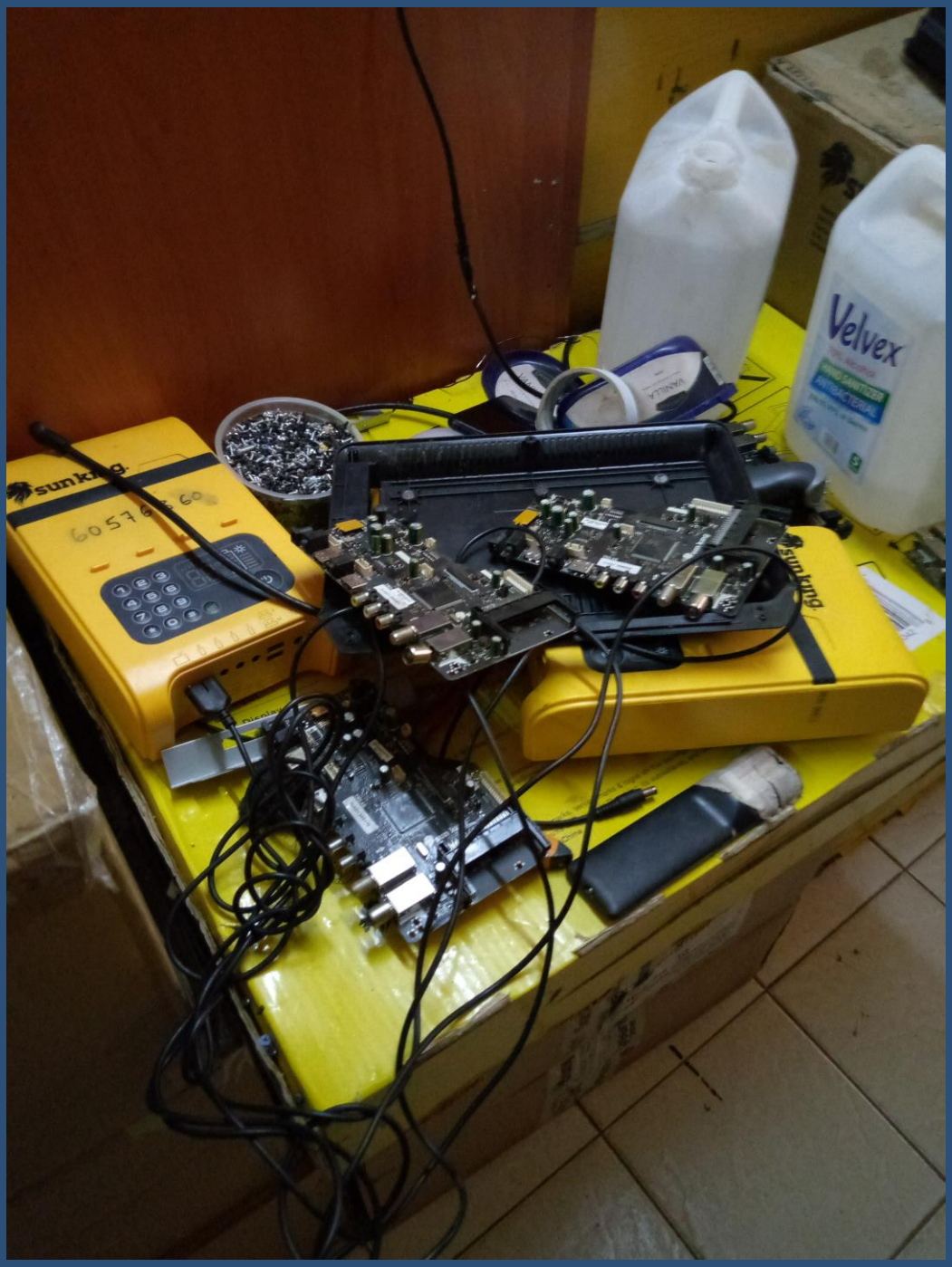
OFF-GRID SOLAR ELECTRONIC WASTE MANAGEMENT IN KENYA




# Recommendations from the research project: Governing solar electronic waste in Kenya

**Drawing on lessons from a research project on waste management in the solar off-grid sector in Kenya, this brief provides recommendations to policy-makers and stakeholders in Kenya and other Sub-Saharan countries on the management of an emerging waste problem**

**Key Messages**

The growth of the solar PV market is a major breakthrough in terms of increasing access to electricity for citizens mostly in remote and rural areas in Kenya in line with SDG 7 on affordable and clean energy.

The dark side of this development is a potential waste problem and lack of structures to support solar e-waste management.

To improve circular economy in this sector:

Government should ensure a fast implementation of the extended producer responsibility (EPR) regulation in place with a focus on i) enforcement procedures; ii) strengthening of repairs; and iii) cost reduction through involvement of the informal sector.

Companies supplying solar PV systems should: i) extend warranty periods; ii) ease financing for repairs; iii) develop products that are easy to repair, iv) make spare parts more available; and v) develop more robust solar products.

## A flourishing market for off-grid solar systems in Kenya

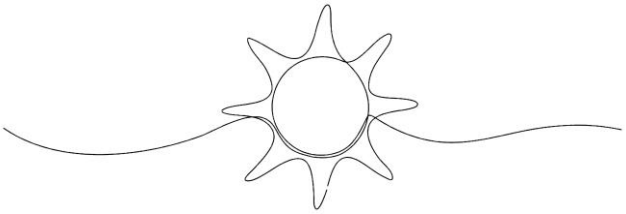
Since 2010 the market for off-grid solar photovoltaic (PV) systems has grown steadily, reaching cumulative sales of around 130 million solar devices in 2017. Recent reports estimate that the total number of customers having purchased an off-grid solar PV system in 2022 amounted to a total of 493 million, a number that is expected to continue to grow in the coming years. The sale of off-grid solar systems is concentrated geographically in Sub-Saharan Africa, especially in East Africa, where Kenya is the leading country in terms of the number of units sold (Davy et al., 2022, Hansen et al., 2022a)

The growth of the off-grid solar PV market plays an important role in providing Africa's rural population with access to sustainable and affordable sources of energy. However, given the increasing number of units sold, the amount of solar electronic waste (e-waste) being generated and disposed of is increasing at a similar pace. It was estimated that in Kenya, around 700 tonnes of solar e-waste were discarded in 2016, a figure that was expected to reach 3,800 tonnes in 2020 (Hansen et al., 2021).

A similar picture is evident across Africa: the total estimated amount of solar e-waste generated in Sub-Saharan Africa was 12,000 tonnes in 2020, a 545% increase from 2016. These estimates have raised concerns about the overall environmental sustainability of the off-grid solar industry, since the systems contain various hazardous materials, such as lead, cadmium, mercury and sulfuric acid, which may cause serious adverse effects on both humans and the environment (Munro et al., 2022).

Kenya is not only a frontrunner in terms of the number of off-grid solar PV systems sold per capita, but in contrast to most other countries, such as Malawi, most of the systems sold are quality-certified by the Global Off-Grid Lighting Association (GOGLA) and sold by brand name companies. The research found that as many as 78.1% of the solar lanterns, 81.0% of the solar lighting systems and 64.7% of the solar home systems were sold by companies affiliated to GOGLA and covered by its certification scheme.

Accordingly, contrary to a widely held understanding in reports published on the subject, off-grid solar PV systems sold as counterfeits or copycat products are actually of minor importance in Kenya. This also implies that the technical and organizational options for these brand-name companies to become part of the solution to this tinkering waste problem in Kenya are much greater than anticipated (Majale et al., under review).



**Waste-handling practices by companies selling solar PV systems**

The research project investigated the current e-waste management practices of some of the main companies selling off-grid solar PV systems under their brand names in Kenya based on a pay-as-you-go (PAYG) model, which are certified by GOGLA.

> The research project entitled "Governing solar electronic waste in Kenya" was carried out through close cooperation between the Technical University of Denmark, University of Nairobi and Kenyatta University. The project was undertaken in the period from 2021 to 2023 and funded by the Ministry of Foreign of Affairs of Denmark.
>
> The project involved research on solar e-waste generated from the increasing sale of small-scale, off-grid solar PV systems in Kenya. The project was designed to cover the entire value chain for off-grid solar PV in Kenya and the key actors involved at various points of the chain. Research conducted in the project therefore aimed at studying the products from their initial design, manufacturing, import by companies selling the solar PV systems over to the consumers and their usage practices, and to the local repair, recycling and final discard of the products.
>
> The study comprised: i) 15 interviews with distributors of off-grid solar PV systems and other stakeholders at the national level, ii) a household survey in two counties, Kakamega and Homabay in Kenya, including 525 questionnaires and 32 interviews, iii) an assessment of economic and environmental impacts of three scenarios for managing solar e-waste based on an expert solicitation with 20 respondents

The research shows that e-waste management is not a main priority for these solar PV companies for the time being. Since the companies are start-ups, their main focus is on creating commercially viable businesses. Their main approach to waste management mainly involves repairs and replacement of defective components within the warranty period, which is typically of one to two years. The company managers consider efforts aimed at improving waste management beyond the warranty period to be an added cost, which could jeopardize the development of their businesses

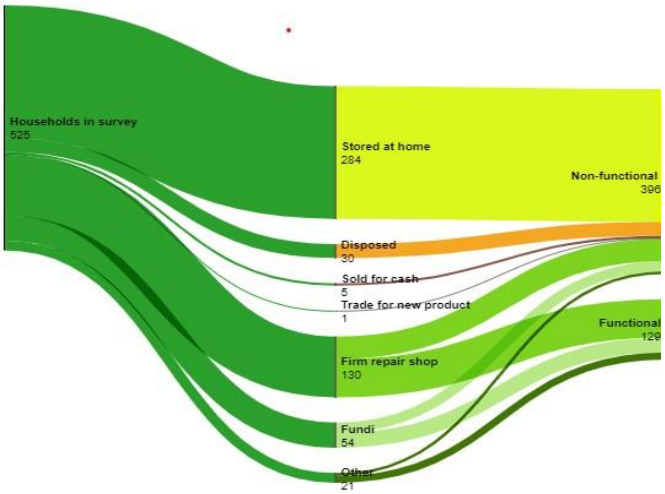
Customers are often hindered from purchasing after-sales services for broken components after the warrantee expires due to the high costs and logistics involved. To the extent that the companies engage in waste management, it was mainly in cases where external funding was provided for such activities (Kamau et al. under review).

The project also investigated the role of external investors who provide the solar PV companies with direct funding through grants, debt or equity financing. The research found that these investors have started to pay greater attention to solar e-waste management as part of their due diligence and monitoring activities. The increased focus of investors on e-waste is mainly motivated by the potential risks to their reputations (Hansen et al., 2022b).

GOGLA plays an important role in providing guidance documents, knowledge exchange and funding for pilot projects aimed at improving e-waste management across the industry. Companies selling solar PV systems are increasingly subjected to requirements for strengthening waste management. Nevertheless, these efforts have not resulted in changing companies' business practices beyond a mere box-ticking exercise. Furthermore, the companies are not subjected to pressure to comply with national e-waste regulations, which could potentially contribute to changing the status quo.

**Repair and waste-handling within households**

When off-grid solar PV systems break down at home, they take on different trajectories. Research conducted with 525 households with broken systems shows that 25% of the latter have actually been repaired and are functional, and that a high share (60%) of those that are taken in for repair end up being repaired and remain functional.

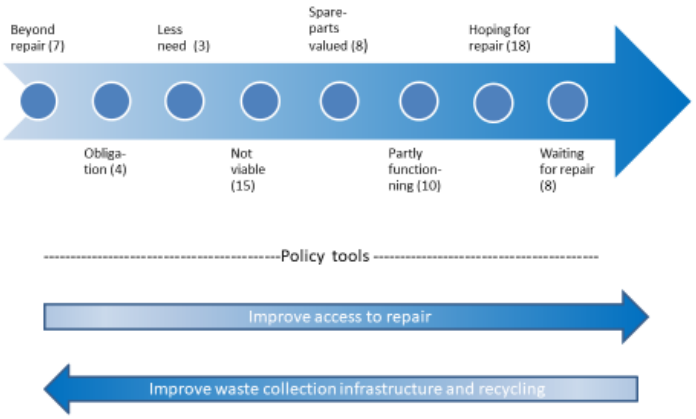



However, of the non-functioning off-grid solar PV systems, about 72% are stored at home, also referred to as 'hibernation', and only 8% are deposited in landfills by consumers. The remaining 20% of broken systems are handled by the formal and informal repair shops, partly as waste and partly being used as spare parts for repairs (Majale et al., under review).

*Hibernation thus becomes an unintended and temporary 'solution' for waste management, in addition to repairing or recycling.*

The hibernation of solar PV systems is occasioned by a number of economic, cultural and symbolic meanings. The likelihood that hibernating systems will be repaired or disposed of is contingent on their economic value as compared to its cost of repair, as illustrated in the figure below.

Devices that fall into the categories of 'waiting for repair' or 'hoping for repair' would benefit from a policy improving access to repair, while devices in the categories 'beyond repair' and not 'viable to repair' would benefit from an improved waste collection and waste-handling strategy to avoid being disposed of in nature or on dumpsites.




More importantly, the research also revealed that the positive symbolic meanings attached to the systems, such as being a gift or a symbol of modernity, may increase the likelihood of keeping the systems at home, and that negative meanings, such as a sign of poverty or of vulnerability attached to the possession of a broken system, may increase the likelihood of hibernation (Opinde et al. under review).

Besides the repair under warranty carried out by the selling companies' own repair shops, a significant share (about 30%) is repaired by local repair shops, the so-called *fundis*, who in general have no formal training. The *fundis* are able to do simple repairs, but they are limited in their work because of their skills levels, as well as by the companies' current practices of 'black-box' engineering the systems and controlling access to spare parts (Majale et al., under review).

### Prospects for improved waste-handling and recycling

The PAYG model of payment, coupled with companies' sales agents, form a strong mode of governing relations between firms and consumers that permits 'personalized interactions' and encourages repairs where broken systems may have otherwise been stored at home. Such consumer relations also provide avenues for traceability and quality control, as well as a unique option for the collection of waste.

On the other hand, the geographical focus of the off-grid solar PV market in remote rural areas with low incomes, poor roads and an absence of proper waste management infrastructure raises several specific concerns regarding the sustainability of the current business model, both economically and in terms of the collection and recycling of the generated waste.

As we have seen above, PAYG companies are taking some initiatives toward waste management through repairs and collection of waste, but there is a need for more government support and regulations in order to increase repairs and waste collection by companies, and for establishing and managing a collection and recycling infrastructure (Majale et al. under review).

### Current regulations and regulations in the making

With respect to regulation of the off-grid solar PV sector, the Kenyan government has followed a 'light touch' regulatory approach. Although various regulations on waste-handling, including the extended producer responsibility (EPR) regulation, were drafted in 2022, companies selling electronic systems are currently not incentivized by the government to take back broken systems (Mugendi et al. 2023).

The EPR regulation is inspired by similar regulations, for instance, in the European Union, which has proved to be costly, but also difficult to operationalize in a way that reduces waste by increasing the lifetimes and reparability of devices, but focuses rather on their collection and recycling. The ongoing negotiations about implementation of the EPR in Kenya will be important for how repairs can preferred to collection and recycling (Mugendi et al. under review).

### Policy recommendations

The research conducted suggests three main avenues for reducing the environmental impact of solar e-waste: i) to improve materials recovery through collection and recycling; ii) to improve lifetimes through repairs and refurbishment of broken systems; and iii) to improve product lifetimes by better product quality and circular product design.

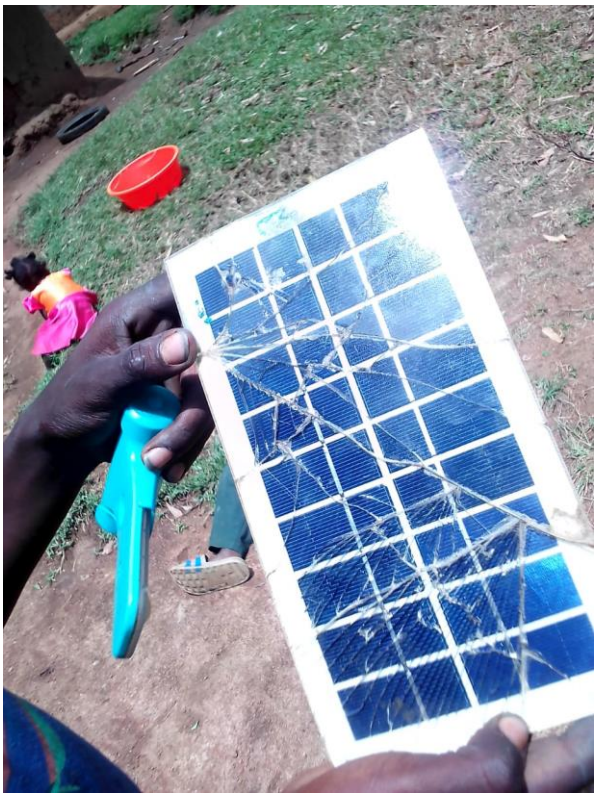
While all three avenues sketched out above need to be supported, this project recommends prioritizing especially the second avenue, 'improving lifetimes through repair and refurbishment'. Secondly, the project recommends improving materials recovery, and thirdly improving product quality and design.

The project's policy recommendations are mainly directed towards the government, which is responsible for regulating the sector and for providing a basic waste-management infrastructure. We also provide specific recommendations to companies selling the systems, as they have the economic capacity, the governance infrastructure and the long-term interest in reducing waste streams and recycling the residuals.

**Recommendations for government**

Ensure rapid implementation of the EPR regulation in place. In this process, it is important to ensure:

1) that the regulation is efficient and enforced by:
    a. clarifying what the consequences will be in case the suppliers fail, individually and collectively, to collect and process as much e-waste as they bring to the market
2) that incentives for repair are strengthened by:
    a. including repair in the EPR compliance rates
    b. providing economic support for increasing *fundis*' repair capacity through training and certification schemes, and
3) that the cost of implementing the EPR regulation is reduced by:
    a. integrating the informal sector via lenient, non-bureaucratic means of gradually formalizing and legalizing formerly informal activities



**Recommendations to companies selling the systems and their investors**

Off-grid solar investors should:

1) allocate resources specifically dedicated to e-waste management that goes beyond the warranty periods.
2) demand end-of-life monitoring of e-waste management and set up stricter compliance mechanisms.

Companies selling off-grid solar PV systems should:

1) extend warranty periods to ensure a greater degree of e-waste collection and repairs.
2) provide finance to repair devices under the same conditions as finance for new devices in order to encourage repairs rather than selling new devices.
3) develop products that can easily be reassembled and repaired.
4) make spare parts available for informal technicians to carry out repairs of branded devices out of warranty.
5) develop products which are more robust and easier to recycle.

**Recommendation for donors**

Donors and international organizations should provide more funding for:

1) training technicians in the informal repair sector.
2) develop a proper infrastructure for the handling and recycling of e-waste.
3) research factors that influence whether a household hibernates its broken devices or takes them in for repair or recycling.

## REFERENCES


Davy, E., Hansen, U. E., & Nygaard, I. (2022). Localizing the solar value chain in Kenya? Innovation and Development, 1–24. https://doi.org/10.1080/2157930x.2022.2121306

Hansen, U. E., Bhamidipati, P. L., Pedersen, M. B., Nygaard, I., & Njoroge, H. N. (2022a). Linking business strategies with upgrading pathways in global value chains: Insights from the Kenyan solar market. Development Policy Review, 41(2), 1–32. https://doi.org/10.1111/dpr.12655

Hansen, U. E., Nygaard, I., & Maso, M. D. (2021). The dark side of the sun : solar e-waste and environmental upgrading in the off-grid solar PV value chain. Industry and Innovation, 28(01), 58–78. https://doi.org/10.1080/13662716.2020.1753019

Hansen, U. E., Reinauer, T., Kamau, P., & Wamalwa, H. N. (2022b). Managing e-waste from off-grid solar systems in Kenya: Do investors have a role to play? Energy for Sustainable Development, 69, 31–40. https://doi.org/10.1016/j.esd.2022.05.010

Kamau, P., & Wamalwa, H. N.; Hansen, U.E. (under review). Post-consumption practices in southern value chains: lead firm governance of solar waste in Kenya.

Majale, C., Opinde, G., Nygaard, I. (under review). Bringing light, connectivity and waste to local communities: a study of the post-consumption value chain for off-grid solar devices in Kenya.

Mugendi, D., Mireri, C., & Korch, M. (2023). Towards Development of Effective Policies and Regulations for Sustainable Off-Grid Solar Electronic Waste in Kenya. Engineering Reports. https://doi.org/10.1002/eng2.12805

Mugendi, D., Mireri, C., & Korch, M. (under review). Future Scenarios for Circular Management of Solar E-waste in Kenya

Munro, P. G., Samarakoon, S., Hansen, U. E., Kearnes, M., Bruce, A., Cross, J., Walker, S., & Zalengera, C. (2022). solar e-waste in the Global South. Nature Energy, 12. https://doi.org/10.1038/s41560-022-01103-9

Opinde, G., Majale, C., Nygaard, I. (under review). Hibernation of off-grid solar e-waste in Kenya: an unintended response to an emerging waste issue.


The brief has been produced under the research project "Governing solar electronic waste in Kenya" funded by the Ministry of Foreign Affairs of Denmark and administered by Danida Fellowship Centre.

The authors are grateful to all the respondents to who took time to respond to our questions when we were conducting this research. We are also thankful to all participating institutions for supporting this study in various ways.

**AUTHORS:**
Ivan Nygaard, ivny@dtu.dk
Ulrich Elmer Hansen, uleh@dtu.dk
Paul Kamau, pkamau@uonbi.ac.ke
Herbert Wamalwa, wnyukuri@uonbi.ac.ke
Christine Majale, majale.christine@ku.ac.ke
Caleb Mireri, mirericaleb@gmail.com
David Mugendi, dmugendi82@gmail.com
Godwin Opinde, opinde.godwin@ku.ac.ke
Martin Enevoldsen, mke@kobra-advice.dk

**Photo**: Work Package 2 fieldwork team

**ISBN:** 978-87-87335-69-0
**DTU report**: DTU Wind Energy E-0241

**Published by**:
Society, Market and Policy Section,
Wind and Energy Systems Department,
Technical University of Denmark