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A circular economy approach for lifecycles of products and services

Report of sustainable design and manufacturing methods

Deliverable 1.5

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Summary

Deliverable 1.5 'Report of sustainable design and manufacturing methods' is the result of Task 1.5 'Sustainable production' of Work package 1 'Co-creation of products/services.' Task 1.5 aims to utilise the results of sustainable impact analysis results obtained from Task 1.2 'Sustainable impact analysis', to identify environmentally and socially sustainable methods, and then implement the methods in production, together with eco-point method developed in Task 1.3 'Development of eco-point method'. Within the production process, co-creation with consumers and actors along the supply chain is achieved with the approaches developed in Tasks 1.4 'Consumer-supply chain interactions' and 7.4 'Stakeholder interactions.'

Firstly, production processes of the CIRC4Life demonstrators with high impacts are identified and reported by using the results of eco-point approach, the details of which are reported in Deliverable 1.2 'Report on sustainable (environmental, social and economic) impact analysis'. Corresponding recommendations of reducing the use of materials, energy, water, greenhouse gas emissions, and reducing production of waste are also given.

Recycling and modular design for domestic and industrial LED lighting products are also described by demonstrating the demonstrators' development processes. On the other hand, food production systems are among the leading drivers of impacts on the environment, the applications of life cycle thinking and assessment to food production are adopted to investigate the agricultural systems, processing and manufacturing activities in a micro organic farm and meat product supply chain.

An eco-procurement case from industrial lighting sector is given then, in order to build a body of evidence to show how tender documents are established in such a way as to trigger the offer of products based on a new or recently developed sustainable products/services. This section describes in detail procurement procedures including the methodology and different theoretical and practical steps undertaken by a bidder.

Last, the investigated sustainable strategies and business concepts provide an introduction to the concept of innovative sustainable service and its application to the lighting sector. Subsequent sections describe the process and contents of leasing service developed. The leasing of LED lighting could be achieved through services offered by LED manufacturers. In order to examine the potential of using leasing to help bringing CIRC4Life demonstrators to the market, a series of activities involved different stakeholders in this business are also designed to conduct in the next phase of CIRC4Life project period.

The CIRC4Life business partners went through an iterative learning process together with all other partners to build up their demonstrator specific products and services. The described sustainable product processes illustrate that this process leads to sustainable innovation providing significant environmental impact reductions. This can be related to increased resource efficiency (by applying circular economy concepts) as well as to improved sustainable production practices.

To conclude it is key to embrace change towards circular economy. This change provides also the insight that sustainable production requires a systemic approach in which each practice phase is crucial. To deal with this complexity CIRC4Life Co-creation of products/services approach (**WP1**) supports good practice to gradually reduce the uncertainties, make assumptions explicit and validate them. This iterative learning makes the companies agile and flexible to deal with the fast-changing conditions of technology, markets, capabilities, etc.

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Acronyms and abbreviations

Abbreviation	Description
FSC	Forest Stewardship Council
GHG	Greenhouse Gas
LPG	Liquefied Petroleum Gas
PEFC	Programme for the Endorsement of Forest Certification
PMMA	Poly(methyl methacrylate)
PSS	Product-Service System
PVC	Polyvinyl chloride

1 Introduction

The CIRC4Life approach developed for co-creation of products/services is demonstrated in Figure 1.1. As shown in the figure, Task 1.5 aims to utilise the results of sustainable impact analysis results obtained from Task 1.2, to implement the results in production, together with eco-point method developed in Task 1.3. Within the production process, co-creation with consumers and actors along the supply chain is achieved with the approaches developed in Tasks 1.4 and 7.4, the outcomes of which are reported in Deliverable 1.4 (M15) and Deliverable 7.3 (M18).

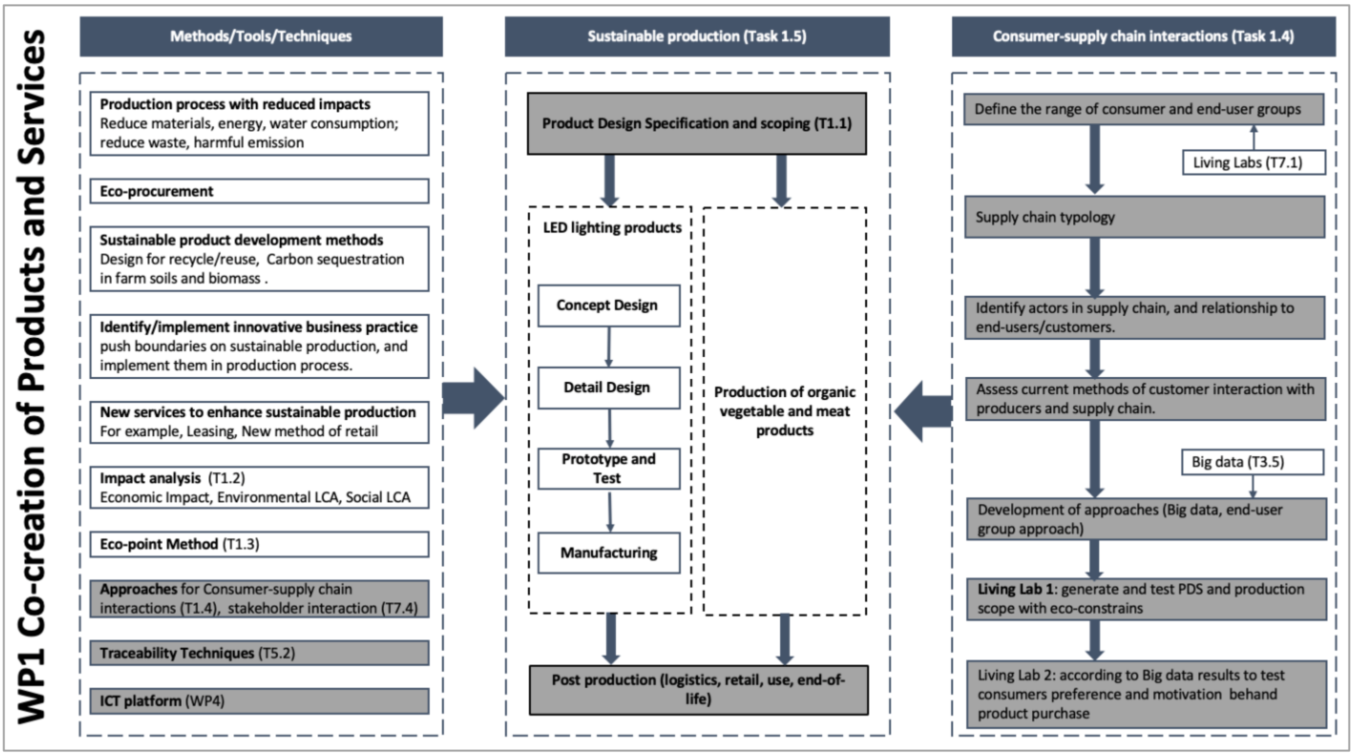


Figure 1.1 Schematic approach for Co-creation of products/services in CIRC4Life

In order to make a successful transition towards a circular economy, companies need - besides technological innovations - to rethink the way their products/services and associated value are preserved throughout their lifetime. It is the objective of WP1 to co-create products/services that support and facilitate sustainable production of CIRC4Life demonstrators in the EU. In order to deliver results that are inspiring and practically applicable by industry, the following approaches are followed:

- Identify and implement production processes with reduced impacts by using the result of eco-point approach. Processes that reduce the use of materials, energy, water, greenhouse gas emissions, and reduce production of waste will be focused on in particular.
- Perform eco-procurement.
- Sustainable product development methods/practices, such as design for recycling and reuse for lighting products, and emissions in food product system (e.g. organic farm production and meat product supply chains) will be investigated and utilised in the production process.
- Identify innovative businesses and business practices that pushes boundaries on sustainable production. Develop new services to enhance sustainable production, for example, leasing products to end-users of the LED lights.

The CIRC4Life consortium represents key actors in the lifecycle of critical resource containing lighting products and food products. This lifecycle knowledge facilitates the exploration of opportunities and barriers at both production and company levels and provides a unique opportunity to define viable sustainable product practices that are grounded to the companies' capabilities and capacities.

The key elements of successful sustainable business are identified from literature, best practices and the industry partners' involved in CIRC4Life experience. They provide insight in the building bodies and the different options for sustainable business models. As such, this document reflects both product level sustainable innovation (to design in the greatest potential for resource effective products) and company level innovation (to define business practices required to realise this potential).

2 Production processes for demonstrators

The details of eco-points result for each demonstrator product are reported in Deliverable 1.2 'Report on sustainable (environmental, social and economic) impact analysis' (M18). The following sections are to focus on the identification of the production/manufacturing phases with high environmental impacts by using eco-point results.

2.1 Impacts through the production processes of domestic LED lighting product

This section explains the total environmental impact of the domestic lighting product production, the environmental impact of the lighting product's life cycle stages. A 0.1% cut off has been applied in the 'process contribution' analysis to obtain the results shown in tables and graphs. Total eco-point of the domestic lighting product is given in Table 2–1.

Table 2–1 Total environmental impact (eco-point) results of the luminaire

Impact category	Eco-point (Pt)
Ecosystems - Agricultural land occupation	8.90E-02
Ecosystems - Climate Change	7.69E-01
Ecosystems - Freshwater ecotoxicity	5.86E-03
Ecosystems - Freshwater eutrophication	2.72E-03
Ecosystems - Marine ecotoxicity	1.05E-03
Ecosystems - Natural land transformation	1.15E-02
Ecosystems - Terrestrial acidification	1.38E-03
Ecosystems - Terrestrial ecotoxicity	1.43E-03
Ecosystems - Urban land occupation	1.54E-02
Human Health - Climate Change	5.38E+00
Human Health - Human toxicity	1.57E+00
Human Health - Ionising radiation	7.11E-03
Human Health - Ozone depletion	5.41E-04
Human Health - Particulate matter formation	1.18E+00
Human Health - Photochemical oxidant formation	2.89E-04
Resources - Fossil depletion	2.74E+01
Resources - Metal depletion	8.23E+00
Total	44.70

The function of a luminaire is to produce a specific quantity and quality of light for a period of time. The quantity of light is measured with the luminous flux (lm) emitted by the luminaire, and the quality of light is mainly measured with the correlated colour temperature (CCT) and the colour rendering index (CRI). Therefore, the functional unit used in this LCA is considered as the production of 948 lm of light (quantity of light) of CCT=4000 K, and CRI=65 (quality of light) for 40,000 hours.

Therefore, the function unit in this study is defined below:
Functional unit = 1 luminaire providing lighting service 948 Lumens per hour + 40,000 working hours

The use of the luminaire is modelled on the basis of the energy consumption. The Spain average electricity mix is modelled as: nuclear power (44.8 %), solar, wind and geothermal (22.4%), biomass and waste (21.1%), hydropower (7.2%) and fossil (4.5%) (Ecoinvent 2018).

The packaging is not considered in this LCA study, as the developed product prototype is still under iterated design, the final developed ONA demonstrator may slightly different from the current prototype, particularly, the lamp leg shape and its length will be redesigned based on the feedback received from the stakeholders. Once the product is finalised, its packaging will be developed under Task 6.2. The impact caused by the packaging will be assessed, the results of which will be reported in the linked Deliverable 6.1

The total eco-point of the ONA luminaire is rounded up 44 Pt. The life cycle stages from higher-to-lower impact are: 1) Use, 2) Production, 3) End-of-life, and 4) Transport. The highest impact process is 'Electricity, low voltage' generation (19.39 Pt.) which corresponds to the 'use' stage of the luminaire's lifecycle. This value is calculated based on an assumption that this luminaire's lifespan reaches 40,000 h. The second process with the highest impact is the integrated circuit (1.27 Pt.) that includes the dimmer and other electronic components that provide the wireless control and touch-switch control functions. Other processes of high impact are the production of aluminium (0.59 Pt.), the cable (0.39 Pt.) and the mechanization process (milling) (0.37 Pt.). The distribution phase (lorry and truck transport) has a minor impact (0.107 Pt.) as well as the disposal of the product (0.068 pt.).

In this study, the disposal scenario assumes that the luminaire is used for 40,000 hours and disposed in domestic bins in the Spain. The used disposal processes from ecoinvent database is 'Market for municipal solid waste | municipal solid waste | APOSU – ES'.

Disposal (0.068 Pt) is the life cycle stage with impact in the luminaire and represents an imperceptible effect in all the impact categories, except in freshwater ecotoxicity and marine ecotoxicity, which represent 57% and 54% of the total impact of those impact categories. The 'Disposal, copper,0% water, to municipal incineration' is major process contributor (3%) for these impacts, which mainly involve the disposal processes to process the copper used in the cables at the end of life.

Table 2–2 shows the absolute impact (in Pt.) and the relative impact (%) of each process included in the total environmental impact of the functional unit. Top four process with highest impacts are explained as follows: 1) 'Integrated circuit, IC, logic type, at plant/GLO S' (42.65% of the total), which accounts for integrated circuit production, used to produce the integrated circuit used in the circuit component. The dimmer and other electronic components that provide the wireless control and touch-switch control functions, 2) 'Aluminium alloy, AlMg3, at plant/RER S'(19.93% of the total) which account for the process of drilling the steel main structure, and in the tube-pole, base and heat sinks, 3)' Cable, printer cable, without plugs, at plant/GLO S' (13.22%) which accounts for the production of copper cable, and 4) 'Milling, aluminium, small parts/RER S' (12.65%), which accounts which accounts for shaping the aluminium material used to make the heat sinks.

The impact of the cable is quite high compared to findings in other similar studies, and since the cable has been selected from a standard cable from the ecoinvent database, which uses PVC ((Polyvinyl chloride) in the cable jacket instead of ONA's material choice, i.e. silicone based cable jacket, this could be one of the causes of this higher impact. The reason of using this substation in the calculation is that the process data for the silicon-based cable is not available in the ecoinvent database at the time of writing this report.

The 'PET (bottle grade) E' (-14.81%) shows, certain amount of the parts made by PET are recyclable in the assumed disposal scenario for this functional unit, which contributes overall positive environmental impacts for the life cycle of this luminaire. The impacts of these recycled parts are assessed by using average recycling practices and outcomes in Spain, which are obtained from the ecoinvent database. In general, the recycled PET made parts are sorted by the recycling centre and proceeded into manufacturing materials, which will used into another product manufacturing proses, but may not directly used into the manufacturing process of this luminaire.

It has been conducted a detailed assessment focused on the manufacturing phase only, because this is the way to understand which components/parts and manufacturing processes within this phase have the highest impact. The total eco-point of the manufacturing phase for the luminaire is 2.97 Pt. A more detailed analysis at the manufacturing stage can show us lesser impact processes that were not shown before in the tables, because this assessment focuses only on the processes involved in the manufacturing phase. Thus, we can see (Table 2–2) how the production of PMMA (Poly(methyl methacrylate)) used in the diffusor and the LED have very little impact within the manufacturing stage of luminaire.

It also has to be noted that use of the product in different member states will have impact on the eco-point values as the electricity mix used are different in these countries. But the differences of eco-point values for per product will not be significant as the energy consumption per hour of domestic LED lighting are relatively low. Additionally, the eco-point value is needed to round from a consumer communication point of view, the minor eco-point value differences caused by the electricity mix are usually rounded.

Table 2–2 Environmental impact of the **production phase** of the luminaire – total and by process.

No	Process	Eco-point	Unit	Eco-point %
	Total of all processes	2.9795422	Pt	
1	Integrated circuit, IC, logic type, at plant/GLO S	1.2706554	Pt	42.65%
2	Aluminium alloy, AlMg3, at plant/RER S	0.59395442	Pt	19.93%
3	Cable, printer cable, without plugs, at plant/GLO S	0.39384786	Pt	13.22%
4	Milling, aluminium, small parts/RER S	0.376912	Pt	12.65%
5	Injection moulding/RER S	0.14766886	Pt	4.96%
6	Disposal, sulfidic tailings, off-site/GLO U	0.10979797	Pt	3.69%
7	Polymethyl methacrylate (PMMA) beads, production mix, at plant RER	0.086180766	Pt	2.89%
8	Light emitting diode, LED, at plant/GLO S	0.084714313	Pt	2.84%
9	Epoxy resin, liquid, at plant/RER U	0.038990531	Pt	1.31%
10	Printed wiring board, through-hole, lead-free surface, at plant/GLO S	0.03894188	Pt	1.31%
11	Copper concentrate, at beneficiation/RER U	0.037375715	Pt	1.25%
12	Sheet rolling, aluminium/RER S	0.034737241	Pt	1.17%
13	Transformer, low voltage use, at plant/GLO S	0.0155211	Pt	0.52%
14	Resistor, metal film type, through-hole mounting, at plant/GLO S	0.014132672	Pt	0.47%
15	Copper, primary, at refinery/RLA U	0.011927867	Pt	0.40%
16	Polycarbonate, at plant/RER U	0.01017739	Pt	0.34%
17	Ferromanganese, high-coal, 74.5% Mn, at regional storage/RER U	0.007438498	Pt	0.25%
18	Bauxite, at mine/GLO U	0.007411063	Pt	0.25%
19	Copper concentrate, at beneficiation/RLA U	0.007399309	Pt	0.25%

No	Process	Eco-point	Unit	Eco-point %
20	Polyvinylchloride, suspension polymerised, at plant/RER U	0.005975639	Pt	0.20%
21	Deformation stroke, cold impact extrusion, aluminium/RER S	0.005807046	Pt	0.19%
22	Copper, primary, at refinery/RER U	0.005166252	Pt	0.17%
23	Aluminium, primary, liquid, at plant/RER U	0.004508448	Pt	0.15%
24	Natural gas, at production onshore/RU U	0.003758045	Pt	0.13%
25	Diesel, burned in building machine/GLO U	0.003635483	Pt	0.12%
26	Disposal, redmud from bauxite digestion, 0% water, to residual material landfill/CH U	0.003557313	Pt	0.12%
27	Lignite, at mine/RER U	0.003234612	Pt	0.11%
28	Disposal, spoil from lignite mining, in surface landfill/GLO U	0.003047139	Pt	0.10%
29	Hard coal, at mine/WEU U	0.002984896	Pt	0.10%
30	PET (bottle grade) E	-0.44129392	Pt	-14.81%

2.2 Impacts through the production processes of industrial LED lighting product

Object of analysis is one unit of a KMSD100LLBE lighting product for general industrial use. KMSD100LLBE is a 100W LED Low Bay Luminaire from Kosnic Lighting Ltd. Functions of KMSD100LLBE are to provide high lumen output and daylight colour temperature light in general industrial areas. The Low bay LED luminaires offer energy savings and high performance, replacing conventional lighting in general industrial areas, manufacturing, warehousing, leisure facilities and retail environments.

The use of the luminaire is modelled on the basis of the energy consumption. The UK average electricity mix is used. The UK average electricity mix is modelled as: Gas (40.2%), nuclear power (20.1 %), wind (10.6%), coal (8.6%), biomass and waste (8.4%), solar (2.8%), hydropower (1.5%), oil and other (7.8%) (Ecoinvent 2018).

The packaging is considered in this LCA analysis for the industrial LED lighting product as Kosnic use a few standard packaging materials to package a wide range of their products. For the analysed product in this study, the packaging materials and used processes from the ecoinvent are reported in Table 2–3.

Table 2–3 Packaging materials for Kosnic industrial lighting product (KMSD100LLBE)

Packaging material	Amount	unit	Process flow from ecoinvent
bord box	1.17	kg	Corrugated board:Corrugated board box {RoW} | production | Alloc Def, U
plastic	0.0003	kg	Thermoplasts:Packaging film, low density polyethylene {RoW} | production | Alloc Def, U
paper	0.0004	kg	Graphic paper:Printed paper, offset {RoW} | offset printing, per kg printed paper | Alloc Def, U
plastic form	0.066	kg	polystyrene production, extruded, CO2 blown | Alloc Def, U

The life cycle stage contribution of eco-point results is shown Figure 2.1. The results show that 60% impacts are generated from production stage. Among the three impact categories, production accounts for around 57% and 61% on resources and human health categories respectively, while contributes 43% to ecosystem. Followed by use phase which plays an important role to the environmental burden in each impact category, especially on ecosystem which accounts for nearly 60% of the total score of the category. Other life cycle stages account for minimal percentage of impacts.

The eco-point breakdowns of the functional unit are presented in Table 2–4. The total eco-point is 120 Pt, human health is the significant contributors (79.1 Pt), followed by resources (38 Pt). The given product system has a minor impact on ecosystems according to the evaluation (2.68 Pt).

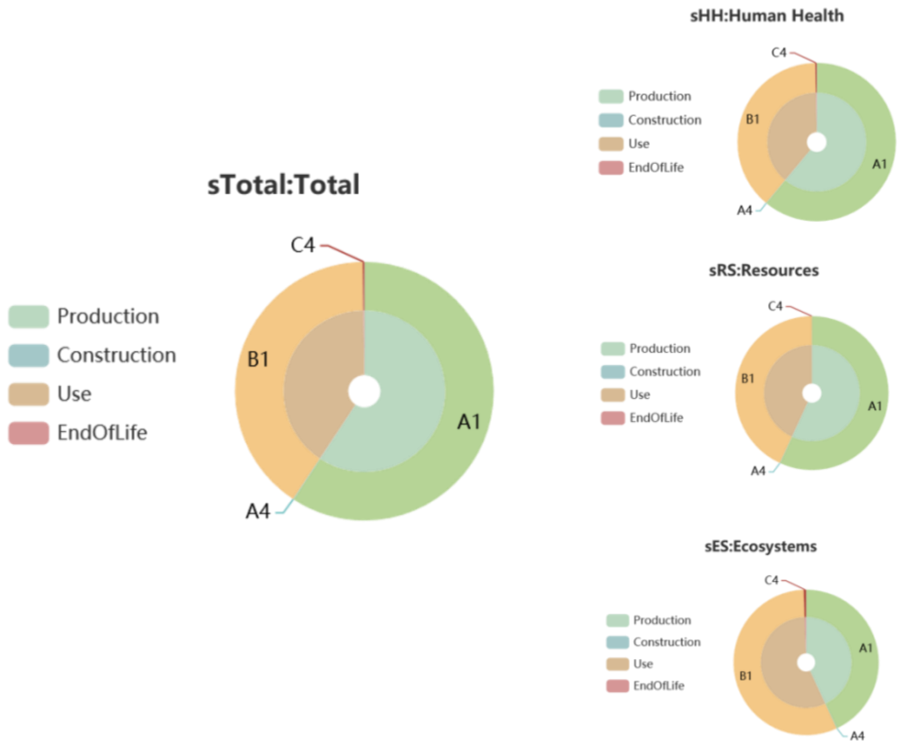


Figure 2.1 Life cycle stage contribution results in endpoint impact categories

Table 2–4 Breakdown of eco-point results

Items	Eco-point	Unit
Total	120.00	Pt
Human Health	79.10	Pt
Ecosystems	2.68	Pt
Resources	38.00	Pt

On human health and resources, the main impact contribution stage is production stage which can be ascribed to production of electronic devices including production of LED driver and LED light panel. Furthermore, due to the production of electricity for the usage of the lighting, the use stage is another key environmental stage within the tree impact categories, especially on Ecosystem which exceeds the impact of production stage (56.3%).

A further break-down of contributions on total impacts is listed in Table 2–5. It shows that manufacture of electronic devices (LED driver and LED light board together) is the hotspot process. LED driver is the key process which most of the potential impacts of electronic devices are risen from. Another hotspot process is production of electricity. Production of other assembly components, end of life treatment, packaging and transportation account for very small percentage of the total impact in each category.

Table 2–5 Contribution tree within all life cycle stages

	Process	Contribution%
Total 100%	All	100
	LED Driver	45.79
	Electricity	40.5
	LED Light Board	11.83
	Housing	1.41
	End of Life Treatment	0.2
	Others	0.27

The negative environmental impacts of the assessed LED lighting product are dominated by the manufacturing stage. As the manufacture stage is input-output intensive activities where the majority consumption of materials and energy usually takes place. The emissions generated from the whole production process also lead to several environmental issues, consequently, contributing more impacts compares to other life cycle stages. The main environmental impacts originate from the following three processes:

- wire printed board production;
- electricity production;
- light emitting diode production.

Wire printed board production is the predominate hotspot process. The extraction of the precious metal material, such as gold and silver etc., together with transportation during the extraction as well as the fabrication of the pre-product, are the main impact contributors on the resource impact category. The emissions from extraction, fabrication and other processes during the production of the wire printed board, are the major ascriptions to high impacts on human health, since emissions on soil, water mostly contain heavy metals which are hazard consequently causing severe potential damages directly or indirectly to human health. Similar causation for the LED light panel production. For ecosystems, electricity production accounts for the main environmental burden. Yet in the assessment case, photovoltaic power is applied thus alleviates the environmental burden on ecosystem compares to other electricity production methods since the emissions during the electricity generation are less. However, photovoltaic power might cause environmental burden on other impact categories due to the production of the photovoltaic equipment and transportation activities during the electricity production.

Kosnic uses the WEEE compliant recycling & collection service to make sure Kosnic is compliant with the latest UK WEEE Regulations. The faulty or end of life products gathered by Kosnic will be transported to the recycling company, where LEDs will be broken down and recycled and Kosnic will have documents, provided by the recycling company, to show they have collected and will be recycled properly.

In this study, the disposal scenario assumes the end of life industrial lighting are all properly proceed by following the WEEE treatment procedures, which is a prospective scenario, based on the document provided by the recycling company, 40 % of landfill (e.g. plastic, wire, municipal solid waste) and 60 % of recycling treatment (e.g. steel, aluminium). The recycling treatment contains also the shredding process and separation of the fractions, the transport of the fractions, and their recycling and disposal, the process flows of which are from ecoinvent database.

The disposal of Kosnic industrial lighting had very little (0.2%) (under 'Other', see Table 2–5) effect on the total life cycle impacts due to the dominance of use and manufacturing stages. However, the benefits of proper recycling of the industrial LED luminaire are recommended to be subjected to a more profound study.

The recommendations regarding eco-redesign towards environmental performance improvement are provided as follows:

- Redesign of the LED driver: redesign the circus board; eliminate or reduce the precious metal input within components in electric devices, substitute the material with more environmentally friendly materials;
- Improve the energy efficiency by replacing the light emitting diode with higher luminous efficiency product;
- Reduce housing material, refine the product's dimension;
- Use recycled aluminium instead of aluminium alloy;
- Use recycled plastic material, make sure chlorine content in the plastic parts are not greater than 50%;
- If there are hazard substances which present in mixtures, make sure the concentration of the hazard substance is lower than 0.1%;
- Implement modular design for easily assemble and disassemble;
- Improve power control system for energy efficiency;
- Use recycled packaging material (80% post-consumer cardboards and 50% recycled plastic materials;
- Provide user guide of use information covers mode setting, end-of-life options for self-operating of the LED product.

2.3 Impacts through the production processes of organic vegetable farm

In 2018, approximated 1.5 tons of potatoes and 2 tons of horticultural crops are yielded from a piece of planting land of 2 hectares in JS organic vegetable farm. The land size for planting potatoes is approximated 0.15 hectares. Horticultural crops include carrots, onions, broccoli, kale, chard, tomatoes, cucumbers, beetroot, squash, lettuce, leeks, courgettes, and low weight crops.

The organic potato is selected as the analytics target in this study, as it is the most yielded product that is able to represent the overwhelming planting resources and activities in the JS organic farm. Considering the farm is located in the island, the soil features and annual rainfall varies from the mainland, the geographical and planting period have to be identified in the functional unit as follows:

One potato (approx. 150g) planted in 0.15 hectares land with coastal soil environment.

Figure 2.2 shows the overall impacts of the functional unit's life cycle, i.e. one organic potato, approx. 150g. Due to the multi-indicator approach, results in the chart are presented in a relative way, normalized to the highest impact of each environmental impact categories among seven life cycle stages/categories; however absolute values and also relative values in percentage are available in Table 2–6 for transparency.

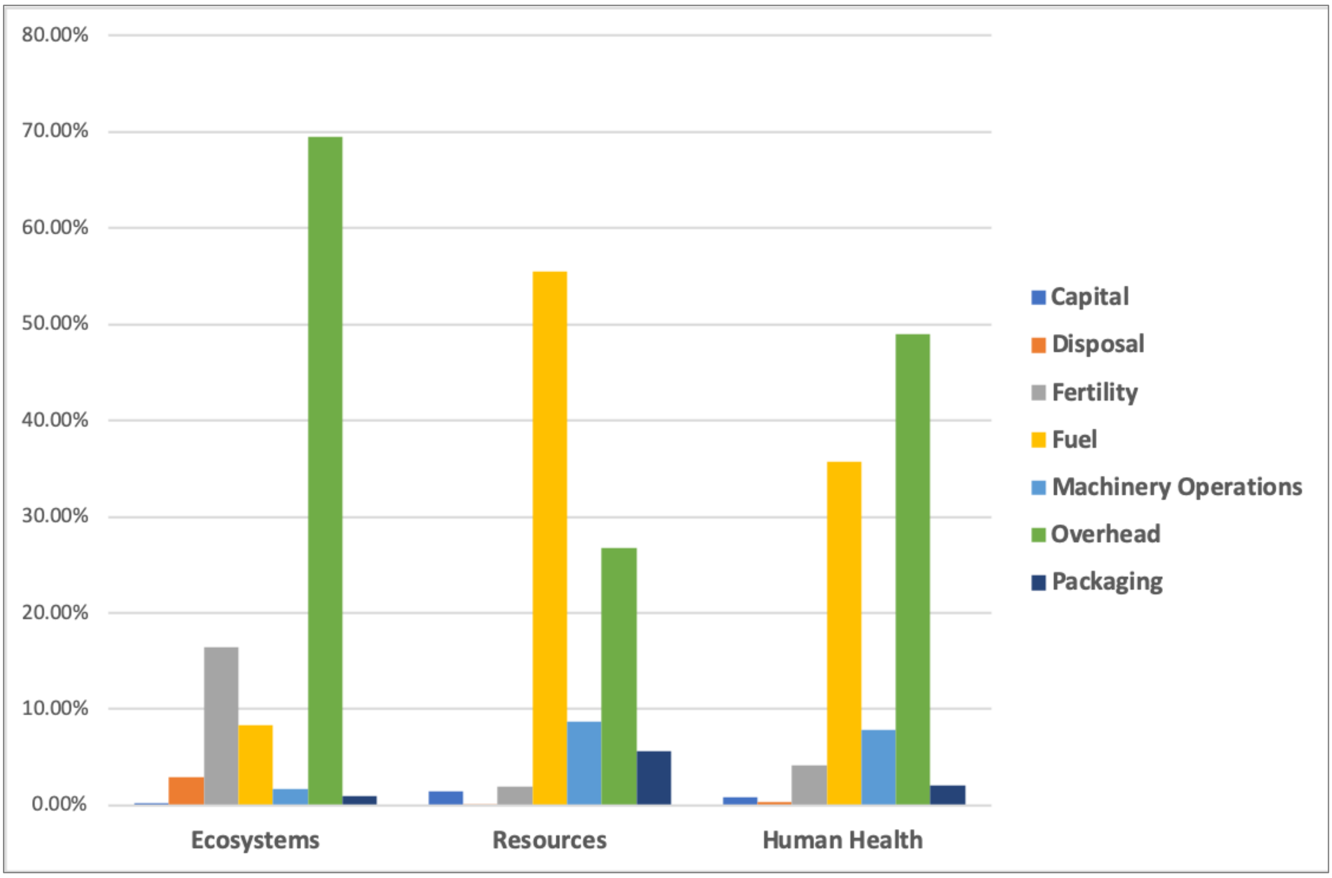


Figure 2.2 Life cycle impact results for 1 yielded organic potato from JS farm in 2018

Table 2–6 Life cycle impact results of the functional unit

	Capital	Disposal	Fertility	Fuel	Machinery Operations	Overhead	Packaging
Ecosystems (species.yr)	1.58E-11	2.61E-10	1.45E-09	7.39E-10	1.48E-10	6.14E-09	8.43E-11
Resources ($)	0.00015	1.02E-05	0.00018	0.00537	0.00084	0.00259	0.00054
Human Health (DALY)	3.90E-09	1.69E-09	1.84E-08	1.60E-07	3.53E-08	2.19E-07	9.46E-09
Percentage normalized to the highest value per impact category							
Ecosystems	0.18%	2.96%	16.39%	8.37%	1.68%	69.47%	0.95%
Resources	1.51%	0.10%	1.89%	55.44%	8.68%	26.79%	5.58%
Human Health	0.87%	0.38%	4.11%	35.67%	7.89%	48.97%	2.11%

Overall, Table 2–6 shows that the functional unit has higher impacts in the Overhead and Fuel stage compared to the other stages. Additionally, human health, resources, ecosystems impacts are dominated by Overhead and Fuel. For ecosystems impact category, more than 70% of impact come from the Overhead, approximate 20% impacts are associated with the Fertility. For resource and human health impact categories, the Overhead and Fuel contribute the most impacts.

The eco-points (total) for the functional unit, which is rounded up 0.05 points (see Table 2–7).

Table 2–7 Total eco-point results of the organic potato (per potato)

Impact category	Amount	Unit
Ecosystems - Agricultural land occupation	0.01611	points
Ecosystems - Climate Change	0.00244	points
Ecosystems - Freshwater ecotoxicity	2.31E-06	points
Ecosystems - Freshwater eutrophication	4.11E-06	points
Ecosystems - Marine ecotoxicity	4.54E-07	points
Ecosystems - Natural land transformation	0.00029	points
Ecosystems - Terrestrial acidification	9.93E-06	points
Ecosystems - Terrestrial ecotoxicity	9.78E-06	points
Ecosystems - Urban land occupation	0.00014	points
Human Health - Climate Change	0.00286	points
Human Health - Human toxicity	0.00046	points
Human Health - Ionising radiation	3.59E-06	points
Human Health - Ozone depletion	7.69E-07	points
Human Health - Particulate matter formation	0.00308	points
Human Health - Photochemical oxidant formation	1.24E-06	points
Resources - Fossil depletion	0.02023	points
Resources - Metal depletion	0.00188	points
Total	0.04752	points

For Ecosystems impact category, forestry for the Pine/Spruce (i.e. wood growing chemicals, emissions from agricultural machines, and water) dominates (78.8%) the total impact, which are mainly involved in the heating generation in the farm. Major pollutants are carbon dioxide, PM 2.5, and methane emitted to the air. Additionally, the green manure growing contributes 18.2% impacts that are mainly contributed from the emissions of diesel burning and electricity consumption of agricultural machines (i.e. mulching, sowing, tillage and harrowing). Main pollutants are nitrate to water, Dinitrogen monoxide, nitrogen oxides that emitted to air.

For Human Health impact category, it is again dominated (67.5%) by forestry for the Pine/Spruce (i.e. wood growing chemicals, emissions from agricultural machines, and water). Additionally, the potato seed production processes and general transport contribute 5.8% and 5.3% impacts, respectively), which mainly come from the emissions to water (i.e. nitrate), ammonia and dinitrogen monoxide to air. Overall, the main pollutants are carbon dioxide and particulates.

Considering the potato seed and vermiculite are bought in fertility, the impacts caused by the Capital Items are already established and can be minimized by prolonging their life spans. An LCA focused on Green Waste Compost and Machinery Operations stages is also performed in order to further detail the impacts generated by those processes.

The relative results of impact analysis are given as follows:

- General transport and Tillage contribute significant impacts that are omitted from the fuel consumptions.
- Agricultural land occupation is mainly generated by fertility process.

- The analysed five stages almost proportionally contribute to the ‘climate change human health’ and ‘climate change ecosystems’ impacts.
- ‘fossil depletion’ is mainly caused by General Transport and Tillage

2.4 Impacts through the production processes of meat products

The functional unit adopted for the study is 1 kg of meat products: 1 kg of pork sausage and 1 kg of pork loin as final product to the customer although they do not represent the actual products. For the purposes of the demonstration of eco-point application for CIRC4Life project the results obtained within the study was converted into a pack of products:

- cured pork sausages: Longaniza Imperial de Lorca of the weight of about 250 g.
- cured pork loin: Lomo Embuchado Mitades of the weight of about 900g.

2.4.1 Curated pork loin product

The main driver for all impact categories is the feed production phase. The two phases: pig farming and slaughterhouse have twice lower environmental impacts then the production phase. This phase is sensitive to the source of feed compounds (especially in the case of soya). Meat processing has a comparably small influence than other phases. Results of the environmental impact assessment are shown in the Figure 2.3.

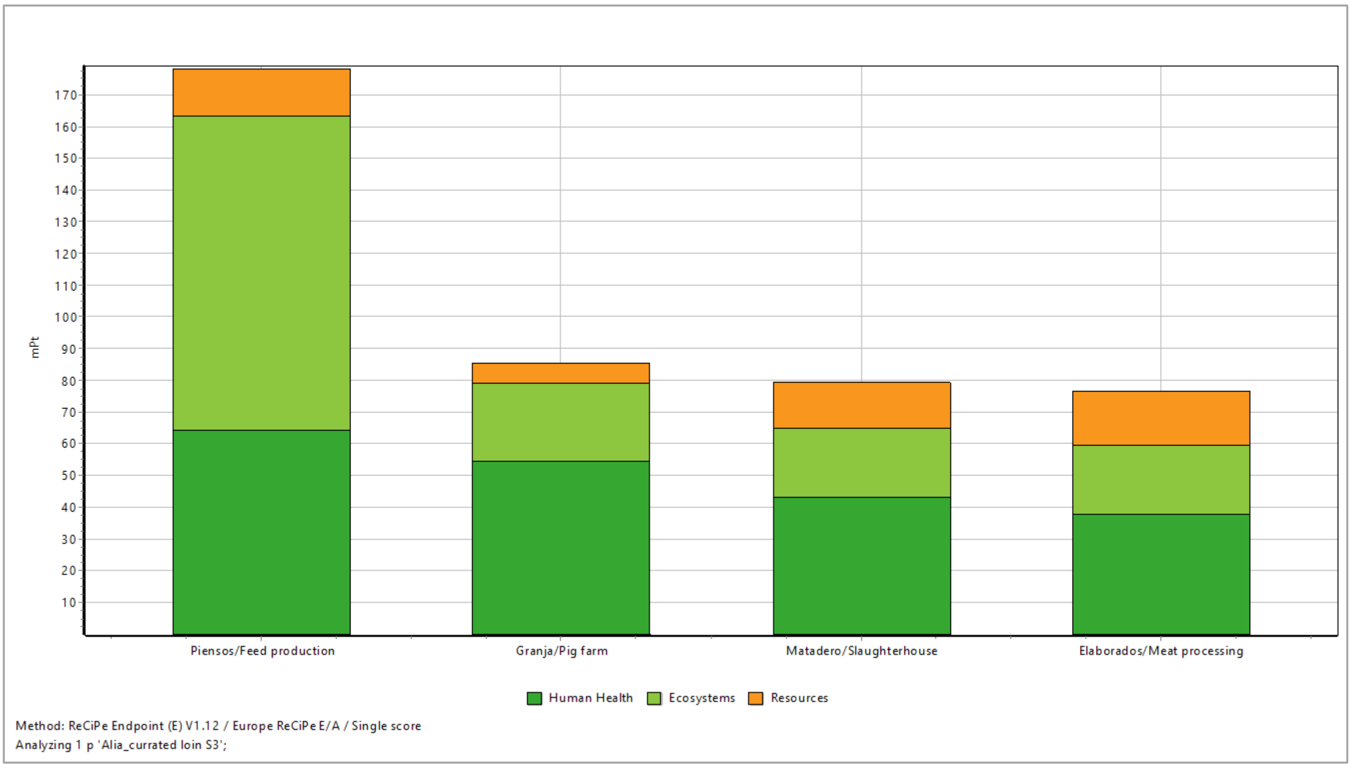


Figure 2.3 Relative impacts of the different life cycle phases of the production of cured loin per impact category

As shown in Figure 2.3, cured pork loin production contributes the most impacts of human health and ecosystem. The impact on resources is relatively low.

The eco-point of the 1 kg cured pork loin is 420 mPt (0.420 Pt). The product weight is 0.9kg which are sold to consumers is 378 mPt (0.378 Pt)[1]. The breakdown of eco-points results is presented in Table 2–8.

Table 2–8 Breakdown of eco-point results for 1 kg cured pork loin

Items	Eco-point	Unit
Total	420	mPt
Human Health	200	mPt
Ecosystems	167	mPt
Resources	53	mPt

The life cycle phase contribution of eco-point results is presented in Figure 2.4. The results show that 43% of impacts are generated by feed production. Each of other phases are responsible for about 20% of generated impacts.

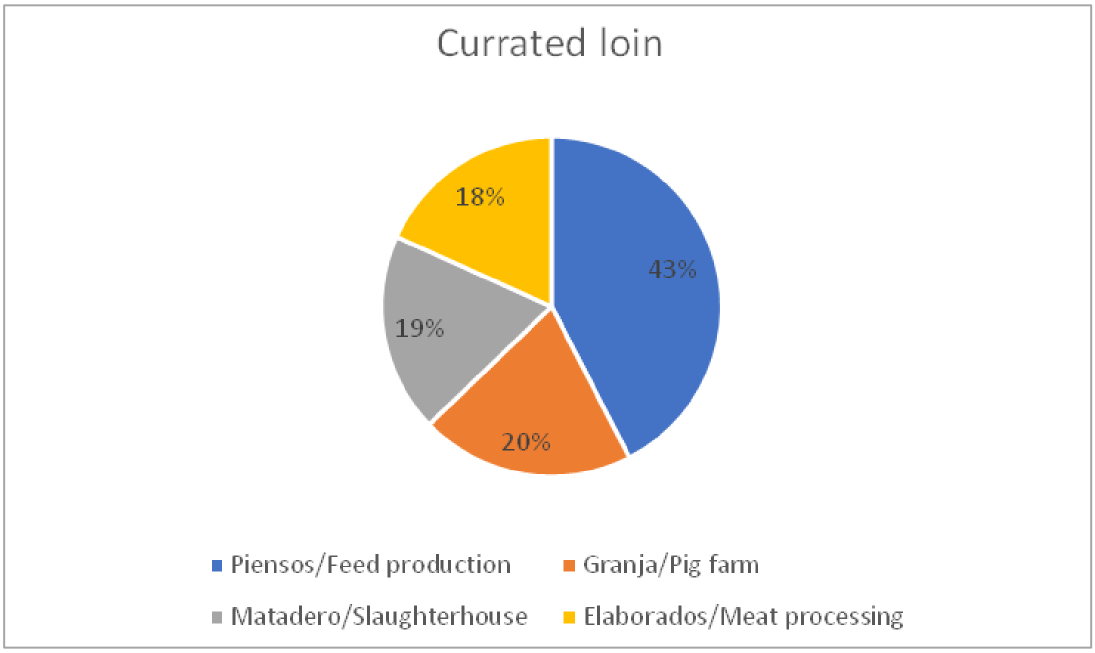


Figure 2.4: Contribution of the life cycle phases of the cured pork loin production to the environmental damages

The main processes contributing to impact damage of human health are pig farming, feed production. Slaughtering activities and meat processing have a slightly smaller impact in this category.

The main process contributing to impact damage of ecosystems is feed production. The other phases, including slaughtering, pig farming and meat processing are less important in this category.

The main processes contributing to damage to resources are meat processing, slaughtering and feed production. Contribution of cured pork loin production phases to the environmental damages per impact categories is presented in the Figure 2.5.

[1] The Eco point is an equivalent with the mPt calculated according to the ReCiPe method.

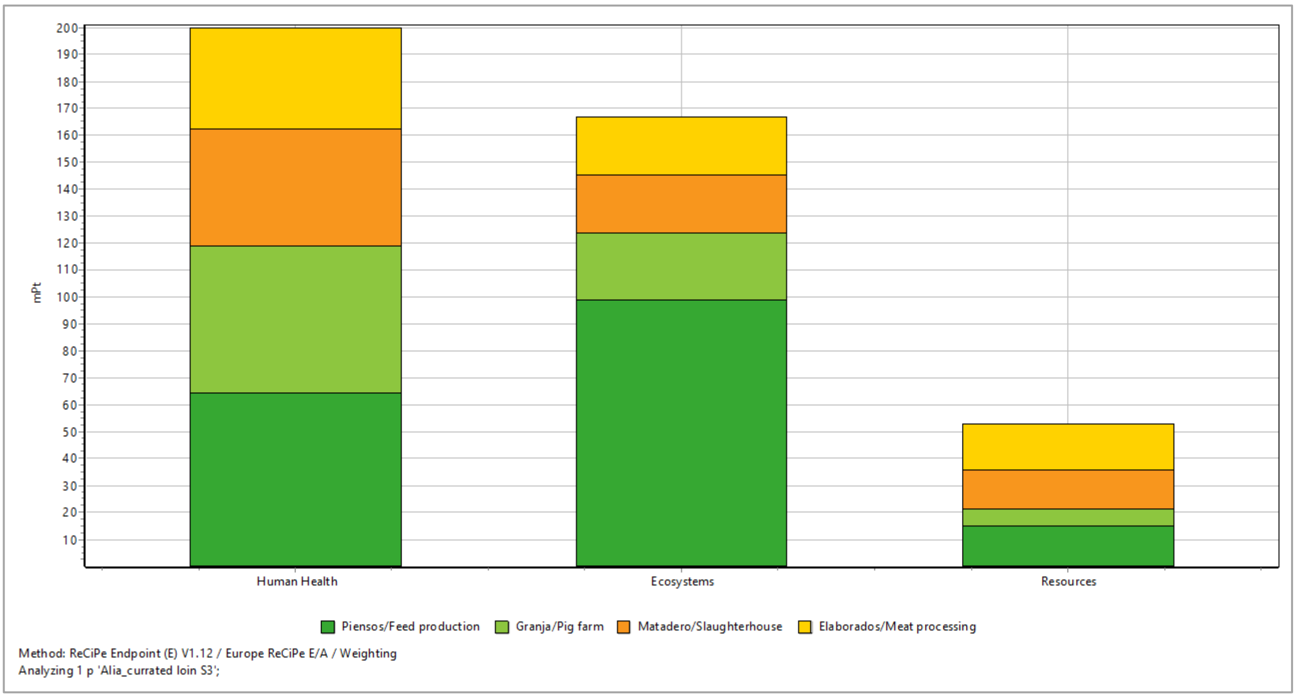


Figure 2.5 Contribution of cured pork loin production phases to the environmental damages

The main factor of the environmental impact of the full life cycle of the production of cured pork loin is electricity consumption. Most of electricity is consumed during the processing of meat (55.25 mPt). This represents 73% of the eco-point value calculated for all the processes of this phase.

For the other phases, including slaughterhouse activities and production of feed, the eco-points value for electricity consumption are respectively: 28.26 mPt and 21.34 mPt.

In the feed production phase, the use of feed compounds, in particular soybean has the highest impact on the environment (39.74 mPt). The eco-points value of the use of peas for feed production is 20.80 mPt.

During the pig farming the highest environmental impacts are generated by pig fattening (46.28 mPt) and piglet feeding by sow (suckling period) (14.72 mPt). The reason is emission of gases to the atmosphere, which is associated with the management of pig manure, solid waste and animals.

The Table 2–9 presents environmental impacts of the life cycle by the five processes ranked by the SimaPro LCA software. These processes are the most important ones in the full life cycle assessment. They were cut off based on expert manner. The environmental impact of these processes represents 54% of the impact of all cured pork loin production processes. In addition to these five processes there are a lot of other processes that are of negligible importance from the perspective of this analysis.

Table 2–9 Environmental impacts of the life cycle phases of the cured pork loin production by the selected processes

No	Processes	Unit	Total	Feed production	Pig farming	Slaughterhouse	Meat processing
1	Electricity	mPt	104.86	21.35	0	28.26	55.25
2	Pig fattening at farm	mPt	46.28	0	46.28	0	0
3	The use of soybean	mPt	39.74	39.74	0	0	0
4	The use of pea for feed production	mPt	20.79	20.79	0	0	0
5	Piglet feeding by sow (suckling period)	mPt	14.72	0	14.72	0	0
Sum of 5 processes		mPt	226.41	81.89	61.01	28.26	55.25
Remaining processes		mPt	192.14	96.19	24.45	51.15	20.33
Total of all processes		mPt	418.54	178.09	85.46	79.41	75.58

2.4.2 Cured pork sausage product

The main driver for all impact categories is the feed production phase. The two phases: pig farming and slaughterhouse have twice lower environmental impacts of the feed production phase. Meat processing – opposite to the production of cured pork loin - also has a big influence on the environment.

Relative impacts of the different life cycle phases of the production of cured pork sausage per impact category is presented in Figure 2.6. **Error! Reference source not found.**

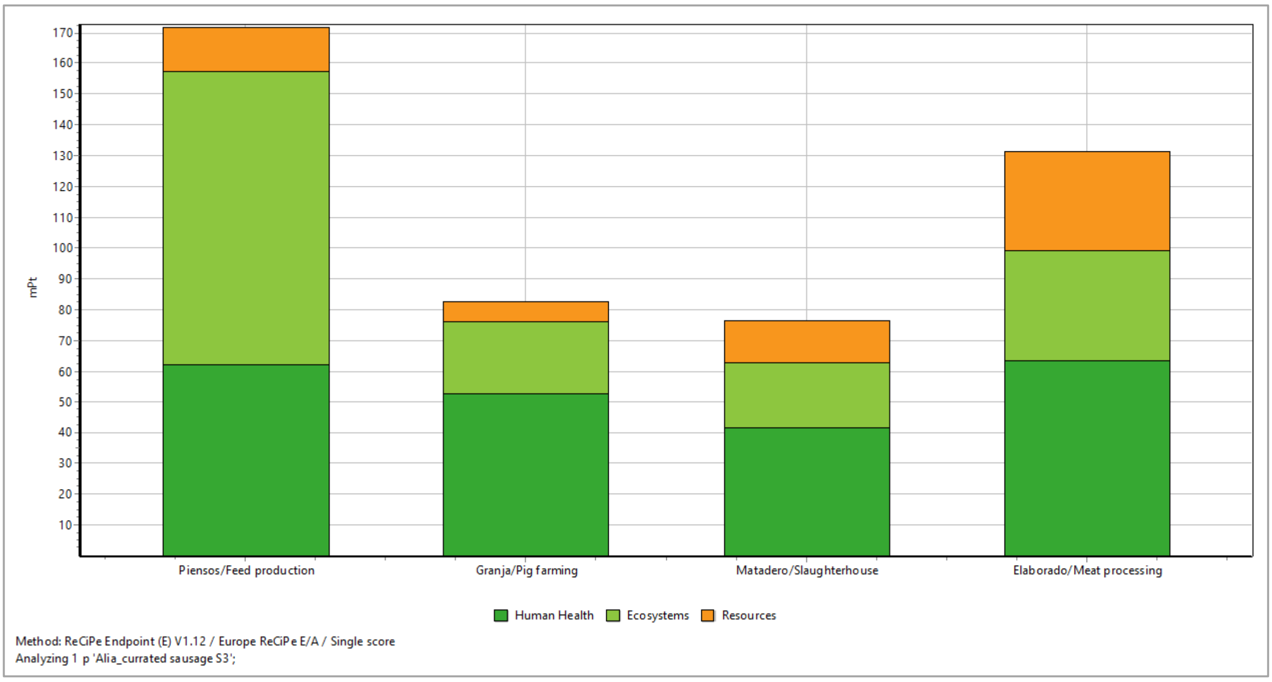


Figure 2.6 Relative impacts of the different life cycle phases of the production of cured pork sausage

The most important impacts of the full life cycle of the cured sausage production is same as the cured loin production, having major impact on human health and ecosystem. The impact on resources is relatively low.

The eco-point of the FU 1 kg cured pork sausage is 462 mPt (0.462 Pt). The eco-point of the product of weight 0.25g which are sold to consumers is 115,5 mPt (0.1155 Pt). The breakdown of eco-points results is presented in the Table 2–10

Table 2–10 Breakdown of eco-point results for **1 kg** cured pork sausage

Items	Eco-point	Unit
Total	462	mPt
Human Health	220	mPt
Ecosystems	176	mPt
Resources	66	mPt

The life cycle phase contribution of eco-point results is presented in Figure 2.7. The results show that 37% of impacts are generated by feed production and 28% by the processing of meat. Pig farming and slaughter activities are in a later position.

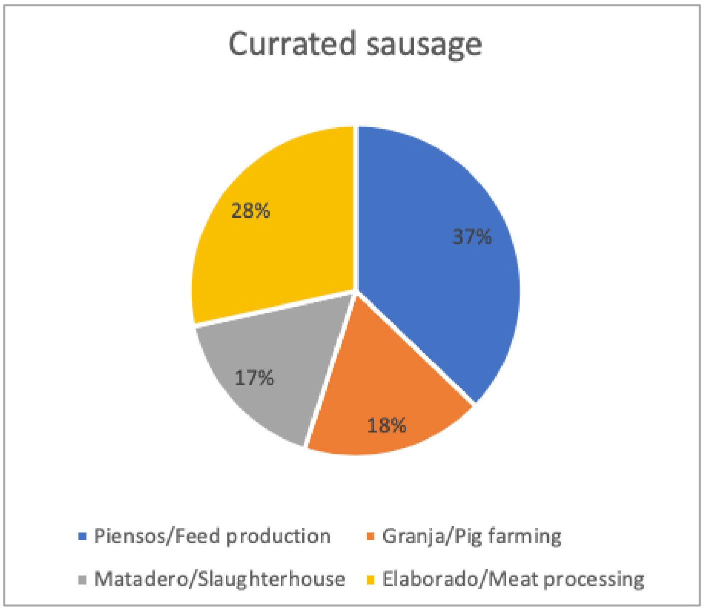


Figure 2.7 Contribution of the life cycle phases of the pork curated sausage production to the environmental damages

The main processes contributing to damage to human health are meat processing and feed production. Pig farming slaughtering activities are characterised by slightly smaller impact.

The main process contributing to damage to ecosystems is feed production. The other phases, including meat elaboration, pig farming and slaughterhouse are relatively of minor importance.

The main process contributing to damage to resources is meat processing. slaughtering, feed production and pig housing have smaller impact in this category.

Contribution of cured pork sausage production processes to the environmental damages per impact categories is presented in Figure 2.8.

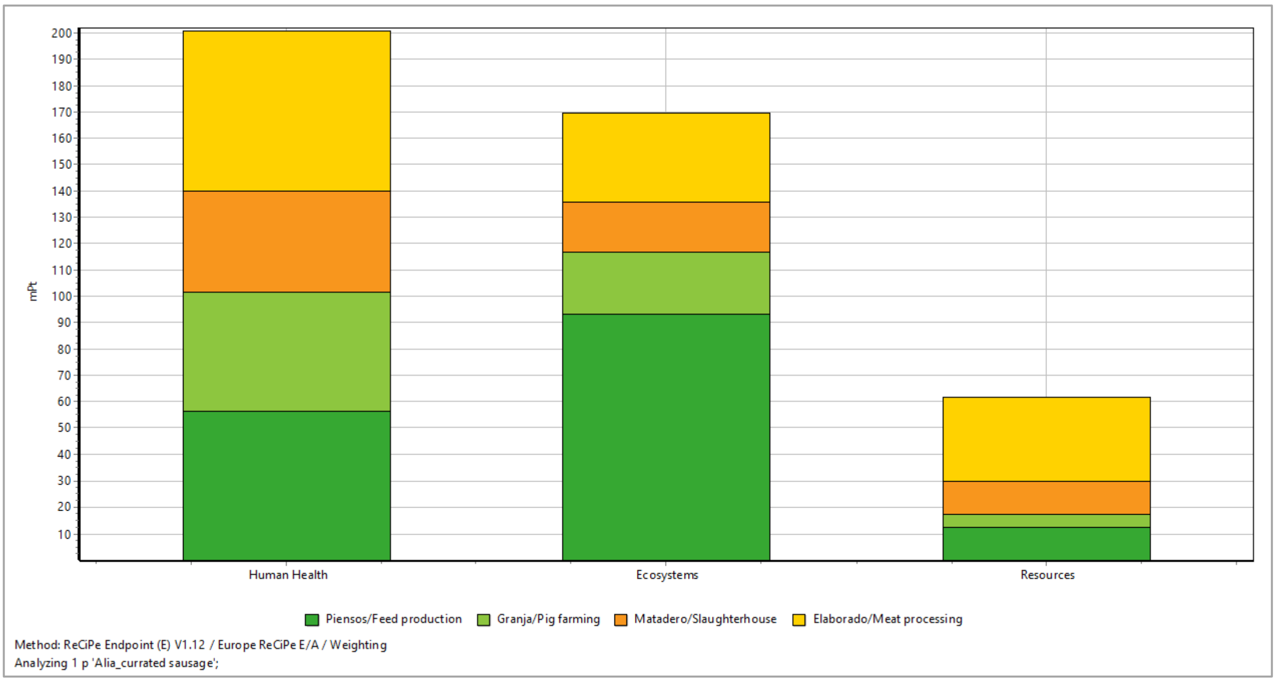


Figure 2.8 Contribution of cured pork sausage production sub-systems to the environmental damages

As in the case of cured pork loin, the main factor of environmental impact of the full life cycle is electricity consumption. Most of electricity is consumed during the processing of meat (111.3 mPt). This represents about 80% of the impact of all the processes in this phase. For the slaughtering activities and production of feed the values of eco-points for electricity consumption are respectively: 27.2 mPt and 20.6 mPt.

In the feed production the use of soybean has got the highest value of eco-points (38.3 mPt). The similar tendency is reported for cured pork sausages. The eco-point values for the use of pea is relatively lower: 20.5 mPt.

In pig farming phase the highest environmental impacts are generated by pig fattening (44.6 mPt) and piglet feeding by sow (suckling period) (14.1 mPt).

The Table 2–11 presents environmental impact of the life cycle phases. These processes are the most important ones in the full life cycle assessment. Similarly, as in the case of cured pork loin they were chosen in an expert manner. The environmental impact of these processes accounts for about 60% of the impact of all cured pork sausage production processes.

The Table 2–11 presents environmental impacts of the life cycle by the five processes ranked by the SimaPro. Similarly, as in the case of cured pork loin they were cut off based on expert manner. The environmental impact of these processes accounts for about 60% of the impact of all cured pork sausage production processes. In addition to these five processes there are a lot of other processes that are of negligible importance from the perspective of this analysis.

Table 2–11 Environmental impacts of the life cycle phases of the cured pork sausage production by the selected processes

No	Processes	Unit	Total	Feed production	Pig farming	Slaughter-house	Meat processing
1	Electricity consumption	mPt	159.14	20.58	0	27.25	111.29
2	Pig fattening at farm	mPt	44.63	0	44.63	0	0
3	The use of soybean for feed production	mPt	38.32	38.32	0	0	0
4	The use of pea for feed production	mPt	20.06	20.06	0	0	0
5	Piglet feeding by sow (suckling period)	mPt	14.19	0	14.19	0	0
The Sum of selected 5 processes		mPt	276.34	78.96	58.83	27.25	111.29
Remaining processes		mPt	185.66	92.76	23.58	49.32	20.00
Total of all processes		mPt	462.01	171.72	82.41	76.57	131.29

The recommendations regarding the increasing of environmental performance of the production of cured pork sausages and cured pork loin are following:

1) Increasing the use of renewable electricity in pig farming, slaughterhouse and meat processing. Potential options include:
   - electrical energy from cogeneration based on local sources.
   - renewable energy from the grid.
2) Paying attention to the origin of agricultural raw materials used for the production of feed. It is preferred to use locally produced materials.
3) The use of waste materials from agricultural production for animal feed production. It is very important that the waste originates in food production processes based on locally available materials.
4) Application of air protection solutions at pig farms in order to minimise gas emission.
5) Animal wastes should be managed in a sustainable way which enables obtaining maximum benefits for the company with a minimum impact on the environment.
   - Animal manures are valuable sources of nutrients and organic matter for use in the maintenance of soil fertility and crop production. It can be also used for energy production with consecutive production of residual material from fermentation that can be used as fertiliser.
   - Implementation of effective and environmentally friendly methods of utilisation of dead animals is a crucial element of waste management.
   - At the same time, it is important to keep the level of mortality of the stock as low as possible considering also the humanitarian aspects of husbandry.
6) It is recommended for pig farms to use renewable energy for heating purposes, based on biomass preferably from local sources.
7) Increasing of effectiveness of transport will minimise its negative environmental effects.

3 Sustainable product development methods

3.1 Design for recycling for sustainable industrial LED lighting product development

This section presents the design (concept design, details design) of the sustainable LED lighting products step-by-step, explaining the design activities carried out at each stage of the approach followed.

The most important benefits related to innovation strategy in lighting product design and manufacturing are:

- Potential reduction of material consumption in manufacturing due to lighter components, use of (refurbished) and or modular components, lower amount of precious metals in drivers, use of recycled materials.
- Potential reduction of component cost in case of refurbished components like heat sinks can be used.
- Potential reduction in assembly time due to modular design and standardized component, connectors etc. This might lead to lead time reductions.
- Reduced material waste streams and better sorted waste streams having a larger value for recycling.
- Capturing value form improved material separation possibilities and anticipated pre-processing highlights the potential of service offerings like product maintenance, product upgrade and modification, etc. by modular design and re-sue and refurbishing of components.

3.1.1 Concept design

Key requirements for the product design:

- Widely used in warehouse, factory, manufacturing areas, barns etc.
- Usually installed with a mounting height of 4 to 12 meters.
- High power (>100W), High efficiency (>120lm/W).
- Save energy by around 50% compared to fluorescent product.

Figure 3.1 A example showing the application of industrial LED lighting products in warehouse

Directives and Standards that the designed products should comply

1) **LOW Voltage Directive 2014/35/EU Referenced standards:**
   - EN 60598-1:2015 (Luminaires. General requirements and tests)
   - EN 60598-2-5:2012 (Luminaires. Particular requirements. Floodlights)
   - EN 62493:2015 (Assessment of lighting equipment related to human exposure to electromagnetic fields)
   - EN 62031:2008+A1:2013+A2:2015 (LED modules for general lighting. Safety specifications)

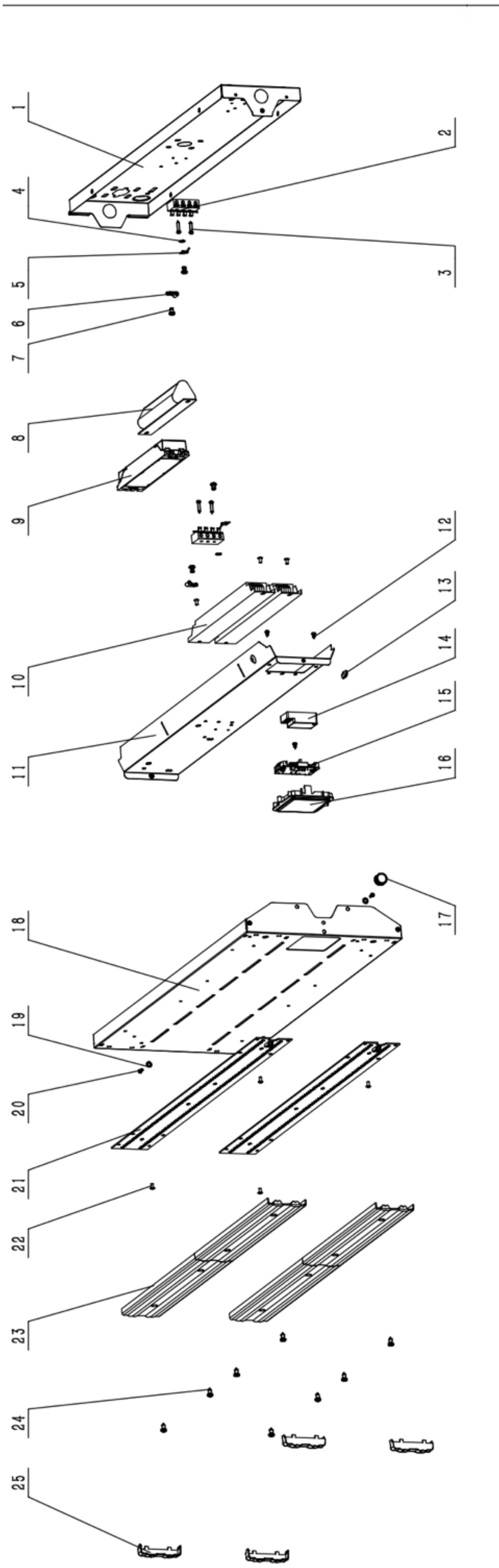
- EN 62471:2008 (Photobiological safety of lamps and lamp systems)

2) **Electro Magnetic Compatibility Directive 2014/30/EU Referenced standards:**
    - EN 55015:2013+A1:2015 (Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment)
    - EN 61547:2009 (Equipment for general lighting purposes. EMC immunity requirements)
    - EN 61000-3-2:2014 (Electromagnetic compatibility (EMC). Limits. Limits for harmonic current emissions (equipment input current = 16 A per phase)
    - EN 61000-3-3:2013 (Electromagnetic compatibility (EMC). Limits. Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current = 16 A per phase and not subject to conditional connection)
3) **Restriction of Hazardous Substances Directive 2011/65/EU**
4) **Energy-related Products Directive 2009/125/EC**
5) **REACH--Registration, Evaluation, Authorization, and Restriction of Chemicals) restriction of SVHC (Substances of Very High Concern) in (EC) 1907/2006**

3.1.2 Detail design

The BOM diagram (**Error! Reference source not found.**) shows all components of the Kosnic demonstrator. in general, there are 3 Units:

- Base: it is fixed to the ceiling or suspended from ceiling;
- Fasten panel: Driver, sensor and the emergency module are all included in this unit;
- Top cover: this is lighting unite that contains LED PCB, heat sink is the plate itself, and also optical lens.



No.	REF.	Name	QTY.	Materials			NOTE
25	01.02.GZ00046	Cover	4	PC			ARCUS-10-01
24	01.02.LS00270	Tapping Screw ST4.2X8F	8	1018			GB/T 845-1985
23	01.02.TJ00102	Lens	4	PMMA			
22	01.02.LS00115	Blind rivets 3.2X7	12	Q235			GB/T12618-1990
21	02.04.MD00527	Lamp panel	2				
20	01.02.LS00272	Machine screw M3X8	2	1018			GB/T973-1976
19	01.02.LS00146	Serrated Lock Washers External Teeth Size:3	2	SUS304			GB/T862.2-1987
18	01.02.DZ00136	Base	1	ST12			ARCUS-11-00
17	01.02.LS00269	Decorative screws M4X8	1	1018			
16	01.02.QT00206	Case	1	PC			ARCUS-40-01
15	02.03.SM00258	switchboard	1				
14	02.01.KMV1013	Microwave Sensor	1	PC			
13	01.02.QT00207	Bushings	2	Rubber			
12	01.02.LS00208	Tapping Screw ST2.9X6C	3	1018			GB/T 845-1985
11	01.02.QT00204	Fastend Panel	1	SGCC			ARCUS-31-00
10	03.15.DR00377	Modular Drive	2				
9	03.15.DR00374	Emergency Drive	1				
8	01.01.A000047	Battery	1	Li-ion			KBA-01-15
7	01.02.LS00271	Tapping Screw ST4.2X6F	4	1018			GB/T 845-1985
6	01.02.QT00208	Cable Clamp	2	PA66			
5	01.02.QT00120	Earthing plate	2	SUS304			
4	01.02.LS00094		2	SUS304			GB/T862.2-1987
3	01.02.LS00274	Tapping Screw ST2.9X16F	4	1018			GB/T 845-1985
2	01.02.JZ00048	Luminaire Pushwire Connector	2	PA66			
1	01.02.DZ00137	Top cover	1	ST12			ARCUS-21-00

Kosnic
Highbay
ARCUS-00-00
DES 2020-03-30
CKD 2020-03-30
TECH
APPD
FIRST ANGLE PROJECTION
DES CONT
SIZE A3
STAGE | WEIGHT | SCALE 1:6
TOTAL SHEETS 1 | NO. 1

Figure 3.2 Bill of materials of the designed industrial lighting product

3.1.3 Manufacturing processes

3.1.3.1 Housing manufacturing

1) Cutting: Use laser cutting machine to cut metal sheets into the designed shape, and holes are also drilled in this process. Approx. 15 minutes are required for per luminaire in this process.

Figure 3.3 Laser cutting machine

2) Bending: Use bending machine to bend these manufactured shapes into base, fasten panel, top cover. Approx. 20 minutes are required for per luminaire in this process.

Figure 3.4 Bending machine

Figure 3.5 Base of the prototype

Figure 3.6 Fasten panel of the prototype

Figure 3.7 Top cover of the prototype

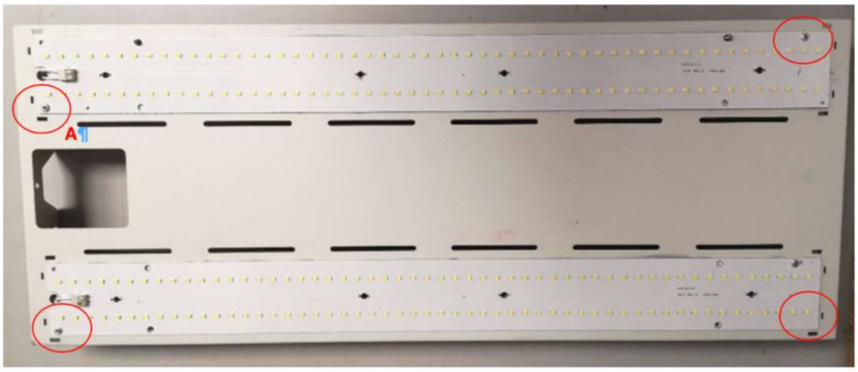
3) Painting: Use electrostatic powder coating machine paint the base and top cover.

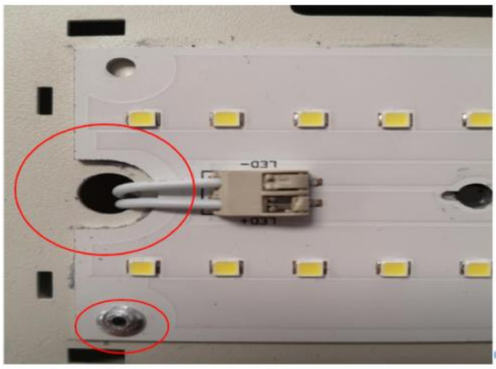
Figure 3.8 Automatic spraying machine

Figure 3.9 Painted top cover and base

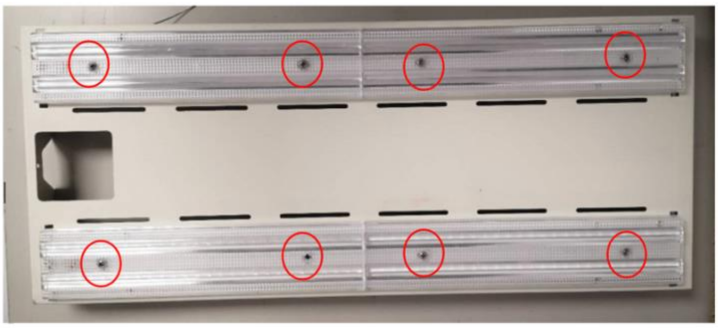
3.1.3.2 Base module assembly

1) Panel installation: use screen printing machine to print Silicone Thermal Grease on the surface of the base, which is for heat dissipation. Then, fasten the panel into the base with blind rivets, and wire the cable through the holes in the base.



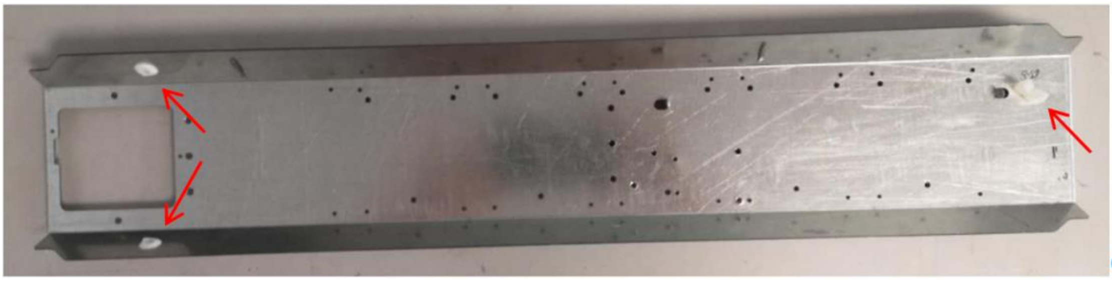


2) Lens installation: fasten the lens into the panel with tapping screws, then tap the cover onto the sides of the lens.

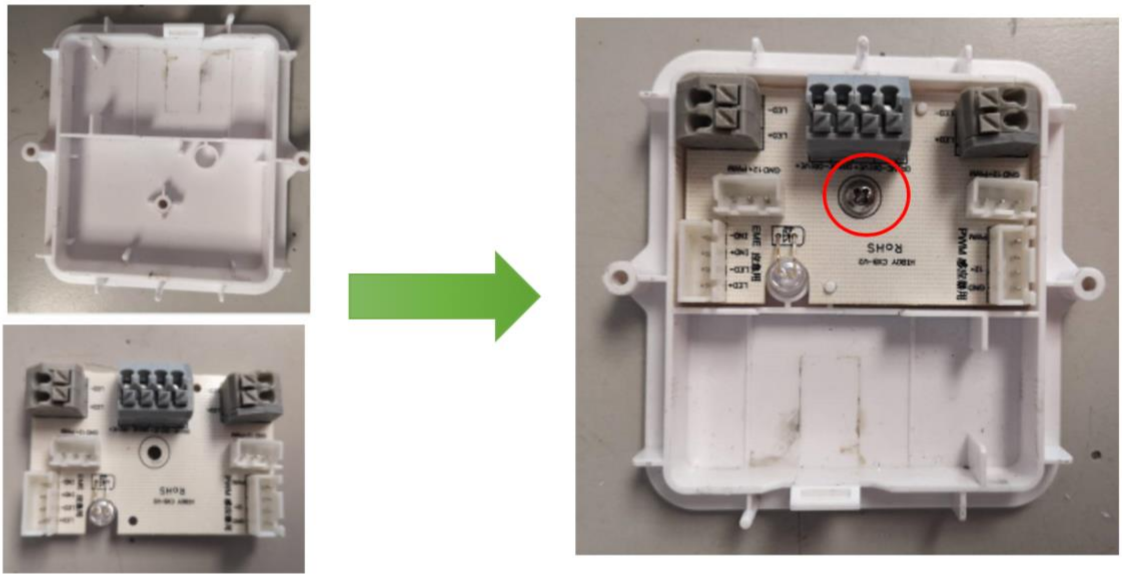


3.1.3.3 Fasten panel assembly

1) Bushing assembly: install bushings and clips into the fasten panel.



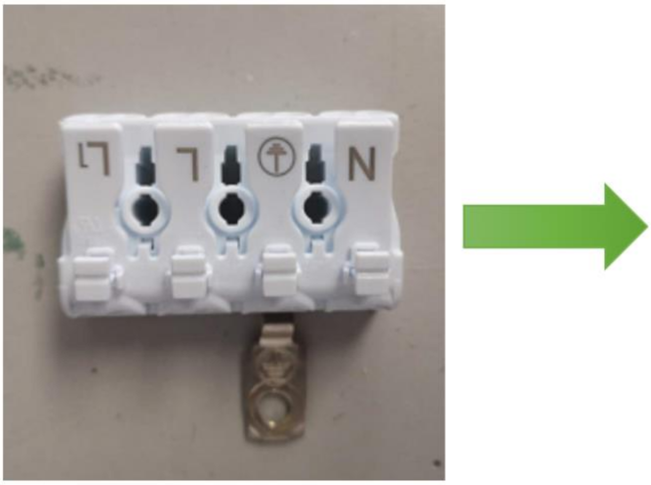
2) Switchboard installation: install switchboard into the case and fasten with tapping screw.



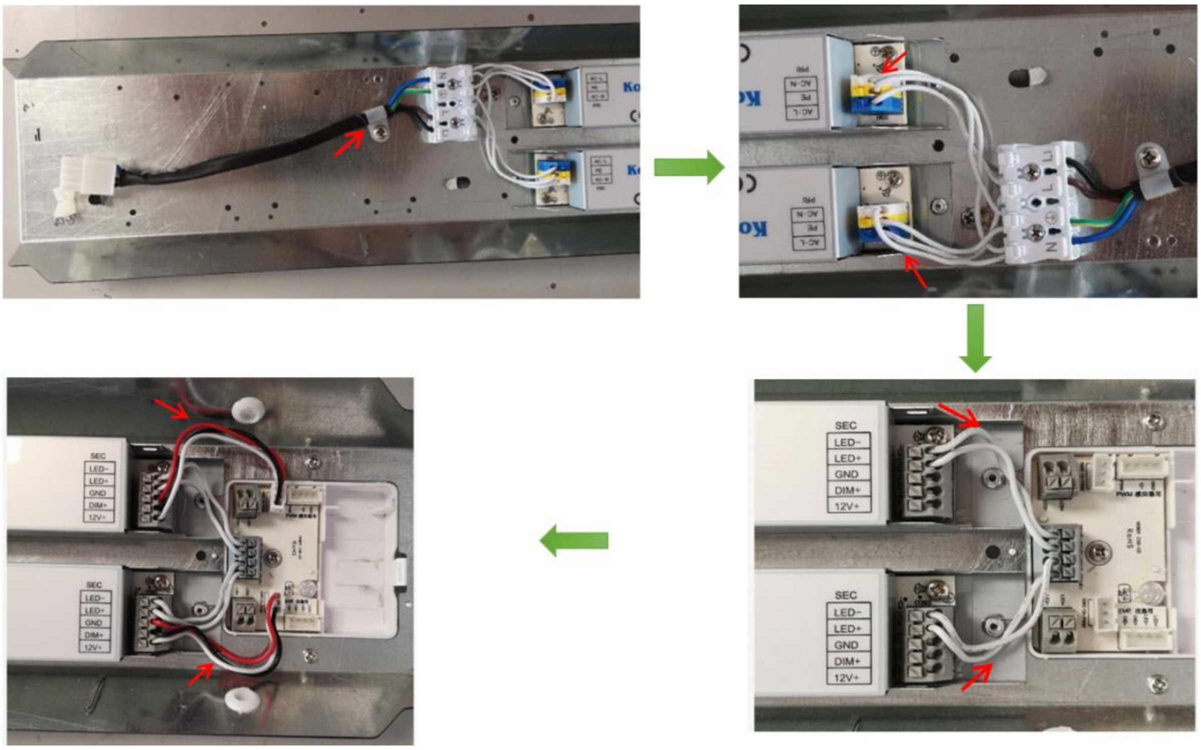
3) Control module assembly: install the control unit into the fasten panel with tapping screw.

4) Driver installation: install the drivers into the fasten panel with blind rivets.

5) Push wire connector installation: install earthing plate into the luminaire push wire connector, then fasten the connector into the fasten panel with the tapping screw (a serrated Lock are placed underneath of the plate to ensure the maximum fasten).

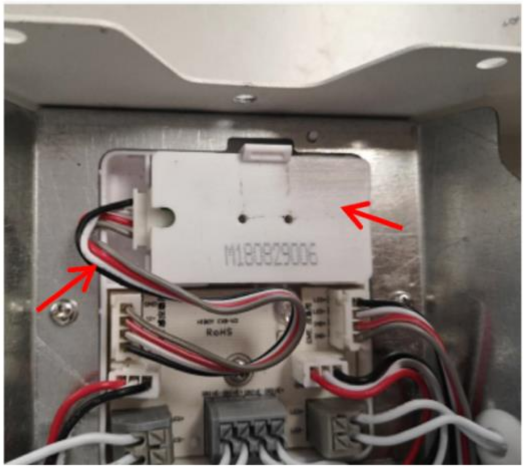


6) Wiring: connect the input wire into the push wire connector and fasten the cable with a clip; connect the input wire of the drivers with the push wire connector; connect output wire and motion out cable of the drivers through the switch board.



7) Emergency module assembly: fasten the emergency driver and a battery into the fasten panel and wire the battery with the emergency driver; connect the emergency driver with the push wire connector, then connect the output wire of the driver with the switchboard.

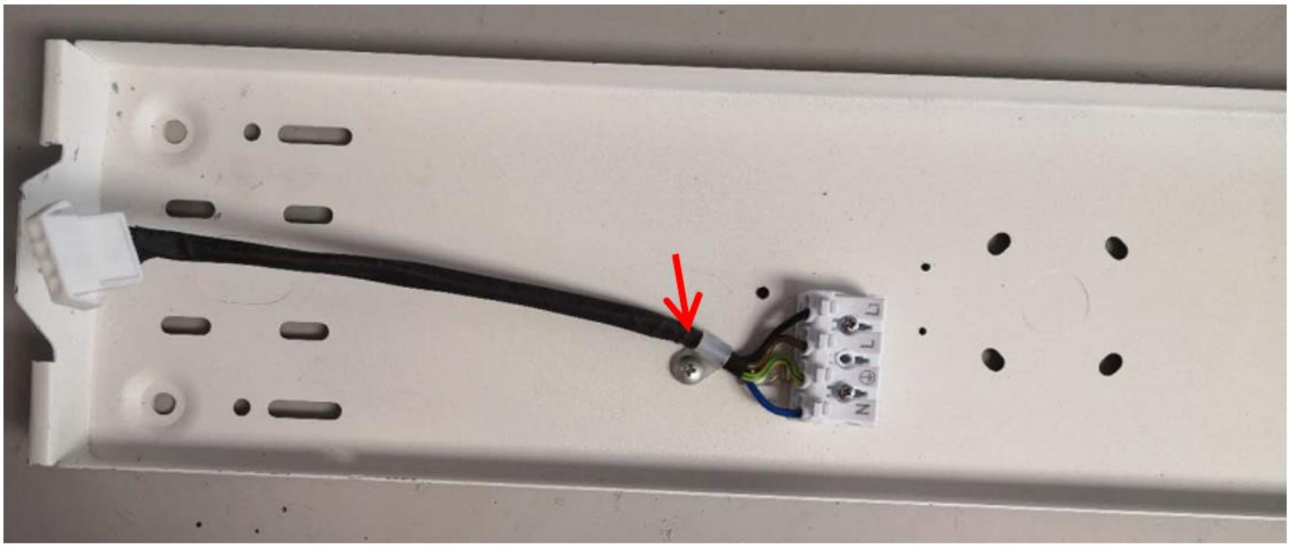
8) Motion module: install the microwave sensor into the case of switchboard, then connect the sensor cable with the switchboard.



3.1.3.4 Top cover assembly

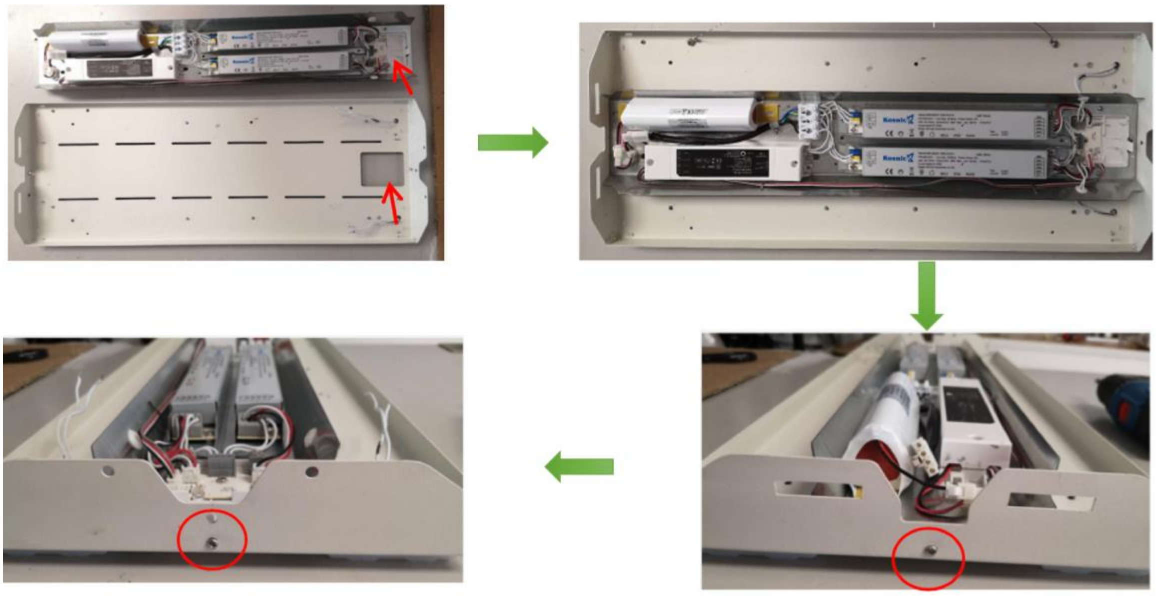
1) Push wire connector installation: install the earthing plate into the top cover with tapping screw.

2) Wiring: connect the 4pin cable with the earthing plate.

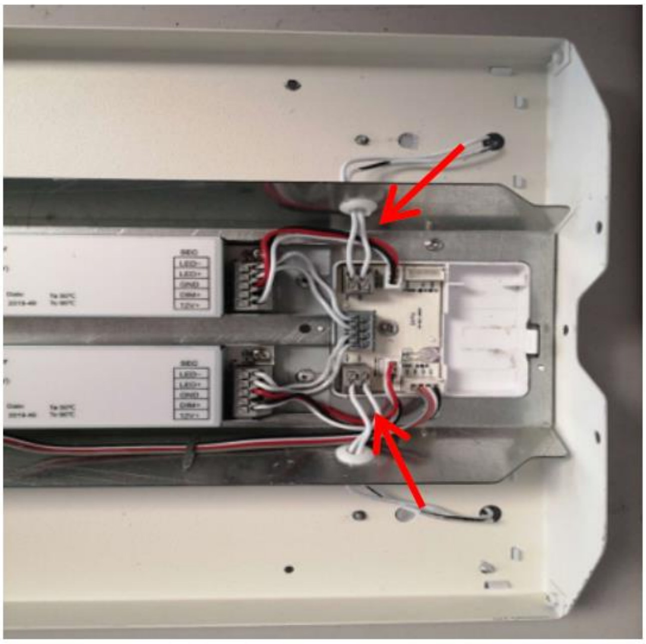


3.1.3.5 Assemble the base and fasten panel

1) Install fasten panel into base: fasten the panel into the base with machine screw.



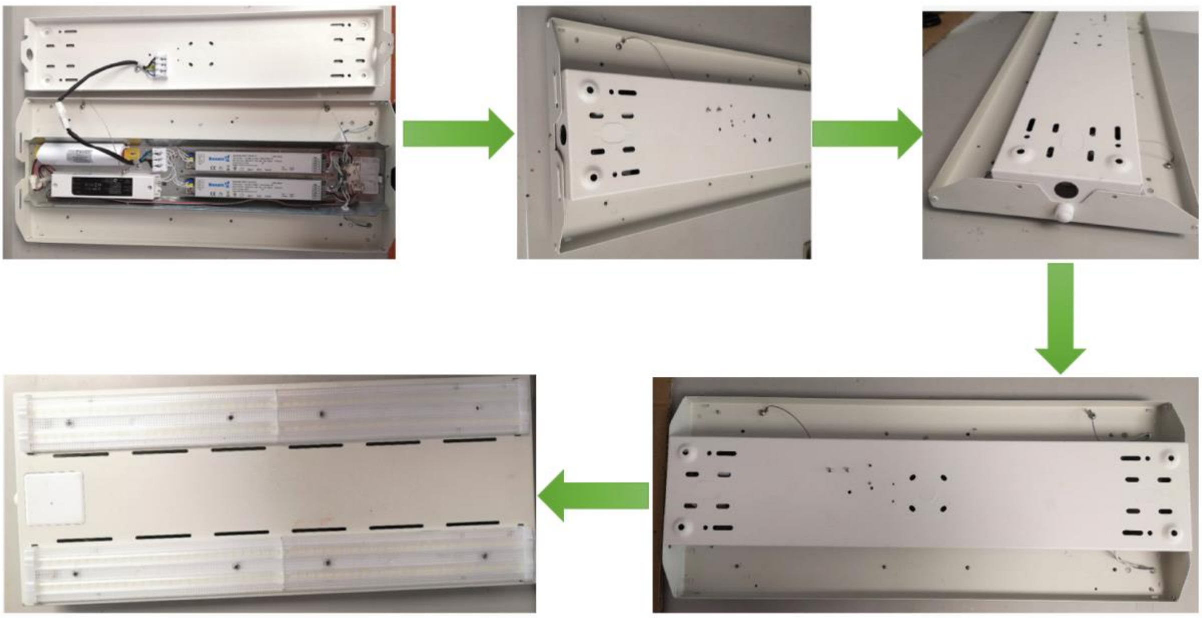
2) Wiring:



3) Sling line assembly: install sling line into the base with tapping screw.

3.1.3.6 Assemble the base module and top cover

1) Connect the 4pin cable in base with the 4pin cable in the fasten panel.
2) Hook the top cover with the base.
3) Fasten the top cover with the base by installing screws into the both sides.
4) Front and back appearance of the luminaire.



3.1.4 Benefits of this design

Each luminaire can contain up to 6 independent LED lighting units. Any component failure will only affect the corresponding lighting unit and not result in complete product failure. Only the faulty module (light engine or driver) is replaced, minimising unnecessary waste and strongly encouraging reuse.

- Driver: Standard, Dimmable, Bluetooth etc.
- Sensor: On/off, Dimming, Daylight Harvesting
- Emergency: Standard, Self-test, DALI

The luminaire can adopt from 1-6 lighting modules depending on the customer lighting needs. It also can adopt new modules with new colours/finishes, as well as new components (i.e., LEDs) which might be developed in the future that may allow new functions. In addition, the LEDs, drivers and heat sinks can be accessed and repaired or upgraded easily.

3.2 Design for recycling for sustainable domestic LED lighting product development

The sustainable domestic LED lighting product developed in CIRC4Life is led by Ona Product S. L., a lighting product manufacturer in Spain, who wanted to develop eco-lighting products in order to meet the demand of new markets and start exporting their products abroad.

3.2.1 Concept design

At this stage concepts are produced informed by product specifications that are developed **in Task 1.1** (Product specification and production scoping with eco-constraints).

The concept that matches a higher number of Product Design Specification (PDS) criteria is detailed sketches (Figure 3.10). The concept selected is a modular luminaire made of extruded post-consumer recycled materials. The key elements associated with the PDS from Task 1.1 and Deliverable 1.1 are given below along with brief explanations.

Materials:
All of the materials (i.e. wood, metal and plastic) used are basic materials that are easily recyclable after they have been used. There is no need for complicated recycling processes.

Structure and components
The initial design idea is to develop a simple product without requiring many different types of parts but also ensure visually appealing to consumers. That is why one of the pieces are used in a similar way but in different sizes. A simple LED bulb is used in the product. This simple LED bulb does not require complex disassembly, so when it comes to recycling, the lighting part is easily disassembled.

- Recycling

The prototype is to be built with three different materials: wood, metal and plastic. Being completely manufactured in these materials without other parts (joints) it can be recycled the whole part directly without having to disassemble them. It is only necessary to remove the electrical system which can also be easily recycled without the need of additional disassembly.

- Production

The main pieces are all extruded post-consumer recycled materials from ONA suppliers. The pieces are joined by an adhesive, so that we cannot add extra parts for the joints, which is able to control overall costs of the product and shorten the recycling time of the product.

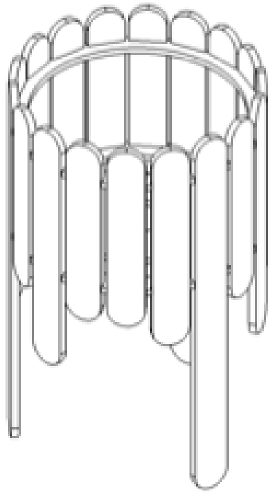


Figure 3.10 First version sketch of the concept design

3.2.2 Detail design

During the detail design stage, the final prototype developed is refined to detail for manufacturing. Components details, technical drawings for manufacturing are needed to finalise in this stage.

The source of light is LEDs feed with energy efficient electronic drivers, which could be chosen with/without dimmers, and for different LEDs wattages depending on luminaire model, price and customer requirements. The housing dimensions are designed to contain a wide range of bulb LEDs types in order to allow customization and upgrading of components over time.

LEDs:
When using standard light bulbs, the client chooses from the entire range of product that exists in the market. Users can choose a conventional LED bulb or a smart, opal or transparent led bulb, colour temperature (k) power (V) etc., which means that it is not limited and in this way each consumer can freely choose the bulb that they want. These LEDs are RoHS compliant.

Housing
The product housing is formed by pieces of the same shape and different size to form the outside of the lamp. They are joined together by two inner ring-shaped pieces which keep the together in a circular shape. The outer pieces are rounded at the ends to avoid edges and aesthetic. The product can be dismantled easily and fast for easy repair and maintenance. All the components have good easy access for repair and/or upgrade.

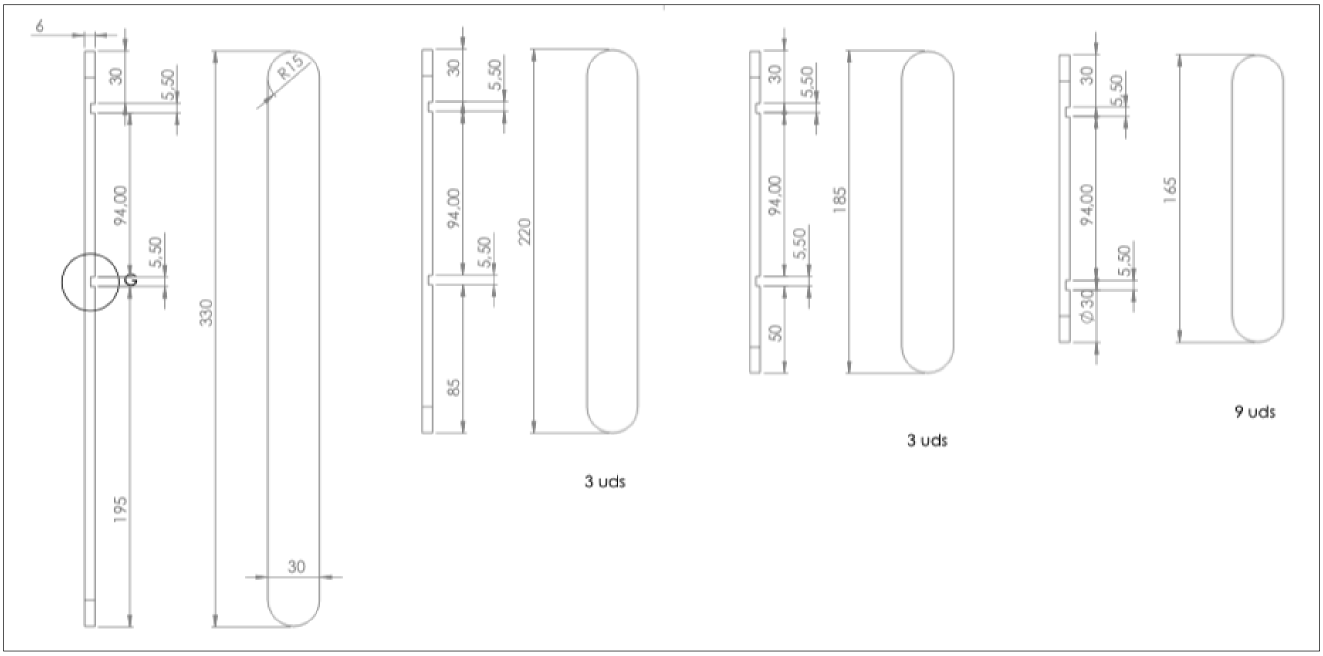


Figure 3.11 Drawing of the housing parts

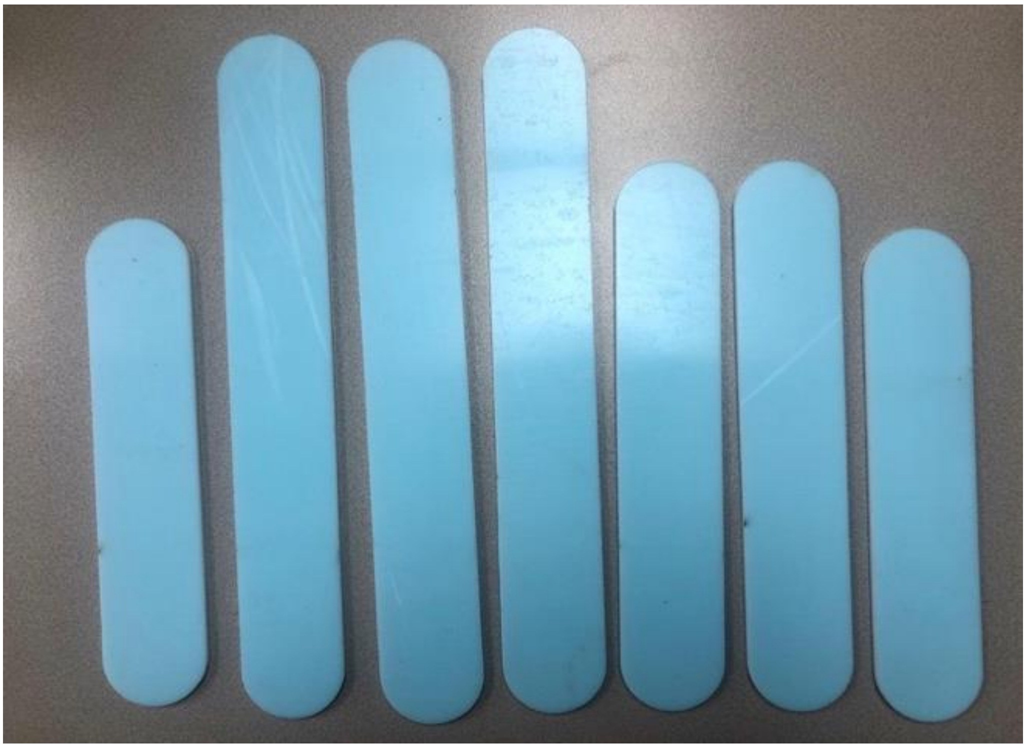


Figure 3.12 Plastic pieces (first prototype) of the housing

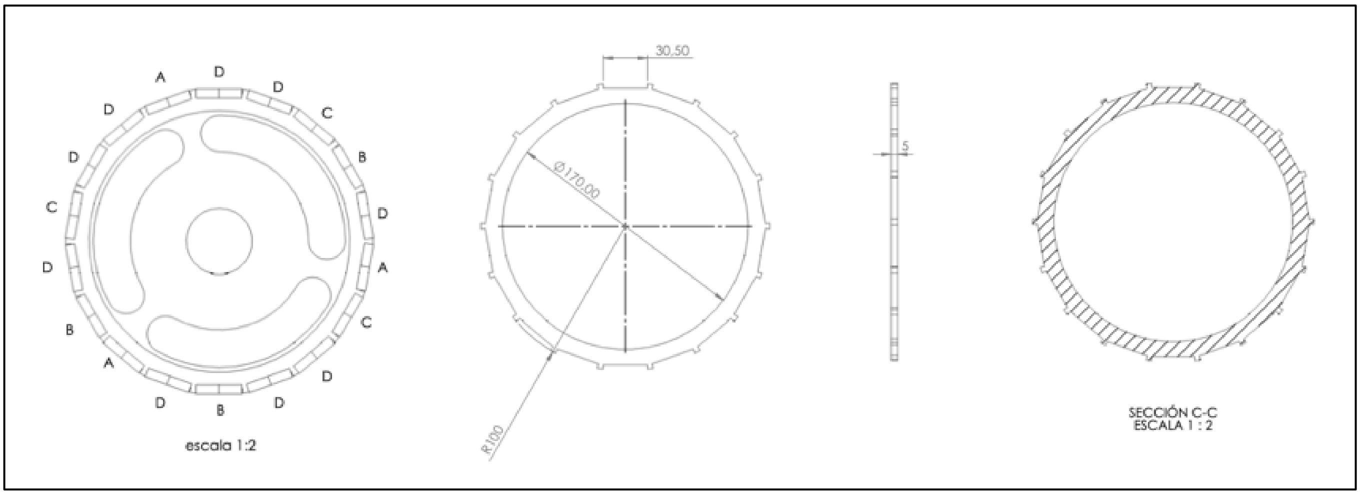


Figure 3.13 Drawings of the housing components

3.2.3 Manufacturing processes

A manufacturing process is the set of unit operations to modify the characteristics of raw materials. These characteristics can be from varied nature such as form, density, resistance, size and aesthetics.

The manufacturing processes for ONA domestic lighting product could be defined in the following steps:

1) Selection
2) Cut
3) Mechanized
4) Paste

The design of the produce has three pieces.
A) Poles (different sizes).
B) Upper rim.
C) Inner rim. This piece is where the electric system is placed.

The pieces B and C are the ones that make possible to form the volume of the product, then all A pieces fit into them.

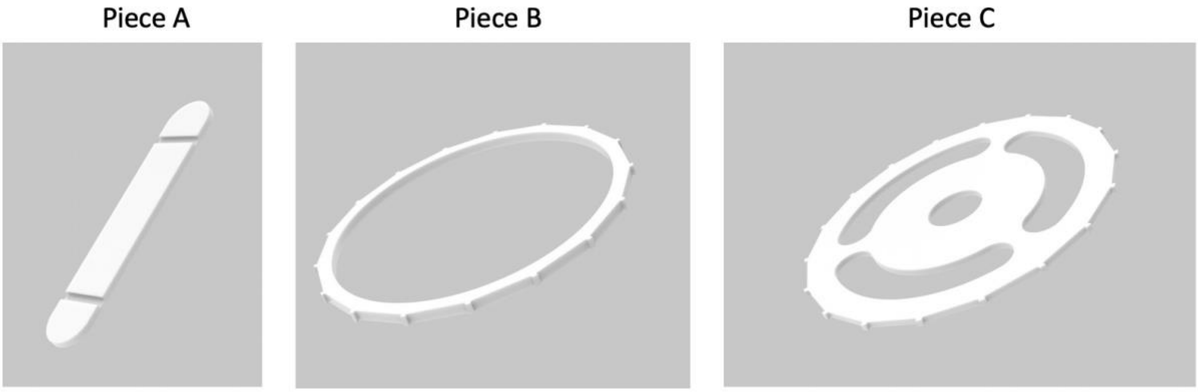


Figure 3.14 Main pieces of the product

3.2.3.1 Selection

As indicated in ONA business model, this design is based on the remnants of material that our suppliers generate in their manufacturing processes. For this reason, the pieces are selected from the containers or the area segment destined for this type of piece (See Figure 3.15).

Figure 3.15 Selected materials for manufacturing the product

The fact that this design is mainly made by straight pieces (material strips) in order to take advantage of these remnants. We have avoided designing objects with complex shapes, since for that we need larger remnants, and this would make it difficult for selecting materials. In this way, we can take more advantage of the remnants and obtain a more piece of them.

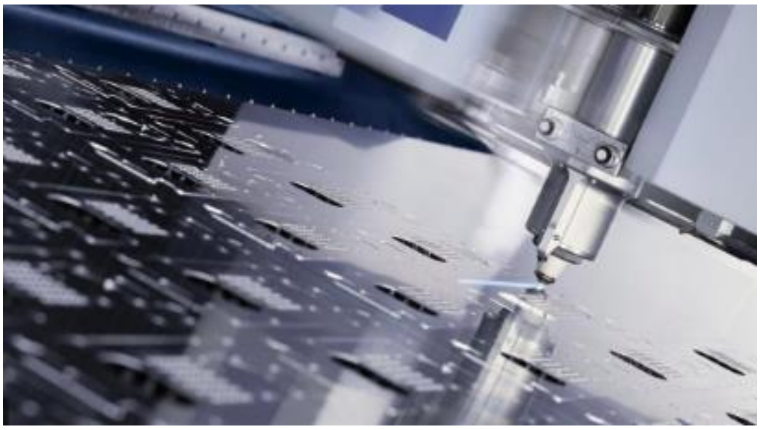
3.2.3.2 Cut

Once the remnants are selected, they are taken to the Cut process

Metal piece
Our supplier uses a laser machine of numerical control (See Figure 3.16). By using this type of cutting process, and due to design of most of the pieces, we can make the most of the selected remnants. The cutting time of a whole set of the product is of 15 to 25 minutes.

Figure 3.16 Computer numerical control (CNC) laser

Plastic piece (methacrylate).
The process of cutting plastic pieces is same of cutting metal pieces, by using the CNC laser cutting machine for plastic. The cutting time of a whole set of the product is of 25 to 35 minutes.



In this case, we not only cut the shape (silhouette) of the pieces, but also the marks of piece A are made, which serve as a reference when gluing in the correct position in the pieces B and C (rings) (see Figure 3.17).

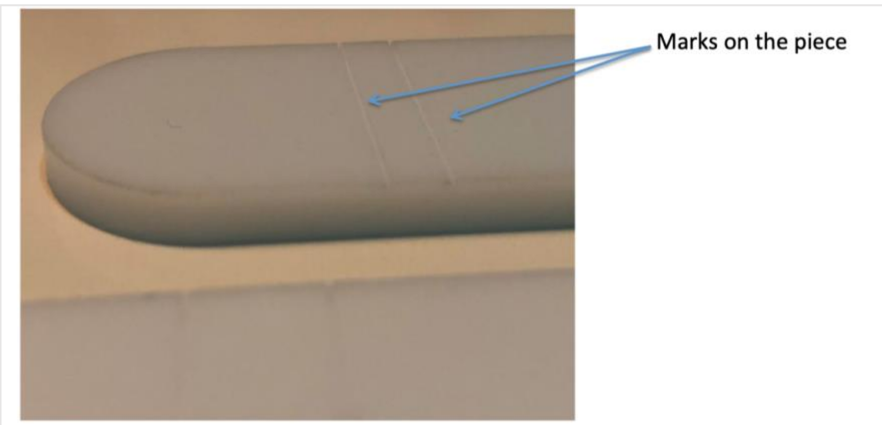


Figure 3.17 Marks in the plastic piece

We do this to reduce the costs and processes. In this process, by the favour of various glue that we use, it dry very quick, and in matter of seconds the pieces can be fused together.

In this way we avoid doing one more process to get the slot shown in Figure 3.18. This has to be done in the pieces of wood and metal, because the glue used in both materials have a slower drying process.

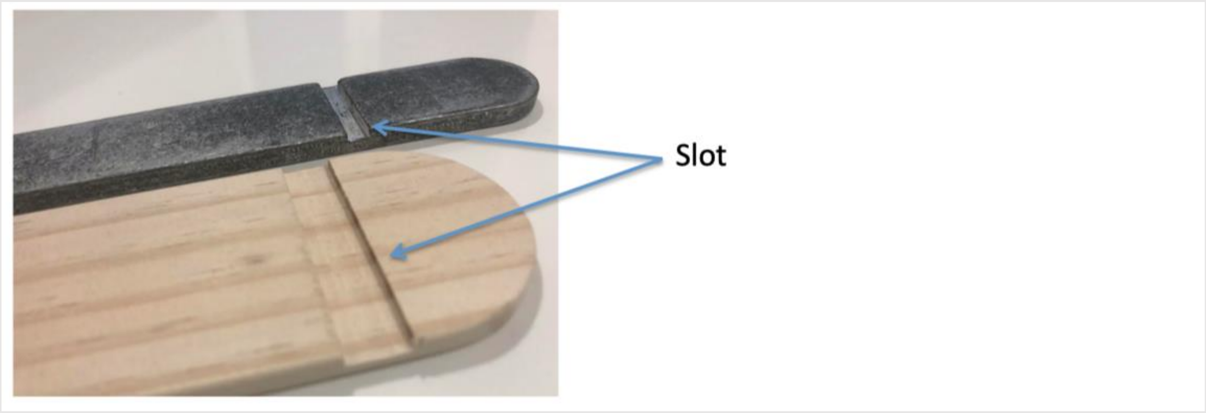


Figure 3.18 Slots in metal and wood piece

Wood piece
The process of cutting wood pieces is same of cutting metal pieces, by using a cutting machine. The cutting time of a whole set of the product is of 25 to 35 minutes. The cutting time of a whole set of the product is of 25 to 35 minutes.

Figure 3.19 Cutting process for wood piece

This machine is not laser, the parts are obtained through the milling process. When making the cuts using a wood bur (see Figure 3.20), this also allows us to make the slots of pieces A (see Figure 3.21).

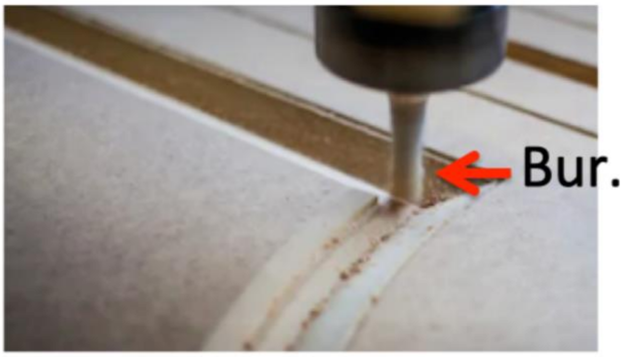


Figure 3.20 Using bur to cut the wood piece

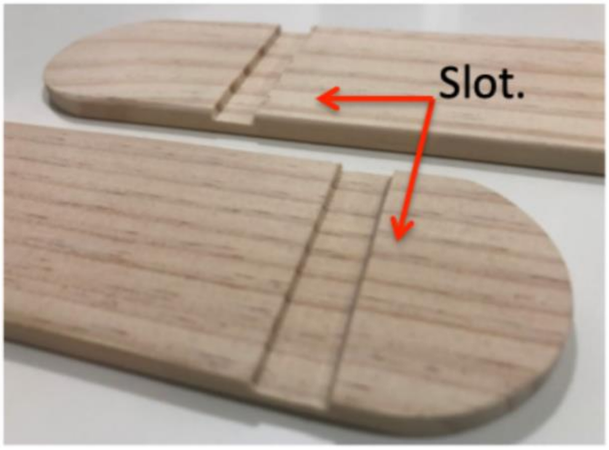


Figure 3.21 Slot in wood pieces

3.2.3.3 Mechanized

The only material to which we perform the mechanized after the cutting process is to aluminium component. Our supplier uses a CNC machine (see Figure 3.22), in this case we have to do it as:

- The CNC laser machine that is used for cutting pieces cannot make the slots, which are needed to place the parts A of the lamp in the correct positions.
- We also cannot make any marks with the CNC laser machine, such as those we make on the plastic pieces due to the type of adhesive, we use to join the aluminium pieces and because the drying time is not as fast as in metal piece.

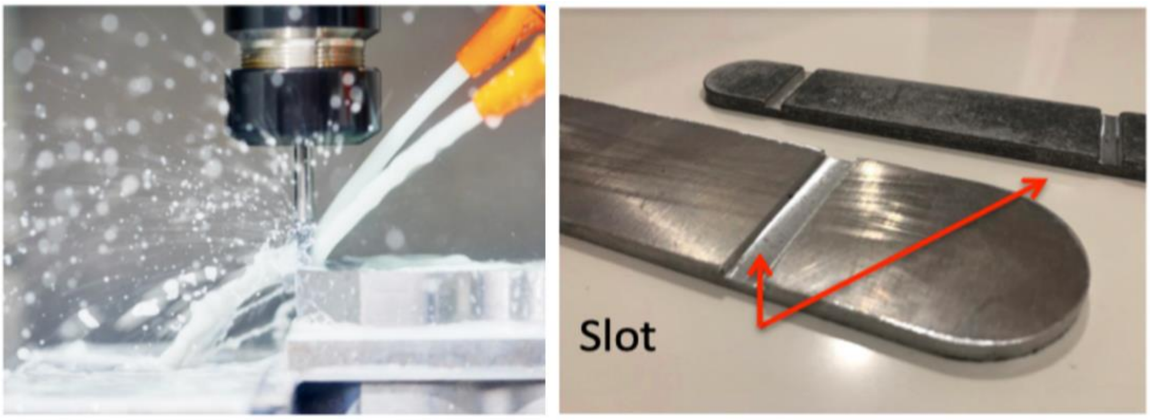


Figure 3.22 Slot on aluminum component

3.2.3.4 Paste

Depending on the type of material, we use the adhesive that best fits the mechanical resistance:

- **Metal piece:** Filler welding - two components
- **Methacrylate piece:** Cyanoacrylate – quick-drying.
- **Wood piece:** Polyvinil acetate, also known as ‘white glue’.

3.2.3.5 Input and output of materials

This design is going to take advantage of those material leftovers (remnants) from our suppliers' manufacturing processes, extending these materials' life cycle, otherwise, our suppliers normally carry these remnants directly to the recycling points. The currently chosen materials are already introduced in the recycling chains so it does not imply any additional effort for recycle the material.

The structure of the per type products is all made of the same material, so it does not need to be manipulated by the operator when it arrives to the recycling point. A simple separate instruction is illustrated in Figure 3.23.

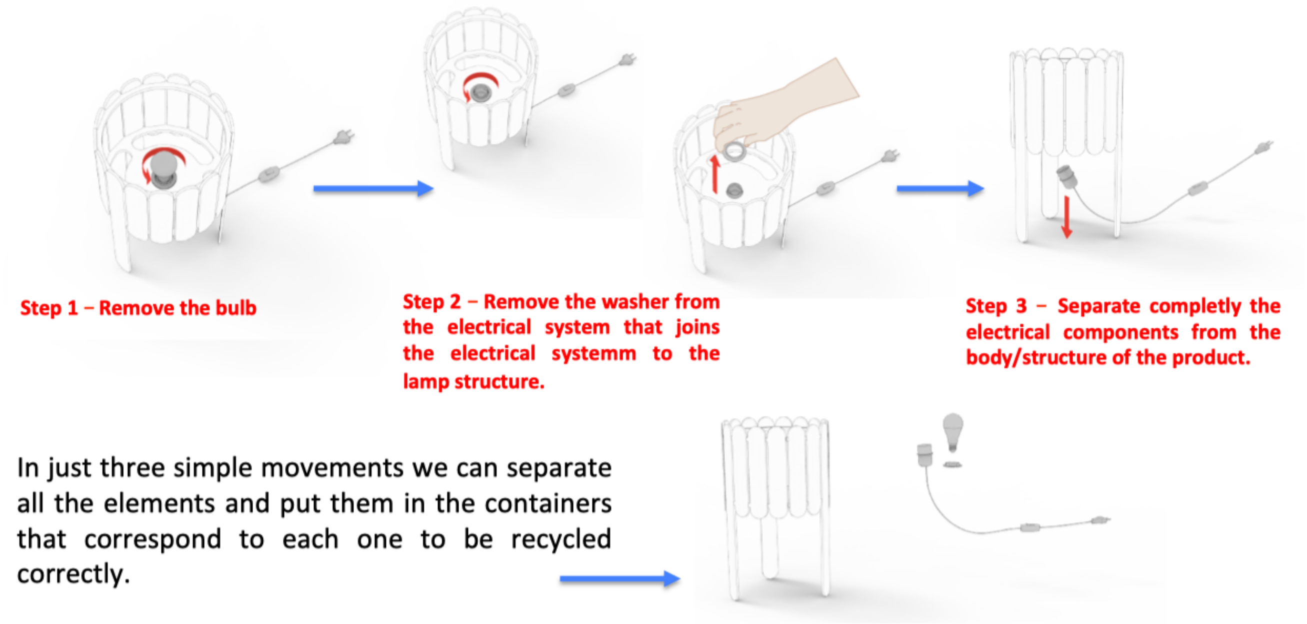


Figure 3.23 Separation process for the product

In three steps, users can separate all the elements and place them in the containers that correspond to one to be recycled correctly (see Figure 3.24). Depending on the material, it must be deposited in the corresponding container.

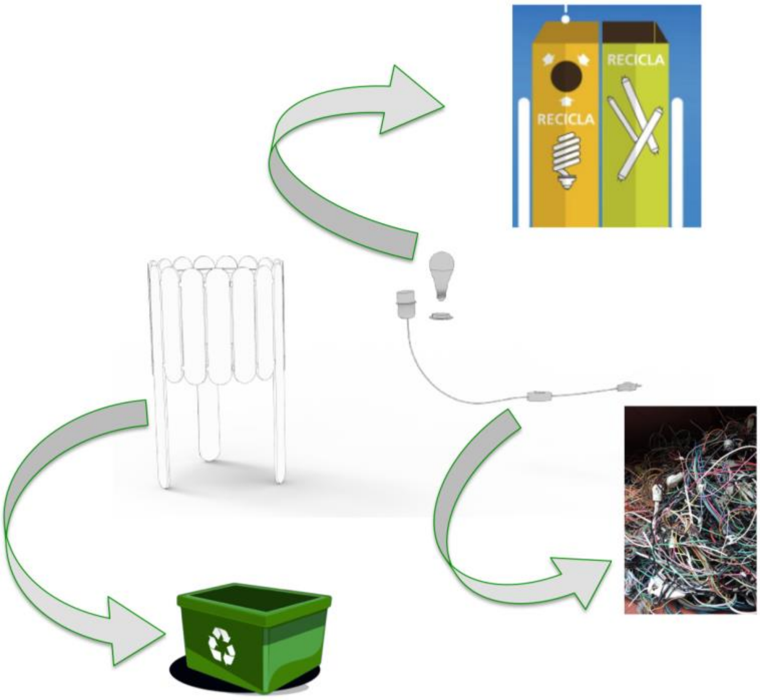


Figure 3.24 Illustrative recycling process for different components of the product

3.2.3.6 Bulb

In the first prototype of the product, LED modules (see Figure 3.25) are used, but this type of product in the end is not applied as it is a very technical product, that is, manufactures change the components of these circuits very frequently due to advances in technology, which occurs many times in our experience that when a replacement is needed but the model is not manufactured.

Figure 3.25 LED module

Second, it is not easy for a consumer to find this type of circuit in stores, so if any LED component fails, the user has to contact the seller directly or ultimately the manufacturer to buy a replacement.

Last, we have also taken into account that the product is sale in different countries where the voltage and the electrical power is different, which would force us to assemble additional circuits in the product.

Estándar LED bulbs (see Figure 3.26) is the bulb used in the product, based on the following consideration:

- It can be purchased in many common shops without the need to attend technical shops.
- It is a standardized product worldwide. No technical problems of voltage in each country.
- Easy to assemble and disassemble.

Figure 3.26 Estándar LED bulb

3.2.4 Market deployment

The market deployment strategy followed in CIRC4Life is based on the 'marketing mix' approach (Cannon, McCarthy and Perreault, 2008), which is based on four key elements (the 4 'P's): Product, Price, Place and Promotion. ONA will focus on the strategy development from these four perspectives to commercialize these prototypes in the next phase of the project period.

Figure 3.27 Prototypes of ONA demonstrators in the first phase of CIRC4Life

3.3 Sustainable practices for organic vegetable farm

Scilly Organics has been actively monitoring and reducing its carbon footprint for 10 years, using the Farm Carbon Calculator, a tool that business owner Jonathan Smith has co-developed. This has led to a consistent decrease in the environmental impacts of the business, through various means.

There are two main learning processes for the business when undertaking carbon footprinting. Firstly, it's the awareness of what emissions are created from what processes within the farm business. Secondly, it's the assessment of where the 'carbon hotspots' are in the business, which often turn out not to be what are commonly expected.

It is very important for farming businesses to assess, as accurately as possible, what Greenhouse Gas (GHG) emissions arise from the biological processes at farm level. Emissions from fertiliser applications, livestock, and soil cultivation are often the largest sources of GHG emissions from food products – yet can be the least expected. Conversely, soils and biomass offer enormous potential to sequester atmospheric carbon.

Understanding these processes thoroughly and taking action to minimise GHG emissions from farm businesses is essential. The analogy with reducing energy use in a house would be 'don't worry about your mobile phone charger, instead increase your insulation and decarbonise your heating'. Deal with the hotspots, not simply the peripheral issues, and ensure your actions are well targeted. The mantra 'every little counts' is not really true; instead it should be 'every big counts'!

3.3.1 Farm

3.3.1.1 Biological systems

As a farm without livestock, the greatest sources of biological GHG emissions arise from fertility building operations. These include green manure growing and compost making, both of which incur some releases of GHGs. However, they are an essential part in building soil carbon levels, which is effectively a counterbalance to GHG emissions.

As such, Scilly Organics will not be reducing the amount of green manures grown, nor of compost produced. Indeed, its intention is to increase the amount produced over the next few years, due to the increase in soil fertility and carbon that it creates.

Soil management is critical for the business to succeed, and to control its GHG impacts. If the soil is cultivated too deep and too frequently, soil carbon will be lost, water holding capacity decreases and fertility will drop. Therefore, the soil management policy of Scilly Organics is to:

- Minimise the number and depth of cultivations;
- Ensure green manures are a key part of the rotation, to ensure maximum ability to increase soil fertility using leguminous plants;
- Make and apply compost to all nutrient demanding crops (tomatoes, cucumbers, high value herbs);
- Apply fresh seaweed (storm-washed, from local beaches) to fields before nutrient hungry field crops (potatoes and salad);
- Minimise soil disturbance at all times;
- Plant more trees (for biodiversity, wood and fruit) to sequester more carbon in their biomass and soil under the trees.

Following a regime of Soil Organic Matter testing on an annual basis since 2009, Scilly Organics has seen an average of at least 11 tonnes of CO2 sequestered across the farm every year. The rate of increase is increasing in recent years. This shows a successful approach to soil management, resulting in positive environmental impacts. Future plans include further planting of perennial crops and more woodland to ensure greater tree cover.

3.3.1.2 Machinery use

One of the largest sources of GHG emissions result from fuel use on the farm. This is mostly attributable to diesel use in the 45hp Kubota tractor that is used on the farm. Tractor use during most parts of the year is fairly minimal and only used for heavy haulage. In the winter the tractor use is highest for seaweed hauling, and then cultivations in spring.

We are always very conscious of not using the tractor unless required. Some minimal savings could be made, but significant decreases in usage would only be achieved by using a smaller machine, or an electric powered tractor.

A smaller tractor would not be feasible to cover the requirements of the heavier haulage jobs, so this is not considered a prudent option. Electric tractors do exist but are currently very expensive and not widely available. However, in years to come this could be a viable option for the farm.

Other smaller machinery use includes a water pump, mower, and brush cutter. Recently the farm has invested in a fully electric mower, which has been successful. This is a small start in the move towards electric powered machinery, which is charged using 100% renewable energy.

3.3.1.3 Inputs

The main inputs, other than packaging (see section 3.3.3) are materials used in construction and repairs (wood, steel, etc), or horticultural supplies. All these inputs are not hugely significant in the carbon footprint of the farm, though there are clearly impacts in terms of resource depletion and material use. We are conscious of two guiding principles when thinking about using materials in the farm business:

- Reuse materials where possible;
- If buying new, ensure they are good quality and will last as long as possible.

Furthermore, there is an important element of planning involved. For instance, understanding if business expansion is planned (and therefore a new structure is required), the following questions are asked: is it of adequate size and functionality to last for many years; are the materials to be used of good quality; is the design itself sustainable?

Of materials bought in we aim to buy products with good environmental performance, if possible. For example, wood products are always FSC (Forest Stewardship Council) or PEFC (Programme for the Endorsement of Forest Certification) certified, a mark of sustainable forestry. We also buy wood from a timber supplier less than 100miles away from our farm, which is grown and processed locally.

Plastic to cover polytunnels (which are re-covered every 7-10 years) are from factories powered by renewable energy.

Plant raising compost – this is from sustainable peat (dredged from water reservoirs). Primary ('sapropel') peat is an ecological disaster, which is never bought (nor has been) by Scilly Organics.

3.3.1.4 Water

The farm is not connected a 'mains' water system, nor has its own borehole. It uses only rainwater for irrigation. The impacts of running this system are fuel for water pumps, and capital equipment (storage tanks and pipes) – this is all captured in the carbon foot printing process already.

Irrigation is only carried out on a regular basis in the polytunnels and glasshouse. Outdoor irrigation is extremely limited due to lack of supplies, and poor infrastructure.

In general, horticulture is a large consumer of water for irrigation, and very careful management of water resources should be employed. Water use can be minimised by:

- Sustainable soil management:
  - Minimise cultivations
  - Maximise organic matter levels in the soil
  - Maintain ground cover where possible
- Grow drought resistant crops and varieties
- Work with the seasons to avoid drought damage
- Grow perennials and deep rooting annuals if possible
- Use efficient irrigation, such as trickle irrigation
- Irrigate in the evening and at night to avoid excessive evaporation

3.3.1.5 Capital items

Capital items cover substantial physical items, such as buildings and machinery. These have substantial environmental impacts during production, including carbon emissions and resource use. Therefore, we calculate the impact of these items in our carbon footprinting, to understand their impact in the context of the overall carbon footprint.

Capital items are depreciated over 10 years, so 10% of the carbon footprint is applied to the overall carbon footprint over 10 years. When the item reaches 10 years old it has paid off its ‘carbon debt’. This is a similar principle to capitalisation in accountancy terms.

Scilly Organics has one 6-year-old tractor, that is still paying off its ‘carbon debt’, and one which is 15 years old. All other machinery is over 10 years old.

It also has two structures (a glasshouse and a polytunnel) which are 7 years old, and therefore still paying off carbon debts. The aim of the company is always to maintain capital assets in good condition, repair when necessary, and build new only when necessary.

There are some general rules of thumb to minimise the impacts from capital items:

- Tractors and machinery – keep them going as long as possible. We do not have a thirst for new machinery and have a reduced dependency on tractors due to the more labour-intensive system we run.
- Buildings – when building new, build to last! Maintain existing buildings as it will have a much lower impact than putting up new ones.

3.3.2 Business travel

Any travel for business needs to be accounted for fully. This is defined as travel for a business purpose, such as business meetings, conferences, events, sales, meeting suppliers, etc. Distribution of produce is accounted for separately.

The core farm business at Scilly Organics generates very little in the way of travel requirements. It usually adds up to one or two trips to events or conferences a year. When travelling we are very conscious of the carbon impacts of the mode of transport, and distances. We have a no-fly policy (except for the 15 mins flight from Scilly to Land’s End in Cornwall), and only drive when public transport is not a viable alternative.

Walking and cycling are the main means for travel on the island! In fact, the only vehicles we possess are tractors.
The principles for travel, in a circular economy context, should be:

- Do you need to travel at all? What are the specific and wider benefits of doing so?
- If you are travelling, how far? Is there a need to travel long distances?
- How many trips per year?
- When you do travel:
    - Use public transport if possible
    - Trains and buses have the lowest environmental impacts
    - Car use is particularly damaging if its one person per car
    - If you have to use a car try to use an electric vehicle powered by renewable energy
    - Flying has the most damaging impacts, not least because of the large distances involved.

3.3.3 Packaging

The plastic-free movement has been one of the fastest growing, engaging and impactful environmental movements of all time. It has rightly shone a light on the very wasteful practice of single use plastics, and the global waste and pollution issues they create.

An important note however is that, in carbon terms, the impact of packaging is quite low. In Scilly Organics our carbon footprint from packaging is under 5%.

The business uses the following packaging:

- Paper bags, made from 100% recycled paper, for potatoes, apples, carrots and other less perishable crops.
- Cardboard punnets, made from 100% recycled board, for tomatoes, strawberries, etc.
- Plastic bags, made from polythene, for salads and other leafy crops

Produce is transported is pre-used cardboard boxes, and polystyrene boxes – which are then used for a local ice cream business. Parcel tape is paper-backed tape (which is compostable) and labels are printed on 100% recycled paper.

The challenge for Scilly Organics is how to reduce the need for packaging and replace single use plastics with compostable alternatives from renewable materials (such as corn or potato starch). We have experimented with these alternatives before but found them largely unsuitable for our needs because (a) they are not translucent, and therefore the produce inside is not properly visible, and (b) they are semi-porous, which means delicate leafy crops will wilt and dry out. In general, for packaging, the hierarchy should be:

- Does it need to be packaged?
- Package with compostable materials
- Buy recycled and/or renewable resourced materials
- Use oil-based plastics as a last resort
- Collect used packaging for recycling

3.3.4 Office

This is one of the easier areas of the business to ‘green’. There is no electricity supply at the farm, but the office electricity is from a 100% renewable electricity tariff (from Good Energy), supplemented by our own solar PV panels. The office is heavily insulated, uses low energy lighting, and has fairly minimal energy requirements.

Recycled paper is exclusively used for printing documents and labels. Office paper-based waste is recycled. Phone contract, website hosting, banking and insurance services are all sourced from ethical providers. Investing and giving business to ethical companies that support the values that you also support is important.

Principles of office:

- Use 100% renewable electricity;
- Insulate the building well;
- Use low carbon heating if possible, make use of natural light, ensure ventilation and natural cooling is also maximised;
- Paper use:
  - Avoid paper use if possible;
  - Use 100% recycled paper products;
- Procure services from ethical and low carbon companies – from insurance and banking, to phone and internet;
- Internet use, cloud-based services and website servers in particular use significant amounts of electricity. Choose those that have committed to 100% renewable electricity use;
- Food and drink – use tap water (install an in-line filter if necessary), use organic and fair-trade products such as coffee, tea, milk, etc.

3.3.5 Waste

There are several sources of waste on the farm, though the majority are re-used and recycled on farm.
Organic wastes:

- This includes weeds, crop wastes, grass clippings, wood chippings, etc. These are all composted on farm and re-seed as soil fertility enhancers.
- The amount of crop wastes is very low indeed, and every effort is made to sell and use what is produced.
- No organic wastes leave the farm, and it is considered a resource, not a waste.

Inorganic wastes:
Various wastes are produced, mostly from purchased inputs, which are directly and indirectly linked to food production. The following types of waste are produced:

- Single use plastics, on inputs received
- Horticultural plastics
- Glass
- Metals
- Rubber
- Batteries
- Oil

A new waste separation and recycling is in place on the Isles of Scilly, which means the following can (and are) now be recycled:

- Cardboard
- Paper
- Metals
- Glass
- Hard plastics
- Rubber
- Oil
- Batteries

This means the only major item that can't be recycled yet is single use (thin) plastics. However, this is a significant amount of waste, not least from various horticultural plastics, and it is desirable that this situation be turned around.

Reducing material inputs:
Talk to suppliers about reducing the amount and type of packaging. Some positive examples exist – for example asking a supplier to use biodegradable packaging materials instead of a lot of plastic-based packaging. That company has now adopted that policy for all their customers!

3.3.6 Distribution & refrigeration

Carbon intensity of transport

- All distribution is local. On island deliveries are often done by walking, bike or wheelbarrow! Deliveries to other islands go via boat and van.
- Future plans include an electric off-road vehicle plus means of charging (solar panels plus batteries) on farm.
- Ideally electric boats would be in operation! Hopefully this will be reality in the future.

Refrigeration
Scilly Organics doesn't have any refrigeration. However, refrigeration can be a significant source of GHGs from businesses, and very careful management of refrigeration needs to be in place. This includes preventing leaks of gases from the system, choice of refrigerant gas, and careful disposal of waste gases.

Scilly Organics has been undertaking carbon footprinting, and management changes to reduce carbon emissions, since 2010. However, there is always room for improvements, and this year we want to go further to reduce the carbon and resource use impacts, in all areas of the farm.

3.4 Sustainable practices for meat product supply chain

ALIA is a company committed to sustainability throughout the whole supply chain. ALIA is involved in the whole supply chain of the meat sector: it owns the livestock feeding production, the farm and the meat elaborates stages. In addition, it participates in the slaughterhouse stage together with other companies of the sector.

During the last few years, ALIA has reduced the environmental impact of its actions, the decrease in energy and water (especially important in an area with a big scarcity of water as the Region of Murcia) consumption as well as the use of the renewable energy as solar energy and biomass have been important achievements for the company.

In addition, worker discrimination, health and safety for workers, consumers and local community, contribution to economic development, local employment and end of life responsibility are social aspects which are at the heart of ALIA's company.

In this direction, because of these efforts, ALIA's products have a lower impact in terms of environmental and social sustainability than the average of the sector, about 30% lower impact in both cases according to the LCA results in Task 1.2. However, there are still lots of opportunities in the meat sector and ALIA will work on reducing the environmental and social impacts of their products in the next few years. The demonstration stage of the project will be an opportunity for implementing new techniques and approaches in order to develop new sustainable products.

3.4.1 Practices in livestock feeding production

Improvement of energy efficiency of buildings.
ALIA has installed LED technology for the lighting system during 2018.The possibility of including new equipment for monitoring the processes and equipment with the highest energy consumption is being studied.

Windows, frames, facades or air conditioning systems will be improved with energy efficiency criteria when its necessary. The reduction of environmental impacts, from the beginning of the design of the process, until its end, is an aspect that is continuously evaluated in ALIA.

Improvement of sustainability of regular equipment.
Study of the susceptible equipment to energy improvement taking into account the energy audit report. The last energy audit report of the livestock feeding stage was done in 2016. Some of the actions mentioned in this document were included as recommendation resulted from it.

Substitution of materials used during the process by others less dangerous or with less impact for the environment.

Continuous optimization of the granulation process with the purpose of reducing energy consumption.

Use of renewable energy.
ALIA has a biomass boiler for thermal energy production. Most of the total amount of thermal energy needed is provided by it. However, it also has a fuel boiler as supporting equipment (to be used when the biomass boiler has to stop). Each year, there are improvements in the ratio of usage of the biomass boiler. This is due to the optimization of the process.

ALIA has also a photovoltaic plant with a power of 50kW which provides the 1% of the total electric consumption of the plant. The limitations to extend this plant is the lack of available space. However, it will be studied the possibility installation of more solar panels or other alternatives as small wind energy in order to reduce de CO_2 emissions of the energy consumption in the process.

Efficiency in water management.
The water consumed in the laboratory is reused for watering plants and trees on the green areas of the factory and also to supply water to the hydrant next to the plant.

The cleaning equipment are purchased in order to reduce water consumption (i.e. Karcher).

Awareness campaign to save water among the staff are conducted every year. Posters and advices are shown in the factory.

Innovation in animal feeding in order to reduce pollutant charge of the slurry.
In the last few years, ALIA has been involved in different innovation projects as *'Swine Feeding: Food Safety and minimizing the environmental impact of slurry'*. CDTi Funding (EDRF Funds). Purpose: to minimize the pollution of slurry through animal feeding. 2006 - 2008.

ALIA has an R&D department who is in continuous improvement of the nutritional formulas in order to reduce pollutant charge in slurry.

Reduction of antibiotics and additives in the nutritional formula.

The R&D department develops innovation projects to reduce the amount of antibiotics and artificial additives needed. ALIA is currently working on two different projects to achieve this objective:

- SALUP: the main objective of this project is to reduce the use of antibiotics through new fibre prebiotic sources.
- MICOTOXIAN: the aim of this project is to develop animal feed for pig livestock through the selection and combination of natural additives to reduce the mycotoxins in the feed.

Reduction of nutritional formula’s environmental impact.
As it has been shown in the E-LCA description of ALIA’s products, the livestock feeding stage is the one with the biggest impact. In addition, it has been shown that soybean content in the nutritional formula is one of the major causes of this impact.

ALIA will develop a sustainable nutritional formula in which the content of soybean as well as other products will be reduced in favour to local and more environmentally friendly products with similar characteristics.

The use of by-products from other industries for the development of animal feeding products is other vital aspects for reducing the environmental impact of this stage. The R&D department is currently working in the incorporation of by-products from other industries in the nutritional formula, in order to save costs and give value to other industries waste. The research work of the department has resulted in the use of the next list of by-products as fat source and proteins:

- Biscuit flour.
- Wheat milling rests.
- Beet pulp.
- Soybean husk.
- Rapeseed flour.
- Sunflower flour.
- Corn “Ddg” (corn without starch).

The department is working in the addition to new by-products as:

- Colza cake.
- Sunflower cake.

These by-products are obtained from national industries (almost in every case) and a lot of them are even obtained from bordering regions. The department is also currently working in the use of by-products as probiotics: citrus pulp, carob, malt rootlet.

Sells in bulk and in big quantities for the reduction of packaging material and the reduction of transport needs.
ALIA sells the 90% of the total amount of animal feed in bulk. Farmers go to the factory with their own storage silos and load the quantity of animal food desired. An information campaign about the environmental and economic benefits of buying in bulk is being developed. However, for those who don’t need big amounts of animal food, ALIA also has the option of buying in sacks. These sacks are made from paper. The weight of sacks is in line with health and safety regulations, and the weight is 40kg.

Different alternatives are being studied such as the use of raffia or the optimization of the package format. However, there are difficulties related to this concern, not only because some client’s preferences, but also because of the equipment needed. The different existing formats in the market are being studied in order to optimize them and reduce paper consumption.

Distribution
A management route system has been installed at the end of 2018 in ALIA’s facilities. This system will help the company planning of routes and the fuel consumption and CO_2 emissions will be reduced. ALIA has 12 lorries and daily distribution. In addition, it is being studied the possibility of replacing some of the oldest heavy

vehicles in the fleet with the highest consumption. Alternatives fuels will be considered when this purchase is necessary.

Waste management
Organic waste, plastic, paper and carboard and glasses produced in the facilities are recycled. In addition, paper and cardboard waste is used directly for the production of pallets.

Besides, selective separation of other products is performed. Some of them are: workshop equipment, aerosol sprays, acid and basic substances, halogenated and non-halogenated solvents, lighting bulbs, toner, and batteries.

The substitution of materials by others which are easier to recycle at the end of their useful life, is another action that is being considered in every stage.

Minimization of resources needed for animal feeding
By planning the feeding process by phases, higher transformation index is achieved. This means improvement of fattening capacity, reduction of energy and water consumption, reduction of the consumption of other resources etc., while obtaining the same quality in animal feeding. At the feeding manufacturing level this means manufacturing different formula for each phase of animal growth.

Green procurement
Defining criteria for green procurement is taken into account in the livestock feeding plant. The proximity of the supplier is one of these criteria considered. ALIA will add to these criteria that will consider that the supplier has an environmental management system.

It has to be mentioned that ALIA livestock feeding has an environmental quality certification (ISO 14001) implemented. Every year, environmental objectives are updated and new actions are proposed.

3.4.2 Practices in livestock farm

Energy renovation of buildings.
LED technology will be installed when the lighting equipment needs to be changed. Energy renovation of the building will be implemented progressively.

Use of renewable energy.
A biomass boiler was installed at the end of 2018 for the supply of thermal energy. This has made a big impact in the reduction of CO_2 emissions in this stage.

Animal welfare.
ALIA's farm are in line with the current normative about animal welfare. In February 2019, ALIA's farm certified with the "INTERPORC ANIMAL WELFARE SPAIN", being one of the first companies with this certification. This certification will be renovated every year as a sign of ALIA's commitment with animal welfare.

Management of the slurry produced in the farm.
To deal with this problem, ALIA is not only working in the reduction of the pollutant charge of the slurry through animal feeding, but it is also working in implementing the most sustainable way for slurry treatment. In the past, ALIA was involved in two projects to improve the treatment of it:

- **MANEV**. LIFE+09 ENV/ES/0000453. Collaboration with Murcia CSIC. Purpose: Use of different slurry treatment technologies in different areas of Europe to reduce GHGs and improve livestock activity.

- **'Agronomic valuation of slurry and swine effluents'.** CDTi Funding (EDRF Funds). Purpose: to study the environmental effect of sustainable agronomic valorisation considering different types of slurry, different application doses and different crops. 2011 - 2013.

ALIA is currently involved in **RE-LIVE WASTE** project, funded by the Interreg MED program. The main objective of this project is to transform livestock waste into organic high-value commercial fertilizers (as Struvite), contributing to smart and sustainable growth and to the creation of new businesses and market opportunities. ALIA will carry out the implementation of innovative technology for separation of liquid and solid fractions of the slurry generated to reduce N and P contents, so the pollutant load will be diminished. After that step, this slurry will be treated in a Struvite Precipitation plant. This process will be performed during the RE-LIVE WASTE project implementation, after that, the possibility of continuing doing it will be also considered.

In addition, this new equipment will add high value to the slurry, as it would be possible to reduce the solid part as compost or fertilizer, and the liquid part may be used by agricultures for watering the crops as the N content will be reduced.

In addition, ALIA has agreements with local agricultures, which use the slurry as fertilizers. The agricultures which collaborates with ALIA are in an action radio of less than 20 km. Directive 91/676/EEC, limits to 170 Kg N/Ha in vulnerable areas can be applied (European Council, 1991), so, because of the N content, not unlimited amount of slurry can be used as fertilizer if the N content is not reduced.

<u>Efficiency in water management.</u>
The cleaning equipment are purchased in order to reduce water consumption (i.e. Karcher). The water used in the cleaning is collected in pits and mixed with the ejections of the animals (forming the slurry) so that the pollutant charge is reduced, and the solid and liquid part of the slurry can be treated and exploited.

<u>Reduction of the use of antibiotics</u>
Organic acids in water are used for its sanitation, so the animals are protected against microorganisms and there is a reduction of the use of antibiotics.

3.4.3 Practices in slaughterhouse

As aforementioned, the slaughterhouse stage is not owned by ALIA in a 100%. This is the reason why some aspects are not ALIA's direct responsibility and to improve the process has more difficulties. However, there are still some aspects which will be implemented.

<u>Energy renovation of buildings and equipment.</u>
The energy (electricity) consumption causes the major impact in this stage, this is why energy efficiency actions and the use of renewable energy should be main objectives for it. Some of the actions that may be implemented are mentioned below:

- Progressive installation of LED technology.
- Air conditioning and heating equipment.
- Addition of isolation in some façades and in the steam pipe.
- Continues optimization of process so it is possible to reduce energy consumption is done.

The incorporation of a biomass boiler has been contemplated in this stage of the supply chain. However, due to the closeness to the urban area and fumes produced by such a big boiler, it was not feasible to do it. In future facilities of the slaughterhouse which will be located not so close to the urban area, this will be considered again.

Efficiency in water management.

- Installation of an osmosis plant to use other sources of water in certain areas.
- Addition of electronic taps in 70% of the installation (where water consumption is higher).

3.4.4 Practices in meat elaborates manufacturing

Energy renovation of buildings.
In this stage, the energy consumption is also the one with the biggest impact according to the environmental LCA results. The progressive installation of LED technology, air conditioning and heating equipment and the addition of isolation in some façades and in the steam pipe are some of the examples of actions to be implemented. In addition, the future use of renewable energy is being considered.

Energy efficiency in the process.
Production is planned so the use of installations and equipment is reduced to be used only when needed. For example, the drying of the product is one of the processes which has a higher energy consumption. So, the process is optimized in order to use it only when it is at the highest capacity levels. Every year, processes are planned in order to reduce the energy consumption of the whole plant.

Efficiency in water management.
Different actions are implemented in the factory in order to improve the efficiency in water management and to reduce water consumption. These kinds of actions are subject to continuous improvement. The meat elaborates plant has reduced the water consumption about a 50% from 2007 to 2018.
This was achieved by implementing different actions:

- Proper planning of the production to minimize the cleanings of the equipment. There is a planning for the production of similar products at the same time, so that water consumption for the cleaning of the equipment used is optimized.
- Adjustment of the water flow to the consumption needs of each operation.
- Installation of devices for the regulation of the flow.
- Installation of sectorized closure systems of the water network, which allows the supply of a zone to be cut off in the event of a leak.
- Wastewater pre-treatment (primary treatment: grease separation and solids decanting).
- Separative network and segregation of the rainwater discharge.
- Installation of water meters in processes.
- Acquisition of low consumption equipment.

Business models that promote the reduction in the use of packaging.
In butcheries of Lorca region, almost every shop has products from ALIA. In these establishments, sales in bulk are the most common practice. ALIA will continue supporting this kind of business models.

Distribution
Distribution routes are planned in order to reduce the distance travelled. However, due to the few number of vehicles, a software for the management of the fleet is not needed.

In the previous sections, actions to be implemented in the whole supply chain have been proposed in order to develop new sustainable products in the meat sector. Some of the actions which are already implemented in ALIA's process will be progressively improved. During the demonstration stage of the process, this list will be a basis for the selection of the activities to be develop for the co-creation of the two products ALIA will develop with environmental and social criteria.

4 Eco-procurement in the industrial LED lighting sector

4.1 Background

Currently, more than 80% of the lighting systems Kosnic sell are designed and manufactured on Kosnic own premises. The company has an environment policy which aims at reducing the use of non-renewable resources, recycling, waste management and awareness raising on sustainability issues. Energy-efficiency is regarded as a key objective in the production process and all products are composed of multiple units . This means that individual parts can be replaced instead of the whole unit and the discarded parts can be recycled.

To be in compliance with the company environmental policy, Kosnic products must fulfil the following requirements:

- Energy consumption must be at least 25% and the fossil energy consumption at least 50% below the average consumption of the state of the art;
- The cost must not exceed 10% of a comparable standard product;
- Used products must be disposable in at least the same way as average standard products.

4.2 Information on the product and the associated lighting service

The general tendering process in Kosnic is to ensure that the lighting product/systems to be managed in an exemplary manner and achieve the best results possible in terms of energy efficiency and environmental performance. In order to achieve this objective, the following standard are usually considered for eco-procurement.

- General maintenance of the whole system;
- Reconstruction and replacement of the lighting units;
- Operation of the lighting systems, and
- Energy management

Kosnic's eco-solution for lighting services comprised the following innovative aspects:

- Integration of green criteria throughout the implementation of the tender (Table 4–1);
- Continuous improvement;
- New environmental technology tested and applied;
- Continuous auditing and monitoring system of the strategy and management of the lighting system.

From an environmental perspective, the following measures have to date been implemented:

Table 4–1 Kosnic's lighting services

Components of the lighting service for tender	Sustainable features
General maintenance of the installation	• Digital lighting system (management software) to guarantee automatic and flexible lighting service, save time and costs as well as avoid excessive resource use. • Use of liquefied petroleum gas (LPG) vehicles in carrying out the contract to limit CO2 emissions.
Reconstruction and replacement of the asset base	• Replacement of the equipment with energy-efficient equipment. • Recycling of the old material and reconstruction with recyclable material, such as glass or cast aluminium.
Operation of the lighting systems	Focus on the reduction of the energy consumption: • Implementation of power reducers and electronic 33 ballasts. • Automatic light modulation (dimmer switch). • Reduction of light pollution.
Energy management	• green energy provided from hydropower. • Use of solar power is in schoolyards and parks is currently being piloted.

4.3 The eco-procurement criteria in industrial lighting sector

Given the level of technical knowledge required to develop the environmental criteria, a series of eco-procurement criteria are usually developed and introduced by the tender to addressing issues such as energy efficiency, renewable energy, reduction of light pollution, and use of recycling material. Sometimes a consultant firm is also part of the tender commission, and hence participated in the examination of the offers provided by the bidding parties. After submitting their bids, the bidders are usually invited to technical interviews, to discuss the technical means of the contract with the tender commission.

Some general sustainable criteria included in the tender are described as follows:

- Reduction of the energy consumption;
- Optimal use of renewable energies;
- Improvement of life quality: suppressing excessive lighting and light pollution;
- Use of recycling materials (masts, apparatus, wall brackets, etc.);
- Replacement of obsolete materials;
- Development of new innovating eco-technologies.

Except the qualifications that the bidders have, the tender usually also focus on the experience of the supplier to provide different kind of maintenance services. The bidders are allowed to submit variants of the offer on the condition that they wouldn't exceed the fixed annual budget. The Tender presented its detailed attribution scheme, including the green award criteria chosen for the evaluation of the bids and the corresponding attributive points (Table 4–2). Table 4–2 is an extract of the award scheme table used by the tender to evaluate the results in a recent bid that Kosnic attended. Only the sections and subsections containing or corresponding to green criteria are appearing, also leaving aside the criteria corresponding to other aspects of sustainable development than the environment.

Table 4–2 Green criteria used for the award phase

Sections and green award criteria used	Points
1. RECONSTRUCTION AND COMMITMENTS TO THE RESULTS:	**/140**
• **Reconstruction of the asset base:** - waste management policy	**/90** /5
• Implementation of innovating and cost-effective equipment with positive impacts on sustainable development: - Quality, choice and lifecycle of the equipment - Reduction of light-pollution - Technologic innovation	**/40** /15 /10 /15
2. ENERGY	**/100**
• **Commitment of the bidder towards the reduction of energy consumption** - Commitments in terms of kWh consumed /year - Year of implementation of the commitments of consumption in kW - Operation mode of the installations - Critical examination of the existing asset base - Power reduction - Control of the applied power	**/50** /10 /20 /7 /5 /5 /3
• **Commitment of the bidders towards the provenance of the electricity and towards sustainable development** - Suggestions for handling sustainable development	**/35** /20
3. MAINTENANCE AND QUALITY OF THE SERVICE	**/60**
• **Assistance and attendance on the City's sustainable development projects** - integration and environmental considerations - suggestions for communication	**/8** /4 /4
TOTAL (IN BOLD)	**300**

Specific targets in the eco-criteria are not always requested in the main tender document; however, Kosnic usually provide to a number of related documents, which can include a series of recommendations for the disposal of waste, the use of environmentally friendly packaging and recyclability of material as well as materials that should be avoided. For instance, suppliers are not allowed to use PVC for the lighting envelope. The bids sometimes had to comply with the local urban planning documents and road regulations.

4.4 Awarding the contract and contract management

Following the evaluation phase, Kosnic was awarded the contract, mainly because sustainability was integrated throughout the whole offer, according to a transversal approach. Kosnic is able to be responsible for the management of the public lighting services. As it is usually specified in the tender documents, the service is regularly evaluated and discussed with the associated authority departments. Regular discussion and continuous evaluation of the results, compliance with the results engagements: correction actions when the results are not satisfying or do not correspond to the commitments.

4.5 Barriers and lessons learned

No major barriers or difficulties have been mentioned in this bid. The specific tender requirements were regarded as highly challenging from a technical perspective. The main difficulty was to obtain maximum light output with minimum energy input in order to reach a clearly defined light level.

To split the tender procedure in two phases is seen as a very effective approach to obtain the best offer on the market of the product concerned. To invite interested suppliers to assist in defining the tender criteria gave a strong signal to the market and triggered the production process. The approach added to the transparency of the tendering process and opened it up to fair competition.

5 Development of leasing service for industrial LED lighting products

5.1 Sustainable strategies and business concepts to support energy and resource efficiency

Sustainable business model strategies can be grouped in three major categories (Bocken *et al.*, 2014):

- Technological strategies;
- Social (or behavioural) strategies;
- Organizational strategies.

This literature highlights the potential sustainability benefits in each of the archetypes:

- Maximize material and energy efficiency;
- Create value from waste;
- Substitute with renewables;
- Deliver functionality rather than ownership;
- Adopt stewardship role;
- Encourage sufficiency or support slow consumption;
- Repurpose for society/environment;
- Develop scale up solutions.

Real life business cases are usually more complex and combine elements of several approaches and archetypes. Translated to LED lighting applications, the following eight product service system concepts can be distinguished:

- Product related service: spare components sales, extended warranty, etc.
- Advice & consultancy: lighting planning, light studies, specification design, etc.
- Product lease: financial operation that allows the customer to spread the investment where the ownership in general eventually can go to the end user.
- Renting, sharing: for lighting this will be limited to easy transportable lighting products that have a high intrinsic product value but temporally used by end users. An example is design lighting used on trade shows and events, outdoor of grid lighting for temporary event driven needs.
- Activity management: this is the dematerialized service associated to the lighting like daylight controls, calendar controls, data capture and data management for predictive maintenance, use profile analysis, etc.
- Pay unit of use: for lighting equipment a very limited to a sale per hour of light use. Contract where the payments are based on hours the lighting is used.
- Functional results: these are the light as a service (pay per lux) models, where the end user pays a monthly fee for having a lighted working area. All investments and technology may remain with the lighting product supplier.

Consideration of the behaviour of the user is paramount in reducing environmental impacts and closing material circles. An important aspect in this regard is the lifetime of the LED product: how long does the customer actually use the product? This product lifetime is determined by both technical and non-technical aspects, which are outlined as follows:

- Impact on extension of life cycle: increasing technical lifetime.
- Impact on extension of product usage: increasing the use time (economic lifetime) by timeless design, upgradeability etc.
- Impact on optimization of product use phase: more value out of the product-service reduced energy consumption; higher light output, dimmable or controllable lighting etc.
- Impact on raising product use intensity: this again links to the renting and sharing which is only to a limited extend applicable for lighting products.

Also, the service concept throughout the lifetime plays an important role in the behaviours/use of the LED product by the customer. Servicing can create the high quality, high tech product perception that is needed to motivate the customer to maintain and repair the lighting product instead of discarding it when new designs or technology features appear on the market. The environmental impact is highly dependent on how the service is linked to the product. If service is used to sell more and faster spare components, or refurbish products prior to technical obsolescence, the environmental impact might even increase, due to the embodied impact of replacement and disposal in this way, services can have a significant rebound effect on the environmental impact.

On the other hand, the services supporting the product life extension technically and economically can significantly reduce the environmental impact. In practice, the relation between a business service and its environmental impact is not absolute. The business service has to perform in a context and are applied and build up based on assumptions and aspirations. While implementing innovative business service, these assumptions must be validated and updated, and services/models fine-tuned accordingly.

Based on the above, an important question is raised: ‘How is it possible to generate stable revenue streams in an innovative business service oriented towards the highest technical lifetime and energy and resource efficiency?’ Kosnic and other involved partners recognized the need to search for additional value related to the product longevity. The next section, we will focus on capturing the value of innovative services/practices in LED lighting solutions throughout the product lifetime.

5.2 Value drivers for innovation business practices in LED lighting sector

In traditional business models most customers do not want to pay extra for green or sustainable products or are not yet concerned with a total ‘environmental’ lifecycle cost at time of purchase. What are the innovative business models and other benefits that potentially could offset the costs?

- The majority of the lighting industry uses the classic sales business model or a variation of it. Often the product sales are extended with some kind of services. Product selection including lighting plans are the most popular service offered followed by the customized product offering like modular lighting concepts or custom length of lighting armatures. Furthermore, lighting controls are offered as well as lighting installation often by partners (contractors) are being deployed.
- Additional none conventional services are entering the lighting market. Primarily Energy Service Companies provide the lighting and are financed through the energy savings their customers gain. Multiple variations exist (guaranteed savings, shared savings, etc.). Literature illustrates the characterization of economic potential of such business models (Van Ostaeyen, Vanhees and Duflou, 2013). Furthermore, models like design-install and operate, leasing and contracting functional use are available in for some market segments. Finally, also a limited number of companies implemented result-oriented business models (Pay per lux).

The cost associated to further implement innovations obviously depends on the business model used. By providing services the additional customer value offsets the associated service cost. By introducing service activities that increase product lifetime the cost tends to increase faster than the customer value due to:

- product design of installed products requiring expensive service operation and spare components;
- scattered product install base impacting the service logistics cost;
- retrofitting products deliver sub optimal performance on light output and energy use due to the fast evolution in LED technologies.

Service driven result-oriented business models like (pay unit of use, pay per lux) have additional cost associated.

- The most significant cost is the high investment cost in lighting equipment (luminaires, controls, etc.) that are only over time are offset by the monthly income. The associated financial risks and credit assurance might be significant.
- Investments in additional sales channels and sales methodologies and markets: defining the economic characterization for profitable services.
- Service cost highly determined by the product quality, product selection and knowledge of the application conditions.
- Cost related to reverse logistics, product stewardship, storage, etc.

The benefits are higher value for the customer that can be captured. This additional value can be situated in several areas like reduction of total cost of ownership (primarily by energy reduction), lower or no investment cost for the customer, often improved light quality, trouble free installation and commissioning, longer product lifetime, etc.

Besides the direct additional value capture the benefits for the lighting manufacturer can be found in:

- Indirect value capture by servicing cross selling of products and services can be generated;
- Long term monthly income;
- If product quality allows the service contracts can be extended beyond the financial depreciation of the products.

The above highlights the need for innovative business models as well as the need for appropriate products that fit the business models.

The input from **WP1** (Co-creation of Products/Services), **WP6** (Demonstrators) and **WP7** (Stakeholder Interaction and End-user Involvement) learned that providing services to the products has a large impact on the product development. The product quality should allow predictive maintenance at low cost which requires reliable controls and modular design supporting serviceability etc. It seems that within the classic business model (selling products) the cost often offsets the benefits for innovation practices in lighting sector. So, the value drivers for innovation should be expected in other life cycle phases.

5.3 The leasing service scheme of industrial LED lighting products

Leasing promotes the use of products which are otherwise expensive for customers. There is various research carried out on the leasing of office furniture within the product-service system literature (Mont, 2002; Besch, 2005; Kang and Wimmer, 2008). Product-service systems started to be developed in the late 1980s. It is found that many companies are using leasing to give service-oriented solutions to business customers, including in the LED sector. A limited number of European manufacturing firms provide leasing services.

LED leasing could also be considered within the scope of 'green lease'. The aim of green lease is to ensure that a leased property has been constructed and managed with sustainable technologies. The tenant and the landlord could also document the sustainability of the property through certification. It is argued that the green lease is on the rise and that there is a convergence across Europe (CMS, 2011).

For the new modular design based industrial lighting LED luminaire, accordingly, Kosnic is proposing a leasing service in which a full maintenance cover is included. Due to the vast energy savings that LED lighting can offer (especially within the industrial sector), the estimated saving on a client's electricity bill should be able to cover the leasing service charge without extra financial burden. Flexible payment plans can be provided to suit the customer's individual financial situations.

5.3.1 How it works

LED Lighting offers a unique opportunity to significantly reduce your energy consumption. In some circumstances, lighting accounts for up to 40% of a building's electricity consumption. Moving to LEDs from conventional light sources such as fluorescent, high intensity discharge and halogen, can achieve substantial cost savings. In fact, the lighting energy bill could typically be reduced by as much as 40 – 60%. Adding smart lighting controls can increase these savings even further.

Some businesses and organisations may not be able to make the capital investment to access these savings. For others, the priorities for capital investment may be geared towards business growth. Kosnic and expert associated service providers can offer customized solutions so that any business can realise the benefits of switching LED lighting by leasing the LED lighting products. The main actors and their main services are illustrated in Figure 5.1.

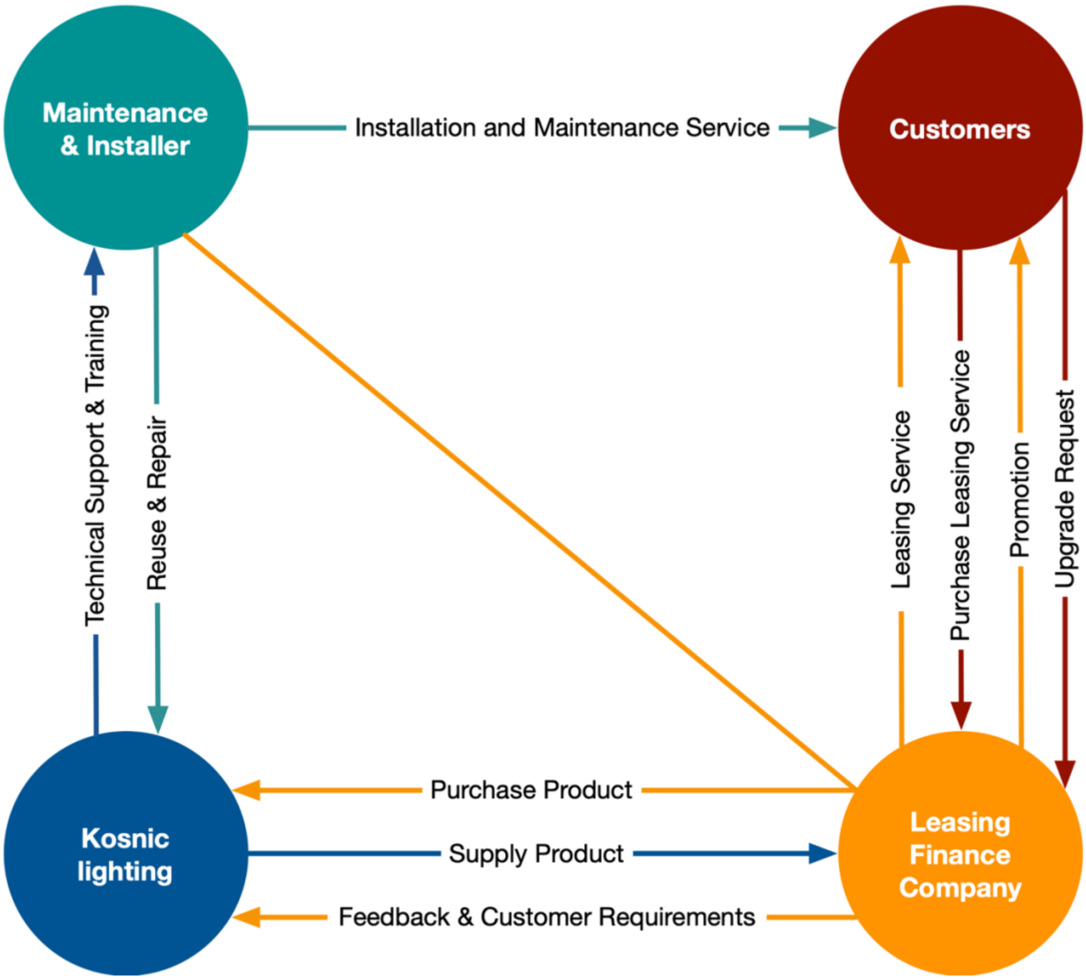


Figure 5.1 Actors and their commitment in the leasing service scheme

Overview of the procedures:

1) Kosnic meets with the client to identify viability for the scheme (viability criteria include a minimum project value of £10K plus and energy payback period.).
2) If the client is interested, Kosnic sends details to the funding partner for the purpose of a credit check prior to the commencement of any work. They will prepare a personalised illustration which will include the payment term and fixed monthly cost of rental.

3) Once the client has been approved, Kosnic carry out a detailed site survey and produce energy savings calculations and payback periods for the client.
4) The client is provided with the lease repayment schedule by the funder and will agree specific terms for their contract.
5) Kosnic arrange the supply and installation of the new fittings and the client commences lease payments to the funder.

Maintenance and technology upgrade:

Kosnic operate to very high-quality control procedures. Very occasionally products may fail prematurely. Kosnic therefore offer a full warranty throughout the lease period, for up to 5 years (emergency lighting 2 years). We will replace or repair the luminaires completely free of charge.

At the end of the leasing agreement, clients have the option to take advantage of the continual improvements in LED efficiency and upgrade to the latest technology, by arranging a further lease agreement. Consequently, this removes any worries of using redundant technology. Simply trade up to the latest, most energy efficient products available with continued full warranty.

Benefits:

- LED Lights can be paid by the energy and maintenance savings.
- Makes the latest in LED technology affordable.
- Offers real value to businesses with limited capital, or those that need to manage their cash flow.
- Keeps money available for other income producing opportunities.
- Manufacturer’s warranty 5 year
- You own the lights at the end of the lease
- Small monthly payment to cover the cost of the products, installation and ongoing maintenance fee.
- The monthly fee will be covered by the electricity cost saved each month.
- Hustle free, the fitting will be regularly checked and fixed if necessary.
- The typical leasing duration is 3-5 years and the leasing contract can be as long as 10 years to minimise the monthly payment, although a long leasing contract (10 years or above) maybe a risk both for customers and leasing company.
- The leasing contract be flexible, and the contract can be transferred and updated if there is a better option available or terminated early as long as the remaining financial cost is covered.

5.3.2 Flexible payment options for industrial applications

Figure 5.2 shows two type of payment plans: stepped payment plan and flat payment plan, which we propose to offer to our leasing customers and use 10 years leasing contract as an example for illustration purpose.

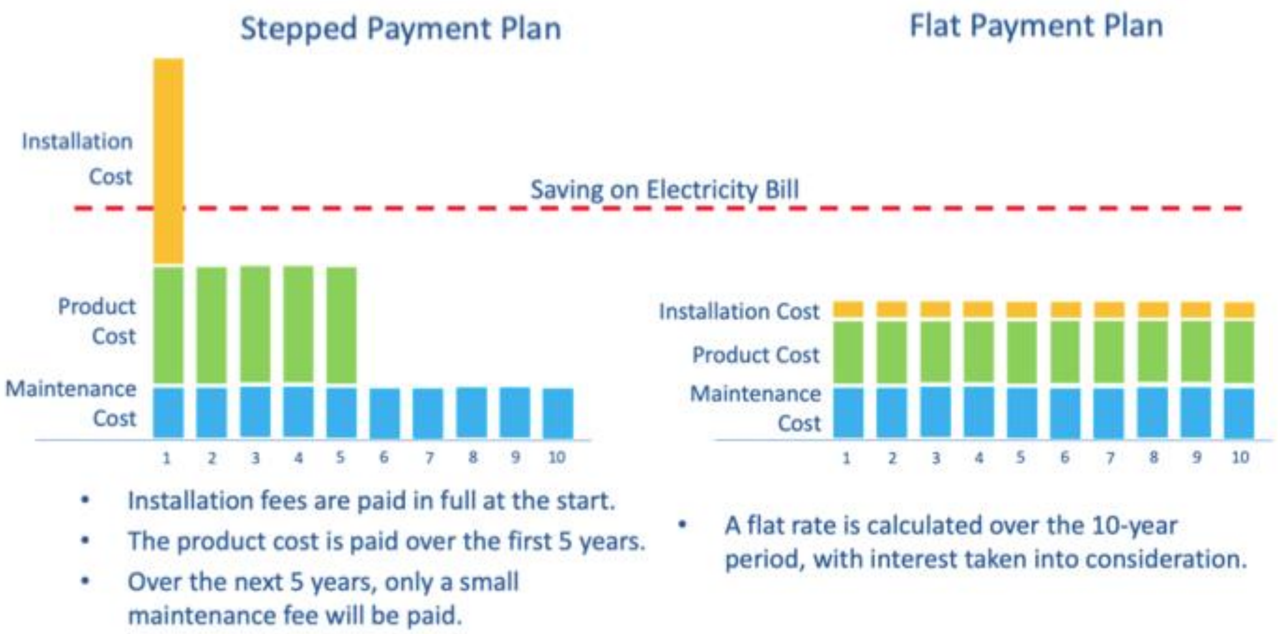


Figure 5.2 Type of proposed payment plans

Table 5–1 representative cost savings based on a large warehouse fitted out with 320 T8 fluorescent fittings of various types which burn for 5000 hours each year. This example looks at the associated costs of the current installation compared with LED replacements over a typical 5-year lease period. As Table 5–1 shown, there is a combined saving of over £20,000 during the 5-year period with considerably more to be made in the years that follow. In addition, this example scenario would also result in a reduction of over 450,000 kg CO_2 which equates to CO_2 emissions from 185,664 gallons of gasoline consumed[2].

Table 5–1 Comparison of costs illustration

	Fluorescent (existing installation)	LED (new installation)
Energy Consumption:	1,350,000 kWh	485,000 kWh
Energy Cost (7.9p per kWh):	£106,650	£38,315
Maintenance Costs:	£5,500	£0
Fittings and Installation: (repaid through lease)	£0	£53,000
Total Costs:	£112,150	£91,315
Total Savings:		£20,835

5.3.3 Further test arrangements

According to Kosnic overall preliminary demonstration schedule, detailed leasing service activities are planned to improve this new business model in the second phase of CIRC4Life project (from September 2019 to October 2020):

[2] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

- Arrange one-to-one meetings with identified FM company/service providers.
- Conduct meetings with FM company/service providers and learn about their current business practices and their thoughts on Kosnic proposed modular product/leasing service model.
- Decide on whether FM company/service providers are a good match to be a project partner.
- Adapt and modify Kosnic product/service ideas accordingly using feedback from the meetings.
- Identify the potential business partner from different areas that apply to the functionality of the leasing service business model such as insurance and finance company and apply same approach method as above.
- If necessary, a further one-day workshop on the leasing service model with these potential business partners could be arranged to enhance Kosnic proposed leasing service model.

6 Conclusions

An important aspect of viable circular business models is the evolution of value throughout the complete life cycle of products. In this regard, WP1 (Co-creation of products/services), WP2 (Collaborative recycling/reuse), WP3 (Sustainable Consumption) deliver important input (insights and concrete figures for analysis). The synopsis of WPs 1-2-3 gathers all relevant information needed to develop feasible business models.

For each of the four demonstrators, a dedicated production processes were described and elaborated through internal workshops/meetings. During the implementation/development of the demonstrators, their specific production processes were further detailed, adapted and assessed by using eco-point approach. The real business environment of the demonstrator companies provided valuable insights and a reality check on their practical application. The influence of the sustainable methods/practices on the development of the demonstrator products and the way they are marketed will deliver significantly lower environmental impacts, through resource efficiency and energy efficiency measures supporting product longevity, servicing, stewardship, upgradeability and light as a service approach.

Sustainable methods have been defined with support from expert technical and industrial partners within CIRC4Life consortium and refined through live application within the development of the two demonstrator products in domestic and industrial lighting. The technical characterisations of longer lasting, resource efficient and recyclable LED lighting products are explored within demonstrator company business model scenarios.

The resulting leasing service for lighting sector to support requirements to manage sustainable innovation in a commercial context, and operation of leasing services, specifically for SMEs across the LED value chain.

7 References

Besch, K. (2005) 'Product-service systems for office furniture: barriers and opportunities on the European market', *Journal of Cleaner Production*. Elsevier, 13(10–11), pp. 1083–1094.
Bocken, N. M. P. *et al.* (2014) 'The front-end of eco-innovation for eco-innovative small and medium sized companies', *Journal of Engineering and Technology Management*. Elsevier, 31, pp. 43–57.
Cannon, J., McCarthy, J. and Perreault, W. (2008) *Basic marketing. A marketing strategy planning approach*. New York: McGraw-Hill.
CMS (2011) *CMS STUDY ON THE USE OF GREEN LEASE CLAUSES IN EUROPE*. Available at: https://cms.law/en/INT/Expert-Guides/CMS-Study-on-the-use-of-Green-Lease-Clauses-in-Europe.
European Council (1991) 'Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources'.
Kang, M.-J. and Wimmer, R. (2008) 'Product service systems as systemic cures for obese consumption and production', *Journal of Cleaner Production*. Elsevier, 16(11), pp. 1146–1152.
Mont, O. K. (2002) 'Clarifying the concept of product–service system', *Journal of cleaner production*. Elsevier, 10(3), pp. 237–245.
Van Ostaeyen, J., Vanhees, H. and Duflou, J. R. (2013) 'Energy service companies for office lighting: Characterization and economic potential', in *Product-Service Integration for Sustainable Solutions*. Springer, pp. 561–572.