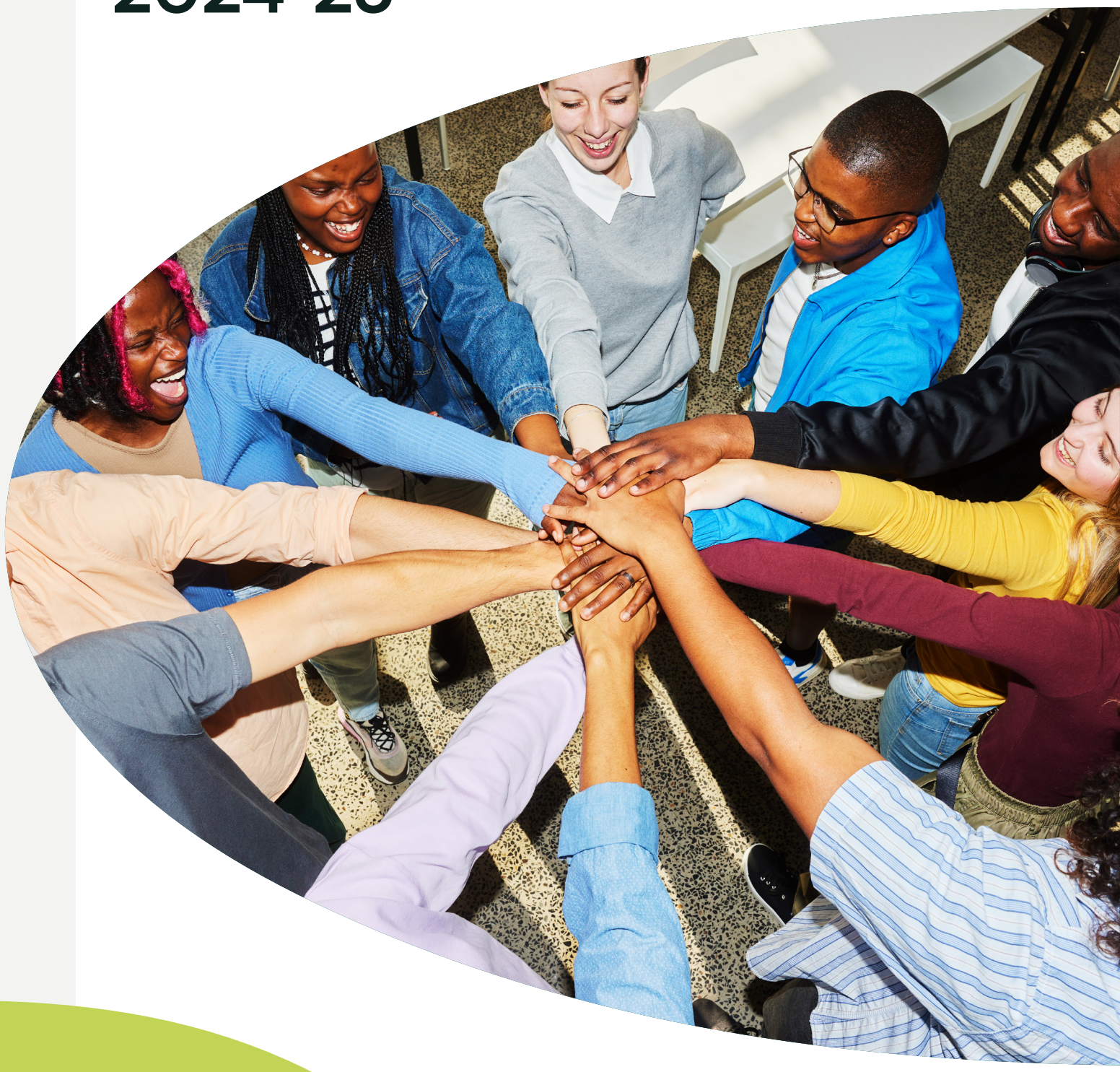
EFFICIENCY FOR ACCESS

ENGINEERS WITHOUT BORDERS UK

Efficiency for Access Design Challenge

HANDBOOK 2024-25



Funded by: IKEA Foundation

UKaid from the British people Transforming Energy Access

EFFICIENCY FOR ACCESS

CONTENTS

ABBREVIATIONS

AC — alternating current

AI — artificial intelligence

BLDC — brushless direct current

DC — direct current

EPC — electric pressure cooker

GHG — greenhouse gas

ICT — information and communication technology

IEA — International Energy Agency

IoT — Internet of Things

KW — kilowatt

LED — light emitting diode

MW — megawatt

PV — photovoltaic

SHS — solar home system

SME — small to medium-sized enterprise

UN — United Nations

USD — US dollars

V — volt

INTRODUCTION

The Efficiency for Access Design Challenge (the Challenge) is a global, multi-disciplinary competition that empowers teams of university students to help accelerate clean energy access. The Challenge is delivered by research and development innovators, Efficiency for Access, in collaboration with Engineers Without Borders UK and funded by the UK government via the Transforming Energy Access platform and the IKEA Foundation.

Efficiency for Access is a global coalition working to promote high-performing appliances that enable access to clean energy for the world's poorest people. It is 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.

To provide sustainable energy for all, 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.

"In the heart of innovation, I found purpose. Through the Efficiency for Access Design Challenge, I harnessed technology to illuminate pathways toward sustainable energy solutions. Together, we rewrote the narrative of possibility - one circuit, one idea at a time."

OLIVIER DUSHIMIMANA, from team 2023-20, University of Rwanda

The Challenge started in September 2019. Since its inception, over 500 students from 40 universities in the following countries have participated with the support of over 100 industry partners:

- Bangladesh
- Benin
- Cameroon
- India
- Kenya
- Mozambique
- Nepal
- Nigeria
- Pakistan
- Rwanda
- Senegal
- Sweden
- Tanzania
- Uganda
- UK
- USA
- Zimbabwe

Due to the global nature of the Challenge, it is delivered remotely by the Challenge team. However, your educator may provide in-person elements to support you. We anticipate that you will receive credit for participation. Check with your educator to find out more about these details.

This is the main guidance document for students participating in the Challenge. It includes information about the energy access sector, the scope of the competition, key dates and deliverables, globally responsible design, and spotlights on technology themes and appliances.

CONTEXT

Maintaining, upgrading, and expanding national electricity grids is expensive. Due to population dispersion in remote and rural areas, it is often not economically viable to extend the national grid to reach the people living and working in these areas. As such, new technology has emerged, known as 'off-grid' technology, which consists of standalone electricity generation and storage. Solar home systems and mini-grids are common examples of these off-grid technologies which can enable energy access for people who don't have access to the grid.

Unlike the national grid, these standalone off-grid setups use direct current (DC) and generate small amounts of electricity. Appliances designed for use on-grid are unsuitable for these systems because they use alternating current (AC) and consume too much energy to be affordable. Some off-grid appliances have been developed to meet people's basic needs, for example for lighting and cooking. However, more affordable and energy efficient technologies are needed to meet people's needs in homes and businesses in off-grid contexts.

The **Sustainable Development Goals** (SDGs) are a set of ambitious aims adopted by the United Nations member states aiming to promote peace and prosperity, end poverty and protect the planet (**United Nations Development Programme**). They recognise the interconnectivity of actions across multiple areas, for example that increasing energy access can also reduce poverty and improve health.

LEARN MORE

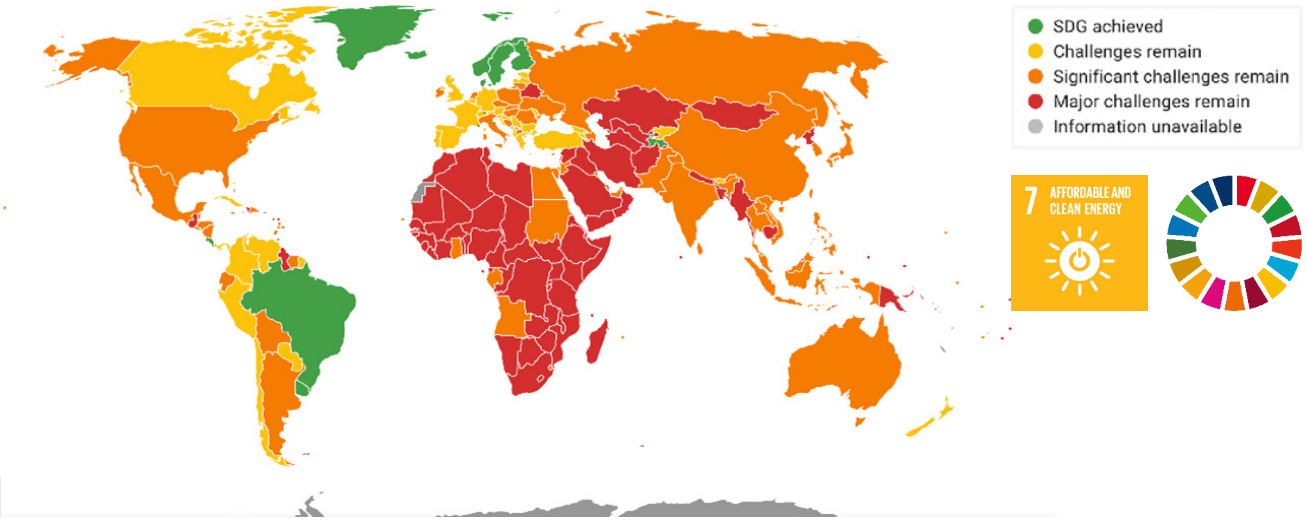
Building Resilience in Low-Income Communities — The Role of Off-Grid Appliances, Efficiency for Access Coalition, 2023

Off-Grid Solar Market Trends Report 2022: Outlook, Efficiency for Access Coalition, 2022

Off-Grid Solar Market Trends Report 2022: State of the Sector, Efficiency for Access Coalition, 2022

Mini-grids are electricity generators and energy storage systems that supply electricity to a localised group of customers. They typically consist of PV modules, micro-hydro and/or back-up generators. They employ small-scale electricity generation.

Solar home systems (SHSs) are standalone photovoltaic (PV) systems that typically include one or more solar panels, a battery to store energy, and a charge controller. Typical solar home systems operate at a voltage of 12V DC and provide electricity for low-power appliances, such as LED light bulbs, radios, and LED TVs.



The **Sustainable Development Report** includes **data visualisation tools** showing each country's progress towards achieving SDGs. This map shows countries' performance on SDG 7 — affordable and clean energy (source: **Sustainable Development Report 2024**).

SDG 7.1 seeks to ensure universal access to affordable, reliable, and modern energy services by 2030. We are a long way from achieving this aim. While **hundreds of millions of people have gained access to electricity since 2010**, **1 in 10 people still don't have access**. Most of these live in rural areas, and over half live in sub-Saharan Africa (**United Nations Development Programme**). As outlined above, these people are most likely to gain energy access through off-grid setups, rather than through connection to national grids. To gain the benefits of electricity in their homes and workplaces, they will need access to high-performing energy efficient appliances.

SCOPE OF THE COMPETITION

The Challenge provides an opportunity to work at the forefront of energy access and aim to address the challenges outlined above. You will be asked to **work in a team of 2-5 students to design an affordable and high-performing solar DC appliance or enabling technology that can be used in off- and weak-grid contexts to improve the quality of people's lives and/or improve business productivity**. Your design should significantly improve upon currently available products/services and have potential to scale.

To be within scope, your design should:

- Be an appliance or enabling technology
- Be for use in contexts with low levels of energy access
- Use solar DC (not use an inverter)
- Use energy (not generate energy)
- Use electricity as its primary energy source
- Improve people's quality of life in homes, and/or increase business* productivity

*A business should be a small to medium enterprise (SME), which could include someone working for themselves (e.g. a smallholder farmer), or a business with up to 250 employees.

If you are unsure whether your idea is within scope, please discuss it with the Challenge team.

"This challenge is the best memory of my life where I had to face my own challenges and overcome with team support! It's a lovely journey and a great memory."

HIRUSAJINI, from team 2023-40, City University London, UK

INTELLECTUAL PROPERTY

Your team will be required to licence your work under the **Creative Commons license CC-BY 4.0**, which allows others to use your work, as long as they credit you, the creators. This can help to create wider benefits and innovation.

Appliance: A device, machine or piece of equipment designed to perform a specific task, such as cooling, heating, refrigeration, cooking, lighting, or entertainment.

Enabling technology: Equipment and/or methodology that, alone or in combination with associated technologies, provides the means to generate leaps in performance (adapted from **businessdictionary.com**). Historic examples include the permanent magnet motor (which increased appliance efficiency and reduced cost), and wireless networks (which combined with other technologies to enable interconnectivity and Internet of Things (IoT)).

To be within scope of the Challenge, enabling technologies must contribute to increased energy access and/or efficiency.

THEMES

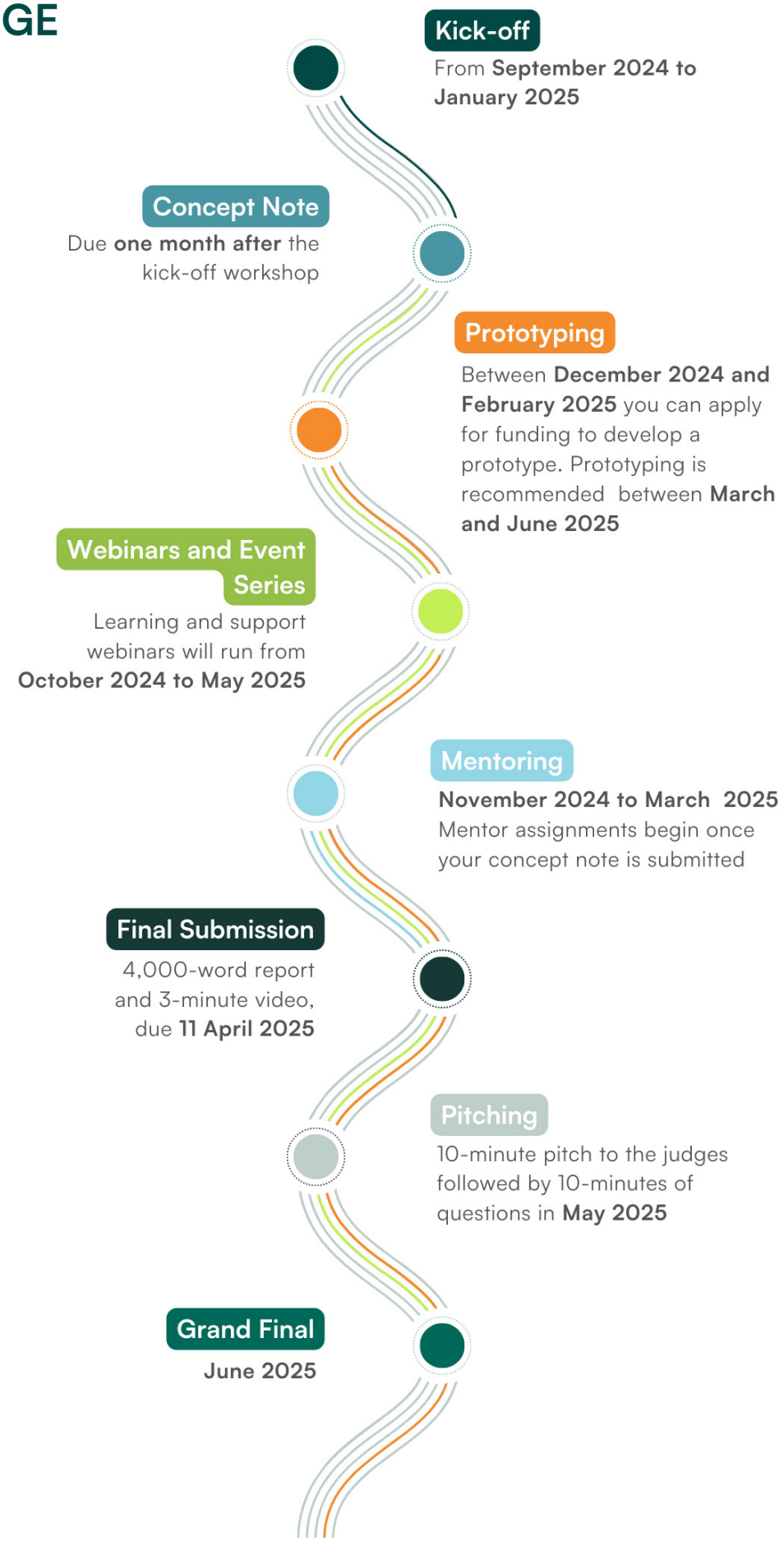
Your team may design any appliance or enabling technology, as long as it is within scope, and you clearly identify the purpose and need that your design addresses. The 115 projects submitted in previous years have included appliances for use in homes, businesses and communities, and software solutions. They can be categorised into the broad technological themes shown below. To learn more about these, check out the **Technologies** section.

Previous Efficiency for Access Design Challenge portfolio of projects

TIMELINE

The Efficiency for Access Design Challenge 2024-25 starts in September 2024 and ends in June 2025. The Challenge involves several milestones, including a kick-off workshop, concept note submission, final submission, pitching session and Grand Final. Along the way, you will attend a series of webinars and be paired with an industry mentor. You will receive feedback on your concept note and final submission from energy access experts and you will have the opportunity to apply for prototype funding.

CHALLENGE TIMELINE



MILESTONES

Kick-off workshop

September 2024 — January 2025

The Challenge begins with a kick-off workshop arranged by your educator. It is an opportunity to learn more about the Challenge, ask questions, meet other participants, and start forming teams.

After the kick-off workshop, you must sign the Challenge terms and conditions to become an official participant.

Concept note

Due one month after your kick-off workshop

The concept note is an initial outline of your planned project, designed to help you start thinking about your design and how you will meet the assessment criteria. We will give you a template in which to complete your concept note, and your full concept note should be no longer than four A4 pages.

Your concept note will be used by the Challenge team to check whether your project is within scope and match you with an industry mentor. Your concept note will not be assessed, but you will receive written feedback from a reviewer on CrowdSolve (more information on this platform in the **Student Support** section) within one month of your submission. The feedback should be used to develop and refine your project.

Before submitting your concept note, your team should create a project space on CrowdSolve. All team members should join their team's project space.

Resources to support you developing your concept note and final submission:

- The **Technologies** section of this document
- **Previous years' recorded webinars**
- **Previous years' project summaries**
- **Efficiency for Access Coalition publications** — a live digital library of reports, market surveys and research papers from Efficiency for Access and our partners
- **The VeraSol-Certified Products Database** - an off-grid appliance data platform

Final submission

Due 11 April 2025

Your team should submit a **4,000-word report (maximum) and three-minute video by Friday, 11 April 2025**. Make sure that you address all the assessment criteria. You may include supporting documents like posters and photographs. For ideas and inspiration, check out our **summaries of previous years' final submissions, and the final submissions** themselves on **CrowdSolve**.

You will receive feedback from reviewers in **May 2025**, which you should use to inform your pitch. You can make changes to your design before pitching (though you may not pitch a new design).

Pitching

May 2025

Your team will pitch your design to a judging panel of industry experts. The pitch will take place online via Zoom. You will have 10 minutes to pitch, followed by 10 minutes of questions from the judges and 5 minutes of feedback.

Please be sure to address all the assessment criteria in your pitch. You can present as a full team or nominate one or more team member/s to pitch on your behalf. We will share more guidance on pitching closer to the time.

The judges' scores will combine with your final submission scores to determine your place in the competition. For more information, see the **Assessment Framework** section.

"Participating in the Efficiency for Access Design Challenge was an unforgettable adventure. Over the course of a year, we dove into engaging webinars and interactive sessions that were as inspiring as they were educational. The highlight was pitching our idea for a multifunctional corn processing machine. This experience wasn't just about the challenge; it was about growing, learning, and realizing that our ideas could make a real difference in the world."

SUSIL CHETRI, *from team 2023-27, Tribhuvan University, Nepal*

Grand Final

June 2025

The Grand Final is an online celebration and awards ceremony which will be held in **June 2025**. It will be a chance to come together with fellow participants, friends, colleagues and industry partners to reflect on the year and celebrate your achievements. We will reveal the winning teams and present the Gold, Silver, Bronze, and People's Vote awards.

STUDENT SUPPORT

Webinar and event series

October 2024 — April 2025

The Challenge team will deliver a programme of online events including workshops, live webinars, and Career Conversations to enhance your learning and networking opportunities. These are essential to help you familiarise yourself with the solar appliance sector and learn key principles to inform your design.

Throughout the Challenge you are encouraged to explore our library of **previous years' recorded webinar series**.

Keen to hear advice from former Challenge participants on mentoring? Watch our mentoring segment from the 2022-2023 Grand Final.

Touchpoints

September 2024 — June 2025

The Challenge team will hold monthly drop-in sessions to answer questions and run two midway workshops to support you in your participating journey. We will also send regular round-up emails to keep you up to date on the Challenge, upcoming events, and milestones. We welcome your questions, comments, or feedback at any time. Email us at **eforachallenge@est.org.uk**.

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

Mentoring

October 2024 to May 2025

Efficiency for Access connects teams who would like to be mentored with specialists from the off-grid appliance sector to guide and support you throughout your project. Mentoring offers exposure to the off-grid industry, insights into the market you are approaching, and an opportunity to develop your soft skills. This is a fantastic opportunity, and all teams with a mentor are encouraged to proactively engage with their mentor.

Prototyping grants

Applications, December 2024 — February 2025
Recommended prototype development, March 2025 — June 2025

Grant funding to support your team to develop a prototype will be available on application. This is a chance to refine and elaborate your project ideas. Prototype development is optional and will not affect the assessment of your designs. Apply early to maximise the time you have to receive and use the funds.

This opportunity can help bring your project closer to market. If you have received funding and developed your prototype early enough, it will help you and the Challenge reviewers and judges to visualise your design. Your team's application must include a needs statement and a detailed budget approved by your educator. If your application is successful, you will need to complete an impact report by **October 2025**. More details, templates, and deadlines will be available closer to applications opening.

Collaboration on CrowdSolve

September 2024 — June 2025

CrowdSolve is an online collaborative space allowing you to engage with fellow students, the Challenge team, and your mentor. You will make your submissions and receive feedback on your concept note on CrowdSolve. Important updates and event information will be shared on the CrowdSolve forum, and you can use private messaging to connect with others.

We will provide guidance on how use CrowdSolve.

You will be asked to post regular reflections on CrowdSolve throughout the Challenge. Reflection is an important part of any design process, and it will help you to become a better designer and problem solver by developing your adaptability, proactivity, and responsiveness. It will help you to critically engage with your work, and spot and respond to challenges effectively. By posting your reflections and engaging with others, you will be able to share your experience, find out what others are working on, solve problems collectively and cheer each other on.

On CrowdSolve, your team will:

- Create your project space
- Submit your concept note
- Make your final submission

On CrowdSolve, you will:

- Set up a profile
- Join your team's project space
- Post regular reflections
- Receive Challenge updates

"Taking part in the Efficiency for Access Design Challenge was an amazing journey. Our team worked hard to create the 'Automated Solar Powered Fresh Produce Cooling Appliance,' and winning the Bronze Award was an incredible reward. We're thrilled to keep innovating for a sustainable future!"
PAMELLA UWICYEZA, from team 2023-20, University of Rwanda

ASSESSMENT

Your team's final submission and pitch will be assessed by experts from the off-grid sector against the 12 Challenge **Assessment Criteria**.

Final submission

At least two reviewers will assess your final submission, scoring it from 0-5 against each assessment criterion. You will receive the scores along with written feedback. The scores will be averaged to determine your final submission score out of a possible 60.

Pitch

Your team will present to a panel of judges, who will score your pitch from 0-5 against the same 12 criteria. You will receive verbal feedback but no scores. As above, the judges' scores will be averaged to determine your pitch score out of 60.

Final score

Your team's final score combines the final submission and pitch scores, with greater weighting given to the pitch score. This will determine your place in the competition.

"Judging the Efficiency for Access Design Challenge was a truly inspiring experience. It was heartwarming to see university students from around the world passionately working on innovative solutions to accelerate clean energy access. The students' designs were impressively well thought out, demonstrating a deep commitment to mitigating and adapting to climate change."

ANGELA CICILY JOSEPH, Research Manager at SELCO Foundation

ASSESSMENT FRAMEWORK

Reviewers and judges will mark your design using the assessment framework on the next two pages. The assessment framework includes 12 criteria split across four categories — innovation, sustainability, social impact and business model. All criteria are weighted equally and should be addressed in your final submission and pitch. Reviewers and judges will score your work from 0-5 against each criterion, using the following assessment rubric.

0	1	2	3	4	5
No description or explanation	**Little/unclear** description and explanation	**Some** description, explanation and **evaluation**	**Good** explanation, evaluation and **justification**	**Very good** evaluation, justification and **analysis**	**Excellent** evaluation, justification and **critical analysis**

INNOVATION

How does your design compare and improve upon existing products/services currently available to your target end user?

Judges will assess whether you've demonstrated a strong understanding of the technological context that you're targeting, and whether you've gone through a well-informed design process to improve upon existing products and services (including solar products and services) that are currently on the market.

- **Increased energy efficiency:** how does your design increase energy efficiency compared to existing products/services?
  Provide a definition of energy efficiency to inform your evaluation; establish a baseline for comparison; and compare your design with direct current (DC) and non-direct-current alternatives.
- **Increased affordability:** how is your design more affordable than existing products/services?
  Estimate the cost of your design and consider possible payment models you could offer.
- **Further innovation:** how is your design innovative beyond its efficiency and affordability?
  Consider key activities across the whole chain from manufacturing, logistics, installation, marketing, customer service, use, maintenance and disposal. Explain how your design innovates and offers value to the sector/market/customer (beyond its efficiency and affordability).

SUSTAINABILITY

How does your design contribute to the Sustainable Development Goals (SDGs), and reduce environmental impact throughout its lifecycle compared to existing products/services currently available to your target end user?

Judges will assess whether you've identified and understood the environmental impacts your design could have, and the SDGs it will contribute to achieving.

- **Environmental impact:** how does your design reduce negative environmental impact, or improve the natural environment, throughout its lifecycle compared to existing products/services?
  Evaluate your design's lifecycle from cradle to grave and assess its environmental impact compared to existing products/services. Consider both intended and unintended impacts.
- **Reduced greenhouse gas emissions:** how do the greenhouse gas (GHG) emissions of your design compare to those of existing products/services?
  Consider the GHG emissions of your design throughout its lifecycle from manufacturing and distribution through to operation and disposal.
- **Contribution to SDGs:** how does your design contribute to achieving the SDGs?
  Evaluate how your design contributes to SDG 7 - affordable and clean energy. Identify other SDGs your design impacts upon and assess how it does so.

SOCIAL IMPACT

What positive impact does your design have on people's lives?

Judges will assess whether you've researched the needs of the people whom your solution could benefit, how your design will target those needs, and how you have considered diversity, inclusion and equity in your design.

- **Improved quality of life:** how will your design improve the quality of people's lives?
  Consider who benefits and what improvement/s your design offers them.
- **Employment generation:** how will your design contribute to creating employment opportunities?
  Consider the labour and expertise required throughout your design's lifecycle, for example in manufacturing, distribution, operating and maintenance.
- **Leave no one behind:** how well has your design considered the SDGs' commitment to 'leave no one behind'?
  Consider the impact of your design upon people and communities who are marginalised or discriminated against, and its potential to reduce inequalities and vulnerabilities.

BUSINESS MODEL

How will your design get to market?

Judges will assess how well you've understood and evaluated the market potential for your design, how well you understand your target customer and your design's unique value proposition, and how you would develop your product/service and business during the next 12 months.

- **Market assessment:** how well have you understood and evaluated the potential market for your product?
  Identify and evaluate your key market, considering its size, your competition, and the main challenges and opportunities to entry.
- **Unique value proposition:** what is your design's unique value proposition?
  Demonstrate a strong understanding of your target customer and your design's competitive advantage, considering why someone would buy your product/service over existing products/services. Present a clear and simple message that you can communicate to customers explaining the unique value of your product/service.
- **Growth plan:** how will you develop your product and business over the 12 months following the Challenge?
  Identify a suitable business model and detail the realistic steps you would take over the 12 months after the Challenge to begin to take your product/service to market.

ACADEMIC INTEGRITY

PLAGIARISM AND REFERENCING

Plagiarism is serious academic misconduct, and it is unacceptable on the Challenge. Your university will have guidance on plagiarism — please refer to it or check with your educator if you are unfamiliar with plagiarism and how to avoid it.

You may use any academic referencing style but note that your university or educator may have a style that they ask you to use. Check with them for guidance if you are unsure.

USE OF ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) can be a useful tool to support learning, yet it also poses risks to academic integrity and standards, and **you must not submit work produced by a generative AI tool (such as ChatGPT) as your own.**

Despite its name, AI is not intelligent, and it can present false information convincingly. You must always ensure the accuracy of information generated by AI. We discourage you from using any AI generated text, but the most important thing is to reference where you have used AI appropriately. This includes where you have paraphrased AI.

It is unacceptable to:

- Submit text produced fully by AI
- Submit work produced by AI without proper referencing
- Copy or paraphrase AI-generated content without proper referencing

It is acceptable to:

- Use AI to find materials that you will read, consider, and use in your work — in this case you should reference the materials directly
- Use tools such as Microsoft Editor or Grammarly to help you edit and proofread your work
- Use translator tools, for example if English is not your first language

GLOBAL RESPONSIBILITY

Engineering has played a significant role in shaping the world we live in. While it has contributed to improving the lives of people worldwide, it has also played a fundamental role in contributing to the unjust and unsustainable practices that dominate the world today. Globally responsible design is critical to ensure society balances the needs of all people with the needs of our planet.

During the Challenge, you should be guided by the **four principles of global responsibility**:

Purposeful: To shape outcomes to be equitable and ethical throughout the life cycle of any project.

Inclusive: To ensure that diverse viewpoints and knowledge are included and respected in the design process and outcomes.

Responsible: To meet the needs of all people within the limits of our planet. This should be at the heart of design.

Regenerative: To maximise the ability of all living systems, to achieve and maintain a healthier state and naturally co-evolve.

We invite you to explore the **Global Responsibility Competency Compass**, developed by Engineers Without Borders UK, which points practitioners towards the capabilities they will need to stay relevant, and provides practical ways to develop these skills.

Diagram courtesy of Engineers Without Borders UK

Purposeful

The responsibility of a designer is to design systems, products, or projects with an adequate understanding of their effects, both positive and negative. Within the Challenge you can design ways to maintain and improve living systems, and to challenge established practices and behaviours that are unsustainable, unethical, or unjust.

- Decisions along every step of a supply chain carry wider impacts. For example, consider the materials used. Mining for materials like cobalt in the Democratic Republic of the Congo can drastically affect local communities and ecologies.
- Jobs are created in manufacturing that support local and global economies. However, a responsible supply chain also takes careful consideration of workers' rights.
- E-waste can be compounded if companies do not create a clear plan for how to contribute to a circular economy where parts can be reused.

Inclusive

Inclusivity requires the careful consideration of specific needs to ensure your design is suitable for all. The diverse world we live in comprises many cultures, values, and ways of interacting with one another. The dimensions of diversity include gender, religious beliefs, race, marital status, ethnicity, parental status, age, education, physical and mental abilities, income, sexual orientation, occupation, language, geographic location, and many more factors.

Throughout the Challenge, consider the importance of inclusive approaches to design in shaping better project outcomes and cultural practices within engineering.

- People who use your appliance will be one of your most critical stakeholder groups. We want you to seek out their opinions and involve them to fully understand their needs and aspirations, rather than view them purely as end users. This empathetic approach is essential to ensure that people with lived experience of the issues you are trying to solve are not just passive recipients.
- Engineers and designers alone cannot address the significant global challenges we face; we must work in collaboration with others.
- Culture in relation to sustainable development plays an important role not only in promoting, but also enabling sustainable development. Culture is often recognised as the fourth pillar of sustainable development, together with economic prosperity, social justice, and environmental sustainability.
- It is important to recognise that appliances need to integrate and work for different cultural practices (for example how you cook or what you make).

Responsible

Designers should act responsibly by focusing on meeting people's needs and ensuring that their work does not negatively impact the natural world. Consider how your Challenge design can responsibly interact with ecological systems, and human communities throughout its lifecycle.

- Ecological emergencies are justice issues. **High-income nations are responsible for 74% of global ecological damage, yet the impact of the damage will be strongest in low and middle income nations.**
- We must recognise our responsibilities as designers. Within the Challenge, exercise your ability to empathise and to deeply consider how ethical or responsible your decisions are. Critically reflect throughout on the impact your solution will, or could, have.

Regenerative

Restorative and regenerative approaches aim to design materials and products that actively restore ecological systems, rather than just reduce impact. Consider how your design interacts with ecological and social systems to benefit the environment as well as the end user.

- You will need to adopt a holistic worldview, integrating the latest good practices, so that your design can help living systems (people and planet) to thrive and continually improve.
- Regenerative Design focuses on seeing nature as a part of the design process, as a living system that interacts directly with the project.
- What patterns and relationships can you see between ecological and social living systems? You might take a 'circular' approach, whereby you deeply consider material choices, or disposal and reuse options, and design with this in mind.

LEARN MORE

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

Purposeful design

Doughnut Economics Action Lab works with changemakers worldwide, turning ideas into transformative action, 2024

Off- and Weak-Grid Appliances Impact Assessment Framework, Efficiency for Access Coalition, 2022

Product Lifecycle and Local Assembly webinar, Efficiency for Access Design Challenge 2020-2021

Inclusive design

Appliance Impacts Over Time, Efficiency for Access Coalition, 2023

Appliances for All: Assessing the Inclusivity of the Solar Lighting and Appliances Sector, Efficiency for Access Coalition, 2022

Responsible design

Resilient Appliances for Resilient People and Planet, Efficiency for Access Coalition, 2023

The Globally Responsible Virtual Experience Programme, EWB UK, 2021

Regenerative design

Blogs on regenerative design, Oliver Broadbent, 2023

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

Leah Gibbons, is regenerative the new sustainability?, 2020

We suggest you review the Inclusivity webinars from **year 2**, and **year 3** of the Challenge and the End User Perspective webinars from **year 1**, **year 2** and **year 3** of the Challenge.

DESIGN CONTEXT

Identifying a context to design for might seem simple, but in practice designing in a globally responsible way for any context is incredibly nuanced and complex. You should carefully consider your choice of context and dedicate time to researching and understanding the complexities of the situation, environment, culture, and people's needs.

For example, you could design for a humanitarian context. Humanitarian settings are in great need of support and offer great potential for innovative and impactful solutions. They are very diverse, so you could narrow down further to a specific displacement setting, which will give you a clearer picture of what, and for whom, you are designing. To narrow it down further, consider whether you are designing for a protracted or an emergency situation, because people's needs will vastly differ (**UNITAR, 2022**).

Globally, 1 in 73 people is forcibly displaced, and more people are displaced now than have been at any other time this century (**Global Humanitarian Overview, 2024**). The growing population of displaced people needs access to energy services, which could be provided by solar appliances. While displacement camps are often seen as a temporary solution by host governments, many large camps have existed for decades. To compensate for the lack of grid access, expensive and environmentally harmful off-grid alternatives like diesel generators are often used to provide electricity.

Understanding the current solutions and innovations available in your chosen context will help you ensure that your design is innovative. In humanitarian settings, for example, clean cooking and lighting dominate energy sector platforms and studies (**IRENA, 2019**). You might therefore find more potential to innovate by designing a different appliance, such as a refrigerator, fan, solar water pump, or television. As well as considering the level of innovation within your chosen context, you can consider the levels of innovation between contexts. For example, solar water pumps are fairly established in agricultural settings, but less so in humanitarian settings. You may find greater innovation potential in one context than another.

If you choose to go down a humanitarian route, ensure that you view the resources under Learn More.

LEARN MORE

Empowerment Through Appliances: Insights from the Humanitarian Energy Sector, Efficiency for Access Coalition, 2024

Efficiency for Access Design Challenge Webinar on Designing for Humanitarian Contexts, 2023

User-Centered Design in Humanitarian Energy Projects, Energypedia, 2023

The State of the Humanitarian Energy Sector 2022, UNITAR, 2022

Energy Solutions for Displacement Settings, GIZ, 2021

"I was born with a desire to make change. I am always thinking 'how can I improve the situation in my community?" The answer was always "there is nothing you can do.' I always hoped for a different answer. I couldn't break the shell. The Efficiency for Access Design Challenge knocked at the shell. They gave me an opportunity to think broad, and make change... The challenge made me grow as a person... The shell has been broken. I have obtained the answer I hoped for 'I can do it!!'"

TAFADZWA CHIPURIRO, from team 2023-33, University of Zimbabwe

TECHNOLOGIES

This section aims to expand your knowledge of the off-grid appliance sector and get you thinking about some of the different technology themes you could work on. It is a knowledge resource with links for further reading. Use it as a starting point for your own research on the sector and your chosen technology area.

AGRICULTURE

In 2022, over a quarter of global employment was in agriculture. Smallholder farmers who engage in manual agriculture experience more inconsistent, weather-dependent yields than 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, which are polluting and inefficient.

Milling requirements, preferences and demand vary geographically and seasonally, making the economic case for the technology a particularly challenging one. However, milling arguably has 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 (**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, energy efficient motors e.g. improved permanent magnet motors
- Improved power electronics to improve efficiency
- Adaptable machines to a more diverse range of products
- New applications relevant to specific local contexts

Spotlight on: Solar water pumps

Moving water using solar pumping systems offers a simpler more environmentally friendly alternative to diesel-driven pumps. 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 improvements could include:

- Remote monitoring systems, including low-cost sensors and controllers that improve efficiency of irrigation
- Highly efficient motors, e.g. brushless direct current (BLDC) motors
- Improved saline water tolerance and filtration to increase durability of the pump
- Modularity and availability of spare parts

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Evaluating Appliance Performance in the Field: Solar Milking Machines, Efficiency for Access Coalition, 2023

How Can Energy Access Practitioners Energise Regenerative Agriculture Settings?, Efficiency for Access Coalition, 2023

Innovator Series — Agsol, Efficiency for Access Coalition, 2021

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

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

Uses and Impacts of Solar Water Pumps, Efficiency for Access Coalition & 60 Decibels, 2021

REFRIGERATION

Refrigeration provides a wide range of benefits from improving health and productivity, to reducing 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 sale. Essential for a sustainable agricultural sector, modern cold chain technology is often out of reach in off-grid settings due to its prohibitive cost and high load requirements.

Refrigeration is vital in healthcare. Cold chains are required for vaccines and medicines such as insulin, antibiotic liquids, chemotherapy drugs, and topical preparations, which require strict temperature controls. These requirements are particularly challenging for off-grid communities.

A key innovation in refrigeration is solar direct drive refrigeration, which makes use of phase change materials like water packs to store energy as 'ice banks' — bypassing the use of a battery and charge controller. Another innovation is solid-state refrigeration, which uses thermo-electric cooling and the Peltier effect to bypass the use of refrigerants and many moving parts. These are important steps forward in solar refrigeration and should be well understood when approaching this technology.

Spotlight on: Refrigerators

Most household refrigerating appliances sold in off-grid settings are conventional, low-price AC refrigerators which 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:

- Using highly efficient motors
- Using low global warming potential refrigerants
- Creating modular cooling system designs for local assembly
- Using technologies that improve the energy efficiency or effectiveness of ice-making or its end use for cooling, storage and transport of foodstuff
- Improving variable speed compressors and their controls

Spotlight on: Walk in cold storage

In Sub-Saharan Africa, 37% of food spoils mainly due to a lack of adequate cold storage. This results in at least a 15% loss of annual income for 470 million smallholder farmers (**Efficiency for Access Coalition, 2021**). As perishable food begins to deteriorate as soon as it is harvested, a robust cold chain system, equipped with walk in cold-rooms, is required to keep produce fresh. This can be a challenge in off-grid settings, particularly in terms of the energy demand required to refrigerate a large area.

Research suggests that improvements could include:

- Using reliable remote tracking and monitoring
- Implementing cooling-as-a-service business models
- Increasing power system sizing
- Using efficient and affordable insulation materials
- Using phase change materials

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Sustainable Cooling in Off-Grid Rural Areas, World Bank, 2024

Chilling Prospect Special: Gender and Access to Cooling, SEforAll, 2023

Innovator Series: Bridging the Gap for the Fish Cold Chain in Lake Turkana, Efficiency for Access Coalition, 2023

Keep It Cool: Harnessing Cold Storage to Reduce Food Loss & Support Sustainable Food Systems in Emerging Economies, Efficiency for Access Coalition, 2023

Life Cycle Greenhouse Gas Emissions Assessment of Off- and Weak-Grid Refrigeration Technologies, Efficiency for Access Coalition, 2023

Walk-In Cold Rooms, A Practitioner's Technical Guide, Efficiency for Access Coalition, 2023

Creating a More Resilient Food System Through Sustainable Refrigeration, Efficiency for Access Coalition, 2022

Innovator Series: Off-Grid Cold Rooms: A Game-Changing Development for Local Smallholder Farmers, Efficiency for Access Coalition, 2022

Innovator Series: Truck-Mounted, Solar Refrigerators to Enable Local Farmers in India to Reach New Markets, Efficiency for Access Coalition, 2022

COOKING

The International Energy Agency (IEA) reports that 2.3 billion people currently cook with polluting fuels such as kerosene, coal or biomass, in poorly ventilated areas. Meanwhile, household air pollution, mostly from cooking, is linked to about 3.7 million premature deaths per year (**IEA, 2022**). Manufacturers in the off-grid appliance sector have designed super-efficient cook stoves, but cooking appliances could be more affordable, efficient, and aligned with traditional cooking methods.

Spotlight on: Electric pressure cookers

The electric pressure cooker (EPC) or multicooker is an appliance capable of steaming, boiling, pressure cooking, frying, and baking, while producing no smoke. Through a combination of insulation, pressure, and high temperatures, EPCs use about one-fifth of the energy of a hotplate to cook over 90% of foods.

EPCs have the enormous potential to provide clean cooking to the 2.5 billion people who rely primarily on biomass or polluting fuels to cook their food. They also have disproportionate potential to improve women's health and socioeconomic standing. Two-thirds of consumers noted their improved health when using an EPC; almost 50% report an improved quality of life; and 35% see a reduction in household fuel expenses (of 400 consumers interviewed in Kenya, **Efficiency for Access Coalition, 2021**). EPCs reduce exposure to indoor air pollution, and the amount of time and labour associated with collecting fuel.

Research suggests that improvements could include:

- Adapting to individual and community ways of life
- Increasing affordability through reduced cost and consumer financing
- Improving reliability by reducing component burnout and improving pressure sealing rings

LEARN MORE

Examining the Experience of Using Electric Pressure Cookers in Urban Households in Kigali, Rwanda, Sustainable Energy for All (SEforAll), 2023

Renewables Based Electric Cooking: Climate Commitments and Finance, IRENA, 2023

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

Gender-Responsive Electric Cooking in Nepal, MECS, 2021

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

POWER MANAGEMENT

The high cost of batteries is a significant barrier to appliance uptake in off-grid settings. Distributors often oversize them to ensure a constant supply of electricity to large appliances like refrigerators. This increases cost and reduces efficiency. Improved power management can help tackle these issues.

Spotlight on: Solar home systems and mini-grids

Solar home systems and mini-grids have finite power supplies. They must 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 they need, while increasing energy efficiency.

Research suggests that improvements could include:

- Creating systems that integrate different appliances or allow them to communicate
- Using cheaper connectivity and control components, e.g. embedded controllers
- Using smart batteries to collect and optimise data
- Using machine learning to improve efficiency and performance
- Implementing innovative business models to provide holistic services

Smart-grids, created through widespread installation of smart meters and sensors, are embedded with an information layer that allows communication between 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**).

LEARN MORE

'Core' modular battery, Aceleron Energy, 2021

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

INFORMATION AND COMMUNICATION TECHNOLOGY

Information and communications technologies (ICT) is a broad term that covers communication enabling technologies such as televisions, radios, mobile phones, and computers, as well as software and hardware such as satellite systems and internet of things (IoT). ICT are essential to how we communicate and interact.

Two technological pillars, digitisation, and interconnection, are driving a digital transformation of all areas of life, complemented by related technologies. Internet of Things (IoT) is a key innovation that allows a network of devices to connect and exchange data using sensors, software and other technologies (**Efficiency for Access Coalition, 2021**). Among other applications, IoT can be used to monitor the location, activities, and status of appliances; control devices remotely; optimise performance through artificial intelligence (AI); and facilitate interoperability (**Efficiency for Access Coalition, 2021**).

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Innovator Series: Innovex Uganda, Efficiency for Access Coalition, 2023

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

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

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

The Connect White Paper: Defining A Universal Connector and Firmware For 12V SHS Kit And Appliance Interoperability, GOGLA, 2021

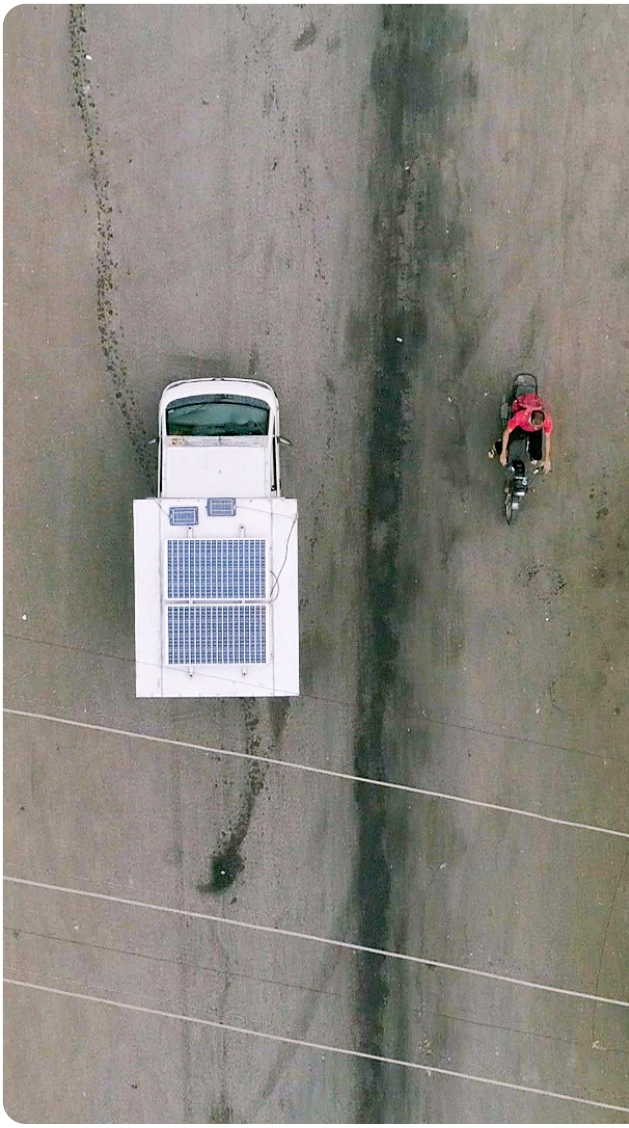
E-MOBILITY

The transport sector is responsible for approximately 23% of total energy related carbon dioxide emissions. To reach global climate change mitigation targets, there will need to be radical transformative changes to the sector (**IPCC, 2022**). E-mobility, encompassing all modes of battery-powered transport, has long established itself as the future of land-based transport. Still, only 1% of road vehicles are electric (**Efficiency for Access Coalition, 2021**). Beyond the wider adoption of non-motorised transport, electric vehicles powered by low emission electricity are the most effective way to decarbonise our land-based transportation (**IPCC, 2022**).

There are many co-benefits to e-mobility, including reduced greenhouse gas emissions and improved air quality. E-mobility also provides the means for rural communities to safely transport their produce, which helps give fair incomes to producers, strengthen food systems, and address SDG 2 — zero hunger (**Efficiency for Access Coalition, 2021**).

The cost and performance of e-mobility technology is heavily reliant on the battery market. The battery comprises nearly 40% of the cost of an electric vehicle and efficiency improvements are mostly derived from improved battery technology (**Efficiency for Access Coalition, 2021**).

Charging-as-a-service is a strong e-mobility related business model that includes battery swapping and renting, which allows customers to swap their discharged battery for a fully charged one for a small fee. This reduces the upfront cost of an e-bike by about 40—50% as it allows customers to rent or purchase their system without a battery, and negates the need for fast-charging, which degrades batteries more quickly.



Spotlight on: Two/three wheelers

Motorcycles are the most electrified segment of road transportation today. Due to their light weight and short driving distances, micro-mobility vehicles require relatively small batteries making them easy to electrify. In many regions, electrification already makes economic sense, and the sales share for electric two/three wheelers was above 20% in 2021 (**IEA, 2022**).

Micro-mobility vehicles also provide great opportunities for productive use applications. For example, two/ three-wheelers are already widely used for taxi services — it is estimated that the Sub-Saharan African motorcycle taxi market was worth USD 62 billion in 2019 (**Efficiency for Access Coalition, 2021**).

LEARN MORE

Mobility for Africa Awarded 2022 Scale Up Project of the Year, EEP Africa, 2023

Global EV outlook 2022, IEA, 2022

Mobility for Africa

Jerr-E-Can Swappable Battery Pack by Powerhive

Remotely Enabled Electric Outboard Engines for Rental by Asobo

Research suggests that improvements could include:

- Integrating with other sectors such as cooling
- Integrating open and interoperable software
- Increasing understandings of end-users and their needs
- Increasing reliability of renewable energy charging services
- Implementing local and integrated recycling systems

OTHER TECHNOLOGIES

Spotlight on: irons

Bboxx has developed a DC-powered iron that aims to reduce ironing time while being efficient, durable, safe, and affordable at a price point of about USD20. The solution hopes to reduce traditional charcoal irons, which are inefficient, expensive, polluting and less safe. Irons help to reduce the burden placed on women and children who are typically responsible for ironing; enable people to work in professional attire; and reduce the potential for health conditions like human myiasis, which is transmitted by insects that infest damp clothes hung up to dry.

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 areas (**Off-grid Refrigeration Technology Road Map, 2019**).

Spotlight on: egg incubators

In the face of climate change impacts, enhancing livestock production could significantly increase farmer resilience through the diversification of income. **OVO Solar** has developed a stackable egg incubation unit that regulates temperature, humidity, and air exchange, and integrates IoT monitoring hardware.

LEARN MORE

Appliance Data Trends, Efficiency for Access Coalition, 2021

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

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