EFFICIENCY FOR ACCESS

Supported by:

UK ENGINEERS WITHOUT BORDERS

Efficiency for Access Design Challenge

Challenge Brief 2021–2022

Funded by:

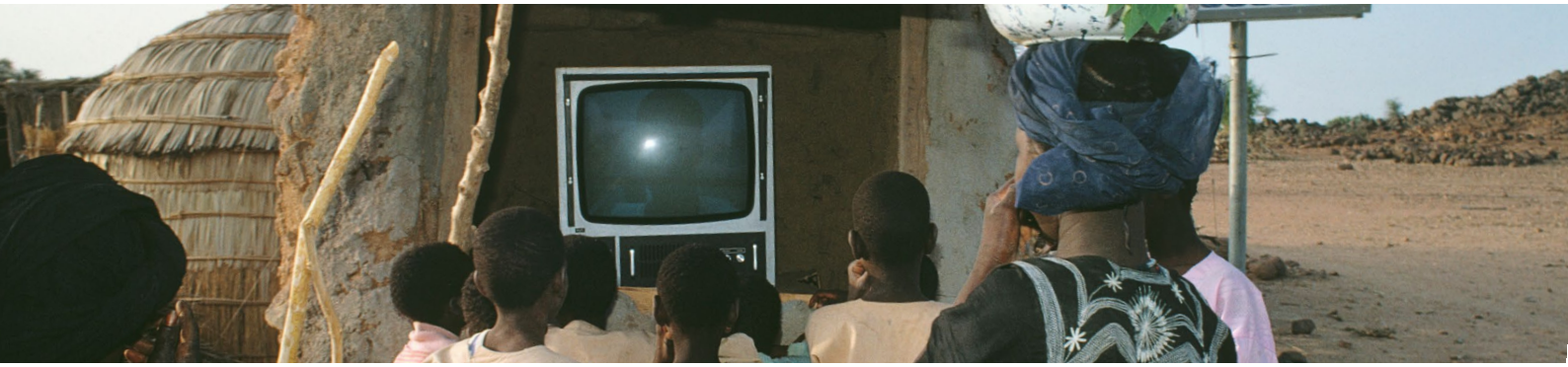
UKaid from the British people

IKEA Foundation

energy saving trust

Table of contents

3 Overview
4 Context
6 Scope of the competition
8 When does it take place?
10 Themes
11 Agriculture
13 Cooking
14 Refrigeration
16 Space cooling
17 Power management
18 Information and communications technologies
20 Healthcare
23 Other subjects
24 Globally responsible design
26 Student support
28 Assessment
29 Assessment framework
31 Contacts



Overview

789 million people live without access to electricity, or access to electric appliances that boost productivity or provide cooling, refrigeration and communications. What's more, the International Energy Agency estimates that a further 100 million people lost access to electricity due to the rising poverty levels resulting from the COVID-19 pandemic. The world is also facing a climate emergency and biodiversity crisis. While an estimated 441 million people have gained access to energy since 2010 alone, a further 660 million people will still not have access to electricity in 2030. As such, it is more important than ever to enhance access to modern energy services that are powered by renewable energy. We also need more innovators to create appliances that are truly accessible. That means we need to design products with, rather than for, the people who need them most. We must also consider the application of these products and how they can address vast inequalities in energy access worldwide.

The Efficiency for Access Design Challenge is a global, multi-disciplinary competition that empowers teams of university students to help accelerate clean energy access. To provide universal energy access, we urgently need to enhance the efficiency and affordability of high-performing appliances. The Challenge invites teams of university students to create affordable and high-performing off-grid appliances and enabling technologies.

Over the year, you have the opportunity to join students from around the world to design affordable and high-performing appliances and technologies for off- and weak-grid settings. The Efficiency for Access Design Challenge team is excited that you are part of the competition, and we are looking forward to the solutions you will submit.

This brief will enhance your understanding of clean energy access and off-grid appliances, helping you frame your project and design your solution.

The competition started in September 2019. In the second year of the competition, over 100 students from 15 universities in Bangladesh, India, Kenya, Sweden, Uganda and the UK participated, and they were supported by over 30 industry partners.

Details on the competition and more resources, including previous years' project submissions and a recording of the Grand Final, which took place online, are available here.

Context

The UN Sustainable Development Goals (SDGs) recognise that access to affordable, reliable and modern energy services is crucial to poverty reduction and sustainable agriculture.

Distributed clean energy technologies such as off-grid solar home systems and standalone solar mini-grids help people and enterprises access life-changing modern energy for the first time. The improvement and expansion of existing grid infrastructure will also play an important role in growing energy access.

According to the International Energy Agency, off-grid solar home systems and solar mini-grids are the most economical ways to reach over 66% of those expected to gain access before 2030 in Africa. As off-grid communities gain access to mobile phone networks, 'Pay-As-You-Go' (PAYGo) financing is helping households and businesses access affordable electricity flexibly. Customers usually pay an upfront deposit, with regular payments (often via SMS or mobile money), which enables them to buy a solar home system outright.

Solar Home Systems (SHSs) are stand-alone photovoltaic systems that offer a cost-effective mode of supplying power to remote, off-grid households. A solar home system typically includes one or more photovoltaic modules consisting of solar cells, a battery to store energy and a charge controller, which distributes power and protects the batteries and appliances from damage. Currently, a typical solar home system operates at a rated voltage of 12V direct current (DC) and provides electricity for low power appliances, such as LED light bulbs, radios and small TVs for about three to five hours a day.

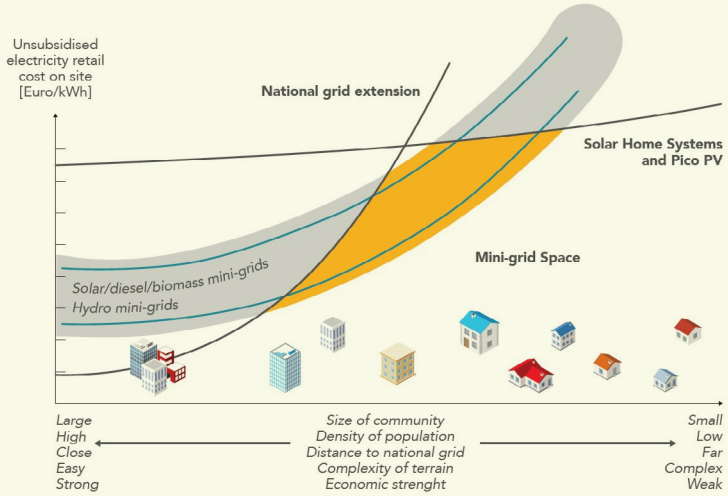
A mini- or micro-grid, can be defined as a set of electricity generators and possibly energy storage systems interconnected to a distribution network that supplies electricity to a localised group of customers. They employ small-scale electricity generation ranging from 10kW to 10MW. These are typically photovoltaic modules, micro-hydro and/or back-up generators, which serve a limited number of consumers via a distribution grid that can operate autonomously without being connected to a centralised grid, often referred to as a 'standalone'.

LEARN MORE

Kate Raworth's Donut Economics model, Donut Economics Action Lab, 2012

Engineering for Sustainable Development: Delivering on the Sustainable Development Goals, UNESCO, 2021

Opportunities for grid-extension, mini-grid and distributed renewable energy systems



Adapted from the EUEI PDF, Mini-grid Policy Toolkit, 2014.

This diagram shows the most economical way to achieve electrification in different settings. For dense, highly populated cities, grid extension remains the cheapest option, whereas for remote rural areas, Solar Home Systems are much more viable. There is a sweet spot in between where mini-grids appear to be the preferable options to power communities, living in villages for example. Source: Integrated Electrification Pathways for Universal Access to Electricity: A Primer, Sustainable Energy for All (SEforAll), 2019.

Conventional appliances consume too much energy to be used affordably with off-grid energy systems such as solar home systems and mini-grids. The combined energy demand of inefficient appliances can overload these energy systems, which contributes to load shedding and power outages.

Affordable and high-performing appliances are essential to delivering modern energy services to underserved communities around the world at the lowest possible economic and environmental cost. These services, in turn, provide great potential for social development, and recently, potential to build resilience in the face of the COVID-19 pandemic (Efficiency for Access Coalition, 2021). These efficient appliances can also help reduce greenhouse gas emissions by replacing incumbent power generation systems and lower demand for future carbon-intensive energy supplies.

Families who gain energy access are reducing their reliance on or completely eliminating, dirty, expensive and dangerous prior fuel sources. This has a positive impact for their health, reducing their exposure to fine particulate matter (PM2.5) by as much as 50–80%; and for the environment, reducing their CO_2e[12] emissions by close to half a tonne per year (60 Decibels, 2020).

Just as super-efficient LED technology has unlocked modern lighting for tens of millions of households and microenterprises, **super-efficient appliances** promise to unlock life-changing modern energy services. These include cooking, cooling, power management or refrigeration. However, more technological advancements and market development are still needed to reach this goal.

Over 90% of households that replaced toxic kerosene lamps with solar alternatives reported that they have experienced improvements in both health and of safety (GOGLA, 2018)

LEARN MORE

Research Snapshot, Efficiency for Access Coalition, 2020

2021 Appliance Data Trends, Efficiency for Access Coalition, 2021

Scope of the competition

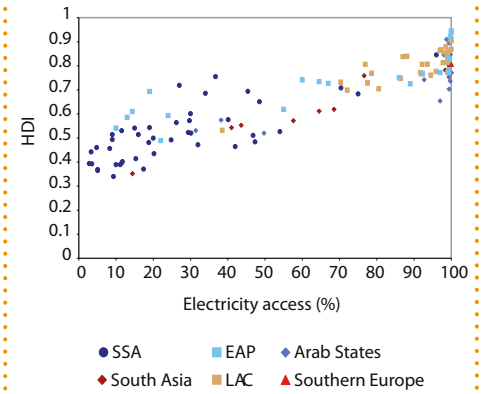
The Efficiency for Access Design Challenge is an opportunity for you to work at the forefront of energy access. You will be required to design affordable and super-efficient appliances that can be used in an off-grid context, e.g. powered by a solar home system or a mini-grid.

You will work on solutions in countries with the lowest rates of electrification and who critically need energy access. Focusing on Sustainable Development Goal 7 – Affordable and Clean Energy, please give special attention to communities with the lowest levels of energy access. Access to clean energy and other basic services is closely correlated with a country's position on the Human Development Index.

We are interested in affordable and efficient appliances that can help improve people's quality of life or increase business productivity. You must identify an opportunity for an appliance that can make a difference in people's lives. Your design should significantly improve on currently available solutions and have the potential to scale.

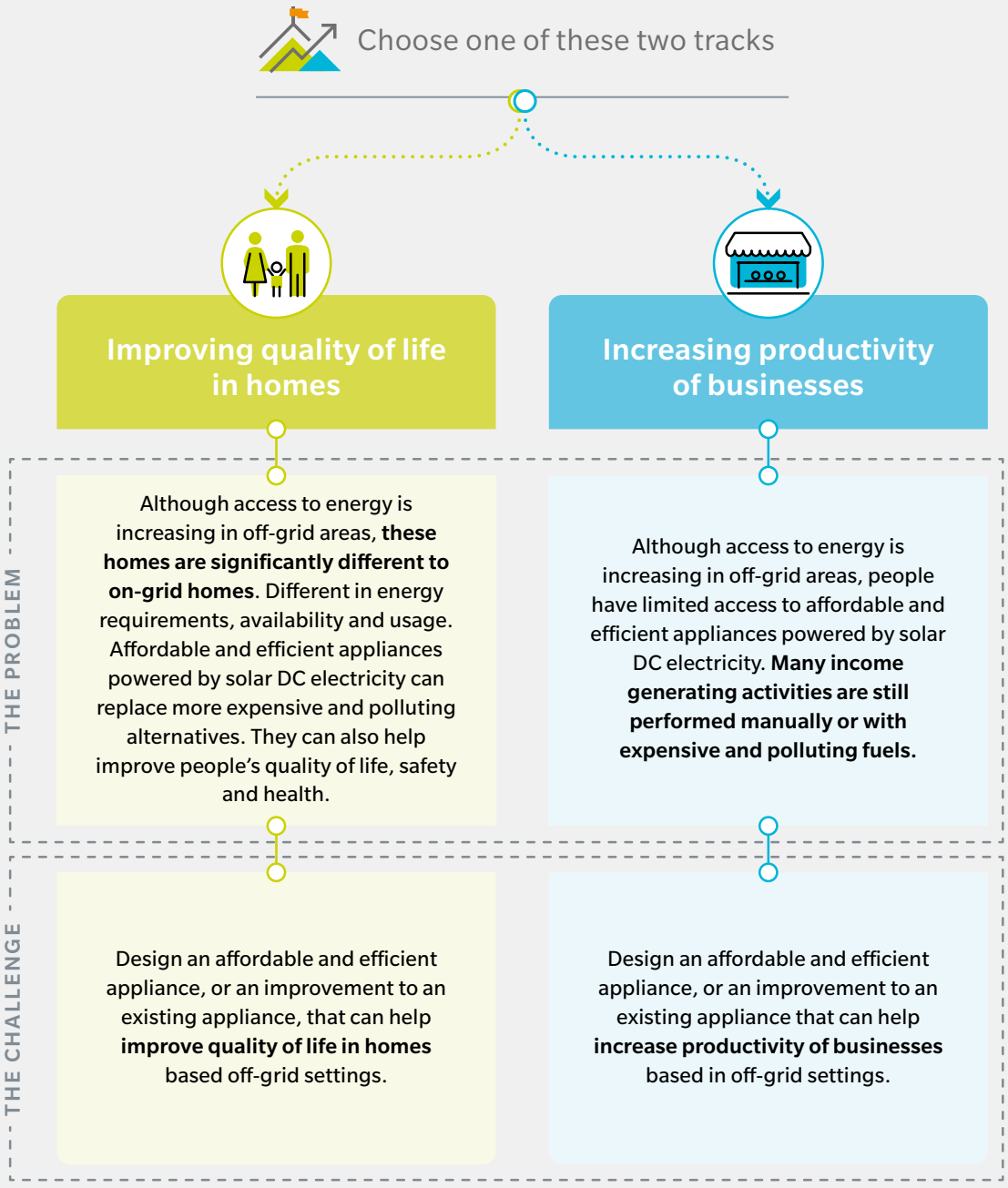
You can choose one of the two tracks represented in the diagram on the following page. A business can be anything from a micro-enterprise, a small business employing no more than 10 people, or someone working for themselves, such as a smallholder farmer, a small retail shop or a bar, to a medium enterprise. It is possible that some of your designs could cover both tracks. In this case, please indicate the main track your design applies to.

The focus is on energy consumption and the appliance's primary source of energy should be electricity (DC - Direct Current). The appliance should directly connect to a solar home system or a standalone DC mini-grid. You are not allowed to design an AC appliance, which connects to an inverter. Energy generation is also out of scope.



Human Development Index versus electricity access rate. (Source: The energy access situation in developing countries, 2009, UNDP and WHO.)

The UN Human Development Index (HDI) was created to emphasise that ultimate criteria for assessing the development of a country should lie in people and their capabilities, not economic growth alone. The HDI is a summary measure of average achievement in: a long and healthy life, being knowledgeable and having a decent standard of living.



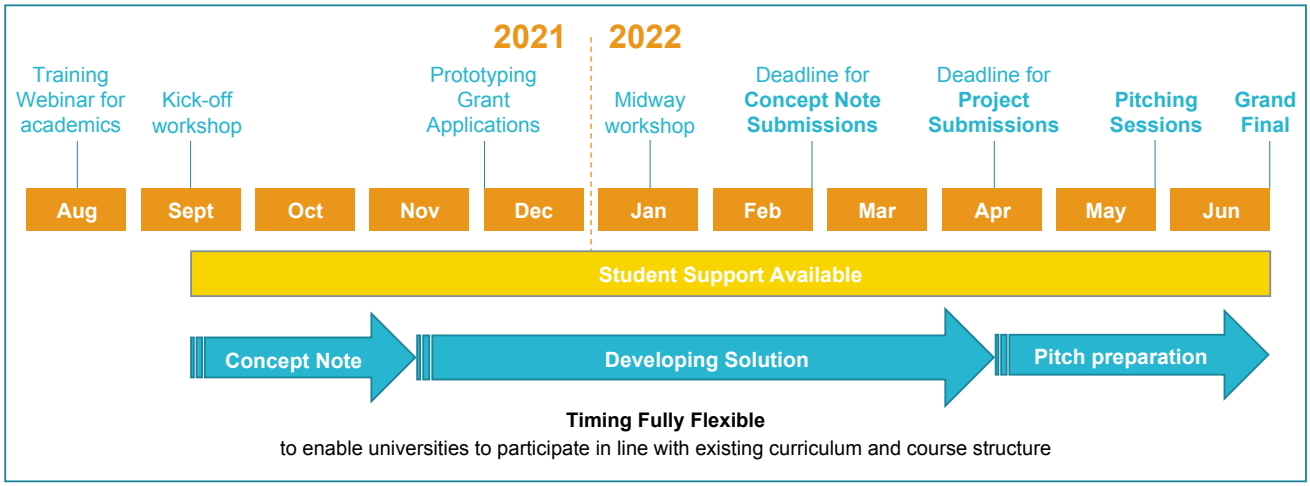
The "Themes" sections below outline several themes, which you could explore when formulating your problem definition. Each theme contains examples of projects that illustrate what you could develop. These themes represent the main trends in the off-grid appliances industry, but do not feel limited to them. You are free to choose your own theme, as long as you can clearly present the following:

- The intended end-user;
- Improvements offered on existing solutions;
- Intended impacts on the end-user's life;
- Sustainability of the design;
- Scalability of the design.

When does it take place?

The Efficiency for Access Design Challenge starts in September 2021 and ends with the Grand Final in June 2022. The timing of the Challenge is flexible, so universities can include the competition in existing curriculum and course structures. Universities decide whether to schedule the project to run over multiple terms or condense the participation period. We anticipate that students will receive credit for participation. The Efficiency for Access Design Challenge team is available to help universities embed the competition in existing curricula.

KEY DATES



The Challenge begins in September: projects can start at any point from September 2021 onwards (depending on your university curriculum). They should start with a digital **kick-off workshop** facilitated by the Efficiency for Access Design Challenge team.

Concept note

Your team should submit a concept note at any point from September 2021 onwards. We encourage you to submit your concept note within a month of the kick-off workshop. The deadline to submit the concept note is **28 February 2022**.

The deadline to submit the concept note is **28 February 2022**

The concept note should outline what your team plans to focus on and be no more than four A4 pages long. It will help the Efficiency for Access Design Challenge team understand how your team plans to approach the problem you want to work on, so that we can procure appropriate support. You will not be assessed on the concept note and it will not be used to decide whether your team can participate in the competition. When submitting the document, you will also sign up to the Challenge's terms and conditions. This concept note will also help the Efficiency for Access Design Challenge team identify a mentor from the off-grid industry sector, who will support your team in developing your project.

Concept note feedback

Within one month, we will provide feedback on your concept note.

Midway workshop

Halfway through the competition, the Efficiency for Access Design Challenge team will facilitate a digital workshop to support you in the design process and answer questions. Throughout the year, the Efficiency for Access Design Challenge team will provide support with regular check-ins to both universities and students. We will also help connect academics and industry partners. The team will organise a series of webinars for all universities, which will allow you to meet industry experts and learn more about off-grid appliances technologies.

Project submission

Your team should submit your project – a 4,000-word (maximum) report and a three-minute video by **Friday 15 April 2022**. Other supporting documentation can be attached to your submission, if deemed useful. These include posters or prototypes. Your team shall own the Intellectual Property of your work but will be required to give the Efficiency for Access Design Challenge team permission to use the research outcomes for a wider benefit. Agreeing to license your work under **Creative Commons license CC-BY 4.0 will achieve this**.

The deadline to submit your project is **15 April 2022**

Feedback

You will receive feedback on your submission in **May 2022**. You can use this feedback to prepare for the pitching session.

Pitching to a judging panel

Before the Grand Final, your team will pitch your project to a judging panel in a digital session in **May 2022**.

Grand Final

All students participating in the Efficiency for Access Design Challenge will be invited to the Grand Final, which will take place in **June 2022**. The Grand Final will showcase student teams' projects and prototypes and host an interactive panel discussion with experts in the sector. It will also include an awards ceremony that presents teams with gold, silver and bronze awards.

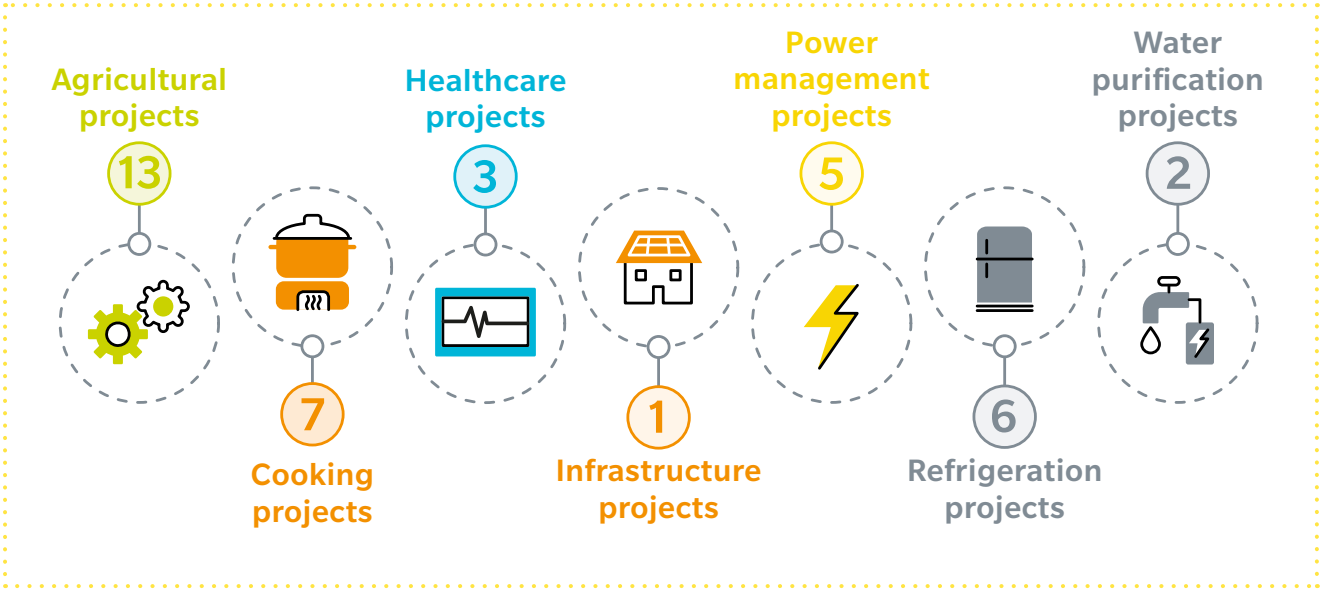
The Grand Final will take place in **June 2022**

Themes

In the Challenge, you can focus on any appliance, as long as you clearly identify the purpose and need that your design addresses. In previous years, students from universities in Bangladesh, India, Kenya, Uganda, and the UK submitted 37 projects.

You can read the project **summaries for year one** and the **summaries for year two**. Please feel free to read through previous years' submissions and gather inspiration for your own design from the designs developed by your peers.

Previous years Efficiency for Access Design Challenge portfolio of projects



You can find further inspiration in the next pages of this Challenge Brief.

Agriculture

Over a quarter of global employment is in agriculture, but many farmers lack energy access. Smallholder farmers who engage in manual agriculture experience inconsistent, weather-dependent yields compared to farmers with access to energy and agricultural appliances. From incubating eggs to milling grain, solar-powered agricultural appliances can help improve productivity for farmers living in off-grid areas.

SPOTLIGHT ON: SOLAR MILLS

Communities without energy access often mill grains manually, a time-consuming task typically performed by women and children. For people with purchasing power, the only off-grid option is diesel-powered mills. This is a polluting and inefficient appliance that is not viable for sparsely populated and remote regions.

Milling requirements, preferences and demand vary geographically and seasonally, making the economic case for the technology a particularly challenging one. However, milling has arguably the potential to become the most important productive use technology. This is because off- grid communities need continual access to milling services and it is a uniquely gender-segregated household task. (Solar Milling: Market Requirements, Efficiency for Access Coalition, 2020).

Recently developed solar mills consume less energy compared to diesel mills. They can also help increase productivity, and help farmers earn more income.

Research suggests that improvements could include:

- Enhanced motors for use in solar mills that increase energy efficiency and are affordable and durable e.g., improved permanent magnet motors
- Improved power electronics to improve efficiency
- Adaptable machines that are able to accommodate a more diverse range of milled products.
- New applications relevant to specific local contexts

EXAMPLES

Solar Milling Pilot Highlights Important Consumer Voices, Efficiency for Access Coalition, 2019

How Agsol brings power to poor farmers, Borgen Project, 2017

There are nearly 500 million smallholder farmers worldwide. Efficiency for Access' research suggests that a **10% increase in agricultural productivity** for smallholder farmers in sub-Saharan Africa could lead to a **7% reduction in poverty**. (**Efficiency for Access Coalition, 2021**)

In Africa, about 40 billion hours of unpaid time from women in off-grid areas are spent on agricultural processing each year, like milling grains, maize and cassava. Automating this process could free up a significant amount of time for women and girls, which could be put towards other productive or educational activities, and support women's empowerment. (**Efficiency for Access Coalition, 2020**)

LEARN MORE

Milling: Solar Appliance Technology Brief, Efficiency for Access Coalition, 2021

From smallholders to small business, IDH, 2016

Costs and Benefits of Clean Energy Technologies in Milk, Vegetable and Rice Value Chains, FAO 2018

In certain contexts, agricultural production and commercialisation of agricultural products could be **compromised by expensive and scarce fuel**. Irrigation systems, including solar water pumps, drip irrigation and water tanks, could help vulnerable farmers to overcome fuel related challenges. (**FAO, 2020**)

SPOTLIGHT ON: SOLAR WATER PUMPS

Moving water using solar pumping systems offer a clean and simple alternative to diesel-driven pump sets. Solar water pumps are often used for farming in remote areas or where an alternative energy source is desired. If properly designed, they can result in significant long-term cost savings and increased agricultural productivity for farmers.

Research suggests that technological improvements could include:

- Remote monitoring systems, including low-cost sensors and controllers that improve efficiency of irrigation using the right amount of water
- Highly efficient motors – e.g., BLDC motors. Experts indicate that while appliances that use BLDC motors present a higher upfront cost, they are more energy efficient, serviceable and reliable than traditional AC motor appliances and, as a result, present a lower net system cost
- Improved saline water tolerance and filtration to increase durability of the pump
- Modularity and availability of spare parts

Solar Water Pump – Technology Road Map, Efficiency for Access Coalition, 2019

EXAMPLES

Solar Water Pumps: Solar Appliances Technology Brief, Efficiency for Access Coalition, 2021

Young Engineer's Guide to Solar Water Pump, Kushal Gautam, shared by Engineers Without Borders UK, 2019

2019 Buyer's Guide for Solar Water Pumps, Global LEAP Awards, 2019

LEARN MORE

The Benefits of Permanent Magnet Motors: Efficiency Opportunities in Off- and Weak-Grid Markets, Efficiency for Access Coalition, 2021

Solar Water Pump Test Method, Global LEAP, 2019

Solar Water Pump Outlook 2019: Global Trends and Market Opportunities, Efficiency for Access Coalition, 2019

Solar Water Pump Durability Research Memo, Efficiency for Access Coalition, 2019

Sustainable Expansion of Groundwater-Based Solar Water Pumping for Smallholder Farmers in Sub-Saharan Africa, Efficiency for Access Coalition, 2021

Cooking

The IEA reports that 2.6 billion people currently cook with polluting fuels such as kerosene, coal or biomass, in poorly ventilated areas. Of those 2.6 billion, around 2.5 million people a year die prematurely from illness attributable to household air pollution. Manufacturers in the off-grid sector have designed super-efficient cook stoves, but cooking appliances could be more affordable, efficient and respectful of traditional cooking methods. Since 2010, 450 million people in India and China have gained clean cooking access due to clean energy policies and liquid petroleum gas programmes. However, progress is notoriously slow in addressing the scale of the issue and many initiatives have failed to reach scale. The COVID-19 pandemic only works to threaten this modest progress.

Household air pollution causes non-communicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer. (WHO, 2019)

LEARN MORE

Open Access Resources, EIStove, year of publication unknown

Why Understanding Real Cooks is fundamental to going beyond fire, MECS, 2019

Overcoming the "Affordability Challenge" associated with the transition to electric cooking, MECS, 2021

Gender-Responsive Electric Cooking in Nepal, MECS, 2021

Solar electric cooking in Africa: Where will the transition happen first? , 2018

Electric Pressure Cookers: Solar Appliance Technology Brief, Efficiency for Access Coalition, 2021

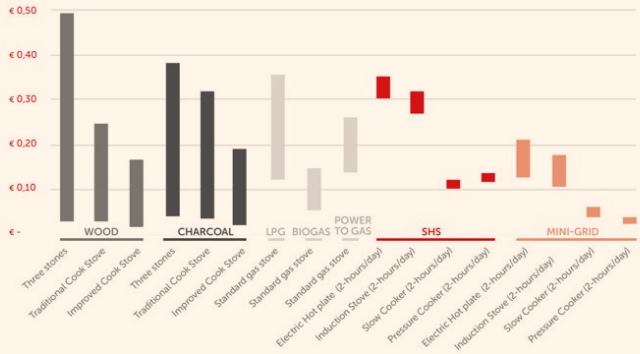
SPOTLIGHT ON: ELECTRIC PRESSURE COOKERS

The Electric Pressure Cooker (EPC) or multicooker is an appliance that comprises an electric hotplate, pressure cooker and insulated hotbox with a fully automated control system. Over a one-hour cooking period, a pressure cooker uses approximately 25% of the electricity of an electric hot plate. (Green Inclusive Energy, 2019).

Over a four-hour cooking period, the gains increase further. A pressure cooker is twice as efficient as a slow cooker, six times more efficient than an induction stove, and seven times more efficient as an electric hot plate. (Green Inclusive Energy, 2019).

COST RANGES OF VARIOUS COOKING TECHNOLOGIES

Per person per day, in €. 2019



Source: Beyond Fire: How to achieve electric cooking

Research suggests that challenges include:

- Adapting EPCs to individual communities' way of life
- Integrating EPCs into prevailing cooking habits
- Limited ability to fry food
- Reliability issues including pressure sealing rings, component burn out and circuitry on button interface models
- Lack of manual heat control

EXAMPLES

The desirability of clean cooking in off-grid households, A2EI, 2019

MECS' e-CookBook, MECS, 2019

Exploring User Personas, MECS, 2019

Clean cooking in refugee camps and COVID-19: what lessons can we learn?, MECS, 2021

Refrigeration

Refrigeration provides a wide range of benefits from improving health and productivity, to reducing domestic labour for women and children responsible for food preparation. It also enables income generating activities through the cold storage of drinks, food, and other perishable items for later sale. Essential for a sustainable agricultural sector, modern cold chain technology is still often out of reach in some markets due to its prohibitive cost and high load requirements. Cold chains manage the temperature of perishable goods from farm or sea to table. This helps ensure quality and safety in the supply chain, reduce food loss, and enhance income generating opportunities.

Refrigeration is similarly vital in healthcare. This has been made abundantly clear throughout the COVID-19 pandemic, as COVID vaccine rollout requires a robust cold chain to deliver vaccinations to communities. The World Health Organisation (WHO) estimates that up to **50% of vaccines were being wasted globally every year**. This level of waste is, in large part, due to inadequate cold chain systems and technologies. This does not only impact vaccine rollout, but also medicines such as **insulin, antibiotic liquids, chemotherapy drugs, and topical preparations**, for example, require strict temperature controls – typically between +2 and +8 °C. These requirements are particularly challenging for off grid communities who need these treatments and preventative measures to survive but may lack the energy requirements to store them.

Due to inadequate food storage and conservation, around 37% of food products are lost between harvest and consumption in Sub-Saharan Africa. (**SEforAll, 2021**)

The most abundant Hydrofluorocarbon (HFCs), HFC-134a, **has a greenhouse effect 3,790 times more powerful than CO_2 over a 20 year period**. If signatory countries implemented the Kigali Amendment to the Montreal Protocol, the world could avoid as much as 0.4°C of global warming by 2100, bringing us much closer to achieving our 1.5°C target. (**International Institute of Sustainable Development, 2019**)

SPOTLIGHT ON: FRIDGES

Most current household refrigerating appliance sold in off-grid settings are conventional, low price AC grid household refrigerators. These require inverters and/or charge controllers when used off-grid. Most refrigerators cost around five times the combined value of all other appliances in the typical solar home system and are uneconomical for users and system suppliers.

Research suggests that improvements could include:

- Improving variable speed compressors and their controls
- Highly efficient motors
- Use of low Global Warming Potential refrigerants
- Modular cooling system designs for local assembly
- Increasing cooling capacity and temperature lift at times of high ambient temperature and high humidity
- Technologies that improve the energy efficiency or effectiveness of ice-making or its end use for cooling, storage and transport of foodstuff
- Approaches that could lead to practical exploitation of Peltier or other solid-state cooling technologies.

EXAMPLES

JUMEME's Mini Grid model used in fish freezing in Tanzania, 2018

Solar-powered refrigerator providing cool clean water in Uganda, 2019

Chill Challenge Teams, Engineers Without Borders USA, 2020

LEARN MORE

Refrigerators: Solar Appliance Technology Brief, Efficiency for Access Coalition, 2021

Phasing down HFCs in off-and weak-grid refrigeration, Efficiency for Access Coalition, 2021

Raising Ambitions for Off-grid Cooling Appliances, SEforAll, 2021

SPOTLIGHT ON: WALK IN COLD-STORAGE

In developing countries, 45% of food spoils mainly due to a lack of adequate cold storage. This results in a 25% loss of annual income for 470 million smallholder farmers. As perishable food begins to deteriorate as soon as it is harvested, a robust cold chain system, fit with walk in cold-storage rooms, is required to keep produce fresh. This can be a challenge in off-grid settings – particularly when considering the size of the room that the off-grid power is required to cool.

Research suggests that improvements could include:

- Greater unit autonomy
- Reliable remote tracking and monitoring
- Implementation of cooling as a service business models
- Greater power system sizing
- Use of efficient and affordable insulation materials

EXAMPLES

Off-Grid Cold Chain Challenge winners, Efficiency for Access Coalition, 2018

Walk-in cold room by **Cold Hubs**, year of publication unknown

Commercial cooling unit by **Fresh Box**, year of publication unknown

Solar cold storage room: Ecofrost by **Ecozen**, year of publication unknown

LEARN MORE

Off Grid Refrigeration – Technology Roadmap, Efficiency for Access Coalition, 2019

2021 Appliance Data Trends, Efficiency for Access Coalition, 2021

Chilling Prospects: Providing Sustainable Cooling for All, SEforAll and K-CEP, 2019

Why cooling?, K-CEP

Space cooling

Beyond basic comfort and productivity, access to cooling solutions such fans can help enhance well-being and reduce mortality and morbidity during severe heat waves. Fans are in high demand among off-grid consumers, but mainstream fans still consume as much as 10 times the amount of electricity compared to lighting in the same setting.

In countries that are most vulnerable to high temperatures, over 1 billion people face significant risks from extreme heat every year. (**K-CEP, 2019**)

On our current carbon emission trajectory, 3 billion people could be living in places as hot as the Sahara by 2070. (**World Economic Forum, 2020**)

Fans that use permanent magnet motors consume up to 42% less energy than those that use conventional motors. (**Efficiency for Access Coalition, 2021**)

LEARN MORE

Solar-powered fans can help support sustainable futures, Efficiency for Access Coalition, 2021

Fans: Solar Appliance Technology Brief, Efficiency for Access Coalition, 2021

Chilling Prospects: Providing Sustainable Cooling for All, SEforAll and K-CEP, 2019

Why cooling? K-CEP, 2021

SPOTLIGHT ON: FANS

Fans are a cost-effective cooling solution that can help save lives, improve productivity and quality of life. Evidence suggests that with each degree the temperature increases a person's productivity can drop by up to 4%. Fans can also reduce exposure to pollution and disease carrying insects for people and their livestock.

The huge benefits and low cost of fans has made them one of the most commonly sold appliances in the world, with 290 million units sold in 2019 alone. Fans – including table, pedestal and ceiling fans- are relatively simple to design and manufacture, comprising five main components: fan blades, a base, motor, finger guard, and motor housing. This has enabled cheap, generic products to enter and dominate the market. However, it is evident from just the last five years that there is still room for innovation in this relatively mature off-grid market. The average efficiency of fans tested increased by 49% between 2018 and 2019, and the price of the average fan dropped by 47% between 2016 and 2018. (**Efficiency for Access, 2021**)

Research suggests that improvements could include:

- Improved motors for use in off-grid fans that both increase energy efficiency and are affordable and durable e.g., BLDC motors
- Enhanced blade designs that increase air delivery and lead to overall service improvement
- Smart/interoperable functionalities that can improve the overall efficiency, affordability, performance, or user experience, e.g., occupancy sensors and remote based functions
- Improved electronic controls for adjusting the speed of a motor, which can enhance its efficiency
- Alternative approaches and designs for fans in space cooling enhancing its usability.

EXAMPLES

Research and Development Fund – Project Spotlights, Cooling Call, Efficiency for Access Coalition, 2020

The socio-economic impact of super-efficient fans in Bangladesh, Efficiency for Access Coalition, 2019

Keeping rural Pakistan cool during a global pandemic (Harness Energy), Efficiency for Access Coalition, 2021

Power management

The high cost of batteries is a significant barrier to the uptake of appliances in off grid settings. Distributors often oversize them to ensure a constant and consistent supply of electricity to large appliances like fridges. This then leads to an increase cost and reduction in efficiency. Improved power management can help reduce the size of batteries required, making larger appliances more affordable for people.

SPOTLIGHT ON: SOLAR HOME SYSTEMS AND MINI-GRIDS

Solar home systems and mini-grids have limited power supplies. They have to balance generation and storage through batteries and a limited number of appliances can be run at any one time. Smart scheduling and balancing ensure that people have the services needed and that systems are used as energy efficiently as possible.

Research suggests that improvements could include:

- Systems that integrate different appliances or allow them to communicate with each other
- Widgets that can be included in a range of equipment so that they can connect to each other
- Cheaper connectivity and control components e.g., embedded controllers
- General data communication for appliances and power supply modules
- Smart batteries: collection and optimisation of data using machine learning to improve the overall system efficiency and performance
- Innovative business model providing holistic services

Smart-grids, created through widespread installation of smart meters and sensors, are embedded with an information layer that allows communication between its various components. They utilise data collection, storage and analysis so that they can better respond to quick changes in energy demand or urgent situations. Paired with powerful data analytics, these smart-grid elements have helped improve the reliability, security, and efficiency of electricity transmission and distribution networks. (IFC, 2020)

EXAMPLES

Harnessing the power of water to provide cooling technology in developing countries, Sure Chill, 2020

'Core' modular battery, Aceleron Energy, 2021

LEARN MORE

A Comparison of Batteries for the MECS Project, MECS, 2020

The Future of Energy Storage, SILA Nanotechnologies, 2020

State of the Global Mini-grid Market Report, SEforAll, 2020

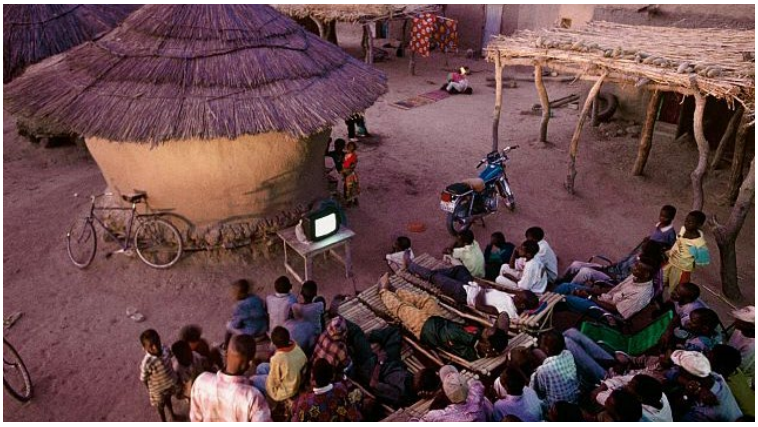
Sustainable solar e-waste and battery technology management (Uganda and Senegal), USAID, 2019

Information and communications technologies

Information and communications technologies (ICT) are essential to how we communicate and interact with each other and society. The COVID-19 pandemic made this increasingly clear, which led to further discussions in many countries on whether access to the Internet is a human right. The ICT sector remains a key driver of innovation, accounting for the largest share of OECD business expenditure on research and development and for over 1/3 of total patent applications worldwide (OECD, 2017).

Two technological pillars, digitisation and interconnection, are driving a digital transformation of all areas of life, complemented by related technologies. Smart devices or objects, connected to the Internet or one another, monitor, communicate and interpret information – the result is an Internet of Things (IoT). Among other applications, networked sensors utilising IoT can be used to monitor: the location and activities of people and animals, the status of production processes in factories, deficiencies in city services or the health of the natural environment. The number of connected devices in and around people's homes in OECD countries is expected to increase from 1 billion in 2016 to 14 billion in 2022 (OECD, 2017).

Digital innovation enables applications and services in a wide range of sectors including agriculture, healthcare or science.



In healthcare, the use of mobile health applications and of electronic health records can help enable the creation of new care models and provides the foundation to improve clinical management. Transformation processes include improved efficiency, productivity and quality of care.

Tractors have become a data-intensive product that can monitor soil conditions, send data to its proprietor and plant with precision. Precision agriculture has transformed farming thanks to big data analytics, which can help improve productivity by optimising the use of resources such as fertiliser, irrigation and farmers' time. (**Villa-Henriksen, et al., 2020**)

SPOTLIGHT ON: LAPTOPS

Access to ICT can help countries upskill their workforces and facilitate social mobility, helping individuals to compete in a global economy. Thus, ICT usage in schools is important to ensure children can develop digital literacy to acquire general life and basic work skills. Where ICTs are absent in households, computers in schools are even more necessary. The integration of ICT in schools requires reliable energy access, so students can use devices like televisions, desktop/laptop/tablet computers and the Internet.

ICT can help improve access to education, employment, community activities and other services for people with disabilities – making them critical in the pursuit of the Sustainable Development Goals such as reduced inequalities, quality education, and decent work and economic growth (Global Sustainable Development Report, 2019).

Research suggests that improvements could include:

- Reduce power consumption of computer processors and monitors
- Improve capacity of storage in batteries
- Modelling accurate load calculation and system sizing to existing and growing needs

EXAMPLES

Solar Power for PC Deployments: Enabling ICT Beyond the Grid, Intel Corporation, 2009

Solar computer, Niwa Solar, year of publication unknown

JIRODESK solar computer, Jirogasy, 2021

A study conducted by the UN on energy poor areas of Yemen found that in proposed solar systems for a large school of 11-15 classes, a computer would only introduce a 2% load on the system. (UNDP, 2019)

Energy access is a particular challenge in countries with more remote communities such as the highly mountainous country of Nepal where only six and 24 of primary and secondary schools, respectively, had electricity in 2011. (UNESCO, 2016)

LEARN MORE

Interoperability Solar Appliance Technology Brief, Efficiency for Access Coalition, 2021

Healthcare

Safe and adequate environmental conditions in health care facilities are essential to protect and improve the health of patients, staff, visitors, and the wider community. These include the availability of water, sanitation, hygiene, energy and waste management, as well as personal protective equipment.

Reliable energy in health care facilities is essential for functional services. Intermittent electricity can create safety hazards and limit patient care. For example, sterilising equipment cannot be operated, lighting is inadequate to perform procedures, and electrically powered tools for procedures cannot be used. Unreliable electricity also affects the use of information technology and communications to inform decision-making. According to the 2020 Off-Grid Appliance Market Survey Report, the highest scoring clinic infrastructure technologies are LED room lighting, energy storage and backup, ICT equipment, water purifiers and water pumps. The ongoing COVID-19 pandemic has magnified this issue. Innovation in the healthcare system is not only required in medical devices, but also the infrastructure of health care facilities. This may include reliable LED lighting, solar water pumps and purification systems for clean water access, ICT technology for medical staff, and medical waste and wastewater management systems.

The World Health Organization estimates that **about 810 women die every day from preventable causes related to pregnancy and childbirth**, and that 94% of these deaths happen in low and lower middle-income countries. With many women still giving birth by kerosene lamp or candlelight, LED lighting by itself can serve as a transformative medical intervention. (WHO, 2017)

Indicators of environmental conditions over almost 130,000 healthcare facilities showed that 50% lack piped water, 33% lack improved sanitation, and 39% lack soap for hand washing. Furthermore, 39% of the above healthcare facilities lack adequate infectious waste disposal, 73% lack sterilisation equipment, and 59% lack reliable energy services. (Science Direct, 2018)

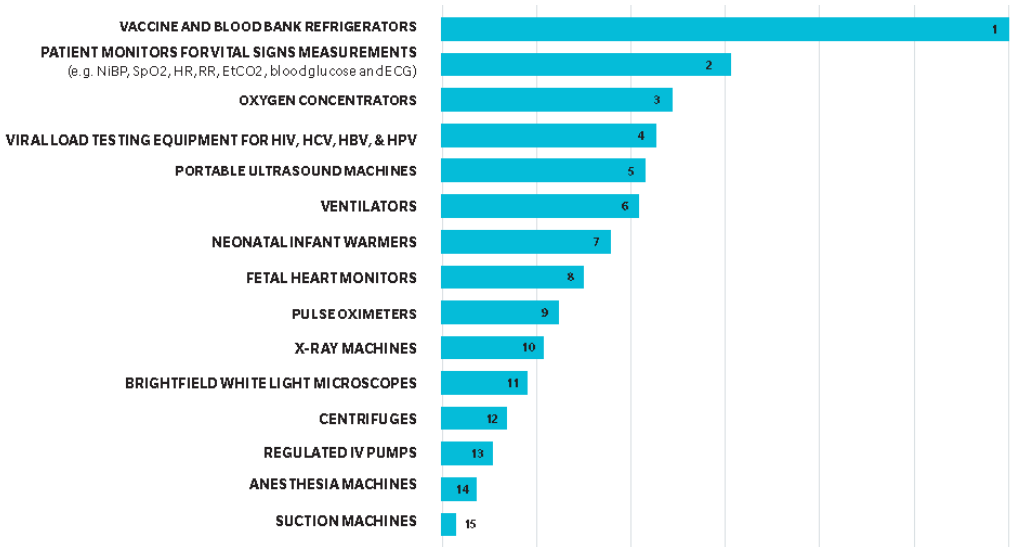
These two graphics illustrate the importance of medical devices for health service delivery and a comparison of clinic infrastructure for general health service delivery versus COVID-19 Response. The 2020 survey included clinic infrastructure as well as medical devices required for provision of health services to provide a holistic perspective on clinic electrification needs. Source: 2020 Off-Grid Appliance Market Survey Report, Efficiency for Access Coalition, 2020.

LEARN MORE

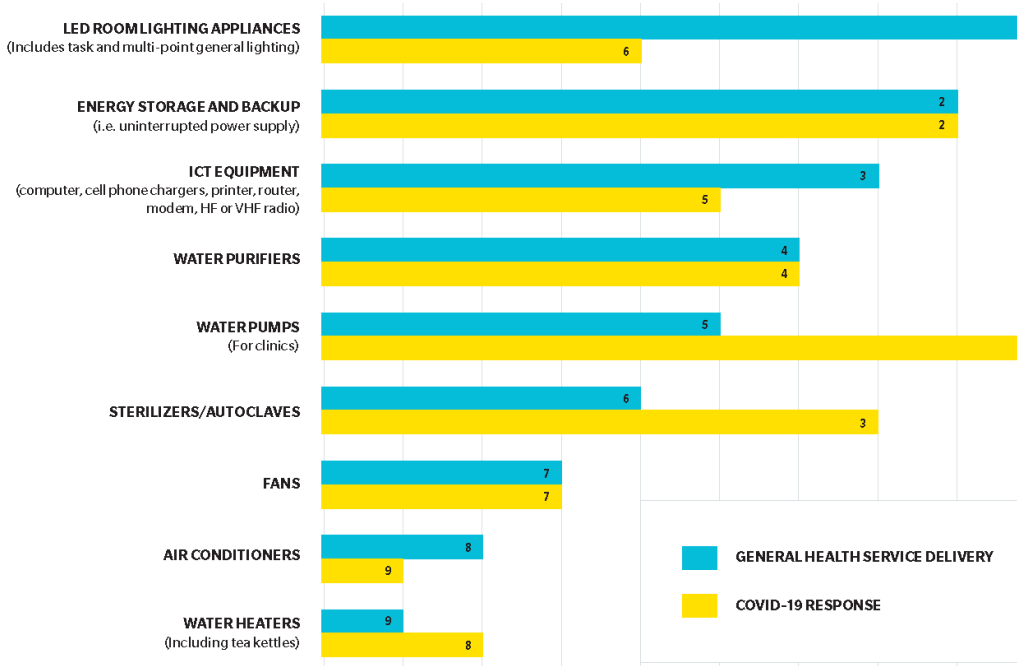
Interagency List of Medical Devices for Essential Interventions, FAO 2015

Limited electricity access in health facilities of sub-Saharan Africa, Global Health: Science and Practice, 2013

IMPORTANCE OF MEDICAL DEVICES FOR HEALTH SERVICE DELIVERY



COMPARISON OF CLINIC INFRASTRUCTURE FOR GENERAL HEALTH SERVICE DELIVERY VERSUS COVID-19 RESPONSE



SPOTLIGHT ON: OXYGEN CONCENTRATORS

Boosting the delivery capacity of oxygen therapy is crucial to the COVID-19 pandemic response. The use of oxygen therapy is recommended for all severe and critical COVID-19 patients. Delivering this therapy in off- and weak-grid settings, however, is a challenge. Oxygen concentrators can help to treat mild to moderate cases of COVID-19 in resource-constrained areas, reserving oxygen cylinders for the treatment of more severe cases.

Oxygen concentrators use a process known as pressure swing adsorption to concentrate oxygen from ambient air, compressing it to the required density and removing the nitrogen present, and then delivering this purified oxygen to the patient through a nasal cannula or oxygen mask.

Beyond the COVID-19 pandemic, there are a myriad of respiratory illnesses whose impacts would be reduced through the use of oxygen concentrators. Pneumonia, for example, takes a child's life every 39 seconds – many of these deaths are preventable. (SEforAll, 2020)

Research suggests that improvements could include:

- Increased flow capacity of the device for use by multiple patients
- Improved reliability of oxygen flow in pulsed-dose models
- Ability to operate autonomously for long periods
- Resistance to extreme temperatures, high altitudes, and dusty environments
- Improved user-design for ease of use in at-home settings

EXAMPLES

MSF Sweden Innovation Unit, 2021

Resilient Oxygen, CREATIVenergie, 2021

Solar Oxygen, Grand Challenges Canada grant winner, 2014

LEARN MORE

Oxygen Concentrators, UNICEF, 2021

WHO estimated that 14% of COVID-19 cases may be severe and an additional 5% are critical and require treatment in intensive care units (ICUs). Oxygen supply is decisive for these patients' survival as it has been found that supplemental oxygen supply can be lifesaving in approximately 80% of these cases. Despite this, many sub-Saharan African countries lack affordable and reliable oxygen supply (**Stein et al., 2020**)

Other subjects

SPOTLIGHT ON: ELECTRIC REELING MACHINES

Resham Sutra has developed a range of affordable, mostly solar-powered electric reeling machines that improve working conditions and help provide a higher income for over 9,000 silk workers.

SPOTLIGHT ON: WATER PURIFICATION SYSTEMS

To achieve SDG 6, "clean water and sanitation for all", clean water and sanitation, water purification and filtration systems are universally required. Off and weak-grid communities are no exception to this. According to IEA, currently 2.1 billion people drink contaminated water in the world. Pairing off-grid energy systems with filtration or purification appliances, like Off Grid Box, could be key in providing these people with safe drinking water.

SPOTLIGHT ON: EGG INCUBATION

Many houses in Africa keep chickens for eggs and meat. A hen can hatch about 20 to 30 chicks per year. However, using an incubator with the same hen could procure a farmer up to 300 chicks per year (Sure Hatch, 2018).

SPOTLIGHT ON: ICE MAKERS

Ice can be used to store freshly caught fish, or cool drinks. Ice making can be done on a small scale to make a living, particularly in remote and hot places (Off-grid Refrigeration Technology Road Map, 2019).

LEARN MORE

Sustainable Energy and Livelihoods – A collection of 50 livelihood applications, SELCO Foundation Off- and Weak-Grid Solar Appliance Market: India, Efficiency for Access Coalition, 2020

2021 Appliance Data Trends, Efficiency for Access Coalition, 2021

Globally responsible design

There needs to be a rapid move towards globally responsible practice. This means critically reflecting on the role of design, engineering and appliance manufacturing in society and understanding the social, environmental and economic impacts, both locally to where it is implemented and globally through supply chains and operational outputs.

Today, those central to the design process are often described as problem solvers, arguably this is too late in the process when we need to be thinking about which problems need to be solved. If we were to reframe our perspective to one that is continuously looking for opportunities for improvement, building on existing strengths and what is already working well, then we challenge the assumption that everything needs to be fixed by starting from scratch which can lead to unsustainable results from the outset.

Equally, the inclusion of a diverse range of people's views and insights in the engineering process has never been more important. We cannot question how else we might build our cities if people are not involved in shaping that vision; we cannot rethink food supply unless the farmers and consumers of food are part of the debate; we cannot consider whether or how we travel unless those who need to get from A to B are also given the opportunity to define that need. Engineers and designers alone cannot address the significant global challenges we face; we must work in collaboration with others.

To gain a deeper understanding of this area we would suggest that you review the '**Gender, Disability, and Social Inclusion**' and '**End-user perspective**' Challenge webinars from 2021, and the '**Gender and Social Inclusion**' Challenge webinar from 2020.

To enable you to bring a globally responsible approach to your design we encourage you to consider the four following principles:

RESPONSIBLE

To meet the needs of all people within the limits of our planet. This should be at the heart of engineering and appliance manufacturing.

Within this Challenge, exercise your ability to empathise and to deeply consider how ethical, or responsible your decisions you make are. Critically reflect throughout on the impact your solution will or could have.

INCLUSIVE

To ensure that diverse viewpoints and knowledge are included and respected in the engineering process.

This includes designing for specific needs. Whether this means a specific context such as a humanitarian or school setting or designing for a specific demographic such as a woman or a person with disabilities, your design needs may vary greatly depending on how you ensure your design is suitable for all.

Ensure to consider deeply how you will value people's perspective in the design process, and how we value lived experience in the decisions you make that may impact people's lives. This empathetic approach is essential to ensure the people with lived experience of the issues you are trying to solve and may use your appliance, are not just passive recipients, but actively heard within the shaping or designing of what the appliance or system is.

LEARN MORE

How can energy access programmes address the needs of people with disabilities?, Efficiency for Access Coalition, 2021

Why off-grid energy matters, 60 decibels, 2020

Addressing the needs of people with disabilities in energy access, Efficiency for Access Coalition, 2021

The role of appliances in achieving gneder equality and energy access for all, ENERGIA, 2020

Silver Bullet - are solare pumps a panacea for irrigation, farmer distress and discom losses?, Centre for Science and Environment, 2019

PURPOSEFUL

To consider all the impacts of engineering and appliance manufacturing, from a project or product's inception to the end of its life. This should be at a global and local scale, for people and the planet.

Challenge yourself throughout the process to iterate continuously in response to feedback you gather on your ideas.

You will need to consider the unintended consequences that may impact people because of your product, appliance or system.

REGENERATIVE

To actively restore and regenerate ecological systems, rather than just reducing impact.

In this design challenge, this principle will challenge you to think about how your design interacts with ecological systems. Is there a loop here? Perhaps it is looking at a 'circular' approach, whereby you deeply consider material choices, or how the appliance will be disposed of or reused (and design for this).

Applying these principles will require great creativity, we are excited to see how you get on!

We would recommend viewing the '**Unintended Consequences of the Sector's Growth**', '**Product Lifecycle and Local Assembly**' and '**Product Lifecycle**' Challenge Webinars

Student support

The Efficiency for Access Design Challenge team will provide a curated programme of support to students, including:

Mentoring

The Efficiency for Access Coalition has an extensive network of contacts with specialists from the off-grid industry. Each student team will be introduced to a relevant industry mentor, who will guide and support your team throughout the development of your project.

Prototyping grants

Grants to support your team in developing a prototype will be available throughout an application process. This is a great opportunity to build on the project concepts developed by your team and develop these ideas from the design process. Prototype development is optional, though it may have an added benefit and value for your team.

This opportunity can help bring your project one step closer to market. It will also assist you in visually demonstrating your concept to the judging panel during your pitching session. The application for funding from your team for the prototype development grant should include a needs statement signed off by your academic supervisor and a detailed budget. More details and deadlines on the application process will be available once the Challenge starts in September.

Resources

You will have access to a comprehensive digital library of reports, market surveys and research papers from the Efficiency for Access Coalition. These resources will support your team in developing your concept note and solution. You will also have access to VeraSol- Certified Products Database, which is an off-grid appliance data platform. Industry partners will deliver thematic webinars throughout the year and previous years' recorded webinars from year 1 and year 2 will also be available.

"Through the Efficiency for Access Design Challenge, students gain invaluable experience of working collaboratively to tackle some of the really big challenges global society is facing today so that when they graduate, they'll be ready to start applying their new technical skills to create the society we all want to live in"

Jon Leary
Senior Researcher,
Modern Energy Cooking Services programme

MECS Modern Energy Cooking Services

Get some inspiration from previous years' students' prototypes showcased in this short video.

"My highlight [of the Challenge] was working with [our] industry partner, it was great to get a business perspective on our ideas and understand how they could be translated into an actual product. This was important because despite some of our initial ideas having merit, the practicalities of delivering them as a product meant they were unfeasible to take forward into more detailed design"

Safia Whitwham
Team 2020-19, UCL

UCL

"Being involved in the Efficiency for Access Design Challenge at all stages from development of the project concept, design, construction and procurement of some materials from abroad was a holistic experience that strengthened skills in engineering design software, report-writing, design considerations, teamwork, business canvas development. These skills and experiences are crucial for any engineer with aspirations to make it in the engineering job market and are huge confidence boosters as we expand in that field."

Mayanja Andrew
Team 2020-10, Gulu University

Gulu University

Learning and networking opportunities

The Efficiency for Access Design Challenge team is developing a programme of online workshops (kick-off and midway workshops), live webinars, career conversations and digital events to enhance learning and networking opportunities for you and your university departments. This will include sessions to help you better understand the off-grid context and ensure that end-users are at the centre of your design.

The career conversations will also allow you to engage with industry experts. This will be an opportunity for you to learn more about the off-grid industry and build relationships with industry leaders.

The Efficiency for Access Design Challenge team will use the concept note you submit to assess the specific needs of your team and adapt the planned activities accordingly.

Online students' working space

Through the Efficiency for Access Design Challenge students' working space, hosted on CrowdSolve, you will be able to contact other students currently participating in the Challenge, as well as students that participated last year. This platform offers you an opportunity to ask questions, collaborate and share ideas with students from other universities in Europe, South Asia and Sub-Saharan Africa. You will be able to connect with students working like you to accelerate clean energy access to provide affordable and efficient high performing appliances.

Assessment

You will work in teams to deliver design and innovation projects that focus on affordable and high-performing off-grid appliances and supportive technologies.

Project submissions

Your team will need to submit your project submission by **15 April 2022**. It will consist of a 4,000-word (maximum) report and a three-minute video. Other supporting documentation e.g., posters or prototypes can be photographed or included within the submission, if deemed useful.

Your team will own the Intellectual Property of your work but will be required to give the Efficiency for Access Design Challenge team permission to have the ability to use the research outcomes for a wider benefit. This will be achieved by students agreeing to license their work under Creative Commons license CC-BY 4.0.

Stages of assessment

The project submissions will be evaluated in two stages and informed by the assessment framework on the next page.

First stage A review panel, comprised of experts from the sector, will review the submissions (including the video) and provide feedback to the teams in **May 2022**.

Second stage A judging panel, comprised of funders, industry experts and investors in the sector, will assess the student teams' submissions during the pitching sessions in **May 2022**.

The Grand Final

The last stage of the competition, the Grand Final, will be held online in **June 2022**. All students and universities participating in the Efficiency for Access Design Challenge will be invited to the Grand Final. The Grand Final will include many opportunities for networking between students and specialists from the off-grid industry and the chance to showcase some of the submissions from the year.

The Grand Final will also include presentations from off-grid industry experts and engaging panel discussions. In addition, many experts and investors from the sector will also be invited. The Grand Final will include an award ceremony to award teams with gold, silver, and bronze standards.

"The Efficiency for Access Design Challenge experience was an accelerated process of self-discovery for myself, helping me channel my energy into meaningful and impactful creations for communities in need. I hope they help many more like me to learn how to dream with their eyes open."

Souryadeep Basak
Team 2020–21,
TERI School of Advanced Studies

teri school of advanced studies

Assessment framework

What are the Reviewing and Judging Panels looking for?

The Assessment Framework on the next page provides guidance on what both the Reviewing Panel and Judging Panel will be looking for in your solution. It should be useful in helping you to structure your project submission. For your submission, regardless of chosen technology, you should demonstrate how your design addresses a need someone or a community is experiencing and provides an improvement in terms of innovation compared to existing alternatives while ensuring it is a sustainable solution and with consideration given to scaling up to market. Depending on what your solution is, some criteria may not be applicable. Each point is given a score of 1–5, 1 indicating poor potential, 3 as moderate and 5 as strong.

SCORING

1 2 3 4 5

Poor ‹····· ○ Moderate ○ ·····› Strong

Innovation

How does your design compare and improve on solutions that are currently available to your target end-user?

Judges will want to see that you have demonstrated and understood the technological context that you are targeting, and that you have gone through a well-informed design process to improve on solutions currently available to the end user.

- What is the potential of your design to improve energy efficiency compared to existing alternatives? Consider how you define energy efficiency (energy used per service provided) and what the baseline is for comparison.
- What is the potential of your design to reduce production costs compared to existing alternatives? Consider materials used, price of components and cost of assembly.
- What is the potential of your design to improve usability compared to existing alternatives? Consider its ease of use, reliability and safety.

Sustainability

How does your design contribute to a positive impact on the environment?

Judges will want to see that you have understood the effects your solution could have and how you demonstrate your solution is worthwhile and contributes to achieving SDGs.

- Is your design reducing the environmental impact throughout its lifecycle compared to existing alternatives? Consider the whole product lifecycle: materials used, repairability and end of life.
- How does your design contribute towards greenhouse gas emissions reduction compared to other technologies that exist in the market? Consider the sustainability of your business model (including manufacturing, distribution and operating) and its scalability.
- How does your design contribute to the Sustainable Development Goals (SDG), in particular SDG7 – Affordable and clean energy? How well have you demonstrated you understood the potential connections with the other 17 SDGs and its associated targets? Consider how the different areas of this assessment framework are contributing to this.

Social impact

What difference does your design make to people's lives?

Judges will want to see how you have researched the needs of the people your solution could benefit. They will want to understand why you think your design will improve peoples' lives, and how you have considered social inclusion and equality in your solution.

- How well have you considered who will be using the design? How well have you understood their needs?
- What is the likely potential of the design to improve quality of people's lives? How does your design improve the desirability of your target end-user? Consider what their livelihood was before and the improvement your design will bring to them.
- How well has your design considered the Sustainable Development Goals' commitment to 'Leave no one behind'? In particular, consider gender equality and disability inclusion.

Scalability

How feasible is it that your design could get to market at scale?

Judges will want to see that you have considered the business case. Including considering the market opportunity, including market size, for your solution, and demonstrated how people will be able to access and afford this.

- How well have you considered the potential market for your product? Consider the target customer, size of market and customer value proposition.
- How well have you considered how people will be able to access and afford your product? Consider affordability, potential customer payment models and existing financial models.
- How well has your business model considered affordability, payment models, existing supply chains, manufacturing, distribution channels, local partners and services associated? Consider the pricing and costs strategies to make your business model commercially viable.

EFFICIENCY FOR ACCESS

Supported by:

UK ENGINEERS WITHOUT BORDERS

You will find more details and information on the Efficiency for Access Design Challenge web page.

You can access the Efficiency for Access Design Challenge student's working space on CrowdSolve.

Contact us

If you have any question about the Efficiency for Access Design Challenge, please contact Efficiency for Access Design Challenge team at

EforaChallenge@est.org.uk

UKaid

IKEA Foundation

energy saving trust