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E-waste Management Recommendations for BGFA Programme

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Acronyms

AECF	Africa Enterprise Challenge Fund
BAN	Basel Action Network
BFA	Burkina Faso (ISO Code)
BGFA	Beyond the Grid Fund for Africa
BGFZ	Beyond the Grid Fund for Zambia
EEE	Electronic and Electrical Equipment
EOI	Expression of Interest
EOL	End of Life
EPR	Extended Producer Responsibility
GEF	Global Environment Facility
GOGLA	Global Off Grid Lightning Association
LBR	Liberia (ISO Code)
LCO	Lithium Cobalt Oxide
LFP	Lithium iron Phosphate
LME	London Metal Exchange
LMO	Lithium ion Manganese Oxide
MOZ	Mozambique (ISO Code)
NCA	Lithium nickel cobalt aluminium oxide
NEFCO	The Nordic Environment Finance Corporation
NMC	Lithium Nickel Manganese Cobalt Oxide
OGS	Off -Grid Solar
OGTF	Off-Grid Task Force
REEEP	The Renewable Energy and Energy Efficiency Partnership
RWA	Rwanda (ISO Code)
SHS	Solar Home System
SIAZ	Solar Industry Association of Zambia
UGA	Uganda (ISO Code)
WEEE	Waste Electronic and Electrical Equipment
ZEMA	Zambia Environmental Management Association
ZMB	Zambia (ISO Code)

Background

According to the latest GOGLA semi-annual report, access to energy keeps expanding. From 2017 onwards, almost 24 million products have been sold globally with 4.42 million in the second half of 2019. More than half of the latter number (2.43 million) have been sold in East Africa - Kenya in particular - while only 370,000 in West Africa and 120,000 in Central Africa. The Swedish government-funded programme (Beyond the Grid for Zambia - BGFZ) implemented over the last few years has been expanded to four more countries (Burkina Faso, Liberia, Mozambique and Uganda), under the umbrella name of Beyond the Grid Fund for Africa (BGFA). The majority of these countries have high potential to adopt Off-Grid Solar (OGS) solutions, as seen in the table below. BGFA initial estimations and the remaining portion of BGFZ could represent up to 25% of the volumes sold by GOGLA members, when considering the second half of 2019 as a baseline.

Table 1: Overview sales in target countries (GOGLA) and electrification status in rural areas (REEEP).

Country	Sales H2/2019	Share sales on total region		Electrification rural areas
Uganda	219,755	9%	East Africa	n.a.
Zambia	118,458	5%	East Africa	6%
Burkina Faso	13,289	4%	West Africa	10%
Mozambique	6,573	0.3%	East Africa	15%
Liberia	n.a.	n.a.	West Africa	3%

While continued efforts are dedicated to enabling access to energy in rural areas, there is increased pressure from donors[1] and the media are simultaneously calling for a broader and more coordinated action to ensure proper management of OGS products at their End of Life (EoL). There is a growing need to ensure that products are not left abandoned or improperly handled, posing a risk to individuals or the environment. To illustrate the scale of the issue, in a survey of 500 M-KOPA customers of OGS products in Kenya (CDC, 2020), between 35% and 40% of the respondents said that their products were returned to the sellers when it was no longer working. Furthermore, 40% said that their products were kept at home, sometimes as source of spare parts, whilst the remaining 20% directly disposed of the product in an un-sound manner. Comparable results were also obtained from a survey conducted by Solibrium targeting 2000 users of OGS solutions from 21 different companies: almost 55% of respondents sought advice from the seller or returned the product when disposing, approximately 20% kept the products at home and the remaining 25% improperly disposed of the products.

While the main aim of the OGS industry is to expand access to energy, there is an emerging interest in ensuring the sustainability of business models, as demonstrated by the publication of the GOGLA Industry Opinion on "lifecycle and recycling" in 2014. Since then, events with specific focus on EoL have been organized at several flagship events such as the Off-Grid Solar Expo in Dubai (2015), Hong Kong (2018) and Nairobi (2020). In 2018, GOGLA's Sustainability Working Group was re-launched as the E-waste Working Group reflecting the importance of e-waste as the main challenger to the environmental credentials of the sector. In February 2019, this working group launched an e-waste toolkit offering practical guidance and information to member companies and organisations. In 2019, USAID unveiled a grant programme (Global LEAP

[1] See: http://www.mynewsdesk.com/swedfund/pressreleases/solar-power-to-360-million-people-but-no-plan-for-e-waste-2857698

Awards - E-waste challenge[2]) to incentivise companies to develop innovative solutions for EoL management of their waste.

However, while the OGS Industry is striving for sustainability, in the majority of African countries, including those targeted by BGFA, there are some conflicting dynamics that are important to take into consideration:

- only very few countries have mandatory legal obligations in place for producers to collect and recycle the waste originated by the products they place on the market, thus take back activities are mostly carried out on a voluntary basis. The policy landscape is however changing;
- in many cases normative requirements that specify licensing regime for collection and storage of out-of-warranty products or waste collected by customers are not entirely clear, thus leaving a lot of grey areas on operations and voluntary activities or pilot projects;
- adequate infrastructure for collection and treatment of e-waste are lacking as well as proper landfill for safe disposal of non-recyclable or hazardous fractions/components: in best cases scenarios we have a few players active in every country; they manually dismantle the products and are able to recycle the base metals locally but a few critical fractions have to be exported, such as batteries:
    - infrastructure for treatment of Lithium-based batteries is currently absent on the continent. There is also a capacity crunch at the global level, most notably for the recycling of Lithium batteries with limited or no presence of Cobalt: existing recyclers and recycling processes are mainly targeting the recovery of Cobalt and thus are more interested in chemistries different from those mainly used in the off-grid sector (Lithium-Phosphate and Lithium Manganese Oxide).
    - while recycling infrastructure for Lead-acid batteries are present in some countries, in many cases they operate with sub-standard treatment processes; in some countries, such as Liberia, this infrastructure are not present at all.
- a thriving informal scrap dealing sector that often cherry-picks the most valuable parts (mostly metals, cables and circuit boards) in any e-waste flow they find, which lowers the value of the rest and consequently makes the recycling more economically challenging.
- different OGS companies, at different stages of their maturity/growth have different ambitions and practices implemented to tackle the challenges that proper EoL management generates.

Sofies has worked closely with NEFCO and their implementing partner REEEP to investigate potential options to find the best practicable e-waste management systems that can currently be implemented on the ground in target BGFA countries, taking into consideration (i) country legal context, (ii) available infrastructure on the ground and (iii) additional activities that can be implemented through the wider context of the BGFA programme.

Best practices in e-waste management in Africa

Local context is important and one cannot expect e-waste management to be on the same level as more developed regions such as Europe. E-waste management in Africa is dominated by a thriving informal sector made up of collectors and recyclers, as take-back schemes and modern infrastructure for recycling are often non-existent or limited. Government control of this sector is minimal and inefficient. Handling of e-waste is typically characterised by manual stripping to remove electronic boards for resale, open burning of wires to recover few major components

[2] See: https://globalleapawards.org/e-waste

(copper, aluminium, iron), and the deposition of other bulk components, including cathode-ray tubes (CRTs), in open dumpsites. Practices of the informal sector are often characterized by illicit labour of pregnant women and minors, as well as a lack of personal protection equipment for the workers. These practices result in severe pollution of the environment, poor recovery of expensive, trace, and precious components, and the exposure of labourers as well as the general population to hazardous chemical emissions such as lead, heavy metals and POPs.

The recycling chain of e-waste consists of three logical steps: (i) collection, (ii) pre-processing and (iii) end-processing. After the collection phase, EoL appliances are treated in order to obtain components (to be reused or refurbished) or material fractions (to be recycled and reused as raw materials). Components or material fractions that are not being re-used or recycled (due to their intrinsic hazardous content or lack of secondary markets) are sent to a suitable disposal site. Notwithstanding the different existing approaches and methods, the aim of the second and third steps of the recycling chain is primarily to:

- take care of hazardous components and fractions in an environmentally sound manner;
- economically recover components and material fractions.

Technology plays a crucial role with e-waste in developed countries, particularly, in the pre-processing and end-processing steps. In emerging economies, e-waste treatment is mainly leveraged on manual disassembly with minimal adoption of technology (e.g. manual dismantling with adequate protection, degassing units to remove gases from fridge circuits or units to treat lamps), as the accessible volumes don’t call for industrial-level infrastructures.

From an environmental perspective, it is crucial to identify those partners that are able to ensure safe and proper treatment (locally) and having access to international markets and players to handle fractions or products that cannot be properly recycled locally[3].

A scoping exercise has been done looking at some of the main formal e-waste recyclers in Africa that can handle fractions resulting from OGS products:

- One of the better-known plants is Enviroserve, located in Rwanda; it is a modern plant processing various waste streams and is currently looking into set-up line for Pb batteries and Li batteries refurbishment as well as treatment of refrigerators and air conditioners.
- Enviroserve Kenya treats all WEEE mainly via manual disassembly and leveraging on the Dubai hub for critical fractions.
- The WEEE centre based in Kenya is able to process off-grid, train other recyclers across Africa and revive LFP batteries. The WEEE Centre has ISO 9001:2015 and ISO 14001:2005 certifications.
- Hinckley Recycling in Nigeria is one of the first 3 e-waste recyclers licensed by the Nigeria’s Government. It is likely to be the most advanced in the country as it has the ability to revive LFP batteries.
- City Waste Recycling in Ghana is a pioneering e-waste recycler, covering all waste streams and exporting Pb batteries to the EU. A key selling point is its mobile de-gassing unit to treat refrigerators and air conditioners.
- While not in Africa, some companies also export to the Enviroserve auxiliary in Dubai, which is a state-of-the-art plant processing all streams. Critical fractions collected and dismantled by other plants in Africa are being shipped there for final treatment or to be exported to final destinations. The plant has ISO 9001:2008, ISO 14001:2004 and BS OHSAS 18001:2007 certifications.
- In terms of the target BGFA countries, there are few recyclers present. Some of those that are licensed (e.g. Click Vert in Burkina Faso, Green Cities in Liberia, 3R in Mozambique) are currently growing and setting-up e-waste processing abilities as a way to expand their operations with limited OGS experience and no international certification.

[3] See Magalini et al., Electronic waste (e-waste) impacts and mitigation options in the off-grid renewable energy sector, DFID 2016

One of the most promising facilities is TCH Zambia, which was set-up by South African E-waste recycler (AST) and is currently the only company licensed by ZEMA; TCH is looking at how to improve and expand their operations to handle e-waste, as well as obtain international certifification.

As seen above, most of the target countries have little pre-processing capacity, mainly manual disassembly and in a few cases the plans to install some machines (shredders) to facilitate volumetric reduction before shipment of fractions. Some of the recyclers (e.g. WEEE Center or Computer for School Uganda) were historically processing ICT equipment as spin-off of "closing-the-digital-divide" operations, others are setting-up operations thanks to experienced gained in other countries (e.g. TCH Zambia, from South Africa) or expanding operations from other waste streams. Nevertheless, we can highlight how there is at least one professional recycler in each of the target countries.

Expected scenarios at EOL and cost estimations

Estimations of the waste generated by OGS products placed on the market by the BGFA programme in the 2021-2025 horizon (including the volumes of the BGFZ programme currently running) have been done using a sales-lifespan model. This model also considers the replacement of batteries during the lifetime of the SHS (or mini-grid installation) when the lifespan of the SHS (or Mini-Grid) is longer than the corresponding life span of the battery.

As displayed in Figure 1, Zambia is the country contributing most to the generation of waste. This is mainly because of the volumes of the BGFZ programme, which have been considered here as well as the Tier 1 and Tier 2 products placed on the market in previous years, which are progressively expected to come back, as they have a shorter life span. It is also possible to estimate the total volume of waste lithium batteries generated and the potential implications on the costs and logistics of shipments. The influence of Mini-Grid is negligible given the long lifespan of the installation and of the lithium battery itself.

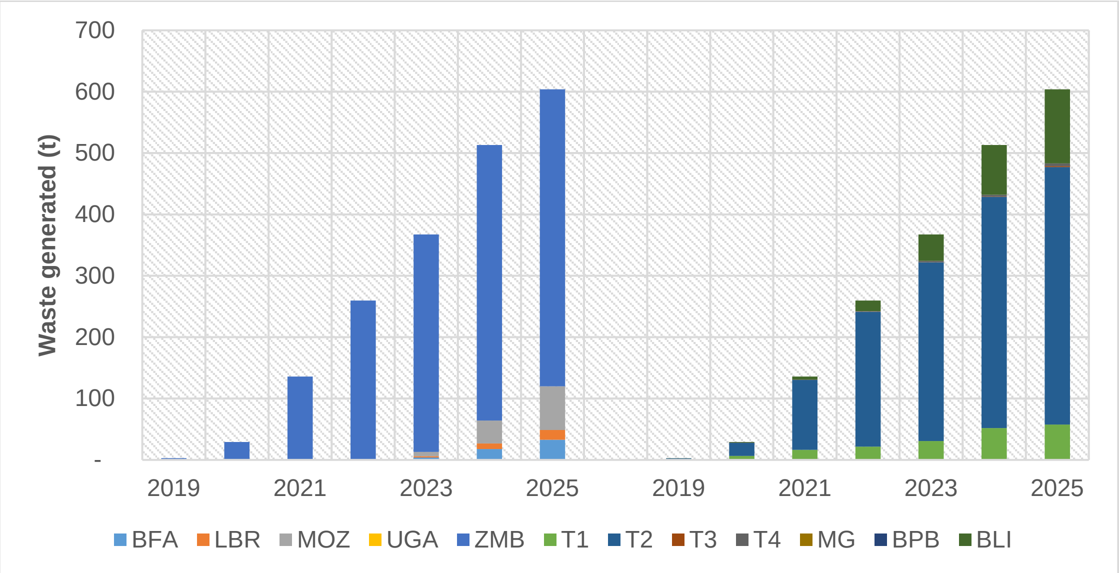

Figure 1: Overview of waste generated (t) by country and tier.

There are two fundamental approaches to define the financial baseline for the EoL management:

- one based on a **procurement quote from recycling contractors** which is built on the acquisition of quotes from recyclers and benchmarking/comparison;
- the other is based on adopting an **activity-based costing** approach[4], which considers the technical cost for each step of the recycling chain; while for collection and transportation it is quite straightforward, the assessment of recycling costs considers the average composition of products, the value of the fractions obtained through the dismantling process and the time/cost associated with the dismantling process itself.

The second approach is usually adopted when assessing or comparing different offers or to evaluate the plausibility of quotes, especially if recyclers are audited and mass balance can be obtained to evaluate the results of the dismantling process. On an operational level, there are four main cost elements in take-back and recycling operations to consider: access to waste, collection, transport, treatment.

In the context of the study the first approach has been adopted, considering quotes and price indications received from different recyclers active in East and West Africa, as well as information available from completed projects and ongoing pilots run by Sofies.

All the costs have been converted in USD/kg ($/kg); only the collection cost has been neglected as there are no collection points currently existing in the countries and usually waste is either stored as OGS shops or collected by forward logistics providers. This means that no costs are assumed for the first mile collection (from the consumer's household to the collection point). The minimum, maximum and average values are indicated in the following to ensure confidentiality of individual recyclers data; for the treatment costs only the main fractions relevant for the treatment of OGS product (and main connected devices) have been included in the table. For Lead-acid batteries a valorisation based on London Metal Exchange price has been adopted, considering the average value for 2019.

Table 2: Access to waste and transport cost ($/kg).

	Access to waste	Transport	Notes
Min	$ -	$ 0.12	• For access to waste the most favourable scenario assumes waste returned free of charge from users. • For transport costs it has been assumed that transport and pick-up is done with lorries or with trucks with a maximum payload of 5t
Max	$ 0.10	$ 0.52	
Average	$ 0.05	$ 0.24	

Table 3 - Treatment cost in $/kg.

	Mixed solar	Mixed solar - no batteries	PV panels only	Li Batteries	LCD Screens	Desktop / Laptop	Other CE/IT	Cables
Min	$ 0.70	$ 0.50	$ 0.50	$ 0.60	Free	Free	Free	Free
Max	$ 1.87	$ 0.75	$ 1.50	$ 6.50	$ 1.70	$ 1.70	$ 1.70	$ 0.94
Average	$ 1.15	$ 0.63	$ 1.00	$ 2.53	$ 0.91	$ 0.71	$ 0.65	$ 0.41

Analysis of minimum, maximum and average cost has been carried out. In the most favourable scenario, access to waste cost is set to zero and the incidence of lithium battery weight is set to 6% of the total product weight while for the less favourable scenario the lithium battery weight is set to 25% (typical for smaller products in Tier 1, like Solar Portable Lanterns). Given the

[4] See an example of the approach in: https://www.gov.uk/dfid-research-outputs/electronic-waste-e-waste-impacts-and-mitigation-options-in-the-off-grid-renewable-energy-sector

progressive transition of OGS players from lead to lithium-based chemistries for the batteries, a scenario with 5% incidence of lead-acid batteries (which mitigate the total cost, being a revenue in the EoL phase) was also considered. In a scenario where only lead-acid batteries are used, the reduction of EoL incidence would be between 55% and 63%.

Table 4: results of simulations. Incidence EoL in $/t

Configuration	100% lithium batteries	5% Lead-acid batteries	100% Lead-acid batteries
Most favourable scenario	$ 0.81	$ 0.75	$ 0.30
Average	$ 1.66	$ 1.57	$ 0.75
Less favourable scenario	$ 3.65	$ 3.52	$ 1.50

Assessment of impact/incidence at Tier level is more difficult as EoL costs largely depend on:

- chemistry of the batteries (in this case we could assume 100% Lithium batteries without presence of Cobalt),
- total weight of the SHS, and the type of connected device(s) might vary a lot especially for Tier 3 and Tier 4 configurations, and
- price structure of the recycler (whether they offer a flat fee or charge differently depending on the type of appliances; the last option might have to be assessed looking at the individual company's portfolio of products. In some cases, cross-financing from other products might also be favourable to the company).

Estimations can be done assuming there are average weights and flat-fee options from recyclers for simplicities sake.

Table 5: Estimation EoL incidence by Tier.

EoL costs (100% Li batteries, no cross-financing Pb)		Tier 1	Tier 2	Tier 3	Tier 4
Average weight (kg)		0.5	4	5	7
Weight battery (kg)		incl.	0.3	1	1.5
Min	$ 0.81	$ 0.41	$ 3.48	$ 4.86	$ 6.89
Average	$ 1.44	$ 0.83	$ 7.14	$ 9.96	$ 14.11
Max	$ 2.65	$ 1.83	$ 15.70	$ 21.90	$ 31.03

From a cost perspective, the incidence is displayed in Table 6 below. When considering the cost estimations over the 5 year horizon of the programme, excluding mini-grids installations, the baseline - assuming the average cost - results in a total respective cost of 3.1 M$ and 4.4 M$.

Such an estimation does not consider the expected and plausible reductions in cost due to progressive optimization of the recycling processes and economies of scale; the impact of those reductions might not be substantial (e.g. 10% to 30% maximum), unless:

- lithium batteries are being disposed of in proper landfill or specific processes targeting batteries with limited amount of Cobalt are developed;
- e-waste recyclers will offer flat fees mitigating the higher costs for recycling of Lithium batteries with the revenues from other fractions (i.e. applying internal cross-financing) like lead-acid batteries or revenues from refurbishment of products.

Furthermore, the impact of the legacy estimation does not consider potential cost reductions linked because not all the products placed on the market will actually be collected for recycling but could potentially be refurbished and re-used.

Table 6: Estimated EoL costs for Tier1 to Tier4 products placed on the market.

EoL costs		Tier 1	Tier 2	Tier 3	Tier 4
Average weight (kg)		0.5	4	5	7
Weight battery (kg)		incl.	0.3	1	1.5
Average cost per unit put on market (POM)	$ 1.44	$ 0.83	$ 7.14	$ 9.96	$ 14.11
Waste generated (2021 - 2025)		1,880 t			
Total cost 2021 - 2025 (M$)		3.1 M$ (1.5 M$ to 6.9 M$)			
Total units POM (BGFZ + BGFA)		661,594	514,578	14,196	3,253
Total cost legacy (M$)		4.4 M$ (2.15 M$ to 9.70 M$)			

For mini-grids, the assessment might be different as the decommissioning is a dedicated service that most of the recyclers will quote as a stand-alone service, especially when collection and transportation is included (plus the potential dis-install on site).

From a cost perspective, the recycling cost of PV panels has to be considered while there is room to negotiate better prices, particularly for long copper cables. Most of the recyclers will quote a cost but copper cables can also be directly sold and represent a revenue, which might mitigate the financial impact of the EoL cost together with any metal part supporting the mini-grid installation.

Legal framework in BGFA countries

While the EU currently has the WEEE Directive, which sets criteria for the collection, treatment and recovery of WEEE, most African countries do not have an overarching framework for e-waste management:

- Ten countries have specific legislation regarding e-waste, which is legally binding (act, law, statutory instrument etc.).
- Seven other countries have policies relating to e-waste that are not legally binding (i.e. strategies, polices, guidelines etc.).
- While currently still in its early stages, more and more African countries are starting to look at take back legislations based on the Extended Producer Responsibility (EPR) principle, thereby legally requiring manufacturers and importers to finance the take back and proper recycling of products placed on the national markets. However, this is still in its infancy and currently three countries in Africa have that in place – Zambia, Nigeria, Ghana, with some other countries such as South Africa revising their systems.

Often not all EEE, including OGS products and batteries, is included in the scope of legislation (sometimes only IT products are covered, not large appliances or air conditioners or lamps). However, it is important to note that proper collection and recycling of e-waste can hardly happen without either a legal obligation or a voluntary initiative from industry (producers and importers or waste holders). This is because the exploitation of the economic value embedded in products might create environmental and human health impacts if not done properly. This is particularly aggravated in developing countries where recycling and separation of e-waste has become a main source of income. Even when some formal recycling infrastructure exists, the risks created by unfair competition of informal recyclers might create an economic barrier to accessing the waste for legitimate recyclers. In many cases, the costs of proper collection and recycling of e-waste exceed the revenues generated from the recovered materials and this is why control over operations and eventually a proper financing mechanism are needed.

The table below summarizes whether or not one of the BGFA countries have a specific legislation on e-waste. It is important to distinguish that there are several possibilities in terms of legislation present in a country:

- there are policies/strategies/plans that are overall principles by which a government sets out to manage public affairs. These are not legally binding, however they do set out a course of action that might lead to further legal developments in the future.
- then there are laws and acts that legally bind the objectives stated in the body of text.
- finally, there are regulations, instruments etc. that are also legally binding and operationalise the law. It will be stated in the table whether these texts are legally binding or not.

It should be noted that only Zambia and Uganda have legislation on e-waste, and in the case of Uganda, it is not legally binding. Developments on e-waste can be on the horizon for these countries, as more discussions are happening regarding this topic and overall the countries have legislation on environmental management, where waste is an issue.

Table 7: E-waste legislation in target countries.

Country	Summary
ZMB	There is a specific law on e-waste, the Extended Producer Responsibility (EPR) Statutory Instrument No. 65 of 2018. Electronic products are within the scope of responsibility. This is legally binding.
BFA	No specific legislation on e-waste
LBR	No specific legislation on e-waste However, they have a national waste management policy that is currently being reviewed and updated to include e-waste. No timelines or specifications given.
MOZ	No specific legislation on e-waste E-waste mentioned by the Hazardous Waste Decree, but not much there.
UGA	There are several official documents mentioning e-waste: Electronic Waste (E-waste) Management Policy for Uganda, 2012 Guidelines for E-Waste Management in Uganda, 2016 Strategy for Electronic Waste Management, 2013 However, none of them are legally binding; the government of Uganda is working on a legally binding piece of legislation concerning e-waste in the future.

Current practices of OGS companies in BGFA countries and beyond

Most of the OGS companies interviewed highlighted how donor requirements have contributed to them looking at the EOL of their operations. This led many of them to start exploring the current options available in terms of waste management. These options, however, were often found to be limited or very burdensome and costly. While the lifespan of products has generally been taken into consideration for economic purposes by all the companies, the stage of the company (e.g. very early stage) as well as the type of products sold (e.g. stoves as a primary product) has contributed greatly to the importance attributed to EoL issues. This is also reflected in the actual waste management practices undertaken by the companies.

The approaches currently being implemented by companies can be summarised in three overarching themes:

- whether they have a waste management policy/standard operating procedure in place,
- if they have recycling or refurbished partnerships, and
- if they are currently engaged with their customers and industry.

Interviews revealed that most companies do have a waste management or a SOP in place, however far they go does depend on the company. Bigger and more established companies tend to already have procedures in place whereas smaller companies just starting operations are mostly storing waste until a solution is made available to them. In most cases companies at early stage of operations do not have the volumes of waste yet. Engagements with the Industry, national stakeholders and communities also tends to be a theme expect for the really early stage companies.

Generally, a consensus exists from OGS companies on wanting to take on the responsibility for their e-waste, which offers a good momentum to take action.

While it needs to be stressed that various challenges exist to the proper implementation of e-waste management plans, it can be noted that some of the more mature OGS companies already have a number of practices in place to support waste management strategies.

Some more mature companies, especially in markets where more waste is arising - like Kenya - are already setting up systems to collect data and assess their e-waste stocks, in addition to engaging their stakeholders for take back and collection of obsolete products.

Building onto these practices as well as the information on the legal context and available infrastructure in the target countries, a number of actionable recommendations on practicable e-waste management practices have been outlined. A few wider recommendations to increase functionality and effectiveness can also be proposed:

- in a country context where specific legislation is already in place, companies should be encouraged to have a mechanism that ensures they stay up to date with legal developments, as well as comply with them;
- in a country context where no legislation is in place, companies should still be encouraged to draw up an initial document that explores EoL management solutions;
- encourage companies to look at their potential waste generation to help them make projections of future waste generation, presuming they will have few existing stocks as well as costs;
- engage with other solar companies as well as industry associations. This can offer several opportunities such as partnering up to reduce shipping costs, keep up to date with legal developments and in some cases join forces to discuss new ideas and initiatives;
- proactively engage with the local community: not only can this help increase the returns of products but also the customer loyalty. The customer-based networks can further be used to promote awareness around e-waste and take back schemes;
- have a detailed standard operating procedure in place in regard to the EoL of their products;
- encourage companies to set up a few voluntary take back collection points. These can be setup at their shops so no further logistics is needed. Other collection points can be setup in partnerships with other solar companies or even shop retailers.

Recommendations for EoL management

Various activities could be included in the BGFA programme to improve e-waste management of future awardees or their take back operations when established. Recommendations can be clustered in few main themes:

Requirements on EOL Management

Companies should be encouraged to assess their estimated EoL stock as this will help to determine what their EoL strategy will be. The methodology would be specific (e.g. use of sales data and life span of products) and tools can be provided. This further helps companies to understand their logistics needs and how to best engage customers in their take back efforts.

A second step should include adhering to the current policy in place in the country. This will of course be more or less easy depending on the context of the countries. In Zambia, OGS companies have a legal responsibility in line with EPR policy and companies are required to develop an EPR strategy. In other countries, companies can be incentivised to draw up an initial outline of an e-waste management plan based on the initial scoping of their EoL stocks and standard operating procedures. This may include partnerships with recyclers or SOPs concerning lithium batteries regarding safety precautions for handling and shipment.

For those companies that have already reached a more mature status and in line with available waste handling infrastructures, they should be incentivised to have contracts in place with an e-waste management facility that also helps in creating the financial baseline in the planning phase.

Requirements on batteries

Lead-acid batteries and lithium batteries have quite specific characteristics and neither lead-acid batteries nor lithium batteries are perfect solutions from an EoL perspective. In the absence of proper and reliable recycling infrastructures for lead-acid batteries, when export is the only viable solution, the choice of lithium appears more reasonable from an environmental and risk-mitigation perspective.

Lithium batteries appear also a better solution in a worst-case scenario where disposal is occurring in landfill that does not uphold the best environmental standards.

Furthermore, having lithium-based batteries a longer lifespan, the current capacity crunch experienced might no longer be an issue with the progressive development of new recycling infrastructure globally.

Requirements for stakeholder engagement, capacity building and awareness raising

A number of criteria can be included to incentivise the development of stakeholder engagement and awareness raising on e-waste management practices. Capacity building is another crucial element when ensuring proper collection and take back of EoL products and e-waste management strategies. Recommended options include incentives to encourage refurbishment and reuse before recycling, in line with the waste hierarchy. Reuse and refurbishment are not only easier to implement compared to recycling but they are also more economically viable as they extend the lifespan of products.

Technical assistance and training for staff on e-waste management is especially helpful during the stage when waste management plans are being drawn up for companies to assess potential options.

Lastly, incentives to encourage the engagement with local communities and more open and transparent communication to foster extended relationships with customers could be provided as customers play a pivotal role in the collection efforts of EoL products.

Requirements to incentivise activities at Industry level

Participation in international (e.g. GOGLA) or national (e.g. SIAZ in Zambia) industry association could enable companies to track and stay up to date with their compliance obligations, but also to exchange ideas on initiatives for e-waste management and to keep track on legal developments. Associations also allow good relationships to flourish between the national government and companies, generating improved opportunities for incubation incentives or participation in funded waste management projects by government entities or international donors (EU, GEF...).

Wider activities suggested

In addition to the commitments of BGFZ/BGFA awardees during the implementation of the programme, there are various activities that can/should be implemented in the programme horizon 2020-2025, which could improve the EoL management in the target countries. Those activities go beyond what a single company can do but rather target structural changes/improvements. The primary ones are described below. They can be completed by BGFA individually (alone) or in partnership with other donors/programmes and are clustered in three main themes: (i) piloting solutions, (ii) activities carried out at Industry level and (iii) support provided at country level.

Table 8: Suggested activities, countries and low hanging fruits (LHF).

Cluster	Activity	Potential country	Relevance
Piloting solutions	Awareness raising campaign	All	*
	Development treatment standards for OGS	All	**
	Pilot take back and recycling **(LHF)**	All	***
Activities Industry level	Set-up/upgrade of new plant for e-waste recycling	BFA, LBR, MOZ, UGA	***
	Set-up of new plant for battery recycling	ZMB	*
	Drafting Standard Operation Procedures / Waste Management Plans **(LHF)**	All	**
	Contracts with local recyclers **(LHF)**	All	**
	Capacity building **(LHF)**	All	**
Activities support country level	Support countries with definition of proper legal and organizational framework	BFA, LBR, MOZ	***

In terms of piloting solutions, the development of a standard awareness raising campaign or material could be encouraged as well as the development of standard waste management plans/SOP. This would be beneficial to all countries and companies.

When considering the set-up of a pilot project to define blue-print of take back operations and baseline for take back costs, it is recommended to start in one country as majority of lessons (except country-specific cost factors) can be transferred to other countries as well. One of the best and most reliable way to understand financial implications and operational challenges of e-waste management in the countries is to pilot take back and recycling at small scale, especially while the volumes of waste generated are still low.

Development of capacity building for OGS in respect of proper waste management operations might include general curricula (valid for all companies/countries) and specific country data/info. The majority of recyclers operating across Africa are currently operating without specific international certifications and their own operations are simply based on mandatory legal requirements from general waste management legislation of the country (which is sometimes basic and minimal at best). In such a context, there is an opportunity for the OGS Industry to define pragmatic requirements and processing. Definition of checklist of requirements and processing options could also serve as a basis for: pre-qualification of recyclers before signing a contract, definition of improvement plan after inspection, and definition of more stringent requirements or lobbing with national authorities to create level playing field in recycling industry

Finally, as a more ambitious venture at industry level, setting up a new plant for e-waste recycling or upgrading an existing plant could also be an additional activity.

References

Baldé, C.P.; Forti V.; Gray, V.; Kuehr, R.; Stegmann,P. (2017). The Global E-waste Monitor . United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna

CDC Group/M-Kopa Project on E-waste (2020)

GOGLA (2019). E-waste Toolkit, Module 1, Technical introduction to recycling of off-grid solar products

GOGLA (2015-2019). Global Off-Grid Solar Market Report. Semi Annual Sales and Impact Data

IFC (2019). E-waste Dismantler Toolkit, Vol. 1. Setting up a Dismantling Facility in India

IFC (2019). E-waste Dismantler Toolkit, Vol. 2. International Best Practice: Infrastructure, Standards and Business Planning

IFC (2019) E-waste Dismantler Toolkit, Vol.3. Operations Guidelines and Micro-Dismantlers

Magalini, F.; Sinha Khetriwal, D.; Kyriakopoulou, A. (2019). E-waste Policy Handbook, ACE TAF, 2019

Magalini, F.; Sinha Khetriwal, D.; & Munyambu, S. (2017). Cost-Benefit Analysis and Capacity Assessment for the Management of Electronic Waste (E-Waste) in the Off-Grid Renewable Energy Sector in Kenya

Magalini, F.; Sinha Khetriwal, D. & Mugabo, C. (2017). Sustainable Management of E-waste in the Off-grid Renewable Energy Sector in Rwanda

Magalini, F.; Sinha-Khetriwal, D.; Rochat, D.; Huismann, J.; Munyambu, S.; Oliech, J.; Nnorom, I.C.; Mbera, O. Electronic waste (e-waste) impacts and mitigation options in the off-grid renewable energy sector. Evidence on Demand, UK (2016)

Manhart, A.; Hilbert, I.; Magalini, F.; (2016). End-of-Life Management of Batteries in the Off-Grid Solar Sector. (GIZ)

Magalini, F.; Sinha Khetriwal, D.; Rochat, D.; Huisman, J.; Munyambu, S.; Oliech, J.; Chidi Nnorom, I.; Mbera, O. (2016) Electronic Waste (e-waste) Impacts and Mitigation Options in the Off-grid Renewable Energy Sector

Ongondo et al, (2010). How are WEEE Doing? A global Review of the Management of Electrical and Electronic Wastes

Secretariat of the Basel Convention (2011), Where are WEEE in Africa? Findings From the Basel Convention e-waste Africa Programme

Tas, A.; Belon, A. (2014). A Comprehensive Review of the Municipal Solid Waste Sector in Mozambique, Carbon Africa Limited