Ecodesign Preparatory Study
Lot 27 UPS
Life Cycle Assessment – Inputs/Outputs
Briefing note

Introduction

The aim of this briefing note is to provide stakeholders with an update on the work since the last stakeholder workshop, September 2012. It is also an opportunity to provide stakeholders with preliminary results on task 5 (Definition of Base Cases and Environmental Impact Assessment). This, we hope, will assist and guide discussions during the upcoming second stakeholder meeting. The document is in two parts with a 4 pages summary, and appendices that provide more detailed data and commentaries.

Since September 2012:

- We have updated and completed task 1: Product Group Definition, task 2: Economic and Market Data and task 3: Consumer/User Behaviour and Local Infrastructure following the first stakeholder meeting. The final draft reports are available to download from the project website www.ecoups.org. Stakeholders can still provide feedback or submit additional information on these reports by e-mailing the project manager at ecoups@ricardo-aea.com.
- We released a second questionnaire to stakeholders (October 2012). The primary focus of this questionnaire was to understand and to collect data on materials that make up UPS.
- Task 4: technical Analysis of Existing Products and task 5. Definition of Bases Cases are well underway, and will be completed following the second stakeholder meeting.
- We have started to look ahead in detail to task 6: Technical Analysis of best Available Technology and task 7: Improvement Potential.

Task 4 of a preparatory study focuses on a technical analysis of existing products. From this, representative base case(s) are devised that provide an appropriate representation of products for use in life cycle modelling using the EcoReport Tool[1] in task 5. Task 4 generates a bill of materials (BoMs) for representative products, inform the team's understanding of how products are typically used and what happen at product end of life. Task 5 objectives are - to complete an environmental impact assessment and - to complete a life cost assessment for each base case.

At the workshop on 15th of May, we welcome stakeholders' views and opinions on the work conducted so far and the team's interpretation of the results. Written feedback is welcome from stakeholders that won't be attending the meeting, please use the ecoups@ricardo-aea.com.

Defining the Base Cases

The choice of base cases and inputs for the streamlined life cycle assessment, using the EcoReport tool, have been informed by the results of previous tasks, stakeholder feedback, existing standards and product dismantling trials undertaken by the project team. All Preparatory Studies undertake an environmental assessment using the EcoReport Tool, which generates a streamlined life cycle assessment of the product, together with a life cycle cost assessment. The purpose of this assessment is to provide an indication of the environmental impacts for a typical product across the different life cycle phases. This allows the importance of non-energy environmental impacts to be understood alongside the environmental impacts associated with in use energy consumption. In order to undertake the assessment of UPS using EcoReport, a number of key steps are required:

- Define base cases categories and representative base case within each category; this has been done on the basis of different sizes of UPS.

[1] http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/methodology/index_en.htm

- Generate input parameters for EcoReport. This includes a bill of materials (BoM - a list of materials and their weight fractions) for a representative base case within each base case category.
- Calculate in use energy consumption for each defined base case.

The following base case categories have been defined in consultation with stakeholder:

- Below 1 kVA
- 1.1 to 5 kVA
- 5.1 to 20 kVA
- 20.1 to 200 kVA

These sizes align with the market data modelled in Task 2, which will enable the scaling of impacts and improvement potential for the EU without the need for further assumptions (part of task 7 and 8 objectives). A base case has not been selected for products above 200 kVA, as these are generally bespoke and cannot be represented by a typical bill of materials. Stakeholder feedback indicated that they agreed with this rationale.

Product Specific Inputs

Product specific inputs are based on Bill of Materials (BoMs) and are broken down for the different life cycle phases in order to complete the environmental assessment using EcoReport. The BoMs are split into three areas UPS, Packaging and Battery. The dominant battery technology is currently lead acid, which has been used as the battery type in all four base cases (further information can be found in Appendix 1). The product life cycle phases are broken down as:

- Material extraction and production
- Manufacturing
- Distribution (including final assembly)
- Use Phase
- End of life

The BOMs with the assumption and data sources are available in details in Appendix 1. We welcome feedback on the BoMs presented and on the assumption we have made.

A key aspect of product specific inputs has been to calculate the UPS in use energy consumption for each base case. The team has used a step approach to develop a calculation formula which is presented in Appendix 1.

On completing the product specific inputs, the team was then able to enter all relevant data into the EcoReport tool to generate an environmental impact assessment for each base case.

Environmental Impact Assessment Results

The EcoReport tool has been used to generate a life cycle assessment for the four base cases as described above:

- Base Case 1: Below 1 kVA
- Base Case 2: 1.1 to 5 kVA
- Base Case 3: 5.1 to 20 kVA
- Base Case 4: 20.1 to 200 kVA

This calculates the impacts for the environmental indicators shown in Table 11, across the different life cycle phases; production, distribution, use and end of life. It is important to note that EcoReport uses different units for the different individual impact categories, thus it is not possible to directly compare one impact against the other.

In the same way, that at this stage it is not correct to compare the four base cases’ environmental impact against each other’s. Indeed each base case is of different electrical power and has different lifetime. At this stage the results shown here enable us to identify for each base case at which stage of the product life cycle do environmental impact incur, at what phase are they the highest, and are these consistent for all base cases or not.

Figure 1 shows a diagram for each base case indicating the life cycle phases that are important for each environmental indicator. Appendix 2 presents further details on the base cases' environmental impact, including a table of the data presented in Figure 1.

The key message through this analysis is that the use phase, driven by in use energy consumption is the key environmental impact, as can been clearly seen in Figure 1. It also shows that across the different base cases some of the environmental impact magnitude is noticeably different. Further work is being done to better understand what drives these differences, to assess if it is purely due to the size of the UPS and the impact of number of batteries that are used through the product life time, or is it something else.

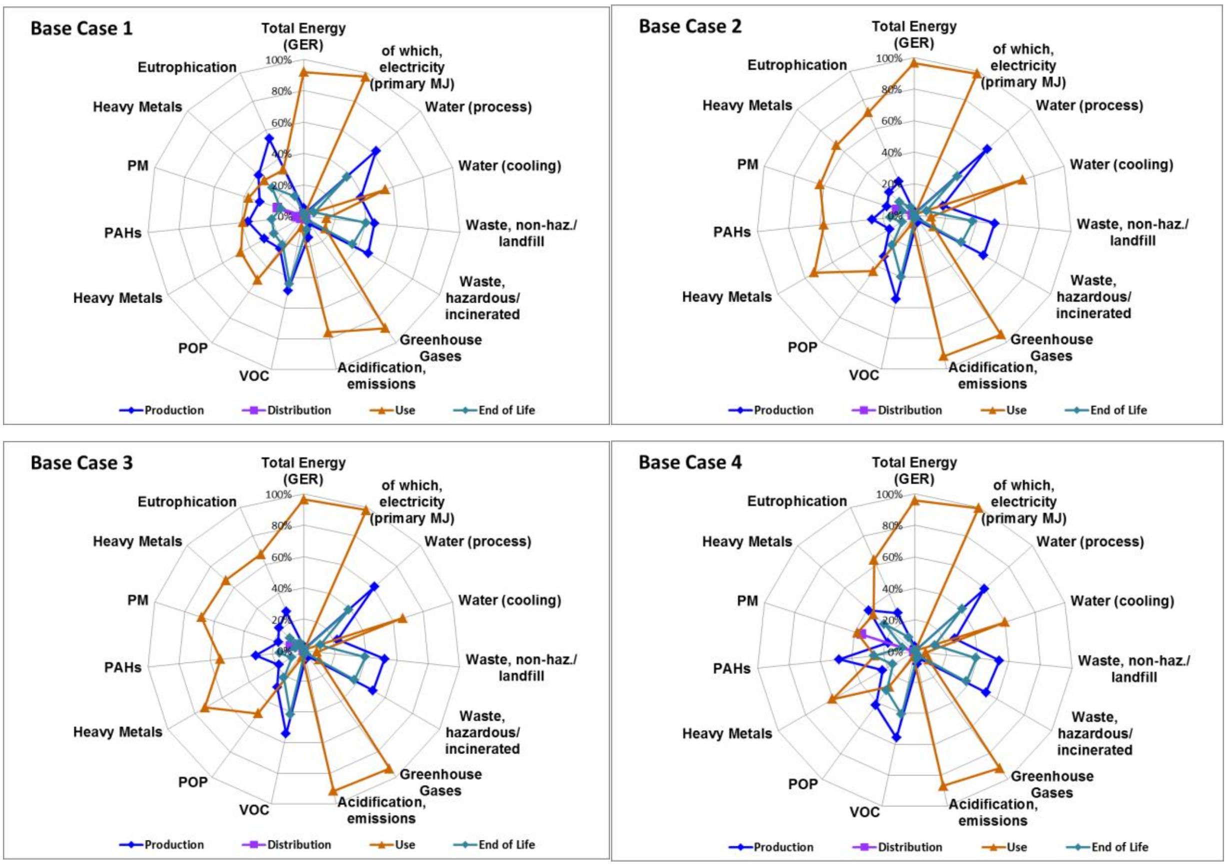

Figure 1: Radar plot showing the relative importance of the different life cycle phases for the environmental indicators

Life Cycle costs - assumptions

The EcoReport tool is also used to assess the life cycle costs of the UPS. This is particularly important when considering improvement options and it is therefore necessary to establish costs for each of the base cases. Cost information was collated as part of Task 2 (Economic and Market Data). Based on this information and the assumptions outlined below the proposed cost information to be used for the base cases is presented in Table 1.

The following assumptions are made regarding costs:

- Product prices based on the averages identified in Task 2.
- It is assumed that 'Below 1 kVA' products are generally "plug and use" and therefore are installed by the end user, with no installation costs incurred.
- Repair and maintenance costs relate to purchase and installation of replacement batteries. It is assumed there is no battery replacement for 'Below 1 kVA' products.

- The industrial (non-domestic) electricity rate[2] has been used, as use is mainly non-domestic.

We would welcome feedback on the proposed costs and any additional information or data stakeholders can provide.

In particular we appreciate that repair and maintenance costs will vary depending on the number of batteries replaced for each base case. We would like to discuss this further at the second stakeholder meeting in order to develop more accurate repair and maintenance cost inputs.

Table 1: Proposed base case cost inputs for EcoReport[3]

	Base Case			
Cost Parameter	**Below 1 kVA** (1 battery)	**1.1 to 5 kVA** (2 batteries changes*)	**5.1 to 20 kVA** (2 batteries changes)	**20.1 to 200 kVA** (2batteries changes)
Product Price (€)[4]	100	1500	3502	28800
Installation Costs (€)	N/A	345	392	474
Repair and Maintenance Costs (€)[5]	N/A	Average single battery cost: 200 Installation: 345	Average single battery cost: 850 Installation: 345	Average single battery cost: 2,500 Installation: 345
Electricity Rate (€/kWh)	0.11	0.11	0.11	0.11

* The product uses 3 batteries during its lifetime

Feedback and Next Steps

At the second stakeholder meeting the detailed EcoReport inputs and outputs will be presented. We would welcome feedback from stakeholders both prior to and during the meeting on the inputs used for the EcoReport analysis, for example the selected base cases, BoM, lifetimes, energy consumption and end of life routes and the outputs from the analysis.

Any feedback on the proposed life cycle costs inputs and any additional cost information/data stakeholders can provide is also welcome.

Feedback and additional information/data should be sent to the project manager using the following email address: ecoups@ricardo-aea.com

The second workshops will also provide an opportunity for stakeholder to provide initial input on Task 6: Best Available Technology (BAT) and Best Not yet Available Technology (BNAT) and Task 7: Improvement Potential.

[2] As defined in EcoReport methodology
[3] Price are exclusive of any taxes
[4] Price review completed by the project team
[5] ErP Lot 27 – Task 2 final draft report and based on price review completed by the project team

Appendices

Appendix 1: Bill of Materials – Inputs

This Appendix provides details of the BoMs that are based on BoMs provided by stakeholders for representative products, dismantling trials undertaken by the project team and additional information from existing literature. Each BoMs has been broken down by the different life cycle phases:

- Material extraction and production
- Manufacturing
- Distribution (including final assembly)
- Use Phase
- End of life

Material Extraction and Production

Table 2 presents the UPS BoM inputs. Some of the product and BoM information provided to us was made available on a confidential basis, we have therefore withheld identities. Table 3 presents the BoMs for UPS packaging.

Table 2: UPS bill of material inputs

EcoReport Material Codes	Base Cases - Weights in g			
	Base Case 1 Below 1kVA	Base Case 2 1.1 to 5 kVA	Base Case 3 5.1 to 20 kVA	Base Case 4 20.1 to 200 kVA
1-LDPE				240
2-HDPE				4,000
8-PVC	85	136	297	11,000
11-ABS	1,216	597	1,132	3,550
12-PA6		22		220
13-PC		83	22	80
14-PMMA				30
15-Epoxy	10	15	50	100
18-Talcum filler		1		
19-E glass fibre		17		10
20-Aramid fibre				5,000
22-Stainless sheet galvanised		5,534	13,304	225,500
23-Stainless tube/profile		10		
24-Cast iron	1,123	1,667		30,000
25-Ferrite	91		935	53,300
26-Stainless 18/8 coil	25			
27-Aluminum sheet/extrusion	117	600	1,490	41,100
29-Cu winding wire	480	643	1,153	35,000
30-Cu wire	232	255	616	53,500
31-Cu tube/sheet		6		43,000
32-CuZn38 cast			275	
40-Powder coating		4	1	4,500
43-LCD per m^2 screen			1	
45-big capacitors & coils	15	144	1,105	34,100
46-slots . Ext. Ports	250		1,250	
47-Integrated circuits avg 5% Si, Au	3	1	10	10
48-Integrated Circuits's avg 1% Si	7	5	50	
49-SMD*/LEDs avg	40	314	1,125	
50-Printed Wiring Board 1/2 lay 3.75kg/m^2	108	400	1,190	
51-Printed Wiring Board 6 lay 4.5 kg/m^2		117		
53-Solder SnAg4Cu0.5	70	168	110	200
Total Weight (g)	**3,872**	**10,738**	**24,114**	**544,440**

*Surface mount devices

Table 3: Packaging bill of material inputs

	Base Cases - Weights in g			
EcoReport Material Codes	**Base Case 1 Below 1 kVA**	**Base Case 2 1.1 to 5 kVA**	**Base Case 3 5.1 to 20 kVA**	**Base Case 4 20.1 to 200 kVA**
1-LDPE		558	1,175	
2-HDPE	36		18	
4-PP		34	80	
6-EPS	78	108	435	
8-PVC				1,500
57-Cardboard	535	946	3,085	15,000
58-Office paper	77	150		
Total weight (g)	**726**	**1,795**	**4,793**	**16,500**

The predominant battery technology used in UPS is lead acid, and is therefore used as the battery type in all four base cases. The following lead acid battery composition[6] has been used to develop the battery bill of materials[7]:

- Lead / Lead Oxides – 60%
- Polypropylene – 10%
- Sulphuric acid – 10%
- Water – 16%
- Glass – 2%
- Antimony – 1%

The weight of the battery varies between the different sizes of UPS. Feedback from stakeholders and information from dismantling trials undertaken by the project team has allowed an average battery weight of 6.23 kg per kW output to be calculated. Using this and the average kW output for each base case, an average battery weight for each base case has been calculated. This information is summarised in Table 4.

Table 4: Battery weight for each base case

Base Case	Battery Weight per kW (g)	kW rating (See Table 8)	Single battery weight for base case (g)
Base Case 1 Below 1 kVA	6230	0.52	3,240
Base Case 2 1.1 to 5 kVA		2.08	12,960
Base Case 3 5.1 to 20 kVA		9.12	56,810
Base Case 4 20.1 to 200 kVA		91.88	572,330

The battery composition (Table 4) is then applied to generate the battery bill of materials for each base case. Battery replacement has been identified as a key maintenance procedure during the lifetime of the UPS. The following assumptions have therefore been made:

- Below 1 kVA – No battery replacement; typically these products do not have their battery replaced during their lifetime.
- 1.1 to 5 kVA, 5.1 to 20 kVA and 20.1 to 200 kVA – Based on the lifetime of these UPSs and batteries, it is assumed that the batteries are replaced twice during the lifetime for these three base cases.

Lead/lead oxides represent 60% of the battery weight. The value of lead means that there is a high level of lead recycling within the battery industry, and therefore not all of the lead used in the battery will be primary lead, a proportion will be secondary/recycled lead. For the purposes of our bases cases, it is assumed that the lead is split 40:60 between primary and secondary lead[8].

Table 5 summarises the EcoReport inputs for the battery component of the different base cases, taking into account the assumptions outlined above.

[6] A Review of battery Life-Cycle Analysis: State of Knowledge and Critical Needs, Argonne National Laboratory, 2010
[7] It is noted that the percentage total is 99%, and is assumed this is due to rounding in the source document, the additional 1% is not attributed to any materials when entering the weight of the battery materials in EcoReport.
[8] http://batterycouncil.org/?page=Battery_Recycling - The typical new lead-acid battery contains 60 to 80% recycled lead and plastic

Table 5: Battery bill of materials

			Battery weight input for each base case (g)			
	EcoReport material Code	Composition (%)	Base Case 1 Below 1 kVA (1 battery)	Base Case 2 1.1 to 5 kVA (3 batteries changes)	Base Case 3 5.1 to 20 kVA (3 batteries changes)	Base Case 4 20.1 to 200 kVA (3 batteries changes)
Lead/lead oxides - total	-	60%	1,944	23,322	102,257	1,030,194
Primary lead (40% of lead content)	Extra*		777	9,329	40,903	412,077
Secondary lead (60% of lead content)	Extra		1,166	13,993	61,354	618,116
Polypropylene	4 - PP	10%	324	3,887	17,043	171,699
Sulphuric acid	Extra	10%	324	3,887	17,043	171,699
Water	Extra	16%	518	6,219	27,269	274,718
Glass	55 – Glass for lamps**	2%	65	777	3,409	34,340
Antimony	Extra	1%	32	389	1,704	17,170
Total	**-**	**100%**	**3,207**	**38,481**	**168,724**	**1,699,819**

***** 'Extra' refers to materials added to EcoReport where they are not adequately covered by the default materials included in EcoReport

****** The Product Cases report[9] written by the developers of EcoReport indicates "55 – Glass for lamps" has been used to represent glass in other product groups, such as shelves and lighting equipment, and is considered an appropriate proxy in this instance, given the relatively small amount of glass used.

Manufacturing

The majority of the inputs relating to manufacturing in EcoReport are fixed and cannot be altered. The percentage of scrap sheet metal produced from the manufacturing process has been set at 10%, in line with the EcoReport guidance for products that have minimal cutting losses.

Distribution (including final assembly)

Table 6 summarises the inputs for each of the bases cases for the distribution phase.

Table 6: Distribution Inputs

	Base Case / Input Response			
Distribution Parameter	Base Case 1 Below 1 kVA	Base Case 2 1.1 to 5 kVA	Base Case 3 5.1 to 20 kVA	Base Case 4 20.1 to 200 kVA
Volume of packaged final product (m^3)	0.022	0.022	0.051	2.9

[9] http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/methodology/index_en.htm

Use Phase

The key EcoReport parameter in the use phase is energy consumption. The project team has used a step approach to develop the calculation which are summarised below.

Data Requirements

Table 7 summarises the key data requirements for the in use energy calculations.

Table 7: Summary of data requirements for in use energy calculations

Data Requirement	Abbreviation	Units	Note / Assumption
Nominal active power	P	kW	Average data collected from datasheets
Tested load levels	l	%	25, 50, 75, 100%
Conversion efficiency at each load level	Ef_l	%	Minimum levels of conversion efficiency defined in the UPS Code of Conduct from JRC, using the version 1[10] for products above 10 kVA and the version 2[11] for products below 10 kVA.
Proportion of time spent at each load level	t_l	%	Loading assumptions extracted from the version 1 of the Energy Star product specification for UPSs[12].

In Use energy calculation Steps:

Step 1 - Power with each load level (P_l in kW)

$$P_l = P \times l$$

Step 2 - Yearly energy input with each load level (Ei_l in kWh)

$$Ei_l = P_l \times t_l \times 8760$$

Step 3 - Yearly energy input (Ei in kWh)

$$Ei = \sum Ei_l$$

This is the input of energy (E_i), but such energy is mainly transferred to the load (E_o) and therefore should be considered as a consumption of the load, since such energy is consumed with or without the use of UPS (Figure 2). The energy consumed by the UPS is the difference between the input of energy (E_i) and the output of energy (E_o), which is the energy spent due to the UPS losses. This is the approach that was also used for the assessment of energy consumption with transformers[13].

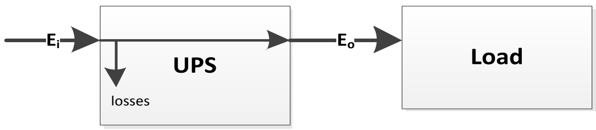

Figure 2: Energy flow in a UPS system

Step 4 - Yearly energy consumption with each load level (Ec_l), in kWh

$$Ec_l = Ei_l \times (1 - Ef_l)$$

Step 5 - Yearly energy consumption (Ec), in kWh

$$Ec = \sum Ec_l$$

Using the equation developed above the use phase energy consumption for each base case has been calculated and is presented in Table 8**Error! Reference source not found.**.

[10] JRC, Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems, 2006
[11] JRC, Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems, Version 2.0, 2011
[12] ENERGY STAR, Program Requirements for Uninterruptible Power Supplies, 2012.
[13] ISR-UC, Ricardo-AEA, PE, RPA, Implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Ecodesign Requirements for Power, Distribution and Small Transformers, 2013.

Table 8: In use phase energy consumption

Base Case	Average kW rating	UPS in use phase energy consumption kWh/year
Base Case 1 Below 1 kVA	0.52	363.64
Base Case 2 1.1 to 5 kVA	2.08	1,399.36
Base Case 3 5.1 to 20 kVA	9.12	4,554.91
Base Case 4 20.1 to 200 kVA	91.88	29,426.41

The in use energy consumption is classified as a direct energy related product impacts. No use phase inputs have been included in EcoReport for indirect energy related product impacts.

In addition to the in use energy consumption, other key parameter required for the in use phase is lifetime. The same lifetimes as used in Task 2 to calculate the stock and sales data have been used for the EcoReport inputs (Table 9).

Table 9: Base Case Lifetimes for EcoReport

Base Case	Lifetime (Years)
Base Case 1 Below 1 kVA	4
Base Case 2 1.1 to 5 kVA	8
Base Case 3 5.1 to 20 kVA	8
Base Case 4 20.1 to 200 kVA	10

End of Life Phase

For the end of life phase, the key EcoReport input relates to the routes for different materials at the end of life of the product.

- Plastics – Specific information regarding plastics from UPSs at the end of life phase has not been identified, but information on plastics in general has been identified[14]. This indicates that approximately 59% of plastics were recovered, with approximately 25% recycled and 34% sent for energy recovery. This information has been used to inform the EcoReport inputs.
- Electronics – Limited information regarding the percentage of electronics recovered at the end of life has been identified. Therefore, it has been assumed 50% are recycled and the remaining 49% (allowing for a small percentage of reuse) are incinerated without energy recovery.
- Miscellaneous – This consist mainly of cardboard and paper used for the packaging of the UPS. The default values from EcoReport have been used.
- Extra – This relates to the extra materials added to EcoReport in order to enable the lead acid battery component to be included. Lead acid batteries experience a high level of recycling, due to the high value of lead. It is therefore proposed that 90% of the extra materials are recycled, and the remaining 9% (after allowing for a small percentage of reuse) of extra materials are incinerated without energy recovery.
- No materials included in the BoM are in the refrigerant, mercury or auxiliary categories, these are therefore left at the EcoReport defaults.
- The value for metals are fixed and cannot be altered in EcoReport.

Table 10 summarises the values used in the EcoReport analysis.

The project team welcome feedback on the proposed end of life percentages, and will be happy to discuss these further at the second stakeholder meeting.

[14] http://www.plasticseurope.org/Document/plastics-the-facts-2012.aspx?Page=DOCUMENT&FolID=2

Table 10: End of life EcoReport inputs

Per fraction (post-consumer)	**1**	**2**	**3**	**4**	**5**	**6**	**7a**	**7b**	**7c**	**8**	**9**	
	Bulk Plastics	**TecPlastics**	**Ferro**	**Non-ferro**	**Coating**	**Electronics**	**Misc. , excluding refrigant & Hg**	**refrigerant**	**Hg (mercury), in mg/unit**	**Extra**	**Auxiliaries**	***TOTAL (CARG avg.) ****
EoL mass fraction to re-use, in %	**1%**										**5%**	*1.0%*
EoL mass fraction to (materials) recycling, in %	**25%**		94%			**50%**	**64%**	**30%**	**39%**	**90%**	**30%**	*71.5%*
EoL mass fraction to (heat) recovery, in %	**34%**		0%			**0%**	**1%**	**0%**	**0%**	**0%**	**10%**	*7.7%*
EoL mass fraction to non-recov. incineration, in %	**0%**		0%			**49%**	**5%**	**5%**	**5%**	**9%**	**10%**	*6.8%*
EoL mass fraction to landfill/missing/fugitive, in %	**40%**		5%			**0%**	**29%**	**64%**	**55%**	**0%**	**45%**	*12.8%*
TOTAL	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100.0%*

* Compound Annual Growth Rate

Appendix 2: Environmental Assessment

The EcoReport tool has been used to generate a life cycle assessment for the four base cases as described above:

- Base Case 1: Below 1 kVA
- Base Case 2: 1.1 to 5 kVA
- Base Case 3: 5.1 to 20 kVA
- Base Case 4: 20.1 to 200 kVA

This calculates the impacts for the environmental indicators shown in Table 11, across the different life cycle phases; production, distribution, use and end of life.

It is important to note that EcoReport uses different units for the different individual impact categories, thus it is not possible to directly compare one impact against the other. In the same way, that at this stage it is not correct to compare the four base cases against each other's. Indeed each base case is of different electrical power and has different lifetime. At this stage the results shown here enable us to identify for each base case at which stage of the product life cycle do environmental impact incur, at what phase are they the highest, and are these consistent for all base cases or not.

Table 11: Environmental Indicators covered by EcoReport

Parameter		Unit
Other Resources & Waste	Total Energy (GER)	MJ
	of which, electricity (in primary MJ)	MJ
	Water (process)	l
	Water (cooling)	lr
	Waste, non-haz./ landfill	g
	Waste, hazardous/ incinerated	g
Emissions (Air)	Greenhouse Gases in GWP100	kg CO_2 eq.
	Acidification, emissions	g SO_2 eq.
	Volatile Organic Compounds (VOC)	G
	Persistent Organic Pollutants (POP)	ng i-Teq
	Heavy Metals	mg Ni eq.
	PAHs	mg Ni eq.
	Particulate Matter (PM, dust)	g
Emissions (Water)	Heavy Metals	mg Hg/20
	Eutrophication	g PO_4

For the purposes of this briefing the high level results and trends are presented in order to identify the key environmental impacts, which life cycle phase they occur in and which elements of the UPS is key in driving the main impacts.

Presentation of Results

This section presents the results from the EcoReport analysis. Firstly the general trends are presented in absolute terms, and then the importance of the impacts across the different life cycle phases are considered. The identification of the key impacts is important, as it will inform the key areas on which to focus when considering the improvement potential and possible policy options in Tasks 7 and 8 of the project.

A high level snapshot is provided in Figure 3, which shows the total results across the lifetime of the different base cases for each of the environmental indicators. This clearly shows that Base Case 4 has the highest impact across all categories. This is to be expected, as this base case has a significantly higher product weight, longer lifetime and capacity compared to the other three base cases.

Figure 3: Results for each base case across the different environmental impact indicators (totals across lifetime)

In order to make the interpretation of the results easier, they can be normalised on the basis of a common parameter. The purchase of a particular UPS is driven by the size of the load that is to be protected, therefore the results have been normalised on a kW rating basis. The different base cases should not be seen as alternatives to one another, as they represent different UPS size groups. For example Base Case 1 would not be suitable for a very high load, for example represented by Base Case 4.

Figure 4 shows the total results normalised on a kW rating basis across the lifetime of the different base cases for each of the environmental indicators. Broadly this shows that the results are much more even across the different base cases. The results for Base Case 2 appear slightly higher than for the other bases cases for the majority of the environmental indicators. This is a factor of the various assumptions used, including the material composition, product weight, UPS efficiencies, time spent at different load levels and lifetime.

While it is useful to note overall trends, it is important to understand the key drivers of the impacts. In order to do this, the relative importance of the different life cycle phases, production, distribution, use and end of life need to be assessed.

Figure 4: Results for each base case across the different environmental impact indicators (normalised by kW across lifetime)

Table 12 presents the detailed data that is presented in the core briefing in Figure 1. It is easy to see that the in use energy is the dominant phase of the UPS with most environmental impact being red. At the stakeholder meeting the project team will further discuss what these mean and outline where these environmental impact arises from 1) the UPS or 2) the batteries.

Table 12: Impacts / Benefits for each parameter across the different life cycle phases

		Base Case 1 Below 1 kVA				Base Case 2 1.1 to 5 kVA				Base Case 3 5.1 to 20 kVA				Base Case 4 20.1 to 200 kVA			
		Production	Distribution	Use	End of Life	Production	Distribution	Use	End of Life	Production	Distribution	Use	End of Life	Production	Distribution	Use	End of Life
Other Resources & Waste	Units																
Total Energy (GER)	MJ	5%	1%	92%	2%	3%	0%	97%	1%	3%	0%	96%	1%	3%	0%	96%	1%
of which, electricity (in primary MJ)	MJ	2%	0%	97%	1%	1%	0%	98%	0%	1%	0%	98%	1%	1%	0%	99%	0%
Water (process)	ltr	62%	0%	1%	37%	63%	0%	1%	37%	61%	0%	1%	39%	59%	0%	1%	40%
Water (cooling)	ltr	38%	0%	55%	7%	19%	0%	72%	8%	23%	0%	66%	11%	27%	0%	60%	13%
Waste, non-haz./ landfill	g	45%	0%	14%	40%	51%	0%	11%	38%	52%	0%	9%	39%	54%	0%	7%	39%
Waste, hazardous/ incinerated	g	48%	0%	16%	36%	51%	0%	14%	35%	51%	0%	12%	37%	52%	0%	10%	38%
Emissions (Air)																	
Greenhouse Gases in GWP100	kg CO_2 eq.	6%	2%	88%	3%	4%	0%	94%	2%	5%	0%	93%	2%	5%	0%	91%	3%
Acidification, emissions	g SO_2 eq.	14%	1%	76%	9%	6%	0%	91%	3%	6%	0%	92%	2%	8%	0%	87%	5%
Volatile Organic Compounds (VOC)	g	49%	0%	7%	44%	54%	0%	5%	40%	54%	0%	4%	42%	56%	0%	3%	41%
Persistent Organic Pollutants (POP)	ng i-Teq	26%	1%	50%	23%	32%	0%	44%	23%	29%	0%	50%	22%	42%	0%	27%	30%
Heavy Metals	mg Ni eq.	29%	3%	46%	22%	18%	0%	73%	9%	18%	0%	73%	9%	24%	0%	60%	16%
PAHs	mg Ni eq.	36%	5%	39%	20%	27%	1%	57%	15%	31%	0%	53%	16%	48%	1%	25%	26%
Particulate Matter (PM, dust)	g	30%	18%	37%	16%	18%	12%	63%	8%	17%	9%	69%	5%	18%	36%	38%	8%
Emissions (Water)																	
Heavy Metals	mg Hg/20	39%	0%	34%	27%	21%	0%	66%	12%	21%	0%	67%	12%	39%	0%	35%	26%
Eutrophication	g PO_4	54%	0%	32%	14%	23%	0%	71%	5%	27%	0%	67%	6%	27%	0%	64%	10%

Note: *The sign of contribution (impact or benefit) is ignored in the colours and %s, which just reflect relative magnitude. For production, distribution, and use phases the contributions are impacts, for end of life the contributions are benefits.*

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