Draft EoL modelling for eCook in SSA_Version 2

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Executive Summary

The objective of this working paper is to present the initial findings of the impacts of End of Life (EoL) and End of Design Life (EoDL) activities for two eCook case studies; Kenya and Tanzania. The study was conducted following the principles of BS/EN ISO 14040 and 14044 and other good practice systems. The findings in this paper are preliminary, and will be further revised in due course.

Field trials were undertaken to provide more information on what happens to products when they break down. The repair shops for both urban and rural areas predominantly repaired consumer items but no evidence of repairs to PV systems (panels, inverters or batteries) were recorded. Repairs to mini-grid equipment were not expected to be undertaken by local repair shops. Repair rates are high for both rural and urban environments (66-100%). EPC repairs are not yet seen in rural areas (an indication that electric cooking with these items has not penetrated much into rural areas yet), but hotplates and rice cookers are visible. Cooking devices contribute only a small part of the total impact for a days' cooking (impacts are dominated by the choice of fuel for traditional cooking devices) thus, once they can no longer be repaired, EoDL activities such as dismantling for component reuse and material recycling add little benefit to the overall system.

For charcoal and wood-based systems, there is negligible improvement to be realised from EoL actions. This is because the disposal for three stone fire place is non-existent, and for street charcoal burners, of the two materials used in manufacture, clay is inert and likely to be broken down over time to small pieces and the steel recovered and sent for recycling, or simply left to degrade. The recycling process for the steel is not considered part of the eCook model, due to the system boundaries chosen.

For LPG and kerosene devices, some benefits at EoDL result from the reuse of components with high manufacturing impact, for example the chromium plated components of the LPG burner.

For the SHS, even assuming a small proportion of repaired and reused items, produces a noticeable improvement for EoL. Since no data regarding PV panels and associated systems is available for EoDL activities, this study has assumed that only the LFP batteries may be broken for parts, all other parts of the system will be thrown away.

For the mini-grid, it is assumed that repairs to poles, cables etc will be carried out until the mini-grid is no longer fit for purpose, or a major component fails that cannot be repaired or replaced. For EoDL it has been assumed that the supporting system will be broken down and where appropriate, parts reused. The reuse of wooden poles (when using a chromium-based preservative) is particularly beneficial.

Increases in emissions that result from open burning of wastes when thrown away cannot be seen in these results. This is likely to be because the mass of material that ends up in this treatment is small e.g: for a hotplate that ends up being thrown away, the metal element and casing will be recovered through mechanical means (hammer, screwdriver etc), plastic controls are likely to dumped with no further processing, and any wiring burned to remove PVC coating so that the copper can be collected. The mass of wiring in a hotplate is very low (grams) and thus its contribution very low.

Table of Contents

EXECUTIVE SUMMARY 2

1.0 BACKGROUND 4

2.0 DEFINITIONS 4

3.0 END OF LIFE OPTIONS 5

4.0 MAPPING THE EOL OPTIONS TO SIMAPRO SOFTWARE 6

5.0 EXISTING INFORMATION ON EOL PRACTICE IN SUB SAHARAN AFRICA 6

6.0 FIELD TRIALS IN TANZANIA TO CAPTURE EOL BEHAVIOUR 7

7.0 RESULTS 7

7.1 GENERAL FINDINGS FROM THE FIELD TRIALS 7
7.2 SHS IN KENYA 8
7.3 MINI-GRID IN TANZANIA 10

8.0 DISCUSSION AND CONCLUSIONS 11

9.0 FURTHER WORK ACTIONS 12

APPENDIX A 13

APPENDIX B 15

APPENDIX C 21

APPENDIX D 24

1.0 Background

This report details the interim findings when incorporating End of Life (EoL) options in to the life cycle assessment for eCook systems. EoL activities are key for moving towards sustainable systems, and understanding of the implications of EoL choices can impact business model development, product development (it is better to reuse, recycle or dispose) and influence consumer behaviour.

For this report, all disposal options have been assumed (a field study planned for July should provide more accurate information on what happens to different classes of eCook items). The LCA was modelled using Simapro.

2.0 Definitions

The following definitions are used throughout this report.

Disposal Scenario: The description of what happens to the item at the EoL stage of product life cycle, e.g. X % sent for waste treatment, Y% sent for disassembly, Z% directly reused, A% hibernated, B% repaired.

Disassembly of parts: The dismantling of an item to components that can each have their own disposal scenario.

End of Design Life (EoDL): The stage of a product life when it can no longer perform its designed function and cannot be repaired.

End of Life (EoL): The stage of a product life when it no longer performs its designed function but has the potential to be repaired/reused.

Hibernate: An item which is no longer used and thus stored, but with no intention of doing anything with it. It is essentially 'lost' from the technical, economic and environmental systems.

Maintenance: Planned activities undertaken during the use stage of the item to ensure it keeps fulfilling its function.

Recovery of material: Processes required to recover materials (not components) from waste treatments.

Repair: Unplanned activities undertaken to ensure item keeps fulfilling its function

Reuse: The direct reuse of a component or item (closed-loop recycling).

Waste Scenario: The description of what happens to materials (not items) at the EoDL stage of product life cycle, e.g. X% goes to incineration, Y% goes to landfill, Z% goes to recycling.

Waste Treatment: The inventory of material and energy inputs to and emission outputs from different waste treatment processes.

3.0 End of Life options

Figure 1 below represents a generic flow diagram indicating all the options for what may happen to an item when it reaches the End of Life (EoL) and End of Design Life (EoDL). There are a multitude of combinations and loops that can occur for any one item. Depending on the materials, product design, local facilities and individual behaviours, some items may follow the circular economy preferred route: reuse, repair, split for component reuse where possible, and finally material recovery. Others may simply be 'hibernated' and lost from the economic, technical and environmental systems.

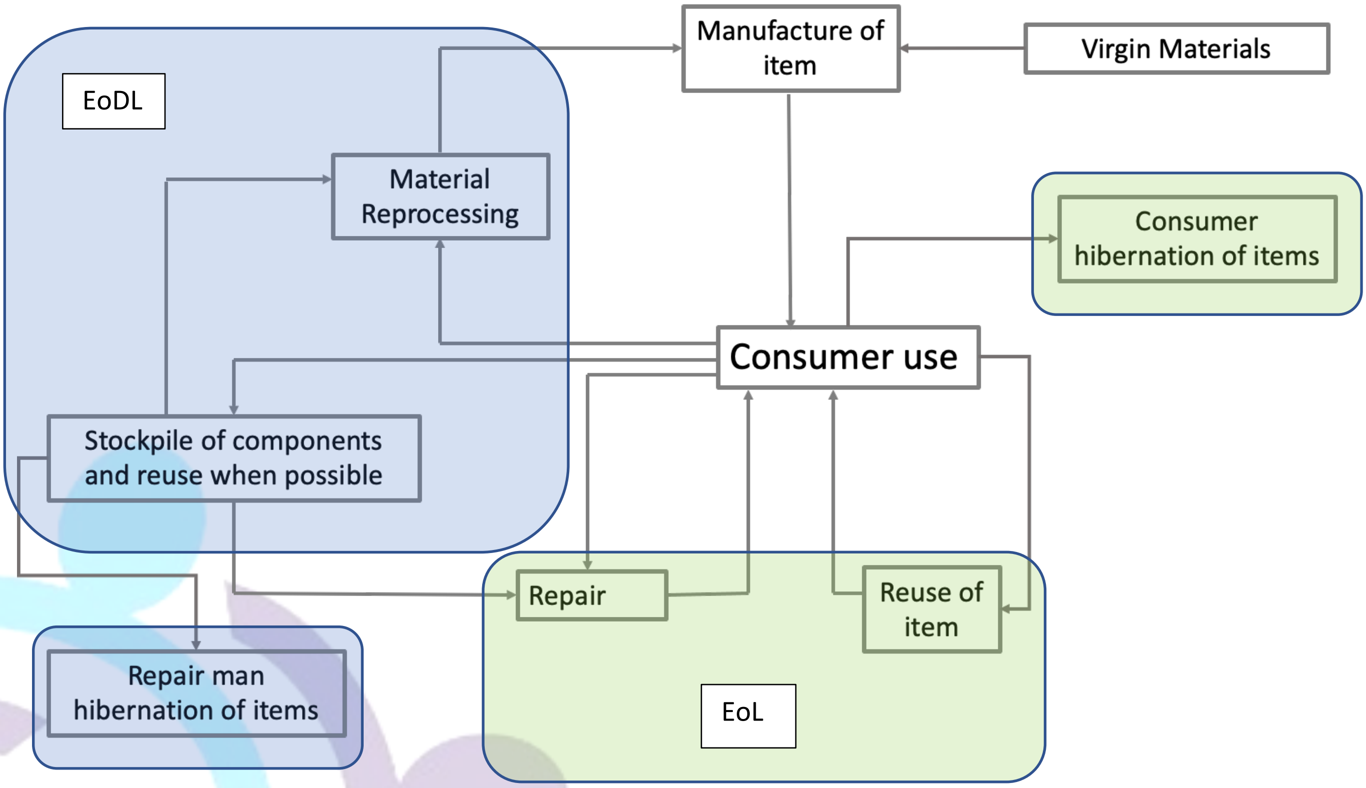

Figure 1: Item and component flows highlighting EoL and EoDL

For a given number of items reaching EoL, it can either be hibernated, repaired or reused. If none of these options is available, then the item has reached its EoDL. When it reaches the EoDL, only two options remain; disassembly, to capture components for reuse and materials for recycling, and to be thrown away. A repair man make choose to repair and resell an item, if the market for that item exists, or they may break the item for parts, if there is likely to be a need for spares in the future, or they may decide that they have enough spares, or that there is no value in holding spares for this particular item, and choose to throw it away. When thrown away, the materials may be captured for recycling, or may simply disappear from the industrial system.

Thus to build a complete EoL and EoDL scenario for the eCook system requires an understanding of what *can* be done with items and components and what *is* done under normal circumstances.

4.0 Mapping the EoL options to Simapro software

Simapro allows the creation of Disposal scenarios for items, that allow the model to specify what happens to the item after use. This allows the item to be sent for waste treatment (incineration, landfill, recycling etc), to be disassembled to component parts, or to be reused. Each disassembled component can then be sent for waste treatment, further disassembly or reuse, and so on. Not all components have an option to be repaired or reused, and so will go for waste treatment. When the disassembly reaches materials (not components), then it must be sent for a waste treatment. Figure A1 in Appendix A shows the EoL/EoDL breakdown for a simple EPC.

The model for eCook has repeated this process for all devices or energy producing items, Appendix B shows the current assigned % for each EoL and EoDL options for each item/component. The associated activities from each option are as follows:

- Hibernation: no inputs to or emissions from the system when an item is hibernated
- Disassembly: no electrical energy is assumed to be used for disassembly, normal disassembly equipment is understood to be a hammer and screw driver.
- Repair: inputs for soldering (solder and energy for 40kW iron) for items with electrical components, and inputs for welding (steel or aluminium and energy) for items with no electrical components. For this interim assessment, it has been assumed that no soldering/welding is required to repair items before reuse.
- Reuse: It is assumed that the items/components that are reused are reused locally, thus no transport is required.
- Thrown away: items/components containing plastics or paper is treated as open burning, all metals, glass are collected for recycling (resources and energy needed for the recycling is not within the system boundary for the LCA of eCook). It is extremely difficult to measure accurate emission from open burning of waste materials as it depends very much on what is being burned at any one time. EcoInvent has a pre-populated waste treatment that emulates this process, so this has been used as a base for the practises used at waste sites in SSA.

5.0 Existing information on EoL practice in Sub Saharan Africa

The waste systems in SSA are not as formally regulated as those in Europe or USA and whilst there are many initiatives to improve the EoL practise, especially with respect to electronic items, current practise is generally within the informal sector. This is a very efficient process, with most easily recoverable materials collected, but the processes used are basic, and extremely hazardous for those employed in the sector[1][2][3].

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[1] The local contours of scavenging for e-waste and higher-valued constituent parts in Accra, Ghana. M Oteng-Ababio, E Amankwaa, M Chama, Habitat International 43 (2014) 163-171 DOI: 10.1016/j.habitatint.2014.03.003

[2] The challenge of electronic waste (e-waste) management in developing countries. O. Osibanjo and I.C. Nnorom, Waste Management Research 2007; 25; 489 DOI: 10.1177/0734242X07082028

[3] Insights from a decade of development cooperation in e-waste management, 2013
M Schluep, E Müller, L Hilty, D Ott, R Widmer, H Böni. Technology and Society Laboratory, Swiss Federal Laboratories for Materials Science and Technology (Empa)

For rural communities, the general process for dealing with the EoL of stoves, and electrical items is to either store it (hibernate), see if the local repair man can fix it, or put outside for collection from the local metal collector. These collectors, tour villages collecting items that no longer work, and take them to the larger cities for processing and disposal. There is no fixed collection day or time, the collectors simply 'turn up' now and then. Other non-metallic or electrical waste is normally collected in one location in the village and burned once a month or so.

If the local repair man is unable to fix the item, they may choose to break it down to get components that they know will be of use in the future, or put for collection. The local repairman does not normally have any official training in repairing, but has learnt 'on the job' and takes knowledge from repairing one type of product to the next. Tools available are basic, so complex repairs are unlikely.

Once the product reaches a central conurbation, there is a clear process for disposal of the items. First they are dismantled, again tools available are basic. Metals, glass are separated ready for recycling. Wiring, and other items of dissimilar materials are either broken to recover the desired fraction, or burned to access it. Circuit boards may be stored or burned or acid leached to recover the precious metals.

As yet, there is little information on how the burgeoning quantity of waste solar based products are dealt with. Lithium-ion batteries are dangerous if punctured and thus these are likely to be stored, and there are some schemes recently set up to recover and reuse the batteries in secondary products. There is value in the components of solar panels, but these require specialist processes to recover, that are unlikely to be available through the existing waste disposal system at the current time. Thus any panels are likely to have any external valuable materials removed, and the main unit stored.

6.0 Field Trials in Tanzania to capture EoL behaviour

A short small-scale field trial with repair shops was undertaken in Tanzania to capture EoDL and EoL activities with respect to traditional cooking and eCooking devices. The aim of this was to provide better understanding of the most likely routes for items at EoL and EoDL, e.g.repaired, hibernated, broken for spares or thrown away. The field trial was carried out in two stages: Stage 1, an interview with repair shop owner (fundi), 3 in urban areas and 3 in rural areas, see Appendix C for questions, and Stage 2, a repair diary, completed by the repair shops, to capture activities over a period of two weeks. A local operative was employed to select the repair shops, undertake the interviews and act as a point of contact and reference for the repair shops when completing the repair diaries. Photos of tools and items brought for repair were collected where possible.

7.0 Results

7.1 General findings from the field trials

Whilst the field trial was short, and limited to only 3 repair establishments in both urban and rural locations, some general observations can be made from the interviews. Detailed analysis of the repair diaries has not yet been completed.

For both the urban and rural repair shops, there was no evidence of repairs to PV panels, inverters, converters or batteries.

Urban repair shops tended to have more items brought for repair than rural shops, and each shop had repaired rice cookers, EPC's and/or hotplates in the past month. Microwave machines were also commonly taken for

repair. Food blenders were by far the most common item taken in for repair. Only one shop had been asked to repair LPG stoves (just 5 in comparison to over 100 electrical cooking device repairs for all shops combined). Repair rates across all repair shops were high (100%).
One shop specialised in buying broken items from other repair shops and repairing in order to sell to new customers, and mainly dealt with microwaves, rice cookers and blenders.
None of the repair shops included in the trial routinely broke items for spares, and all sold or left broken items for scrap collectors. However, some repair shops must break for spares as evidenced by the fact that repair shops buy parts from other repair shops, as well as making new components themselves where necessary.

Rural repair shops had less items brought in for repair than their urban counterparts, and electric cooking items were far less common, and did not include EPC's, (microwaves, rice cookers and hotplates were repaired). Only one repair shop repaired rice cookers, and one shop LPG burners. Blenders and kettles were the most common items brought in and these had high rates of successful repair. Repair rates for hotplates was high (although few were brought in). Rice cookers had the lowest repair rate of all items.
Where repair was not completed, this tended to be because the customer could not afford it, rather than the repair not being possible. When items were returned to customers it is not known whether they are the simply thrown away, or hibernated in the hope that at some point they may have the financial resources to complete the repair.
Where repair was not possible, one shop broke devices for spares to keep, one shop sold unmended items to the scrap collector or other repair men and the third returned broken items to the customer.

7.2 SHS in Kenya

Table 1 provides the parameter values for the case study in Kenya. These are based on data from ESMAP[4], and represent daily requirements for a 4.2 person family.

Scenario	Devices	Quantity per household per day	
(A) 100% Charcoal	Ceramic Jiko	1.75kg charcoal	
(B) 100% Firewood	Three stone fire place	3.5kg firewood	
(C) 100% LPG	2 Ring LPG burner	0.23kg LPG	Table 3
(D) 100% Kerosene	Simple wick burner	0.25kg kerosene	
(E) 100% SHS	SHS sEPC Hotplate	PV array, 3.94m2 LFP Battery 2.22kW Inverter, 2.5kW	Efficiency of PV panels assumed to 16%

Table 1: Daily energy and device needs for a 4.2 person family in Kenya.

The overall improvement for one day's cooking, resulting from EoL activities on selected midpoint impact categories can be seen in Table 2 and Appendix D Figure D1. The results show that for charcoal and wood-based cooking, there is very little impact of EoL practises. This is because for a three stone firepit, there is no EoL for the cooking device and for a street charcoal burner, whilst it is assumed that 95% will be thrown away, it is made

[4]https://documents1.worldbank.org/curated/en/920661600750772102/pdf/Cooking-with-Electricity-A-Cost-Perspective.pdf

from inert clay and sheet steel. The steel is likely to collected and recycled from the disposal location, but the impacts from this recycling process are not included within this system boundary.

For the LPG and Kerosene burners, more benefits from EoDL activities can be seen, (Appendix D: figures D2 and D3). These benefits result from the % of items reused once a broken item has been dismantled for spares. Of particular note is the relatively large reduction in impact for LPG for the human carcinogenic toxicity impact category. This can be attributed to the reuse of components, within the LPGB, that are chromium plated, such as the pot rest griddle. (No EoL benefits have been assumed in the manufacture of either the LPG or kerosene).

For the SHS, greater benefits can be seen. The overall contribution of the cooking devices to the environmental impact for one days' cooking is small[5], and for the SHS system, the EoL and EoDL is therefore dominated by the PV system. The current assumptions for reuse, hibernation and disposal of the components of a SHS system are set such that many of these items are simply hibernated, and do not enter the disposal or reuse systems. However, despite the relatively low percentages allocated to repair and reuse, they deliver a noticeable improvement over the worst case (essentially 100% hibernation). Within these items, there is little plastic or paper, thus any increased emissions due to the open burning disposal of these items is likely to be small, and be outweighed by the benefits accrued through reuse.

		Global warming kg CO2 eq	Fine particulate matter formation kg PM2.5 eq	Human carcinogenic toxicity kg 1,4-DCB	Human non-carcinogenic toxicity kg 1,4-DCB	Mineral resource scarcity kg Cu eq	Fossil resource scarcity kg oil eq
Charcoal	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Firewood	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
LPG	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	99.0%	94.4%	78.9%	87.6%	86.4%	98.8%
Kerosene	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	99.9%	99.9%	93.9%	97.7%	94.2%	100.0%
SHS	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	85.2%	84.7%	83.6%	84.5%	82.8%	85.0%

[5] https://mecs.org.uk/wp-content/uploads/2021/02/V2_Environmental-Assessment-of-ESMAP-scenarios-1-and-5.pdf

Table 2: % reduction in impacts for selected midpoint impact categories for charcoal, wood, LPG, Kerosene and SHS cooking

7.3 Mini-grid in Tanzania

Table 3 provides the parameter values for the case study in Tanzania. These are based on data from ESMAP[6], and represent daily requirements for a 4.2 person family.

Scenario	Devices	Quantity per household per day	
(A) 100% Charcoal	Ceramic Jiko	1.88kg charcoal	
(B) 100% LPG	2 Ring LPG burner	0.35kg LPG	
(C) 100% Wood	TSFP	3.72kg wood	
(D) 100% Mini-grid	sEPC Hotplate	PV array, 1705 m2 LFP Battery, 249 kWh Inverter, 98.2 kW	Efficiency of PV panels assumed to 16%
(E) 100% Mini-grid with Diesel generator	SEPC Hotplate	PV array, 944 m2 LFP Battery, 165.6 kWh Inverter, 54.6 kW 88kW diesel generator operating for 0.0127 hours per day	Efficiency of PV panels assumed to 16%

Table 3: Daily energy and device needs for a 4.2 person family in Kenya.

As found with the Kenya case study, the benefits to be realised from EoDL activities from the traditional fuel cooking system are negligible whereas there are some significant opportunities when analysing the mini-grid system options, see Table 4 and Appendix D Figure D4. Within the mini grid itself, there are benefits to be realised from the reuse of a number of the non-energy related components, such as the poles, overhead items and the shipping container. It is unlikely that transmission cables and would be reused, for safety reasons, but these would be recycled for their metal content. Figures D5 and D6 show the life cycle for the mini-grid with and without the diesel generator and the benefits from the non-energy related reuse can clearly be seen. For the energy related components, (PV panels, battery etc), the same assumptions have been made as for the SHS; some repair and reuse, but a higher proportion is hibernated.

For the human carcinogenic toxicity, a reduction of over 50% can be realised through the judicious reuse of those items that embody high toxicity, in this case the chromium-based preservative on the poles and stays. This highlights that good practice would be to reuse wherever possible those items that have high manufacturing impacts. These items have high value as components and should only be treated as material resources at EoL if there is no reuse options available, i.e. whilst it would be possible to use old wooden poles as fuel (notwithstanding the health and air pollution issues of burning wood that has been preserved using a chromium -based preservative), the value of the wood is as a pole, not fuel.

[6]https://documents1.worldbank.org/curated/en/920661600750772102/pdf/Cooking-with-Electricity-A-Cost-Perspective.pdf

		Global warming kg CO2 eq	Fine particulate matter formation kg PM2.5 eq	Human carcinogenic toxicity kg 1,4-DCB	Human non-carcinogenic toxicity kg 1,4-DCB	Mineral resource scarcity kg Cu eq	Fossil resource scarcity kg oil eq
Charcoal	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Firewood	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
LPG	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	99.3%	95.9%	79.2%	89.8%	88.6%	99.2%
Mini-grid	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	85.7%	82.1%	44.7%	74.7%	78.6%	86.2%
Mini-grid with diesel generator	Worst Case	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	With EoL and EoDL	83.8%	78.8%	42.2%	70.1%	75.1%	84.5%

Table 4: % reduction in impacts for selected midpoint impact categories for charcoal, firewood, LPG, mini-grid and mini-grid with diesel generator.

8.0 Discussion and Conclusions

The repair shops focus on consumer items (kitchen devices, heaters etc) and there is no data from the field trial in relation to repair of power producing equipment, such as PV panels, inverters/converters and battery systems. This maybe because these items are taken to different types of repair shops, or that if broken, they are simply hibernated or thrown away. Repair of consumer items is generally successful, extending the product life. EPC repairs are not yet common in rural areas, this is expected since electrification is less widespread, but rice cookers, microwaves and hotplates have penetrated these areas to some extent and are visible in the repair system. However, it should be noted that the field trials on successful repair depend on self-reported data from the repair shops. This should be confirmed by interviews with customers on their experience in getting items repaired

It is not known if the repair shops chosen by the local operator were renowned for their electrical repairs, and thus repairs to non-electrical cooking devices (very few repairs to these were recorded) may have been taken to alternative repair venues. When repair is unsuccessful, dismantling for component reuse is highly dependent on each repair shop modus operandi.

There are significant benefits to be realised through appropriate EoDL management of items, most noticeably for those that are seen to embody 'value' (high manufacturing impact)[7,8]. Examples of this are the pole and stays for a mini-grid, or the chromium plated pot rest griddle. These benefits were seen even with relatively low levels of reuse, and would increase if repair and reuse proportions were to increase. Additionally, the EoDL model can be used to identify components or items that would benefit from being designed such that easy access and reuse is possible.

The results are somewhat unexpected in that increase in emissions from the various EoL activites, most notably the open burning of plastic and paper-based waste does not appear to feature. There are two factors at play here, one relates to the choice of system boundaries for the model, and the other to the quantity of materials that end up in open burning.

For the first aspect, any energy and emissions required to process recyclable material (such as metal and glass) are considered to be part of the input system for the process that uses the recycled material, and this not part of the EoL processes for the eCook model. Additionally, at the current time transport of the items/materials to the locations where EoL activities occur have not yet been included as this is, at the current time, an unknown.

The second aspect, the quantity of material that ends up in open burning is relatively small in comparison to the overall mass of materials in the system. From section 5, the processes used by the informal waste system are effective at removing the metals, glass fractions, and the items that need separation by burning (wires, some PCB's) are a proportionally small weight. Nevertheless, the emissions from open burning are a high environmental threat, and should be minimised wherever possible.

9.0 Further Work Actions

Further refinement of the EoDL and EoL model is required as follows:

- Undertake further analysis of the field study data to better understand the values for repair and reuse, and disposal for each of the cooking devices and energy production systems.
- Undertake field trial to analyse consumer behaviour when products reach EoDL to capture data on hibernation rates and why these behaviours are practised.
- Identify transport distances from consumer to EoDL and EoL activities
- Undertake a sensitivity assessment on the various proportions of each item sent to each EoDL and EoL activities

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[7] https://mecs.org.uk/wp-content/uploads/2020/12/V3_Cradle-to-Gate-Environmental-Assessment-of-Cooking-Devices.pdf

[8] https://mecs.org.uk/wp-content/uploads/2021/02/V2_Environmental-Assessment-of-ESMAP-scenarios-1-and-5.pdf

Appendix A

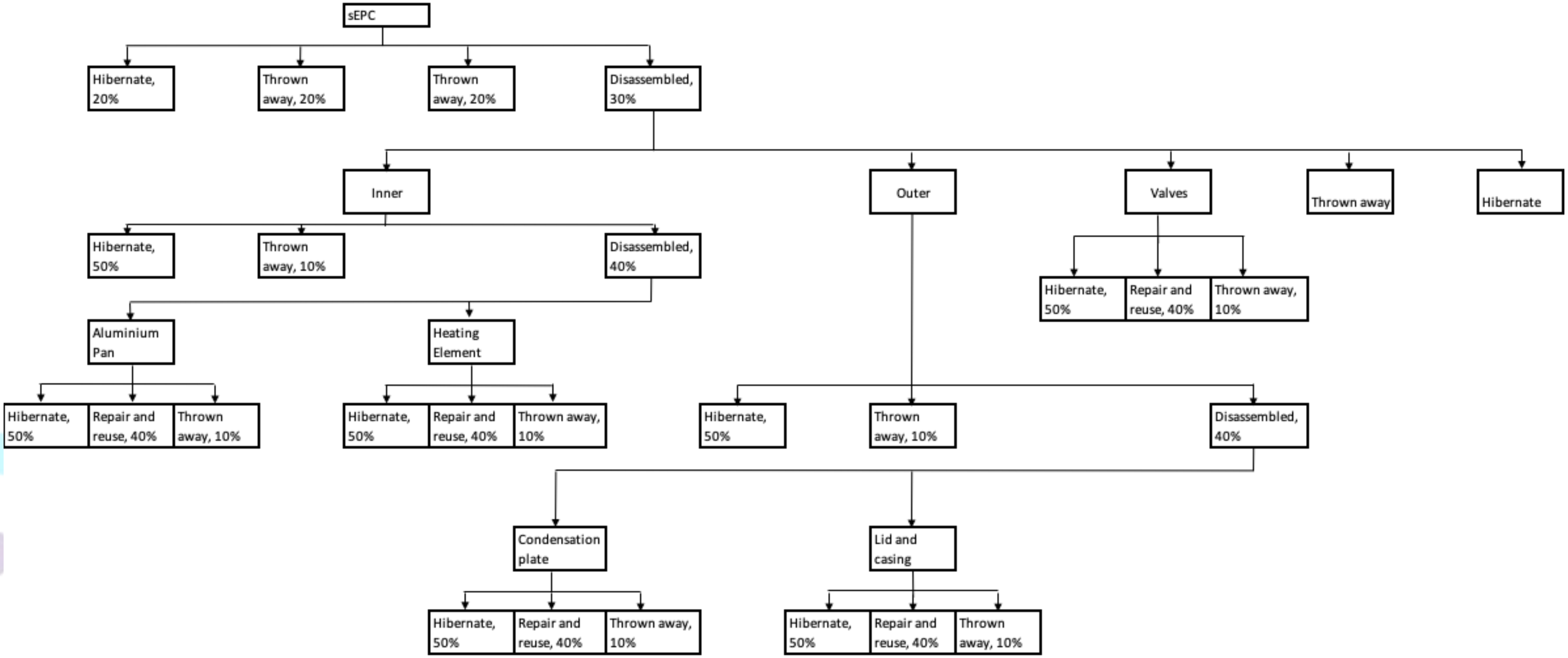

Figure A1: Breakdown of EoL activities for a simple Elecrric pressure cooker (sEPC)

Appendix B

sCHB

sCHB	Disposal Option	%	
EoL	Hibernated	5	
EoDL	Thrownaway	95	

iCHB

iCHB	Disposal Option	%	
EoL	Hibernated	20	
EoDL	Thrownaway	70	
EoL	Repaired and reused	10	Need to add length of weld repair (St, Al or both) Need to add country for electricity

More hibernated as more expensive product. May hope that later can be fixed. Not broken for spare parts.

HP

Hotplate	Disposal Option	%	
EoL	Hibernated	20	
EoDL	Thrownaway	50	
EoL	Repaired and reused	30	Need to add length of weld repair (St, Al or both) Need to add mass of product for solder repair Need to add country for electricity

KB

Kerosene Burner	Disposal Option	%	
EoL	Hibernated	10	
EoDL	Thrownaway	70	
EoL	Repaired and reused	20	Need to add length of weld repair (St, Al or both) Need to add country for electricity

LPBG

LPGB Burner	Disposal Option	%	
EoL	Hibernated	10	
EoDL	Thrownaway	15	
EoDL	Broken for parts	55	

EoL	Repaired and reused	20	Need to add length of weld repair (St, Al or both) Need to add country for electricity

LPGB Burner: Control	Disposal Option	%	
EoL	Hibernated	60	
EoDL	Thrownaway	10	
EoL	Reused as it	30	

LPGB Burner: Cr Plated Rod	Disposal Option	%	
EoL	Hibernated	60	
EoDL	Thrownaway	10	
EoL	Reused as it	30	Need to add length of weld repair (St, Al or both) Need to add country for electricity

LPGB Burner: Cr Plated Sheet	Disposal Option	%	
EoL	Hibernated	60	
EoDL	Thrownaway	10	
EoL	Reused as it	30	Need to add length of weld repair (St, Al or both) Need to add country for electricity

LPGB Burner: Painted Sheet	Disposal Option	%	
EoL	Hibernated	60	
EoDL	Thrownaway	10	
EoL	Reused as it	30	Need to add length of weld repair (St, Al or both) Need to add country for electricity

sEPC

sEPC	Disposal Option	%	
EoL	Hibernated	20	
EoDL	Thrownaway	20	
EoDL	Broken for parts	30	
EoL	Repaired and reused	30	Need to add length of weld repair (St, Al or both) Need to add mass of product for solder repair Need to add country for electricity

sEPC: Inner	Disposal Option	%	
EoL	Hibernated	50	
EoDL	Thrownaway	10	
EoL	Broken for parts	40	

sEPC: Inner: Aluminium Pan	Disposal Option	%	
EoL	Hibernated	50	
EoDL	Thrownaway	10	
EoL	Repaired and reused	40	Need to add length of weld repair (St, Al or both) Need to add country for electricity

sEPC: Inner: Heating Element	Disposal Option	%	
EoL	Hibernated	50	
EoDL	Thrownaway	10	
Eol	Repaired and reused	40	Need to add length of weld repair (St, Al or both) Need to add country for electricity

sEPC: Outer	Disposal Option	%	
EoL	Hibernated	50	
EoDL	Thrownaway	10	
EoDL	Broken for parts	40	

sEPC: Outer: Condensation plate	Disposal Option	%	
EoL	Hibernated	50	
EoDL	Thrownaway	10	
EoL	Repaired and reused	40	Need to add length of weld repair (St, Al or both) Need to add country for electricity

sEPC: Outer: Lid and casing	Disposal Option	%	
EoL	Hibernated	50	
EoDL	Thrownaway	10	
EoL	Repaired and reused	40	Need to add length of weld repair (St, Al or both) Need to add country for electricity

sEPC: Valves	Disposal Option	%	
EoL	Hibernated	50	
EoDL	Thrownaway	10	
EoL	Reused	40	

TESGVA HP

TESGVA Hotplate	Disposal Option	%	
EoL	Hibernated	20	
EoDL	Thrownaway	50	
EoL	Repaired and reused	30	Need to add length of weld repair (St, Al or both) Need to add mass of product for solder repair Need to add country for electricity

Converter

Converter	Disposal Option	%	
EoL	Hibernated	60	
EoDL	Thrownaway	30	
EoL	Repaired and reused	10	Need to add mass of product for solder repair Need to add country for electricity

Inverter

Inverter	Disposal Option	%	
EoL	Hibernated	60	
EoDL	Thrownaway	30	
EoL	Repaired and reused	10	Need to add mass of product for solder repair Need to add country for electricity

Diesel Generator

Diesel Generator	Disposal Option	%	
EoL	Hibernated	10	
EoDL	Thrownaway	30	
EoL	Repaired and reused	60	Need to add mass of product for solder repair Need to add country for electricity

LFP Battery

LFP Battery	Disposal Option	%	
EoL	Hibernated	10	
EoDL	Thrownaway	50	

EoDL	Broken for parts	10	
EoL	Reused with no modification	30	

LA Battery

LA Battery	Disposal Option	%	
EoL	Hibernated	10	
EoDL	Thrownaway	50	
EoDL	Broken for parts	30	
EoL	Reused with no modification	10	

LA Battery: Lead grid	Disposal Option	%	
EoL	Hibernated	10	
EoDL	Thrownaway	90	

Mini-grid

Mini-Grid	Disposal Option	%	
EoDL	Broken for parts	100	

Mini-Grid: Cables wires and conductors	Disposal Option	%	
EoDL	Thrownaway	50	
EoL	Reused with no modification	50	

Mini-Grid: Earth Rods	Disposal Option	%	
EoL	Hibernated	10	
EoDL	Thrownaway	70	
EoL	Reused with no modification	20	

Mini-Grid: Overhead materials	Disposal Option	%	
EoDL	Thrownaway	70	
EoL	Reused with no modification	30	

Mini-Grid: Poles and Stays	Disposal Option	%	
EoL	Hibernated	10	
EoDL	Thrownaway	20	
EoL	Reused with no modification	70	

Mini-Grid: Shipping container	Disposal Option	%	
EoL	Hibernated	20	
EoDL	Thrownaway	60	
EoL	Reused with no modification	20	

PV

PV	Disposal Option	%	
EoL	Hibernated	60	
EoDL	Thrownaway	30	
EoL	Repaired and reused	10	Need to add mass of product for solder repair Need to add country for electricity

Appendix C

Shop: Date and time:

eCooking Life Cycle Repair Shop Survey

1. How many of the following items are brought to you for attention over a period of a month:

	How many per month?	Average of how many repaired?	What happens to the rest?
LPG cooker	*(e.g. 0)*		
Hot plate	*(e.g. 2)*	*(e.g. 1)*	*(e.g. Thrown away and put out for collection by scrap collector)*
Kerosene burner			
Rice cooker			
Electric pressure cooker			
Mobile phone			
Photovoltaic panel			
Solar lantern			
Inverter			
Lead acid battery			
Lithium ion battery			
Radio			
Fridge			
Light			
Other			

2. What tools do you have available? (Take photos of each tool, send in the whatsapp group, and where unclear, state use)

3. When you repair items, what methods do you use?

	Tools used	Type of repair
LPG cooker		
Hot plate	*(e.g. soldering iron, screwdriver)*	*(e.g. Access electronics, remove faulty part and solder replacement in place)*
Kerosene burner		
Rice cooker		
Electric pressure cooker		
Mobile phone		
Photovoltaic panel		
Solar lantern		
Inverter		
Lead acid battery		
Lithium ion battery		
Radio		
Fridge		
Light		
Other		

4. Do you take items apart for spare parts? Which of the following would you take apart?

	How many per month?	Which bits do you normally keep?	What happens to the rest?
LPG cooker	*(e.g. 0)*		
Hot plate	*(e.g. 2)*	*(Heating plate, wires and PCB)*	*(Metals: thrown away for collection Glass: thrown away)*
Kerosene burner			
Rice cooker			
Electric pressure cooker			

Mobile phone			
Photovoltaic panel			
Solar lantern			
Inverter			
Lead acid battery			
Lithium ion battery			
Radio			
Fridge			
Light			
Other			

5. What happens to items collected by scrap collectors? (If they know)

Appendix D

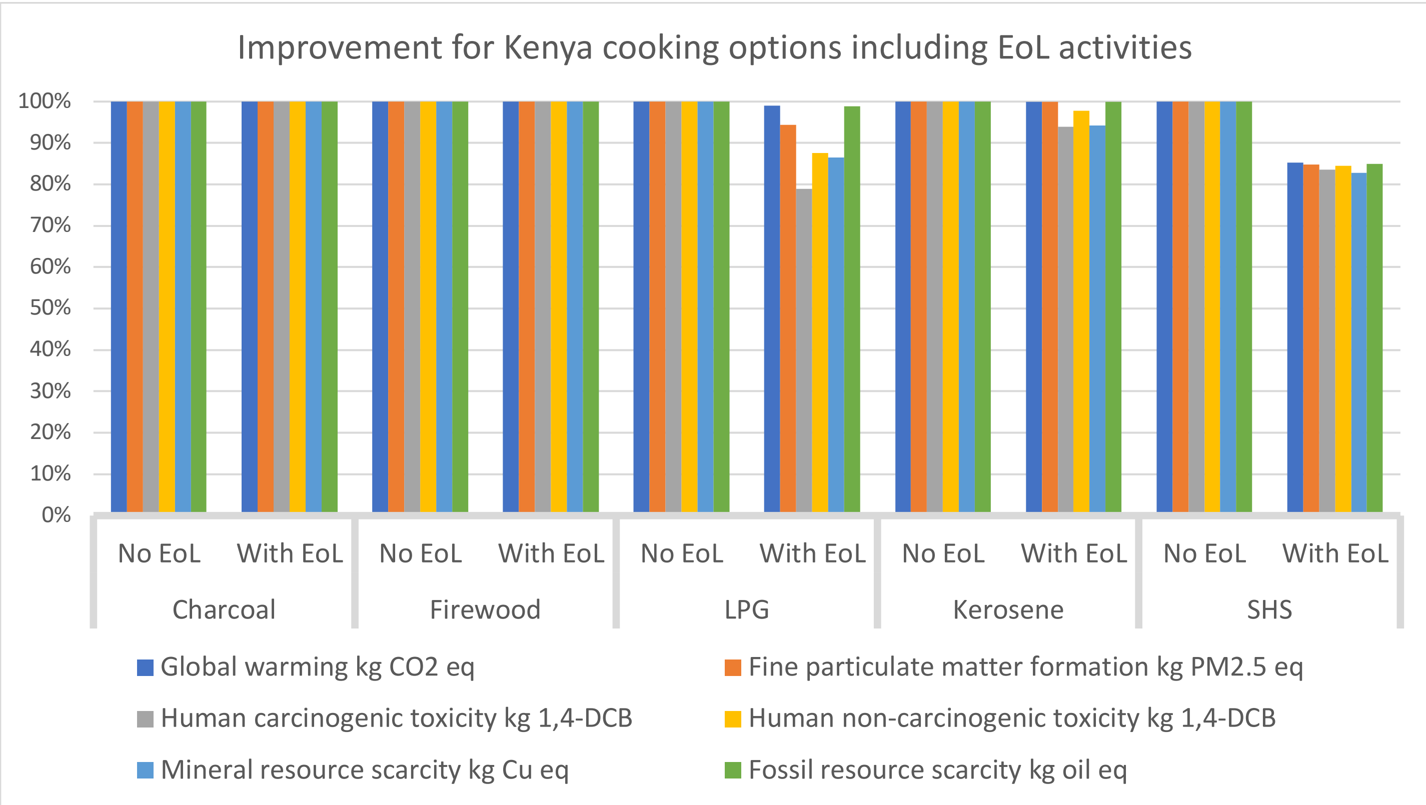

Figure D1: Improvement to select midpoint indicator categories resulting from EoL activities for cooking options in Kenya

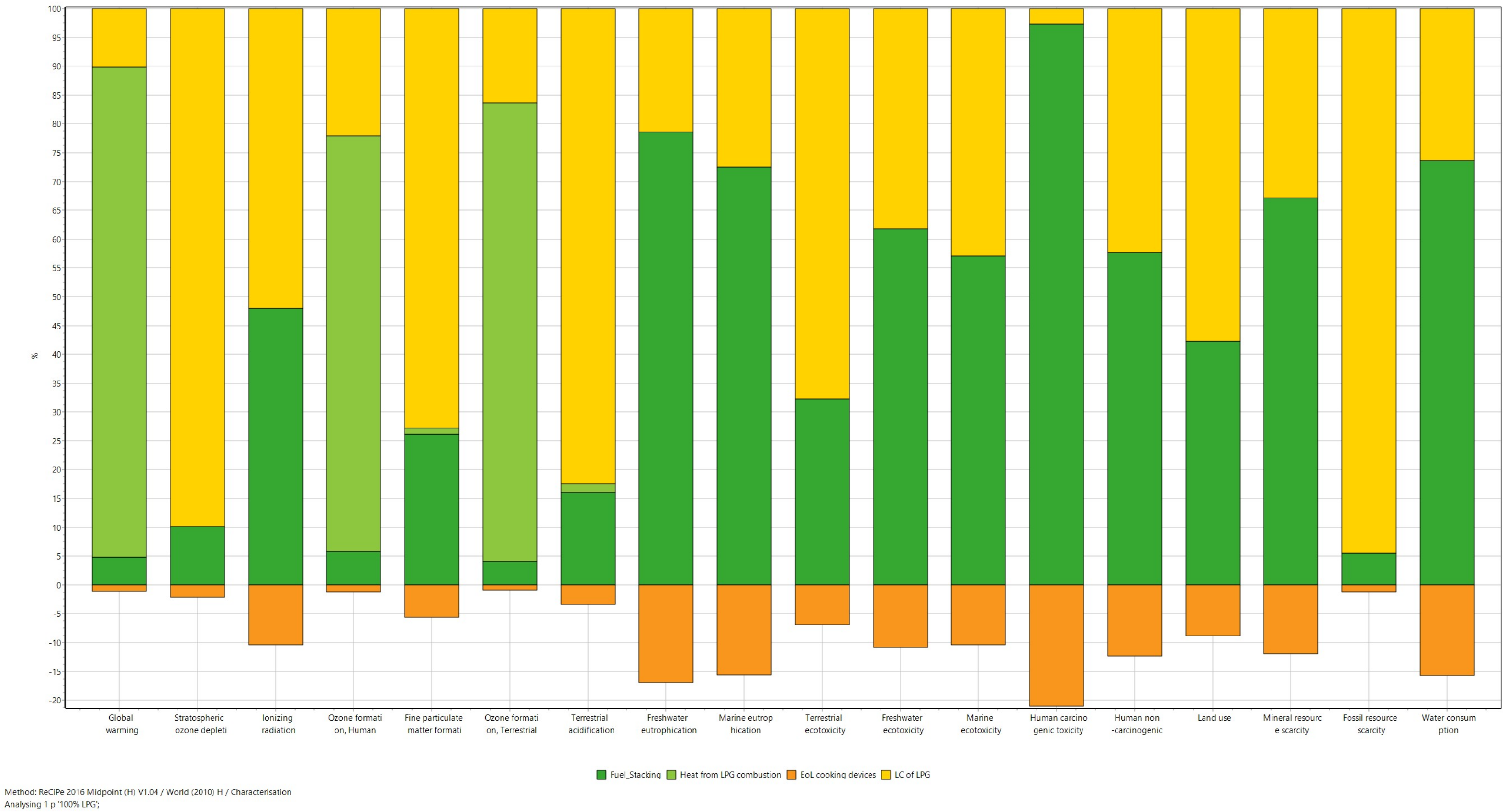

Figure D2: Midpoint Impact categories for the life cycle of cooking on a LPG stove.

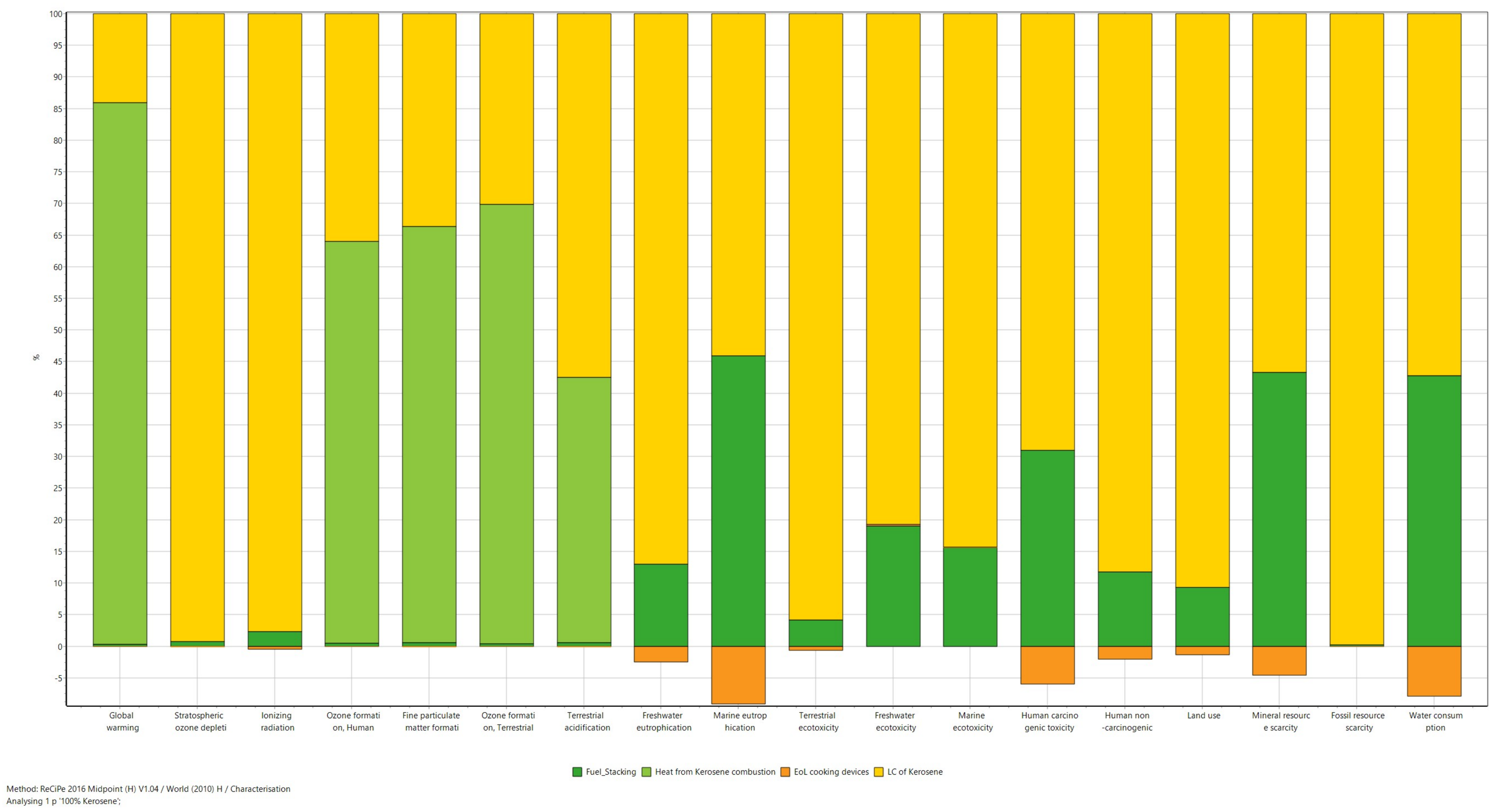

Figure D3: Midpoint impact categories for the life cycle of cooking on a kerosene stove

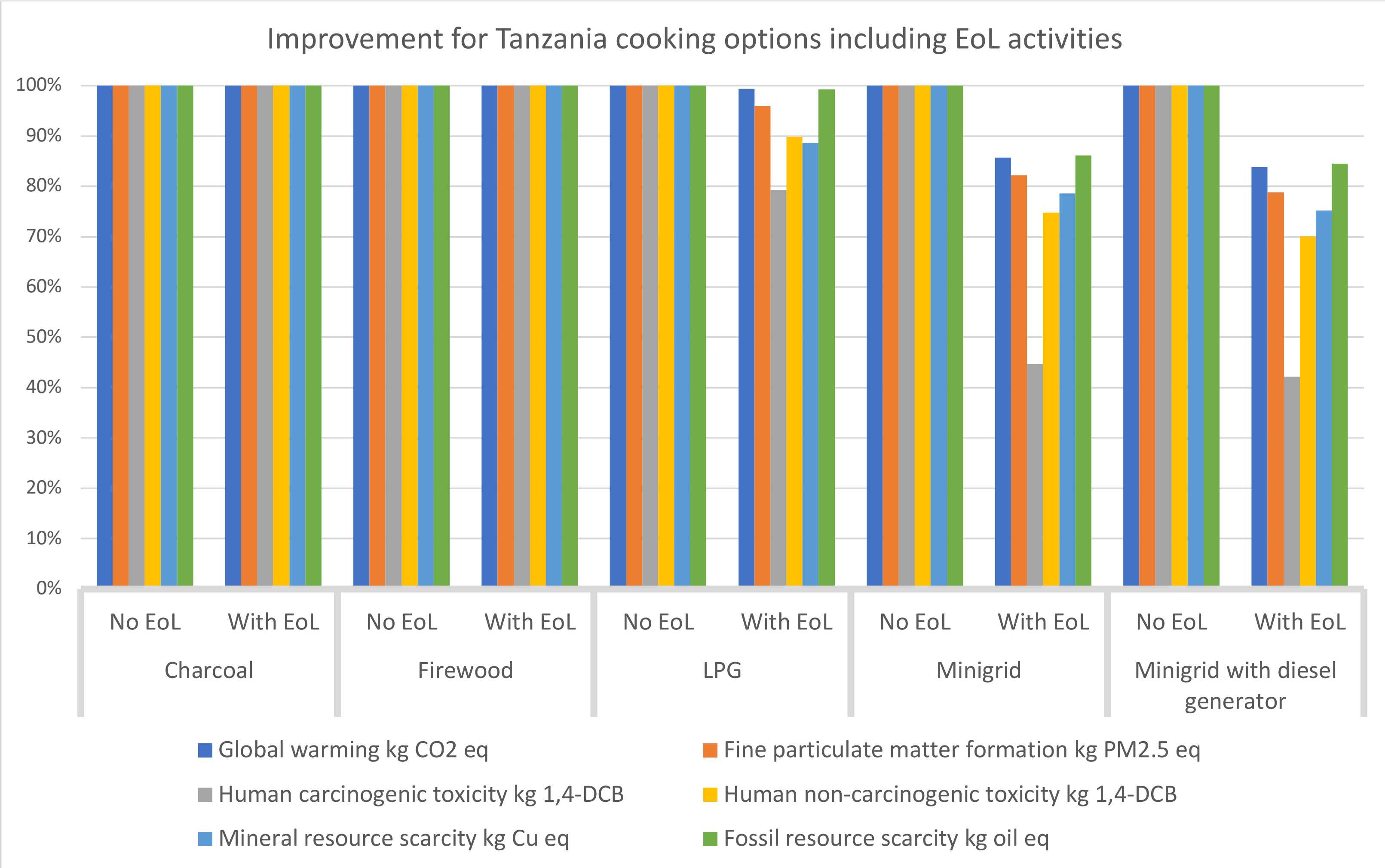

Figure D4: Improvement to select midpoint indicator categories resulting from EoL activities for cooking options in Tanzania

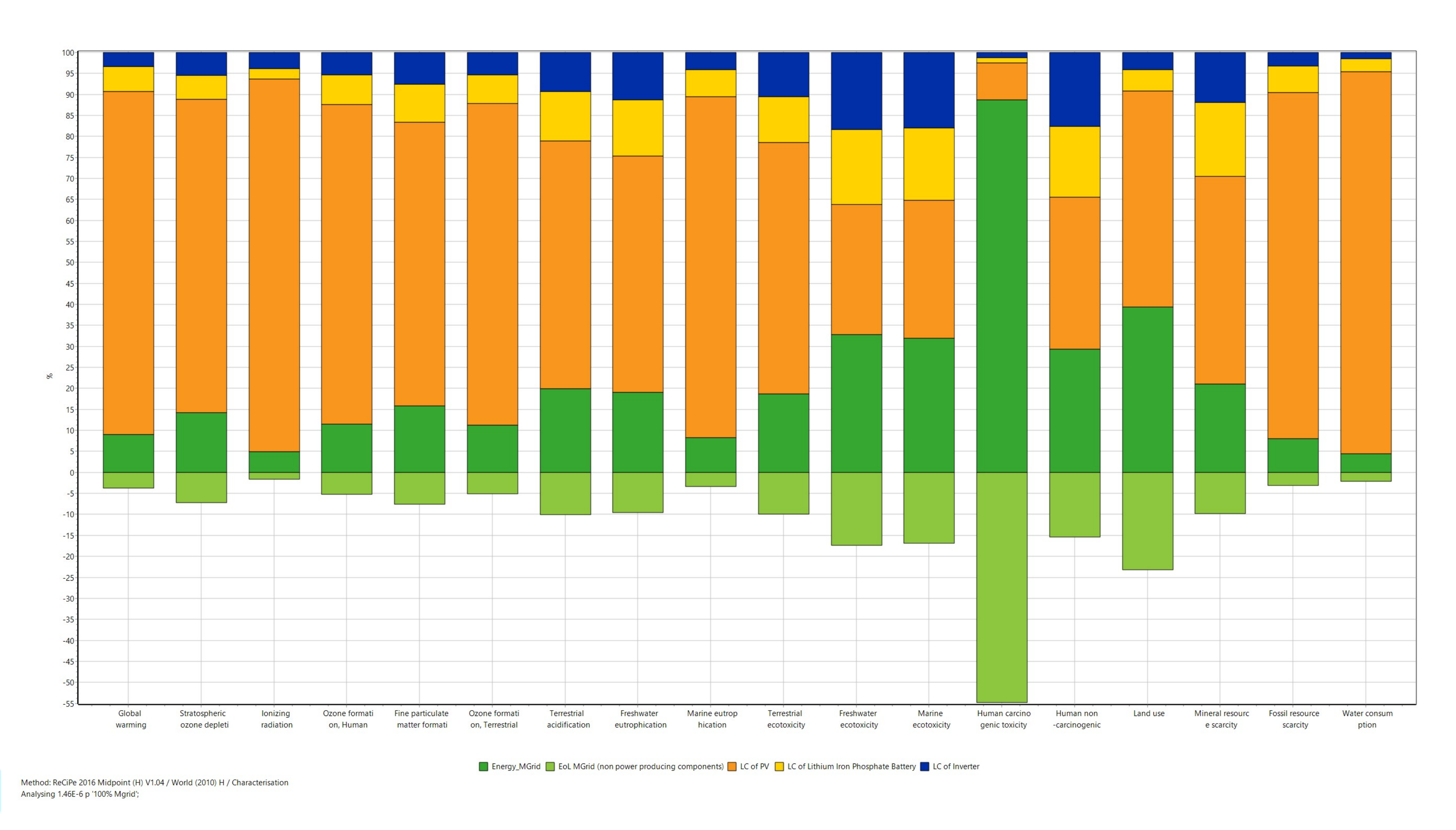

Figure D5: Midpoint impact category results for the mini-grid components only (no diesel generator), 1 days cooking

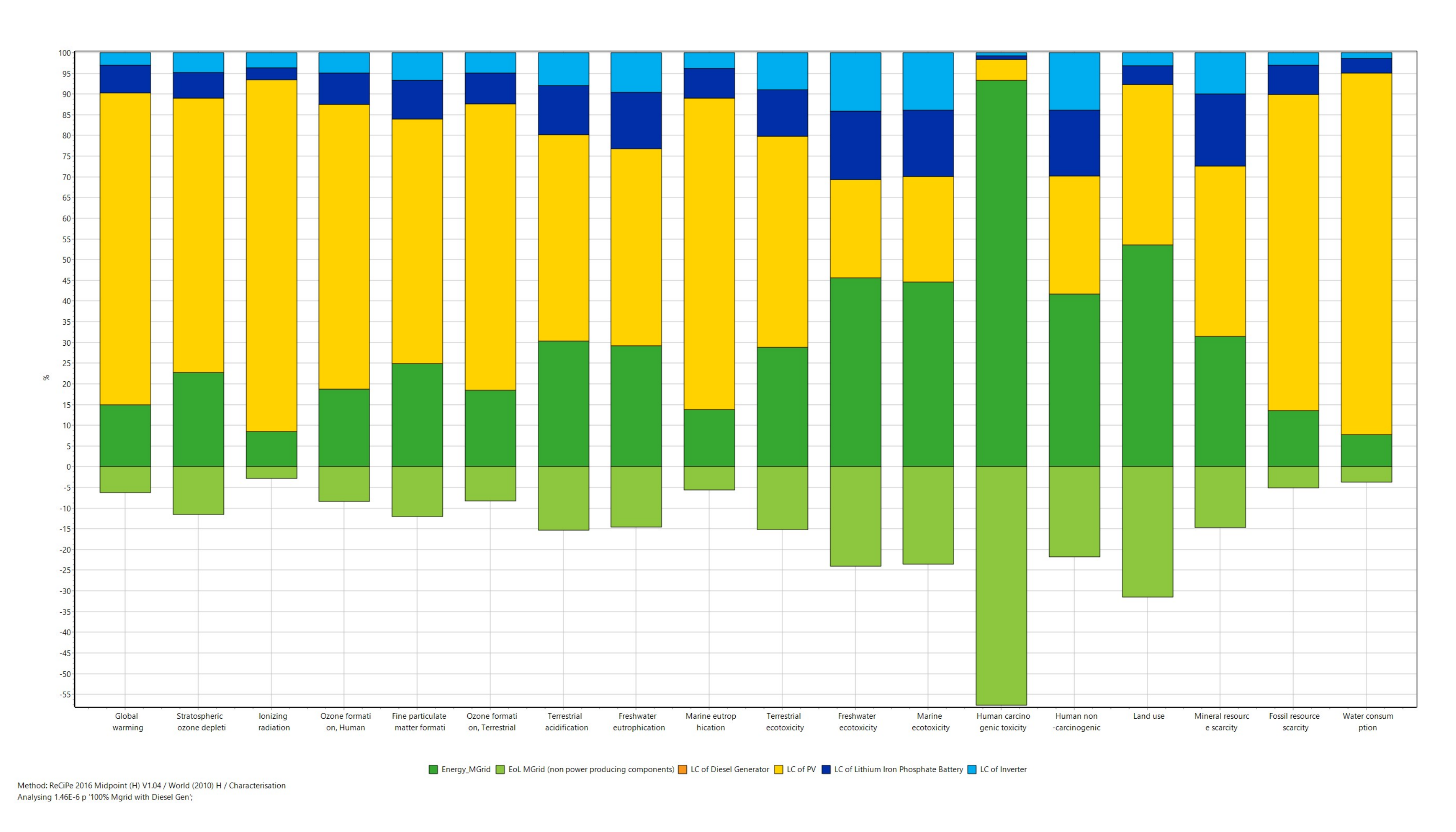

Figure D6: Midpoint impact category results for the mini-grid components only (including diesel generator), 1 days cooking