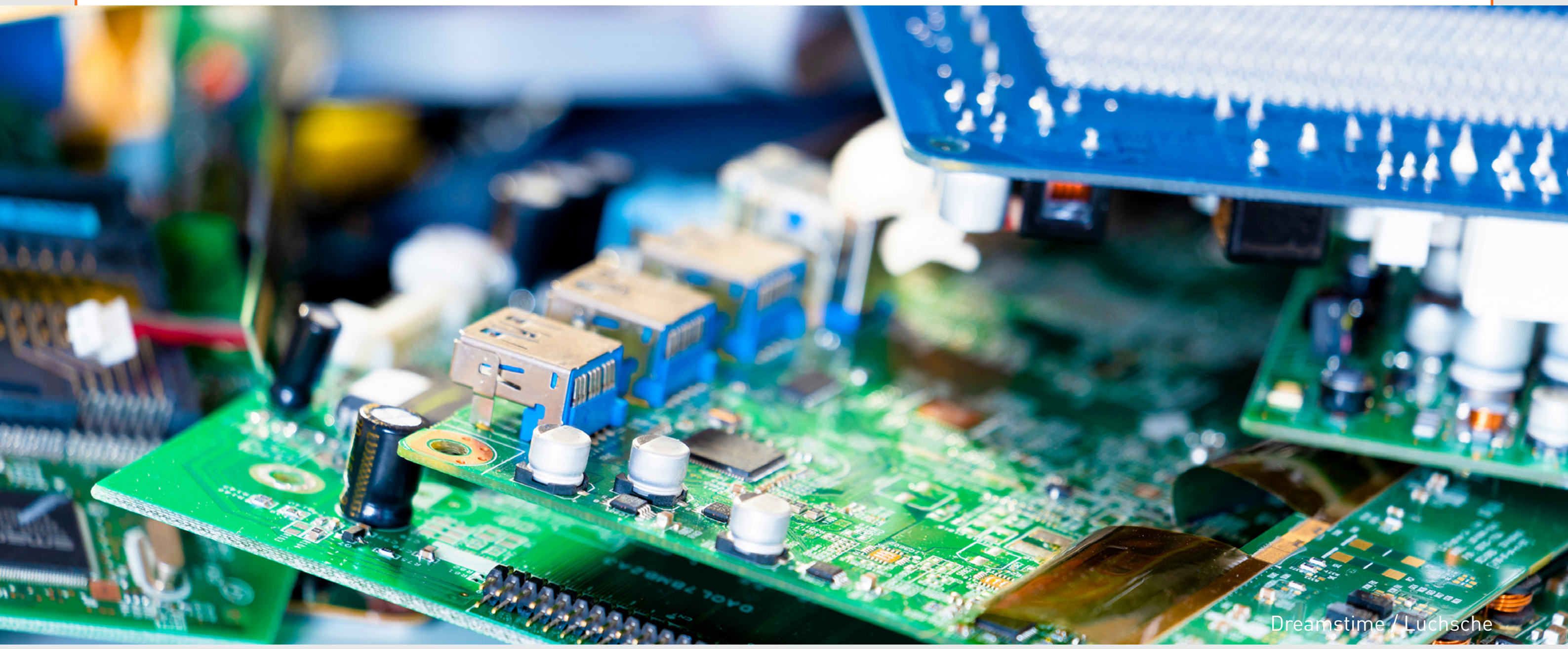
FACTSHEET 10

E-Waste from off-grid solar solutions

SESA
Smart Energy Solutions for Africa



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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

Electronic waste (e-waste) is the fastest-growing waste stream in the world and has severe impacts on human health and the environment (UNITAR, 2020). At the same time, e-waste is also a source of scarce and valuable materials. Off-grid solar (OGS) products currently make up only a small proportion of the global e-waste stream. In 2020, around 10,000 tonnes of e-waste resulting from OGS products were produced globally (EEP Africa, 2020), compared to over 50 million tonnes of total e-waste (GOGLA, 2020). However, as the OGS industry continues to grow, managing its e-waste is becoming increasingly important.

This factsheet focuses on solutions for the **collection, handling, recycling and disposal** of e-waste components resulting from OGS products, particularly in the African context. It focuses on solutions for the end-of-life (EoL) stage of OGS products, when options of extending the product life such as reuse and repair have been exhausted (see Figure 1). However, it is important to remember that the prevention of e-waste during the design, manufacture and use stages of the product plays a key role in reducing e-waste. For details on these solutions, please consult the factsheet "Circularity and sustainable energy" in this catalogue.

2 The technology

The main components of OGS e-waste are: photovoltaic (PV) solar modules, batteries (which can be lithium-based, lead acid, or other), electronic controls, cables, metal components, and end-use appliances (e.g., light bulbs, televisions, monitors) (GOGLA, 2019a). Each of the components requires a specific treatment technology due to the different materials they are made of (Figure 2).

Different technologies come into play in the different steps of e-waste treatment: **collection, recycling** and **disposal** of OGS products.

2.1 Collection

At the end of the life of an OGS product, or when a repair is needed, the product needs to be collected. This is very important to avoid that products are abandoned, and that e-waste is disposed of improperly. **Information and communications (ICT) and Internet of Things (IoT) technologies** are increasingly used to support collection operations. **Remote performance monitoring**, such as tracking battery performance, helps to understand which products are due for repairs or replacements (Efficiency for Access, 2021). Commonly, OGS companies have established schemes to take-back products when they are defective during the guarantee period (Cross and Murray, 2018). It is important that the technologies supporting take-back schemes continue to operate beyond the expiration of the product warranty, as most products reach EoL after the warranty period (GOGLA, 2020). More information on different business models for collection (such as take-back schemes or third-party collection), is given in the Business and financing models section below.

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

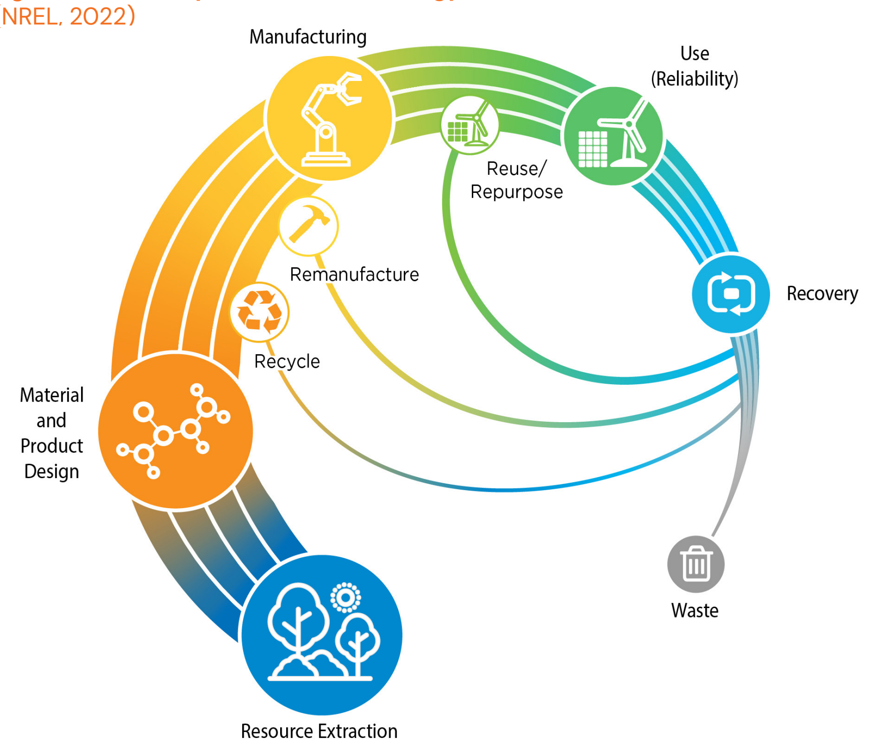
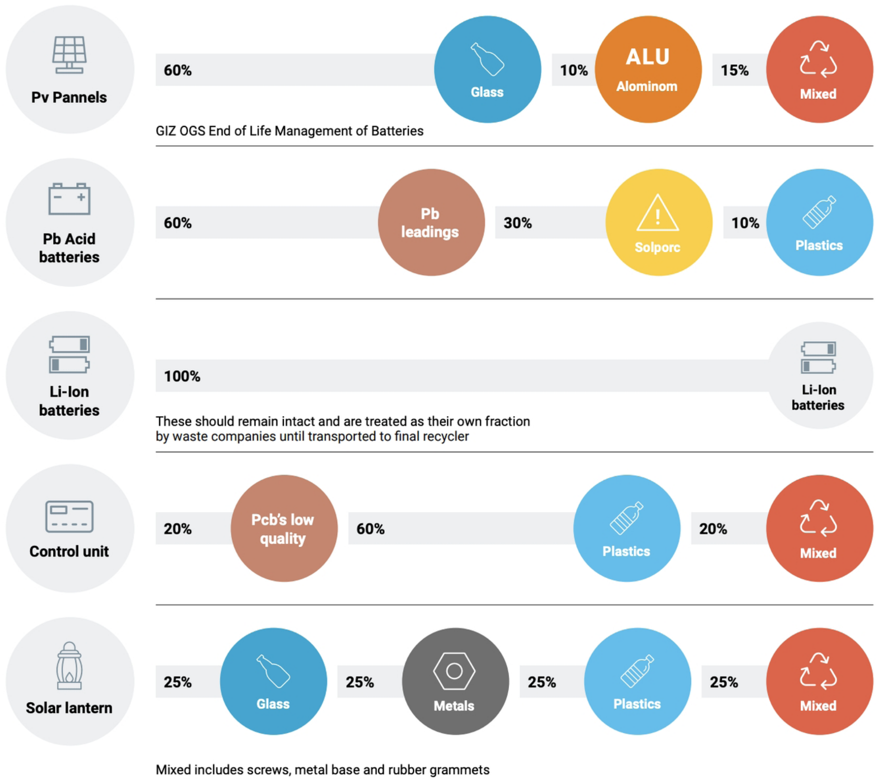


Figure 2: **The waste components of off-grid solar products** (Gibson and Demir, 2022)



2.2 Recycling

After e-waste is collected, it is dismantled and separated into smaller parts and fractions (see Figure 3). Dismantling means the mechanical or manual disassembly of products while the separation into fractions refers to the grouping of waste according to materials it is composed of (GOGLA, 2019a).

The subsequent handling, transport and recycling of the fractions then depends on the characteristic of each fraction and the level of risk they pose. Some fractions have more complex recycling needs than others. For example, Li-ion battery recycling requires mechanical shredding, while plastics require careful sorting as not all types of plastics are recycled at the same melting point (GOGLA, 2019a). Fractions that contain hazardous or toxic substances are recycled separately.

2.3 Disposal

Disposing of e-waste in appropriate engineered landfills can be less harmful to the environment than incineration or uncontrolled disposal. The landfilling process involves excavating soil and burying the e-waste, using a liner of plastic or clay to isolate. However, landfilling e-waste can still lead to the leaching of toxic materials into the soil and groundwater. Therefore, the ultimate goal should be that all OGS components can be fully diverted from landfill through reuse and recycling.

Examples of application in the African context 1

Hinckley Associates, Nigeria

The company: First formally registered e-waste recycler in Nigeria, one of the largest and fastest growing electronics and solar off-grid markets on the continent

The approach:
- Collection and recycling of e-waste, re-use and redeployment
- Alliance with Hewlett Packard (HP) and other key electronics manufacturers across Africa
- Engagement with the Lagos informal e-waste sector, including health and safety trainings, awareness campaigns, provision of protective equipment, capacity building on safe dismantling
- Testing out incentive schemes and mechanisms to formalize relationships with informal recyclers through contracts and health insurance plans
- Partnership with Lumos, one of the biggest PAYG distributors in Nigeria, to recycle their batteries
- Development of a battery testing and refurbishment laboratory in Lagos

For further information visit:
→ https://hinckley.com.ng
→ https://medium.com/efficiency-for-access/hinckley-recycleing-takes-on-nigerias-informal-recycling-industry-d8f8880e9b2c

Figure 3: **Dismantling of computers at WEEE Centre in Nairobi, Kenya** (TNO Netherlands, 2022)

3 Business and financing models

Most off-grid solar companies in Africa are not yet in the position to bear the full cost of managing the e-waste they produce. The cost of solar e-waste solutions poses a challenge in what is already a high-risk market. Moreover, there is a lack of necessary widespread collection infrastructure of e-waste that is needed for effective collection (Hansen et al., 2022). Different business models are being used to address the affordability and infrastructure problems. It is essential that these are complemented via a supporting enabling environment, e.g., through regulation and policies (see Scaling-up section below for more details on these).

3.1 Types of solar e-waste businesses

It is important to note that there are different types of businesses in the solar e-waste market. Some are solar companies that incorporate e-waste treatment (or some of the steps) into their core business. An example is ENGIE Energy Access, which developed a comprehensive buy-back scheme to get access to defective OGS components and used lead acid batteries from the informal sector (Blair et al., 2021) (see more under Examples section). Other businesses focus on e-waste treatment in general, and solar e-waste is only one of many e-waste streams they deal with. This is the example of Nigerian Hinckley Associates (see Examples section).

3.2 Consumer- vs producer-financed models

While many African countries are yet to develop policies to manage e-waste, business models for solar e-waste companies will be influenced by the existing policy framework. Two major policy approaches can be applied. In the consumer-financing approach, the consumer carries the costs of the e-waste that is produced. When purchasing a product, the consumer pays a fee (sometimes known as an "advanced recycling fee") that is used to cover the collection and processing of the e-waste. Occasionally, the fee is refunded to the consumer when the device is correctly disposed of (Ichikowitz and Hattingh, 2020).

The second main approach is the one where the producer finances the costs. Under Extended Producer Responsibility (EPR) policies, the manufacturer (or the importer) of the product pays for the e-waste treatment and bears the responsibility for managing the end-of-life of its products (GOGLA, 2019b). A key goal of EPR policies is to incentivize producers to consider environmental aspects during the design phase and ultimately reduce the volume of e-waste (IRENA and IEA-PVPS, 2016).

In reality, in the EPR model, the costs for recycling are often transmitted into the price the consumer pays for the product (Ichikowitz and Hattingh, 2020). The passing on of the costs of e-waste treatment to solar product customers can create an obstacle for low-income households and dampen investment in the businesses (GOGLA, 2019b).

3.2.1 Public-private partnerships

In public-private partnerships (PPPs) a mutually beneficial alliance between government and the private sector is forged to tackle e-waste. Through a long-term contractual agreement, a specific service is provided to the public and private entities share some of the risks involved (Awuku et al., 2021). An example for a PPP in e-waste is the Rwandan company Enviroserve (see Examples section).

Hybrid PPPs are a further solution to finance e-waste management. They entail arrangements between non-conventional

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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

stakeholders, e.g., the informal sector, NGOs and private companies (Ndzibah et al., 2022). An example of a hybrid PPP is the Kenyan company WEEE Centre (see Examples section).

3.2.2 Take-back models

In the absence of a widespread collection infrastructure, solar businesses use different approaches for effective take-back of their used solar products. Companies may set up collection points, partner with third parties or engage with informal collectors. Moreover, they will provide customers with incentives such as receiving a new product at a discounted rate ("trade-in"). Such schemes need to be accompanied by effective customer education campaigns and labelling. Take-back schemes can benefit companies by providing an additional customer touchpoint, which allows them to retain customers or acquire new ones and strengthen their brand recognition (Blair et al., 2021).

Examples of application in the African context 3

EnviroServe Rwanda Green Park, Rwanda

The company: Pioneering e-waste management company in East Africa, focused on e-waste recycling

The approach:
- Operates the region's only state-of-the-art e-waste dismantling and recycling facility
- Has processed more than 4,000 tons of e-waste and created more than 600 jobs
- Collection and repair point infrastructure spanning all districts in the country and entry points at borders with other countries
- Works in partnership with the Rwandan government to develop policies, regulations and collection infrastructure

For further information visit:
- → https://enviroserve.rw
- → https://medium.com/efficiency-for-access/enviroserve-rwanda-accelerates-green-growth-through-e-waste-management-ee752093f88a
- → https://edition.cnn.com/2021/02/26/africa/marketplace-africa-ewaste-electronics-recycle-rwanda-spc-intl/index.html

4 Socio-economic and sustainability impacts

E-waste from solar solutions contains toxic and hazardous substances such as lead and mercury. If disposed of or recycled improperly, it poses **severe risks to ecosystems, human health and livelihoods** (CDC, 2021). This section reviews the impacts of e-waste in the African context, and highlights the benefits of appropriate e-waste management. It is important to remember that e-waste from solar products still represents only a small proportion of the general e-waste stream. Therefore, existing knowledge of the impacts of e-waste in Africa is not specific to e-waste from solar products.

Most e-waste recycling in Africa is carried out in the **informal sector** with the purpose of extracting valuable materials such as copper and aluminum. The valuable materials in e-waste are extracted by heating and burning, immersion in acids, and other methods (Lebbie et al, 2022). Workers in the e-waste sector often rely on inefficient tools and inadequate safety clothing that can increase their exposure and health risks (Maphosa and Maphosa, 2020).

Moreover, e-waste burning and dismantling activities are frequently undertaken at informal e-waste treatment sites, often in or near homes. As a result, toxic pollutants concentrate in the water, air, soil, dust, fish, vegetable, dairy products, eggs and human breast milk and affect those living in the surrounding areas, even if they are not directly involved in the recycling. For example, Agbogbloshie in Ghana is a large e-waste treatment site. It is estimated that about 40,000 people live and work within the environs of this site.

Children and pregnant women are particularly at risk from the exposure to toxic chemicals from e-waste (WHO, 2021). Children absorb more pollutants relative to their size, are less able to metabolise them, and are impacted most strongly due to their rapid rate of growth and development. Exposure to lead from e-waste recycling activities has been associated with neurological impacts in newborns, changes in lung function, DNA damage, impaired thyroid function and increased risk of some chronic diseases later in life, such as cancer and cardiovascular disease.

Despite the lack of safety and poor working conditions, **e-waste collection and treatment represent a major income source for many households and communities** (Maes and Preston-Whyte, 2022). In West Africa, for instance, workers can make significantly more money in e-waste management than in some other industries. In Ghana alone, between 120,00 and 200,000 people depend fully or partially on informal e-waste recycling, collection or repairs for their livelihood (WHO, 2021). In fact, appropriate recycling of solar e-waste poses a great opportunity for the creation of businesses and decent jobs. However, safe recycling facilities remain rare and regulations to improve safety and working conditions are lacking or not enforced (Asante et al., 2019).

Recovering valuable metals through appropriate and safe solar e-waste recycling brings economic and environmental benefits. It is estimated that recycling or repurposing solar PV appliances can unlock an estimated stock of 78 million tonnes of raw materials (including valuable components) by 2050 (IRENA and IEA-PVPS, 2016). This can lower the need for extraction of new materials as well as reduce the costs of new products.

Examples of application in the African context 4

WEEE Centre, Nairobi, Kenya

The company: Provides e-waste collection, dismantling and automated processing services in Nairobi and several other major cities in Kenya

The approach:
- Sources e-waste from the private and public sectors
- Raises awareness through collection campaigns aimed at individual households
- Partners with SMEs across Kenya, international NGOs and the Kenyan government
- Trained over 1,000 youth to repair solar products, extend the product lifespan, segregate OGS e-waste and direct it back to the WEEE Centre

For further information visit:
- https://weeecentre.com/services
- https://medium.com/efficiency-for-access/weee-centre-creates-an-economically-viable-e-waste-management-model-c9ee1ed4b5af

Figure 4: **Discarded e-waste at a refuse site on the outskirts of Accra, Ghana** (Amanda Bennett via Getty Images)

5 Scaling-up

The health and economic benefits of scaling-up recycling of OGS products in Africa are significant. As the market for OGS products increases, so will the volume of e-waste related to this sector. To scale up safe and environmentally sound e-waste treatment in African economies, an **effective enabling environment and policy framework** are urgently needed. Other barriers to scale-up the recycling and appropriate disposal of OGS e-waste include the insufficient infrastructure and the lack of profitability due to the high cost of safe recycling.

Policy is the foundation of a thriving e-waste market because it can allocate the cost fairly among producers and enable profit for recycling businesses (GOGLA, 2019b). Moreover, enforcement needs to be strengthened significantly (Maes and Preston-Whyte, 2022). Most regulations supporting e-waste recycling in Africa are still in draft form and governments often lack resources for implementation (EEP Africa, 2020).

The treatment of solar e-waste in Africa needs to be understood in the context of the scale of **imported e-waste**. Domestic generation of e-waste in Africa only amounts to 50%-85% of the whole volume, the rest originates from imports from the Americas, Europe, and China (Maes and Preston-Whyte, 2022). As well as being illegal, the importation of e-waste displaces the capacity of African countries to recycle their own domestic e-waste.

6 E-waste from solar off-grid 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 countries are considering the treatment of e-waste from solar off-grid solutions. 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.

The company takes an **integrated approach to e-waste management** by sensitizing and incentivising community members and stakeholders to return e-waste. The company makes users aware that devices that are out of use are valuable resources with potential to be repaired or recycled to their full extent. 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. Furthermore, WeTu handles its own e-waste such as fisher lanterns and other technical components from the charging hubs.

6.2 Ghana Living Lab

In the SESA Ghana Living Lab, the company **Nastech** is **collecting e-waste** and repurposing it into solar generators. This is an interesting example of a business model centred around **recycling of e-waste and plastics into new products** to decrease costs and make solar power more affordable to low-income households. As part of the SESA Incubator Programme Nastech will test and validate an innovative business model around recycling of electronic waste and plastics to produce renewable energy solutions for rural communities and small businesses in Ghana. The validation will focus amongst others on the growth potential of a subscription-based business model for solar charging stations and micro grids made of electronic waste.

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. In order to achieve that, projects have to be screened for climate risks, vulnerabilities and opportunities early in the design stages.

The exact approach to climate proofing solar e-waste solutions will depend on the location and context, but the design and siting of e-waste collection, storage, transportation and processing infrastructure should consider climate variability and risk of physical damage. E-waste contains many hazardous materials and its management involves significant risks to the environment and human safety, for example in case of fire (Kazancoglu et al., 2022).

8 Relevant tools and capacity building materials

E-waste toolkit from GOGLA

This toolkit addresses the main challenges in setting up sustainable e-waste recycling chains. It consists of the following training modules: 1. Technical introduction to recycling of off-grid solar products, 2. Design for reduction of e-waste, 3. Financials of e-waste management, 4. E-waste policy and regulation, 5. E-waste and the consumer, 6. Take-back and Collection, and a service provider catalogue.

→ www.gogla.org/what-we-do/circularity/e-waste-toolkit

Circularity Toolkit: E-Waste Blueprints

Building on the GOGLA E-waste Toolkit, the Blueprints provide OGS companies with practical tools to improve e-waste management practices in OGS companies, regardless of company stage, product type or country of operations. The toolkit addresses different stages: assessment, planning and execution.

→ www.gogla.org/resources/circularity-toolkit-e-waste-blueprints

E-waste toolkit from EEP Africa

The e-waste toolkit from EEP Africa includes resources to support companies overcome many of the barriers to e-waste management and recycling in East and Southern Africa. The toolkit provides best practices for project developers and consumers, resources on local legislation, and recommendations for recycling services.

→ https://eepafrica.org/resources/e-waste-toolkit

E-waste Training Manual from GIZ

The publication assembles knowledge on practical dismantling of different types of equipment, output fractions after manual dismantling, the management of a small-scale recycling facility, and the organising of training.

→ www.giz.de/de/downloads/giz2019-e-waste-management.pdf

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 in this paper 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

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101037141. This material reflects only the views of the Consortium, and the EC cannot be held responsible for any use that may be made of the information in it.

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