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NEGAOCTET

DEVELOPMENT AND TESTING
AN EVALUATION FRAMEWORK OF
THE ENVIRONMENTAL PERFORMANCE
OF DIGITAL SERVICES TO THEIR ECO-DESIGN
– *Final Report* –

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SUMMARY

ABSTRACT

The last decade has seen an acceleration in the growth of new technologies that have marked the digital landscape with speed, quality and connectivity through multimedia content and communication tools. While many areas of activity have been able to take advantage of these numerous innovations (industry 4.0, e-commerce, telecommunications, etc.) to develop, this growth has always been coupled with a significant increase in pressure on the environment and natural resources.

Since 2018, awareness of the environmental impacts of digital technology has increased, both at the level of individuals (development of tools such as the Fresque du numérique, publication of "Le guide d'un numérique plus responsible", publication in magazines and newspapers for the general public: Le Monde, Kaizen, Usbek et Rica, Alternatives Economiques, etc.), companies and professional organisations (ARCEP, CNUMM, Syntec numérique roadmaps, ... Creation of numerous working groups: ARCEP, INR, Planet tech care, ...) and public authorities (AGEC law, Responsible digital roadmap, Report of the High Council for the Climate on 5G, etc.)

This awareness based on few figures and publications has also highlighted a lack of reliable, robust and homogeneous information on that topic and the need for objective and shared tools to address this issue.

In this context, NegaOctet, a reference framework developed jointly by APL Datacenter, DDemain, GreenIT.fr and LCIE, aims to propose a method and tools for accounting for the environmental impacts of digital technology with a view to reducing them. The project is based on 4 pillars:

- *The initiation of a state of the art which was the basis for other related projects, such as the ADEME ARCEP study on the environmental impact of digital technology in France*
- *The proposal of methodological rules which could be implemented in a concrete way both during the pilots and in the implementation of Article 13 of the AGEC law*
- *The creation of a life cycle inventory database with 4 levels of depth and having questioned the impact data on semiconductor components:* Level 0 – Semiconductors, Level 1 - Digital component, Level 2 - Generic and specific equipment, *Level 3 - Infrastructure tier, Level 4 - Digital Services*
- *Testing of the NegaOctet framework in a dozen pilot case studies for public and private actors (ADEME, Airbus, BLADE, CYME, OVEA, OVH, Orange Business Service, RTE, Teads, Worldline) as well as in two studies outside the initial scope of NegaOctet: Update of the "mail" study carried out by ADEME in 2014 and creation of a comparative case study on two solutions for providing Life Cycle Assessment software - EIME*

This project also identifies subjects to be studied in depth, such as the variability of the lifespan of storage equipment or the impacts of AMR depending on the technology, and recommends that the following methodological points be explored through research projects: the allocation of impacts (cost of ownership vs. cost of use, average vs. marginal environmental cost), the consideration of indirect effects with a consequential lifecycle analysis, the multiple uses of digital technology, and the development of a complete green-claim labelling scheme.

1. THE CONSORTIUM

The NegaOctet consortium is composed of actors with complementary skills and different backgrounds, gathered around a subject: responsible digital, its tools and its generalization. Working together since 2005, the consortium decided to carry out this project in order to pool its skills at the service of consolidated and suitable tools for the implementation of an objective and documented quantification of the environmental impacts of digital technology.

1.1. APL

Key skills :
Technical expertise, particularly on the issue of datacenters - Project management - Knowledge of the ecosystem

APL Datacenter, through the integration of Neutreo by APL, has allowed the marriage between two key skills which are:
- Implementation of complex digital systems. APL Datacenter has been orchestrating the construction of data centers around the world for more than 25 years, giving it undeniable technical expertise
- Active participation in the development of responsible digital technology and its dissemination in companies and communities: initial evaluation, construction of action programs, implementation of indicators, audits, certifications (ISO 14001, ISO 9001, ISO 50001, CSR), realization of LCA, environmental communication approach (unlike greenwashing!)

Our goal is to support our customers in the design of products and services **with less impact on the environment, over the entire life cycle**.

1.2. DDemain

Key skills :
Expertise on the implementation of life cycle assessment - Project management - Transmission and development of actors - Popularization - Taking a step back

DDemain's activity revolves around environmental assessment, and more specifically on digital issues. DDemain proposes an approach through the transfer of skills and a permanent dialogue with the sponsors of the studies so that they acquire the level of competence that will allow them to sustain their approach independently.

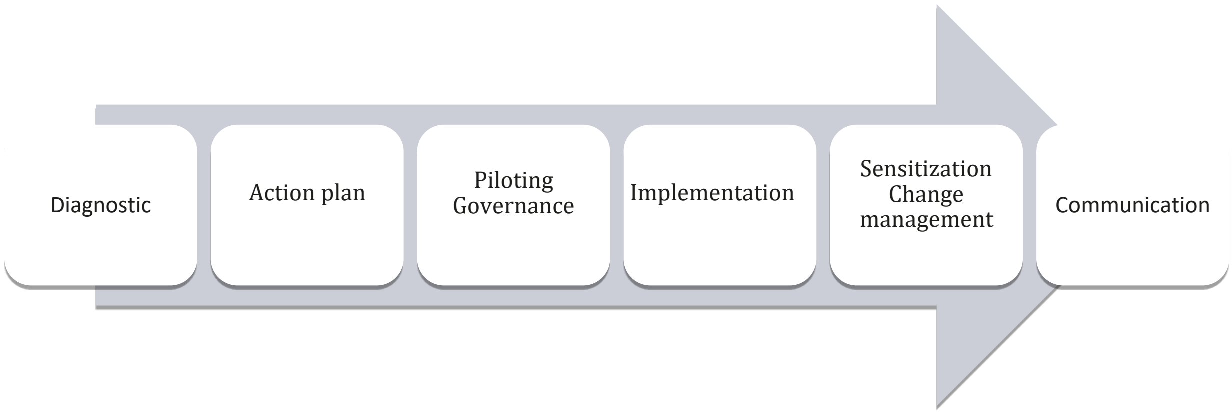
Driven by the conviction that the transmission of knowledge on environmental impact assessment is a real lever for action in organizations, the issue of co-creation, transfer of skills, adaptation of tools and training is central to DDemain's work.

1.3. GreenIT.fr

Key skills :
Co-design of digital services - LCA of information systems - Publication - Support of companies - Creation of standards, certifications and ecodesign tools

At the origin of the digital sobriety and responsible digital initiatives, GreenIT.fr is a collective of independent experts created in 2004. Led by Frédéric Bordage, it brings together the best French specialists in fields such as green IT audit, the environmental assessment of information systems, the eco-design of digital services, etc.

GreenIT.fr supports organizations throughout the life cycle of digital sobriety projects:



The expertise of GreenIT.fr and its network is recognized by organizations such as Ademe, Cigref, Afnor, etc. For example, GreenIT.fr co-developed the official France method for evaluating and reducing greenhouse gas emissions from information systems, on behalf of Ademe and Cigref. GreenIT.fr advises Afnor on Green IT standardization and frequently intervenes on files of French public authorities (e.g. repairability index) and the European Commission.

1.4. LCIE

Key skills :
Expertise on the implementation of life cycle assessment - Creation of databases - Creation of methodology in accordance with national and supranational regulations - Environmental labelling

A subsidiary of the Bureau Veritas group, LCIE (Laboratoire Central des Industries Électriques) has the CODDE departement dedicated to supporting manufacturers in their environmental analysis and eco-design process.

For more than 15 years, the company has been developing environmental tools and data for the characterization of the environmental impacts of digital products and services through EIME and its database, but also through assistance in the production of methodological documents (PCR, PSR, environmental labeling).

2. PROJECT CONTEXT

2.1. Generality

The digital transition, initially perceived as a vector of jobs, growth and new economic models, is profoundly changing the codes of all sectors of activity. From home to work, including business, city and public services, digital services are at the heart of our daily lives and have changed our behaviours and consumption patterns.

The immateriality of the services offered is increasingly called into question by the underlying materiality of the equipment and infrastructure necessary for the digital sector (energy, resources, etc.). : Stakeholders (businesses, the general public, institutions, States, administrations) are now calling for more transparency on the subject. However, this can only be achieved through the publication of robust and consensual data.

The studies and projects carried out over the past ten years have focused on specific themes, such as the energy consumption of data centers, the premature obsolescence of terminals or the management of electronic waste. For several years, publications (Global Digital Environmental Footprint – EENM 2019 and Digital Impacts in France – iNUM 2020 GreenIT.fr, Shift Project Report, Studycommissioned by the Senate, Report of the High Council for Climate on 5G, etc.) have shed light on the debate and highlight the need for a more comprehensive approach that is both:

- **Multi-criteria**, because the environmental impacts of digital technology are not limited to greenhouse gas emissions
- **Multi-step**, in order to integrate the impacts generated during all stages of the equipment life cycle and on three-thirds of a digital service (terminal, network, datacenter)

- **Multi-components**, in order to understand these complex systems that are the association of user terminals, datacenters and telecommunications networks, all composed of a multitude of equipment each with its own life cycles

This is the interest and relevance of the standardized method of life cycle assessment, a method at the heart of the NegaOctet project but also at the heart of the environmental impact assessment and environmental labelling work carried out at the national level.

However, to make informed decisions and propose unbiased communications, it is necessary to agree on inventory data, impact data, flows, methods and use cases related to the deployment of digital sector services at a given time. Thus, the four pillars of the NegaOctet project are:
- The state of the art
- Methodological rules
- The creation of a life-cycle inventory database
- Implementation of the method

are part of this dynamic.

2.2. Reminder of locks to be lifted

2.2.1. First lock – Lack of data – Lack of knowledge of the real impact of digital services

One of the main conclusions of the work commissioned in 2016 by ADEME on the "Potential contribution of digital technology to the reduction of environmental impacts" is that knowledge of the environmental impact of ICT is mostly limited to the impacts of the use phase of terminal equipment. Few life-cycle assessments (multi-stage and multi-criteria) have been carried out in order to have a more complete picture of the impact of ICTs.[1]

In addition, all the roadmaps proposed by the various players in the ecosystem focus on the need to better assess the impact of digital development and to have basic data for evaluation, as shown in the following figure.

[1] http://www.ademe.fr/sites/default/files/assets/documents/ademe_contribution_du_numerique_synthese.pdf

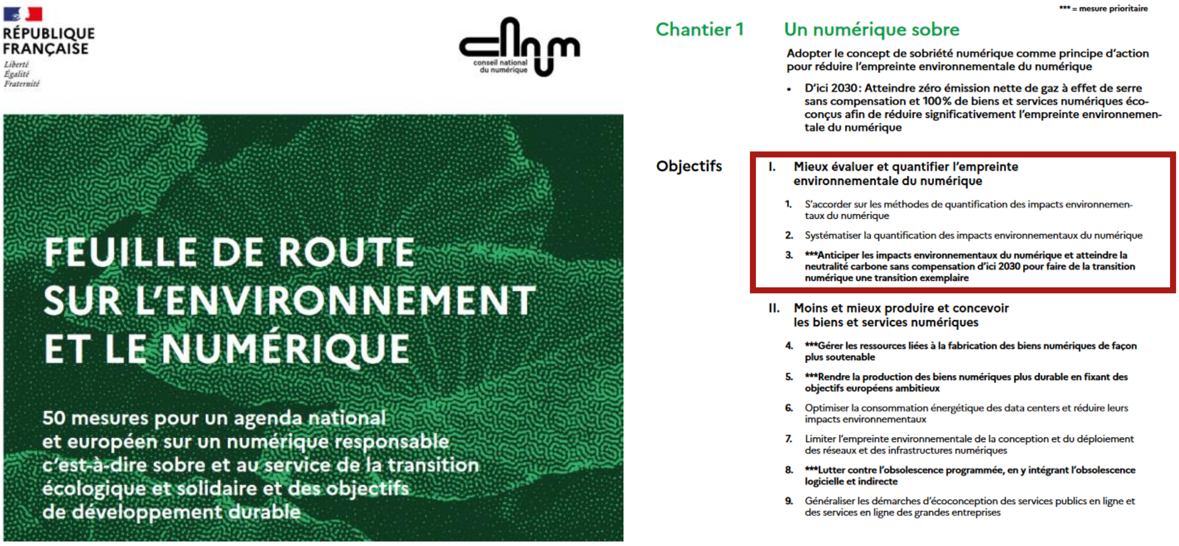


Figure 1- Government Roadmap on the Environment and Digital

2.2.2. Second lock – Uncertainties related to the use of disparate and poorly documented data

With the development of SaaS-type offers and solutions associated with connected objects (80 billion by 2020 according to IDATE), the environmental impact of a service is no longer limited to the impact of its design and use on terminals. It is now necessary to consider a digital service as a real ecosystem since its use uses delocalized resources such as the network and the datacenter. This expansion of the scope therefore requires the combination of a very large amount of data that is not always available or of sufficient quality.

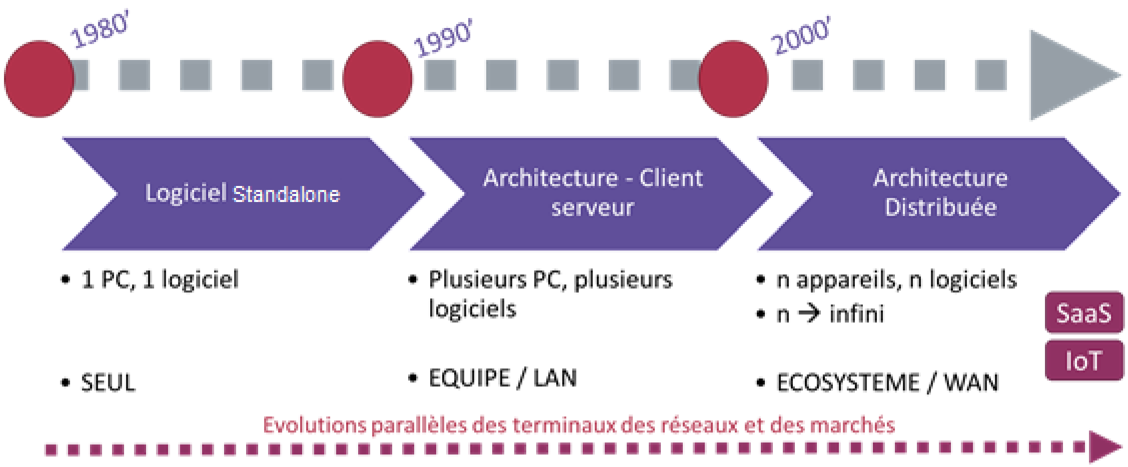


Figure 2 - Evolution of the digital industry towards digital services and IoT

In addition, when data are available, they may be of different orders of magnitude without clarifying the difference between improvement in actual performance or methodological difference:

- Scope difference: full lifecycle integration, infrastructure integration
- Difference in location
- Methodological difference in carbon credit accounting

It should be noted that the study commissioned by ADEME, cited above, points out:[2]

[2] "Potential contribution of digital technology to the reduction of environmental impacts" ADEME, 2016

- Obsolete equipment data as technologies evolve rapidly
- An almost systematic lack of assessment of data quality

2.2.3. Third lock – Comparability of results and lack of evaluation reference

Carrying out an ecodesign project and assessing the environmental gains often require comparative assessments. However, carrying out such evaluations implies that the results of each of them are obtained using comparable methods, particularly in terms of scope, data and indicators. Thus, the study commissioned by ADEME recommends standardization work, which the NegaOctet project should make it possible to initiate.

2.2.4. Fourth lock – Cost of conducting digital service LCAs

Finally, the expansion of the scope of digital services LCAs induced by the development of "aaS" offers makes their implementation more complex and therefore more expensive. By creating a defined evaluation repository (method, data, tools), the NegaOctet project should simplify the realization of LCAs for digital services.

2.3. Project Objectives

The objectives of the NegaOctet project are to::
- Better define the appropriate study scope (framework) to carry out an environmental impact assessment of digital services with a view to their eco-design
- Produce harmonized life-cycle inventory data to perform reliable life-cycle assessments and identify sensitive parameters
- Produce a configurable assessment model of the environmental impact of digital decision support services with a view to their ecodesign (tested but not finalized)
- Produce evaluation results based on these first three elements in order to have data on common digital uses and identify good practices in evaluation, design and use.

Thus, this project is a first step towards the development of a reference system for environmental labelling of digital services.

The framework, data, and model will form what we will later refer to as the NegaOctet repository.

2.4. Technical scope of the project

2.4.1. What is covered by the repository

The NegaOctet framework will make it possible to quantify the **direct environmental impacts** of digital services, through **attributional life cycle analyses,** in accordance with the three bricks presented below:
- Fixed and mobile **terminals** such as televisions, computers, tablets, connected objects, smartphones, etc.
- **Networks** already deployed in France and Europe
- **Data centers** as defined by ISO 30134 and EN 50 600 and everything contained therein (including IT equipment such as servers, network equipment and storage arrays)

2.4.2. What is not covered by the repository

Taking into account software developments, through the impact of the human resources that are used (transport, office, meals, etc.) is not systematically considered in the repository in its current state. This subject may be broadened in the scope of the study but raises questions of ethics and indirect impacts that we have chosen to exclude from this first phase.

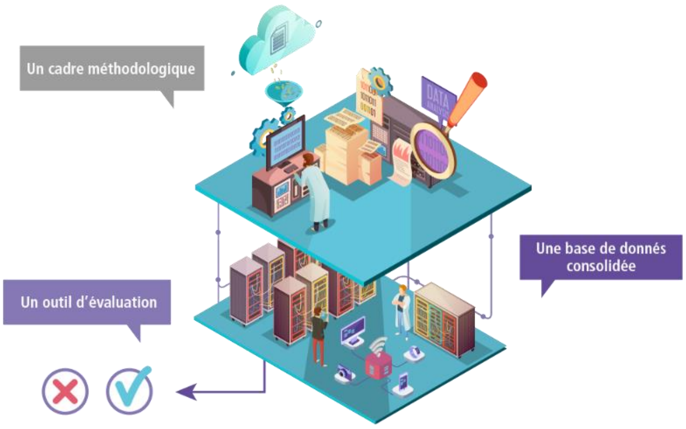
The indirect impacts of digital technology: induction effect, efficiency effect and rebound effect are not dealt with in the framework of this framework, although this subject is central in the context of the systemic changes generated by digital technology.

2.4.3. Opening tracks

The opening tracks for the next work to be carried out would be:
- Taking human resources into account
- Development of a methodology for taking into account the indirect impacts of digital developments from an environmental and social point of view. This could be addressed by the development of consequential life cycle assessment.
- Expansion of the assessment scope to include economic (CVMA) and social (ASCV) impacts

2.5. Better consideration of the cloud (PaaS and SaaS), once the repositories are completed and made available by the GAFAM - Normative and methodological scope

Built with a view to standardization, the NégaOctet standard is in line with the standards applicable to life cycle analysis, including:
- ISO 14040 : 2006 Environmental Management – Life Cycle Assessment – Principles and Framework
- ISO 14044 : 2006 Environmental Management – Life Cycle Assessment – Requirements and Guidelines



But also French, European and global standards for environmental assessment and labelling such as:
- ITU L1410 – Methodology for life-cycle environmental assessments of information and communication technology assets, networks and services[3]
- PEF and PEFCR standards for IT equipment[4][5]

3. Methodological reminder

3.1. LCA Methodology

3.1.1. General principles of LCA

Life cycle assessment is a method used to assess the environmental impact of products, services or organizations. There are other methods of environmental impact assessment, such as carbon footprint or impact assessments, but LCA has specificities that make its holistic approach unique. Indeed, used since the late 1990s and standardized in the ISO 14040:2006 [6]and ISO 14044:2006[7] series, this method proposes to establish the ecological baggage of a product or service according to several key concepts:

[3] https://www.itu.int/rec/T-REC-L.1410/en
[4] https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_guidance_v6.3.pdf
[5] https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_ITequipment_Feb2020_2.pdf
[6] ISO 14040:2006 – Environmental management — Life cycle assessment — Principles and frameworks
[7] ISO 14044:2006 - Environmental management — Life cycle assessment — Requirements with guidance

- **Multi-criteria :** Several environmental indicators are to be considered in a systematic way through the global warming potential, the depletion of abiotic resources, the creation of photochemical ozone, the pollution of water, air, soil, human ecotoxicity, biodiversity. The list of indicators is not fixed but depends on the sectors of activity.
- **Life cycle :** in order to integrate the impacts generated during all stages of the life cycle of equipment, from the extraction of natural resources often inaccessible to the production of waste through energy consumption during the use phase.
- **Quantitative :** Each indicator is qualified in a quantified way in order to be able to put on the same scale all the externalities of a product or service and to make objective decisions.
- **Functional :** The object of study is defined by the function it performs in order to be able to compare different technical solutions.
- **Attributional or consequential:**
    - Attributionnal : It describes the potential environmental impacts that can be attributed to a system (e.g. a product) during its life cycle, i.e. upstream along the supply chain and downstream after the system has been used, and the end-of-life value chain. Focuses on the direct effects related to a system.
    - Consequential : it aims to identify the consequences that a decision in the foreground system has for other processes and systems of the economy; both in the background system of the scanned system and on other systems. It models the system analyzed around these consequences. It includes indirect effects related to a system.

Even if LCA is initially more applied in the field of products, its scope of action has been expanded in recent years. First thanks to the ETSI 203 199[8] standard and today thanks to the many works carried out by professional telecommunications organizations such as the ITU, by the NegaOctet consortium for digital services or by the Ecodesign Pole for services in general.
Moving from a product to a service means maintaining the multi-criteria and functional philosophy but moving from a circular approach (from cradle to grave) to a matrix approach integrating the life cycle of all the equipment that makes up the three thirds (equipment, networks, datacenter) that allow the digital service to function.
Thus, such an environmental diagnosis makes it possible to identify and avoid pollution transfers from one phase to another and also from one third of the service to another. For example, when moving from an on-premises solution to a SaaS solution in the cloud, lifecycle analysis will ensure that avoided impacts on user endpoints are not offset by additional impacts on the network.

3.1.2. Methodological approach to LCA

3.1.2.1. The different stages of an LCA

As presented in ISO 14040:2006[9], an LCA study consists of four interrelated steps:

1. Definition of the objective and scope
2. Life Cycle Inventory Assessment (LCI)
3. Life Cycle Impact Assessment (LCIA)
4. Interpretation of life cycle results

LCA is an iterative technique in which each phase uses the results of the others, contributing to the integrity and consistency of the study and its results. It is a holistic approach and, therefore, transparency in its use is crucial to ensure proper interpretation of the results obtained.
NOTE: LCA addresses potential environmental impacts and therefore does not predict actual or absolute environmental impacts.

3.1.2.2. Definition of the objective and scope

The definition of the purpose of the study should describe the purpose of the study and the decision-making process for which it will provide support in environmental decision-making. The purpose of an LCA should determine the intended application, the reasons for conducting the study, the intended audience, i.e. the persons to whom the results of the study are intended to be communicated, and whether the results should be used for comparative purposes that will be disclosed to the public.
The scope of an LCA - including system limitations, level of detail, data quality, assumptions made, study limitations, etc. - depends on the subject and intended use of the study. The depth and breadth of a scope may vary considerably depending on the particular purpose pursued.

[8] https://www.etsi.org/deliver/etsi_es/203100_203199/203199/01.03.00_50/es_203199v010300m.pdf
[9] ISO 14040:2006 - Environmental management — Life cycle assessment — Principles and framework

An LCA has a structured approach, relating to a functional unit and/or a declared unit. All subsequent analyses are therefore linked to this unit. If a comparison is necessary - only goods or services performing the same function - it is necessary to choose a functional unit referred to the function that the goods or services in question perform.

3.1.2.3. Life Cycle Inventory Analysis

Data collection
This phase consists of the collection of data and calculation procedures to quantify the inputs and outputs of the system relevant to the study. The data to be included in the inventory shall be collected for each unit process considered, within the limits of the system under study.

Inventory of elementary flows
In an LCI, elementary flows must be accounted for within the limits of the system, i.e. flows of materials and energy that originate from the environment, without prior transformation by humans (e.g. consumption of oil, coal, etc.) or that go directly to nature (e.g. atmospheric emissions of CO2, SO2, etc.) without further transformation. Elementary flows include resource use, air emissions, and releases to water and land associated with the system.
The data collected, whether measured, calculated or estimated, make it possible to quantify all the inputs and outputs of matter and energy from the different processes.

Assignment and assignment rules
Reality confirms that few industrial processes produce a single output; In fact, and normally, industrial processes produce more than one product and/or intermediate products or their waste is recycled. In this case, the application of criteria for allocating the environmental burden to the different products is required, as is the case in the study carried out.

Assessing data quality
LCA and LCI data related to digital services and equipment remain a challenge. Most LCA-inspired studies use single-criteria data (such as energy or global warming) or heterogeneous datasets. In this project, we developed our own database.

3.1.2.4. LifeCycle Impact Assessment

3.1.2.4.1. *Selection, classification and characterization of impacts*

This phase aims to assess the significance of potential environmental impacts based on the results of the inventory. This process involves selecting impact categories and associating inventory data with impact categories (e.g. climate change) and with impact category indicators (e.g. climate change in 100 years according to the CML impact model) via the characterisation factor. This phase provides information for the interpretation phase.

3.1.2.4.2. *Standardization and weighting*

The numerical results of the indicators may also be ordered, standardised, grouped and weighted. This approach facilitates interpretation, but there is no scientific consensus on a robust way to conduct such an assessment.

3.1.2.4.3. *Interpretation of life cycle results*

Interpretation is the final phase of LCA.
It includes the results of the inventory or evaluation where/or so? Both are summarized and discussed in an understandable way. This part is used by the recipients of the study as a basis for conclusions, recommendations and decision-making, in accordance with the established objective and scope.

3.1.2.4.4. *Sensitivity analysis and uncertainty*

Considering that part of the data collection is based on a literature review, the model is based on secondary data that may be uncertain. In order to qualify the order of magnitude of the variation of the results, a sensitivity and uncertainty analysis must be performed.

3.1.3. Environmental Assessment Criteria and Methodology

The advantage of developing our own life-cycle inventory database is to allow the assessment of many environmental indicators, provided they are robust. Thus, the advantage of the NegaOctet framework is to allow the evaluation of the indicators below.

NOTE THAT : As part of the project, we integrated the MIPS indicator into the EIME software, whose pragmatic approach is complementary to those of conventional models.

3.1.3.1. Selection, classification and characterization of impacts

In our context, we will base our analyses on some or all of the indicators proposed by the European Commission as part of the Product Environmental Footprint (PEF) project, using PEF 3.0.[10]

Impact category	**Model**	**Unit**	**LCIA method recommendation level**
Climate change	IPCC 2013 , GWP 100	kg CO_2 eq	I
Ozone depletion	World Meteorological Organisation (WMO), 1999	kg CFC-11 eq	I
Particulate matter	Fantke et al., 2016	disease incidence	I
Acidification	Posch et al., 2008 ; Seppälä et al. 2006	mol H+ eq	II
Eutrophication, freshwater	Struijs et al, 2009	kg P eq	II
Eutrophication, marine	Struijs et al, 2009	kg N eq	II
Eutrophication, terrestrial	Posch et al., 2008; Seppälä et al. 2006	mol N eq	II
Ionising radiation, human health	Frischknecht et al., 2000	kBq U235 eq	II
Photochemical ozone formation, human health	Van Zelm et al., 2008, as applied in ReCiPe, 2008	kg NMVOC eq	II
Human toxicity, non cancer	USEtox (Rosenbaum et al., 2008	CTUh	III
Land use	Soil quality index (based on Beck et al. 2010; LANCA,Bos et al., 2016)	pt	III
Abiotic resource use, fossils fuels	ADP for energy carriers, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016)	MJ	III
Abiotic resource use, minerals and metals	ADP for mineral and metal resources, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016)	kg Sb eq	III
Water use	AWARE 100 (based on Boulay et al., 2018)	m3 world eq	III
Ecotoxicity, freshwater	USEtox (Rosenbaum et al., 2008)	CTUe	III/Interim*
Human toxicity, cancer	USEtox (Rosenbaum et al., 2008)	CTUh	III/Interim*

Figure 3 - Full set of impact indicators recommended in the EFP methodology

In the various pilots, a selection of indicators was made. For example, in the case of the study conducted for OBS, we selected the following indicators:

Impact category	**Model**	**Unit**	**LCIA method recommendation level**
Climate change	IPCC 2013 , GWP 100	kg CO2 eq	I
Particulate matter	Fantke et al., 2016	disease incidence	I
Acidification	Posch et al., 2008	mol H+ eq	II
Ionising radiation, human health	Frischknecht et al., 2000	kBq U235 eq	II
Photochemical ozone formation, human health	Van Zelm et al., 2008, as applied in ReCiPe, 2008	kg NMVOC eq	II
Abiotic resource use, fossils fuels	ADP for energy carriers, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016)	MJ	III
Abiotic resource use, minerals and metals	ADP for mineral and metal resources, based on van Oers	kg Sb eq	III

[10] https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml (last retrieved: 19/08/2021)

	et al. 2002 as implemented in CML, v. 4.8 (2016)		
Ecotoxicity, freshwater	USEtox (Rosenbaum et al., 2008)	CTUe	III/Interim*

Figure 4 - Selection of relevant indicators on the basis of standardization and weighting

Some indicators with outliers have been discarded; This is the case for the indicator "water use".

3.1.3.2. Standardization and weighting

Where relevant, the numerical results of the indicators have been ordered, standardized, grouped and weighted. This approach facilitates interpretation, but there is no scientific consensus on a robust way to conduct such an assessment. In our study, we used the normalization and weighting factors provided by the JCR in the PEF/OEF (EF 3.0) method, published on November 20, 2019, as reported in the table below.

Impact category	Normalization factor	Unit
Climate change	8,10E+03	kg CO_2 eq./person
Ozone depletion	5,36E-02	kg CFC-11 eq./person
Particulate matter	5,95E-04	disease incidences/person
Acidification	5,56E+01	mol H+ eq./person
Eutrophication, freshwater	1,61E+00	kg P eq./person
Eutrophication, marine	1,95E+01	kg N eq./person
Eutrophication, terrestrial	1,77E+02	mol N eq./person
Ionising radiation, human health	4,22E+03	kBq U-235 eq./person
Photochemical ozone formation, human health	4,06E+01	kg NMVOC eq./person
Human toxicity, non cancer	2,30E-04	CTUh/person
Land use	8,19E+05	pt/person
Abiotic resource use, fossils fuels	6,50E+04	MJ/person
Abiotic resource use, minerals and metals	6,36E-02	kg Sb eq./person
Water use	1,15E+04	m3 water eq of deprived water/person
Ecotoxicity, freshwater	4,27E+04	CTUe/person
Human toxicity, cancer	1,69E-05	CTUh/person

Figure 5 -Standard-setting factors proposed by the JRC

Impact category	Weighting factor(%)
Climate change	21.06
Ozone depletion	6.31
Particulate matter	8.96
Acidification	6.20
Eutrophication, freshwater	2.80
Eutrophication, marine	2.96
Eutrophication, terrestrial	3.71
Ionising radiation, human health	5.01
Photochemical ozone formation, human health	4.78
Human toxicity, non cancer	1.84
Land use	7.94
Abiotic resource use, fossils fuels	8.32
Abiotic resource use, minerals and metals	7.55
Water use	8.51
Ecotoxicity, freshwater	2.8
Human toxicity, cancer	2.13

Figure 6 -Facteurs de pondération proposés par la JRC

4. WORK PROGRAMME

4.1. <u>REMINDER - Scientific program and structuring of the project</u>

The project is therefore broken down into 2 major operational phases composed of several lots and two independent cross-functional lots, relating to project management (**Lot 1**) and capitalization on results (**Lot 7**).

4.1.1. Phase 1 - Creating the repository

In order to guarantee relevance and robustness of the results obtained through it, the NegaOctet repository is constituted:

- **<u>An evaluation framework – methodology</u>** of the digital services evaluated (reflection on the concept of software life cycle, definition of the scope of the study, cut-off rule, substitution rule, relevant environmental indicators, etc.) – **Lot 2**
  This part facilitated the development (excluding the Perfecto 2018 NégaOctet project) of the RCP on digital services
- **<u>A database of life cycle inventories to</u>** map previously defined life cycle elements to environmental impacts – **Lot 3**
- **<u>Tools for the proper implementation of methodology and data</u>–** This phase has not been fully completed. Various specific tools were developed as part of the pilots, but the late availability of the database did not allow the creation of a generic tool. – **Lot 4**

This work has had valuations at different levels:
- Creation of the RCP for the implementation of Article 13 of the AGEC law
- Use of the database as part of the ADEME ARCEP study on the assessment of the environmental impact of digital technology in France

4.1.2. Phase 2 - Testing the repository

The purpose of this phase is to consolidate (Lot **5**) and deploy the method (**Lot 6**).
The consolidation of the method was carried out in two ways:

- **<u>Realization of two test case studies</u>**:
  - Update of the email study carried out by ADEME in 2014
  - Creation of a comparative case study on two solutions for the provision of a Life Cycle Assessment software – EIME
- **<u>Realization of case studies on behalf of public or private actors</u>** financed by them, but subject to feedback within the framework of NegaOctet. The pilot companies that wished to see their contribution appear are: ADEME, Airbus, BLADE, CYME, OVEA, OVH, Orange Business Service, RTE, Teads, Worldline.

4.1.3. Transversal lots

Project management is included in a specific batch (**Lot 1**) that extends over the entire duration of the project.
In order to ensure the recognition of the project and its adequacy with the needs of the market, a continuous dissemination of the results is essential, it is therefore the purpose of **lot 7** – Capitalization.

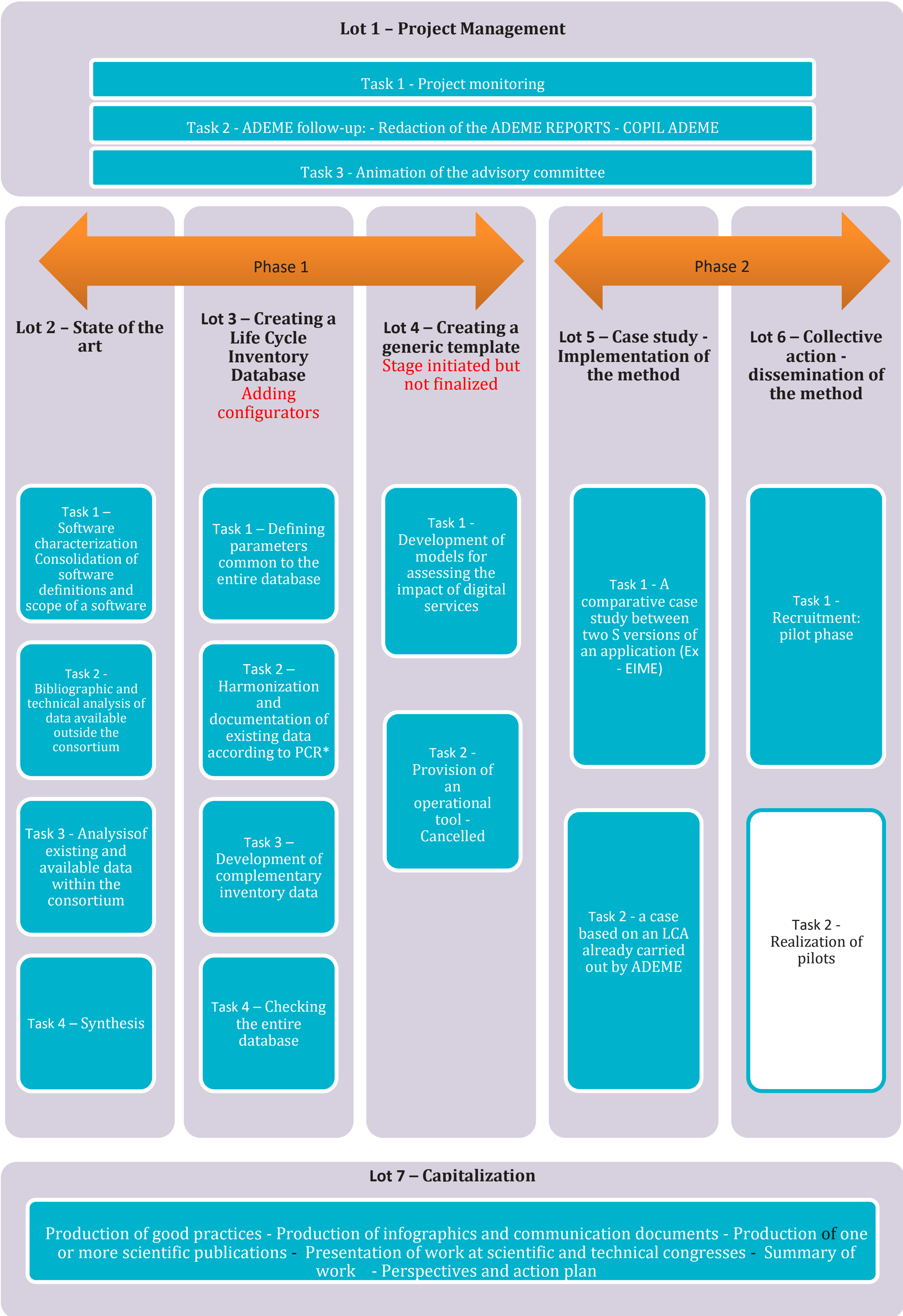


Figure 7- Articulation of the different phases of the project

*PCR – Product Catergory rule

5. Project management - methodology and results

Given the collaborative and multidisciplinary dimension of the project, project management is a central axis.

Lot 1 : Project Management					
Responsible	DDemain				
Duration	The entire duration of the project				
Beginning	June 2018				
Partners involved	DDemain	LCIE	NEUTREO BY APL	GreenIT.fr	
Related Deliverable(s)	Minutes of team meetings, advisory committee meetings, Copil ADEME Interim report to ADEME Final report to ADEME				

Content

Objectives

Good project management ensured that quality deliverables were delivered on time:

- to ensure the coordination of the actors for the realization of the different lots and tasks, to ensure the material organization of the regular points between the partners, between the partners and ADEME, between the partners and the advisory committee
- to produce the follow-up deliverables associated with the project: report, ADEME report
- document all discussions and decisions that may have an impact on the progress of the project

Realization

Over the course of the project, consortium members carried out:

- A monthly point of one to two hours of project management. These points took place every first Monday of the month and then every third Thursday of the month.
- A monthly point of collective work, every second Monday of the month and then every first Thursday of the month. This collective working time makes it possible to move forward on subjects requiring the validation of the consortium and/or a common reflection.

In addition, during the first two years of projects, four advisory committees were organized:

- The first took place **on January 13, 2019 at the premises of APL datacenter** – TH THME: federation of actors – Definition of the scope of digital services
- The second took place **on June 18, 2019 at EcoInfo's premises** – THTHME: database content to be expected – Collection of partners' needs
- The third advisory committee took place **on January 17, 2020 at APL datacenter** – THTHME: Presentation of the bibliography – Content of the database
- The fourth took place **on November 9, 2020 remotely** (following various postponements related to the COVID crisis) – THME: regulatory news and articulations of the project with the current regulations – Management of the human resources part – Announcement of the extension of the project

Content

To ensure the follow-up of the project with ADEME, various steering committees were held:

- le **5 February 2019**
- le **17 January 2020**
- le **5 June 2020**
- le **29 September 2021**

All steering committees were held by videoconference.

Given the expansion of the scope of actions of the project, the regulatory news and the needs of recovery of the EIME database to ensure the homogeneity and timeliness of equipment modeling, a request to extend the project by one year was made in the first half of 2020.

In addition, project monitoring includes:

- the response to the requests of the various members of the CoCon, the temporal, administrative and financial follow-up (in particular the creation of the project monitoring tools: load plan?)
- the creation of materials to ensure the smooth running of the meetings (the materials presented during the various meetings were sent to ADEME and CoCon members and are available on request)
- the drafting of reports

6. WORKS

6.1. Phase 1 – Development of the repository

6.1.1. Lot 2 – State of the art

6.1.1.1. Workflow

Lot 2 – **State of the art**					
Responsable	DDemain				
Partners involved	DDemain	LCIE	GreenIT.fr	NEUTREO BY APL	
Related Deliverable(s)	Synthesis of the state of the art State-of-the-art monitoring table at the end of 2019				

Content

Objectives

- Identify and consolidate the characterization of digital services
- Synthesize the knowledge available within the consortium but also externally, in order to obtain a global and up-to-date vision of the work carried out on the subject of environmental assessment of software in view of the change in the market (increase in the SaaS offer and decrease in the desktop offer)
- Identify and consolidate the list of available data and their level of quality
- Identify and consolidate the list of data to be developed as well as potential sources to be studied in Lot 2

Task 1 - Consolidate the definitions and scope necessary for the realization of an LCA of digital services - carried out
Realization: Consortium – Reporting : LCIE

This task was carried out in the form of a meta-analysis of existing definitions. A position paper was produced. The definitions were validated by the consortium and presented and validated by the CoCon.

The following terms have been the subject of a consolidated definition adapted to the scope of our project: LCA, Allocation, API "Application Programming Interface", Cloud, Lifecycle, Co-design, Software Consulting / Technology Consulting / IT Consulting and Service, IaaS, Environmental Impacts, Infrastructure, IoT, LAN, Software, MAN, PaaS, PAN, Network, SaaS, Usage Scenario, Server, Digital Service, SMACS, Terminal, ICT/ICT, Declared Unit, Functional Unit, WAN.

In order to arrive at these definitions, no less than 23 general or sectoral standards were studied, compared and consolidated, namely: ILCD handbook, Larousse, NF X 30 264, ISO 14 040/44, ETSI 103 199, ETSI 203 199, GHG Protocol ICT Sectoral Guidance Hardware, GHG Protocol ICT Sectoral Guidance Software, NF EN 62075, PEFCR IT Equipment, PEFCR UPS, PEFCR Battery,PEP Ecopassport®, International EPD System, AGIT White Paper (Ecodesign of Digital Services), Syntec Digital Green Paper, Ecolog Greenspector White Paper,GHG Protocol ICT Sectoral Guidance TNS, GHG Protocol ICT Sectoral Guidance DMS, GHG Protocol ICT Sectoral Guidance Cloud Computing & Datacenter, The NIST Definition of Cloud Computing, Realization of a Greenhouse Gas Emissions Assessment, Digital Technologies, Information and Communication, SECTORAL GUIDE 2012.

All the work has made it possible to feed into the work on the digital services PCR.

Task 2 - Bibliographic and technical analysis of data available outside the consortium
Realization: DDemain – Validation/complement: LCIE, NEUTREO BY APL, GreenIT.fr

It can be considered that the bibliography was carried out in two phases:

- Context analysis – macroscopic level
- Complement of the findings associated with the pilots and complement to the database – systemic and microscopic levels

Initially planned over a five-month period, the literature review was finally completed over the entire first year and was repeated in 2020 as part of the pilot studies. This work was reused and extended as part of the ScoreLCA project: environmental impacts of connected objects, as well as as as part of task 1 of the ADEME ARCEP study**.**

In phase 1, a complete analysis of a hundred studies was carried out and was the subject of a publication that was presented as part of the Avnir 2019 congress. At the end of the NegaOctet project, a documentary corpus of more than 250 publications was analyzed and exploited in order to:

- Consolidate the methodology
- Populate the life-cycle inventory database
- Compare the results of the pilot studies with other experiments.

[…] After the analysis of more than 90 publications, standards and tools, the main conclusions are as follows. À Today, although the life cycle assessment method is presented as the most recognized in terms of relevance, it is applied in its entirety mainly at the level of equipment only. The assessment of the environmental impact of digital services or third parties of infrastructure outside equipment (network, datacenter) focuses mainly on energy consumption and global warming potential. Knowledge about the impact of networks is very weak and needs to be consolidated. [...] Excerpt from the abstract article Avnir.

Only studies on the assessment of the direct environmental impacts associated with digital technology were referenced. We excluded:

- Sectoral technology studies focusing solely on the technical aspects of software and services
- Studies associated with specific phenomena not quantifiable by LCA such as electrosensitivity
- Macroeconomic studies of the sector

It should be noted that on the second phase of our analysis, current topics seem to be beginning to attract attention, this is the case of:

- IOT and complex digital services such as blockchains (specifically bitcoin)

- Indirect effects and rebound effects in digital

We will also note various publications to validate the NegaOctet approach putting at the center the production of silicon Wafer integrated into components such as CPU, RAM, Storage:

- The Environmental Footprint of Logic CMOS Technologies - A DTCO-based analysis
- Green Cloud Computing Lebenszyklusbasierte Datenerhebung zu Umweltwirkungen des Cloud Computing de Jens Gröger, Ran Liu Öko-Institut e.V., Berlin Dr. Lutz Stobbe, Jan Druschke, Nikolai Richter Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (IZM), Berlin, 2021

Task 3 - Analysis of existing and available data within the consortium (in particular within the GreenIT, AGIT, GreenConcept club)

Task 3.1. – Study of existing tools

This task was carried out in the form of analysis via SWOT matrices of existing tools in 2019:

	Type d'outil	Organisation	Service	Equipement	Réseau	Datacenter
Barometre AGIT	Sondage + Outil d'autoévaluation	X				
BDD REN	BDD Facteur d'émission			X	X	X
BenchMark WeGreenIT	Outil d'autoévaluation	X				
Carbonalyser	Extension		X			
Cleermodel	Outil en ligne					X
EcoIndex	Site Web		X			
EcoMeter	Site Web		X			
EIME	Outil ACV ISO 14040			X		
GreenConcept	Outil ACV screening		X	X	X	X
GreenIT Analysis – Extension	Extension		X			
PIAI	Base de données I/O			X		
Self Assessment Tool – ICT Footprint	Outil d'autoévaluation en ligne	X				

***Tableau** 1 - Résumé des outils identifiés et analysés*

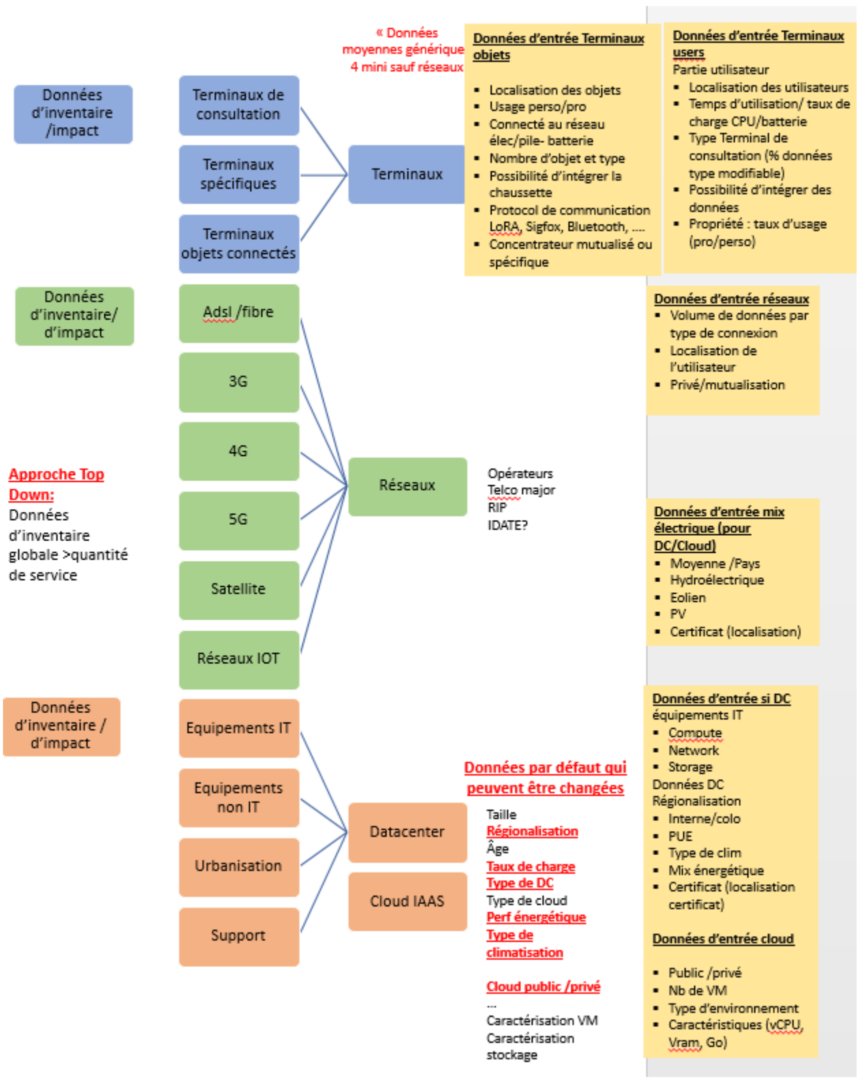
As with publications, we observe the emergence of an abundance of new tools.
For almost all of these tools, a major challenge is the **quality and homogeneity of the environmental data used to assess and reduce impacts**. All these tools are based either on extrapolations based on a conversion of electricity consumption into CO2 geq, or on data from the literature, the Impacts® database or environmental statement whose methodology is not homogeneous.
We have therefore chosen to refocus the project on its heart, namely:

- **The <u>evaluation method to arrive at intelligible multi-criteria results</u> through the feeding of RCP projects, the provision of the MIPS indicator and the testing of the applicability of the PEF method**
- **The <u>creation of homogeneous data at all levels of the digital service</u>: from the semiconductor component to the parameterized third of the infrastructure**

Task 3.2. – Study of existing and available inventory data

In order to anticipate the work to be carried out under Lot 3, a list of data necessary for the assessment of the environmental impacts of digital services was drawn up on the basis of:

- Reflections associated with scope and definitions
- Parameters of variations/allocation factors that can be identified a priori:



At the end of task 3, the following observation was made: the majority of the data available in the usual databases are the data associated with the consultation terminals.
For network impacts, no reliable public data was available.
Regarding the impacts of the datacenter, the CleerModel model proposes a parameterization approach in an American context but the tool has a "black box" operation that is not in accordance with the prerequisites of the project.
ICV databases such as EcoInvent, Gabi, EIME only offer equipment/terminal or component scale data, but there is no data accessible for the other two-thirds of the infrastructure.
In addition, the availability of new data on the production of semiconductors and displays led to the complete takeover of the EIME database, which should have been the basis of the database.

Finally, the approach presented in this state of the art will be questioned during the development of the database.

Task 4 – Synthesis
Realization: Consortium – Validation : Advisory committee

See main teaching paragraphs below

6.1.1.2. Key lessons learned

Phase 1 – Analysis of the general bibliography - 2019-2020

Taking into account the results of the previous work, we can affirm that:

The level of granularity "digital service" is the appropriate level. Indeed, it makes it possible to take into account the impacts associated with the digitization of practices and services with a systemic and exhaustive approach and therefore, to highlight important ecodesign pathways.

The life cycle assessment method is the most appropriate method to ensure a systemic, life cycle and multi-criteria approach. To date, the majority of the available data are single-criteria(GHG or energy).

The method should make it possible to answer in a documented way questions that are currently unanswered such as: Is it better to store in the cloud or on-premises? How to eco-design a digital service?

The article presented at Avnir can be considered as an intermediate and incomplete synthesis but which gives the content of the initial analysis.

Phase 2 – Analysis of the specific bibliography - 2019-2020

Question of impact at the microscopic level:

The modeling of IT equipment must integrate a careful consideration of the semiconductor part, and the parameters sizing the environmental impact for IT equipment are in particular: the silicon surface, the implantation on the silicon die and the drop rate. These three parameters lead to the need to set the environmental impacts of IT equipment according to their CPU, GPU, RAM and storage capacity in addition to previously known parameters such as screen size and type.

Question of consideration of indirect effects:

Taking into account indirect effects is essential, because of their relative importance, both in terms of the potential for impact reduction (IT for green) and the risk of adverse effects of increased impacts. The order of magnitude of these indirect effects is currently little known, but some studies consider it superior to direct effects. By way of illustration, ADEME's study "Study on the characterization of the rebound effects induced by telework" shows that rebound effects and the way to manage the implementation of physical and digital services around telework can greatly vary the impacts, to the point of making telework beneficial, or on the contrary worsening environmental impacts. However, these impacts are difficult to quantify in a timely manner and resources that are affordable for most LCA practitioners, and require the intervention of experts from various fields (economists, sociologists, behaviorists, etc.).. On the other hand, they generate a high degree of uncertainty due to their predictive nature, in an area such as digital services subject to strong developments and technological leaps. However, it is possible to identify and categorize them. For this, different classifications are possible. The study "Known unknowns: indirect energy effects of information and communication technology" is to date the most advanced study on the classification of indirect impacts of digital services. If it focuses on an energy approach, its methodology is applicable for the realization of LCA.

Question of allocation method: environmental cost of ownership and environmental cost of use

Digital services are often used as a substitute for traditional services. Their impact profiles are different, with specific causes and consequences. Among these differences, there is a transfer of impacts from the production, distribution, installation and end-of-life phases to the use phase. Indeed, digital services use electricity and data-consuming equipment that generates environmental impacts. This produces a modification of part of the causes of impact, from a cost of ownership (the impacts are conditioned to the acquisition of the product) to a cost of use (the impacts are conditioned to the use of the product). If this modification is to be put into perspective (a significant part, or even the majority of the impacts, remains associated with the manufacture of terminals), the use also determines the sizing of network infrastructures (cumulatively for all consumption) and servers (in a targeted manner on the digital service concerned). This vision amounts to considering the consumption and use of data (network and servers) as a resource generating impacts, in the same way as electricity consumption. Resource whose use should be limited in an ecodesign approach.

Today, the approach to digital services we offer includes both the cost of ownership and use.

Question of average environmental cost and marginal environmental cost

Digital services are generally interconnected through the use of shared equipment. This equipment is sometimes present independently of the service studied. For example, an email service uses terminal equipment (computers, tablets, smartphones) but is not directly the cause of their production. This equipment would be acquired and produced anyway.

Two visions are thus possible:

- Calculation of the average cost: it corresponds to the classic calculation carried out in LCA: the impacts related to the production of equipment already used are allocated to the service in relation to an allocation key that depends on each situation
- Calculation of marginal cost: it corresponds to the cost related to the increase in environmental impacts following the implementation of the service compared to the previous situation. It excludes the production of equipment already in use.

Note that in the context of the marginal cost calculation, equipment may have some of the impacts associated with the service (electricity consumption in active mode), and others not (manufacturing, electricity consumption in standby mode, etc.).

This raises the question of the responsibility of stakeholders in relation to the impacts of shared equipment and the levers of action that can be envisaged as part of an ecodesign approach:

- If the infrastructure is not installed prior to the service, or if it is dedicated entirely to the service over a period of time, the marginal cost and the average cost are confused. Reducing impacts means limiting the need for new equipment, and may lead to the search for pooling of functions on existing equipment, for example by promoting a remote display on a smartphone rather than a dedicated display.
- If the infrastructure is installed and not fully dedicated to the service over a period of time, the practitioner should determine whether to choose a marginal or average cost approach. Ideally, it can calculate impacts according to both approaches to have complementary reading prisms. Reducing impacts involves optimizing the service so that it limits the use of bandwidth, compute and/or storage resources on the equipment used in order to reduce energy consumption and limit equipment obsolescence and thus its replacement.

This problem is not dealt with in the pilots but has come up systematically in the interpretation phases. This is a key opening point in the context of the realization of LCA of digital services in the long term and the opening towards the consequent LCA.

Questions of multiple uses of a digital service:

Like any good covered by an LCA, digital services can cover several functions, or several usage scenarios relating to a common function. However, the multiplicity of actors working around the same digital service leads to a wide variety of potential uses compared to a conventional good.

Understanding these different actual uses and functions is essential in order to determine the environmental impacts of these services in a relevant way. Moreover, identifying the actors involved in these uses makes it possible to identify the levers of action to reduce impacts more precisely.

Two elements must be differentiated:

- Different use: the same digital service fulfills a function via several different usage scenarios. Example: A video-on-demand service can be used via a computer, tablet, smartphone, wired or mobile network, and on different server architectures.
- Different function: The same digital service can perform several functions. Example: a social network may have for its users a function of exchanging information in text, photo or video format, and for its manager a function of collecting data and maximizing advertising revenue.

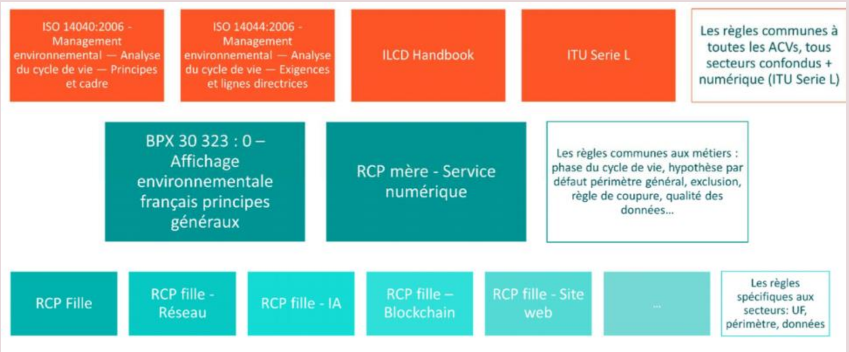
These elements are not specific to digital services, but the explosion of uses, many of which are very specific (e.g. LCA of reading the newspaper on the smartphone with the wifi of the train), as well as sometimes the impossibility of separating functions through allocation rules, leads to an increased importance to take this aspect into account.

6.1.1.3. Opening

Contribution of Lot 2 beyond the NegaOctet project

The work carried out in the framework of the NegaOctet project has made it easier to develop the rules by product categories necessary for the development of environmental labelling for digital services, and particularly telecommunication networks, thus meeting the requirements of Article 13 of the AGEC law.:

III.-After 1 of I of Article 6 of Law No. 2004-575 of 21 June 2004 on confidence in the digital economy, a 1 bis is inserted as follows: "1 bis. As of 1 January 2022, and in compliance with Law No. 78-17 of 6 January 1978 relating to data processing, files and freedoms, the persons mentioned in 1 also inform their subscribers of the amount of data consumed as part of the provision of access to the network and indicate the equivalent of the corresponding greenhouse gas emissions. 'The greenhouse gas emission equivalents corresponding to the consumption of data shall be established according to a methodology made available by the French Environment and Energy Management Agency. »



Indeed, two referentials could be drawn up on the basis of the work carried out here:

- The PCR for the digital services: Methodological framework for the environmental assessment of digital services
- The PSR relating to telecommunication networks: methodological reference for the environmental assessment of the provision of Internet access (ISP)

Available here: http://www.base-impacts.ademe.fr/gestdoclist

Other standards are under development.

6.1.2. Lot 3 – Creating a Life Cycle Inventory Database

6.1.2.1. Workflow

Lot 3 - Creating a Life Cycle Inventory Database					
Responsible	LCIE				
Duration	36 mois				
Beginning	November 2018				
Partners involved	LCIE	DDemain	NEUTREO BY APL	GreenIT.fr	

Related Deliverable(s)	Scoping note for database consistency (public) Life Cycle Inventory Database (private + data for integration into the base impacts®)

Content

Objectives

Develop a database of life cycle inventories: complete, robust, homogeneous (especially in terms of scope, system boundaries and indicators), documented (source, temporal representativeness, technological, quality) allowing the feeding of the tool developed under lot 3 and compliance with the method from lot 1.

Observation – Alert

Impact data, particularly in the literature, is not very available and the data necessary for a detailed assessment of the impacts of a digital service, for their part, are numerous. More than a hundred pieces of data will have to be updated or developed (compared to 40 initially planned) to evaluate and propose ecodesign options. From this hundred basic bricks, we managed to establish about 500 LCIs.

In addition, it is a question of collecting primary data, which requires the mobilization of external partners whose partnerships are concluded over a long period of time.

Method

The method for developing life-cycle inventories is largely based on recommendations from the ILCD handbook and the work of the PEF in order to allow use in a broad and international context**.**

Success Criteria

Possibility to perform a comparative LCA of software (lot 4) with data complying with the requirements of the ISO 14040 standard with a cut-off rule of at least 5%.

Detailed programme of work

NOTE The tasks initially planned in the file have been modified in order to best respond to the new context.

Task 1 – Definition of parameters common to the entire database

Steering and implementation: LCIE – Validation : DDemain – NEUTREO BY APL – GreenIT.fr

In order to guarantee homogeneity and compatibility between system ***boundaries, granularity, representativeness (geographical, technological, temporal)*** and to *allow the Third Party verification body to carry out its verifications according to an established and reliable reference system, a methodological data development report was prepared.*

Task 2 – Harmonization and documentation of existing data according to the parameters defined in task 1

Realization: LCIE

The aim here was to adapt and update the data already in the possession of the consortium according to the format defined in the previous task. This work was carried out on two data points in particular in order to launch the verifications carried out by EcoInfo and to consolidate the methodology.

This task eventually focused on all semiconductor data.

Task 3 – Development of complementary inventory data

Realization: LCIE – Collection assistance: NEUTREO BY APL – DDemain – GreenIT.fr

Data development took place at four levels:

- ***Level 0 - Semiconductor***
- ***Level 1 - Digital components:*** *Touch screen and non-touch panel, SSD, HDD, RAM, processor, motherboard, graphics cards, chassis, fan, DVD player, power supplies, etc.*
- ***Level 2 – Generic and specific equipment :*** *Terminal equipment (TV, PC, Smartphone, etc.), network equipment (box, DSLAM, ONT, OLT, etc.), IT datacenter equipment (server, array, etc.), non-IT datacenter equipment (air conditioning, generator, etc.)*
- ***Level 3 - Third-tier infrastructure:*** *Data center by typology/technology and performance level, fixed networks (ADSL, FFTX per line and per GB), mobile networks (3G, 4G, (5G) per line and per GB), cloud services in the datacenter by type (public cloud, private cloud + location: IAAS (VM, storage), PAAS (BDD) average data)*
- ***Level 4 –Digital Services:*** *Sending an email, streaming video, downloading a file, storing data in the cloud, web conferencing, web request*

For each level, a review of some data was carried out in order to validate the methodology.

Task 3.0 – Partner engagement

Realization: APL

In order to have a maximum of primary data, we have:

- *Requested by the Advisory Committee*
- *Solicited our networks*
- *Met network and data center players*
- *Discussed partnership contracts on the subject*
- *Signed confidentiality agreements.*

The actors solicited to date in the framework of partnership ***for the development of the database*** *and having responded present are the following:*

-Terminals and equipment: Nodixia & Ecologic
- Network: Orange (validation by decision-making committees, negotiation of partnership conditions), SFR (first meeting), Sigfox (first meeting)
- Datacenter: Eolas – Business and Decision (presentation of the project and visit of the datacenter; leaving for a partnership)

Task 3.1 – Data collection

Data collection is carried out by (in descending order of interest):

- *Field data collection within the advisory committee*
- *The formatting of existing data at one of the project partners according to the requirements defined in task 1*
- *Compilation of field data and data from the technical literature*
- *Formatting data from the literature*

We have preferred the development of primary data or the updating of primary data in our possession, the other avenues will be explored only if we do not obtain them.

Equipment data collection

To do this, we organized the first reverse engineering workshop in June 2019. During this workshop, more than 30 pieces of equipment were made available by Nodixia and dismantled in order to collect primary data. Watch video here: *https://youtu.be/VPq4FA2eAIs*

Network data collection
The impacts of the network are probably the least known impacts but we are fortunate to work with a quality partner, namely Orange. In addition, as part of the work carried out on behalf of ADEME on the PSR for Internet service providers, we were able to collect information that allowed us to broaden our vision.

We therefore have a macroscopic vision of the impacts of wired and mobile networks (without the possibility of distinguishing technologies at this stage).

As part of this work, more than 320 kg of equipment were dismantledand analyzed to achieve the creation of the database.

Task 3.2 et 3.3 – Data development and availability
The data were developed in EIME software. Each major data is the subject of a documentation sheet in ILCD entry level format.
Once the major data was developed, models made it possible to make variations according to hardware or service references through configurators.
The data will be made available, both in an ILCD node in life cycle inventory format, and both in an excel file in the form of emission factors.

Task 4 – Checking the entire database
Realization: NEUTREO BY APL – DDemain – GreenIT.fr – External critical review provider

Data verification is carried out:

- *Internally and primarily by the project actors who did not participate in the realization of the inventories (NEUTREO BY APL, DDemain)*
- *Externally, by Ecoinfo*

The audit conducted by Ecoinfo validated the methodology at each of levels 1 to 4.
It does not cover all data but strategic data:

- *Semiconductor manufacturing*
- *Manufacture of terminals and equipment*
- *Manufacture of DC and network equipment*
- *Articulation of third parties of the infrastructure: network, datacenter*

This audit strengthened the robustness of the data and the consistency of the database.

6.1.2.2. Database articulation

The data developed are presented according to five levels. Each successive level being ensured by the combination of the data of the previous level:

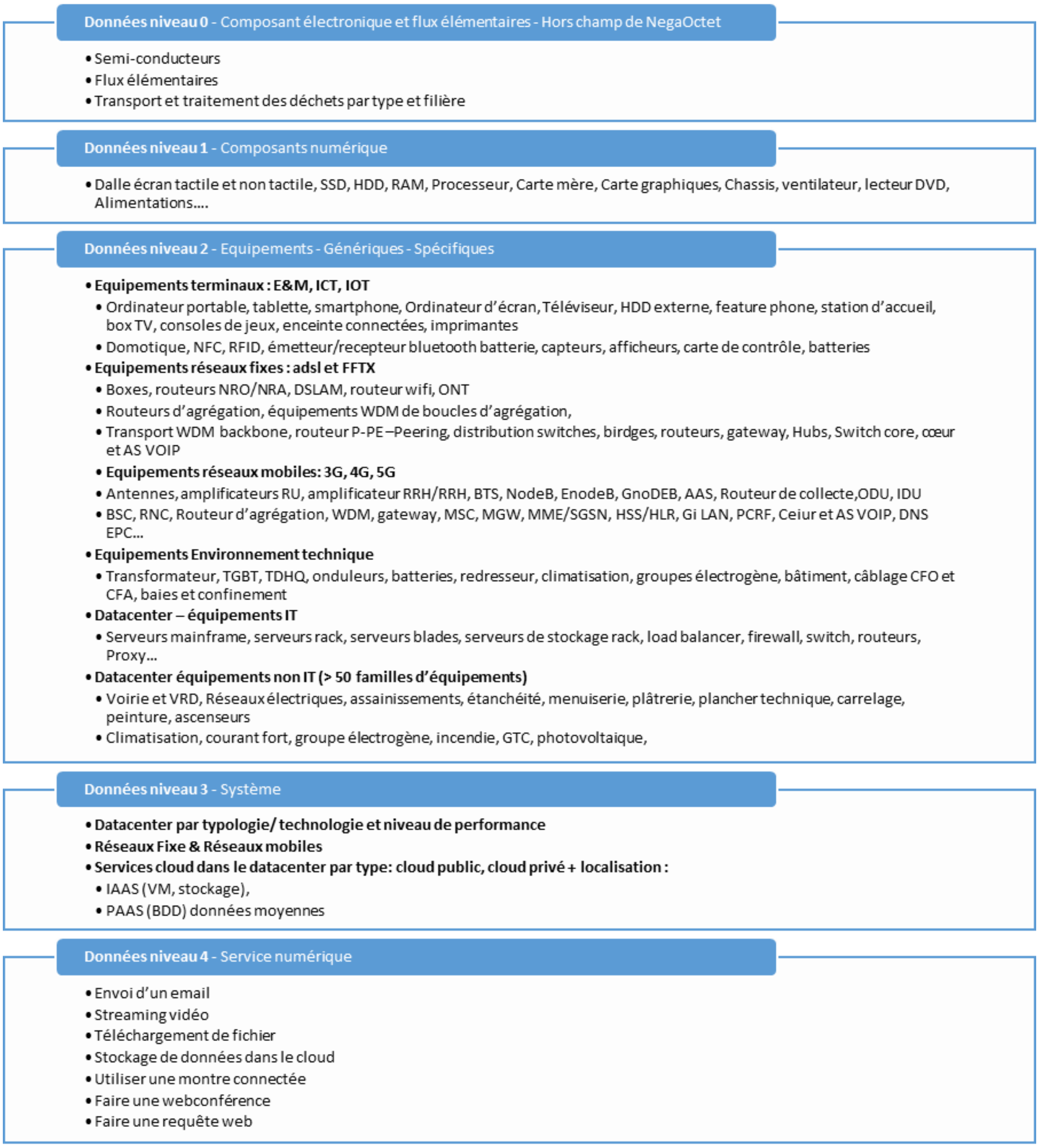


Figure 8 - Summary of the database (available on codde.fr)

6.1.2.3. Creation of equipment data – From level 0 to level 2

6.1.2.3.1. *Introduction*

Digital equipment (whether terminal or integrated into a data center) is composed in a relatively similar way, it presents:

- A case
- Electronic cards
  - Motherboard
  - Video card
  - Memory
  - Power card
  - Other cards
- Storage equipment
  - Hard drive: SSD or HDD
  - Memory card
- A screen (optional)
  - LCD ou OLED
- One or few supply (s)
  - Internal or external power supply
  - Battery + Charger
- Connectors
- Cable
  - Copper or fiber cable

During our analyses, we were able to identify that the majority of manufacturing impacts came from:

- Power components: CPU
- Memory components: RAM
- Storage equipment: SSD in particular
- Screens.

The screens have been the subject of a specific update that we will not detail here. The other components then all have in common the use of silicon semiconductors whose production has a preponderant impact that had to be consolidated.

6.1.2.3.2. *Step 1 – Component-level work (Level 0/1)*

Summary of the process

In the course of our work, we were able to consolidate our data at all levels of semiconductor component production. Making it configurable and thus allowing to configure types of CPU, RAM and storage component. The process is summarized below:

Step1: Manufacture of silicon wafer

The first step in creating the semiconductor chip (die) is the creation of the wafer (disk 200 to 300 mm in diameter being doped to create the chips).

Step2: Setting the chip size and the number of masks

For a given component, you must define:
- The surface of the chip
- The number of masks

An abbaque has been created to facilitate this configuration.

Step3: Chip cutting and losses

Once the surface of the chip is known, the yield must be determined. Indeed, due to cutting losses (kerf), edge losses, and chips with defects (considering a defect density of 0.15 defects per cm²), it is possible to calculate the amount of losses.

Step4: Encapsulation

Finally, the chip is encapsulated in order to be usable by card designers. There are different encapsulation designs. Examplesinclude PBGA-type components, used for memories and processors.

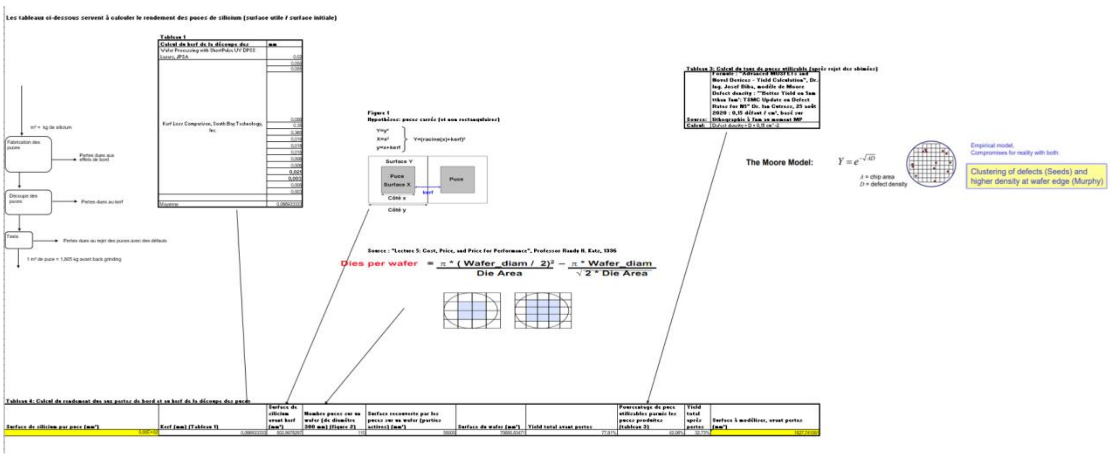


Figure 9 - Yield definition chart

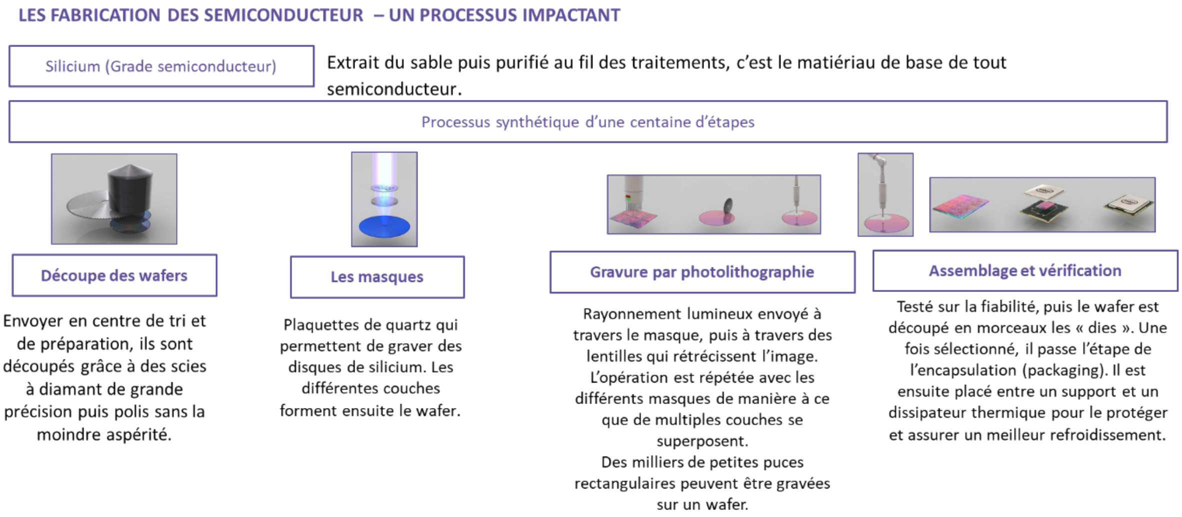


Figure 10 - Summary - Manufacturing a semiconductor

This work has therefore made it possible to characterize in a specific way the components such as CPU, RAM, disk... and is very useful to know the impact of a specific configuration of servers for example.

Step5: Integration

Once the components are characterized, they are integrated into their environment: motherboard for the CPU, case for the hard drives. Environmental data were defined on the basis of field collections.

Key lessons learned

The main factors sizing the environmental impact of the production of a silicon chip are:

- The environmental impact of the semiconductor chip is directly related to the number of masks (see figure below). Indeed, increasing the number of masks amounts to increasing the number of processes operated to produce a wafer. Each operation involves a very high consumption of energy and chemical substances.

CONFIGURATION	Broadwell LCC
Surface die avant pertes (mm2)	548
Surface die (mm2)	**246**
Nombre de masques	58

CONFIGURATION	Skylake XCC
Surface die avant pertes (mm2)	2 614
Surface die (mm2)	**694**
Nombre de masques	58

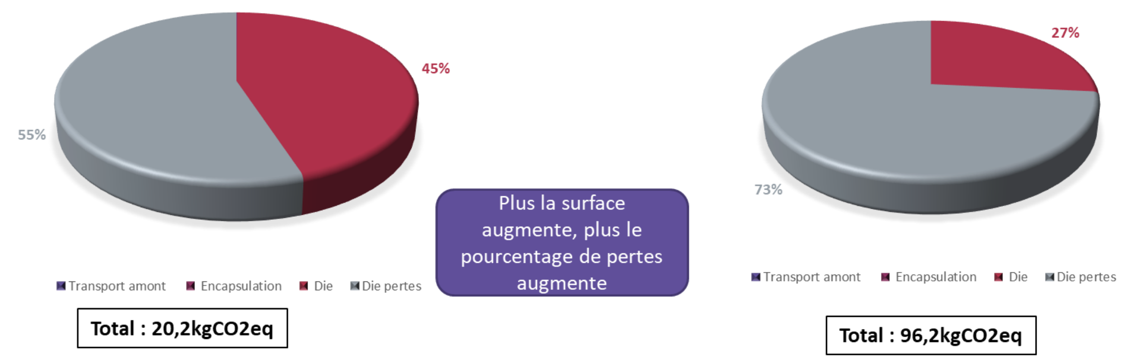
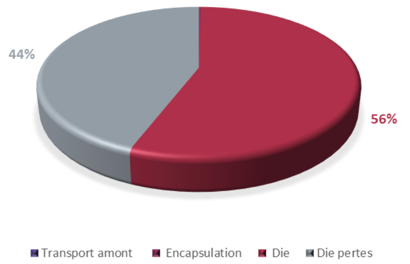


Figure 11 – Evolution of impacts as a function of the surface of die

- The second parameter sizing the impact is the die area:
  - in a direct way: the greater the impact, the greater the impact
  - Indirectly, each surface is the cause of losses whose quantity does not evolve linearly but according to the space available on a wafer

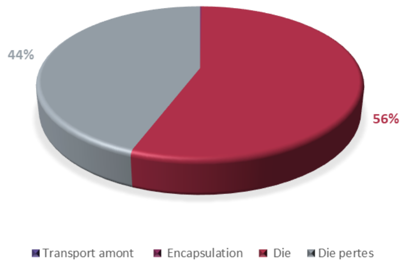
CONFIGURATION	Intel 8th Generation
Surface die avant pertes (mm2)	226
Surface die (mm2)	126
Nombre de masques	**58**

CONFIGURATION	Théorique
Surface die avant pertes (mm2)	226
Surface die (mm2)	126
Nombre de masques	**75**



Total : 8,34kgCO2eq

Les impacts environnementaux sont proportionnels au nombre de masques



Total : 10,7kgCO2eq

Figure 12 - Distribution of impacts of the production of semiconductors with equivalent surface area - Variation according to the number of masks

6.1.2.3.3. *Step2 – Working at the sub-assembly level*

Technical elements

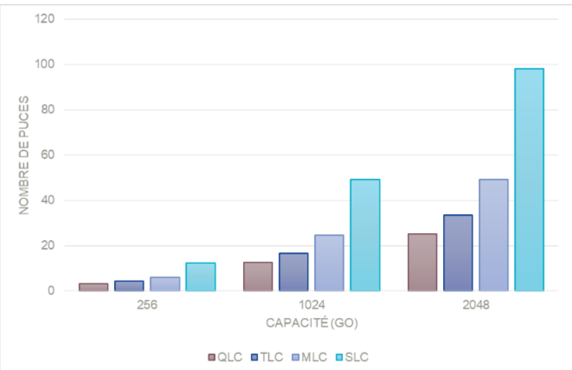
Once components are characterized, they are sometimes integrated at the subassembly level, such as hard drives. Special work has been done on the subject. Indeed, during the study, it appeared that a significant difference was to be considered between storage on SSD hard disk (technology based on semiconductor components) and HDD hard disk (technology based on aluminum wafer engraving – more mechanical).

In addition, SSD technologies are variable, resulting in significant variability in environmental impacts.

	Bits par cellule	Vitesse d'écriture	Durée de vie	Prix	Utilisation
Single Level Cell (**SLC**)	**1**	++++	++++	++++	**Industrie Entreprise**
Multi Level Cell (**MLC**)	**2**	+++	+++	+++	**Utilisateur Joueur**
Triple Level Cell (**TLC**)	**3**	++	++	++	**Utilisateur**
Quad Level Cell (**QLC**)	**4**	++	++	+	**Utilisateur stockage**

Figure 13 - Description of the different types of SSD technology

Triple Level Cell SSD technology is the most common. Each technology requires a different number of chips to perform data storage.



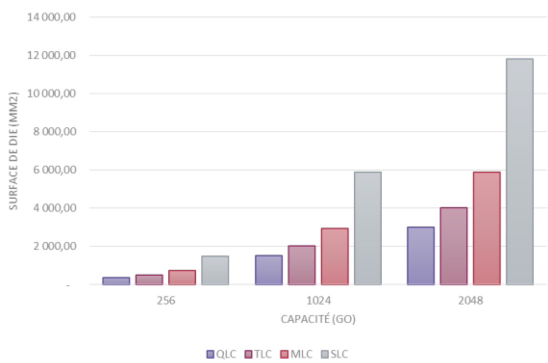


Figure 14 -Correlation between storage capacity and number of chips, between storage capacity and die surface area as a function of technologies

Following the analysis of the literature, it would appear that the different technologies have a variable lifespan; We have not been able to pursue this point further. But the lifespan of archival media is a central issue because, in addition to being more impactful, it seems that SSD hard drives have a shorter lifespan.

The same reasoning (in terms of capacity vs. die size) is applied to RAM.

Presentation of impacts

There is a significant variation in impacts between different storage and memory technologies. Indeed, within the same storage family (namely SSD storage) and for the same capacity, there is a variation of impacts of up to 3.8, thus bringing the impact of the fabication of a 2TB SSD hard drive from 137 kgeqCO2 to 525 kgeqCO2.

The lifespan of storage media is a subject to be explored, because in parallel it seems that the SLC has a longer lifespan, but this subject could not be investigated further. The increase in lifespan could partially compensate for the difference, but it does not seem realistic that the difference is of the order of a factor of 4.

In contrast, the impact of AMR evolves linearly. We have not been able to measure the impact of different RAM technologies. An impact of the order of 2.3 kgeqCO2/GB of RAM is observed.

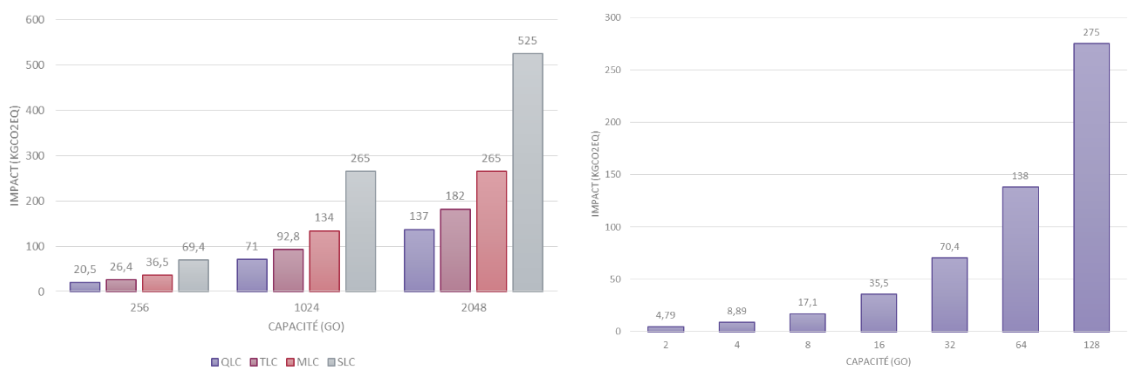


Figure 15 - Variability of SSD and RAM carbon footprint depending on capacity and technology

Openness and perspective

Given the significant impact of SSD storage technologies and the resilience of our information system, work should be carried out on the qualification of the lifespan of the various equipment. Indeed, it should be noted that the evolution of storage technologies (from paper to hard disk) is at the origin of:

- An increase in storable data volumes
- Better data availability

But a contratio, we will note:

- An increase in the volume of data to be stored
- A non-distinction between important and unwanted data (spam, failed photos, etc.)
- Decreased media reliability with less storage time before duplication

In addition, it would seem relevant to carry out the same work of analysis of technologies for RAM as for SSD.

6.1.2.3.4. *Step 3 – Work on equipment*

Technical modelling elements

Once the components have been characterized, they are integrated at the equipment level according to the standard architecture defined in the introduction. This architecture has been integrated into the EIME software, allowing data parameterization to obtain different configurations.

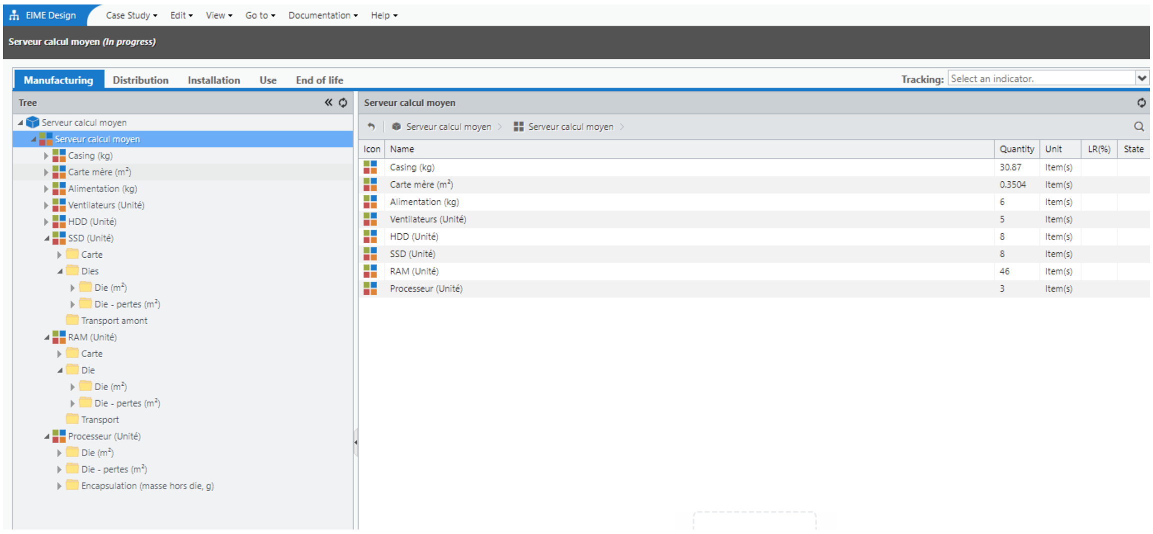


Figure 16 - Configurable model integrated into EIME

Integration into the EIME software allows the calculation of indicators, the tracking of contributors and the understanding of sources of impact.

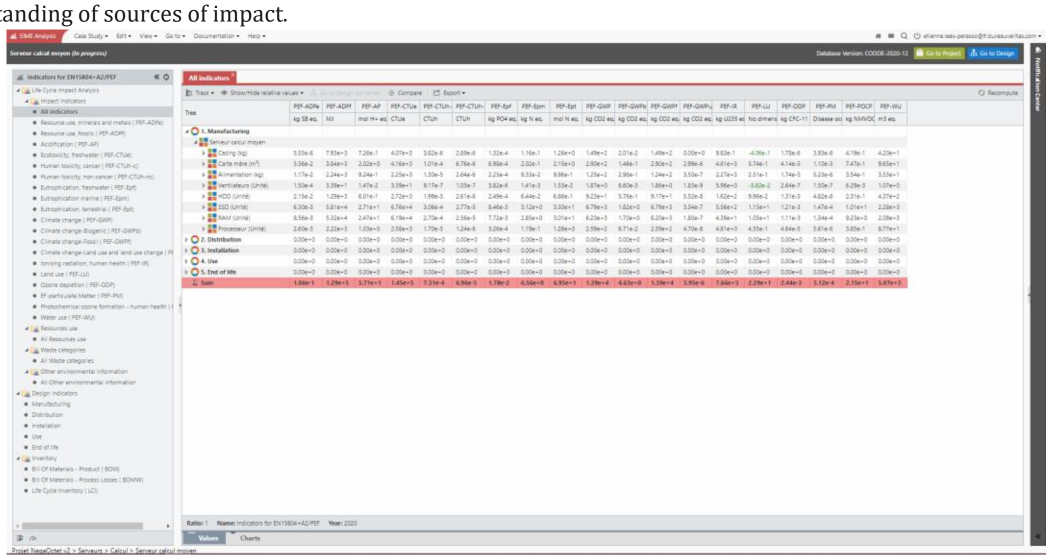


Figure 17 - Impact result for equipment

Key results

The analysis of the results obtained as part of these models allowed us to note that:

- For equipment without screen, the impacts were divided between storage (if SSD), RAM, CPU and motherboard
- For equipment with screen, the screen occupies a preponderant place but not the majority

6.1.2.3.5. ***Step** 3 – Configuring references*

Technical modelling elements

There are strong variations in impacts (change of order of magnitude) between different configurations. Thus, thanks to configurators from EIME software, it is possible to extract the impacts of different equipment configurations. The data required to configure impacts for a computer are as follows:

Données nécessaires pour les serveurs et PC			
Général			
Masse totale		kg	Optionnel
Surface carte mère		m^2	Optionnel
Surface autres cartes		m^2	Optionnel
Processeur			
CPU : surface du die		mm^2	Optionnel
Référence du/des CPU			Obligatoire
Carte graphique			
GPU : surface du die		mm^2	Optionnel
Référence du/des GPU			Obligatoire
SSD			
Technologie de SSD (SLC, MLC, TLC...)			Obligatoire
Nombre de SSD			Obligatoire
Capacité des SSD (total)		Go	Obligatoire
HDD			
Nombre de HDD			Optionnel
Capacité des HDD (total)		Go	Optionnel
RAM			
Nombre de RAM			Obligatoire
Capacité des RAM (total)		Go	Obligatoire
Autres			
Masse de l'alimentation		kg	Optionnel
Nombre de ventilateurs			Optionnel

Figure 18 - Input parameters to configure the impacts of a PC

Key results

Detailed analyses could be carried out for all personal and professional equipment. Two examples are presented below.

It emerges a preponderance of the impact of electronics in general in the impact of equipment (the impact of boxes is often very low, even if their mass can be important). There is a strong variation in impacts within the same product family depending on the configuration of the hardware, factor 1 to 5 for PCs for personal use, factor of up to 50 for a server.

The distribution of impacts is very different depending on the indicators considered, particularly between the depletion of natural resources and climate change..

UN EXEMPLE COMPLET : LE PC FIXE TYPE FAMILIALE

CONFIGURATION	PC fixe Familial
Boitier- Masse (kg)	2,4
Ventilateur- Masse (kg)	0,084
Alimentation- Masse (kg)	1,2
Carte mère- Surface (cm2)	359
Processeur Surface die (mm2) Nombre de masques	Intel Core i5 150 58
Mémoire RAM - Nombre x Capacité (Go)	2x4
Carte Graphique Surface(cm2) Poids Casing (g) Surface die (mm2) Nombre de masques	 12 558 cm2 266g 132 58
SSD- Capacité (Go)	250
Disque dur HDD – Capacité (Go)	2 000
Graveur DVD- Masse (kg)	0,7

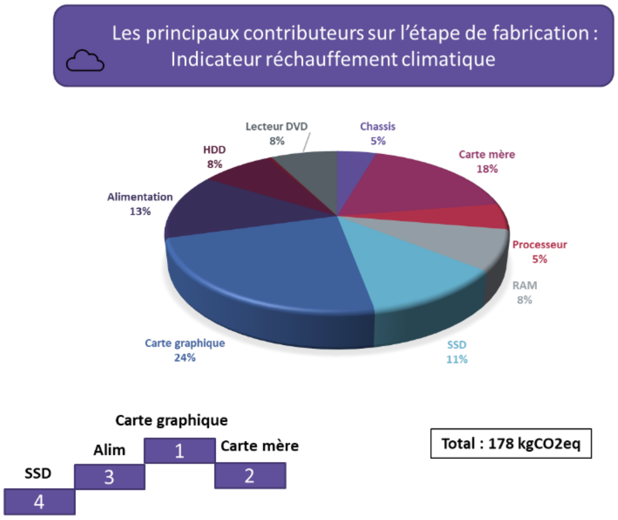


Figure 19 - Example of results for a desktop PC (off-screen) – Climate change

UN EXEMPLE COMPLET : LE PC FIXE TYPE GAMING

CONFIGURATION	PC fixe GAMING
Boitier- Masse (kg)	6,8
Ventilateur	Inclus dans la carte graphique
Alimentation- Masse (kg)	1,7
Carte mère- Surface (cm2)	686
Processeur Surface die (mm2) Nombre de masques	Intel Core i9 192 58
Mémoire RAM - Nombre x Capacité (Go)	2x8
Carte Graphique Surface(cm2) Poids Casing (g) Surface die (mm2) Nombre de masques	 30 972 cm2 587g 545 58
SSD- Capacité (Go)	500
Disque dur HDD – Capacité (Go)	2 000
Graveur DVD- Masse (kg)	0,7

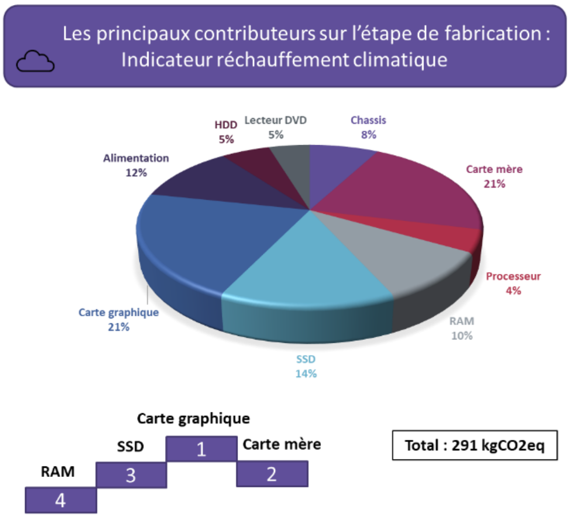


Figure 20 - Example of results for a fixed gaming PC (off-screen) – Climate change

6.1.2.4. Creation of third-party infrastructure data – The case of data centers

Data centres or datacenters are defined by EN 50600-1 as structures or a group of structures, dedicated to the centralized hosting, interconnection and operation of telecommunications equipment, information technology and networks providing data storage, processing and transport services, as well as energy distribution and environmental control facilities and infrastructures, but also the necessary levels of resiliency and security required to deliver the desired service availability. In other words, these are the spaces dedicated to the hergement of the centralized part of the organizations' information system. This definition covers a wide spectrum of datacenters that can range from a local server of about ten square meters integrated into a tertiary building to a dedicated building equipped with several thousand square meters of computer rooms. Data centers must meet three complementary levels of requirements:

- **Resilience,** to enable uninterrupted operation 24/7. Several standards detail the requirements for sizing by level of availability (Uptime Institute, EN 50600, TIA 942);
- Physical and logical **security** , to guarantee the integrity of hosted equipment and data ;
- Energy and environmental **performance**, because data centers, like other digital players, are increasingly questioned about their environmental impacts.

Data centers are defined according to several characteristics:

- **Their size, which can vary from several tens of square meters (example of** computer rooms associated with tertiary spaces) to several thousand square meters (example of so-called hyperscale datacenters)
- **Their typology**, which can be dedicated to the hosting of the information system of a so-called "internal" datacenter organization or operated by a third party that will ensure the maintenance in operational conditions and offer its customers data center hosting services called "**colocation**" or the **so-called** "edge" datacenters mainly to networks and uses requiring very low latency or called "HPC" (**High Performance Computing**); These are the datacenters dedicated to supercomputing
- **Their architecture,** datacenters can be in the form of computer rooms integrated into a building dedicated to other uses (tertiary) or in the form of independent buildings responding to this single function
- **Their density,** expressed in electrical power (kW or kVA) installed per unit of computer room area (per bay or per square meter); the density corresponds to the maximum electrical power usable by the computer equipment on a unit of area

Cloud computing refers to access via a telecommunications network to shared and configurable computing resources. It can be hosted in data centers located in France or abroad, in a cloud operator's own datacenter or in a colocation.

Data centers are organized into several types of spaces and equipment corresponding to different functions and service levels.

On the one hand**,** the building **level** constituted by the building whose elements are :

- Roads and concrete structures
  - Roads (heavy and light + pedestrian access): insulation layer, shape, foundation and finish
  - Ballasted columns diameter 400 mm
  - Column distribution mattresses
  - Concrete for retaining walls, rafts and exteriors, infrastructure and superstructures
  - Underwall walls, prewalls
  - Concrete slabs
  - Edges, thresholds, surveys
  - Concrete staircase
  - Bituminous coating
  - Buried insulation
- Electrical network
  - Sheath and nozzles
- Sanitation
  - Buried pipelines (EU/EP)
  - HVAC evacuation network and DIEI EU/EV PVC sampling
  - Concrete gutters
  - Retention tank
  - Siphons
  - Drain
- Sealing
  - Sealing + Insulation
- Carpentry (interior and exterior)
- Curtain wall grid
  - Glass door
  - Solid door a leaf
  - Full gate
  - Chassis
  - Glazed partition
  - Grated tablecloth
  - Galvanized steel staircase
  - Wooden door
  - Full steel door
  - Wooden baseboards
  - Wood-wall, floor, ceiling cladding
  - Galvanized steel posts
  - Galvanized steel beam
- Plastering
  - Distribution partition 72/48
  - Single dubbing
  - Acoustic flocking
  - PLACOSTIL fire partition walls
- Technical flooring
  - Technical floor removable slabs
  - False hollow floor not removable
  - Cladding + cylinders
  - Copper braid (grounded)
- Tiling
  - Protection under SEL tiles
  - SPEC tile protection
  - Tiling
  - Flexible coating
- Paint
- Elevator

The integration of this level of granularity is quite new in the context of LCA. The input data comes from the knowledge accumulated by APL datacenter over time. The data associated with thex emission factors are derived in particular from the compilation of environmental declarations produced such as EPD, FDES, PEP.

The technical environment level, which includes so-called "non-IT" equipment. The functionalities of these equipment are:

- Air conditioning and air treatment to maintain IT equipment in environmental conditions (temperature and humidity) compatible with their operation

- Securing and distributing electricity to ensure continuous, high-quality power to IT equipment, even in the event of a data center power failure
- Protection against energy, systemic, intrusion risks...
- Physical security with access control and video surveillance adapted to the context
- Connection with telecommunication networks operators

Until then, the impacts of the technical environment were only taken into account through their energy consumption through the concept of PUE. It is now possible to integrate the manufacturing and end-of-life impacts of equipment and to complete the scope of the study.

The computer **park level** housed in the computer rooms, which is composed of various equipment of different generations and constraints. Depending on the activity, the distribution of computer equipment varies. However, it is possible to classify these equipment according to three categories of functionality:

- Calculation and data processing via servers
- Data storage via storage arrays
- Network connectivity via switches and routers

Thanks to the ability to configure the impacts of servers and storage arrays according to their CPU, RAM and size and storage mode, it is now possible to differentiate between server typologies: compute server, hyperscaler, etc.

6.1.2.5. Data review

The review was carried out by a panel of three people (Françoise Berthoud, Laurent Lefevre and Guillaume Mandil). A verification framework was proposed in accordance with the ELCD Entry Level reference.
It covers all the data made available to the Impact® Database, and sampling on the Negabyte database including the most critical data (silicon wafer, CPU, RAM, SSD, power supply, motherboard, casing, hard drives, computers, smartphones, tablets, screens, networks, servers, cloud, digital services, etc.).
It started in January 2020 and is currently being finalized.
The audit made it possible, for each data, to identify strengths, weaknesses, and areas for improvement. These are dependent on each piece of data, depending on the available data sources, and therefore there is no overall conclusion for the entire database.
All the comments made by the auditors were taken into account throughout the database.

6.1.2.6. Opening

Contribution of lot 3 beyond the NegaOctet project

The creation of the NegaOctet database has made it possible to:

- Have homogeneous **multi-criteria** data to assess the environmental impact of a digital service
- To carry out **data consolidation and development** work at all levels of the digital industry:
  - At the component level: by updating the data associated with the production of silicon wafers that are at the heart of semiconductor impacts, by updating data on the production of LCD and OLED screens (based on recent CSR reports from major manufacturers), by performing an analysis on the impact of different storage technologies
  - At the equipment level: by allowing the creation of configurable models according to the technical characteristics (which are also dimensioning from an environmental point of view) namely the CPU, RAM and storage capacity/technology

Contribution of lot 3 beyond the NegaOctet project

  - At the network level: by updating fixed and mobile network data (this aspect was done rigorously by combining the NegaOctet repository and the data collected as part of the PSR for Internet Service Providers)

- At the data center level, by allowing:
  - The transition from the PUE approach to an approach combining PUE and integration of the impacts associated with buildings and equipment of the technical environment
  - The configuration of servers and technical equipment according to technical criteria: CPU, RAM, storage but also load rate
- Carry out evaluations on all PEF criteria and standardize indicators to present the interest of multicriteria
- Evaluate the MIPS indicator

The data will be made available:

- In an ILCD node as a life cycle inventory for LCA practitioners and as emission factors for others. These elements will be private and made available for a fee.
- In the Impact® Database for key uses of digital services (e-mail nvoi, video streaming, file download/upload, cloud data storage, use a connected watch, Webconference, web request, and connected object with its information package), terminal equipment (o laptop, tablet, smartphone, desktop computer, computer screen, television, power supply - external laptop, power supply - external smartphone and tablet, external hard drive, external SSD, USB key, smartphone battery, box and connected watch), network equipment and datacenter. This data is made available free of charge.

MISE À JOUR ET MAINTENANCE

Faire vivre la base de données nécessite des travaux annuels : création, mise à jour et vérification de données

ADHÉSION – CRÉATION DE DONNÉES SPÉCIFIQUES

La base de données créée comporte des données génériques. Il est envisageable de créer et d'intégrer des données spécifiques d'industriels

DÉVELOPPEMENT MÉTHODOLOGIQUE

Des développements pourront être faits en lien avec les règles méthodologiques (PCR, PEFCR, etc.) Création de bases de données sectorielles

Perspectives and topics to investigate

In order to complete the vision of the impacts we have, the subjects are numerous. But among them, we can consider the following two, as priorities:

- Lifespan of storage equipment
- Variability of AMR impacts by technology

In addition, it should be noted that, given the rapid evolution of the sector, both in terms of hardware and service architectures, it is necessary to consider a follow-up to this project, which will:

Contribution of lot 3 beyond the NegaOctet project
- Enable database update and maintenance - Enable data enrichment - Allow the expansion of the consortium of actors in charge of its governance

6.1.2.7. Contents of the database

Beyond the free provision in Database Impacts® of data for sixty digital services and equipment for key use cases, the NégaOctet database will be marketed to allow use by other market players. The provision is made in different formats:

- Impact factors in excel format
- Lifecycle inventories in .eime and ILCD node format with configurators
- Configurators

Thus, this consolidated database now includes more than 800 references of products or services, declined on the different phases of the life cycle for a dozen indicators.

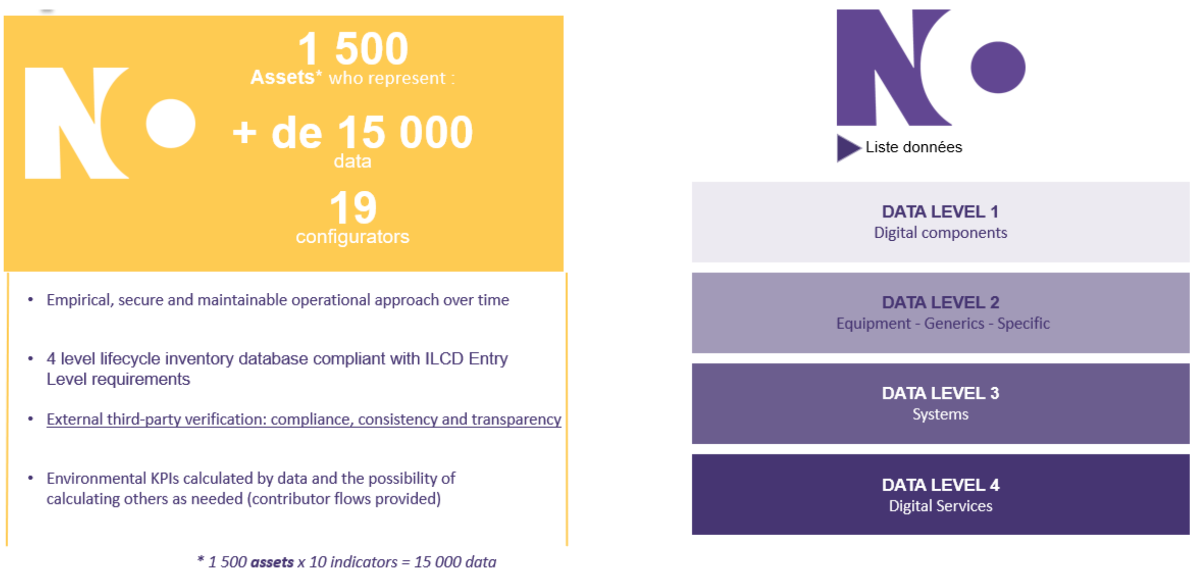


Figure 21 - Description of the NegaOctet database

6.1.3. Lot 4 – Creation of a parameterized generic model for the environmental impact assessment of digital software/services

6.1.3.1. Workflow

Lot 4 – Creation of a configurable generic model for the environmental impact assessment of digital services					
Responsible	LCIE				
Partners involved	LCIE	NEUTREO BY APL	GreenIT.fr	DDemain	
Related Deliverable(s)	Configurable model + Explanatory note Related documentation Critical review report of the model				
Content					

Objectives

- Enable the assessment of the environmental footprint of a digital service
- Allow the identification of significant environmental parameters at the origin of the environmental impacts of the service
- Allow the configuration of the tool according to different criteria, such as:
    - Type of project: IoT, management tool, platform, social networks, media
    - The sector of activity: agriculture, transport, banking and services, energy, water, construction
    - Company size: startup, SME, large groups
    - The geographical location of the different third parties

Success Criteria

Applicability of the tool in the context of collective action without the need to rework the tool

Detailed programme of work

After having initiated the mock-up of several tools in excel format, this batch could not be realized in its entirety for several reasons:

1- Due to lack of time, since the creation of the database required much more energy and time than anticipated as part of the project.

2- Because, following the realization of the different pilots, we realized that the computers should be adapted according to:

- Type of digital services:
    - User: general public or industrial
    - Communication/Entertainment, AI, IoT, DeepLearning, Home Automation
- Access to collection data:
    - The sponsor knows the entire value chain and has specific metrics for all the elements:
        - Nomenclature of specific terminals
        - Composition of its datacenter and infrastructure
    - The client subcontracts IT management or uses third-party services and only has invoices for services or hosting (PaaS, IaaS cases)

3 – Because the indicators to be calculated are different if we look at it in the case of comparison with non-digital services and products.

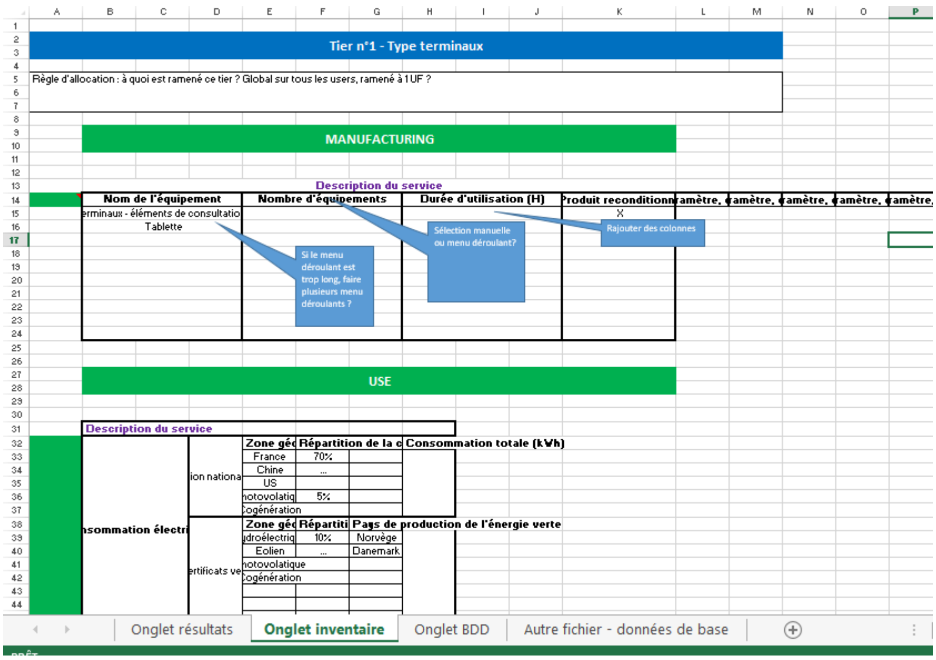


Figure 22 - Presentation of the model in its first version

We have therefore produced computers adapted to each case study implemented during the pilots. A pooling between the guides is planned in order to produce specifications for the development of a computer tool (not excel) to meet the above challenges.

6.1.3.2. Some examples

6.1.3.2.1. *Synthetic vision*

The figure below summarizes the general philosophy of establishing a calculator:

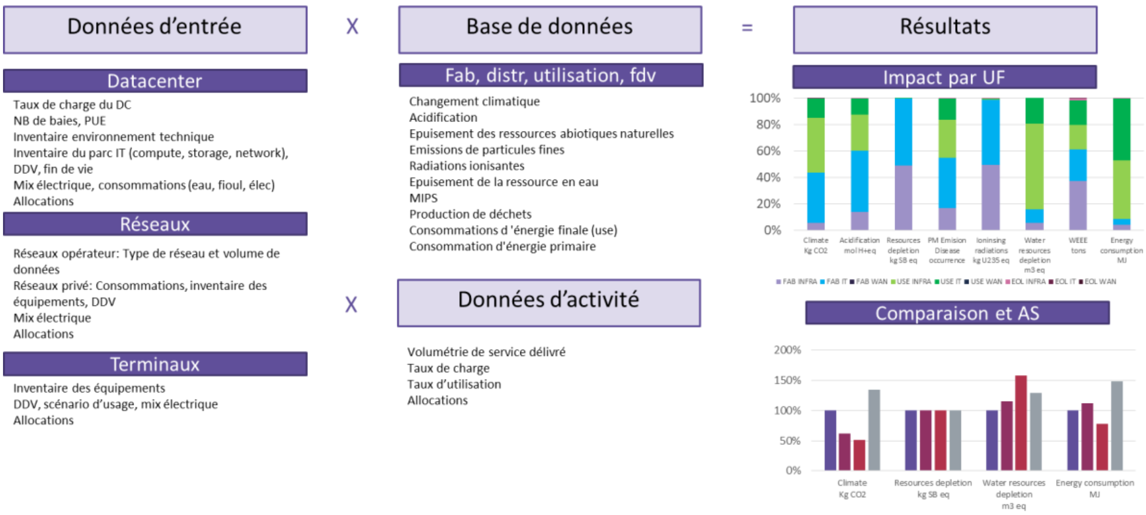


Figure 23 - Synthetic vision of the evaluation process for the development of a calculator

6.1.3.2.2. *The CYME case*

As part of the CYME pilot project, LCIE Bureau Veritas has developed an environmental calculator specific to the PEAKTO digital service. Based on feedback from previous tools developed by the NégaOctet consortium, LCIE has added specificities specific to the project:

- The technical parameters describing the functional specifications of the digital service have been included as input parameter of the ECU.
- Specific terminals have been added, including the consideration of a local Raspberry server.
- Environmental impacts are calculated and presented monthly over a 24-month period. As the service is rolled out, PEAKTO can identify the gradual evolution of its impacts.
- The concept of functional unit and business act has therefore been replaced by a unit declared monthly. This is better suited to CYME's business model.

The calculator makes it possible to compare the environmental impact of two scenarios to facilitate the identification of ecodesign paths. This project highlighted the need to adapt each NégaOctet computer to the specificities of the digital service studied. In the absence of this specific support, the environmental analysis only partially answers the questions asked by customers.

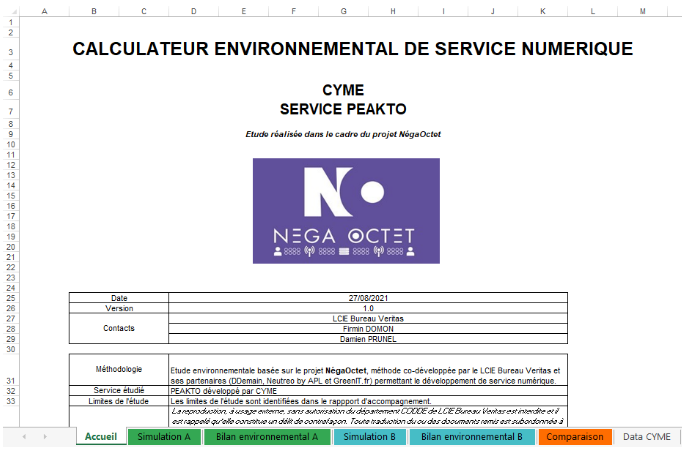


Figure 24 - Home page

	Données d'entrées du calculateur - Scénario A					
2	**Données d'entrées du calculateur - Scénario A**					
3						
4	**Hypothèses**					
5						
6	**Hypothesis**			**For Readability**		**Remarque**
7	HD Size	2048*2048	[redacted]		[redacted]	La taille en pixels des images Haute Résolution (HR) stockées dans le cloud
8	HD Weight (GB)					Le poids moyen d'une image HR
9	Preview Size	MultiThumbnails				Le scenario choisi pour les preview (simple / multiple).
10	Preview Weight (GB)					Le poids moyen d'une aperçu
11	# downloads					Pourcentage des HD Size téléchargées
12	# library access / month					
13	# Previews Downloaded					Pourcentage des previews téléchargées
14	% of masters accessed					Pourcentage des HD Size téléchargées (originaux)
15	# searchs/sort/... per day					
16	Display HD on any device	oui				
17	Request Average Weight (GB)					Taille d'une requete
18	# steps to create backup					
19	Kind of photo Obj in database	Normal				Le type de scénario pour l'empreinte d'une photo en Base de données BDD
20	Weight of photo Obj in database(GI					Poids d'une photo en BDD dans le scénario (poids des météadonnées)
21	% of objs added on Day 1					Pourcentage du stock photo ajouté le premier jour (backlog)
22	% of images added by month					Pourcentage du stock photo ajouté chaque mois
23	# years of usage					Durée d'utilisation du programme
24	average # of images added in trial					Nombre de photos ajoutées pendant la phase d'essai
25	DB Provider	MongoDB				
26	facteur correctif MongoDB					Facteur correctif prenant en compte la compression par MongoDB
27	**BackBlaze Hypothesis**					
28	Storage per Gb		$0,005			
29	Download per Gb		$0,01			

Figure 25 - Technical parameters describing the functional specifications of the digital service

37	Temps mensuel par utilisateur	4	h		
38					
39	**Terminaux de consultation**	Répartition	Durée de vie (ans)	Valeur par défaut	
40	Ordinateur fixe + écran	50%	6	6	
41	Ordinateur portable	50%	5	5	
42	Tablette	0%	3	3	
43	Smartphone	0%	3	3	
44	TOTAL	100%			
45					
46	**Terminaux de stockage local**	Répartition	Durée de vie (ans)	Valeur par défaut	
47	SSD	0%	5	5	
48	HDD	0%	5	5	
49	TOTAL	0%			
50					
51					
52					
53	**Terminaux de stockage à distance**	Répartition	Durée de vie (ans)	Valeur par défaut	
54	SSD	0%	5	5	
55	HDD	0%	5	5	
56	Raspberry	0%	5	5	
57	TOTAL	0%			
58					
59					
60	**Consommation d'énergie des terminaux**				
61	Mix énergétique des terminaux	Mix national, France			

Figure 26 - Specific terminal settings

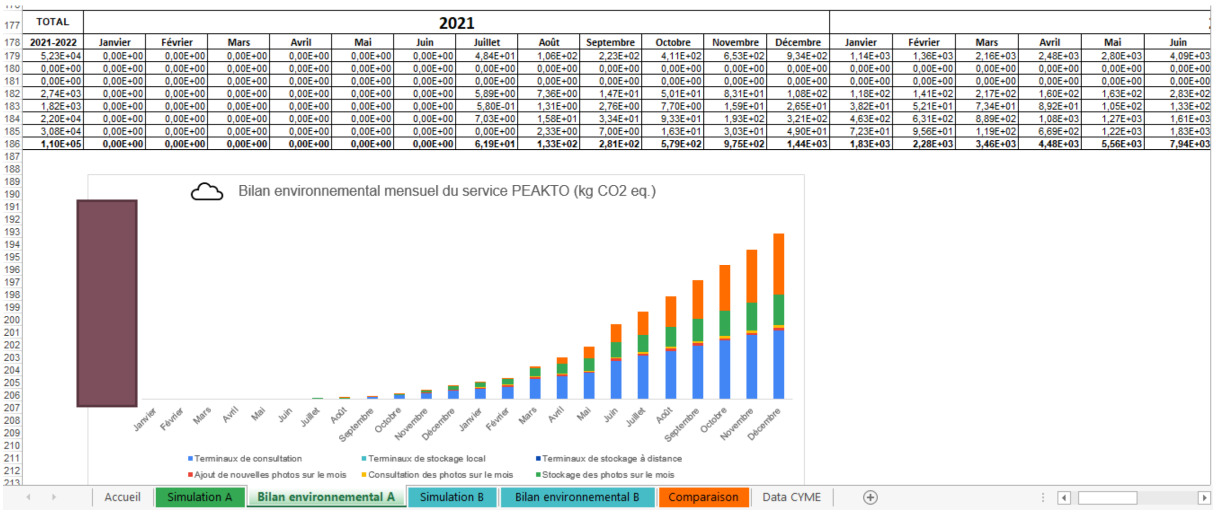
Bilan environnemental mensuel du service PEAKTO

	Service [redacted]	Energie	Ressources		Climat	Eau	Energie	Ressources
127	BLOC TERMINAU … +03	1,53E+06	3,01E+00		48%	34%	20%	34%
128	+00	0,00E+00	0,00E+00		0%	0%	0%	0%
129	+00	0,00E+00	0,00E+00		0%	0%	0%	0%
130	BLOC TRANSMISS … +01	2,00E+05	1,88E-01		3%	1%	3%	2%
131	+01	1,33E+05	1,25E-01		2%	0%	2%	1%
132	BLOC DATACENT … +03	2,46E+06	2,26E+00		20%	27%	32%	26%
133	+03	3,44E+06	3,16E+00		28%	38%	44%	36%
134	TOTAL … +03	7,77E+06	8,74E+00		100%	100%	100%	100%

139	7	**Contribution annuelle moyenne d'un foyer français**
140		*La contribution annuelle d'un ménage français moyen est 15,5 Tonnes de CO2 eq.*
141	101	**A/R Paris New-York**
142		*Un aller/retour Paris New-York en avion emet en moyenne 1 008 kg CO2 eq.*
143	963	**A/R Paris Londres**

Accueil | Simulation A | Bilan environnemental A | Simulation B | Bilan environnemental B | Comparaison | Data CYME

Figure 27 Specific division of the three-thirds of the digital service to specificities ?? CYME



TOTAL	2021																	
2021-2022	Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Août	Septembre	Octobre	Novembre	Décembre	Janvier	Février	Mars	Avril	Mai	Juin
5,23E+04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,84E+01	1,06E+02	2,23E+02	4,11E+02	6,53E+02	9,34E+02	1,14E+03	1,36E+03	2,16E+03	2,48E+03	2,80E+03	4,09E+03
0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
2,74E+03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,89E+00	7,36E+00	1,47E+01	5,01E+01	8,31E+01	1,08E+02	1,18E+02	1,41E+02	2,17E+02	1,60E+02	1,63E+02	2,83E+02
1,82E+03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,80E-01	1,31E+00	2,76E+00	7,70E+00	1,59E+01	2,65E+01	3,82E+01	5,21E+01	7,34E+01	8,92E+01	1,05E+02	1,33E+02
2,20E+04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,03E+00	1,58E+01	3,34E+01	9,33E+01	1,93E+02	3,21E+02	4,63E+02	6,31E+02	8,89E+02	1,08E+03	1,27E+03	1,61E+03
3,08E+04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,33E+00	7,00E+00	1,63E+01	3,03E+01	4,90E+01	7,23E+01	9,56E+01	1,19E+02	6,69E+02	1,22E+03	1,83E+03
1,10E+05	**0,00E+00**	**0,00E+00**	**0,00E+00**	**0,00E+00**	**0,00E+00**	**0,00E+00**	**6,19E+01**	**1,33E+02**	**2,81E+02**	**5,79E+02**	**9,75E+02**	**1,44E+03**	**1,83E+03**	**2,28E+03**	**3,46E+03**	**4,48E+03**	**5,56E+03**	**7,94E+03**

Figure 28 - ÉMonthly assessment of digital service impacts over 24 months

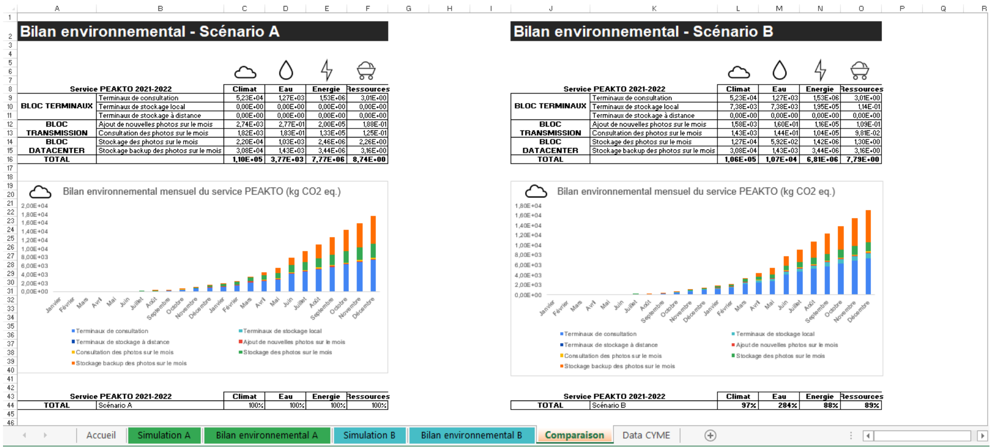


Figure 29 - Comparison of two scenarios

NOTE – The results presented are fictitious

6.1.3.2.3. *The Worldline case – DDemain support – GreenIT.fr*

As part of the support provided for Worldline, it was necessary to have a vision by scope of direct and indirect responsibility: cardholder, merchant, network operator, Worldline, Bank, etc. as well as a comparative vision between two scenarios, digital and physical.
For each perimeter, the allocation factors and geographical representativeness in particular had to be adapted.
Thus, the calculator was made according to the following structure:

- Input parameters
- Scope of responsibility 1
- Scope of responsibility 2
- Scope of responsibility 3
- Scope of responsibility 4
- Aggregate results by functional unit
- Aggregate results by year
- Sensitivity analysis
- Database

As such, the challenges were:

- Get readability for each step
- Integrate data associated with specific modeled items into EIME
- Allow the database to be easily updated, since it will be a question of updating the study with the new PEF indicators
- Allow different levels of interpretation

- Allow comparison between scenarios with common and divergent elements

About - Worldline payment transaction		
General informations		
Period of realisation	*Nov-19 to Nov-20*	
version	2	
Project Leader	*Pierre DECROCQ*	*CSR officer*
Operationnal Team		
Project Manager	*Julie ORGELET*	*Ddemain*
Expert	*Frederic BORDAGE*	*GreenIT.fr*
Review	No external review	
Processus		
Process~~us~~ of realisation		
Data collection period	*2019*	
How does it works?		
Database sheet	*Environmental data in background* *The database sheet groups environmental data gathered by Airbus, Ddemain and LCIE in order to be able to calculate the environmental impact associated with each step included in the scope.* *The environmental data are presented relating to 4 indicators:* *- Primary Energy* *- Global Warming potential* *- Water Depletion* *- Raw material depletion - mineral* *For each item, the data relates to manufacturing (distribution and end of life are out of scope)* *It is possible to change the data included in the sheet. Any modification will have an influence on the final results*	
Workflow	*Description of the scope and allocation method* *The workflow sheet describes the step included in the considered functional unit and* *It is possible to change the data included in the sheet. All data with a yellow colored background have an influence on the results.*	
Step description and impact (	Data collection for each step *The "Steps description sheet" described the data collected. The data are used in order to calculate the total impact of the step in the right part of the table.* *Any change in the T column have an influence on the results*	
Impacts	Impact calculation for the complete process (1 calcul – X job) *The impacts sheet presents the results of the evaluation in:* *- absolute value for the whole calculation process* *- absolute value for one job (functional unit)* *- vulgarised values* *No change has to be done in this sheet*	
Sensitivity Analysis	Comparative evaluation of alternative scenario *This sheet has to be complete in order to compare the different scenario*	

Figure 30 - Description of the Worldline Phase 1 calculator

6.1.3.3. Opening

Contribution of Lot 4 beyond the NegaOctet project

The realization of Lot 4, even if the latter did not lead to the realization of one but several computers, made it possible to understand the ins and outs of the creation of a software allowing to realize ergonomically an LCA of digital service.

It allowed the development of detailed specifications for the creation of an LCA software platform.

6.2. Phase 2 – Testing the repository

6.2.1. Lot 5 – Case study - Implementation of the method

6.2.1.1. Workflow

Lot 5 – Pilot case - Implementation of the method					
Responsible	NEUTREO BY APL				
Duration	12 mois				
Beginning	Mars 2021				
Partners involved	LCIE	NEUTREO BY APL	GreenIT.fr	DDemain	
Related Deliverable(s)	Pilot LCA Report Summary document of the results of the pilot LCA Benchmarking document obtained using existing input data				
Content					
Objectives Consolidation of the repository through its implementation. Validation of the results obtained via the repository.					
Prerequisite The availability of the database is a prerequisite for carrying out these studies. The database is not sufficiently advanced, so starting this step is not possible at this time..					
Success Criteria Obtaining comparative assessment results of the environmental impact of a software solution allowing the identification of ecodesign avenues.					
Detailed programme of work **Task 1 - Method Testing - A Case Study Comparing Two Versions of an Application: The EIME Case (Confidential)** **Task 2 - Test of the method - a case from an LCA already carried out by ADEME for example: The mail case** Pending finalization of the database data, these case studies are not finalized at this time..					

6.2.1.2. Case study mail – Summary

The objective of this pilot was to update the study "Comparative analysis of the environmental impacts of electronic communication - E-mail component: Final report - BioIS for ADEME, July 5, 2011", with NégaOctet data.

A life cycle analysis of the digital service for sending an email according to ISO 14040 and ISO 14044 standards was carried out.

The functional unit considered is as follows::

"Sending a 1 MB document to a person by e-mail".

Perimeter

The complete life cycle of the digital service (equipment) was taken into account:

- **Manufacture** of electrical and electronic equipment (computers, servers, etc.);
- **Usage** that includes the time of use of the terminals;
- **Sending and possibly storing** on the transmitter's server;
- **Transmission,** from the transmitting computer to the receiving computer;
- **Information processing** within data centers;
- **Receiving and using** received items (on-screen playback, server recording);

- **End of life** , which includes the end of life of equipment to perform the function of the digital service (terminals and datacenter equipment).

Data sources

All the data necessary to model the equipment through which the information flows used when sending and receiving a letter pass were derived from extensive bibliographic research and data from the 2011 study. The main lines of evidence are:

- Use scenario: Comparative analysis of the environmental impacts of electronic communication - e-mail component: Final report" - BioIS for ADEME, 5 July 2011
- Terminal usage time: Global Web Index Device report, Digital BBAROMETER - 2021 edition, ARCEP
- Information sur le datacenter : Google's Green Computing: Efficiency at Scale, NegaOctet
- Spam rate: Radicati Group, February 2019
- LCA Model Information:
  - NegaOctet database and jobs
  - Comparative analysis of the environmental impacts of electronic communication - olet e-mail: Final report" - BioIS for ADEME, 5 July 2011

Reference Case

The main assumptions used for the Reference Case are as follows:

- Sending an email of a size of 1 MB to a person in a context of professional use and a French geographical context with a laptop
- Reading the document on the screen by the recipient, no printing.
- The duration of storage of the email by the sender and the recipient is one year
- The sending and reading of the email is done on a computer

Results

For the baseline scenario, the results are as follows:

		E**greenhouse gas emissions in** g eq CO2	**Primary energy consumption in** MJ	**Consumption of natural resources in** g eq Sb
Sending a 1 MB email to a person	Result BioIS	19	0,39	0,13
	Result NégaOctet	6,68	0.35	0.00623
	Deviation in %	**-65%**	**-11%**	**-95%**

There is a significant variation from the 2011 study, which is explained by:

- A variation in the lifecycle inventory database
- An increase in equipment utilization rates
- An improvement in the energy efficiency of data centers and an increase in the volume of emails that can be processed by the same server
- An evolution in the consideration of the impact of the Data Center and the Network

The results of the environmental scan are shown in the figure below:

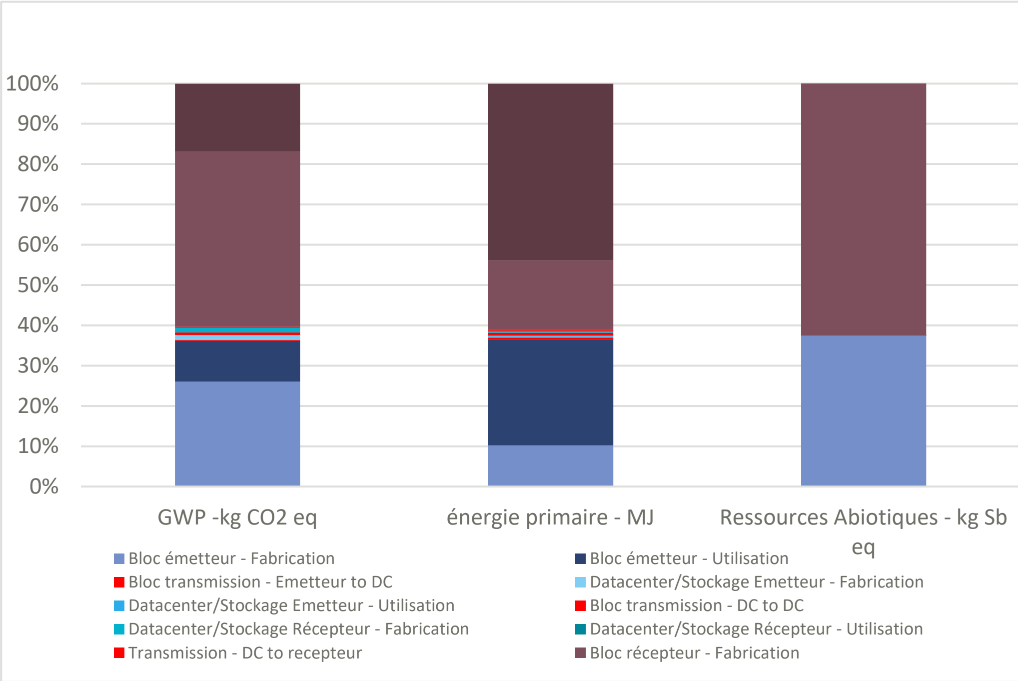


Figure 31 - Presentation of the distribution of results for a reference email

The potential environmental impacts associated with sending an email with a 1MB attachment to a person are mostly from the sender and recipient of the mail. Terminal manufacturing is an important contributor to the impacts of e-mail and is followed by the use of these terminals. If we consider the use of a stationary computer, the rest of the impacts are almost anecdotal.
NOTE – This again raises the question of the allocation method for non-dedicated multifunctional terminals: cost of use, marginal cost or average cost?

Variability and sensitivity analysis

The impacts presented vary drastically depending on:

- Terminal Type
- Message and attachment size
- Storage time
- Country of issuance, storage and receipt of the email
- Number of recipients, read rate, read time

All these variations can be evaluated thanks to the calculator carried out on the subject.
The table below identifies variations under different scenarios. We then observe variations of the order of +86% to -97% on the ADP indicator but also from -35% to +15% compared to the reference scenario.

	GWP -kg CO2 eq	Primary energy - MJ	Abiotic Resources - kg Sb eq	GWP - kg CO2 eq	Primary energy - MJ	Abiotic Resources - kg Sb eq
Reference	6,68E-03	3,53E-01	6,23E-06	100%	100%	100%
Reference- DC US	6,70E-03	3,50E-01	6,23E-06	100%	99%	100%
Laptop	4,36E-03	1,04E-01	2,13E-07	65%	30%	3%
Smartphone	4,42E-03	1,39E-01	1,15E-05	66%	40%	184%
Reference - 10 Mo - Stored 10 ans	7,71E-03	3,87E-01	6,25E-06	115%	110%	100%
Smartphone - 10 Mo - 10 ans – mobile Network	7,64E-03	3,89E-01	1,16E-05	114%	110%	186%

To understand these variations, here are some impact profiles. If for the reference case, only the impacts of the terminals appeared, for the case "I send a 10 MB message that I store and that my receiver stores for 10 years", there is an increase in the network share and the Datacenter share. This supports the good practice of avoiding large attachments and deleting messages as soon as they are used.

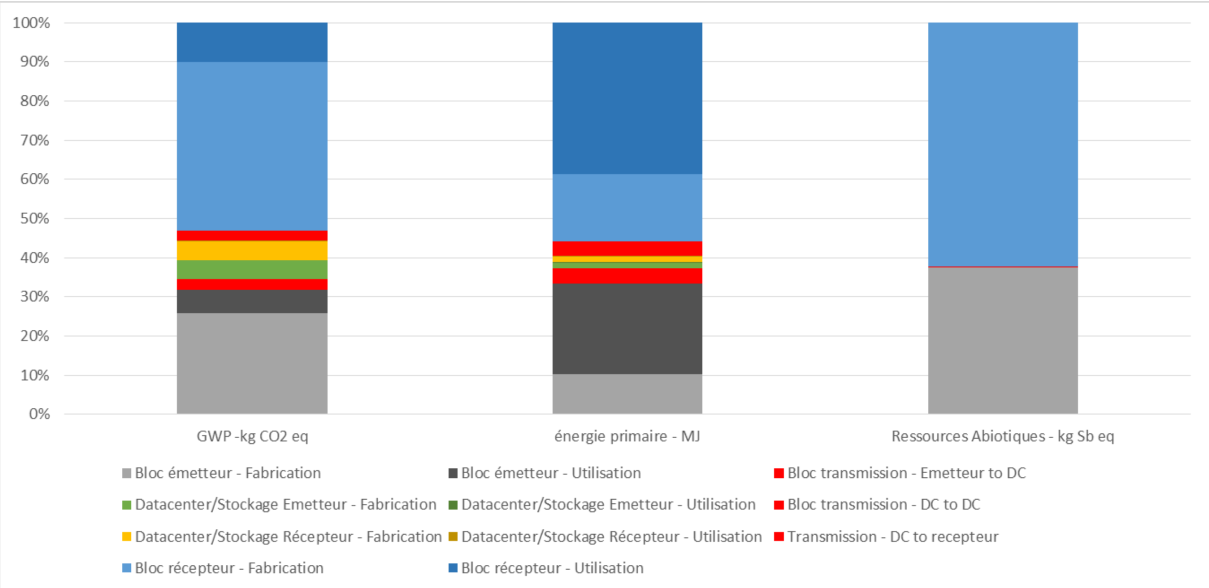


Figure 32 - Presentation of the distribution of results for a 10 MB email stored for 10 years by the sender and receiver

In an even more extreme case, an email with a 10 MB PJ sent by smartphone on the mobile network to a receiver who reads it and stores it for 10 years, we observe a preponderant part of the mobile network in the results. Thus, it is important to choose your equipment, its network and the size of the information to be transmitted.

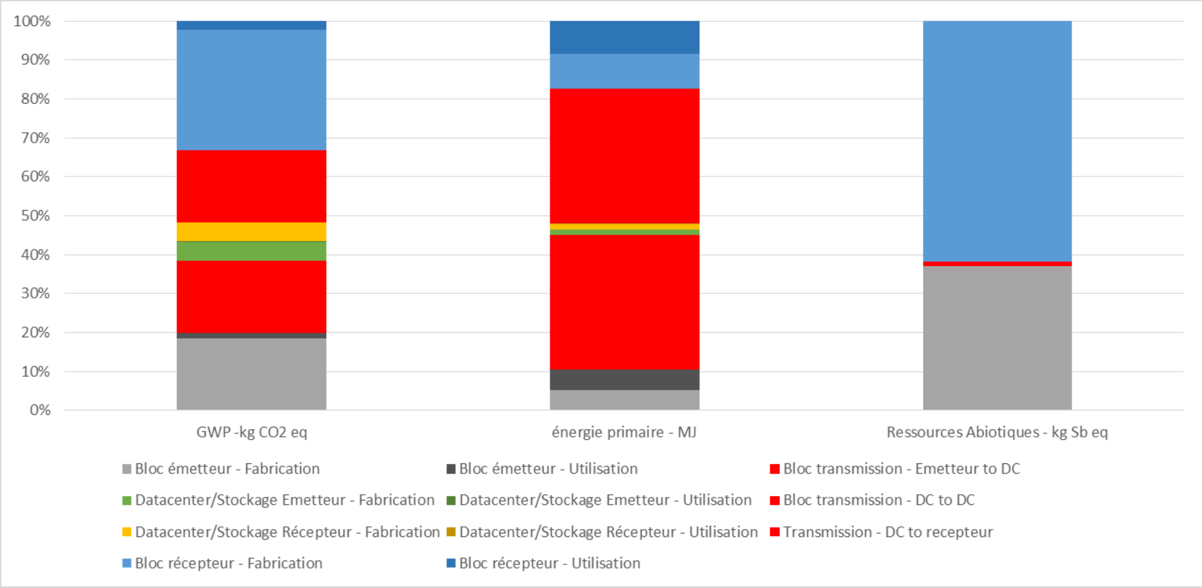


Figure 33 - Presentation of the distribution of results for a 10 MB email stored for 10 years by the sender and receiver and sent/received on smartphone

<u>Example of an email campaign</u>

The calculator also allows simulations on larger cases, such as sending an e-mailing campaign. The characteristics of the campaign are as follows:

- 1 transmitter writes for 2 hours on fixed PC – mail of 1 MB
  - 2000 Receivers of this mail only 10% read it.
  - Distribution of terminals (France use) 24% desktop PC, 24% mobile PC, 5% tablets, 45% smartphone
  - Localisation 100% France

	GWP g CO2 eq	**Primary energy- MJ**	**Abiotic Resources - g Sb eq**
E-mailing campaign	819	30,8	1,01

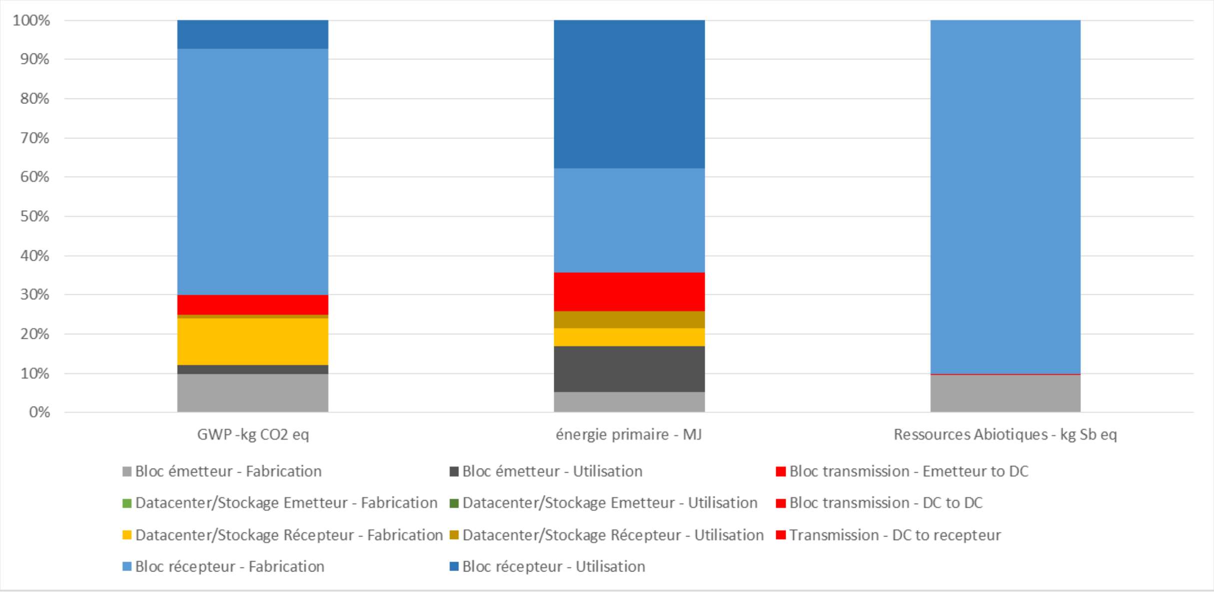


Figure 34 – Impact of an email campaign

Most of the impacts take place at the receiver, through its consultation material. Smartphone consultation remains the least impactful. Storage on the datacenter has a significant impact correlated with attachment size and storage time.

Analysis

The conclusions of the study are that the environmental impacts, from a global point of view for the entire life cycle of an email, depend on several factors including:

- The size of the attachment;
- The number of recipients;
- The type of terminal;
- The geographical location of the emitter or the energy mix considered.

It is therefore extremely difficult to give the carbon weight **of an email because there are strong variabilities associated with user behavior. However, the study shows that the good practices conveyed are relevant. The first is not to acquire new equipment and to extend the life of our equipment, to avoid the use of the mobile network when an alternative is available, not to store emails and to unsubscribe from newsletters.**

6.2.1.3. Opening

Contribution of Lot 4 beyond the NegaOctet project

Lot 4 made it possible to update a flagship study on the environmental impact of emails and to understand its evolution, as well as to test our approach on a case of migration to the cloud.

6.2.2. Lot 6 – Class Action - Dissemination of the Method

6.2.2.1. Workflow

Lot 6 – Class Action - Dissemination of the Method					
Responsible	GreenIT.fr				
Duration	30 mois				
Beginning	Juin 2019				
Partners involved	LCIE	NEUTREO BY APL	GreenIT.fr	DDemain	
Related Deliverable(s)	Summary of collective action				

Content

Objectives

- Use the benchmark to assess environmental impact and eco-design the digital software and services of tomorrow.

Success Criteria

- Support a dozen eco-design projects for digital services over the duration of the project

Detailed programme of work

Task 1 - Recruitment pilot phase

Achievement: Consortium with Advisory Committee support

In order to enable the implementation of the standard, we have included in the project a recruitment phase for companies wishing to eco-design their software solutions and digital services. We have presented the project in many congresses, events (ecodesign symposium, AvniR congress 2018/19, LCT Forum). In addition, several specific recruitment events were carried out:

- September 13, 2019 – Grenoble: Pilot breakfast with a testimonial from the company Arkadin – 15 participants
- October 10, 2019 – Webinar: 19 participants
- Montpellier: during the closing meeting of the GreenConcept project, presentation of the NégaOctet project (100 participants)
- Montpellier: during the conference The Green IT Day, October 8th, presentation of the NégaOctet project (150 participants)

Due to the COVID crisis, we have not been able to reproduce planned face-to-face events. However, we carried out more than fifty additional interviews that led to the completion of project description sheets.

The following organizations have participated or participated in the pilot phase:

- ADEME, AIRBUS, AWS, BLADE, CYME, CITÉ DES SCIENCES, OVH, OVEA, RTE, WORLDLINE
- A confidential company

Task 2 - Realization of the pilots – See summary sheet below

We have made (or are in the process of making) 11 pilots with the NegaOctet repository. These pilots, covering very different services, allowed us to:

- Consolidate the method
- Adapt database granularity to partners' knowledge level
- Completing our modeling models
- Identify the differences in impact and their source between the LCAs made before the method is made available and after

6.2.2.2. Results

6.2.2.2.1. *Synthesis*

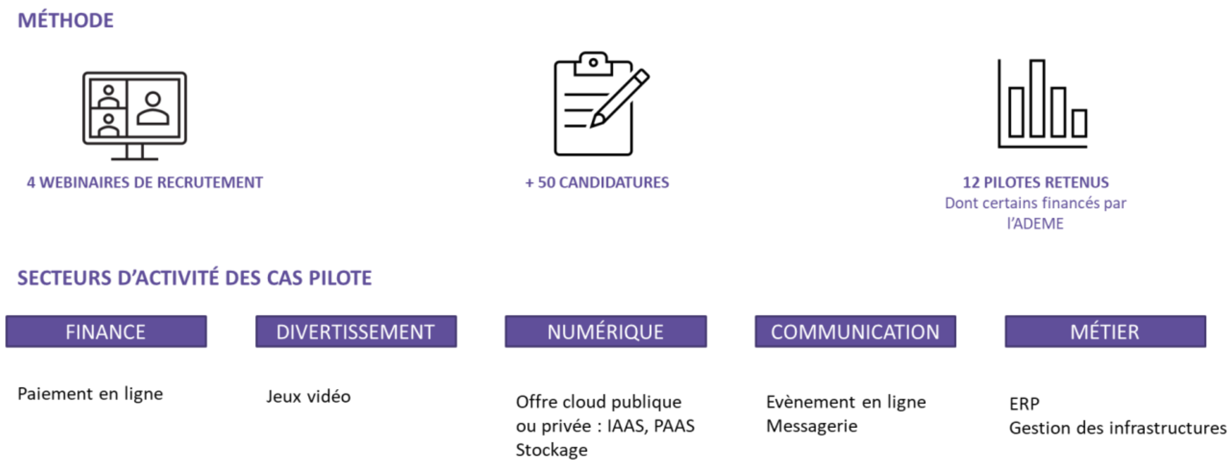


Figure 35 - Summary of collective action

6.2.2.2.2. *Summary sheet – BLADE case*

Enterprise: BLADE
Following : LCIE Bureau Veritas
Critical review: No
Study Statutes: Finalized
LCA type : Complete
Services studied: Shadow, A cloud computing service dedicated to gamers.
Comparative: Yes. The Shadow service has been compared to the use of a local computer.
Perimeter:

FU : The environmental impacts of the digital services studied are given according to the following declared unit:
" Use an operating system (Windows 10 64 bits, GeForce GTX 1080, processeur 3,4 GHz, mémoire 12 Go, stockage 256 Go) XX hours a day for a year, including two-thirds of the time reserved for video games. "
With XX is
- 2.59 hours per day for Case Study 1 - European Zone
- 1.88 hours per day for Case Study 1 - American Zone

It was not possible to define a functional unit dedicated to one hour of video games due to the accuracy of the data collected by Blade. The proportion, two-thirds video games and one-third other uses, is representative of Shadow Boost users.

Advantages of the approach and awareness:
The BLADE team was highly motivated throughout the study and greatly appreciated the support and the results obtained. BLADE was aware of environmental issues and only knew how to make macro calculations to give orders of magnitude (e.g. consumption of a computer vs. consumption of a datacenter). The NégaOctet approach has been beneficial on many topics:

- Discovery of the multi-criteria approach
- Awareness of the issues related to the allocation of environmental impacts
- And that before embarking on a customer communication, the LCA version NégaOctet makes it possible to bring a requirement and a scientific rigor

Contribution in relation to the method (what it brought to NegaOctet) :
On the NégaOctet side, the LCIE was able to:

- Challenge the coherence of the database in terms of geographical and temporal representativeness of the data, particularly on energy mixes. In addition to modeling a datacenter in Paris, the novelty was to consider data at the level of the United States.
- Identify that the choice ofenergy mix and terminal lifespan has a very strong influence in the calculation of environmental balances. Depending on these criteria, the environmental balance can be positive or negative. Customers therefore need to better understand the use of these parameters.
- easily highlight ecodesign axes with strong levers (>20%).

Improvement lever for the method:
At the level of life cycle inventory models, LCIE is increasingly trying to create models where energy mixes can be changed on the fly according to customer needs..

Next steps: BLADE wanted an update of the study to go into more detail. This project is currently on hold following the acquisition of BLADE by OVH.

6.2.2.2.3. *Summary sheet – CYME case*

Share Type: Result - Report – Teaching (ReX)
Enterprise: CYME
Following : LCIE Bureau Veritas
Critical review: No
Study Statutes: Finalized
LCA type : Simplified
Services studied: The "PEAKTO" service is a photo visualization, analysis and backup platform for photographers and other photography enthusiasts wishing to have an eco-responsible approach..
Comparative: Yes. No environmental scale.
Perimeter: The LCA study includes:

- User-wide:
  - Consultation terminals
  - Local storage terminals
  - Remote storage terminals (Raspberry type)
- The transmission block (exchange of data on the network)
- Data centers allowing the hosting of the PEAKTO service

FU : The functional unit as studied in this study can be summarized as follows:

« Provide a platform for viewing, analyzing and backing up photos to a set of users according to the baseline two-year usage scenario. »

Difficulties : The PEAKTO digital service was under development. The interest for CYME is to integrate ecodesign principles. The difficulty for the LCIE Bureau Veritas is the lack of primary data.
Advantages of the approach and awareness: The CYME team already had training in responsible digital technology led by Frédéric Bordage. CYME greatly appreciated our ability to quantify environmental impacts and to have set up a whole series of sensitivity analyses to consider a very large number ofcomparisons.
Contribution to the method:
The CYME study:

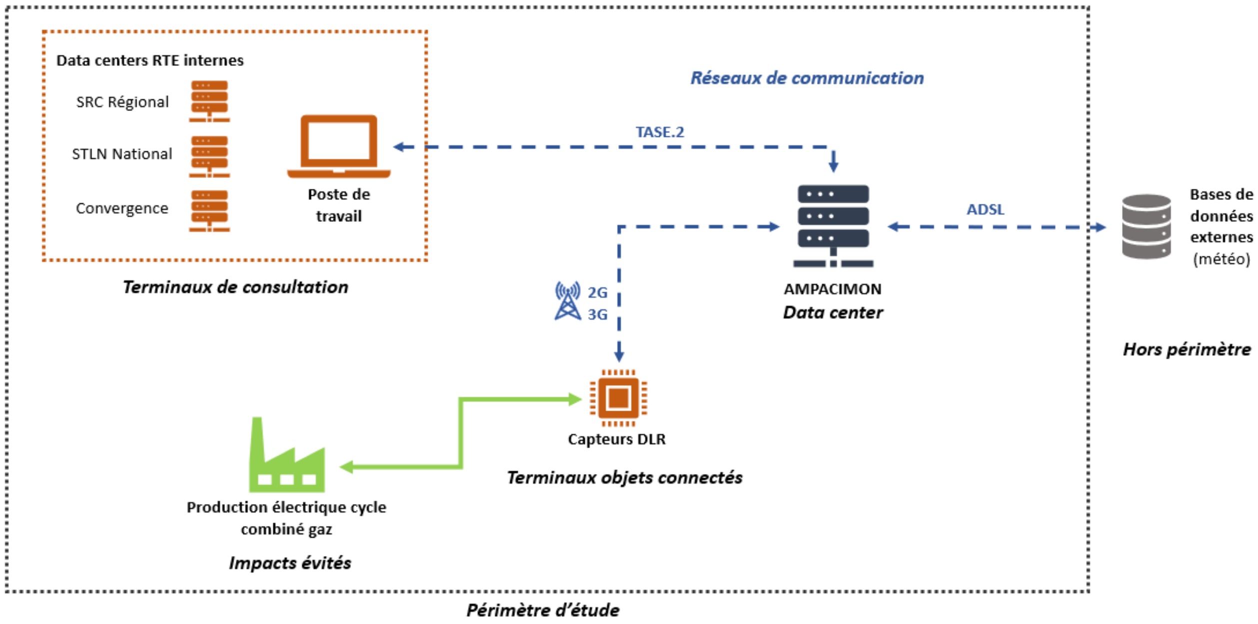
- Build a Raspberry-style local private data center model
- Create new electricity mixes
- Challenge IT equipment allocations with a "data storage in TB" approach
- To bring objectivity in the choice of allowances. These reflections can be considered for the construction of future PCR ADEME. Indeed, aclient like BLADE is familiar with CPU allocations since his job is to sell compute. A customer like CYME is familiar with storage allocations since their job is to sell storage space. Through their business, customers learn their analysis biases.

Improvement lever for the method:
The NégaOctet method probably lacks default scenarios and semi-specific data so that companies that design their digital service can integrate an environmental study well in advance..

Next steps: CYME wishes to integrate the results of the NégaOctet support to display the carbon impact of its users in order to raise their awareness to favor eco-responsible options in the PEAKTO service. CYME has dedicated a person in its organization to continue the NégaOctet project.

6.2.2.2.4. *Summary sheet – Case of RTE*

Enterprise: RTE
Following by : APL DATACENTER
Critical review: Yes by LCIE BUREAU VERITAS
Services studied: DLR monitoring system
Comparative: Yes + Environmental balance
Perimeter:



Functional Unit FU : « Monitor the eligible capacity on the 400kV Tavel-Realtor line for one year. " and "Monitor the eligible capacity on the Prauthoy-Rolampont 63kV line for one year. »
Study Statutes: Finalized
LCA type : Complete
Advantages of the approach and awareness:
RTE has been able to evolve its LCA practices by taking into account the digital aspect.
Difficulties :
Delay in deploying the NégaOctet database. The study went through two iterations.
The customer already had modelling practices on its energy mixes. The most important thing would have been to take into account the customer's energy mixes in the NégaOctet database to ensure consistency. This was not done for technical reasons.
Improvement lever for the method:

- Create NégaOctet models configurable according to the energy mix. Perform a breakdown of impacts by separating the extraction of materials and manufacturing processes. Integrate the avoided impacts related to the recycling of equipment (module D of the ed4 RCP)

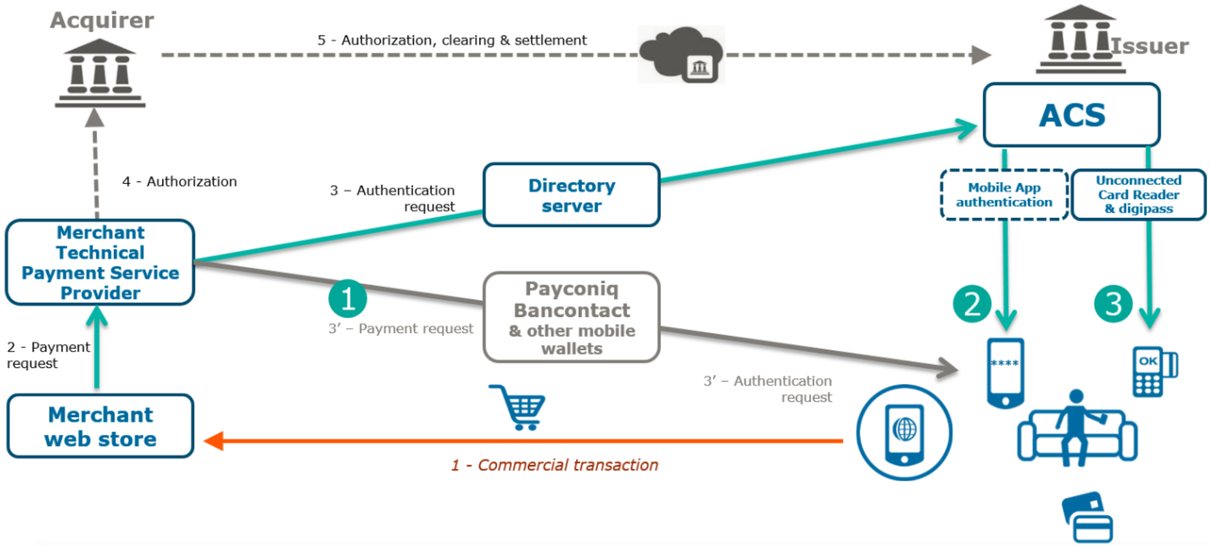
Contribution of critical reviews:
As a NégaOctet pilot project, the RTE DLR service analysis project highlighted the following lessons and reflections for the NégaOctet project.:

- In the case of consultation terminal modelling, the allocation over the duration of use is generally the most chosen allocation. However, an allocation on the amount of data used may be more relevant in the case of consultation terminals shared with other digital services. The application of these two types of allocation should be used in the other NegaOctet pilot projects.

- The RTE project highlighted the value of being able to modify the energy mixes used in the NégaOctet database. This was also noted in another NegaOctet pilot project. A methodological reflection on the use of energy mixes in the NégaOctet database was added to the NégaOctet study report.
- The significant impact of installing DLR sensors could show that, in general, at the lifecycle of a digital service, the system boundaries of non-shared equipment can or should be increased. This reflection must be confirmed with the other NégaOctet drivers for a possible integration into the NégaOctet repository.

6.2.2.2.5. *Summary sheet – Worldline case*

Share Type: Result - Report
Enterprise: WORLDLINE
Following by : DDemain
Critical review: Yes, External
Study Statutes: In progress
LCA type: Simplified
Services studied: Service allowing the payment transaction in store (from the bank card to the payment platform through the terminals) or online (including authentication services)
Comparative: Yes
Perimeter:



Functional Unit: The functional unit:

« Completing a financial transaction»

Contributions:
The study of the payment transaction made it possible to highlight the different contributors to the payment transaction and to estimate its impacts. We were able to identify ecodesign paths on all third parties from the payment terminal to the platforms and study more or less interesting alternatives to distinguish optimums.
The study and use of the NegaOctet database made it possible to put on the same methodological level the impacts associated with the associated product and service.
The number of indicators and in particular the availability of the MIPS indicator are a plus for the restitution of results.
The possibility of standardizing the results makes it possible to highlight the interest of focusing on the depletion of natural resources as a priority.
We plan to do an analysis between LCA before and after using NegaOctet to understand the disparities.

Difficulties :
The service is complex and in connection with different actors. We had primary data for all items associated with the Worldline group. On the other hand, the data associated with the banking players could not be made available.
Data associated with the data center environment is not considered. We only considered the PUE.

Improvement lever for the method:

The study highlights inconsistencies between the different indicators, particularlyend-of-life data. This will need to be clarified.
The issue of allocation, including existing terminals and equipment (what about payment by smartphone) is a key point. A clear methodology use versus possession is to be put forward.

Next steps: Updating the study with NegaOctet data. The realization with the impacts of a fiduciary transaction.

6.2.2.3. Opening

Contribution of Lot 6 beyond the NegaOctet project

Lot 6 and its collective action made it possible to:

- Improve database method and granularity
- Improve the tools and prepare the specifications of a tool for the dissemination of the methodology
- Identify the sources of impacts of different types of digital services
- Identify discrepancies generated by the use of NegaOctet data
- Provide pilot stakeholders with construction expertise
- Anticipating the increase in skills of certain actors

Beyond the pilot phase, the NegaOctet database could be used in other contexts such as:

- The ADEME-ARCEP study on the impact of digital technology in France to be published in March 2022. The consolidation and use of NegaOctet data in this model made it possible to:
  - Compare the results of the study on a France perimer with the results of pre-existing studies, including study GreenIT.fr iNum impact of digital in France
  - Consolidate medium terminal models for consumer terminals, reference servers, etc.
- The implementation of the ADEME RCP as part of the regulatory application of Article 13 of the AGEC law relating to the communication of the carbon footprint of data transmission.

6.2.3. Lot 7 – Capitalization

6.2.3.1. Workflow

Lot 7 – Capitalization					
Responsible	NEUTREO BY APL (Cible entreprise/public)				
Duration	Total duration of the project				
Beginning	Start of the project				
Partners involved	NEUTREO BY APL	LCIE	DDemain	GreenIT.fr	
Related Deliverable(s)	- A web page presenting the action and a flyer - Summary presentation of the action - A closing event open to all - An infographic presenting the repository - An infographic presenting the results of the action - One or more scientific publications				
Content					
Objectives - Make known the NegaOctet repository and the result of the work carried out - Articulate NegaOctet work with other work nationally and internationally - Disseminate feedback and good practices to increase the offer of eco-designed digital services					
Success Criteria					

Recognition of the repository with the three targets targeted by the project:

- Priority 1 - Company target: through the implementation of the repository and its dissemination
- Priority 2 - Scientific target: through the recognition of the reference system
- Priority 3 - Target for the general public: through knowledge of the reference framework and the results it has highlighted

Detailed programme of work

Achievement: Consortium – Advisory Committee

The capitalization and dissemination of the results of the project involves several types of actions.

1 – Recurring or continuous actions – Intervention and follow-up of working group

A good dissemination of the nature and results of the project is essential, for this we must have efficient means of dissemination, including a web page and a brochure presenting the repository.

We presented the NegaOctet project and disseminated the project to instances with ongoing repository creation work, namely:

- ADEME/ARCEP Committee of Experts
- AFNOR Working Group
- Planet tech Care Working Group

2 – One-off actions – Organization of events and participation in one-off events

We participated in the presentation meetings of the winners of the Perfecto project and in the monitoring committees.

The COVID crisis having prevented us from holding face-to-face events, we organized webinars, participated in web conferences (ecodesign conference, AvniR Congress (publication), the LCT Forum (publication) and congresses (France Stratégy, MeetUp SNCF, Meetup GirlzInWeb CNRS, INR, GreenIT Days, Boavizta....) to present the project and its progress.

The capitalization phase is still at its beginning. We will intervene in particular as part of an HPC and frugality symposium with ORAP in December 2022.

3 – Sustainable actions – Participation in books or publications for the general public and scientific

We have written publications and posters that have been presented at conferences.

Given the health context and the time lag of the project, the number of actions had to be reduced. However, we plan to offer different publications once the database is stabilized, namely:

- SETAC
- LCA journal
- EGG – Electric goes green

Topics will focus on the environmental impact of data storage, allocation and multifunctionality issues, methods for assessing the environmental impacts of digital services..

Actors

In order to ensure the dissemination of the contributions of the NegaOctet project, we wanted to involve from the outset a large part of the community of actors in software development and digital services. We have therefore set up an advisory board including: The Green IT Alliance, EcoInfo, the Responsible Digital Design Collective, the GreenIT club, the ecodesign pole, GIMELEC, C3D, CCI France, IGNES, AFNOR*, France Datacenter*
whose role is to:

1. Disseminate the principles of the repository,
2. React on the orientations taken,
3. Propose avenues for reorientation if he foresees points whose treatment is not satisfactory,
4. Propose content if it is able to do so,
5. Provide data if available,
6. Recruit companies for the pilot phases and the testing of the method.

The creation of this committee has allowed a real acceleration of the notoriety of the repository and its application through the pilot cases.
*joined the committee in January 2019

6.2.3.2. Some focus

6.2.3.2.1. *Communication media*

For effective dissemination and increased awareness, media coverage of the project is key. We have therefore carried out the following actions:

- Realization and online of a web page dedicated to the project: https://negaoctet.org/
- Launch of a linkedIn page: https://www.linkedin.com/company/n%C3%A9gaoctet/ (712 subscribers – January 2022)
- Creation of a video presentation of the project: https://www.youtube.com/watch?time_continue=10&v=VPq4FA2eAIs
- Creation of a video presentation of the data collection workshop: https://www.youtube.com/watch?time_continue=10&v=VPq4FA2eAIs

We have planned:

- The provision of an infographic describing the database
- Publication of a white paper on feedback on pilots

6.2.3.2.2. *Participation in expert committees and articulation with environmental labelling work*

The consortium participates in the expert committees responsible for establishing tools and rules for measuring the environmental impact of digital services, namely:

- The ADEME-ARCEP expert committee during which the NegaOctet approach was presented. In addition, during this committee, our team was able to share its expertise, particularly regarding the applicability of existing standards (ITU L1410 in particular) in the field.
- The AFNOR Specification working group during which a presentation was also made and during which our technical complementarity and our knowledge of the market made it possible to highlight the feasibility and relevance of certain choices.
- The Planet Tech Care Working Group
- The ADEME working group to develop the PCR as part of the regulatory application of Article 13 of the AGEC law on the communication of the carbon footprint of data transmission. Belonging to the NegaOctet group was a real asset. Indeed, this work has made it possible to ensure consistency with the French and European display standards and to mobilize the network's actors around the theme of measuring environmental impacts.

It is, among other things, these working groups that have made it possible to anchor the NegaOctet method in reality and to educate the actors.
In addition, the work was presented to the offices of Cédric O, Barbara Pompilli, Jean-Michel Blanquer, the Digital Working Group responsible for the Ministry of Health, the deputies and senators met during our advocacy Climate Law and PPL REEN, members of the Green IT Club, AGIT, INR and Boavizta.

6.2.3.2.3. *Participation in seminars and events*

The work was presented throughout the three years of the project at:

- Research event: LCA forum LCE 2020, EcoSD, LCM, ScorLCA, Avnir, GreenDayx Anglet... in order to present the NegaOCtet approach and to confront it with academic perspectives
- Professionalevent: Morning Inies, Produrable, We love GreenIT... in order to inform future users of the current process and to raise awareness among digital players of the challenges of quantifying the environmental impacts of digital services
- Events initiated by the Café Pilot' consortium

In addition, we were able to contribute to initiatives to benefit from our data and confront them with the reality on the ground outside our consortium. This is what was achieved with the participation in the BioInspired exhibition and the SODECO project.

Figure 36 - Project Dissemination Pathways

The end of 2021 was intended to disseminate the work. To do this, we have carried out:

- Two webinars to present the database on October 15 and 25, 2021
- A presentation at the ORAP seminar on frugality and high performance computing - http://orap.irisa.fr/
- A closing event for Advisory Committee members
- A launch event for the database

6.2.3.2.4. *Training*

The work carried out during the NegaOctet project made it possible to feed two training courses:

- Co-design training of digital services provided by GreenIT.fr: 958 trainees from around 700 different companies
- Digital Services Life Cycle Assessment training provided by DDemain and LCIE: 143 trainees

7. Synthesis

In a context of accelerating awareness of the environmental impacts of digital technology, the NegaOctet consortium has been able to put its complementary skills at the service of:

- Increasing knowledge about the environmental impact of digital services
- Harmonization of environmental impact assessment practices
- The provision of a practical and robust reference system to facilitate an objective and consistent quantification of environmental impacts

Figure 37 - Synthesis

The work carried out as part of the Perfecto project has led to the publication of a reference framework for accounting for the environmental impacts of digital technology with a view to reducing them. The project was structured around four pillars:

Pillar 1 - State of the art

The initiation of a state of the **art** that has been the basis for other projects, such as the ADEME ARCEP study on the environmental impact of digital technology in France. This state of the art has made it possible to have a 360-degree vision of the knowledge associated with the subject of the environmental footprint of digital leading to the following observation: the current vision of the digital footprint is fragmented and is often satisfied with the energy and/or carbon footprint approach. There are very few multi-criteria studies on a complete digital service perimeter. There is a clear evolution in the number of publications between 2018 and 2021 showing the importance of the subject.

In addition, topics specific to LCA of digital services were identified. These topics should feed into future research. These are the question of indirect environmental impacts (too often treated solely from the angle of benefits and efficiency), the question of allocation rules with the distinction between the cost of use and the cost of ownership, the question of average cost and marginal cost that arises when a service uses existing equipment, and the issue of multifunctionality.

Pillar 2 - Methodological rules

Methodological rules (common rules of the game) have been proposed and implemented in practice, particularly in the pilot case studies. In addition to the Perfecto project, these rules have also been formalised by product categories as part of the work on SPCs relating to the implementation of Article 13 of the AGEC Law. Dhaving explicit rules for carrying out LCAs makes it possible to guarantee homogeneity and comparability of the results obtained by all the actors. It is also essential to have homogeneous rules, both at the level of equipment and third parties of the infrastructure and digital services as a whole. Indeed, it ensures the sharing of data at all levels of the chain of responsibility. To this end, we have ensured that the rules proposed in the Perfecto project are, as far as possible, harmonized with BP-X-30 323, PEFCR IT equipment and ITU-L-1410.

Pillar 3 - Life Cycle Inventory Database

The creation of a **database of life cycle inventories** at four levels of depth and having questioned the impact data on semiconductor components:

- Level 0 - Semiconductors
- Level 1 - Digital components: Touch and non-touch screen, SSD, HDD, RAM, processor, motherboard, graphics cards, chassis, fan, DVD player, power supplies
- Level 2 - Generic and specific equipment: Terminal equipment (TV, PC, Smartphone...), network equipment (box, DSLAM, ONT, OLT....),IT datacenter equipment (server, array...), non-IT datacenter equipment (air conditioning, generator...)
- Level 3 - Third tier of infrastructure: Data center by typology/technology and performance level, fixed networks (ADSL, FFTX per line and per GB), mobile networks (3G, 4G, (5G) per line and per GB), cloud services in the datacenter by type (public cloud, private cloud) and location (IAAS (VM, storage), PAAS (BDD) average data)
- Level 4 - Digital Services Tier: Send an email, stream video, download file, cloud data storage, use of a smartwatch, web conferencing, web request

Thus, the realization of the NegaOctet database has made it possible to:

- Have homogeneous multi-criteria data to assess the environmental impact of a digital service
- Conduct data consolidation and development work at all levels of the digital industry:
  - At the component level: by updating the data associated with the production of silicon wafers that are at the heart of semiconductor impacts, by updating data on the production of LCD and OLED screens (based on recent CSR reports from major manufacturers), by performing an analysis on the impact of different storage technologies
  - At the equipment level: by allowing the creation of configurable models according to the technical characteristics (which are also dimensioning from an environmental point of view) namely the CPU, RAM and the storage capacity/technology
  - At the network level: by updating fixed and mobile network data (this aspect was done rigorously by combining the NegaOctet repository and data collected as part of the RCPs for Internet Service Providers)
  - At the data center level, by allowing:
    - The transition from the PUE approach to an approach combining PUE and integration of the impacts associated with the building and equipment of the technical environment
    - The configuration of servers and technical equipment according to technical criteria: CPU, RAM, storage but also load rate
- Carry out evaluations on all PEF criteria and standardize indicators to present the interest of multicriteria
- Evaluate the MIPS indicator

The data will be made available:

- In an ILCD node as a life cycle inventory for LCA practitioners and as emission factors for others. These elements will be private and made available for a fee.

- In the Impact Database® for some of the key uses and made available free of charge.

Pillar 4 - Testing as part of the drivers

In order to ensure the applicability of the method, the consortium was keen to apply the method and the data produced; thus the method has been tested thanks to its application on a dozen pilot projects as well as in two studies external to the initial field of NegaOctet.

This pilot phase made it possible to:

- Improve database method and granularity
- Improve the tools and prepare the specifications of a tool for the dissemination of the methodology
- Identify the sources of impacts of different types of digital services
- Identify discrepancies generated by the use of NegaOctet data
- Provide pilot stakeholders with construction expertise
- Anticipating the increase in skills of certain actors

The development of the NegaOctet project has been able to be part of a fertile ground for its development since the project has had a strong media relay and has aroused the interest of a large number of actors, thus generating synergies with ambitious diagnostic projects: the ADEME-ARCEP study is a very good example.

8. Openness and perspectives

8.1. Provision of data

8.1.1. Mode of provision

In addition to the free availability of some key data in Base Impacts®, the NegaOctet database will be made available as an annual license in 2022. This rapid diffusion corresponds to a strong market demand. It appears strategic since it is a unique database of its kind that seems while many actors wish to embark on the management of the environmental performance of their service and that the regulations push for this.

In order to meet the demand of as many people as possible, it will be made available in two formats:

- Excel format, very adapted to the needs of developers of digital services who do not currently have an environmental background and for whom it will be necessary to combine elements of its scope but also from its supplier. This format is particularly suitable for the implementation of an eco-design approach for digital services.

- ILCD Node format for LCA practitioners, allowing them to integrate the digital dimension into their LCAs regardless of the sector of activity. This format is particularly suitable for integrating the digital dimension in the development of ecodesign projects for connected products or in the case of technology integration into LCAs for other sectors (agriculture, textiles, etc.).

8.1.2. Database governance

If the database was built through the APL, DDemain, GreenIT.fr, LCIE consortium, it seems crucial to us that it can evolve outside of the latter. Thus, we propose to create an association that will be in charge of carrying the database, ensuring its maintenance and renewal.

8.1.3. Recommendation on update frequency

Given the rapid evolution of the sector, both in terms of hardware and service architectures, it is necessary to consider a follow-up to this project, which will:

-Allow the update and maintenance of the database

-Allow the enrichment of the data

-Allow the expansion of the consortium of actors in charge of its governance

We recommend updating the database at least every three years.

8.1.4. Topics for further study

At the equipment level, the topics to be explored are as follows:

- The variability of the service life of storage equipment. Indeed, data archiving is a key topic in digital. It touches on resilience and information security.

- The variability of RAM impacts depending on the technology. Indeed, this work has not been done and could have an impact.

8.2. Transfer of competence

8.2.1. Formation

Since the beginning of the NegaOctet project, we have sensitized more than 900 people to the challenges of life cycle assessment in the digital sector and trained more than 170 people in its practice. We have consistently come up against the issue of data.

Thus, the provision of the database as well as the creation of a training offer dedicated to the NegaOctet repository will allow the dissemination of LCA practices of digital services on a larger scale.

8.2.2. Tools

To date, the data will be made available to everyone in two formats:

- A .xls format, in which data will be disseminated as an impact factor

- An ILCD node format, usable in all compatible life cycle assessment software

No less than 1500 data and twenty calculators will be made available. But to continue the dissemination effectively, it appears that the creation of preformatted tools is a must. To date, specifications have been drawn up to this effect.

8.3. Methodological point to be explored in the context of research projects

8.3.1. Impact Assignment

8.3.1.1. Impact of everyday product connectivity – Cost of ownership vs. cost of use

Digital services are often used as a substitute for traditional services. Their impact profiles are different, with specific causes and consequences. Among these differences, there is a transfer of impacts from the production, distribution, installation and end-of-life phases to the use phase. Indeed, digital services use electricity and data-consuming equipment that generates environmental impacts. This produces a modification of part of the causes of impact, from a cost of ownership (the impacts are conditioned to the acquisition of the product) to a cost of use (the impacts are conditioned to the use of the product). If this modification is to be put into perspective (a significant part, or even majority, of the impacts, remains associated with the manufacture of terminals), the use also determines the sizing of network infrastructures (cumulatively for all consumption) and servers (in a targeted manner on the digital service concerned). This vision amounts to considering the consumption and use of data (network and servers) as a resource generating impacts, in the same way as electricity consumption. Resource whose use should be limited in an ecodesign approach.

In order to better take into account the impact of connectivity (IoT, home automation, etc.), it will be necessary to put in place rules that would make it possible to better integrate the SMART aspect into environmental declarations for products or buildings, for example.

8.3.1.2. Average Environmental Cost and Marginal Environmental Cost – Better Integrating New Uses

Digital services are generally interconnected through the use of shared equipment. This equipment is sometimes present independently of the service studied. For example, an email service uses terminal equipment (computers, tablets, smartphones) but is not directly the cause of their production. This equipment would be acquired and produced anyway.

Two visions are thus possible:

- Calculation of the average cost: it corresponds to the classic calculation carried out in LCA: the impacts related to the production of equipment already used are allocated to the service in relation to an allocation key that depends on each situation.
- Calculation of marginal cost: it corresponds to the cost related to the increase in environmental impacts following the implementation of the service compared to the previous situation. It excludes the production of equipment already in use.

Note that in the context of the marginal cost calculation, equipment may have some of the impacts associated with the service (electricity consumption in active mode), and others not (manufacturing, electricity consumption in standby mode, etc.).

This raises the question of the responsibility of stakeholders in relation to the impacts of shared equipment and the levers of action that can be envisaged as part of an ecodesign approach:

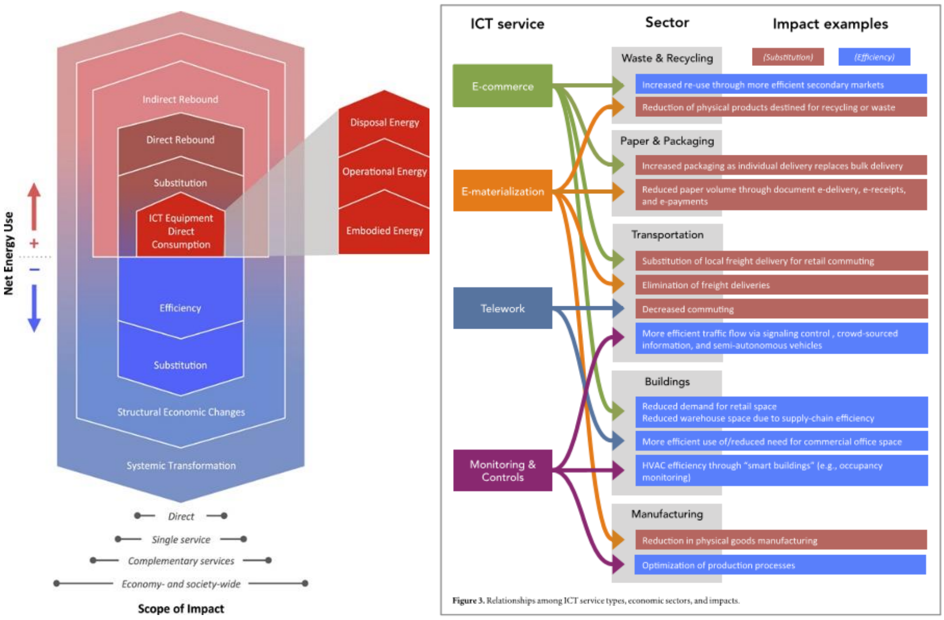
- If the infrastructure is not installed prior to the service, or if it is dedicated entirely to the service over a period of time, the marginal cost and the average cost are confused. Reducing impacts means limiting the need for new equipment, and may lead to the search for pooling of functions on existing equipment, for example by promoting a remote display on a smartphone rather than a dedicated display.
- If the infrastructure is installed and not fully dedicated to the service over a period of time, the practitioner should determine whether to choose a marginal or average cost approach. Ideally, it can calculate impacts according to both approaches to have complementary reading prisms. Reducing impacts involves optimizing the service so that it limits the use of bandwidth, compute and/or storage resources on the equipment used in order to reduce energy consumption and limit equipment obsolescence and thus its replacement.

If this problem is not dealt with directly in the pilots, it has come up systematically in the interpretation phases. This is a key opening point in the context of the realization of LCA of digital services in the long term and the opening towards the consequent LCA.

8.3.2. Taking indirect effects into account – Implementation of a consequential life cycle assessment method dedicated to digital services

As digital technology acts as a facilitator in relation to all sectors, taking into account both positive and negative indirect effects is essential. Indeed, if we consider digital technology today as an unquestioned opportunity for the ecological transition, the reality is quite different. The digital sector is the first to be affected by the Jewons paradox: as an exception, more digital = more paper, more digital = more transport...

Thus, if the indirect effects associated with efficiency are well treated, the rebound effects are little studied, yet they are of several types (see figure below) and occur very often in the sector that interests us.



Nathaniel C Horner et al 2016 Environ. Res. Lett. 11 103001

Figure 38 - Categorization of indirect effects

The order of magnitude of these indirect effects is currently little known, but some studies consider it superior to direct effects. By way of illustration, ADEME's "Study on the characterization of the rebound effects induced by telework" shows that rebound effects and the way to manage the implementation of physical and digital services around telework can vary the impacts strongly to the point of making telework beneficial, or on the contrary worsening environmental impacts.

However, these impacts are difficult to quantify in a timely manner and resources that are affordable for most LCA practitioners, and require the intervention of experts from various fields (economists, sociologists, behaviorists, etc.). . In addition, they generate a high degree of uncertainty due to their predictive nature, in an area such as digital services subject to strong developments and technological leaps. However, it is possible to identify and categorize them. For this, different classifications are possible. The study "Known unknowns: indirect energy effects of information and communication technology" is to date the most advanced study on the classification of indirect impacts of digital services. If it focuses on an energy approach, its methodology is applicable for the realization of LCA.

More broadly, the consideration of the systemic impacts of digital technology could be better achieved through the implementation of consequential LCA. A specific methodology could be proposed.

8.3.3. Multiple uses of a digital service

Like any good covered by an LCA, digital services can cover several functions, or several usage scenarios relating to a common function. However, the multiplicity of actors working around the same digital service leads to a wide variety of potential uses compared to a conventional good.

Understanding these different actual uses and functions is essential in order to determine the environmental impacts of these services in a relevant way. Moreover, identifying the actors involved in these uses makes it possible to identify the levers of action to reduce impacts more precisely.

Two elements must be differentiated:

- Different use: the same digital service fulfills a function via several different usage scenarios. Example: A video-on-demand service can be used via a computer, tablet, smartphone, wired or mobile network, and on different server architectures.

- Different function: The same digital service can perform several functions. Example: a social network may have for its users a function of exchanging information in text, photo or video format, and for its manager a function of collecting data and maximizing advertising revenue.

These elements are not specific to digital services, but the explosion of uses, many of which are very specific (e.g. LCA of reading the newspaper on the smartphone with the wifi of the train), as well as sometimes the impossibility of separating functions through allocation rules, leads to an increased importance of taking this aspect into account.

8.4. Environmental Labelling Project

All the work carried out as part of the Perfecto NégaOctet project was carried out with a view to compatibility with national and international environmental labelling standards. This should facilitate the implementation of environmental labelling.

In addition, the first step towards such a display has already been carried out following the Perfecto NégaOctet project via the drafting of documents:

- General principles for the environmental labelling of consumer products - Methodological framework for the environmental assessment of digital services
- General principles for the environmental labelling of consumer products - Methodological reference for the environmental assessment of Internet Access Provision (ISP)

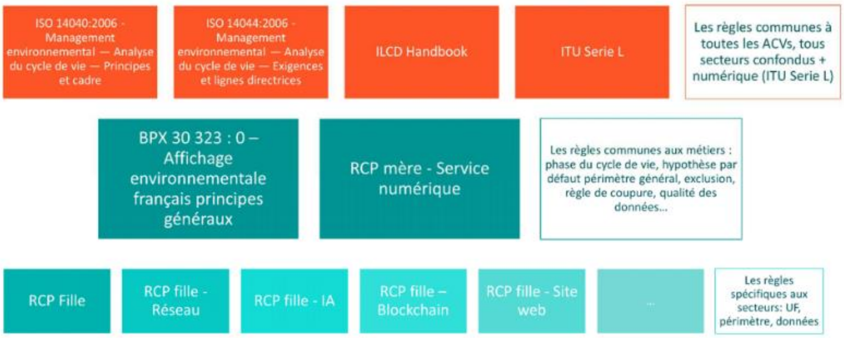


Figure 39 - Preparation of an environmental label - Articulation with the existing

Based on this model, two other product categories will be addressed, namely enterprise networks and cloud and data center.

In order to switch to an environmental label, it will then be a question of obtaining a large sample of actors by categories of services in order to establish scales of conversion of environmental impacts into environmental note A, B, C, D or E.

Projet Timeline

The duration of the project initially proposed was 24 months. **However, in view of the delays in data collection and the contractualization challenges for the pilot phase as well as the COVID crisis, the project has been extended to 32 months**.

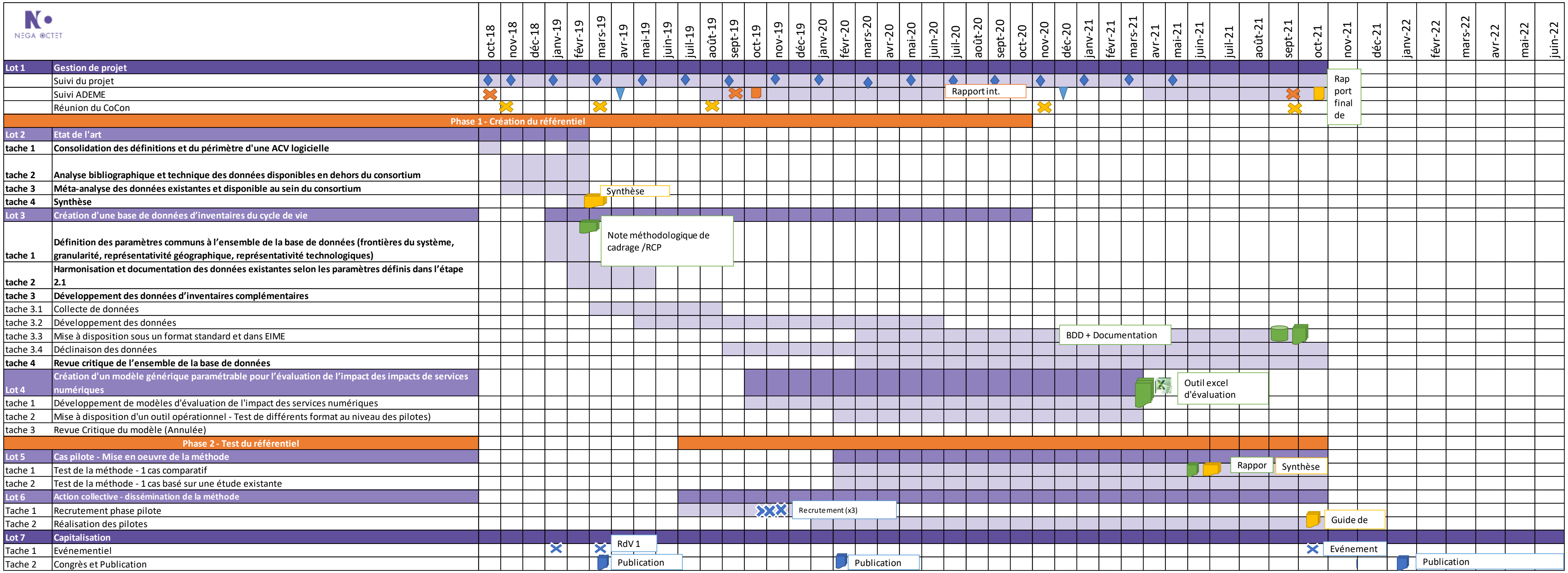


Figure 2 – Planning of the action

Legend

- Réunion du CoPil
- Réunion du CoCon
- Point d'avancement ADEME
- Rapport intermédiaire ADEME
- Rapport final ADEME + Synthèse
- Livrables privés
- Livrables public
- Evènement public
- Outil Mis à jour

INDEX OF TABLES AND FIGURES

Glossary

- **Life Cycle Assessment (LCA) complete :** LCA that takes into account all aspects of the system. The precise scope of study and the boundaries of the system vary from one LCA to another.
- **Life Cycle Assessment (LCA) hybrid:** method that combines the LCA approach based on the economic analysis of input-output with the specificities of the process-based LCA approach.
- **Life Cycle Assessment (LCA) screening**[11] : there is no official definition of this term, but many studies agree that it is a so-called comprehensive LCA that does not aim to quantify environmental impacts but to identify areas of the system and/or key aspects of the life cycle that contribute significantly to the impact and should not be overlooked in a comprehensive LCA study. LCA screening can be based on emission factors from the literature without consideration of homogeneity and life cycle inventory database.
- **Life Cycle Assessment (LCA) simplified**[11] : there is no formal definition of this term, but it is generally a non-complete LCA, i.e. narrower in scope, including fewer processes and/or fewer impact categories. We can find in English the terms "simplified" or "streamlined" to qualify this type of LCA.
- **LCA-A, Attributional (or attribute analysis)**[12] : LCA whose system under study is composed of elementary processes linked by flows from the technosphere directly attributable to the system. The system is considered established (steady-state). The consequences induced by the alternatives compared do not massively call into question the chains of suppliers.
- **LCA-C, consequential (or analysis by consequences)**[12]: LCA whose system under study is composed of elementary processes linked by economic flows but also processes indirectly affected by the implementation of the life cycle of the product studied or by its change.
- **Method** (environmental assessment)[13]: A set of rules and calculation steps leading to the assessment of the environmental impact of a system, the purpose of which is to measure and analyse environmental effects in order to prevent harmful effects on the environment.
- **Life Cycle Assessment (LCA) method**[14] : Compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system over its life cycle.
- **PCR - Product Category Rule :** A set of specific rules, requirements and guidelines for the preparation of Type III environmental declarations and carbon footprint communications for one or more product categories.
- **Repository**: A structured set of recommendations, prescriptive or non-normative, and good practices used for the implementation of a method in a particular context, product category, or objective.
- **ICT - Information and Communication Technologies**[15] : A set of technological tools and resources for transmitting, recording, creating, sharing or exchanging information, including computers (laptop or desktop, terminals, etc.), the Internet (websites, software, blogs and e-mail), technologies (data centers, servers, etc.) and live (radio, television and Internet broadcasting) and deferred (podcast, audio and video players and recording media) and broadcast equipment, and Telephony (fixed or mobile, satellite, videoconferencing, etc.)
- **Digital Service**[16] : A digital service is an association of:
  - Equipment for storing, manipulating, displaying bytes (servers, user terminals, ADSL boxes, etc.);
  - Infrastructure that hosts and connects equipment (operator networks and data centers in particular);
  - Multiple software stacked on top of each other, running on top of the equipment;
  - Other third-party digital services that may be.

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11 Gradin, K.T., Björklund, A. (2021*). The common understanding of simplification approaches in published LCA studies—a review and mapping.* Int J Life Cycle Assess 26, 50–63. https://doi.org/10.1007/s11367-020-01843-4

12 European Commission Joint Research Center (JRC), ILCD handbook – The International Reference Life Cycle Data System, 2012.

13 ADEME. (2020, 07 Octobre). *L'évaluation environnementale dans l'industrie et les services. Outils et méthodes.*

14 International Organization for Standardization (ISO). (2006). *ISO 14040:2006(fr) - Management environnemental — Analyse du cycle de vie — Principes et cadre.*

15 UNESCO. (n.d). *Technologies de l'information et de la communication (TIC).*

16 Western Australian Government. (n.d). *Digital services definition and examples*.

It meets a specific need, one or more features and users [158].

ACRONYMS

LCA	Life Cycle Assessment
ADEME	Agence de l'Environnement et de la Maîtrise de l'Énergie
AFPIA	Association pour la Formation Professionnelle dans les Industries de l'Ameublement
Arcep	Autorité de Régulation des Communications Électroniques et des Postes
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ATTM	Access, Terminals, Transmission and Multiplexing
CCDC	Cloud Computing and Data Center
CHU	Centre Hospitalier Universitaire
CHRU	Centre Hospitalier Régional et Universitaire
COMUE	Communauté d'Universités et Établissements
CUE	Carbon Usage Effectiveness
DC	Data Center
DCMM	Data Center Maturity Model
DDV	Durée De Vie
DEEE	Déchets d'Équipements Électriques et Électroniques
DMS	Desktop Managed Services
EN	Normes du comité Européen de Normalisation
EPEAT	Electronic Product Environmental Assessment Tool
ErP	Energy related Products
ETSI	Energy Related Product
EuP	Energy using Product
EPIC	Établissement Public à caractère Industriel et Commercial
ES	ETSI Standard
ETI	Entreprise de Taille Intermédiaire
FAI	Fournisseur d'Accès à Internet
GES	Gaz à Effet de Serre
GeSI	Global enabling Sustainability Initiative
GHG	GreenHouse Gas
HDD	Hard Disk Drive
HPC	High Performance Computing
HW	Hardware
ICT	Information and Communication Technology
IE	Ingénierie Environnementale
IEC	International Electrotechnical Commission
ILCD	International Reference Life Cycle Data system
iNEMI	International Electronics Manufacturing Initiative
IoT	Internet of Things
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
KPI	Key Performance Indicator
LCA	Life Cycle Analysis

MFA	Material Flow Analysis
PCR	Product Category Rule
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rule
PME	Petite et Moyenne Entreprise
PRG	Pouvoir Réchauffant Global
PUE	Power Usage Effectiveness
REACH	Registration, Evaluation, Autorisation and Restriction of Chemicals
REF	Renewable Energy Factor
RoHs	Restriction of Hazardous substances in electrical and electronic equipment
RSE	Responsabilité Sociétale des Entreprises
SDIS	Service Départemental d'Incendie et de Secours
SSD	Solid State Drive
SW	Software
TIA	Telecommunications Industry Association
TIC	Technologie de l'Information et de la Communication
TNS	Telecommunications Network Services
TS	Technical Specification

L'ADEME EN BREF

À l'ADEME - l'Agence de la transition écologique - nous sommes résolument engagés dans la lutte contre le réchauffement climatique et la dégradation des ressources.

Sur tous les fronts, nous mobilisons les citoyens, les acteurs économiques et les territoires, leur donnons les moyens de progresser vers une société économe en ressources, plus sobre en carbone, plus juste et harmonieuse.

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CLÉS POUR AGIR
L'ADEME facilitateur : Elle élabore des guides pratiques pour aider les acteurs à mettre en œuvre leurs projets de façon méthodique et/ou en conformité avec la réglementation.

ILS L'ONT FAIT
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EXPERTISES
L'ADEME expert : Elle rend compte des résultats de recherches, études et réalisations collectives menées sous son regard.

HORIZONS
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EXPERTISES

PERFECTO 2018 NEGAOCTET : DEVELOPMENT AND TESTING AN EVALUATION FRAMEWORK OF THE ENVIRONMENTAL PERFORMANCE OF DIGITAL SERVICES TO THEIR ECO-DESIGN

NégaOctet is a repository research and development project, funded by ADEME as part of the call for Perfecto 2018 projects, and jointly carried out by APL Datacenter, DDemain, GreenIT.fr et LCIE.
The project was structured around the following four pillars:

1. State of the art
2. Proposal for methodological rules
3. Creating a Life Cycle Inventory Database
4. Testing with pilot case studies

It has been the subject of numerous valuations, and allowed direct contributions to the implementation of the AGEC law (Article 13) or to the ADEME-ARCEP study on the impact of digital technology in France.

NégaOctet, the first framework for assessing the environmental impacts of digital services according to a life cycle approach

3 years of development

Tested and validated on 12 case studies of public and private actors