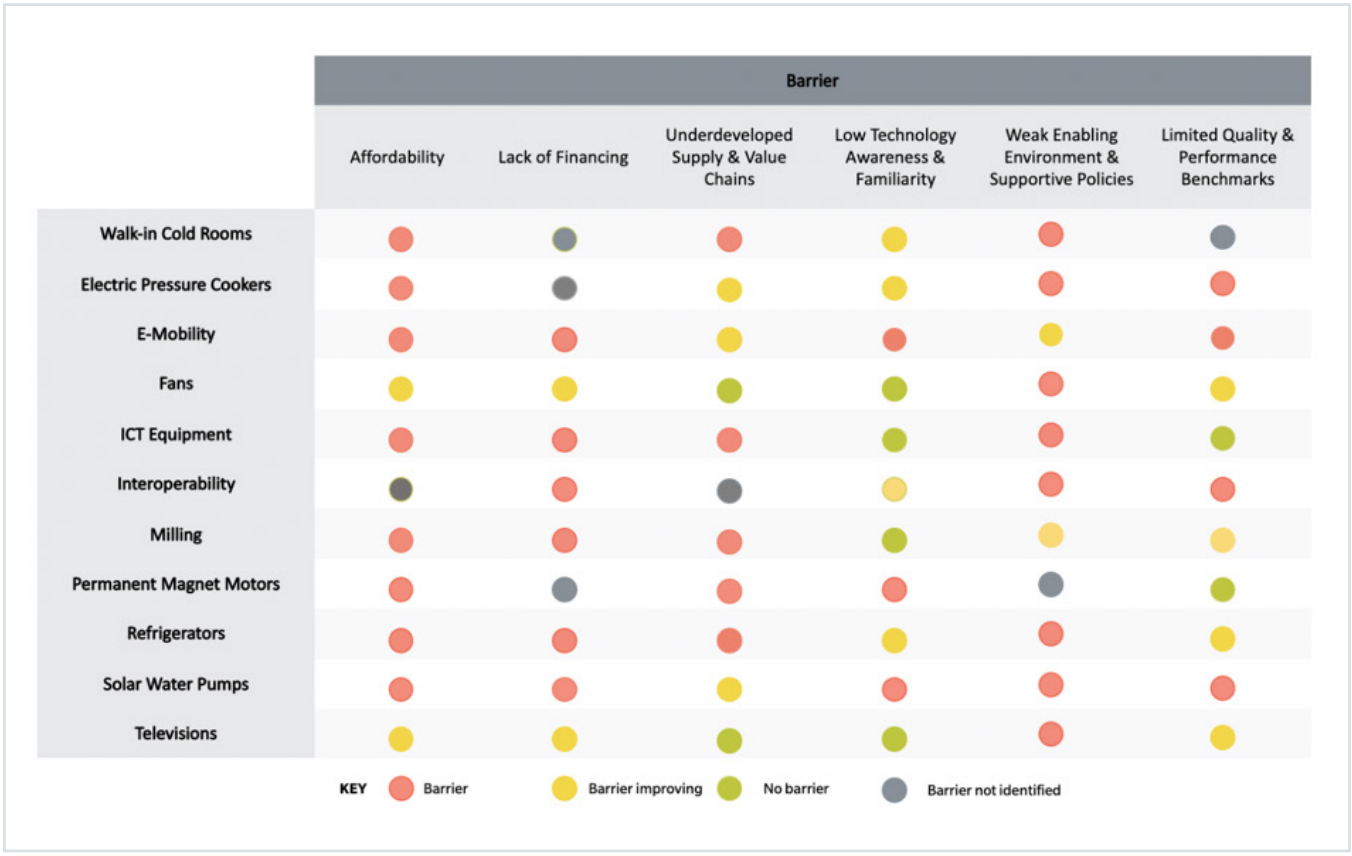
Although the fast-moving distributed energy and appliance sectors have come a long way in the last few years, it still has a way to go before a suite of affordable, high-quality and durable appliances will be readily available for communities in resource-constrained settings, from the first mile (e.g., the farmer) to the last mile (i.e., the customer).

Regarding broad sector funding, the Efficiency for Access Coalition has channeled £278 million over four years to support the uptake of high-performing off-grid appropriate appliances. There has also been a modest uptick in private capital flowing to companies operating in this space. Investors, however, are still cautious as nascent companies rely mostly on grant funds to enable them to trial new business models and fund their R&D. More grant funding and high-risk capital are critical to support the companies operating in these markets and to develop the enabling environments they need to thrive. And as these funding decisions are made, the end-user must be front and centre to create lasting solutions. People who live far away from end users make the majority of funding and programme design decisions. This dynamic is not likely to change in the near term. More needs to be done to base decisions on actual rather than perceived needs.

On the technology front, a number of interventions are needed to address a wide range of barriers. And whilst each technology has its own flavor of successes and challenges, looking at them collectively allows us to identify a number of persistent, common gaps, like the top barriers listed in Figure 4.

Affordability remains the most significant barrier, especially for larger, more complex appliances with more specialised use cases. High upfront product cost and lack of consumer financing are a top barrier in all but one of our technology briefs – interoperability – and many identified having to sacrifice either the performance or the efficiency aspect of product design when attempting to bring down costs. Affordability continues to be a double-edged sword impeding market growth: for companies, the inability to access working capital and financial investment, exacerbated by the COVID-19 pandemic; for consumers, a lack of end-user financing to make appliances attainable. Volatile market prices for rare components and materials can also impact the consistent affordability or prevalence of certain technologies such as PM motors and e-mobility.

Figure 4. Barrier Matrix for the 11 Technologies Included in the 2021 Summaries



A lack of financing options is still prevalent in the sector, but technologies big and small stand to benefit from the positive effects of appropriate subsidies and incentives. Programmes like the Global LEAP Results-Based Financing Mechanism play a critical role in assisting the development of these emerging markets and in expanding access, especially amongst marginalised groups, like women. Quality-based eligibility criteria used in conjunction with performance assessments and after-sales service guarantees attract companies with long-term market commitments; enable the extension of credit and more favourable credit terms to consumers; diversify energy service offerings that stimulate energy demand and mini-grid use; and accelerate sales and marketing efforts.

Underdeveloped supply and value chains in high potential markets at the last mile are a common concern for all appliances. These challenges make it difficult to achieve satisfactory unit economics to justify expansion of channels to reach and service rural consumers: top issues cited include lack of equipment manufacturers that sell high quality products at an affordable price and complicated supply chain logistics. For some larger-scale appliances like solar mills, a viable catchment area both in terms of quantity of cereals and presence of enough customers is also a necessary factor in making the economics work. The same issue holds true for ICT equipment, where mobile service providers find installing cell towers in sparsely populated, rural and remote areas unprofitable.

For certain products, it can be prohibitively expensive to convert sales and provide maintenance, especially at the last mile. Selling, installing and maintaining productive use equipment all require expertise, particularly to optimise performance through installations that consider additional system input. For solar water pumps this includes water quality, weather and distance to crops and water sources. These challenges can be magnified at the last mile, where a lack of capacity and trained technicians.

Low customer awareness and familiarity with off-grid technologies remains a hurdle to sales growth. This holds true for many products, regardless of their relative market maturity. For example, we interviewed 400 commercially oriented farmers in Tanzania. Whilst most irrigated their land, there was very low awareness of solar pumping technology and no uptake.[20] Even if we address distribution and affordability issues, we will not see a conversion to sales unless efforts are made to better inform consumers of the choices available in the market.

The sector needs harmonised quality and performance benchmarks that enable accurate product quality and performance comparisons. Lack of quality benchmarks make it difficult for stakeholders to compare and differentiate the quality of fans and TVs independently from solar home system (SHS) kits. Supporting the development of quality assurance (QA) frameworks, which includes developing standardised product testing approaches, quality criteria and sharing test data, for near-to-market technologies can be an important first step towards closing the information gap on product performance and quality. Programmes like the Global LEAP Awards and VeraSol are working to expand test methods, quality assurance frameworks and supporting policies for a growing number of off-grid appropriate appliances and equipment.

A stronger enabling environment and market-supportive policies can help the market develop further. In many countries, manufacturers face high and varying VAT and duty rates. Supportive policies, like quality criteria and minimum energy performance standards, can level the playing field for manufacturers and distributors of high-performing products. Governments can impose new policies, improve existing policies and develop strategies (e.g., reduce import taxes, tariffs and value added taxes, standards and labeling) to incentivise uptake of high-quality, energy-efficient products. For example, in its Finance Act 2021, Kenya recently reintroduced the VAT exemptions on solar products – a significant success for the sector.

On that note, no man, or appliance, is an island: in order to reap the most benefits from access to modern energy services and equipment, we cannot look at each technology in a vacuum. In most cases, sector silos reduce the efficacy of food security (energy-agriculture-water sectors) or healthcare outcomes (energy-health-infrastructure sectors). For others, increased partnership and engagement within individual sectors is key. For example, underdeveloped EPC supply chains are likely to become more established as they are adopted into offerings by energy companies and utilities. Likewise, establishing a dedicated body to unite actors from distributors and financing agents to parts manufacturers, and coordinates supply chain activities could greatly enhance the efficiency and responsiveness of cold chains.

20. Efficiency for Access, Tanzania Market Snapshot: Horticultural Value Chains and Potential for Solar Water Pump Technology. 2018: https://efficiencyforaccess.org/publications/tanzania-market-snapshot-horticulture-value-chains-and-potential-for-solar-water-pump-technology.

Some technologies, whilst highly desired, are not yet fully feasible in the off-grid context. Electric cooking is a striking example: off-grid e-cooking is viable only with a large power source not commonly sold or easily accessible to off-grid consumers. All Global LEAP Awards EPC Competition finalists were AC products. According to a baseline survey conducted as part of the corresponding results-based financing mechanism, only 20% of customers used the EPC with a solar energy source. Our forthcoming report on the use and benefits of EPCs found that growth in the off- and weak-grid e-cooking sector could yield significant benefits for customers. In a survey of 400 EPC customers, 86% of respondents found their EPC to be a "good" or "very good" value for money and 100% were able to reduce the time they spent cooking.

For other products, the path to deployment is incredibly complex. For example, finding a partner farm that could support the setup of walk-in cold rooms, an off-taker who can aggregate produce from smallholder farms and support navigating customs and sourcing components are needed for local installation. These needs make walk-in cold rooms difficult to incorporate into product supply chains that move through many different sets of hands. Whilst this is just one example of a model for walk-in cold rooms, other options are similarly complex.

Lastly, knowledge is power. Limited market intelligence and reliable data sustain market opportunity and impact knowledge gaps for all technologies regardless of their market maturity. As we conduct and analyse more field testing and research, access to data can help stakeholders understand appliance performance, market conditions and consumer impacts: for example, field testing of refrigerator use cases is leading to the development of a more appropriate test method; feedback from consumer research is leading Efficiency for Access – and companies participating in its Solar Water Pump Technology Working Group – to focus more on durability.

BOX 2

Inclusivity

DESIGNING ACCESSIBLE PRODUCTS FOR ALL

Usability and accessibility are important considerations for manufacturers. Usability requires manufacturers to understand customer behavior and preferences, as well as their gender and cultural context. For example, women are often both the primary cook and decision makers in purchasing an EPC. Understanding their unique needs is thus an important component to successful product design. Manufactures may also wish to design more accessible products. For example, diesel mills are labour-intensive to operate and can inhibit the participation of people with disabilities. Solar mills with push-start button mechanisms can instead help lower use barriers.

Through programmes like the Global LEAP Awards and the Efficiency for Access Research and Development Fund, we are working to strengthen usability and accessibility in the market. For example, the 2020 Global Awards EPC Competition Usability Testing Buyer's Guide highlights products that effectively reflect the needs of the everyday cooks using the appliances. Usability testing complements the performance and safety laboratory testing process by deploying EPCs into the kitchens of Kenyan households, measuring appliance performance under real-life conditions, and inviting everyday cooks to provide feedback on their experience. he Efficiency for Access Research and Development Fund's 2020 Enabling Technologies Call provided funding for projects or products with a focus on inclusivity, with many resulting projects predominantly benefiting women. Among these, PEG Africa combined refrigeration solutions with affordable financing, allowing female entrepreneurs to access high-quality refrigeration products and services easily. The project has helped small businesses in Ivory Coast and Senegal to increase revenues.

WHERE SHOULD THE SECTOR GO FROM HERE?

Since 2017, technology and business model innovations, new market entrants, and increased financial support has led to market growth for the off-grid sector. There are plenty of reasons to be optimistic and assume that if we revisit these technologies in four more years we will have continued with steady progress. However, this growth is uneven across technologies and geographies, and COVID-19 and climate change are exacerbating long-standing global inequities. For example, 2% of the world's 789 million people without grid electricity live in Kenya, yet solar appliance sales in Kenya currently represent 29% of the global share. Whilst this is a success story, this largest market is still relatively small, and its success needs to be replicated in more markets – and fast – for a true step change.

There is no appliance that is close to reaching market saturation—new partnerships, more funding, and continued innovation are critical to get more appliances in the hands of consumers and close the energy access gap. It is time to double down on global energy access efforts. Achieving 100% global electrification is not ambitious enough; we need to make sure that people have appliances they need to access cooling, connectivity, communications, mechanisation and mobility that will improve outcomes for health, education, productivity, and livelihoods.

A suite of high-level recommendations are summarised in Table 1. These recommendations cut across all 11 briefs and suggest a path forward for the off-grid appliances market and its supporters. For further details, you may access all of the Technology Briefs here.

Table 1: Summary of Recommendations

ISSUE	SUMMARY OF GAPS	RECOMMENDATIONS

Affordability	• High upfront cost
	• Difficulty balancing efficiency, performance and cost
	• Lack of consumer financing
	• Companies struggle to access working capital and financial investment
	• Volatile market prices for components and materials
		• **Interweave relevant consumer resources for appliance co-benefits** and connect end users with the services that adjacent sectors provide to maximise impacts from productive uses (e.g., seeds, farmer training).
		• **Enable access to investment capital** to allow more companies to grow or demonstrate proof-of-concept for bigger appliances, thus enabling commercial investment in productive use companies.
		• **Support viable financing schemes and experiment with business models** to address affordability challenges and reduce financing risks. Examples include:
		  • Providing business support when entrepreneurs purchase productive use appliances
		  • Leasing or shared, communal use
		  • PAYGo for specific appliance use cases (e.g., "pay as you grow", "pay as you cook")
		  • Incorporating interoperability within PAYGo
		  • Risk guarantee funds
		  • Off-taker setups
		  • Utility-enabled appliance financing
		  • Guarantee funds for end-user finance
		  • A direct line of subsidy accessed from governments

RECOMMENDATIONS AND PATHWAY TO SCALE

ISSUE	SUMMARY OF GAPS	RECOMMENDATIONS
Lack of appropriate subsidies and incentives	• Lack of quality-based eligibility criteria • Few incentives are paired with performance assessments and after-sales service guarantees to attract companies with long-term market commitments • Energy service offerings are not diversified enough to stimulate energy demand and mini-grid use and accelerate sales.	• **Put in place more RBF mechanisms and subsidies coupled with quality assurance** to expand global product markets and increase affordability for end users. Demand stimulation will be the most expedient way to scale off-grid appliance markets. • **Invest in sustainable funding models for public good technologies**, from ICT to agro-processing equipment, as many productive use appliances are a good candidate for government and donor subsidies.
Underdeveloped supply and value chains in high potential markets	• Lack of equipment manufacturers that sell high quality products at an affordable price • Complicated supply chain logistics • Lack of viable catchment area re: customers or resources to make profit	• **Digitalise supply chains** to reduce transaction costs and delays. • **Establish strong supply chains and effective last mile distribution strategies** to reach more rural consumers, including a close-knit network of distribution points and sufficiently developed road infrastructure. • **Leverage big data and expand mapping efforts** to identify high-potential areas with appropriate resources and population densities for appliances like mills.
Prohibitive cost of converting sales and maintenance	• Persistent lack of capacity and presence of trained technicians for ease of installation and repair • Hard to optimise performance through installations that need to consider additional system inputs	• **Improve after-sales technical support** and build local capacity to carry out installation and repairs; support, where possible, local manufacturing capacity and supply chains. • **Develop capacity building programmes** to create a pool of technicians to provide after-sales services for solutions that may require regular maintenance or require expertise to service. • **Invest in remote monitoring and self-diagnostics** for more companies to enable predictive maintenance and improve repair processes.
Low customer awareness and familiarity	• Technology and provider lock-in and interoperability issues lead to low customer acquisition and the distribution and fewer consumer choices. • Persistent low awareness of solar technologies limit conversion to sales unless efforts are made to better inform consumers of the choices available in the market.	• **Launch consumer education campaigns** to increase consumer awareness of off-grid appliances and equipment, and stimulate demand. • **Consider incentives beyond subsidies** to switch from incumbent products, e.g., carbon financing; resilience metrics; putting a "price" on labour and time spent to translate time into economic growth potential. • **Centre customers in decision-making**. Feedback from real users can benefit design and servicing decisions, from appliance durability to aesthetic and cultural preferences to right sizing equipment.

RECOMMENDATIONS AND PATHWAY TO SCALE

ISSUE	SUMMARY OF GAPS	RECOMMENDATIONS
Lack of enabling environment and market-supportive policies	• High and varying VAT and duty rates • Little to no quality criteria or minimum energy performance standards or labeling programmes • Lack of standardisation inhibits interoperability	• **Support the development of quality assurance initiatives** such as VeraSol, appropriate standards and labeling programmes, and leverage smart subsidies to bridge the affordability and quality gap. • **Advocate for the creation and implementation of positive policy instruments and government schemes** that facilitate the uptake of nascent productive use technologies. • **Supportive import policies can level the playing field: governments can impose new policies**, improve existing policies, and develop strategies (e.g., reduce import taxes/ tariffs/VAT) that favour high-performing appliances.
Piecemeal approaches to technology dissemination	• Sector silos reduce the efficacy of food security or healthcare outcomes • Lack of partnerships within individual sectors leads to underdeveloped and localised supply chains • No dedicated body to unite stakeholders and coordinate supply chain activities	• **Implement holistic approaches** by developing joint policy papers, research and sectoral lobbying to enhance the regulatory environment for topics that sit across energy, agriculture, health and other relevant sectors. • **Increase partnerships and engagement with adjacent sectors** to benefit both sides by learning more about the entire ecosystem a given appliance fits into (e.g., water availability, soil conditions, fertiliser, seed banks, etc. for agricultural products). • **Increase engagement within the broader energy sector**, including utilities, to address interoperability and other challenges that will allow high-performing appliances to be used across energy systems.
Limited market intelligence and reliable data	• Knowledge gaps for all technologies regardless of their market maturity • Limited access to data to help stakeholders understand appliance performance, market conditions, and consumer impacts	• **Consider market intelligence for different aspects of "quality"**, from durability to standardisation of components to repairability. • **Increase R & D funding** to catalyse product innovation, integrate new or existing components that can be standardised, and develop business models. • **Look towards improvements beyond efficiency**, and tailor mass-produced products to specific off-grid location/ use case needs. • **Conduct more field testing and proofs of concept** to improve sector understanding of changing market dynamics and determine the "low hanging fruit" across diverse crop, culture, financial, geographical and demographic variables. • **Listen to the customer.** Manufacturers and distributors can use baseline survey data to design better products that meet consumers' needs in key markets and drive adoption. • **Leverage big data analytics and productivity modelling** to identify high potential markets for productive use appliances and conduct targeted marketing and tailor-made financial solutions.

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