Eco-Design of Digital Services

Methodology for the assessment of the environmental Impact of a Node in a Blockchain

Summary

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Study conducted for	Study conducted by	Critical review by
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1 METHODOLOGY FOR THE ASSESSMENT OF THE NODE ENVIRONMENTAL IMPACTS

The environmental impacts evaluation of the nodes are conducted according to the standardized method of life cycle assessment (LCA) defined in the ISO 14040 and ISO 14044 standards and based will be based on data from a database like NegaOctet (database of environmental impacts of digital equipment, infrastructures, systems, and services). This methodology was peer reviewed in order to ensure consistency and reliability.

1.1 Workflow of the assessment

The node operators will be responsible of the data collection and the auditors will be responsible of the data validation (Figure 1).

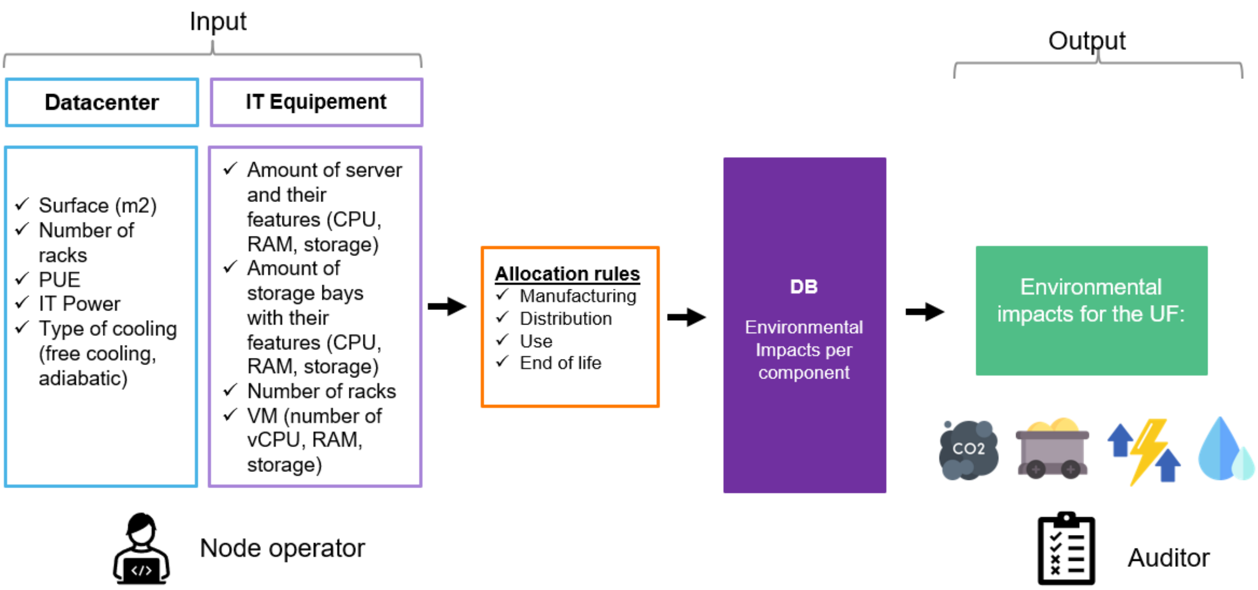

Figure 1- Workflow of the assessment

The steps of the assessment workflow are the following:

1.2 Data collection.

Every node operator will provide detailed information about its node's setup (IT equipment, datacenter or cloud). Nodes operators will make sure to produce a complete inventory of their setup so that the environmental score can be calculated. For datacenter and IT equipment, sample data required from the node operators are the following:

Building and technical environment (if necessary)	▪ Surface (m2) ▪ Amount of racks and IT rooms ▪ PUE ▪ IT Power consumption ▪ Type of cooling (free cooling, adiabatic) ▪ Location of the DC ▪ Electrical mix
IT equipment	▪ Amount of server and their features (CPU, RAM, storage) ▪ Amount of storage bays with their features (CPU, RAM, storage) ▪ Number of racks ▪ VM (number of vCPU, RAM, storage) ▪ Etc.

Full data required from the node operators will be found on the Excel sheet following this methodological node.

1.3 Data verification

The auditors will review the data and its global coherence. The auditors will guarantee the reliability, consistency and quality of the data.

1.4 Environmental assessment

The auditors will assess the environmental of the nodes leveraging the methodology below. Since the proof of authority consensus is designed to only allow a known set of nodes to create blocks in a round robin way, every node will seal approximately the same quantity of nodes over the year.

As such, determining the environmental footprint of the node will consist in calculating the environmental footprint of the IT infrastructure allowing the node to create and verify blocks from the manufacturing of the equipment to its end-of-life. This is to have an end-to-end environmental footprint. The LCA standard and on other frameworks such as the digital services Product Category Rules (PCR) and the PCR data center and cloud have been used.

1.4.1 The method in short

Life cycle assessment is an environmental assessment method like carbon footprint or impact assessments, but it has specificities that make its holistic approach unique. This method has been used since the end of the 90s and standardized in the ISO 14040:2006 and ISO 14044:2006 series; it is used to determine a product or service's ecological baggage, using an approach that is:

- **Multicriteria:** Several environmental indicators are to be considered systematically, including global warming potential, depletion of abiotic resources, photochemical ozone creation, water, air and soil pollution, human ecotoxicity and biodiversity. The list of indicators is not fixed but depends on the sector of activity.
- **Life cycle:** to integrate the impacts generated during the stages of the equipment's life cycle, from the extraction of hard-to-reach natural resources to waste production, including the energy consumption during use.

- **Quantitative:** each indicator is quantified to put all the externalities of a product or service on the same scale and help make objective decisions.
- **Functional:** the object of the study is defined by the function it fulfills to compare different technical solutions.

1.4.2 What has been measured? The functional unit

The functional unit is the unit of measurement used to assess the service provided by the service. It allows us to compare the environmental impacts of two services based on a common unit. This unit reflects the function that the service provides to the end user. The functional unit (FU) chosen depends on the service studied and the client's objective and must be defined during the life cycle assessment.

Each service studied is associated with a functional unit that will allow us to evaluate the two scenarios, on premises and cloud, according to a common unit. The functional unit studied is:

FU: Evaluation of the environmental footprint of a node with maximum 119 M gas per block (a block every 4s) and over a year.

119Mgas and 4 seconds per block are the configuration parameters of the proof of climate awareness consensus.

1.4.3 What will be considered on the scope?

Within the framework of the study, several facilities and infrastructures are considered depending on the scenario.

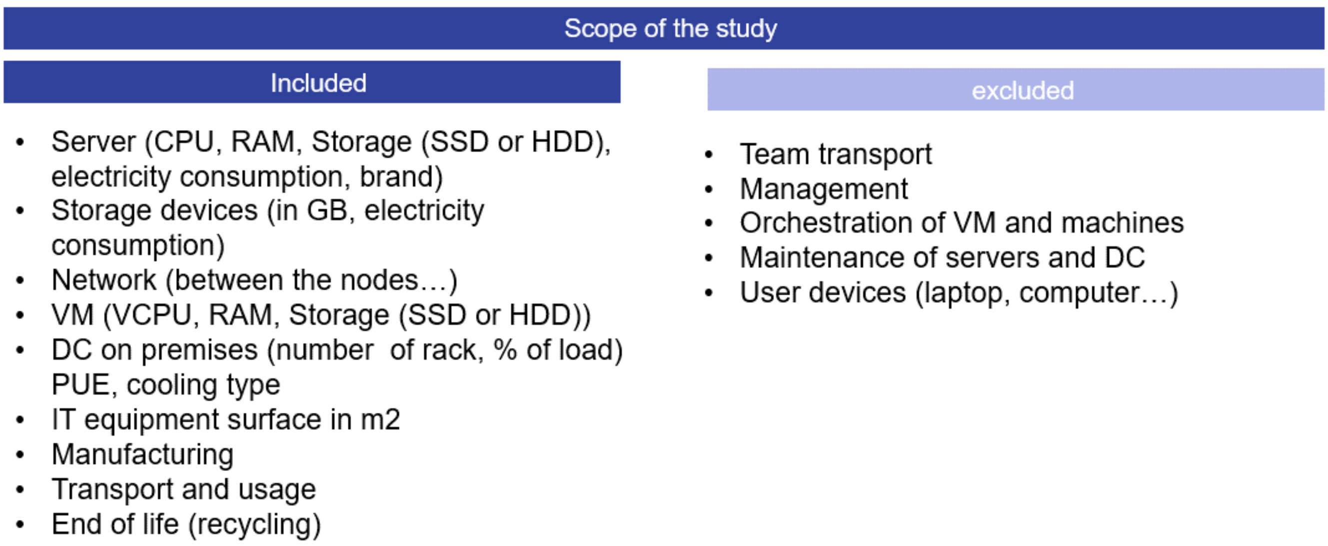

Figure 2: Overall scope of the study

The lifecycle stages considered are: **manufacturing, distribution, use and end of life.**

1.4.4 How will be the assessment made ?

From the data collected by the operator nodes, an allocation is made to bring the impacts of the equipment back to the functional unit described above. The allocations are as follows:

Computer equipment and LAN networks (in computer rooms)

IT equipment and LAN networks

Manufacturing and distribution:

- Lifespan of each component
- 100% attributed to the platform

Use

- Power rating x load factor x 365 x 24 if power measured during operation is not available
- Operating power x 365 x 24 if operating power is available

End of life

- Lifespan of each component
- Type of waste
- 100% attributed to the platform

Technical infrastructure and data center structures

Building and technical environment

Manufacturing and distribution:

- In proportion to the duration of the FU over the life of each component
- In proportion to the surface area used for the platform versus the surface area of the IT room in the data center

Use

- Platform energy consumption x (PUE-1)

End of life

- In proportion to the duration of the FU over the life of each component
- By type of waste
- In proportion to the surface area used for the platform versus the surface area of the IT room in the data center

TIER		On premises scenario	Cloud scenario
Data center	Manufacturing, distribution and end of life	$\frac{1}{LS\_DC} \times \frac{PowerEqt}{PowerT\_Tot}$	$\frac{1}{LS\_DC} \times \frac{NrackFU}{NracksTotal}$
	Use	$\frac{PowerEqt}{PowerIT\_Tot}$	$EF(NrackFU)$
IT equipment	Manufacturing, distribution and end of life	$\frac{1}{LS\_eqt}$	$\frac{1}{LS\_eq}$
	Use	$EF(usage\_eq)$	$EF(usage\_eq)$

Table 1: Allocation rules and reference flows for the FU if the nodes are on premises

Thus, the environmental impacts will be considered over one year while the consumption of the equipment used will be considered over one year of operation.

Note: PUE (Power Usage Effectiveness) is the energy performance indicator used for data centers. PUE is standardized according to ISO/IEC 30134-2:2016.[1] It is calculated as follows:

$$PUE = \frac{Datacenter\ electrical\ consumptions\ (over\ 1\ year)\ in\ kWh}{\text{Electrical consumptions of IT equipment (over 1 year)}\ in\ kWh}$$

To avoid being influenced by seasonal variations, the PUE value used is the one defined over the last 12 months.

Moreover, environmental databases provides elementary impact data (for example, the environmental footprint of a server) are used to determine the impacts of each piece of equipment.

By multiplying these elemental impacts by the allocation ratios, the equipment impacts are obtained. Thus, the environmental impact of a node is equal to the environmental impact of each of the equipment that contributes to the operation this node.

$$\boldsymbol{FootprintNode_i = \sum_{k=1}^{l} ImpEq_k}$$

$$\boldsymbol{ImpEq_k} = \sum((\boldsymbol{ManEq_k} \times \boldsymbol{AllocMan}) + (\boldsymbol{DisEq_k} \times \boldsymbol{AllocDis}) + (\boldsymbol{UseEqq_k} \times \boldsymbol{AlloUse}) + (\boldsymbol{EolEq_k} \times \boldsymbol{AllocEol}))$$

[1] https://www.iso.org/standard/63451.html

The table below specifies the various parameters and their corresponding units or designations.

Parameters	Definitions	Units
LS_DC	LifeSpan of the DC	Year
LS_eq	LifeSpan of the equipment	Year
EF(usage)	Emission Factor is a coefficient that describes the rate at which a given activity releases for example greenhouse gases into the atmosphere). EF(usage_eq) refer to the emission factor linked to the usage of the equipment (Power(kW)*usage (h)* Impact (1 kWh)	kg CO_2 eq, MJ, kg Sb eg or m^3
$PowerEqt$	Total power of the IT equipment used for the service	kW
$PowerIT\_Tot$	Total power installed on the DC	kW
$NracksUF$	Number of IT racks	Racks
$NracksTotal$	Total number of racks in the DC	Racks
$FootprintNode_i$	Footprint of the Node i	kg CO_2 eq, MJ, kg Sb eq or m^3
$ImpEq_k$	Footprint of the equipment k	kg CO_2 eq, MJ, kg Sb eq or m^3
$ManEq_k$	EF of the manufacturing of the equipment k	kg CO_2 eq, MJ, kg Sb eq or m^3
$AlloMan$	Allocation rule of the manufacturing	
$DisEqe_k$	EF of the distribution of the equipment k	kg CO_2 eq, MJ, kg Sb eq or m^3
$AllocDis$	Allocation rule of the distribution of equipment	
$UseEqe_k$	EF of the use of the equipment k	kg CO_2 eq, MJ, kg Sb eq or m^3
$AllocUse$	Allocation rule of the use of the devices	
$EolEqe_k$	EF of the end of life of the equipment k	kg CO_2 eq, MJ, kg Sb eq or m^3
$AllocEol$	Allocation rule of the end of life	

Table 2: The different parameters of the reference flows

1.4.5 What will be the results?

All environmental assessment results will be presented using four indicators presented above on section :

- **Greenhouse gas emissions or climate change kg CO eq,**
- **Depletion of abiotic resources depletion kg Sb eq,**
- **Primary energy consumption MJ.**

- **Water resource depletion m3 eq,**

The last two indicators will be assessed as relevant, **but their maturity is still questionable with respect to possible limitations on the confidence in the databases (e.g., on blue water).**

IMPACT INDICATORS	**Depletion of natural resources (minerals and metals)** • Type of indicator: Problem-oriented impact indicator (mid-point) • Abbreviation: **PEF-ADPe** • Unit: **kg of Antimony equivalent (kg Sb-eq**) • Evaluation Method: **ReCiPe 2018** • **Definition**: Industrial exploitation leads to a decrease in available resources, which have limited reserves. This indicator measures the amount of mineral and metal resources taken from nature, as if they were antimony. Antimony is a resource considered to be depletable on a human scale and has a value of 1 by convention. A value greater than one for a resource indicates that a scarcer resource than antimony is being consumed.	**Climate change** • Type of indicator: Problem-oriented impact indicator (mid-point) • Abbreviation: **GWP** • Unit: **kg CO_2 equivalent (kg CO_2-eq)** • Evaluation Method: **IPCC 2017 methodology** • **Definition**: Greenhouse gases (GHGs) are gaseous compounds that absorb infrared radiation emitted by the Earth's surface. The increase in their concentration in the Earth's atmosphere contributes to global warming.
	Primary energy consumption • Type of indicator: **Flow indicator** • Unit: **Primary MJ** • **Definition**: Primary energy is the first form of energy directly available in nature before any transformation: wood, coal, natural gas, oil, wind, solar radiation, hydraulic energy, geothermal energy, etc.	**Water resource depletion** • Type of indicator: **Impact Indicator** • Unit: **m^3** • Abbreviation: **PEF-WU** • Unit: **m^3-world eq** • Evaluation method: **Available WAter REmaining (AWARE) as recommended by UNEP, 2016** • **Definition**: This indicator represents water consumption multiplied by a factor that takes into account the water stress of the region where the water is consumed. For example, water consumption in the Sahara will have a greater impact than in Scandinavia

Table 3: Summary table of the different environmental indicators

After these results will normalized and weighted in order to have a unique indicator.

The normalization in the LCA framework is the division of the impact computed for the system under study, by the impact of a reference value named the normalization reference[23]. LCA normalization has been identified as a leading driver in the aggregation process.

$$Normalized\ results = \frac{Value\ of\ the\ environmental\ Indicator}{Reference\ value}$$

For this study, normalization will be used for

- facilitating communication of LCA results:

[2] https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

  - by giving order of magnitude
  - by comparing with a product reference to help comparison

- weighting

Furthermore, one aspect particularly important in normalization is the selection or calculation of references values. We considered then the following reference values[4]:

Impact category	Unit	Normalization reference values
Climate change	kg CO2 eq./person	7,55E+03
Abiotic resources depletion	kg Sb eq./person	6,36E-02
Water use	m3 water eq of deprived water/person	1,15E+04
Primary energy consumption	MJ/person	6,50E+04

Table 4: Normalization reference values

After normalized, impact factors are weighted. This step aims to figure out the significance of each category and how important it is relative to the others. It allows studies to aggregate impact scores into a single indicator. Weighting is a mandatory step in several framework like PEF studies. Weighting supports the interpretation and communication of the results of the analysis.

For doing it, normalised results are multiplied by a set of weighting factors (in %) which reflect the perceived relative importance of the life cycle impact categories considered. Weighted results of different impact categories may then be compared to assess their relative importance. They may also be aggregated across life cycle impact categories to obtain a single overall score.

The weighting factors[5] that will be used here are provided below:

Impact category	Weighting factor (%)
Climate change	21%
Abiotic resources depletion	8%
Water use	9%
Primary energy consumption	8%

Table 5 : Weighting factors

[4] https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml

Since we only consider 4 indicators, we could also add a second weighting factor as follows:

Impact category	Weighting factor (%)	Second Weighting factor (%)
Climate change	21%	21/46=**46%**
Abiotic resources depletion	8%	8/46=**17%**
Water use	9%	9/46=**20%**
Primary energy consumption	8%	8/46=**17%**

Table 6: Weighting factors updated

We will consider the second weighting factor for the calculation. Once the impacts have been normalized and weighted, they are thus aggregated to form a single indicator which will constitute the environmental rating of the node. It is this note that will ultimately allow the remuneration of the nodes to be calculated.

$$SingleIndicator = \sum_{i=1}^{n} Weighted\_indicator_i$$

This single indicator is not expressed in any unit.