FACTSHEET 7

Circularity and Sustainable Energy

SESA
Smart Energy Solutions for Africa

Dreamstime / Lucian Coman

About the Sustainable Energy Solutions Catalogue

The Sustainable Energy Solutions Catalogue provides an introduction to the solutions deployed during the SESA project. The catalogue targets energy practitioners, policy makers and civil society, especially at local level. In the catalogue, readers can find key facts about specific sustainable energy solutions (technologies, business models, impact areas), and learn about approaches and concepts that help ensure the viability and long-term success of sustainable energy in the African context.

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1 Introduction

Today's predominantly linear economy works by using resources to manufacture products which are later disposed of at the end of their useful life. A **circular economy** can be defined as a sustainable economic system where the loop linking waste and raw materials is closed, and where economic growth is decoupled from resource use. Achieving circularity in businesses and economies is a necessary step to sustainability, as well as a source of economic opportunities.

Applying circular approaches to sustainable energy solutions aims to eliminate waste throughout the lifecycle of the energy technologies (Figure 1). This includes, for example, improving the design of products so that they last longer, or maximising their recycling potential when they reach the end of their life.

This factsheet focuses on how different approaches to circularity can be integrated into different sustainable energy solutions (such as sustainable e-mobility or solar off-grid solutions) in the African context. It also presents the socio-economic impacts of circularity and the potential for scaling up the approaches, and gives examples of the application of circularity principles in sustainable energy in the African context and within the SESA project.

It is important to note that circular economy approaches focus on the entire lifecycle of a product and not only on the end-of-life (EoL) stage. For more details on the EoL stage of solar off-grid systems, please consult the "E-waste from solar off-grid solutions" and the "Second life of Lithium-ion batteries" factsheets in this catalogue.

2 The technology

The technological innovations that most contribute to circularity in sustainable energy are those that **prevent the production of waste** in the first place. A mini-grid, electric vehicle or solar home system that strives for circularity is one that seeks to prevent waste production during all phases of the product's life: manufacture, distribution, storage and use.

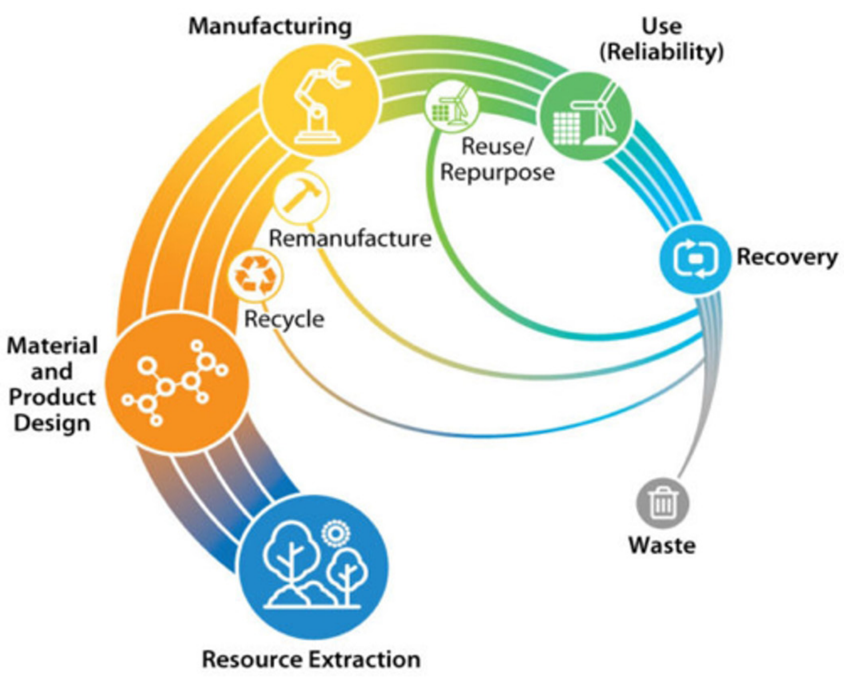
The most effective innovations to prevent waste are those that are integrated into **product design**. Designing products that are **durable** and **easier to maintain and repair** is central to extending the use phase and therefore to preventing waste production. Durable and repairable products that stay in the loop for a longer period of time also bring significant side benefits to users (see "Socio-economic impacts" section below). There are different examples of innovations that have been implemented by off-grid solar companies to increase the repairability of their products (Spear et al., 2020). For example, Solarly solar home systems (Solarly, 2022) are designed so that the batteries and fuses are accessible for ease of repair, as opposed to other designs where the whole system needs to be replaced in case of failure.

The appropriate operation of products also helps to extend their life. For example, the life of batteries can be extended significantly by avoiding frequent rapid charging, strong acceleration, mechanical shocks and extreme temperatures (Mosshammer, 2022).

Similarly, innovations that make it **easier for the product to be reused, refurbished and recycled** also prevent waste creation. For example, Lithium-ion batteries in electric vehicles are increasingly designed to make it easier for them to be used as storage units in off-grid solar applications during their second life (see the "Second life of Lithium-ion batteries" factsheet in this catalogue). There are also multiple ways to **improve the recyclability** of a product: using recyclable materials, limiting the number of material types and composites, or increasing modularity.

Making products less material-intensive or introducing **recycled materials** into the design of products is a further avenue towards circularity. Ecolife in Uganda is an example of how this can be integrated into the design of PUE (productive use of energy) appliances. They manufacture cold storage rooms that use locally available agricultural waste, plastic bottles and other recycled materials as isolation material (Efficiency for Access, 2020).

Figure 1: **Circularity in sustainable energy solutions** (NREL, 2022)



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Strategies for waste prevention during **manufacturing and distribution** include, for example, the use of local materials and suppliers (to reduce the waste, water and carbon footprint of transport), the minimising of packaging and the use of sustainable logistics infrastructure.

Finally, **Information and Communication (ICT)** and **Internet of Things (IoT) technologies** are key to achieving circularity, as they allow remote monitoring of components of sustainable energy solutions, such as electric vehicles or batteries. This facilitates repair and maintenance services, therefore contributing to extending the life of the product. Moreover, it allows for learning from product-in-use data, which can inform innovations and improvements in design (Ingemarsdotter et al., 2019).

Examples of application in the African context — 1

Solibrium-Solar, Kakamega, Kenya

The company:

- Solar Home System company that considers the entire life cycle of products, including: production phase with as little material input as possible, use phase accompanied with regular maintenance and a component-based repair system to avoid waste, and end-of-life phase ensuring reuse or recycling of the SHS

The approach:

- Modular household solar kits, coupled to solar-based appliances
- Flexible and variable payment system (e.g., PAYGo)
- Work with micro-franchisees to grow entrepreneurs from the grassroots
- Take-back/buy-back system for faulty or broken products
- Repair and refurbish of products for resale
- Refurbish components for resale to informal sector

For further information visit:

→ www.solibrium-solar.com/rewmos-2
→ https://medium.com/efficiency-for-access/the-global-leap-awards-are-an-international-competition-to-identify-and-promote-the-worlds-best-d33623740612

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3 Business and financing models

Business models that support circularity increase the lifetime of sustainable energy products and are potentially a source of savings and benefits for businesses, as they can lower maintenance costs, improve efficiency and lead to new revenue streams (e.g., through sale of parts or recovered materials). However, circular economy approaches can also pose challenges. For example, companies may be concerned that, by increasing repairability (and thus extending lifetime) they will sell fewer products and experience a loss in revenue, or that using more expensive materials or increasing the investment in product design will lead to substantial costs. Many manufacturers may be reluctant to design systems for repair and disassembly because of fears that this will make it easier to copy components or bypass smart payment mechanisms (Spear et al., 2020).

There may also be trade-offs between different circularity approaches. For example, solar home system businesses may perceive a trade-off between increasing durability and repairability: if a product is easier to open, it may lose the protection required to keep out dust and rain (Spear et al., 2020). Some businesses may be concerned that increasing the repairability also affects their ability to honour warranties (as warranties require that the product is untampered with).

New business models are emerging in the sustainable energy space with the aim of tackling these challenges and closing the loop of the product life cycle. This factsheet focuses on business models addressing the design and use phase. For information about models dealing with e-waste (e.g., public-private partnerships, take-back models), please consult the "E-waste from solar off-grid solutions" factsheet in this catalogue.

In the **Productive Service System (PSS) model**, customers can purchase a service for a limited time while the provider maintains ownership of the product. The provider remains incentivised to maintain the product and enhance its durability (Jensen, 2022). The benefits for product owners are continuous customer contact and insights into how their products are used. Additionally, companies can potentially gain access to new remanufacturing and refurbishment markets. IoT facilitates these models. An example for a PSS approach is battery swapping in e-mobility solutions (for more details see Sustainable E-mobility factsheet in this catalogue).

Business models focused on **peer-to-peer trading** seek to use existing assets or infrastructures, enabling a more efficient use of resources. Electricity trading, for example, allows households with solar panels to sell unused energy to their neighbours instead of wasting it (Efficiency for Access, 2021).

Applying a **decentralised repairs** approach can help reduce the costs to businesses by outsourcing repairs. Three variants of this model can be distinguished (Efficiency for Access, 2020):

- Training product distributors for repair (and making spare parts and repair tools available).
- Leveraging third party repair technicians in the informal economy
- Empowering end-users - making provisions for providing spare parts and repair guides publicly to the customers to repair the products themselves or by a third party.

Local assembly or manufacturing of products, and using some degree of locally manufactured components, can improve the availability of spare parts and appropriate repair tools, and bring about substantial co-benefits in terms of local skills and job creation.

Examples of application in the African context — 2

Engie Energy Access, various countries

The company:
- Leading solar home system and mini grid developer who integrates waste management into its model

The approach:
- Piloted a comprehensive buy-back scheme to retrieve faulty off-grid solar components (of any brand) in Uganda, along with off-grid solar lead acid batteries from the informal sector
- Tested two buy-back prices and found that a 16% price drop (3,000 UGX (USD 0.86) to 2,500UGX (USD 0.73)) resulted in a 79% drop in the quantity of e-waste collected
- Set up of 8 e-waste collection points and collected over 77 tonnes of OGS e-waste which were forwarded for safe recycling and disposal. The largest category of e-waste collected was batteries
- Trained 748 people, including key industry actors and consumers (via community-based education)
- Developed learnings to help the off-grid solar sector understand the risks and find possible solutions to the e-waste challenge

For further information visit:
→ https://engie-energyaccess.com
→ www.clasp.ngo/research/all/innovations-in-off-grid-solar-e-waste-management

4 Socio-economic and sustainability impacts

Africa's demographic and economic growth is leading to an increase in waste generation, with devastating health and environmental impacts. The African Union projects that by 2050, the volume of waste will triple from current levels. Currently, more than 90% of Africa's waste is disposed of at uncontrolled dumpsites and landfills, often followed by open burning (Dugbazah et al., 2021). The generation of e-waste is also increasing rapidly, driven by international trade and domestic consumption. When disposed of or recycled improperly, e-waste poses severe risks to ecosystems, human health and livelihoods. Moreover, resource extraction can lead to environmental impacts (such as water shortages, in the case of Lithium extraction) and threaten the livelihoods of local communities.

While sustainable energy solutions can bring about a range of social, economic, and environmental benefits, there is a risk that they contribute to problems linked to waste generation and resource extraction in Africa. Applying circular economy approaches to sustainable energy solutions can help prevent waste and reduce material demand (and therefore the impacts of material extraction). Indirectly, circularity helps to harness the value of materials and can create new local industries and income generation activities.

In many African countries, circular economy activities such as waste collection, repair or remanufacturing are an important source of employment. These jobs are predominantly in the informal sector, where they lack legal and health protection as well as social security coverage (Gower and Schröder, 2016). Nonetheless, they are an important source of income. Increased support for product repairability can lead to creation of new jobs related to repair, and an opportunity to upskill repair technicians (Spear et al., 2020). Additionally, circular economy interventions can create new job opportunities in higher-value supply chains, and improve the quality of employment (World Economic Forum, 2021).

Examples of application in the African context 3

Innovex, Kampala, Uganda

The company:

- Develops digital technologies to remotely monitor and control solar PV systems and equipment, supporting preventative maintenance and repair activities

The approach:

- Competencies include embedded systems, connected devices, web and software development, mobile money integration and wireless communication technologies
- Home-grown IoT solution 'Remot' offers after-sales service support and manages preventative maintenance and repair activities

For further information visit:

→ https://innovex.org

Figure 2: **Dismantling of computers at WEEE Centre in Nairobi, Kenya** (TNO Netherlands, 2022)

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5 Scaling-up

Circularity approaches within the sustainable energy sector in Africa have only recently started emerging and still have an immense potential for scale up. An effective enabling environment and policy framework are urgently needed to drive a widespread application of circularity concepts in African sustainable energy businesses. Policy can allocate the cost of waste generation fairly among producers and enable profit for businesses that promote durability, repairability and recycling. Some examples of policy instruments include **Extended Producer Responsibility** (EPR) schemes, eco-design policies and favourable tax regimes.

EPR schemes shift the responsibility for waste management towards the producer and away from local governments. They thus provide incentives for producers to improve the design and manufacturing of their products and ensure recycling for recovery of materials. Some of the challenges with EPR implementation in Africa include the sharing of responsibility between importers and manufacturers (Africa Clean Energy, 2019), as well as the difficulty in enforcing the policies.

Eco-design policies can help to integrate circularity into all stages of product development (EEA, 2001). For example, they can stipulate the use of less material, or a modular design of components which facilitates their reuse or the use of interchangeable components across products.

The shortage of spare parts impairs repairability. This shortage can be due to the high costs of imports and the small order sizes of local repairers. Policymakers can counter this with **favourable import tax regimes** for solar components while the spare part supply chain can be supported by local original equipment manufacturers (OEMs,) by building regional supply networks and sharing information (Blair et al., 2021).

6 Circularity solutions in SESA

Implemented in nine African countries, the EU-funded SESA project is developing and testing solutions to accelerate the energy transition in Africa. The focus of the project is on the exploration of innovative technologies and services in urban and rural contexts. SESA partners in various are working on circular economy approaches in their Living Labs. Their activities are briefly outlined below.

6.1 Kenya Living Lab

SESA partner **WeTu** is developing innovative solutions for e-waste as part of the SESA Kenya Living Lab. The main objective in this Living Lab is to demonstrate sustainable energy access solutions that are relevant for both urban and rural contexts in Africa, centred around solar PV off-grid electricity generation for multiple uses (fishing sector, water pumping, water purification, e-mobility), e-waste management, and integration of local Info Spots for digital access to information on energy, climate change and digital skills.

The Living Lab comprises two project sites: Kisegi, a rural village in Homa Bay County, and Katito, a peri-urban community in Kisumu County. The solar charging hub in Katito uses a lead-acid battery bank and conventional inverter system, while Kisegi tests a hybrid inverter system with Li-ion storage and a “hot swapping” system.

WeTu takes **circularity** into account in the **design stage of new products**. For example, fisher lanterns are designed to be easily repaired and therefore stay in circulation much longer. Moreover, the company takes an **integrated approach to waste management**, by making users aware that devices that are out of use are valuable resources with potential to be repaired or recycled to their full extent. WeTu searches for suitable partners for the handling of different waste streams such as plastics, metals, glass, and its specific e-waste components.

Several WeTu hubs are established as e-waste collection centers and an e-waste pre-processing plant is being developed in the Homa Bay hub. WeTu also handles its own assets from different appliances which came to the end of life as e-waste such as fisher lanterns and other technical components from the charging hubs.


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7 Climate-proofing

Climate proofing is a term that refers to the process of mainstreaming climate change into mitigation and/or adaptation strategies and programmes (Climate Policy Info Hub, 2022). The goal of climate proofing is to ensure that climate-related risks and opportunities are integrated into the design, operation, and management of products and infrastructure. To achieve that, projects must be screened for climate risks, vulnerabilities and opportunities early in the design stages.

Circularity approaches are linked to the climate proofing of sustainable energy solutions in different ways:

- Integrating ease of repair, refurbishment and replacing in product design also makes sustainable energy infrastructure and products more climate-resilient and able to recover from damages caused by extreme climatic conditions.
- To lengthen the useful life of products, the choice of materials, components, technical specifications and operation guidelines should take into account future changes in climate conditions. For example, the choice of batteries should consider the increase in the range of expected ambient temperature, to avoid premature battery failure.
- The resilience of energy infrastructure to extreme weather events can also be improved by considering future changes in climate during the design stage.

8 Relevant tools and capacity building materials

Circular Economy Learning Hub

Created by the Ellen MacArthur Foundation, this Hub contains many different capacity building elements to expand the understanding of circularity concepts and to learn how the concepts can be applied to different parts of the economy.
→ https://ellenmacarthurfoundation.org/explore

GOGLA Circularity Toolkit: E-waste Blueprints

The E-waste Blueprints provide practical resources and tools, including an assessment framework, policy template and KPIs (Key Performance Indicators), that can be adapted to suit the individual needs and context of OGS companies. A plan with 3 steps (assess-plan-execute), helps companies implement and improve e-waste management across their operations, in line with their business, operational, and geographical context.
→ www.gogla.org/circularity/tools

Business Model Innovations Project – Efficiency for access

This project provides information on a range of business model innovations in the off-grid appliance sector, including those oriented towards circularity. It includes various case studies.
→ https://efficiencyforaccess.org/publications/business-model-innovations-project

StEP Initiative – Partnerships between the informal and formal sector for sustainable e-waste management

The informal sector plays an important role in the collection and management of e-waste. In this context, this paper presents approaches and case studies on current informal-formal partnership models in different countries around the world, among which the African continent stands out. The partnership concept presented aims to support the achievement of high recycling rates and legislative requirements, in the framework of extended producer responsibility (EPR) or other collection systems in low- and middle-income countries.
→ www.step-initiative.org/files/_documents/publications/Partnerships-between-the-informal-and-the-formal-sector-for-sustainable-e-waste-management.pdf

ACE Africa – Accelerating Circular Economy in Africa

The ACE Africa project aims to support the growth of circular economy businesses in Africa. The desired outcomes of the capacity building webinars are to support a number of businesses to mature, to contribute to improved innovation ecosystems for circular economy, and to provide guidance to local governments on how to improve or support innovative businesses that enhance circular development.
→ https://riseafrica.iclei.org/aceafrica/#circularity-is

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