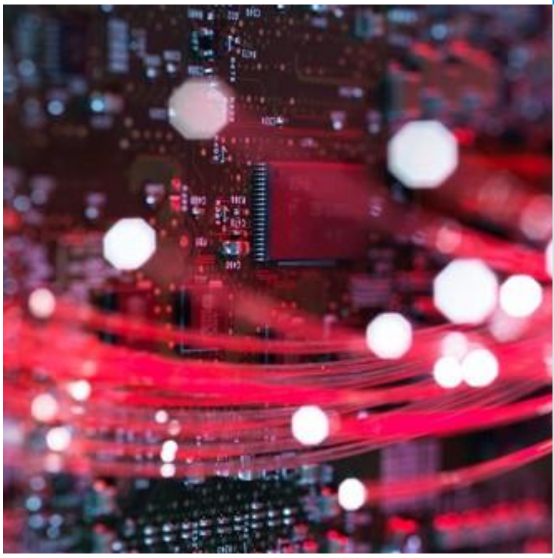

Study for the review of Commission Regulation 2019/424 (Ecodesign of servers and data storage products)

Task 5 Environment and Economics – DRAFT

May 2024

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Document Control

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Date	May 2024

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5 Introduction to Task 5 Environment and Economics

5.1 Overview of Base cases

This section aims to define and elaborate on base-cases derived from prior tasks, stakeholder inputs, and a thorough literature review. These base-cases, intentional abstractions of reality, are crucial in encompassing the diverse range of servers and storage systems across the European market. They aim to strike a balance: being few enough for streamlined analysis yet comprehensive enough to represent the technological breadth of servers and storage systems. Guided by the MEErP methodology, the objective is to define two base-cases for servers and one base case for storage system that effectively encapsulate the study's scope. Each base-case's characteristics allow for the multiplication of its impacts during the use phase, production and distribution, and end-of-life stages with the respective total number of products in use, sold, and discarded, thereby providing a holistic representation of the environmental impact of this equipment.

Table 5.1 below serves as the key and shows the number of models in the SERT dataset segregated by product type. This includes models from 2016-2021.

Table 5.1 SERT dataset overview

Entire Data set				
Server Type	# installed Processors	Count in data set	# Families	# of families with Typical Configs
Rack	1	152	57	37
Rack	2	247	90	70
Rack	4	58	19	17
Tower	1	30	10	7
Tower	2	23	7	6
Blade	2	77	25	24
Blade	4	22	8	7
	Total	609	216	168

The equipment under scrutiny in the Lot 9 preparatory study relies heavily on its configuration. To ensure a comprehensive yet manageable approach, a selected subset of base-cases has been curated to represent this diversity. Rack servers represent 75% and Blade 16% count in the SERT dataset. Notably, the utilisation of a 2-socket server with only one socket populated falls short of optimal usage, and market data lacks clarity on the prevalence of underpopulated 2-socket servers. Given that 2-socket servers constitute over 50% of the SERT dataset, the analysis focuses on this dominant market segment. Within this segment, the study distinguishes between rack and blade servers, as outlined in the conclusion of Task 4. Tower servers represent about 8.7% of the SERT dataset and therefore are not eligible to considered as a base case. BC-1 and BC-2 in the table below are developed using the average technical characteristics of the most popular configurations in the SERT dataset and identifying the closest representative model.

The selection of the storage system hinges significantly on the dataset characteristics, which play a pivotal role in determining its suitability. The base case BC-3 was constructed using Online 3 systems where multiple drive type configurations are commonly deployed. Online 2 systems typically deploy a single drive type and are not an ideal base case candidate. Primarily, the choice is rationalised based on the predominant connectivity model, where Block I/O constitutes a substantial 73% of the dataset. Aligning with workload optimisation, the decision leans towards a Transaction-oriented approach, mirroring the dataset's composition, where Transactions account for 47%, with Streaming at 28% and Composite at 25%. Furthermore, the configuration of the storage controller heavily leans towards Scale Up, representing a dominant 70% of the dataset. Considering these vital characteristics, the proposed storage system configuration emerges as the optimal choice. It not only encapsulates these crucial traits but also integrates a hybrid storage model—incorporating both HDD and SSD components, aligning seamlessly with prevalent applications in the field. This hybrid configuration is a common and versatile solution, addressing the diverse demands present within the dataset while ensuring comprehensive adaptability and performance. Internal shipment data was used to ensure that models identified were representative of commonly installed configurations. Table 5.2 below summarises the retained technical specificities of the different base cases.

Table 5.2 Technical specifications of BC-1, BC-2, and BC-3.

Base Case	Description
BC-1 2 socket Rack Server	• Silver level Intel processor • 2021 model • 2U volume • 16 memory DIIMMs • 2 storage devices • 800-Watt nameplate power • 136 idle watt measurement • 27.1 efficiency score
BC-2 2 socket Blade Server	• 2 storage devices • 3000-Watt nameplate power • Memory capacity: 3TB • Number of blade slots: 8 • SERT Score (typical config): 31.2 • Idle measurement (typical config): 166 watts
BC-3 Storage (virtual product, hybrid system)	• Taxonomy: Online 3 • Workload optimization: Transaction • Storage model connectivity: Block I/O • Storage controller config: Scale-up • 1100-Watt nameplate power • 22 storage devices in optimal configuration (6 SSD + 16 HDDs)

5.2 Product specific inputs

It should be noted that the Task 5 methodology, modelling inputs and outcomes should not be directly compared to the outputs from the prior preparatory study which underpinned regulation 2019/424. This is because a newer version of the EcoReport tool has been utilised for this review study, with the prior version (2013) being withdrawn. In addition, since the last preparatory study, the servers and data storage industry has seen a dramatic increase in the performance rate of their products.

5.2.1 Servers

5.2.1.1 Inputs and Assumptions common to all BCs

5.2.1.2 Discount Rate and Escalation Rate

The discount and escalation rates used for BCs were provided in the MEErP and are presented in Table 5.3.

Table 5.3 Discount rate and Escalation Rate

Input / Assumption	Value	Unit	Source
Escalation rate (annual growth of running costs)	3%	per year	MEErP, 2024
Discount Rate	3%	per year	MEErP, 2024

5.2.1.3 Electricity Rate

The electricity rate used for all BCs was calculated based on the values and methodology provided in the MEErP[1] and are presented in Table 5.4.

Table 5.4 Electricity rates

Input / Assumption	Value	Unit	Source
Electricity prices	0.6	Euro/kWh	MEErP 2024

5.2.1.4 Water rate

The water rate used for all BCs were provided in the MEErP are presented in Table 5.5.

Table 5.5 Water rates

Input / Assumption	Value	Unit	Source
Water rate	1	Euro/m3	MEErP, 2024

[1] Section 2.3 of the MEErP 2011 Methodology Part 1 - Final provides guidance for estimating the electricity prices. Because Servers are not a household appliance, the electricity prices used were those presented in Section 2.4 for the Industry.

5.2.1.5 Critical raw materials

CRM as per the EcoReport tool are: Antimony, Baryte, Bauxite, Beryllium, Bismuth, Borates, Cobalt, Coking coal, Fluorspar, Gallium, Germanium, Hafnium, Indium, Lithium, Magnesium, Natural graphite, Natural rubber, Niobium, Phosphate rock, Phosphorus, Scandium, Silicon metal, Strontium, Tantalum, Titanium, Tungsten, Vanadium, Platinum Group Metals, Heavy Rare Earth Elements, Light Rare Earth Elements.

Hazardous materials as per RoHS Directive are: Lead, Mercury, Cadmium, Hexavalent chromium, Polybrominated biphenyls (PBB), Polybrominated diphenyl ethers (PBDE)

5.2.1.6 Inputs in the production phase of BC1 – Rack Server

The bill of materials for the BC-1, a rack server is presented below in Table 5.6.

Table 5.6 Bill of Materials of BC1 (Rack Server)

Input / Assumption	Value	Unit
Ag - Silver	0.0013	kg
Al - Aluminum	1.42	kg
Au - Gold	0.0012	kg
Ba - Barium	0.04	kg
Ca - Calcium	0.07	kg
Co - Cobalt	0.01	kg
Cr - Chromium	0.01	kg
Cu - Copper	1.00	kg
Dy - Dysprosium	0.0001	kg
Fe - Iron	12.14	kg
In - Indium	0.0001	kg
Mg - Magnesium	0.01	kg
Mn - Manganese	0.03	kg
Mo - Molybdenum	0.00001	kg
Nd - Neodymium	0.0005	kg
Ni - Nickel	0.07	kg
Pb - Lead	0.0019	kg
Pr - Praseodymium	0.0001	kg
Sb - Antimony	0.0004	kg
Sn - Tin	0.06	kg
Sr - Strontium	0.0006	kg
Ta - Tantalum	0.0003	kg

Input / Assumption	Value	Unit
Ti - Titanium	0.01	kg
W - Tungsten	0.01	kg
Zn - Zinc	0.03	kg
Zr - Zirconium	0.0001	kg
Plastic	0.91	kg

The above data have been obtained from and aggregated from several industry stakeholders and internet research. The total weight of BC-1 amounts to around 15.80 kg.

The BC-1 values for packaging, distribution, the direct and in-direct use-phase values, maintenance and repair, and input values for EU totals and economic life cycle costs, are presented in Table 5.7 to Table 5.12, respectively.

Table 5.7 Packaging of BC-1

Input / Assumption	Value	Unit	Source
HDPE	0.078	kg	CEDaCI data
GPPS/Styrofoam	1.026	kg	CEDaCI data

Table 5.8 Distribution of BC1

Input / Assumption	Value	Unit	Source
Transport mean 1	Ship		ICF, assumption
Weight of the transported product	0.02	t	CEDaCI data
Distance 1	16000	km	ICF, assumption. Servers are mostly shipped from Hong Kong & San Francisco. Taken the average of “shipping distance” from these 2 cities to Rotterdam port
Transport mean 2	Lorry		ICF, assumption
Weight of the transported product	0.02	t	CEDaCI data
Distance 2	450	km	ICF, assumption Average distance by road from Rotterdam to Frankfurt

Table 5.9 Use Phase Direct ErP of BC1

Input / Assumption	Value	Unit	Source
ErP Product service Life in years (see comment)	4	years	Task 2
Electricity			

Input / Assumption	Value	Unit	Source
Electricity mix (Click & select)	243-Electricity grid mix 1kV-60kV technology mix consumption mix, to consumer 1kV - 60kV		ICF assumption
On-mode: Consumption per hour, cycle, setting, etc.	0.185256224		Calculated
On-mode: No. of hours, cycles, settings, etc. / year	8760	#	Calculated
Standby-mode: Consumption per hour	0.136817869		Calculated
Standby-mode: No. of hours / year	2682.75	#	Calculated
Off-mode: Consumption per hour	0		Calculated
Off-mode: No. of hours / year	0	#	Calculated
TOTAL over ErP Product Life	7.959570642	MWh (=000 kWh)	Calculated
		Heat	
Type (click & select)			
Avg. Heat Power Output	0	kW	
No. of hours / year	0	hrs.	
Efficiency (insert the value manually)		please choose your item in cell D284	
TOTAL over ErP Product Life	0	GJ	

Table 5.10 Use Phase Indirect ErP of BC1

Input / Assumption	Value	Unit	Source
ErP Product (service) Life in years	4	years	Task 2
		Electricity	
Electricity mix (Click & select)	243-Electricity grid mix 1kV-60kV		Calculated

Input / Assumption	Value	Unit	Source
	technology mix consumption mix, to consumer 1kV - 60kV		
On-mode: Consumption per hour, cycle, setting, etc.	0.185256224		Calculated
On-mode: No. of hours, cycles, settings, etc. / year	8760	#	Calculated
Standby-mode: Consumption per hour	0.136817869		Calculated
Standby-mode: No. of hours / year	2682.75	#	Calculated
Off-mode: Consumption per hour	0		Calculated
Off-mode: No. of hours / year	0	#	Calculated
TOTAL over ErP Product Life	7.959570642	MWh (=000 kWh)	Calculated
	Heat		
Boiler dataset (click & select)			
Avg. Heat Power Output (when saving use a negative value)	0	kW	
No. of hours / year	0	hrs.	
Efficiency (insert the value manually)		please choose your item in cell D314	
TOTAL over ErP Product Life	0	GJ	

Table 5.11 Maintenance & Repair of BC1

Input / Assumption	Value	Unit	Source
Spare parts % of product materials	158.0964243	g	ICF assumption

Table 5.12 Inputs for EU-Totals & economic Life Cycle Costs of BC1

Input / Assumption	Value	Unit	Source
Product expected lifetime	4	years	Task 2
Latest Annual sales	1.38	mln. Units/year	Calculated
EU Stock	5.523837678	mln. Units	Calculated

Input / Assumption	Value	Unit	Source
Product price	23420	Euro/unit	Task 2
Installation/acquisition costs (if any)	340	Euro/ unit	Task 2
Fuel rate (gas, oil, wood)	0	Euro/MJ	
Electricity rate	0.6	Euro/kWh	MEErP 2024
Water rate	1	Euro/m3	MEErP 2024
Auxiliary material 1	0	Euro/kg	
Auxiliary material 2	0	Euro/kg	
Auxiliary material 3	0	Euro/kg	
Auxiliary material 4	0	Euro/kg	
Auxiliary material 5	0	Euro/kg	
Repair & maintenance costs	400	Euro/ unit	Task 2
Discount rate (interest minus inflation)	0.03	%	MEErP 2024
Escalation rate (project annual growth of running costs)	0.03	%	MEErP 2024
Present Worth Factor (PWF) (calculated automatically)	4	(years)	MEErP 2024
Ratio efficiency STOCK: efficiency NEW, in Use Phase	0.9		MEErP 2024

5.2.1.7 BC2 – Blade Server

The bill of materials for the BC2 blade server is presented below in Table 5.13.

Table 5.13 Bill of Materials of BC2 (Blade Server)

Input / Assumption	Value	Unit
	Chassis	
Steel	65.25	kg
	Fans (6)	
Steel	0.964	kg
Copper	0.194	kg
Iron base	0.137	kg
Plastic (PBT-GF30)	0.515	kg
Plastic (PCABSFR40)	0.052	kg

Input / Assumption	Value	Unit
Plastic (undefined)	0.499	kg
	PSUs (3 x 3000W)	
Low-alloyed steel	7.004	kg
Chromium steel	0.448	kg
Brass	0.284	kg
Copper	0.06	kg
Zinc	0.045	kg
Aluminum	3.35	kg
High Density Polyethylene (HDPE)	1.25	kg
Polyvinylchloride (PVC)	0.62	kg
Paper	0.344	kg
Electronic components	2.44	m2
Solder	0.21	kg
PCB	0.73	m2
	Chassis	
Steel	16.8	kg
	CPUs (8)	
Copper	0.122	kg
Gold	0.0015	kg
PCB	0.028	m2
IC	0.0024	m2
	CPU heat sinks	
Copper	0.844	kg
Steel	0.28	kg
	Memory	
PCB	0.125	m2
IC	0.049	m2
	CPU heat sinks	
Copper	0.844	kg
Steel	0.28	kg
	Memory	

Input / Assumption	Value	Unit
PCB	0.125	m2
IC	0.049	m2
	HDDs (8)	
Steel	0.0235	kg
Low Alloyed Steel	0.444	kg
Aluminium	2.67	kg
PCB	0.116	m2
	Mainboards	
Controller Board	1.047	m2

The above data have been obtained from and aggregated from several industry stakeholders and internet research. The total weight of BC-2 amounts to around 116.4 kg.

The BC2 values for packaging, distribution, the direct and in-direct use-phase values, maintenance and repair, and input values for EU totals and economic life cycle costs, are presented in the Table 5.14 to Table 5.19, respectively.

Table 5.14 Packaging of BC2

Input / Assumption	Value	Unit	Source
HDPE	0.16	kg	CEDaCI data
GPPS/Styrofoam	2.116	kg	CEDaCI data
Cartons	7.484	kg	CEDaCI data

Table 5.15 Distribution of BC2

Input / Assumption	Value	Unit	Source
Transport mean 1	Ship		ICF, assumption
Weight of the transported product	0.126	T	CEDaCI data
Distance 1	16000	km	ICF, assumption. Servers are mostly shipped from Hong Kong & San Francisco. Taken the average of “shipping distance” from these 2 cities to Rotterdam port
Transport mean 2	Lorry		ICF, assumption
Weight of the transported product	0.126	T	CEDaCI data

Input / Assumption	Value	Unit	Source
Distance 2	450	km	ICF, assumption Average distance by road from Rotterdam to Frankfurt

Table 5.16 Use Phase Direct ErP of BC2

Input / Assumption	Value	Unit	Source
ErP Product service Life in years (see comment)	4	years	Task 2
		Electricity	
Electricity mix (Click & select)	243-Electricity grid mix 1kV-60kV technology mix consumption mix, to consumer 1kV - 60kV		ICF assumption
On-mode: Consumption per hour, cycle, setting, etc.	1.46	kWh	Calculated
On-mode: No. of hours, cycles, settings, etc. / year	8760	#	Calculated
Standby-mode: Consumption per hour	0.67	kWh	Calculated
Standby-mode: No. of hours / year	2682.75	#	Calculated
Off-mode: Consumption per hour			Calculated
Off-mode: No. of hours / year		#	Calculated
TOTAL over ErP Product Life	58.30	MWh (=000 kWh)	
		Heat	
Type (click & select)			
Avg. Heat Power Output		kW	
No. of hours / year		hrs.	
Efficiency (insert the value manually)		please choose your item in cell D284	
TOTAL over ErP Product Life	0	GJ	

Table 5.17 Use Phase Indirect ErP of BC2

Input / Assumption	Value	Unit	Source
ErP Product (service) Life in years	4	years	Task 2
		Electricity	
Electricity mix (Click & select)	243-Electricity grid mix 1kV-60kV technology mix consumption mix, to consumer 1kV - 60kV		Calculated
On-mode: Consumption per hour, cycle, setting, etc.	1.46	kWh	Calculated
On-mode: No. of hours, cycles, settings, etc. / year	8760	#	Calculated
Standby-mode: Consumption per hour	0.67	kWh	Calculated
Standby-mode: No. of hours / year	2682.75	#	Calculated
Off-mode: Consumption per hour			
Off-mode: No. of hours / year		#	
TOTAL over ErP Product Life	58.30	MWh (=000 kWh)	
		Heat	
Boiler dataset (click & select)			
Avg. Heat Power Output (when saving use a negative value)		kW	
No. of hours / year		hrs.	
Efficiency (insert the value manually)		please choose your item in cell D314	
TOTAL over ErP Product Life	0	GJ	

Table 5.18 Maintenance & Repair of BC2

Input / Assumption	Value	Unit	Source
Spare parts % of product materials	1164	g	ICF assumption

Table 5.19 Inputs for EU-Totals & economic Life Cycle Costs of BC2

Input / Assumption	Value	Unit	Source
Product expected lifetime	4	years	Task 2
Latest Annual sales	0.35	mln. Units/year	Calculated
EU Stock	1.4	mln. Units	Calculated
Product price	8435	Euro/unit	Task 2
Installation/acquisition costs (if any)	340	Euro/ unit	Task 2
Fuel rate (gas, oil, wood)	0	Euro/MJ	
Electricity rate	0.6	Euro/kWh	MEErP 2024
Water rate	1	Euro/m3	MEErP 2024
Auxiliary material 1	0	Euro/kg	
Auxiliary material 2	0	Euro/kg	
Auxiliary material 3	0	Euro/kg	
Auxiliary material 4	0	Euro/kg	
Auxiliary material 5	0	Euro/kg	
Repair & maintenance costs	400	Euro/ unit	Task 2
Discount rate (interest minus inflation)	3%	%	MEErP 2024
Escalation rate (project annual growth of running costs)	3%	%	MEErP 2024
Present Worth Factor (PWF) (calculated automatically)	4	(years)	MEErP 2024
Ratio efficiency STOCK: efficiency NEW, in Use Phase	0.9		MEErP 2024

5.2.2 Data Storage

5.2.2.1 BC3 – Storage system

Please note the modelled BC3 which has been developed by the study team is only representative of data storage products in 2023. However, with the advancement of data storage products, by 2025 it is expected that SSDs will be the predominant product across EU market. Thus, by 2025, the modelled BC3 may no longer be representative of the market, which is when the Regulation is expected to be updated by.

The bill of materials for BC3 data storage is presented below in Table 5.20.

Table 5.20 Bill of Materials of BC3 (Data Storage: SSDs)

Material/ component	Weight	Unit
	3,5 HDD (9)	
Steel	0.03	kg
Low alloyed steel	0.51	kg
Aluminum	3.09	kg
PCB	0.13	m2
SSDs (6)		
Electronic components	0.12	m2
IC	0.003	m2
	2.5 HDD (7)	
Steel	0.14	kg
Low alloyed steel	0.11	kg
Aluminum	1.28	kg
PCB	0.02	m2
ABS	0.003	kg
	Disc Array Enclosures (2)	
	Chassis	
PC	0.20	kg
ABS	0.05	kg
Steel Sheet part	7.69	kg
Zinc Part	0.15	kg
Steel Machined Part	0.002	kg
PSUs in DAEs (2)		
Mainboard	0.7	m2
Cables	4.0	m
Chassis and bulk materials	2.3	kg
	Fans in PSUs (4)	
Steel	0.3	kg
Copper	0.2	kg
Iron based	0.033	kg
Nylon 6	0.024	kg
PC	0.1	kg

Material/ component	Weight	Unit
ABS	0.048	kg
Controller cards (2)		
Electronics	0.4	m2
Mid plane boards (1)		
Electronics	0.1	m2
Controller (1/2)		
Controller		
Steel	7.5	kg
Stainless Steel	1.7	kg
Aluminum Sheet	0.3	kg
Copper	0.5	kg
ABS	0.5	kg
PET	0.039	kg
HDPE	0.1	kg
PP	0.018	kg
PC	0.031	kg
Nylon 6	0.005	kg
PVC	0.1	kg
Other Plastics	0.012	kg
Printed Circuit Board	0.2	m2
PSU Controller		
Mainboard	0.3	m2
Cables	1.5	m
Chassis and bulk material	0.9	kg
PSU Fans		
Steel	0.1	kg
Copper	0.1	kg
Iron based	0.013	kg
Nylon 6	0.009	kg
PC	0.035	kg
ABS	0.019	kg

The BC3 values for packaging, distribution, the direct and in-direct use-phase values, maintenance and repair, and input values for EU totals and economic life cycle costs, are presented in the Table 5.21 to Table 5.26, respectively.

Table 5.21 Packaging of BC3

Input / Assumption	Value	Unit	Source
HDPE	3.629	kg	CEDaCI data
GPPS/Styrofoam	0.078	kg	CEDaCI data
Cartons	1.026	kg	CEDaCI data

Table 5.22 Distribution of BC3

Input / Assumption	Value	Unit	Source
Transport mean 1	Ship		ICF, assumption
Weight of the transported product	0.126	t	CEDaCI data
Distance 1	16000	km	ICF, assumption. Servers are mostly shipped from Hong Kong & San Francisco. Taken the average of “shipping distance” from these 2 cities to Rotterdam port
Transport mean 2	Lorry		ICF, assumption
Weight of the transported product	0.126	t	CEDaCI data
Distance 2	450	km	ICF, assumption Average distance by road from Rotterdam to Frankfurt

Table 5.23 Use Phase Direct ErP of BC3

Input / Assumption	Value	Unit	Source
ErP Product service Life in years (see comment)	6	years	Task 2
		Electricity	
Electricity mix (Click & select)	243-Electricity grid mix 1kV-60kV technology mix consumption mix, to consumer 1kV - 60kV		ICF assumption
On-mode: Consumption per hour, cycle, setting, etc.	0.278	kWh	Calculated

Input / Assumption	Value	Unit	Source
On-mode: No. of hours, cycles, settings, etc. / year	8760	#	Calculated
Standby-mode: Consumption per hour	0	kWh	Calculated
Standby-mode: No. of hours / year		#	Calculated
Off-mode: Consumption per hour	0	kWh	Calculated
Off-mode: No. of hours / year		#	Calculated
TOTAL over ErP Product Life	14.61168	MWh (=000 kWh)	Calculated
		Heat	
Type (click & select)			
Avg. Heat Power Output		kW	
No. of hours / year		hrs.	
Efficiency (insert the value manually)		please choose your item in cell D284	
TOTAL over ErP Product Life	0	GJ	

Table 5.24 Use Phase Indirect ErP of BC3

Input / Assumption	Value	Unit	Source
ErP Product (service) Life in years	6	years	Task 2
		Electricity	
Electricity mix (Click & select)			
On-mode: Consumption per hour, cycle, setting, etc.	0.278	kWh	Calculated
On-mode: No. of hours, cycles, settings, etc. / year	8760	#	Calculated
Standby-mode: Consumption per hour		kWh	
Standby-mode: No. of hours / year		#	
Off-mode: Consumption per hour		kWh	

Input / Assumption	Value	Unit	Source
Off-mode: No. of hours / year		#	
TOTAL over ErP Product Life	14.61168	MWh (=000 kWh)	Calculated
		Heat	
Boiler dataset (click & select)			
Avg. Heat Power Output (when saving use a negative value)		kW	
No. of hours / year		hrs.	
Efficiency (insert the value manually)		please choose your item in cell D314	
TOTAL over ErP Product Life	0	GJ	

Table 5.25 Maintenance & Repair of BC3

Input / Assumption	Value	Unit	Source
Spare parts % of product materials	340.6162364	G	ICF assumption

Table 5.26 Inputs for EU-Totals & economic Life Cycle Costs of BC3

Input / Assumption	Value	Unit	Source
Product expected lifetime	6	years	Task 2
Latest Annual sales	32.10	mln. Units/year	Calculated
EU Stock	192.6	mln. Units	Calculated
Product price	24400	Euro/unit	Task 2
Installation/acquisition costs (if any)	425	Euro/ unit	Task 2
Fuel rate (gas, oil, wood)	0	Euro/MJ	
Electricity rate	0.6	Euro/kWh	MEErP 2024
Water rate	1	Euro/m3	MEErP 2024
Auxiliary material 1	0	Euro/kg	
Auxiliary material 2	0	Euro/kg	
Auxiliary material 3	0	Euro/kg	
Auxiliary material 4	0	Euro/kg	
Auxiliary material 5	0	Euro/kg	
Repair & maintenance costs	220	Euro/ unit	Task 2
Discount rate (interest minus inflation)	0.03	%	MEErP 2024

Input / Assumption	Value	Unit	Source
Escalation rate (project annual growth of running costs)	0.03	%	MEErP 2024
Present Worth Factor (PWF) (calculated automatically)	6	(years)	MEErP 2024
Ratio efficiency STOCK: efficiency NEW, in Use Phase	0.9		MEErP 2024

5.3 BASE CASE ENVIRONMENTAL IMPACT ASSESSMENT

5.3.1 Scope

Using the EcoReport tool and the above inputs, it is possible to calculate environmental impacts for the following phases of a product life cycle:

- Raw Materials Use and Manufacturing;
- Distribution;
- Use phase;
- End-of-Life Phase.

This chapter provides the environmental impacts of the Base-Cases throughout all the life cycle stages. The results were calculated using the EcoReport tool of the MEErP, based on the inputs presented in the previous section. The MEErP tracks 16 impact categories used in the EF method by using the Circular Footprint Formula (CFF).

Circular Footprint Formula (CFF) parameters

The simplified version of the CFF (material part only):

$$\boxed{(1 - R_1)E_V + R_1 \times \left(AE_{recycled} + (1 - A)E_V\right)}$$

Where:

- R1 (recycled content): it is the proportion of material in the input to the production that has been recycled from a previous system.
- R2 (recycling output rate): it is the proportion of the material in the product that will be recycled (or a component to be reused) in a subsequent system. R2 shall therefore consider the inefficiencies in the collection and recycling processes. R2 shall be measured at the output of the recycling plant.
- A (allocation factor): allocation factor of burdens and credits between supplier and user of recycled materials.
- Ev: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material.

- Ev*: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials. It will be set by default equal to Ev.
- Erecycled: specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled material (or reused component), including collection, sorting and transportation process.

5.3.2 Servers

BC-1 Rack Server

Figure 5.1 below presents the results of the environmental analysis of BC-1 (rack server). According to this, the energy consumption during the use phase is by far the predominant aspect contributing to the environmental impacts from the product's entire life cycle.

Figure 5.1 Distribution of BC-1 environmental impacts by life cycle phase

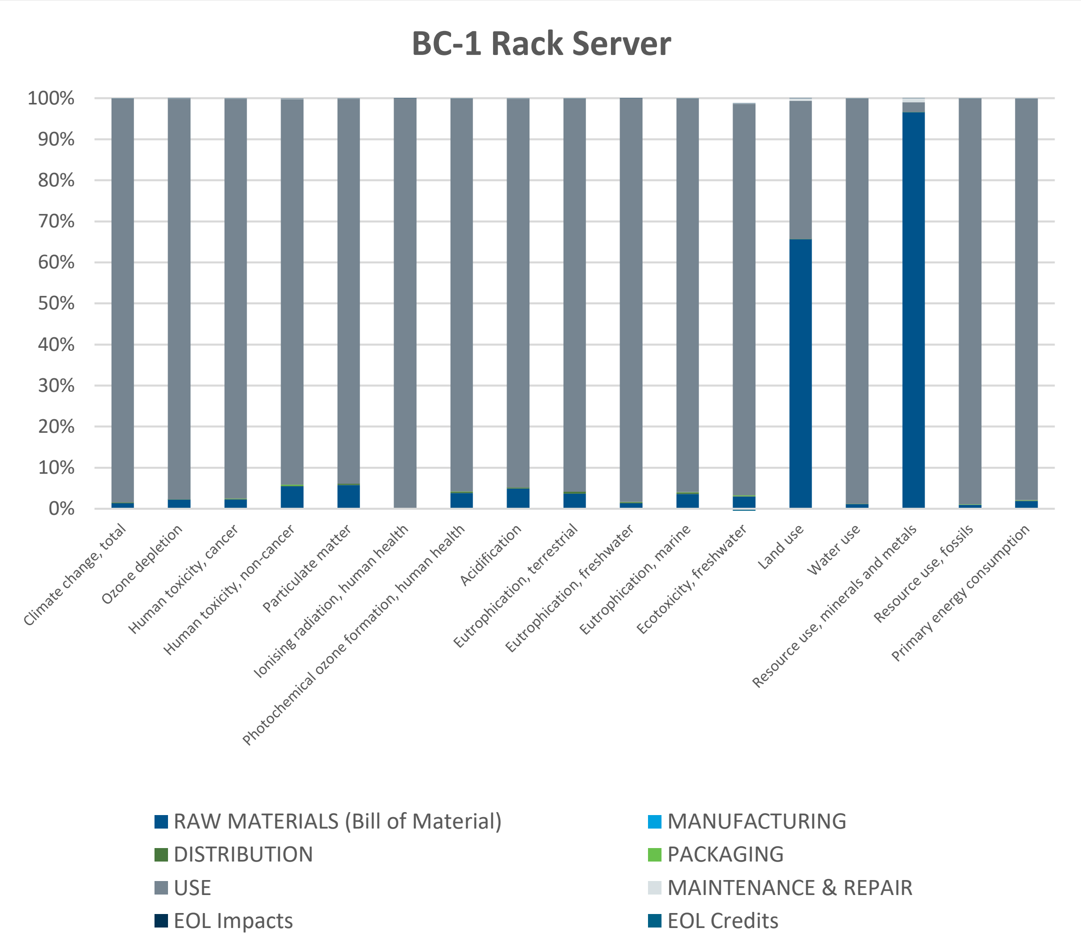


Table 5.27 below presents the Life Cycle Impacts (per unit) of BC-1

Table 5.27 Life Cycle Impacts (per unit) of BC-1: Rack Server

Life Cycle phases -->		RAW MATERIALS (Bill of Material)	MANUFACTURING	DISTRIBUTION	PACKAGING	USE	MAINTENANCE & REPAIR	EOL		TOTAL
Resources Use and Emissions								Impacts	Credits	

PEF Impact categories	unit									
Climate change, total	kg CO2 eq	9.3E+01	0.0E+00	6.6E+00	2.4E+00	6.7E+03	9.3E-01	1.6E-01	-6.4E+00	**6.8E+03**
Ozone depletion	kg CFC-11 eq	5.8E-08	0.0E+00	4.3E-12	4.3E-11	2.5E-06	5.8E-10	1.3E-11	-1.6E-09	**2.5E-06**
Human toxicity, cancer	CTUh	2.6E-08	0.0E+00	1.6E-09	1.1E-09	1.1E-06	2.6E-10	2.6E-11	-1.5E-09	**1.1E-06**
Human toxicity, non-cancer	CTUh	1.3E-06	0.0E+00	4.0E-08	4.1E-08	2.2E-05	1.3E-08	3.7E-10	-5.1E-08	**2.4E-05**
Particulate matter	disease incidence	1.3E-05	0.0E+00	6.7E-07	3.1E-08	2.1E-04	1.3E-07	4.2E-09	-2.8E-07	**2.3E-04**
Ionising radiation, human health	kBq U235 eq	3.7E+00	0.0E+00	3.1E-02	7.9E-02	2.8E+03	3.7E-02	1.6E-02	-1.7E+00	**2.8E+03**
Photochemical ozone formation, human health	kg NMVOC eq	4.3E-01	0.0E+00	4.2E-02	4.4E-03	1.1E+01	4.3E-03	4.2E-04	-1.2E-02	**1.1E+01**
Acidification	mol H+ eq	1.1E+00	0.0E+00	5.4E-02	4.2E-03	2.0E+01	1.1E-02	4.8E-04	-2.7E-02	**2.1E+01**
Eutrophication, terrestrial	mol N eq	1.6E+00	0.0E+00	2.0E-01	1.2E-02	4.1E+01	1.6E-02	1.7E-03	-4.3E-02	**4.3E+01**
Eutrophication, freshwater	kg P eq	1.8E-04	0.0E+00	3.6E-05	6.5E-06	1.4E-02	1.8E-06	2.0E-07	-2.0E-06	**1.4E-02**
Eutrophication, marine	kg N eq	1.4E-01	0.0E+00	1.8E-02	1.1E-03	3.8E+00	1.4E-03	1.5E-04	-3.9E-03	**4.0E+00**
Ecotoxicity, freshwater	CTUe	9.4E+02	0.0E+00	6.4E+01	4.3E+01	3.0E+04	9.4E+00	3.3E+00	-4.1E+02	**3.1E+04**
Land use	pt	5.6E+04	0.0E+00	4.5E+01	1.8E+00	2.9E+04	5.6E+02	4.6E-01	-3.3E+00	**8.5E+04**
Water use	m3 water eq. of deprived water	2.6E+01	0.0E+00	5.1E-01	4.2E-01	2.3E+03	2.6E-01	3.2E-02	-3.3E+00	**2.3E+03**
Resource use, minerals and metals	kg Sb eq	6.8E-02	0.0E+00	3.1E-06	6.8E-07	1.7E-03	6.8E-04	4.0E-08	-7.7E-07	**7.0E-02**
Resource use, fossils	MJ	1.1E+03	0.0E+00	9.0E+01	8.3E+01	1.2E+05	1.1E+01	2.7E+00	-9.1E+01	**1.2E+05**

Additional technical information										
Primary energy consumption	MJ	1.1 E+03	0.0E+00	9.0E +01	8.3 E+01	5.7 E+04	1.1E+01	2.7 E+00	-9.1E +01	**5.8 E+04**

BC-2 Blade System

Figure 5.2 below presents the results of the environmental analysis of BC-2 (blade server). According to this, the energy consumption during the use phase is by far the predominant aspect contributing to the environmental impacts from the product's entire life cycle.

Figure 5.2 Distribution of BC-2 environmental impacts by life cycle phase

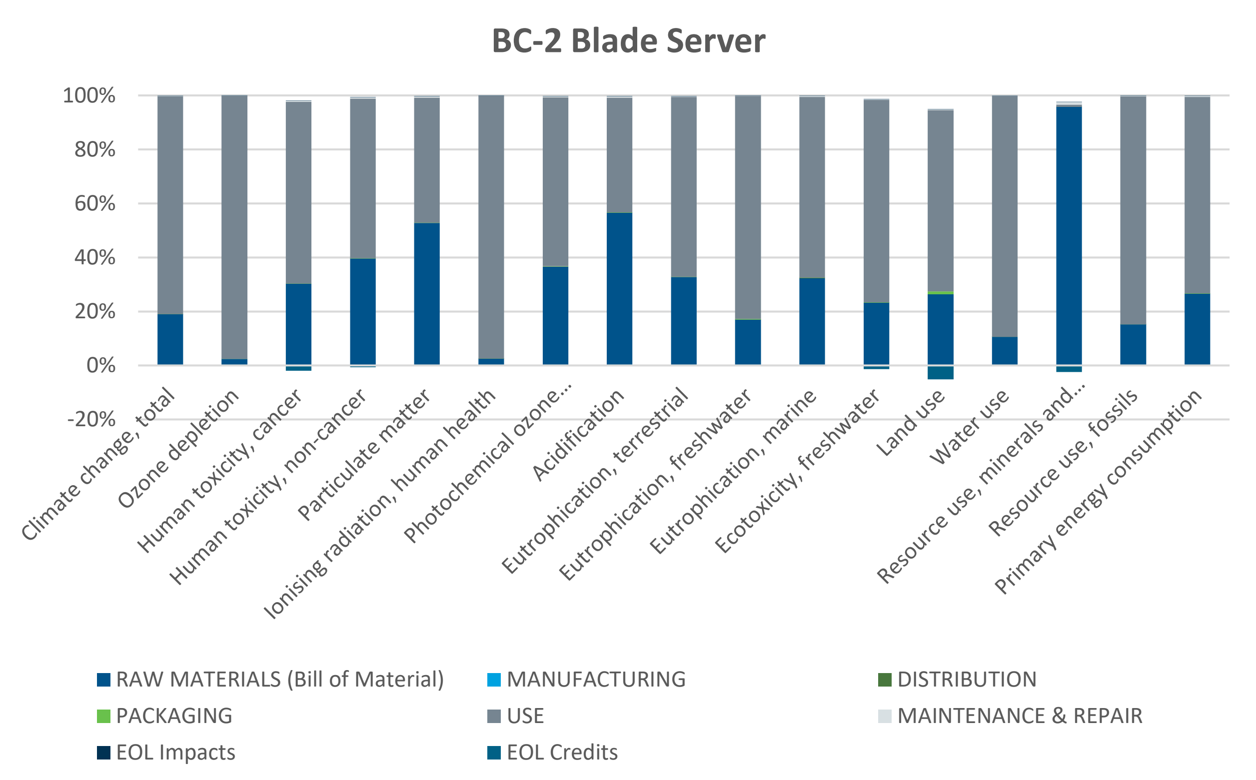


Table 5.28 below presents the Life Cycle Impacts (per unit) of BC -2

Table 5.28 Life Cycle Impact (per unit) of BC2: Blade Server

Life Cycle phases ->		RAW MATERIALS (Bill of Material)	MANUFACTURING	DISTRIBUTION	PACKAGING	USE	MAINTENANCE & REPAIR	EOL		TOTAL
Resources Use and Emissions								Impacts	Credits	
PEF Impact categories	**unit**									
Climate change, total	kg CO2 eq	1.1 E+04	0.0E+00	1.3E +01	1.4E +01	4.9 E+04	1.1E+02	2.9 E+01	-8.3E +01	**6.0 E+04**

Ozone depletion	kg CFC-11 eq	4.6E-07	0.0E+00	4.8E-12	5.3E-10	1.8E-05	4.6E-09	5.2E-09	-7.8E-09	**1.9E-05**
Human toxicity, cancer	CTUh	3.7E-06	0.0E+00	3.3E-09	4.6E-09	8.1E-06	3.7E-08	5.1E-09	-2.4E-07	**1.2E-05**
Human toxicity, non-cancer	CTUh	1.1E-04	0.0E+00	5.9E-08	1.4E-07	1.6E-04	1.1E-06	3.2E-07	-1.7E-06	**2.7E-04**
Particulate matter	disease incidence	1.8E-03	0.0E+00	4.3E-06	4.6E-07	1.6E-03	1.8E-05	1.0E-06	-9.0E-06	**3.3E-03**
Ionising radiation, human health	kBq U235 eq	5.4E+02	0.0E+00	4.6E-02	6.8E-01	2.1E+04	5.4E+00	6.4E+00	-8.6E+00	**2.1E+04**
Photochemical ozone formation, human health	kg NMVOC eq	4.7E+01	0.0E+00	2.0E-01	6.2E-02	8.0E+01	4.7E-01	5.9E-02	-3.1E-01	**1.3E+02**
Acidification	mol H+ eq	2.0E+02	0.0E+00	2.7E-01	4.9E-02	1.5E+02	2.0E+00	8.4E-02	-9.4E-01	**3.5E+02**
Eutrophication, terrestrial	mol N eq	1.5E+02	0.0E+00	8.1E-01	1.6E-01	3.0E+02	1.5E+00	2.1E-01	-1.0E+00	**4.5E+02**
Eutrophication, freshwater	kg P eq	2.1E-02	0.0E+00	3.8E-05	2.9E-04	1.0E-01	2.1E-04	4.9E-05	-8.0E-05	**1.2E-01**
Eutrophication, marine	kg N eq	1.4E+01	0.0E+00	7.4E-02	1.7E-02	2.8E+01	1.4E-01	1.9E-02	-9.6E-02	**4.2E+01**
Ecotoxicity, freshwater	CTUe	6.9E+04	0.0E+00	1.4E+02	1.3E+02	2.2E+05	6.9E+02	1.1E+02	-3.9E+03	**2.9E+05**
Land use	pt	8.3E+04	0.0E+00	4.7E+01	3.2E+03	2.1E+05	8.3E+02	1.0E+02	-1.6E+04	**2.8E+05**
Water use	m3 water eq. of deprived water	2.0E+03	0.0E+00	5.2E-01	2.6E+00	1.7E+04	2.0E+01	9.0E+00	-2.2E+01	**1.9E+04**
Resource use, minerals and metals	kg Sb eq	1.5E+00	0.0E+00	4.4E-06	5.4E-06	1.2E-02	1.5E-02	7.3E-06	-3.8E-02	**1.5E+00**

Resource use, fossils	MJ	1.5 E+05	0.0E+00	1.7E +02	2.7E +02	8.5 E+05	1.5E+ 03	4.7 E+02	-1.1E +03	**1.0 E+06**
Additional technical information										
Primary energy consumption	MJ	1.5 E+05	0.0E+00	1.7E +02	2.7E +02	4.2 E+05	1.5E+ 03	4.7 E+02	-1.1E +03	**5.7 E+05**

5.3.3 Data storage

BC-3 Storage Unit

Figure 5.3 below presents the results of the environmental analysis of BC-3 (data storage). According to this, the energy consumption during the use phase is by far the predominant aspect contributing to the environmental impacts from the product's entire life.

Figure 5.3 Distribution of BC-3 environmental impacts by life cycle phase

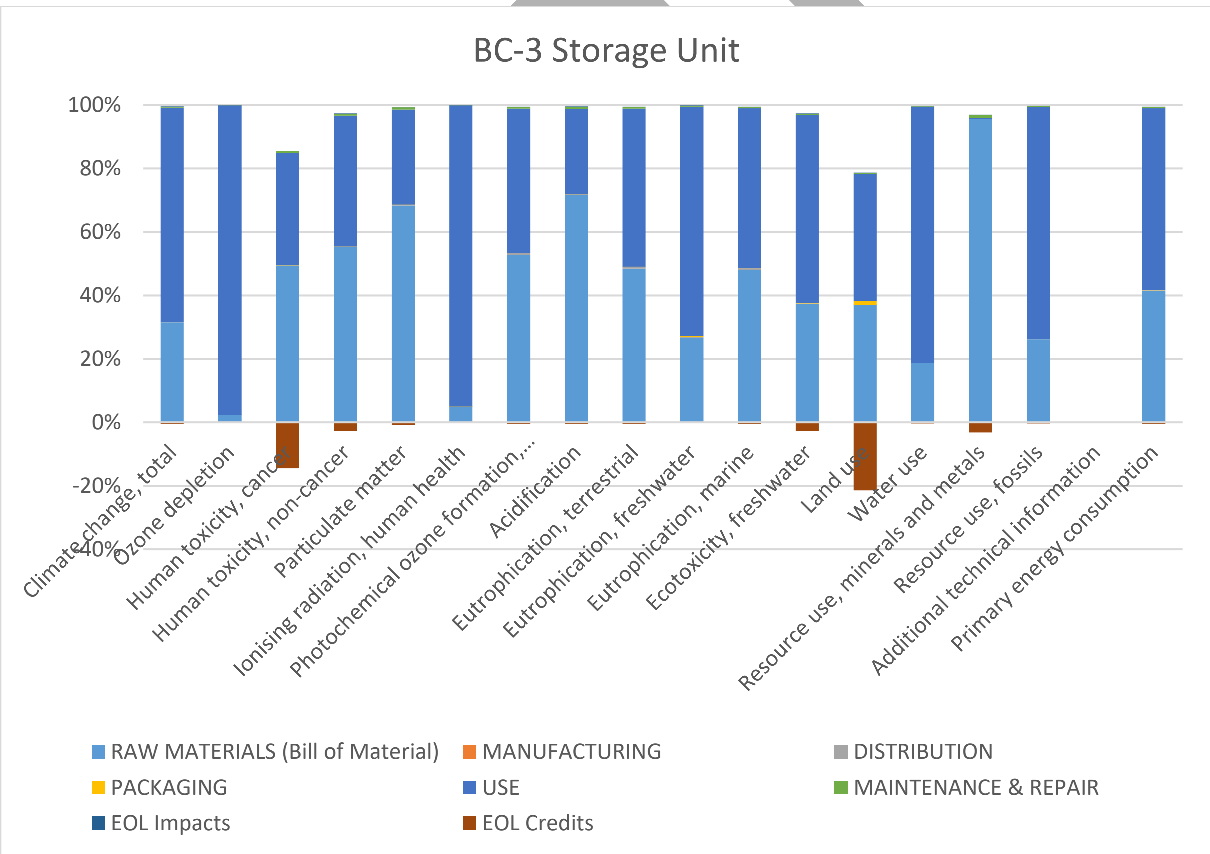


Table 5.29 below presents the Life Cycle Impacts (per unit) of BC-3

Table 5.29 Life Cycle Impact (per unit) of BC3: Data Storage

Life Cycle phases -->		RAW MATERIALS (Bill of Material)	MANUFACTURING	DISTRIBUTION	PACKAGING	USE	MAINTENANCE & REPAIR	EOL		TOTAL
Resources Use and Emissions								Impacts	Credits	
PEF Impact categories	**unit**									
Climate change, total	kg CO2 eq	5.7E+03	0.0E+00	1.3E+01	6.6E+00	1.2E+04	5.7E+01	9.1E+00	-9.5E+01	**1.8E+04**
Ozone depletion	kg CFC-11 eq	1.1E-07	0.0E+00	4.8E-12	2.6E-10	4.5E-06	1.1E-09	1.2E-09	-6.4E-09	**4.7E-06**
Human toxicity, cancer	CTUh	2.8E-06	0.0E+00	3.3E-09	2.2E-09	2.0E-06	2.8E-08	1.7E-09	-8.3E-07	**4.1E-06**
Human toxicity, non-cancer	CTUh	5.5E-05	0.0E+00	5.9E-08	6.6E-08	4.1E-05	5.5E-07	1.4E-07	-2.7E-06	**9.4E-05**
Particulate matter	disease incidence	8.9E-04	0.0E+00	4.3E-06	2.2E-07	3.9E-04	8.9E-06	2.7E-07	-9.5E-06	**1.3E-03**
Ionising radiation, human health	kBq U235 eq	2.7E+02	0.0E+00	4.6E-02	3.3E-01	5.2E+03	2.7E+00	1.6E+00	-7.3E+00	**5.5E+03**
Photochemical ozone formation, human health	kg NMVOC eq	2.3E+01	0.0E+00	2.0E-01	3.0E-02	2.0E+01	2.3E-01	1.7E-02	-2.7E-01	**4.3E+01**
Acidification	mol H+ eq	9.9E+01	0.0E+00	2.7E-01	2.4E-02	3.7E+01	9.9E-01	2.3E-02	-7.2E-01	**1.4E+02**
Eutrophication, terrestrial	mol N eq	7.3E+01	0.0E+00	8.1E-01	7.8E-02	7.5E+01	7.3E-01	6.2E-02	-9.0E-01	**1.5E+02**
Eutrophication, freshwater	kg P eq	9.2E-03	0.0E+00	3.8E-05	1.4E-04	2.5E-02	9.2E-05	1.4E-05	-9.4E-05	**3.4E-02**
Eutrophication, marine	kg N eq	6.7E+00	0.0E+00	7.4E-02	8.4E-03	7.1E+00	6.7E-02	5.6E-03	-8.3E-02	**1.4E+01**
Ecotoxicity, freshwater	CTUe	3.5E+04	0.0E+00	1.4E+02	6.5E+01	5.6E+04	3.5E+02	3.8E+01	-2.6E+03	**8.9E+04**
Land use	pt	4.9E+04	0.0E+00	4.7E+01	1.6E+03	5.3E+04	4.9E+02	2.8E+01	-2.8E+04	**7.5E+04**
Water use	m3 water eq. of	9.7E+02	0.0E+00	5.2E-01	1.3E+00	4.2E+03	9.7E+00	2.6E+00	-2.1E+01	**5.1E+03**

	deprived water									
Resource use, minerals and metals	kg Sb eq	7.0E-01	0.0E+00	4.4E-06	2.6E-06	3.1E-03	7.0E-03	2.0E-06	-2.3E-02	**6.9E-01**
Resource use, fossils	MJ	7.6E+04	0.0E+00	1.7E+02	1.3E+02	2.1E+05	7.6E+02	1.5E+02	-1.1E+03	**2.9E+05**
Additional technical information										
Primary energy consumption	MJ	7.6E+04	0.0E+00	1.7E+02	1.3E+02	1.1E+05	7.6E+02	1.5E+02	-1.1E+03	**1.8E+05**

5.4 BASE CASE LIFE CYCLE COST FOR CONSUMERS

This section presents the results of the Life Cycle Cost (LCC) analysis of the Base-Cases using the Ecoreport tool. In the analysis, all the consumer expenditures throughout the life span of the product are considered, which include:

- Average sales prices of the Base-Cases (in Euro);
- Average installation costs (in Euro);
- Average repair and maintenance costs (in Euro);
- Average electricity rates (in Euro Cent/kWh);
- Average lifetime of the Base-Case (in years);
- Average annual energy consumption (in kWh).

A typical consumer of the server/data storage products will be the owner of the equipment (e.g. data centre / server room). Table 5.30 below presents the Ecoreport outcomes of the LCC calculations for all base-cases per product per year.

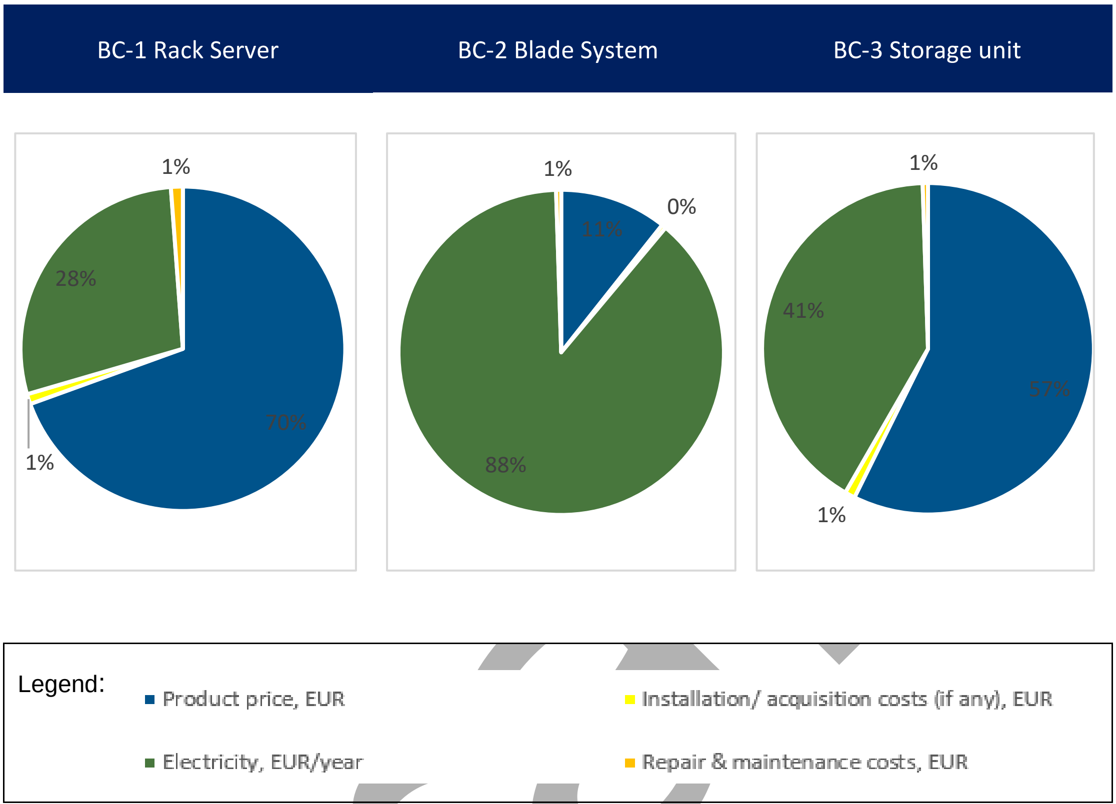
Table 5.30 Life Cycle Costs for all Base Cases per product per year

	BC-1 Rack Server	BC-2 Blade System	BC-3 Storage Unit
Product price, EUR	23,420	8,435	24,400
Installation/ acquisition costs (if any), EUR	340	340	425
Electricity, EUR/year	9,551	69,956	17,534
Repair & maintenance costs, EUR	400	400	220
Total, EUR/year	**15,591**	**72,249**	**21,708**

Figure 5.4 below visually presents the distributions of the values represented in Table 5.30 for all three base cases. It is clear for all base cases the largest costs in each comes from the product prices and electricity costs per year to operate the product. However, each base case cost breakdowns varies dramatically. For example, BC1 has the highest initial product price whereas BC2 requires a significantly lower capital expenditure however, its running costs are dramatically higher, close to seven times BC1 electrical costs. There are similarities across all three base cases with the installation costs, BC3 is slightly more expensive to install

than the server products. Meanwhile, BC1 and BC2 have the same repair & maintenance costs, although for BC3 this cost is close to 50% less.

Figure 5.4 Life Cycle Costs for all Base Cases presented as pie charts.



5.5 BASE CASE LIFE CYCLE COSTS FOR SOCIETY

The societal life cycle costs are a sum of direct environmental costs, externalities and other indirect costs. The calculations are based on MEErP 2024 tool using the following formula:

Societal LCC = LCC consumer + LCC external.damages

Where:

LCC external.damages = PP damages + Lifetime operating expense (N* OEdamages) + End of Life (EoLdamages)

And

- PPdamages = Impacts (GWP in kg CO2 eq., AP in kg SO2 eq., etc.) in Production and Distribution phase x Damage unit value (in €/kg)
- OEdamages = Impacts in Use Phase x Damage unit value
- EoLdamages = Impacts in End-of-Life Phase x Damage unit value

Table 5.31 below presents the life cycle costs per product per year for society calculated by the factors given in MEErP 2024 tool.

Table 5.31 Total Societal Life Cycle Costs per product per year

	BC-1 Rack Server	BC-2 Blade System	BC-3 Storage Unit
PP damages, EUR	33	2,748	1,376
N*OE damages, EUR	893	6,540	1,639
EoL damages, EUR	-1	-17	-24
Total External Damages, EUR	925	9,272	2,992
LCC (excl. ext. damages), EUR)	15591	72,249	21,708
Total Societal LCC, EUR/year	15823	74,567	22,207
Total External damages as % of Total Societal LCC	5.8%	12.4%	13.4%

5.6 EU TOTALS

5.6.1 Lifecycle Environmental Impact at EU-27 Level

In this section, the environmental impact data is aggregated at the EU-27 level using stock and market data from Task 2. The aggregated results of the life cycle environmental impacts per year corresponding to the EU stock of products are presented in Table 5.32.

Table 5.32 EU Total Annual Impact of Stock of Products

Main life cycle indicators	unit	**BC-1 Rack Server**	**BC-2 Blade System**	**BC-3 Storage Unit**	**Total**
PEF Impact categories					
Climate change, total	**kg CO2 eq**	**37,371**	**84,636**	3,456,785	3,578,791
Ozone depletion	kg CFC-11 eq	1.4E-05	2.6E-05	9.0E-04	9.4E-04
Human toxicity, cancer	CTUh	6.3E-06	1.6E-05	7.8E-04	8.1E-04
Human toxicity, non-cancer	CTUh	1.3E-04	3.8E-04	1.8E-02	1.9E-02
Particulate matter	disease incidence	1.3E-03	4.7E-03	2.5E-01	2.5E-01
Ionising radiation, human health	kBq U235 eq	1.6E+04	3.0E+04	1.1E+06	1.1E+06
Photochemical ozone formation, human health	kg NMVOC eq	6.3E+01	1.8E+02	8.4E+03	8.6E+03
Acidification	mol H+ eq	1.2E+02	4.9E+02	2.6E+04	2.7E+04
Eutrophication, terrestrial	mol N eq	2.4E+02	6.3E+02	2.9E+04	2.9E+04
Eutrophication, freshwater	kg P eq	7.6E-02	1.7E-01	6.6E+00	6.9E+00
Eutrophication, marine	kg N eq	2.2E+01	5.9E+01	2.7E+03	2.8E+03
Ecotoxicity, freshwater	CTUe	1.7E+05	4.0E+05	1.7E+07	1.8E+07
Land use	pt	4.7E+05	3.9E+05	1.5E+07	1.5E+07
Water use	m3 water eq. of deprived water	1.3E+04	2.6E+04	9.9E+05	1.0E+06
Resource use, minerals and metals	kg Sb eq	3.9E-01	2.1E+00	1.3E+02	1.4E+02
Resource use, fossils	MJ	6.5E+05	1.4E+06	5.6E+07	5.8E+07
Additional technical information					

Primary energy consumption	MJ	323,597.40	805,385.84	**35,149,544.43**	**36,278,527.67**

Table 5.33 below presents the life cycle environmental impacts of new products.

Table 5.33 EU Total Impact of New Products over their lifetime

Life Cycle phases --> Resources Use and Emissions		BC-1 Rack Server	BC-2 Blade System	BC-3 Storage Unit	Total
PEF Impact categories	**unit**				
Climate change, total	kg CO2 eq	9.3E+03	2.1E+04	5.8E+05	6.1E+05
Ozone depletion	kg CFC-11 eq	3.5E-06	6.5E-06	1.5E-04	1.6E-04
Human toxicity, cancer	CTUh	1.6E-06	4.1E-06	1.3E-04	1.4E-04
Human toxicity, non-cancer	CTUh	3.3E-05	9.5E-05	3.0E-03	3.1E-03
Particulate matter	disease incidence	3.1E-04	1.2E-03	4.1E-02	4.3E-02
Ionising radiation, human health	kBq U235 eq	3.9E+03	7.5E+03	1.8E+05	1.9E+05
Photochemical ozone formation, human health	kg NMVOC eq	1.6E+01	4.5E+01	1.4E+03	1.5E+03
Acidification	mol H+ eq	3.0E+01	1.2E+02	4.4E+03	4.5E+03
Eutrophication, terrestrial	mol N eq	5.9E+01	1.6E+02	4.8E+03	5.0E+03
Eutrophication, freshwater	kg P eq	1.9E-02	4.2E-02	1.1E+00	1.2E+00
Eutrophication, marine	kg N eq	5.5E+00	1.5E+01	4.5E+02	4.7E+02
Ecotoxicity, freshwater	CTUe	4.3E+04	1.0E+05	2.8E+06	3.0E+06
Land use	pt	1.2E+05	9.8E+04	2.4E+06	2.6E+06
Water use	m3 water eq. of deprived water	3.2E+03	6.5E+03	1.7E+05	1.7E+05
Resource use, minerals and metals	kg Sb eq	9.7E-02	5.1E-01	2.2E+01	2.3E+01
Resource use, fossils	MJ	1.6E+05	3.5E+05	9.3E+06	9.8E+06
Additional technical information					
Primary energy consumption	MJ	8.1E+04	2.0E+05	5.8E+06	6.1E+06

5.6.2 Life Cycle Costs for Consumers at EU-27 Level

Table 5.34 below presents the aggregated results of the annual consumer expenditure per Base-Case in the EU-27. This represents the total expenditure at EU level per year, assuming that the Base-Cases represent the entire installed stock in the EU-27.

Table 5.34 Total Annual Consumer Expenditure in the EU-27 million €

	BC-1 Rack Server	BC-2 Blade System	BC-3 Storage Unit
Product price, EUR	32,320	2,952	783,240
Installation/ acquisition costs (if any), EUR	469	119	13,643
Electricity, EUR/year	52,761	98,006	3,377,837
Repair & maintenance costs, EUR	552	140	7,064
Total, EUR/year	**86,102**	**101,217**	**4,181,783**

5.6.3 Life Cycle Costs for Society at EU-27 Level

Table 5.35 below presents the total annual social life-cycle costs at EU-27 level. Adding the external costs to society to the LCC gives the total annual social life cycle costs.

Table 5.35 Total annual social life-cycle costs in the EU-27

	BC-1 Rack Server	BC-2 Blade System	BC-3 Storage Unit
PP damages (m €)	45.86	961.97	44,176.35
N*OE damages (m €)	1233.20	2,290.74	52,634.45
EoL damages (m €)	-1.29	-5.78	-763.28
Total External Damages (m €)	1277.78	3,246.93	96,047.52
LCC (excl. ext. damages) (m €)	86,102	101,217	4,181,783
Total Societal LCC (m €)	87,380	104,464	4,277,830