



The holistic metric
guiding environmental
action

NET ENVIRONMENTAL CONTRIBUTION 1.0 ALL FRAMEWORKS

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NET ENVIRONMENTAL CONTRIBUTION 1.0 HANDBOOK

KEYWORDS

Asset management, comprehensive evaluation of the environmental impact of economic activities, contribution to the environmental transition, Net Environmental Contribution, NEC, climate, energy, water, biodiversity, land, resource, waste, air quality, natural capital, eco-obstruction, eco-solution, alignment with climate change attenuation objectives, 2°C pathway, environmental footprint, environmental metrics, E score, Greenhouse Gases (GHG), plastics, open-source, value chain, utility, Life Cycle Assessment (LCA), investment strategy, bonds, listed equities, private equity, infrastructure and project finance, issuer, market value, article 173 of the French Law on Energy Transition for Green Growth, Energy and Ecological Transition for the Climate / Greenfin certification, brown assets, stranded assets, green share, Task force on Climate-related Financial Disclosures (TCFD), EU Action Plan for Sustainable Finance, Sycomore Eco Solutions, Sustainable Development Goals (SDGs), transition risk and opportunity.

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1. Why the NEC?

1.1. The environmental challenge

Natural capital is the very foundation of everything on earth. There can be no prosperous human activity without maintaining the stability of the ecosystems that keep mankind alive today. The services carried out by these ecosystems, noted by the Millennium Ecosystem Assessment in 2005, span pollination by bees through the water cycle, through to climate regulation.

The environmental degradation caused by human activities has become one of the biggest challenges that mankind must face in the 21st century. Extreme weather events are intensifying and estimates around global warming suggest we should expect a rise in temperature of between 3°C and 6°C by 2100. This would

cause sea levels to rise by 2 meters and create hundreds of millions of climate-related refugees. But it goes way beyond just global warming. The Global Footprint Network and the World Wide Fund for Nature (WWF) have shown that each year since the 1970s we have been using more natural capital than the planet can regenerate, and producing more pollution than the biosphere can absorb. According to the World Health Organization (WHO), 23% of global mortality is attributable to unhealthy environments – this represents 12.6 million deaths every year.

1.2. The regulatory landscape

In 2015, the United Nations adopted 17 Sustainable Development Goals (SDGs). These goals are gradually becoming recognized as a global framework for the public and private sector to measure the attempts made to improve the lives and prospects of everyone, everywhere. Nine of these goals cover environmental issues:

- Goal 6: Ensure availability and sustainable management of water and sanitation for all
- Goal 13: Take urgent action to combat climate change and its impacts
- Goals 2, 14 and 15 relate to ecosystems and the sustainable food supply that they can produce
- Goals 7, 9, 10 and 11 cover industrial and urban energy consumption, production, and systems

Article 173 of the French Energy Transition Law for Green Growth¹, passed in 2015, marked a turning point in climate-related disclosure requirements for issuers, asset managers and institutional investors. Since 2016, these entities have had to publish information not only on the integration of environmental, social and governance (ESG) criteria into their investment policy, but also on their own corporate strategy, their contribution to the energy and environmental transition, and their response to climate change.

At the same time, the French government launched the Greenfin² certification. This is designed to identify investment funds contributing to the energy and ecological transition, based on a green taxonomy of eco-activities. It demands the strict exclusion of fossil fuels and nuclear energy, with partial exclusions for companies operating in the value chain of these activities. Additionally, it requires companies to measure the actual contribution their investments make to the environmental transition. For instance, to report their impact on at least one of the following four areas: climate change, water, natural resources, biodiversity.

In June 2017, the Task force on Climate-related Financial Disclosures (TCFD), responding to a request from the G20 and Central Bank governors to the Financial Stability Board (FSB), drew up a set of reporting recommendations.³ The TCFD did this with a view to developing disclosure on climate-related risks and opportunities that investors could use when making investment decisions. The TCFD developed four widely-adopted recommendations that were structured around four thematic areas representing core elements of how organizations operate: governance, strategy, risk management, and metrics and targets.

In 2018, further to the European Commission's Action Plan on Sustainable Finance, a package of legislative proposals was issued in May. The proposed regulation sets out six environmental objectives:

- Climate change mitigation

¹ Voted on August 17th, 2015 with implementing enactment n°2015-1850 setting out measures for the enforcement of article 173 published on December 29th, 2015.

² Initially named Energy and Ecological Transition for the Climate Label, EET4C, cf. website of the French Ministry for Ecology and Inclusive Transition: <https://www.ecologique-solidaire.gouv.fr/label-greenfin> and https://www.ecologique-solidaire.gouv.fr/sites/default/files/Label_TEEC_Criteria%20Guidelines.pdf

³ See <https://www.fsb-tcfid.org/publications/final-recommendations-report/>

- Climate change adaptation
- Sustainable use and protection of water and marine resources
- Transition to a circular economy, waste prevention and recycling
- Pollution prevention and control
- Protection of healthy ecosystems

This new European Union (EU) regulatory framework is a clear step forward for a comprehensive approach towards environmental management that is not only focusing on carbon.⁴

1.3. The need for improved metrics

Like any industry, the financial sector is being impacted by the ecological challenges facing the world, and it is trying to better understand the resulting risks and opportunities. As the saying goes, you can only manage what you measure. As investors try to address the energy and environmental transition, the use of environmental ratings and carbon footprinting have become popular in the industry. Even so, attempts by the industry to both measure and report on the environmental challenges have proven inadequate at identifying the underlying risks and opportunities.

Environmental ratings are usually structured on a three-pillar basis:

- Policies and commitment
- Implementation of programs, systems and mechanisms
- Results, such as performance and controversies

While environmental ratings may help investors to understand how a company deals with environmental issues in its own operations, their ability to measure to what extent a business model is aligned with the energy and environmental transition, or is compatible with the natural environment resilience, is questionable. Various studies⁵ have demonstrated that environmental ratings are biased either by a company's CSR reporting activities, its geographic location, or the industry in which it operates. This means they fail to provide an accurate view of risks, and they do not distinguish between different business models within an industry.

Measuring the carbon intensity or carbon footprint of companies usually consists of computing the tons of carbon dioxide equivalent (CO₂e) emitted annually by the company and dividing it by the company sales, market capitalization or enterprise value. Using this method, the carbon footprint can change every day with stock price fluctuation, and it is dependent on carbon data scope. Due to scope limitations, this method generally misses up to 97% of car manufacturers' GHG emissions (occurring upstream and downstream of their activity, as illustrated in Figure 3), and overlooks the avoided emissions provided by insulation, renovation, recycling or technological shift. Furthermore, by using the carbon footprint as a proxy for environmental impact, one ignores the environmental impacts on biodiversity, water pollution, air pollution or natural resources depletion. Due to this narrow scope, it favors low carbon solutions like nuclear electricity, diesel-fueled vehicles or plastic packaging, and ignores their impacts on waste generation, biodiversity and air quality. As such, the carbon footprint fails to provide the relevant information needed both for risk assessment or investment decision-making, as well as for impact reporting.

⁴ For an activity to be environmentally-sustainable, it must contribute substantially to one or more of these objectives, not significantly harm any of them, and comply with minimum safeguards and technical screening criteria, which will be set out in a Delegated Act; see for example <https://home.kpmg.com/ie/en/home/insights/2018/06/fs-regulatory-insights-june-2018-eu-strategy-on-sustainable-finance.html>

⁵ *Ratings that Don't Rate: The Subjective World of ESG Ratings Agencies, ACCF, July 2018* http://accfcorp.gov.org/wp-content/uploads/2018/07/ACCF_RatingsESGReport.pdf

The NEC methodology enables finance professionals to avoid the following three limitations coming from the use of existing metrics, such as carbon footprinting:

- Narrow scope - focusing on one issue at the exclusion of others
- Incorrect scope - misjudging the scope and excluding relevant parts of the value chain
- Incorrect conclusions - confusing economics with physical data (as illustrated below)

1.4. Avoiding a mono-issue approach

A carbon-only approach will position nuclear power generation as the best power generation solution, or will prefer a diesel engine to a gasoline one, as it emits 15% less CO₂ per km. The multi-issue NEC methodology enables users to consider additional impacts, such effects on air quality of diesel engines, or the effects of radioactive waste and the threat to biodiversity embedded in nuclear power.

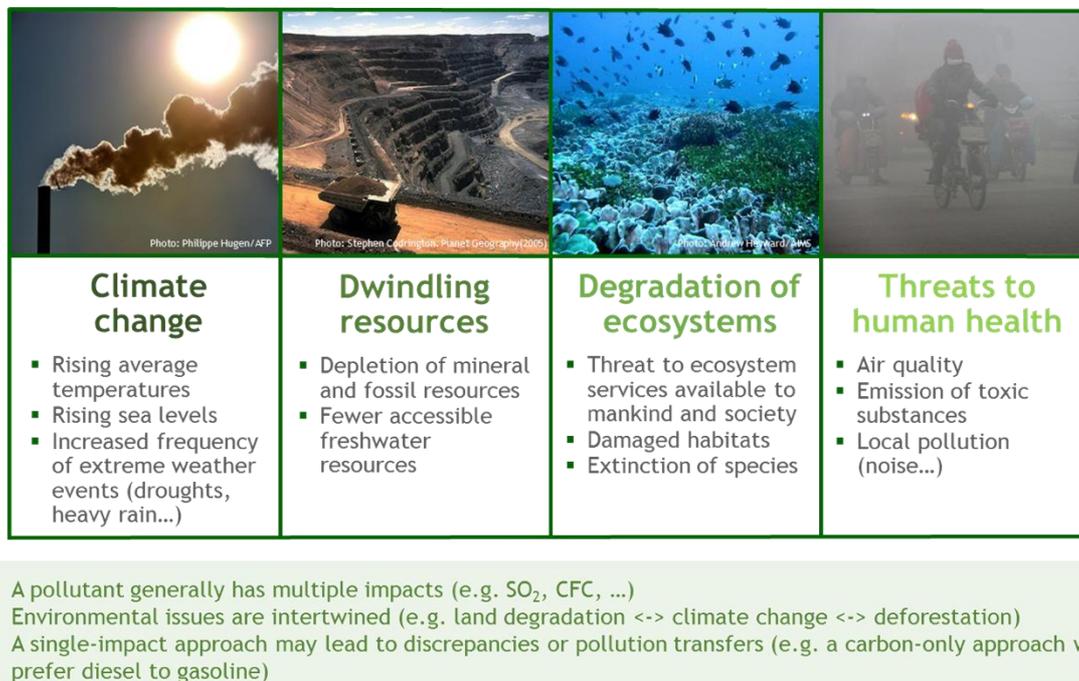
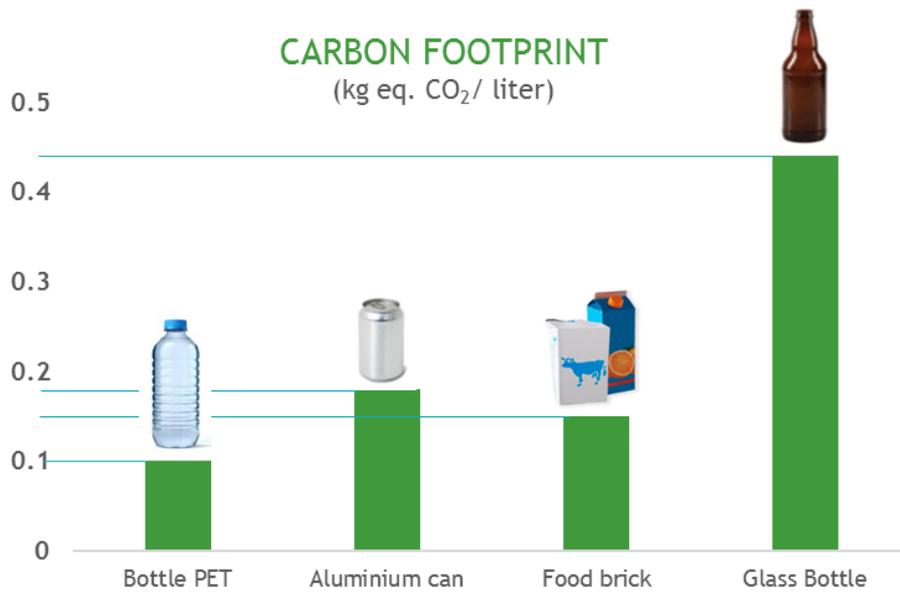


Figure 1: the multiple damage-oriented categories of Life Cycle Assessment, LCA, 2018.

In the case of plastic packaging, a life cycle assessment limited to quantifying greenhouse gases (GHG) emissions would present Polyethylene Terephthalate (PET) bottles as the greenest solution compared to other packaging options, ignoring the consequences of plastic leakage as illustrated in the figure below.

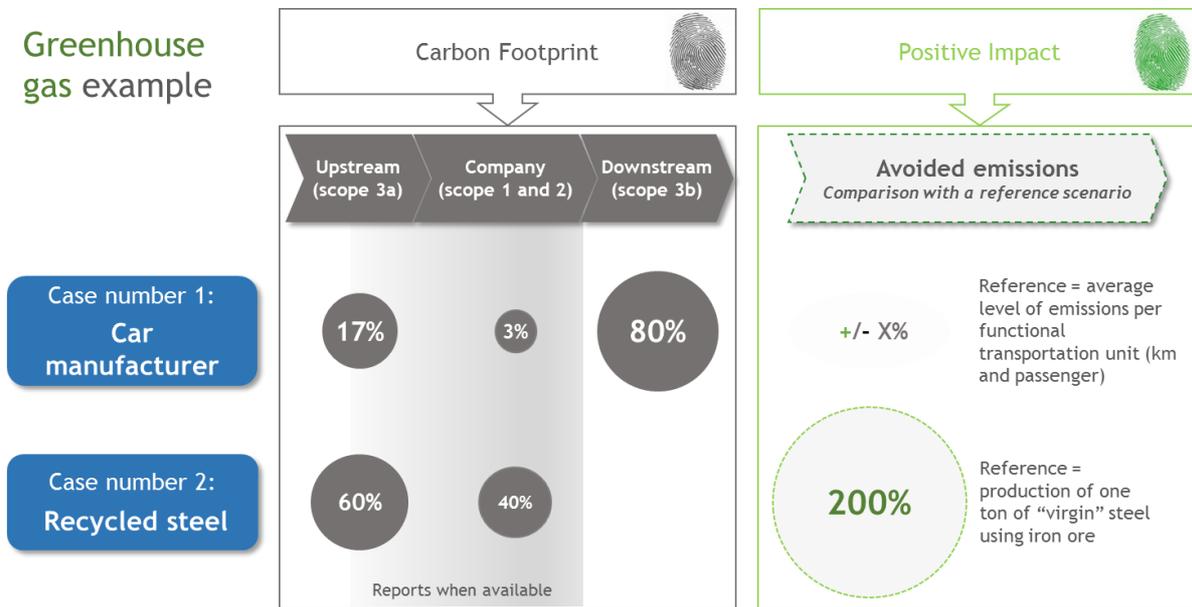


Source: carbon footprint of packaging according to the Ecoinvent greenhouse gas emissions factor and the ADEME FOODGES database, Quantis calculations, 2018.

Figure 2: carbon footprint of packaging in beverages, 2018.

1.5. Focusing on the relevant scope

Greenhouse gas example



- Available data on GHG emissions do not often include the biggest impacts
- Carbon footprinting tells nothing about adaptation to climate change
- The carbon footprint does not help defining a decarbonisation strategy nor does it help contributing to the green transition or the 2 °C target

Sources: Carbon Disclosure Project, French Carbon Base and I Care & Consult's analysis.

Figure 3: two case studies of available carbon footprint versus total carbon impacts, 2018.

Both cases above show that focusing on scopes 1 & 2 often represents a marginal share of total carbon emissions. An increased scope that incorporates both upstream and downstream scope 3 emissions is

required. It also overlooks avoided emissions, sometimes referred to as “scope 4”, or other environmental benefits that can be provided by the activity.

1.6. Appropriately mixing economics and physics

The final limit of carbon footprinting comes from the use of a denominator, such as market value or annual sales. In the case study presented below, the numerator has been properly assessed and includes downstream scope 3 emissions, the main carbon impact of cars, which represent 80% of total lifetime emissions. The use of the financial denominator, which favors expensive, high value cars, provides misleading results as highlighted by the red cells in Figure 4.

Figure 4: comparison between 3 carbon emissions metrics over scope 3 downstream, 2018.

When comparing car manufacturers’ GHG emissions, **which indicator should be looked at ?**

| Manufacturer |  |  | Observations |
|--|---|--|--|
| Model (both gasoline) | Smart FORFOUR 2 | Land Cruiser Serie 150 | the smallest is... |
| Consumption in l/100km | 4.3 | 11.0 | the most frugal is... |
| Emissions in g CO ₂ /km | 97 | 248 | the least emitting is... |
| Tare weight in kg | 975 | 2 100 | the lightest is... |
| Sale price in € excl. tax | 10 000 | 50 000 | the cheapest is... |
| Emissions in teq.CO ₂ /€M of annual sales | 2 910 | 1 488 | Carbon intensity depends on selling price ... |
| Emissions in teq.CO ₂ /year/€M invested | 5 820 | 1 984 | Carbon footprint depends on stock price ... |
| Emissions in g eq.CO ₂ /km/passenger | 69 | 177 | GHG impact per functional unit |

NB : Calculations by Sycomore AM on the following simplified hypothesis: 1.4 passenger per car on average in Europe (data from I Care & Consult), 20,000 km per year, 15 years’ life span, 1 million vehicles sold per year by each manufacturer, enterprise value = market capitalisation = 5xEBITDA (no net debt, no provision), EBITDA margin = 15% for BIG and 10% for SMALL, real-life emissions = normalised emissions according to car manufacturers’ data, 2016.

As a result, the carbon footprint and the carbon intensity cannot be used to support an efficient decarbonation strategy, nor be used for accurate climate impact reporting.

2. Introduction

2.1. The NEC genesis

In this context, Sycomore AM started to work in 2015 on a new, disruptive metric to overcome the limits of currently available methodologies. Sycomore AM wanted to capture the main impacts that companies have across various environmental categories and identify investment opportunities in areas that are aligned with current and future trends of the environmental transition. This metric is designed to identify the business models that are damaging natural capital in such a way that they could end up obsolete or seriously challenged. On the other hand, it identifies companies that develop eco-solutions, and helps to fully capture growth from transition opportunities. Thus, the prototype version of the metric was tested on the Sycomore Eco Solutions listed equity fund, the first fund to receive the French Greenfin Label⁶ in May 2016.

Sycomore AM decided to leverage the experience it gained through the development of its Sycomore Eco Solutions fund by creating the Net Environmental Contribution (NEC) metric, and by applying it to all of its assets under management. The NEC was developed with the support of I Care & Consult, a consulting and innovation company dedicated to the environmental transition, and Quantis, a provider of environmental sustainability solutions. In 2017, BNP Paribas Securities Services joined forces with Sycomore AM to accelerate the NEC implementation and testing phases in its beta version.⁷

In 2018, Sycomore AM and its partners improved the methodology integrating the main learnings of the 2017 full-scale deployment over more than 1,100 companies. This led to version 1.0 of the NEC metric being applied in 2019 to more than 2,000 issuers by Sycomore AM, I Care & Consult, Quantis, and their customers and proposed as an open-source metric by the NEC Initiative.⁸ The NEC eventually moved in 2019 from a proprietary development into a collaborative initiative in order to mutualize R&D, updates, standardization, awareness, expertise and efforts towards transparency.

2.2. Main features

After four years of applied research and development, 15 frameworks have been designed, tested, calibrated and implemented leading to version 1.0 of the NEC. In brief, the NEC:

- Captures the full value chain impacts using life cycle assessment based on physical data
- Evaluates transition risks & opportunities
- Goes beyond carbon footprinting, and captures several environmental issues identified by the EU regulatory framework on sustainable finance
- Provides a unified, user-friendly set of frameworks aggregating bottom-up product/service-based analysis by function/utility, activity by activity
- Is based on NGO, industry and academic tools, databases and studies about environmental impacts assessments

⁶ Novethic, part of Caisse des Dépôts Group, is a Greenfin/EET4C accredited verifier; see Novethic press release:

https://www.novethic.com/fileadmin//user_upload/tx_ausynovethicpresse/communiqués/PR-Green-Label-TEEC-Sycomore.pdf

⁷ this partnership included an exploration of the NEC characteristics versus other environmental ratings and of the relationship between the NEC indicator and the financial risk and return. This work led to an academic publication under review (see publications);

<https://securities.bnpparibas.com/about-us/news/sycomore-am-sign-research-partne.html>

⁸ See: <https://quantis-intl.com/net-environmental-contribution/>

- Is applicable across all asset classes (listed equity, private equity, loans, bonds, real estate, infrastructure)
- Provides a single metric that is a proxy for the positive or negative net environmental contribution of a given activity

From a technical standpoint, the NEC has been designed to be:

- A bottom-up method based on physical environmental impacts. It is a pure environmental measure, not a social impact measure
- Aggregated from the product, service, technology, and business unit level, all the way up to the whole company, a group of companies, a portfolio or an index
- Modular, allowing each part, each sector specific dimension, to be updated and improved by block or module

NEC definition: the NEC is a user-friendly, advanced metric that enables investors to measure the extent to which a given business model is strategically aligned with the energy and environmental transition. Using physical data across the whole value chain, it provides a snapshot of an activity's net environmental contribution and can be aggregated at a company, portfolio or index level.

To assess an environmental impact, the NEC uses a multi-criteria approach and considers at least two of the following five issues in order to capture a comprehensive proxy of the environmental footprint:

1. Climate
2. Water
3. Resources and waste
4. Air quality
5. Biodiversity

The indicator is calculated on a scale from -100%, for the most damaging activities, to +100% for clear environmental solutions among high-impact intensity activities. It provides an order of magnitude of the net impact. The 0% point is given for the world average environmental impact of the function that the given activity is fulfilling. A company's contribution is measured by analyzing its activity breakdown, and computing it at company level using activities' relative economic weight. The relative economic weight is usually given by the share of turnover, contribution to earnings, enterprise value, or market value attributed to the activity.

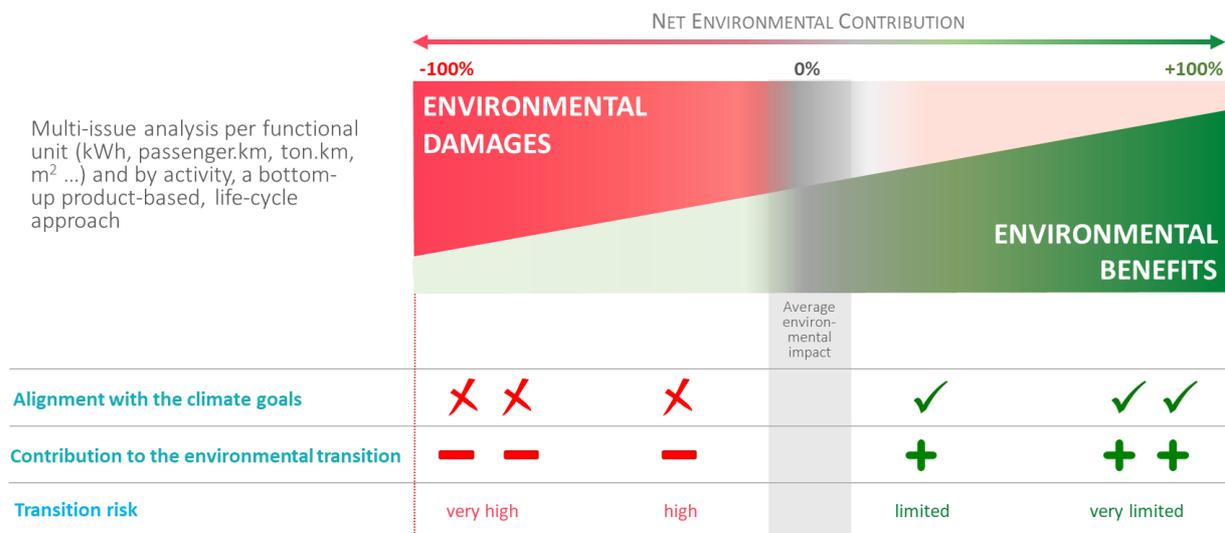


Figure 5: NEC illustration, 2019, Sycomore AM.

2.3. A value chain approach

Each methodological framework covers a specific value chain, such as waste, or a group of value chains providing a given function, such as transportation or electricity. Each of these frameworks is applicable to an industry or a group of industries, such as mining, metals and basic materials. In some cases, frameworks can be more granular, at sector or subsector level. Even though many different enterprise and/or activity classification systems exist, there is no widely-accepted standard to classify the type of utility, or the physical functional unit, that an activity is providing. Therefore, the NEC frameworks have been categorized in 5 different groups, following a utility-based approach:

- Ecosystems-based frameworks: food & beverage and water**
 These frameworks encompass food, beverage and water-related activities. The underlying physical units are the mass (expressed in kg) and the volume (in liters) of product, and its underlying content of **proteins, lipids, carbohydrates and water**. These activities **directly rely on an ecosystems' outputs** and extensively use land and water resources. The value chains under analysis are agriculture, livestock farming, fishery, food and beverage industries, water and wastewater companies.
- Energy frameworks: fuel, electricity and heat**
 These frameworks address the "access to energy" issue and cover all forms of the energy utility. The underlying physical unit is the **energy**, which is usually expressed in electric **kiloWatt hour (kWh)** for power, thermal kWh or **Joule (J)** for heat, and **tons of oil equivalent (toe)** for fuel. The framework refers to fuel extraction, power production, heating, energy conversion, transport, storage, distribution and final use of energy. They include equipment manufacturers and service providers all along the value chain from energy transportation to electricity metering or heat regulation. It considers all types of fossil and renewable fuels, regardless of the physical form: solid (biomass, coal, waste-to-energy), liquid (crude oil, gasoline, diesel, biodiesel, liquified natural gas) or gaseous (natural gas, biogas, hydrogen, methane).
- Mobility & transport framework:** This framework covers all activities related to passenger transportation and freight, regardless its position in the value chain or its purpose - business, private or leisure. The common underlying physical unit is **the distance in km for one transported**

unit, expressed in **passenger.km** for human mobility and **ton.km** for goods transportation. The framework refers to all kinds of transportation operations, mobility services, logistics, vehicle and equipment manufacturers, businesses in the automotive, railway, aircraft, and shipping industries, bicycle rental, sharing or manufacturing, the construction of motorways, waterways, and harbors.

- **Building & real estate framework:** This framework addresses access to shelter, homes, workplaces, land and living areas. The common underlying physical unit is the **surface area in m²**. It gathers all activities that are related to **buildings and real estate**, regardless of the position in the value chain. It includes the whole building industry, all types of construction, infrastructure, renovation, rehabilitation, building management, real estate, architecture and urban design.
- **Other production and consumption-related frameworks:** This category encompasses methodological frameworks covering **apparel & textile, appliances, household & personal care**, as well as the **information technology** and other resource-intensive production activities. These resources may be non-renewable, as in the case of mining, minerals, metals and chemicals activities. These activities are covered by the **basic materials** and **chemistry** frameworks, whereas the industries based on "renewable" resources such as forestry, pulp and paper, and packaging are covered by the **wood & paper** framework. It gathers the value chains of the **linear economy** as well as the **circular economy**, including waste management and pollution remediation via the **waste** framework. The only common utility unit in those very heterogeneous cases is the **utility value in monetary unit (€) attributed by the economy** over a significant time frame (10 to 20 years).

All other activities not mentioned above adopt the NEC framework of the specific activities they are providing services to. For example, a car financing activity adopts the NEC framework of the industry it is financing - car manufacturing in the mobility framework.

Each NEC framework interacts with one or several Sustainable Development Goals (SDGs). Figure 6 presents a preliminary mapping between the NEC frameworks and nine environmental SDGs.

| NEC specific frameworks | Related Sustainable Development Goals |
|---|--|
| Ecosystems-based frameworks: Food & Beverage, Water |      |
| Energy frameworks: Fuel, Electricity, Heat |   |
| Mobility & transport |    |
| Building & real estate | |
| Wood and paper, Basic Materials, Chemistry, Waste, Apparel & textile, Household & personal care, Information technology, Appliances |   |

Figure 6: interactions between NEC frameworks and environmental SDGs, 2019.

A detailed examination of the NEC components and the SDGs could be investigated as part of a future research and development program.

3. Guiding principles

Version 1.0 of the NEC methodology is constructed in 4 steps. It contains 15 specific frameworks along with generic guidelines for applying the frameworks. The following diagram gives an overview of the NEC construction process.

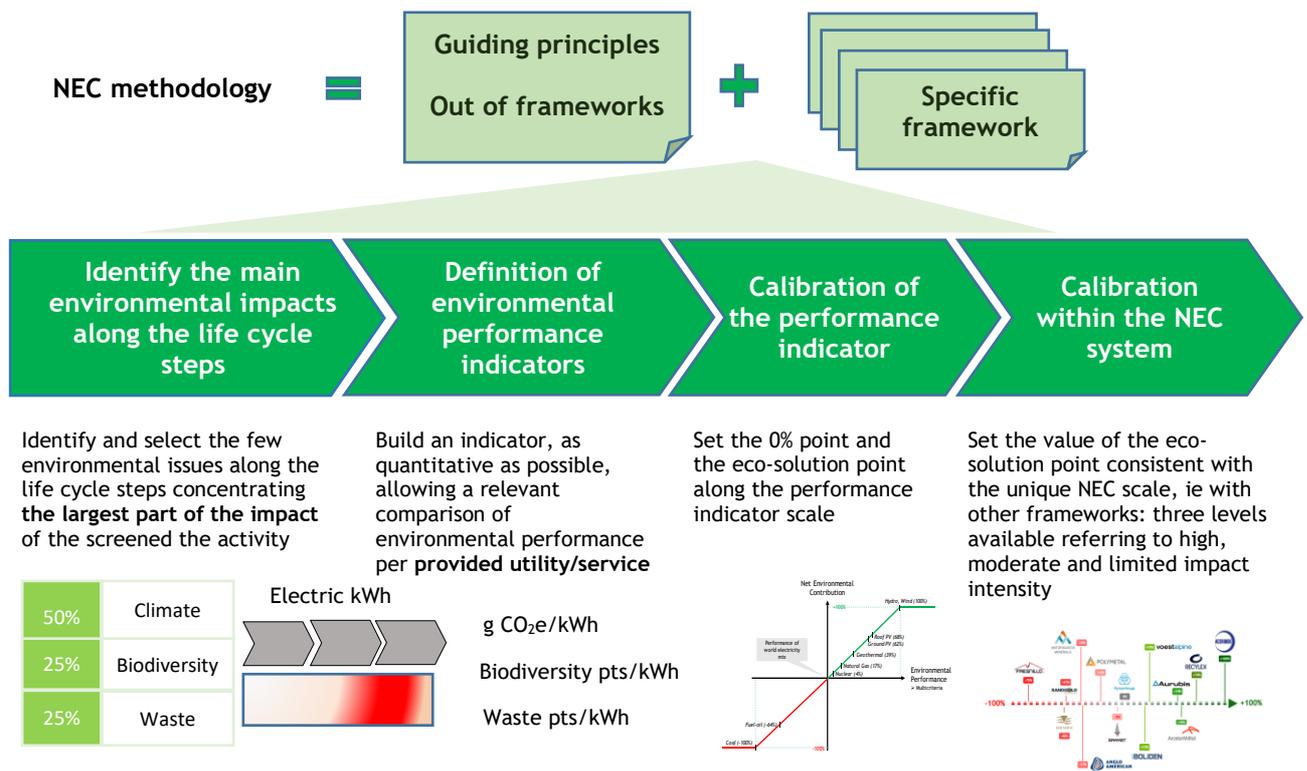


Figure 7: the 4 NEC construction steps, 2018.

3.1. Construction steps

The first two steps lead to an aggregated environmental performance indicator, and the last two steps translate it into the NEC score. It is summarized below:

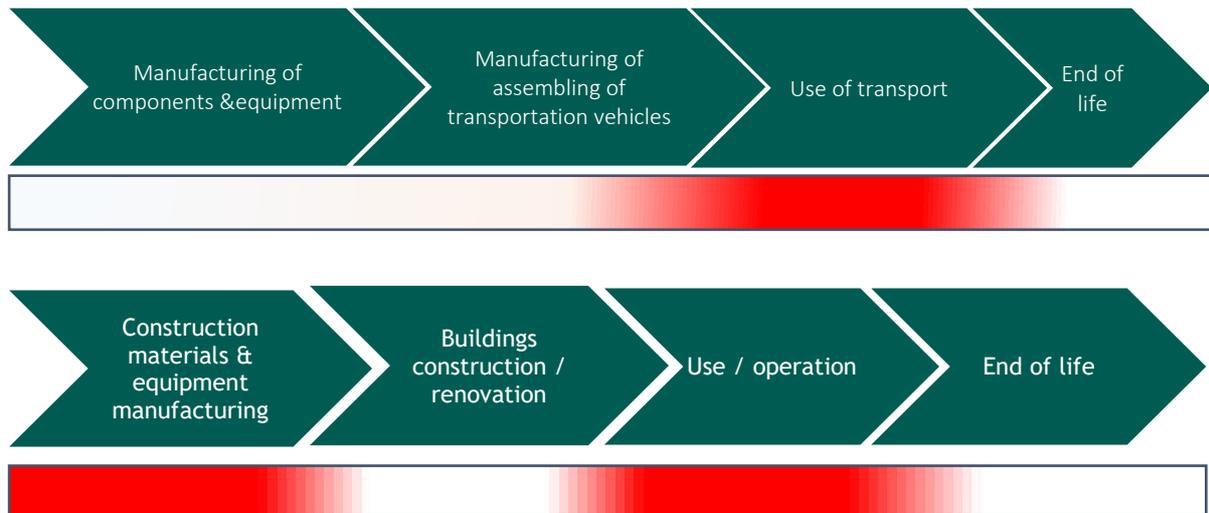
1. Identify the main environmental impacts along the life cycle
2. Build the performance indicator that quantifies the environmental impact
3. Calibrate the zero and the eco-solution points
4. Calibrate the eco-solution point with the NEC

Step 1

The first step is **to identify the main environmental impacts along the whole life cycle**. The most relevant environmental issues are selected and weighted following life cycle assessment (LCA) standards.

Economic activities generally have more than one significant environmental impact at a given step of the life cycle. For each activity, two to four main environmental issues are identified at different phases of the product's or service's life cycle. In some cases, this is relatively simple. An example for the mobility framework, where the use phase is the most impacting step, is shown below.

For food, the upstream phase at the farm concentrates the largest impacts. For many other value chains, several phases of the life cycle have similar impact intensities. Figure 8, below, illustrates the intensity of the environmental impacts for the building framework.



Step 2

For each studied activity, the most relevant environmental impacts are quantified in **the second step** and **performance indicators** are chosen. The diagram below illustrates the indicator selection process for the food and building industries.

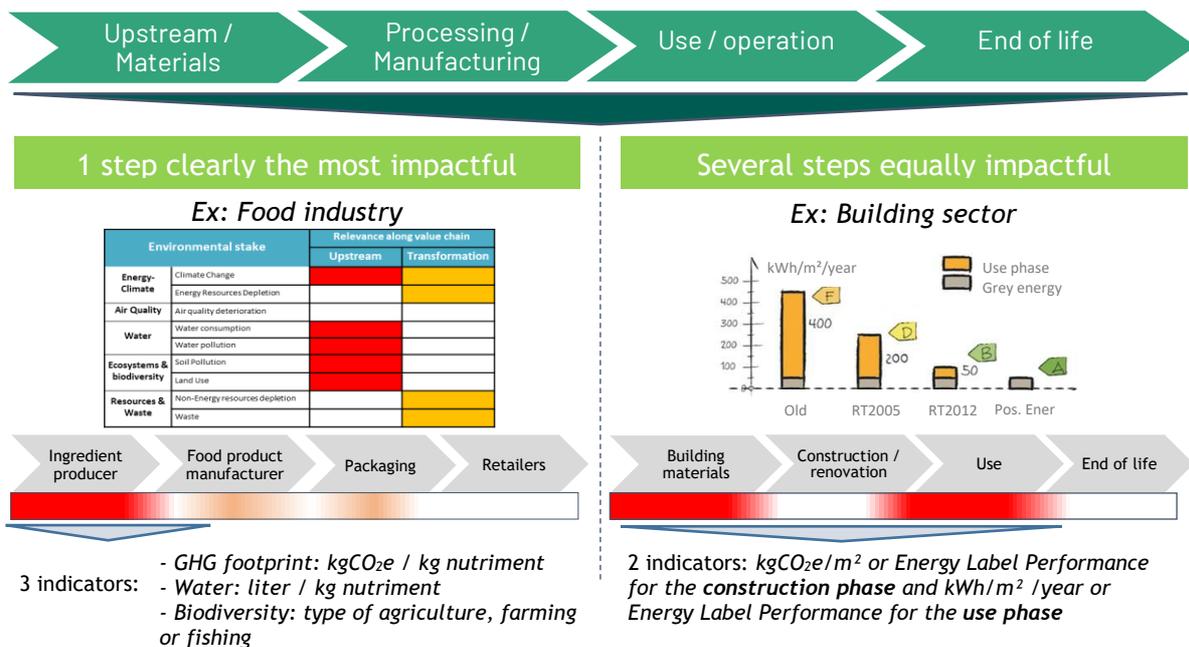
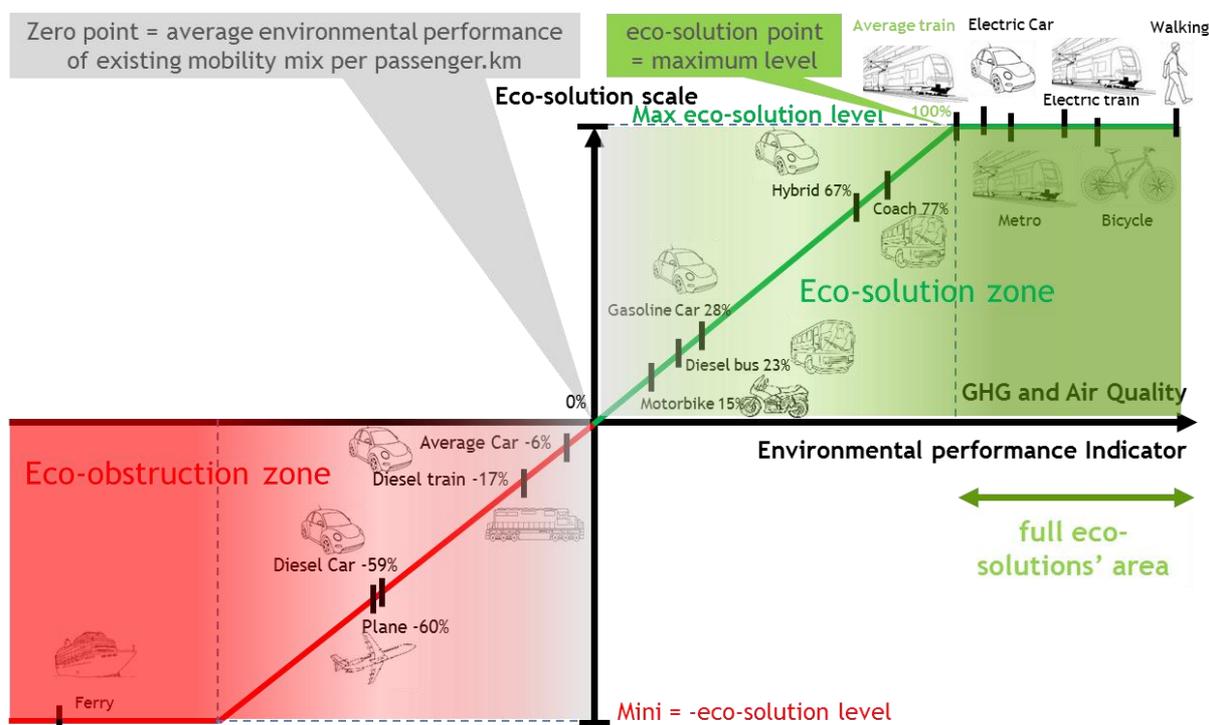


Figure 8: illustrations of performance indicator selection step in the NEC construction process, 2018.

In some cases, there is a reliable scoring metric that already aggregates the environmental performance of an activity, or a part of the activity, to be evaluated, such as the MSI score for textile fibers.

Step 3

The third step consists of setting **the 0% point and eco-solution point of the framework, which defines the average and maximum performance levels for an industry**. It also provides **the minimum level** by linear interpolation of the opposite of the eco-solution point. The eco-solution point is defined as the best, significantly scalable solution that is clearly aligned with the environmental transition and with the 2°C climate objectives. Examples include railway transportation and wind power generation in their respective industries. Step 3 tests dozens of real cases and includes extreme examples. This approach **calibrates the performance indicator** by positioning it on an industry-specific scale, where the industry activities can be easily plotted with significant dispersion. This is illustrated below by the transport services performance indicator, within the mobility framework.



Sources: I Care & Consult calculations based on IEA, Eur. Env. Agency, IUC, ICCT, ADEME, transportenvironment.org, 2017.

Figure 9: setting the 0% and eco-solution point for passenger transportation in the mobility framework, 2018.

Step 4

The last step is the **second calibration** step, which considers the NEC as a system of interconnected frameworks. **Step 4 sets the value of the eco-solution point** (or the score of the best solution in that sector), defined in step 3, and assigns it to one of three possible NEC levels - +10%, +33% or +100% - as shown below.

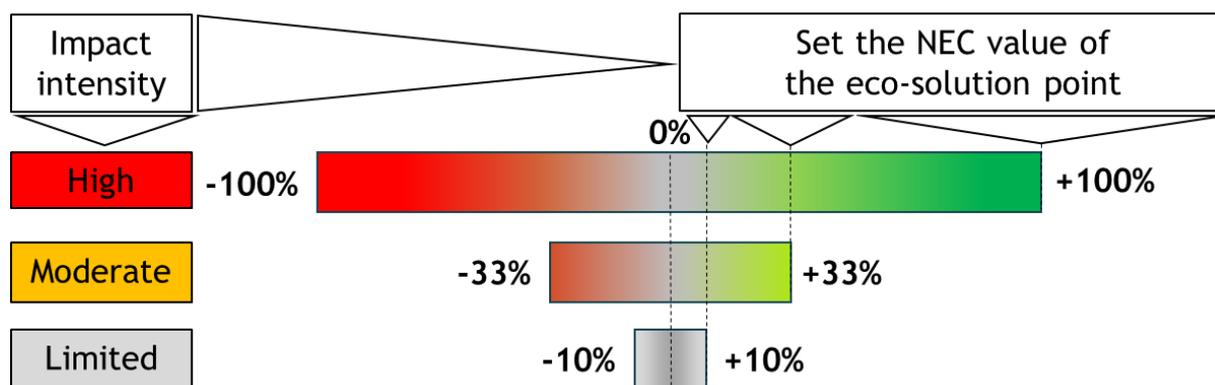


Figure 10: impact intensities setting the order of magnitude of eco-solution point on the NEC scale, 2018.

These three impact intensity levels have been defined during the cross-sector calibration step, as explained below.

3.2. Cross-sector calibration

To ensure the NEC metric can be compared and aggregated across all the different activities it covers, plotting this diversity on a unique scale, a full-scale calibration has been performed in 2017 over the 21 investigated frameworks of NEC Beta version. The NEC 1.0 is the result of this calibration exercise and of other improvements leading to the use of 15 specific frameworks: 12 high impact frameworks and 3 moderate impact frameworks. Of the original 21 frameworks, three have been merged with other frameworks for better consistency, and three have been classified in the limited impact category, no longer requiring a specific framework.

The calibration consists of classifying the eco-solutions of each framework by comparing the impact gap between the 0%-point and the maximum point on the NEC scale. The 0%-point is the world average for each framework's utility and the maximum point is the world's best scalable solutions. The value of each eco-solution point changes according to the impact intensity of each of the frameworks. The minimum NEC level for a framework is set as the opposite of the eco-solution point, i.e.: **maximum NEC = eco-solution NEC = - minimum NEC**. For example, if the maximum NEC eco-solution is +33%, then the minimum level will be -33%.

For each framework, an environmental impact for 100 NEC percentage points has been calculated by using a semi-quantitative method that mixes equally weighted components:

- **Climate and air quality impact component:** The avoided GHG emissions per person are provided by an eco-solution and compared to the world average, or 0%-point, expressed in tCO_{2e} per person per year and rebased on a 0 to 1 scale. The air quality issue has been integrated in the carbon evaluation assuming carbon was a proxy of the air quality impact.
- **Biodiversity, water, and waste & resources impact component:** This is a qualitative evaluation of the biodiversity, water and waste impacts with three levels ranked on a 0 to 1 scale. Level 1 signifies a high impact level, 0.25 significant level and 0.06 low level.

The test has been carried out on the entire set of value chains, enabling the creation of three impact intensity categories:

- **High impact:** This category includes activities that have **strong interactions with natural capital**, classifying them as destructive or weakening, preservatory or restorative, or both. The environmental gains obtained by switching from the world average to eco-solutions are very significant in this impact intensity category. They deliver improvements in the same order of magnitude (+/-50%). For this category, **the value of the eco-solution point is +100% NEC**.
- **Moderate impact:** This category includes activities that have **significant interactions** with natural capital, classifying them as negative (destructive or weakening), positive (depreciative, preservatory, or restorative), or both. The environmental gains obtained by switching from the world average to eco-solutions are significant or **non-negligible, but** deliver improvements lower than the average of the high impact category by a factor 2 to 4 (3 on average). The moderate impact has an **eco-solution point value of +33% NEC (+100%/3)**.
- **Limited impact:** This category includes activities whose interactions with natural capital cannot compare to previous categories. The environmental gains obtained by switching from the world average to eco-solutions are **not significant, and achieve improvements of at least 10 orders of magnitude lower** than the average high impact category. The limited impact category has an **eco-solution point value of +10% NEC maximum**.

Three investigated frameworks resulted in having a limited-impact intensity. These include the software, telecoms and furniture industries and have not been integrated into NEC 1.0. They could be included in future versions of the NEC. The incremental NEC from these industries cannot be placed on the same NEC scale compared to the high- or moderate-impact activities. As part of the limited-impact category, where the NEC is ranging from -10% to +10%, their NEC would very often be in the range -2% to +2% with a default value of 0%. **It is not significant enough to be worth calculating it.**

The testing and additional improvements have delivered the following classifications:

| 21 frameworks NEC β | Impact intensity | 15 frameworks NEC 1.0 |
|---------------------------|------------------|--|
| Food | High | Food & beverage |
| Beverages | | Water |
| Water | | Fuel |
| Fuel | | Heat |
| Heat | | Electricity |
| Electricity | | Mobility & transport |
| Passenger mobility | | Building & real estate |
| Freight | | Wood & paper |
| Building | | Basic materials |
| Wood | | Chemistry |
| Mining | | Waste |
| Metals | | Apparel & textile |
| Chemistry | | Household & personal care |
| Waste | | Information technology |
| Clothing/textile | Appliances | |
| Personal & House Care | Moderate | Integrated in the IT framework (hardware, devices and software) and not modelled (furniture) |
| Information Technology | | |
| Appliances | | |
| Telecom | Limited | |
| Furniture | | |
| Software | | |

Figure 11: calibration results on specific frameworks of NEC Beta and 1.0, 2019

For all activities not explicitly referenced, such as banking, insurance, or consulting services, their NEC is calculated via the activities that they encompass or facilitate. For example, a leisure or tourism activity is assessed using the mobility framework for travelling, hotel catering activities using the food & beverage framework, and accommodation provision using the building framework.

3.3. The 15 frameworks

The NEC 1.0 methodology refers to 15 function-specific frameworks that have been designed using a value-chain approach and organized into three categories, based on their environmental impact intensity (see Figure 11 for details). For illustrative purposes, some default values from the food & beverage framework are plotted below. It equally weights climate, biodiversity and water issues, with the middle point (0%) defined as the global average environmental impact.

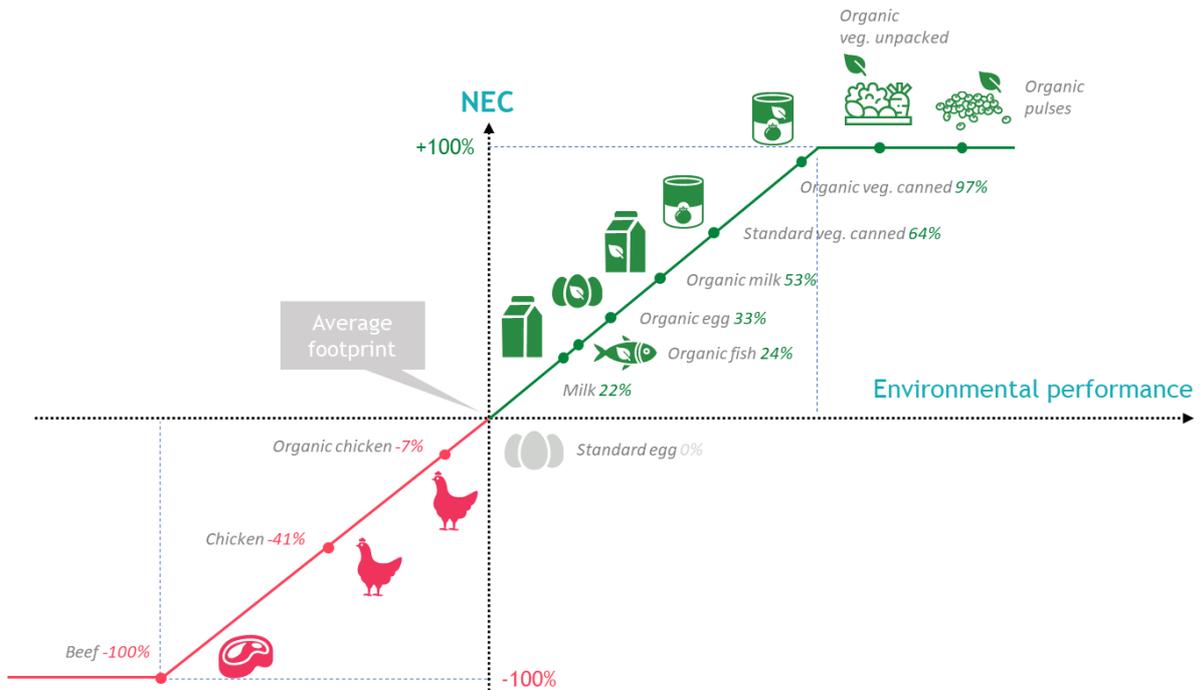


Figure 12: default NEC by food products, as per the food framework of the NEC 1.0, 2019.

For illustrative purposes, examples of salient NEC are given below by utility.

| Utility /function | Physical unit | Negative NEC | Positive NEC |
|---|----------------|--|---|
| Inhabit / enjoy shelters and living areas | m ² | Energy-inefficient buildings, concrete and cement-based building solutions | Renovation, thermal insulation, timber framing, home exchange |
| Eat and drink | kg | Pesticides, nitrogen-based inputs, intensive farming, animal protein | Local, vegetal, organic food, sanitation |

| Utility /function | Physical unit | Negative NEC | Positive NEC |
|---|-----------------------|---|--|
| Access to energy / fuel, heat and electricity | J | Thermal coal, non-conventional oil & gas, carbon-rich electricity | Renewable energy, smart electricity grids, energy storage |
| Move / mobility for humans and goods | pass.km and t.km | Air transportation, vehicles with high fuel consumption, road freight | Vehicle sharing, bicycles, public transportation, railways |
| Consume / produce | units, tons, monetary | Linear economy, disposable goods, cotton, cement | Circular economy, recycling, function-driven economy |

Figure 13: illustration of highly positive and negative net contributions by area as per NEC 1.0 version, 2018.

3.4. Out of the specific frameworks' scope

All economic activities need to have a NEC in order to cover all universes and indexes. Some activities have very heterogeneous environmental impacts but have important ethical dimensions. Therefore, a default NEC of 0% has been used for the following activities:

- Tobacco, drugs and health-related activities
- Aerospace, weapons, military businesses, defense, security and peacekeeping activities
- Educational, cultural, lobbying, recreational and religious activities

All these activities can have a very positive environmental impact, such as meteorological or earth observation for aerospace, or environmental education. These activities can also have very negative impacts such as aiding the continuation of wars or generating unhealthy addictions. At this stage of the methodology construction, these activities have been voluntarily set at 0% NEC.

In brief, the best guide in decision-making for judging these activities remains common sense. There are 3 reasons for a default NEC of 0%:

- Activities set voluntarily at 0% listed above due to heterogeneous environmental impacts intertwined with unquantifiable ethical concerns;
- The activities have **non-significant quantifiable impact**. This includes activities in the media, communication, furniture & decoration, administration, office management, art and justice industries;
- Activities with **unquantifiable impacts** due to insufficient disclosure about the value chains they serve (e.g. most of banking, insurance, legal service, etc.).

In brief, when the NEC assessment is insignificant or impossible for the reasons mentioned above, **the 0% point is the least negative scoring option.**

3.5. Calculation rules of thumb

1. The final use prevails

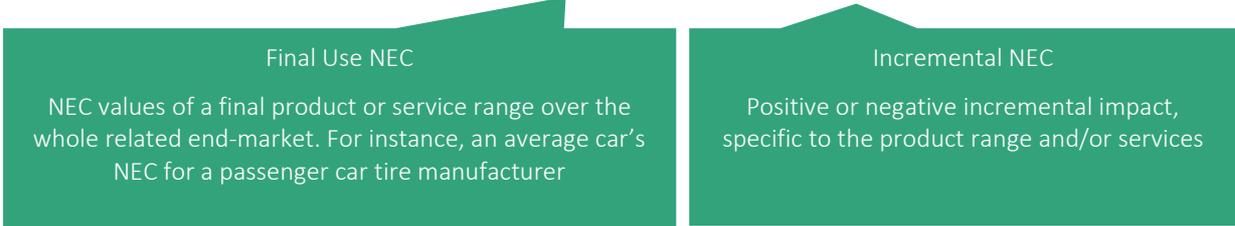
The preliminary step for the calculation of a NEC is to determine which value chain or industry the activity is associated with. **The final use or function of the products and services determines the framework to be used**, except for the cases where a 0% default NEC applies. For instance, a food ingredient is assessed along the food & beverage framework, paper production along the wood and paper framework, and an automotive equipment manufacturer along the mobility framework.

When an activity could be classified in two different frameworks, such as the construction of railways infrastructure, which relates to construction and mobility, the final use prevails. Therefore, the construction of a train station is assessed via the mobility framework. In the case of an energy efficiency service or product, the development of a hybrid engine for a car would relate to the mobility framework, while an energy saving process in pulp and paper would relate to the wood and paper framework.

2. Resulting NEC of an activity = Final Use NEC + Incremental NEC

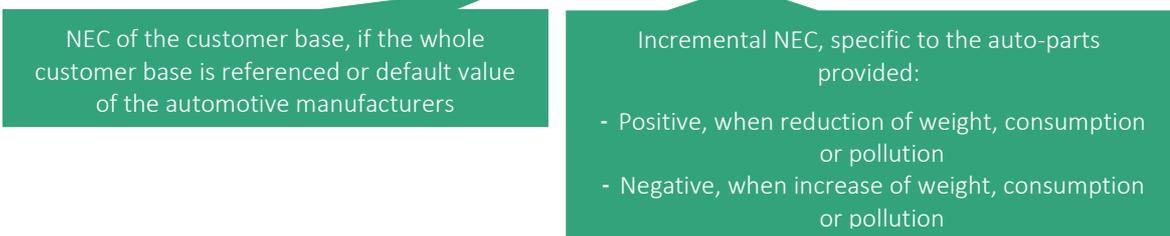
The NEC is an additive metric that can be refined as soon as more detailed and reliable information is available. The NEC follows the following **generic equation** resulting from the first rule, which features as the second rule:

Resulting NEC of an activity = Final Use NEC + Incremental NEC



For example, for an equipment manufacturer for the automotive industry, the equation is:

Resulting NEC of an auto-part = Auto NEC + Incremental NEC of the part



3. When two equally valid NEC calculations are possible, the lowest resulting NEC is preferred.

NEC calculation ways may be plural. For example, a waste incinerator with energy recovery can be assessed for the treatment fees as a waste treatment solution in the waste framework with a +50% NEC and for the sale of energy as a solution to provide renewable power in the electricity framework with a +100% NEC. The waste value chain connects to electricity and heat value chains with the waste-to-energy activities. In the case of the waste incinerator, the resulting NEC will fit in the range [+50%; +100%]. In practice, the profit or revenue breakdown between energy production and waste treatment fees is generally unknown. By default, the incineration activity NEC will be assessed according to the waste framework as waste treatment, as this is the main purpose of the facility. Its resulting NEC of +50% is the conservative option.

Another example is an airways catering provider. It can be assessed as a supplier of the mobility framework with the negative NEC for long-haul (-17%) and medium-haul (-70%) air transportation, or with a 0% NEC as food-related activity if the delivered food is close to the average world food mix. In this case, as catering is fully customized and dedicated to airways (and it is unlikely anyone would enter an airplane to have diner), the first option applies, as airplane catering is fully embedded within the air transportation value chain.

Calculation options are not always clear cut when several options leading to different NEC may coexist. To arbitrate these cases, a conservative rule has been successfully tested and is used to secure the anti-

greenwashing ambition of the NEC. Therefore, the third rule is that **when two equally valid NEC calculations are possible, the lowest resulting NEC is preferred.**

More broadly, the methodology has been tested and adjusted during 2017 and 2018 to limit such discrepancies between the frameworks and value chains.

4. Main limits

The NEC provides a proxy value that has proved to be consistent, manageable and user-friendly. Nevertheless, it is a work in progress, built on the numerous approximations that such an ambitious endeavor requires. These approximations are of different kinds and refer to different steps of the NEC construction and calculation process:

- In step 1, only the main environmental issues for each activity have been integrated, ignoring secondary ones.
- In step 2, when available, the underlying data stemming from environmental assessments, certifications and life cycle assessment are estimates and averages, and very often, they are a few years old.
- In steps 1 and 2, when data is unavailable or highly complex, rough assumptions and simplifications have been formulated to compute the NEC, thereby introducing an additional layer of approximation.
- In step 3, the notion of having an “average solution provided on a world basis” used to determine the 0% point is difficult to set when the environmental performance differs strongly between old and new solutions. This is the case for long lasting goods such as vehicles and built infrastructure. These specific cases have been managed by introducing two specific 0%-point definitions in two frameworks: for mobility, new vehicle fleets have been distinguished from existing fleets; and in the building framework, existing buildings have been distinguished from new constructions. Nevertheless, this distinction has not been applied systematically in all frameworks.
- In step 4, only an order of magnitude of the impacts have been tested with +/-50% limit for the categorization.
- During NEC calculation of assets, the ideally required activity breakdowns are often not available and their relative economic weights are often obtained by extrapolation from estimated volumes, revenues or earnings’ breakdowns.

As a result, the NEC methodology is mixing a quantitative approach with a semi-quantitative approach. There are areas where reliable data is still not available and this is presented in the following table per framework and per environmental issue. This overview shows that the climate component of the NEC is the most quantitative one, that the level of coverage for environmental issues is quite high, and that air quality has the weakest integration level.

| NEC component per framework | Climate | Resources and Waste | Biodiversity | Water | Air quality |
|---|---|---------------------|--------------|-------|-------------|
| Food & beverage | +++ | + | + | +++ | - |
| Water | - | + | + | +++ | ∅ |
| Wood & paper | + | + | + | + | ∅ |
| Fuel | +++ | ++ | ++ | + | ++ |
| Electricity | +++ | +++ | +++ | ∅ | - |
| Heat | +++ | ∅ | ∅ | ∅ | ++ |
| Mobility & transport | +++ | - | - | ∅ | +++ |
| Building & real estate | + | + | - | ∅ | ∅ |
| Basic materials | +++ | +++ | +++ | +++ | - |
| Chemistry | ++ | ++ | ++ | ++ | ++ |
| Waste | + | + | + | ∅ | ∅ |
| Apparel & textile | ++ | + | ++ | ++ | ∅ |
| Household & personal care | + | + | + | ++ | ∅ |
| Information technology | +++ | ++ | ∅ | ∅ | ∅ |
| Appliances | ++ | + | ∅ | ++ | ∅ |
| Healthcare, media, furniture, ... | ∅ | ∅ | ∅ | ∅ | ∅ |
| Out of specific frameworks (finance, ...) | Accuracy of the final uses' frameworks if any | | | | |

| Legend | Methodology accuracy |
|--------|--|
| +++ | Relevant issue, quantitative assessment |
| ++ | Relevant issue, semi-quantitative assessment |
| + | Relevant issue, qualitative assessment |
| ∅ | Not relevant or marginal |
| - | Relevant issue, not integrated yet |

Figure 14: underlying accuracy per environmental issues and per framework, 2019.

The consolidated NEC calculations end up cumulating all presented underlying approximations. As a result, the ambition is to holistically capture the right order and magnitude of environmental impacts, providing only a reasonable and manageable proxy, rather than aiming for an unrealistic accuracy or comprehensiveness. The accuracy level can be summarized in three statements:

- **The NEC only provides an order a magnitude;**
- **Decimals for the NEC makes no sense;**
- **A difference below 10 percentage points of NEC may not be meaningful.**

Being pragmatic, detailed NEC calculations for a small activity or efforts to reach an authoritative judgement about a few NEC percentage points for a large activity may be done in vain.

5. Comparability

The NEC is designed to capture an economic activity's contribution to the environmental and energy transition on a -100% to +100% scale. The 0%-point stands for the global average environmental impact generated today by an activity in order to fulfil its function. The +100% point represents the eco-solution for highest impact intensity category, in other words, it has the lowest environmental impact to fulfil a function or to solve a problem, such as recycling or treat wastewater. Eco-solutions are defined as the best, significantly scalable solutions that are aligned with the environmental transition and with the 2°C climate objectives. Activities are classified in three impact intensities so that all frameworks can be compared and added together.

Therefore, a positive NEC means an activity's overall impact is better than the measured average and is thereby helping to reduce the environmental footprint of a function, such as providing electricity, heating space, feeding people, or building homes, and it is contributing towards an environmentally resilient economy.

While the various attempts to establish 2°C compatible scenarios or pathways, such as the SBT initiative, SEI metric, and Transition Pathway Initiative, have only been able to cover a limited scope of activities, the NEC offers the benefit of assessing a full range of environmental impacts, as it is not only focused on carbon.

In some frameworks, such as fuel or mobility, the link between a 2°C scenario and the NEC percentage point can be drawn quite easily. Nonetheless, climate and other environmental issues are clearly interrelated and reaching the 2°C target will only result from a whole systemic shift. One sector being able to offer a trajectory to 2°C relies on others doing the same. While most other 2°C metrics are based on top-down sectoral GHG allocations, the NEC takes a bottom-up approach and then consolidates the net contributions of activities across all sectors on a unified scale of environmental impacts.

As such, the NEC is a relevant metric for understanding the transition risks and opportunities, as defined in Article 173 of the French law on Energy Transition for Green Growth and in recommendations issued by the TCFD. The NEC is a valuable metric for assessing an activity's contribution to international goals on climate change and the environmental transition. It is a useful tool for identifying which business models are already aligned with a 2°C world as well as which companies are transforming their business models.

The NEC can also be used to track business model transformation and detect, over time, whether a company is aligning with global environmental goals or moving away from them. For example, Orsted, the Danish utility (formerly DONG Energy) adopted a transformation plan in 2008 entitled "From Black to Green".

Its transformation included many divestments and an impressive investment plan. Consequently, its NEC moved from -23% in 2006 to +72% in 2018. Acquisitions can also be easily tracked, as the NEC of a merged entity is the weighted average of the NEC of the pre-merger entities, as illustrated in the case study below with Danone and Bayer.

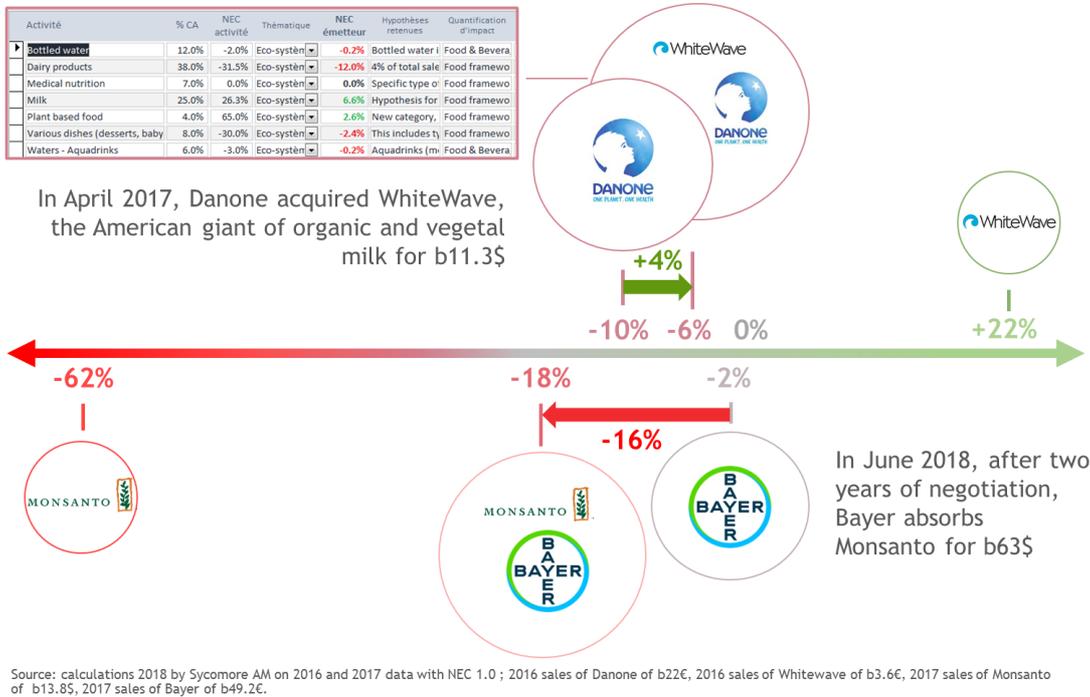


Figure 15: NEC assessing corporate positioning and strategic moves, 2018.

However, the NEC has not been designed to perform scenario analysis as suggested by the TCFD recommendations, nor to assess physical risks as mentioned by both Article 173 and the TCFD.

It is important to note that the French Greenfin governmental label offers more guidance for green investment and for the reallocation of assets towards the environmental transition. The specifications drawn up by the French authorities stipulate which activities are excluded and give a detailed sector-based list of green activities, which must make up a minimum proportion of the financed activities in the portfolio. The result is a whole taxonomy of green activities and a taxonomy of brown activities limited in the form of an exclusion list.

According to Sycomore AM’s long experience in managing a Greenfin certified fund, a positive NEC usually matches green activities as defined by the French authorities, while excluded activities usually have a negative NEC. As such, the NEC appears to be a useful signal of compliance with the Greenfin label.

The NEC is going beyond the binary approach of a taxonomy by capturing the degree of green and brown content of the underlying assets.

6. Glossary

In order to reliably account for environmental issues and sectors' complexities, the Net Environmental Contribution methodology relies on a number of key concepts defined here. These concepts are consistently used in the various frameworks and guiding principles.

Activity: This is defined as any economic activity has an environmental impact. Therefore, there is virtually no activity that would be out of the NEC methodological scope. Additionally, the NEC provides an estimate of a given activity's environmental impact and bears no relation to any legal, financing, ownership, asset class or purpose driven characteristics. Thus, the term "activity" and the related NEC apply for any type of economic activity:

- Formal or informal
- For profit or not for profit
- Listed or private equities, bonds and loans
- Business units, companies, projects or infrastructures
- Products or services

Activity breakdown: As the NEC is a modular and bottom-up metric, the granularity of calculation can theoretically start with one product used in given conditions, such as a Tesla S fueled by the Californian power mix and with an average occupational rate of 1.4 passengers per car. The relevant granularity of assessment depends on the objectives of the assessment and often relies on a trade-off between accuracy, relevancy and manageability.

For instance, there is no significant added value in assessing precisely the NEC of a business line representing a small percent of the whole activity. It is better to try to keep a number of NEC segments, limited to about ten, with each NEC segment corresponding to a specific calculation pattern.

The NEC of a multi-activity entity is the weighted average of its activities' NECs, according to their economic weight. At the portfolio level, in financial products or for conglomerate holdings, the weight of each element depends on their market value for stocks and bonds. At the company or issuer level, the market value is the sum of the market values of the business units, which are themselves the sum of the products or services provided by each business unit. Therefore, in the case of a multi-entities group, the activity share or weight of a given entity is used to determine its weight on the group's NEC calculation. This weight is estimated with available data, so it is a proxy of relative market value or enterprise value. The most frequently used proxies for activity breakdown are based on:

- EBITDA (earnings before interest, taxes, depreciation, and amortization)
- Operating profit, EBIT (earnings before interest and taxes) or net profit
- Revenue or physical volume such as number of units, tons, or MWh

These metrics are the most commonly used to measure the materiality of a given business unit. For highly vertically integrated activities, such as oil and gas, mining, metals and utilities, the contribution to EBITDA is generally the most relevant proxy of the activity. In those cases, the EBITDA split will be preferred. More generally, when revenue breakdown is not available, the EBITDA split can be used and if not available, the EBIT split.

Default NEC: Within sectors, the most common activities or categories of products, services, and technologies have been assessed and their default NEC have been calculated to reflect the average

environmental impact of the observed global mix. This default NEC applies when no further information is available on the products', services', or technologies' performance or when a more granular breakdown is not available. For instance, a default NEC is available for several types of food products such as poultry, beef, and eggs.

Eco-solution: The eco-solutions are the lowest environmental impact solutions that fulfil a function or solve environmental challenges, such as the recycling of waste or treatment of wastewater. The eco-solution point is defined as the best, significantly scalable solution that is clearly aligned with the environmental transition and with the 2°C climate objectives.

Final use NEC: The NEC aims at accounting for value chain impacts in a utility-oriented set of frameworks, so the products, services, and technologies that contribute specifically to a value chain are allocated the same NEC as the value chain. This is referred to as **final use NEC** and the NEC calculation is not based on a product, service or technology's direct environmental impact, but rather on the direct and indirect impacts of its final use. The final use NEC is applied on top of the product, service or technology's NEC as soon as the relevant value chain is identified. For instance, a software for waste collection planning will adopt the NEC of the waste framework.

Incremental NEC: This approach refers to **an adjustment, positive or negative, to a product, service, technology, or final use NEC**. This corrective factor is expressed as Δ (delta) in NEC equations. It is applicable when a technical parameter, specific to a product, a service, a final use, or to company practices, significantly improves or degrades its environmental performance and thereby creates a performance delta. For example, a tire generating 1% fuel saving, based on an independent, reliable audit and compared to the average performance of peers' tires, benefits from a +1.5% incremental NEC according to the mobility framework.

A product's incremental NEC can be based on a **substitutability effect**, when an alternative product, service or technology is used as a replacement of a more environmentally impactful solution. For instance, synthetic leather has a positive incremental NEC as it comes as a replacement to animal leather, which has high environmental impacts. A positive incremental NEC is also applicable to recycled materials, for which the incremental NEC is based on the environmental gain of the recycled/secondary material production compared to the virgin/primary material.

An incremental NEC can also be calculated based on **indirect environmental benefits** generated by a given technology, service or product. It is calculated to be commensurate with the estimated benefits generated by the solution. For instance, smart grid technologies are eligible to receive an incremental NEC commensurate to its estimated energy efficiency effect and to its additional incorporation effect of variable renewable power.

An incremental NEC can also be applicable when **specific company practices** significantly affect the product or technology's environmental impact. For instance, unconventional extraction in the oil and gas sector has a specific negative incremental NEC due to its higher environmental footprint compared to conventional extraction.

NEC component: As a multi-criteria metric, the NEC results from the consolidation of several components and most frameworks have separate NEC components. They generally refer to a **key driver of the NEC** or

to one of selected environmental issues: **climate, water, biodiversity, resources and waste, and air quality.**

Zero % NEC: The 0%-point stands for the **global average environmental impact** generated today to fulfil a function or a utility. In short, it stands for the average impact of that function or utility in the world economy as measured by the underlying data sets and sources. These generally range between 2012 and 2017.

APPAREL & TEXTILE FRAMEWORK

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1. Introduction

The apparel and textile framework cover companies involved in the production of textile fibers, their transformation into apparel (including footwear) and other textile products and related retail activities. The growing volume of garments produced and associated demands for fiber production put environmental resources under significant pressure.



The sector relies on a wide variety of materials to manufacture final products, including both bio-sourced and synthetic fibers, so environmental impacts vary. Moreover, the scale of the environmental issues is multiplied by a “volume effect”, as shortening lifespans of fashion trends lead to sharp increases in production volumes and shortens products’ use phases.

2. Main environmental issues

| Environmental stake | | Relevance along value chain | | | Comments |
|---------------------|-----------------------------|-----------------------------|------------|------------|---|
| | | Upstream | Production | Downstream | |
| Climate | Climate change | Red | Red | Red | Bio sourced & animal fibers cultivation, petro-sourced fibers production, apparel use phase (>10% of the average EU household’s footprint) generate significant GHG emissions (est. 8% of global GHG emissions) |
| | Use of energy resources | Yellow | Yellow | Yellow | Energy consumption at each lifecycle stage (agricultural machinery, fiber transformation, transportation, use phase) |
| Air Quality | Air quality deterioration | Yellow | White | White | Air pollutants emissions (SOx, NOx, PM) associated with processes in the textile value chain, such as transport |
| Water | Water consumption | Red | White | Red | Water use for fiber production, especially cotton cropping (very water-intensive commodity), water use for washing in use phase |
| | Water pollution | Red | White | Red | Cotton culture (use of chemicals) and fiber production (leather tannery effluents) can generate local water pollution, as well as apparel use phase (washing) effluents |
| Biodiversity | Soil pollution | Red | White | White | Agricultural impacts of bio sourced fibers production such as cotton (use of chemicals) |
| | Land use | Red | White | White | Land use for bio-based fibers production (e.g. cotton) |
| Resources & Waste | Use of non-energy resources | Yellow | White | White | Use of biotic resources for fiber production (no significant pressure on rare materials) |
| | Waste | White | White | Yellow | Fast-fashion generates significant amounts of textile waste, and textile use phase generate microfiber pollution |

The production of textile fibers, especially cotton, is a source of significant global environmental impacts. Industry pressure on prices is reflected on producers, thus impacting local ecosystems: while occupying only 2.4% of agricultural land, cotton production accounts for 24% and 11% respectively¹ of global insecticide and pesticide sales. Conventional cotton agriculture consumes massive quantities of water (average of 4000 liters consumed/kilo produced²). Synthetic fibers such as polyester and polyurethane do

¹ http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_problems/thirsty_crops/cotton/

² [The water footprint of cotton consumption](#), Unesco 2005. The stated figure is for blue water only.

not generate the same impacts as bio-sourced fibers, as their production relies on fossil fuels. This applies to both clothing and footwear.

The Sustainable Apparel Coalition's textile fiber database (MSI) reflects the diversity of environmental impacts, with a single environmental impact score for each fiber type. The score aggregates each fiber's impact on global warming, eutrophication, water scarcity, fossil fuel resource depletion and chemical usage. This database is used to calculate an aggregated **fiber environmental impact** score at both the product and company level in order to reflect impacts generated by textile fiber production. Assessments are performed separately for clothing, household textiles and footwear.

However, when considering a garment's entire lifecycle, it is important to note that the greatest climate change impact stems from a product's use phase: washing clothes consumes a significant amount of electricity and generates wastewater effluents. This use phase represents on average more than 50% of a tee-shirt's lifecycle impact on climate change³. Because companies have little or no room to influence use phase, these impacts are not included in this assessment.

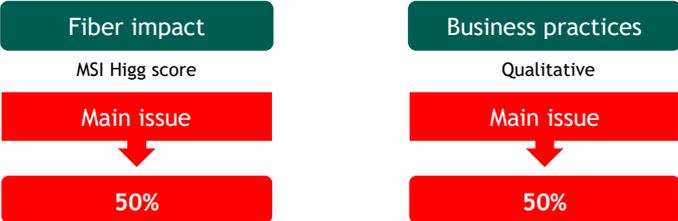
The second crucial impact of the apparel industry's business model is a company's impact on product life expectancy by promoting more versatile fashion trends with continually renewed collections ("fast fashion" effect) and offering services that lessen consumer renewal needs such as long-lasting warranty or repair services. These elements are evaluated in the **business practices** indicator.

³ Source: [The Carbon Trust](#).

3. Environmental performance indicators

Environmental performance indicators for the apparel and textile company assessment are:

| Environmental stakes | Selected KPI |
|---------------------------------------|---|
| Climate, resources, water, ecosystems | Fiber impact, based on Higg Index score (corrected) |
| Climate, resources, water, ecosystems | Business practices (qualitative assessment) |



The first indicator represents a majority of the apparel and textile industry’s environmental impact (outside of use phase), and the second one can be considered as having a “multiplier effect”. Indeed, garments’ lifecycle impacts must be normalized by their average lifespan, to reflect products efficiency. Therefore, business practices affecting products lifespan (like fast fashion model) are key determining factors of apparel & textile products and companies’ environmental impact.

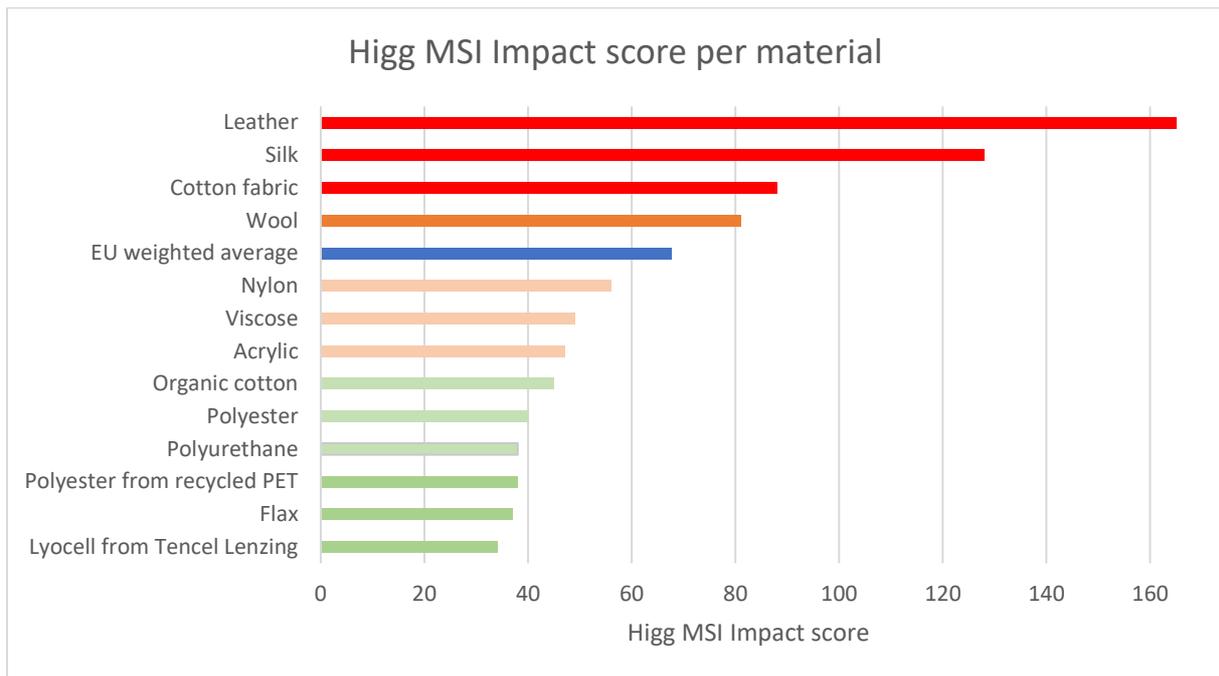
3.1. Fiber impacts component

With the assistance of key apparel sector companies, the Sustainable Apparel Coalition (SAC) determined a single environmental impact score for the main types of fibers per kilogram of material. The five environmental impacts considered include:

- **Climate change**, based on IPCC 2013 data
- **Eutrophication**, which occurs when excessive nutrients pervade a body of water, typically from land runoff, and cause dense plant growth that affects local fauna through oxygen deprivation.
- **Water scarcity**, to measure environmental impacts of freshwater consumption
- **Abiotic resource depletion**, to account for fossil fuels that are consumed faster than they are replenished
- **Chemistry**, a qualitative assessment of chemicals used in the fiber production process

Each fiber is assessed on these five indicators by calculating the deviation of its impact from the industry average, based on company data. The fiber’s impact is compared to the industry’s weighted average (fibers used in volume) to obtain a fiber’s score for each indicator. These indicators are then aggregated into a single score, with an equal weighting. Higher scores reflect greater environmental impacts.

The full methodology and underlying assumptions used by the SAC are available [here](#). The following graph indicates each principal material type’s score:



3.1.1. Apparel case

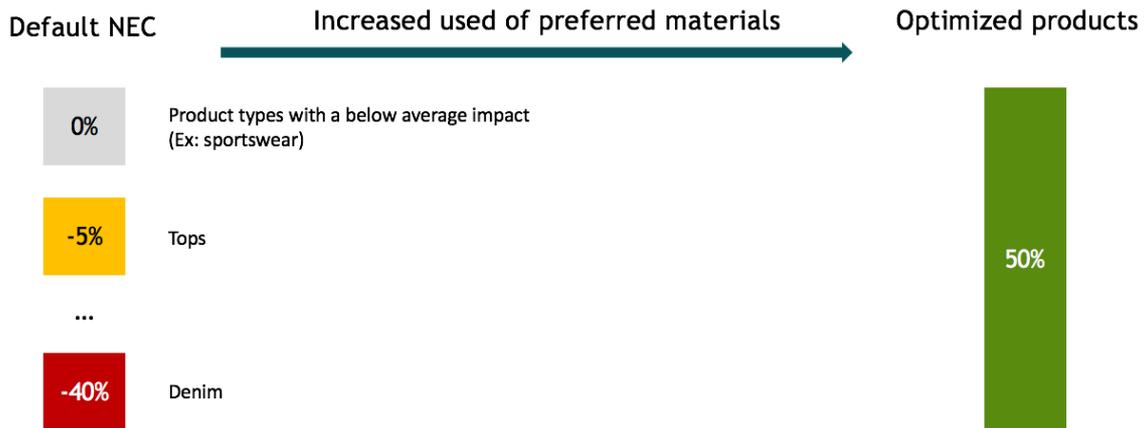
To account for only limited disclosures of information by companies, more details for other garment types are obtainable from the European Commission’s IMPRO textiles study. For instance, sportswear on average uses more polyester than the ready-to-wear industry, which uses more cotton. Thus, **an average score** is determined for different garment types.

It is important to note that a company’s choice of **preferred materials** such as organic cotton over conventional cotton, or recycled PET instead of polyester, can significantly alleviate environmental impacts. As seen in the graph above, while conventional cotton is among the most impactful fibers (scored at 88), organic cotton is less harmful (scored at 45, largely because of lower water consumption). This framework therefore considers both the nature of a company’s activities (i.e. making more cotton-based garments increases impacts) and efforts to reduce their effects (incorporating organic cotton, for instance).

To determine a product’s Net Environmental Contribution (NEC), an average MSI score is defined based on average garment composition, as well as an optimized score based on ideal use of preferred materials: optimized garments replace all cotton with organic cotton, all polyester with PET-recycled polyester, and replace 5% of viscose and nylon with Lyocell (limited substitutability).

For each garment type, a fiber impact component is evaluated based on fiber distribution and company-specific efforts to use preferred materials. The NEC of garment types with low impact fibers such as sportswear ranges from 0% to 50%, whereas the NEC of garment types with impactful fibers ranges from -50% to 50%.

These methodological principles account for both the **relative impact of garment categories** (some products are more impactful than others, and therefore not using preferred materials is negative), and their **limited substitutability** (garments are not simply compared based on fibers’ average impacts).



For example, the average score for denim products is not equal to a 0% NEC, as denim products have higher impacts due to a proportion of cotton. Average denim products with no preferred materials have negative impacts.

For cotton, industry certifications such as the Better Cotton Initiative (BCI) ensure that environmental impacts are at least partially optimized. This can be considered a partial “eco-solution” with a 50% NEC.

It is important to note that **leather** is by far the most impactful material in the apparel and footwear industry, with an MSI score of 165 due to cattle ranching’s high climate change and water footprints. Given that leather is highly substitutable in the clothing industry, if garments with leather are broken out among a company's products, they are then scored -50%.

3.1.2. Household textile and footwear case

Household textiles such as bed and table linens are assessed and scored using this same approach since the IMPRO study provides fiber volume and distribution of these items. Note that cotton-based products are assessed separately from non-cotton based products given their limited substitutability. The latter are scored between 0% and 50%, as their fiber production has fewer impacts than cotton production.

The **footwear sector** is different due to the prominent use of leather. According to Eurostat, leather shoes represent 25% of produced and imported European footwear, with shoes that incorporate some leather accounting for another 32%. Thus, any comparison to the EU average would make non-leather shoe types appear as “eco-solutions”, and would not meaningfully reflect a company's true environmental performance. We’ve thus adopted a footwear-specific approach based on two parameters.

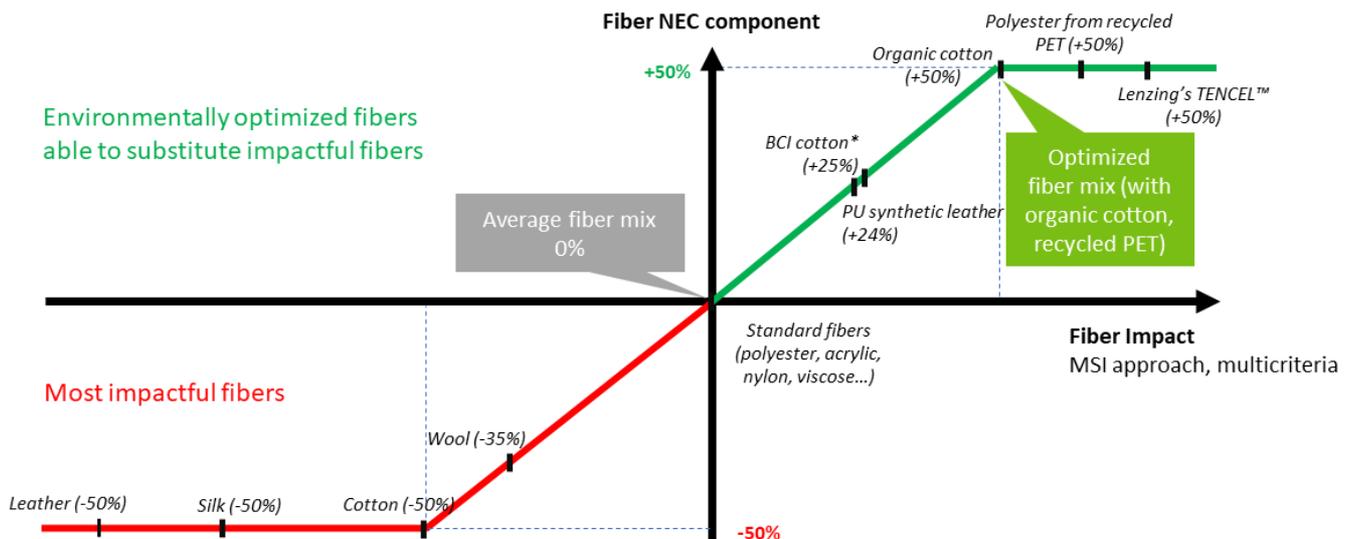
First, company's **dependence on leather** is analyzed by comparing the company's product mix to the market average. If a company's average score is negative, then a company uses more leather than average. If a score is positive, this parameter is zeroed out to avoid artificially favoring specific types of shoes such as sports shoes. The second parameter considers the use of **preferred materials** for each shoe type using the EU Product Environmental Footprint, which provides a distribution of materials per shoe type (“bill of materials”) to which the Higg score can be applied. Preferred materials may include organic cotton, recycled PET or recycled polyurethane, among others. For instance, leisure shoes generally incorporate a significant portion of cotton; the use of organic cotton significantly improves a product’s environmental impact score.

3.1.3. Fiber producers case

Fiber producers are responsible for producing fibers with minimal environmental impacts and developing alternative fibers with clear **substitutability effects**. To consistently allocate NEC to fiber types, three categories are identified:

- **Standard fibers:** fibers such as polyester and nylon, parts of the global standard fiber mix. For instance, even though polyester has a limited environmental footprint according to the Higg approach, it cannot be considered an Eco-solution because of unaccounted environmental issues (plastic leakage, microfiber pollution) and its limited substitutability with other fibers. Therefore, despite a lower MSI score, standard petro-sourced fibers like polyester are considered “business as usual” solutions, and have a 0% NEC.
- **Fibers/materials with significant environmental impact:** production of leather, conventional cotton and wool has significant global environmental impacts. Despite being standard fibers, their NEC reflects impacts relative to the market average.
- **Fibers with optimized environmental impacts/substitutability effects:** fibers that are substitutes for standard/impactful ones and that have clear environmental benefits such as organic cotton and Lenzing’s Tencel. These have a positive NEC; NEC is proportional to the environmental benefit compared to market average.

The graph below illustrates the application of these scoring principles:



This fiber component is then added to the **business practices** component, if specific business practices can be identified for fibers produced (e.g. fibers used for fast fashion products).

Data availability and practical tips

Companies do not usually disclose data on the distribution of fiber types. If no further information can be obtained, distribution is estimated based on a company's product lines. If product distribution is estimated (by counting catalogue references, for instance), then the user can use the tool to estimate a company's fiber use and impact score.

Example:

number of jeans references for H&M woman apparel, H&M website

Companies often report shares of preferred materials, especially for organic cotton, thanks to stakeholder expectations.

Example Inditex reporting on organic cotton:

product integrity. In 2014, at Inditex we have placed 34 million items of certified 100% organic cotton items on the market. This translates to consumption of 4,219 tonnes of organic cotton, which implies growth of 318% in weight.

Source: Inditex website

As this report does not provide the percentage of organic cotton used and lacks other information, we assume the share is in line with the share of organic cotton in global cotton production (approximately 1%).



3.2. Business practices component

Lack of clear quantitative indicator over apparel and textile products lifespan makes business practices assessment difficult. However, given the crucial importance of this parameter in the sector's footprint, the framework includes reasonable proxies that reflect the sustainability of apparel and textile companies' business practices.

Frequency of collection renewal reflects a company's involvement in "fast fashion": the more a company bases its revenue on short-term collections and continual purchases by customers, the more it promotes apparel overproduction and shortened garment lifetimes. "Fast fashion" garments are worn an estimated average of seven times compared to 125 times for a regular garment. Moreover, fast fashion brands produce an average of 20 collections per year, compared to a "common sense" rhythm of two collections per year for regular garments (see sources for details).

Therefore, if a company relies on quick and frequent collection turnaround, its business practices are inherently harmful and earn a -50% business practices NEC.

Contrastingly, certain business practices can significantly mitigate a company's environmental externalities, and therefore generate a positive business practices NEC. These practices increase items' lifetimes, thereby decreasing pressure on production resources. Doubling the average number of times a garment is worn can decrease greenhouse gas (GHG) emissions associated with the textile value chain by an estimated 45% (see Ellen Mc Arthur foundation report for details).

Extended warranties and **clothing repair, resale or rental** are positive business practices apparel & textile companies can implement. Since all of these practices may help significantly lengthen a product’s lifetime, they have a positive NEC of +25% (significant contributors to lowering the textile value chain’s impacts).

Each parameter’s influence on a company’s NEC is summarized in the table below:

| Apparel & footwear business practices | Business practice NEC |
|--|-----------------------|
| Fast fashion | -50% |
| Undifferentiated business practices | 0% |
| Clothing resale | 25% |
| Clothing rental | 25% |
| Repair services and/or extended warranties | 25% |

These business practices components are to be applied only to applicable product lines (e.g. only jackets are subject to extended warranties).

Data availability and practical tips

The “fast fashion” business model is often clearly stated by analysts or the company itself, with an emphasis on the short timeframe between product conception and rollout in retail stores.

Example:

Business

Companies

Example:

Source: Patagonia’s program to promote reuse and recycling, Patagonia website

Zara’s strategy involves stocking very little and updating collections often. Instead of other brands that only update once a season, Zara restocks with new designs twice a week, [reported Suzy Hansen at the New York Times](#).

Insider, 2012

that promote longer product lifetimes and the circular economy usually broadcast policies prominently.



3.3. Jewelry, eyewear and accessories

Although jewelry is sometimes classified within the apparel/luxury value chain, it should be analyzed using the metals required for manufacturing. However, given the limited quantity jewelry represents as a final use for precious metals and the absence of **specific quantifiable function**, this activity has a **default 0% NEC** for undifferentiated final use.

Fashion accessories and eyewear segments are not assessed either, as environmental impacts of these segments largely differ from those of clothing and footwear. However, for certain products such as handbags, leather is considered substitutable (a leather bag does not fulfill a function distinct from that of a textile bag), so the **share of leather products has a -50% fiber component NEC**. Due to limited environmental impacts and the absence of **specific quantifiable function**, accessories have a **default 0% NEC** for undifferentiated final use.

4. Main limits

As a key specificity of this framework, the methodological approach for apparel products sets an **average below 0%** for several apparel types, because best practices are marginal (organic cotton accounts for less than 1% of global cotton production⁴). “Doing nothing” in terms of preferred materials integration therefore generates a 0% NEC. However, in order to reflect specific environmental impacts of some apparel types (e.g. denim), and to spread company performances from -100% to +100%, the average is below 0% for the apparel types relying mostly on impactful fibers. Overall, ready-to-wear apparel has an average -1% NEC.

Another limitation is the lack of robust quantitative indicators to rank the sustainability of corporate business practices, while still needing to account for practices when scoring. Companies do not disclose metrics like “collection renewal rate” or “product average lifespan”, metrics needed to precisely assess and benchmark performance.

A key advantage of this approach is accounting for both the impact of a company’s activities (e.g. using more cotton than polyester is more impactful) as well as specific efforts to reduce and optimize impacts. The use of SAC data enables the aggregation of various environmental impacts with a common metric, essential for comparing organic versus synthetic materials. Moreover, it provides a clear definition of “eco-solutions” by taking into account specific sector issues (i.e. leather in the footwear sector).

Considering fashion accessory impacts, assessing more alternative substitute materials (such as specific natural rubbers and bioplastics) and refining business practice assessments with more granular options could further enhance this framework. Including use phase (e.g. temperatures required to efficiently wash fibers) in the environmental impact assessment would be another valuable but complex enhancement.

5. Key data sources

| Data | Sources |
|--|--|
| Textile fiber environmental impact | Sustainable Apparel Coalition Higg MSI index: http://msi.higg.org/sac-materials |
| Distribution of fibers types per garment and household textile | European Commission IMPRO textiles study http://susproc.jrc.ec.europa.eu/textiles/docs/120423%20IMPRO%20Textiles_Publication%20draft%20v1.pdf |
| Footwear production and imports in the EU | Eurostat website http://ec.europa.eu/eurostat |
| Average bill of materials per shoe type | European Commission Product Environmental Footprint (PEF): http://ec.europa.eu/environment/eussd/smgp/ef_pilots.htm |
| Statistics on garments use | https://www.ellenmacarthurfoundation.org/assets/downloads/publications/A-New-Textiles-Economy_Full-Report_Updated_1-12-17.pdf |
| Fast fashion details | https://www.mckinsey.com/business-functions/sustainability/our-insights/style-thats-sustainable-a-new-fast-fashion-formula https://www.abc.net.au/news/2017-03-28/the-price-of-fast-fashion-rivers-turn-blue-tonnes-in-landfill/8389156 |

⁴ Source : [Organic Trade Association](http://www.organictradeassociation.com)



The holistic metric
guiding environmental
action

APPLIANCES FRAMEWORK

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1. Introduction

The appliance value chain includes companies that produce household and professional appliances as well as associated retail activities. As key contributors to household electricity consumption, appliances have a direct and significant impact on energy demand.

The industry can be split between large domestic appliances (refrigeration, cooking and washing/drying equipment) and small domestic appliances (kitchen robots, lighting items etc.).



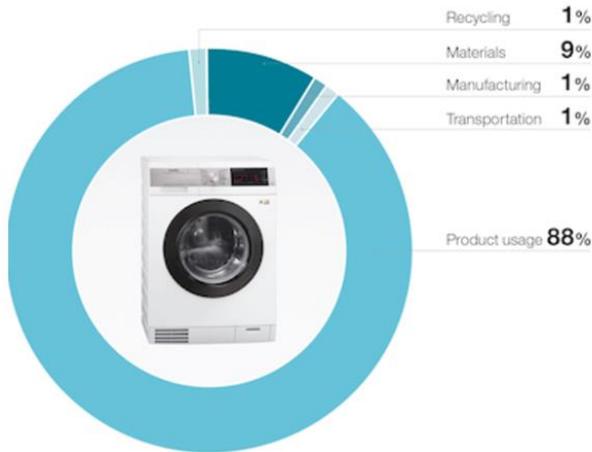
These products’ primary impact, especially large appliances, is on climate (through electricity consumption) and water (if relevant) due to use-phase consumption. Altogether, appliances account for most of a household’s electricity consumption despite continuous performance improvement.

2. Main environmental issues

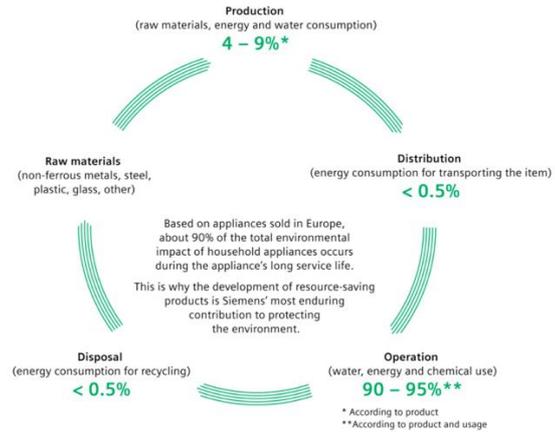
| Environmental stake | | Relevance along value chain | | Comments | Data availability |
|---------------------|-----------------------------|-----------------------------|-----|---|---|
| | | Direct | Use | | |
| Climate | Climate change | | | Significant impact on household electricity consumption | Product's energy labelling |
| | Use of energy resources | | | Idem | |
| Air Quality | Air quality deterioration | | | Marginal issue | |
| Water | Water consumption | | | Mainly associated with large domestic washing appliances | Product's environmental labelling |
| | Water pollution | | | Impacts associated with detergents use | Outside company scope |
| Biodiversity | Soil pollution | | | Marginal issue | |
| | Land use | | | Marginal issue | |
| Resources & Waste | Use of non-energy resources | | | Metals and plastics required for appliance production, IT components | Integration of recycled materials reported by companies |
| | Waste | | | The sector produces significant volumes of non-hazardous waste, product lifespan shortening | Difficult to hierarchize impact of company policies |

| Legend | |
|---|------------------------------|
|  | High impact intensity |
|  | Significant impact intensity |
|  | Limited impact intensity |

As illustrated by the figures below, the environmental impacts of domestic appliances are mostly concentrated in products' use phase, as these products generate intensive energy/water consumption.

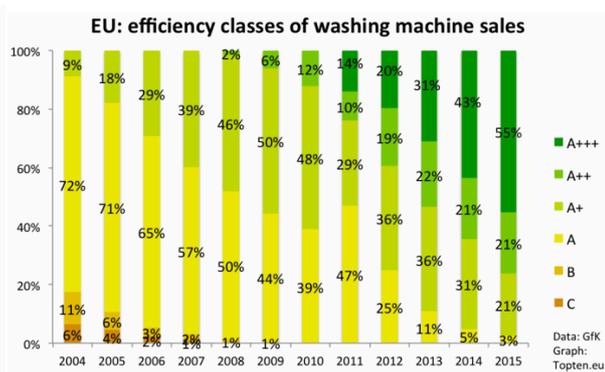
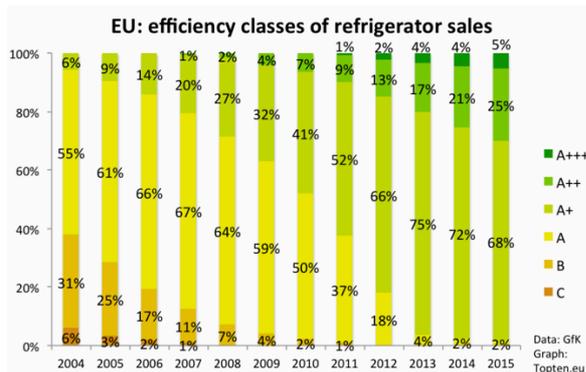


Source: Electrolux website

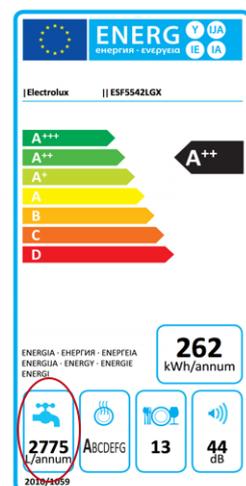


Source: Siemens website

Appliances' **energy** and **water efficiency** (if relevant) can be benchmarked against the performance of available products in the market. However, since products' performance improves rapidly over time, best performing products become standard performers in a short amount of time (illustrated by the number of products sold in the EU that achieve the best European energy label in some categories).



The graphs above underline how diverse average energy performance can be depending on appliance type. For example, A+ products dominate the EU refrigerator market, whereas most washing machines are already A+++. These labels are defined by fixed minimum energy performance standards (MEPS), updated in 2018 at the European level given the fast evolution of the baseline. European domestic appliances' environmental labelling also includes annual water consumption when relevant.



Therefore, the most relevant information to rank companies on performance and/or consumption is to be collected at the **product level**, especially if a company does not disclose aggregated environmental labelling statistics by product type.

| Category | Subcategory | EU environmental labelling |
|----------------------------------|--|----------------------------|
| Large domestic appliances | Domestic cold appliances (refrigerator, freezer) | Yes |
| | Domestic washing appliances (dishwasher, washing machine, dryer) | Yes |
| | Large domestic cooking appliances (oven, cooker hood) | Yes |
| | Other: TV, lighting, vacuum cleaner | Yes |
| Small domestic appliances | Small kitchen appliances (robots, beverage makers) | No |
| | Other (small heating/cooling appliances) | No |

Source: ADEME

Moreover, impacts associated with domestic appliance material use (especially plastics and metals) and end-of-life (significant waste volumes to manage) can be improved via responsible corporate **business practices**, especially through specific policies that enhance **product lifespans**. Product lifespans are estimated using reliability testing and warranty conditions.

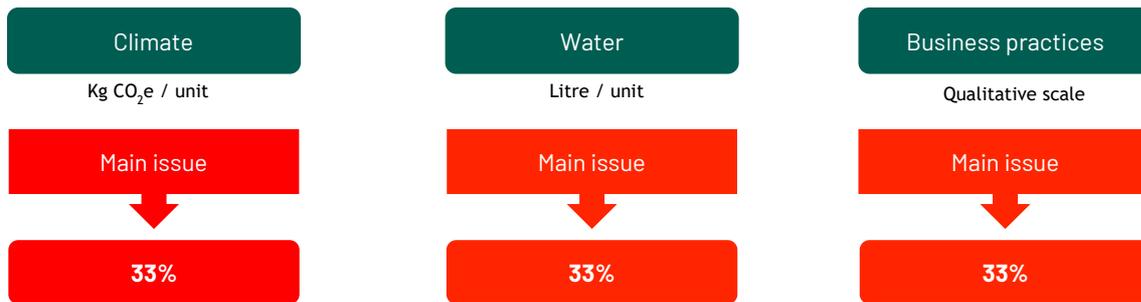
The primary environmental issues that are both key for the sector and measurable at product category level are:

- **Climate change impact through product energy efficiency**
- **Product water consumption (if relevant)**
- **Business practices**

3. Environmental performance indicators

To quantify the impact of each of the environmental issues, the following set of performance indicators has been selected:

| Components | Selected KPI |
|---------------------------------|---|
| Climate | Product energy efficiency (kg CO ₂ e/unit) |
| Water (optional, when relevant) | Water consumption (litre/unit) |
| Business practices | Warranty and reliability scales |



Climate change, water and business practice indicators are equally weighted, as these are all key in determining impacts of domestic appliances. When water is not relevant to a product category, climate change and business practices are equally weighted, as summarized in the table below.

| Product type | Climate | Water | Business practices |
|--|-----------------------|----------------|--------------------|
| Water-consuming large appliance (ex: dishwasher) | 33% | 33% | 33% |
| Non water-consuming large appliance (ex: Oven) | 50% | Not applicable | 50% |
| Small electric appliances | 50% (0% component) | Not applicable | 50% |

Also, since domestic appliance impacts are **moderate** compared to high-impact sectors (e.g. oil & gas or food), appliances are ranked in the “moderate” impact value chain category. Consequently, a company’s Net Environmental Contribution (NEC) in this value chain is calibrated, and **final NECs are divided by 3**.

4. NEC calculation

The application of NEC principles to Appliances companies relies on the following equation:



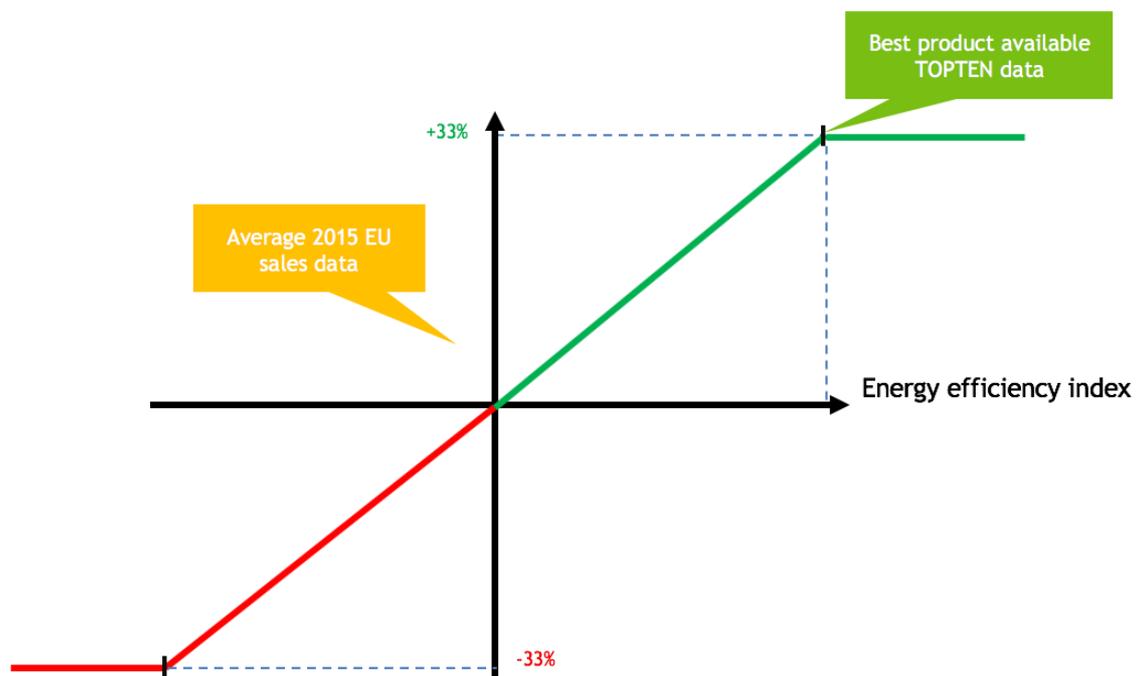
This equation has to be applied at **product level**, and therefore requires the collection of **energy** and **water** data for the different product ranges. **Business practices** data on products’ reliability have been computed from an external database, and warranty practices usually cover a product range or a complete brand.

The calculation of each component, based on these input data, is detailed below.

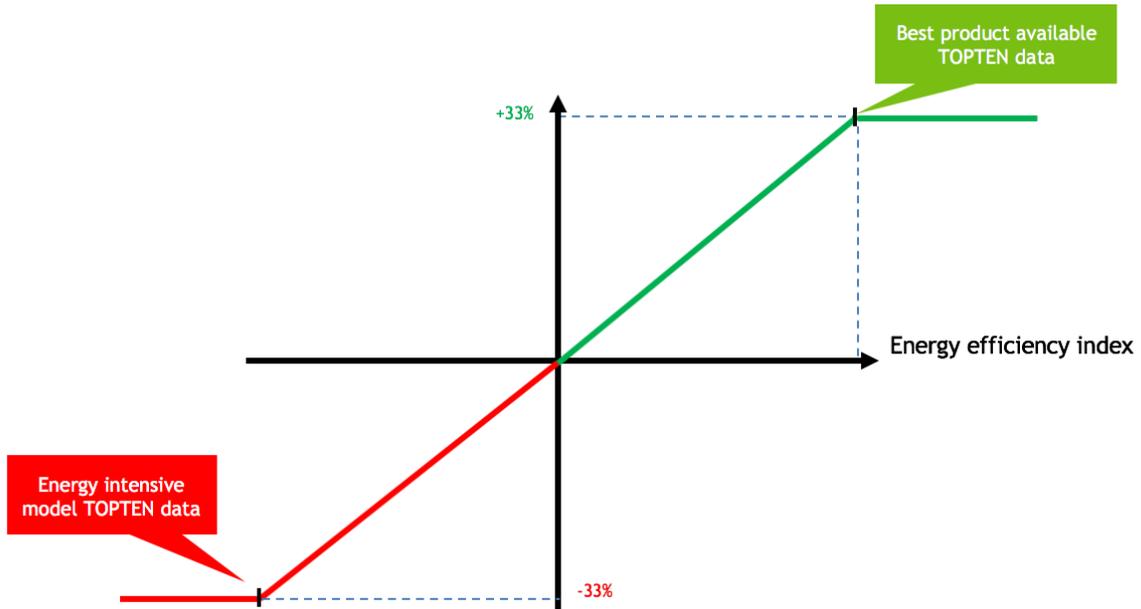
4.1. Climate component

Domestic appliance energy efficiency is expressed as an energy efficiency index (EEI), then normalized on a A+++ to F scale. Most appliances are now available in only the best categories, and the bottom of this scale has become obsolete. For instance, the lowest performing washing machines are now ranked A+. A+++ products, therefore, cannot be considered as a *de facto* eco-solution given that high ratings are now the market average for certain appliance types. Thus, it is necessary for each large domestic appliance type to have a specific rating scale.

For refrigerators, washing machines and tumble dryers, www.topten.eu provides the distribution of 2015 sales by energy label – providing a market average to use as the scale’s “point 0%”. The Topten website also discloses the **best available technology** for each product type and identifies the current **eco-solution** in the market. These two points define the rating scale.



For other domestic appliance categories that do not have sales data available, the scale is defined by two extremities – the deviation between best and worst performing products, found using TOPTEN data.



Moreover, **small electric appliances**, for which no standard product-level information is provided, have a 0% climate NEC component since this component is relevant but not assessable (no standard product labelling). The business practices indicator remains applicable.

Data availability and practical tips

Collecting product-specific data may be time-consuming but is seemingly the only way to reflect product performance without reliable company-level data. Product environmental data is collected from commercial websites that follow the same format.

Example:



Environmental labelling of a washing machine, Electrolux website

When a precise EEI is not disclosed, the user substitutes a default value for each energy class (e.g. A+++, A++) provided in the Excel tool. Of note, some companies may have numerous references with the same

rating, especially if only the energy label is disclosed. All products can be entered in a single line by completing the “number of references” column.

Revenue breakdown by product category can be found in a company report. When provided data is not granular enough, approximate the breakdown by counting the **number of references** for each product type.

Example:

| | 2016 |
|----------------------------|------|
| Laundry Appliances | 28% |
| Refrigerators and Freezers | 28% |
| Cooking Appliances | 18% |
| Other | 26% |
| Net Sales | 100% |

Whirlpool 10K report 2016

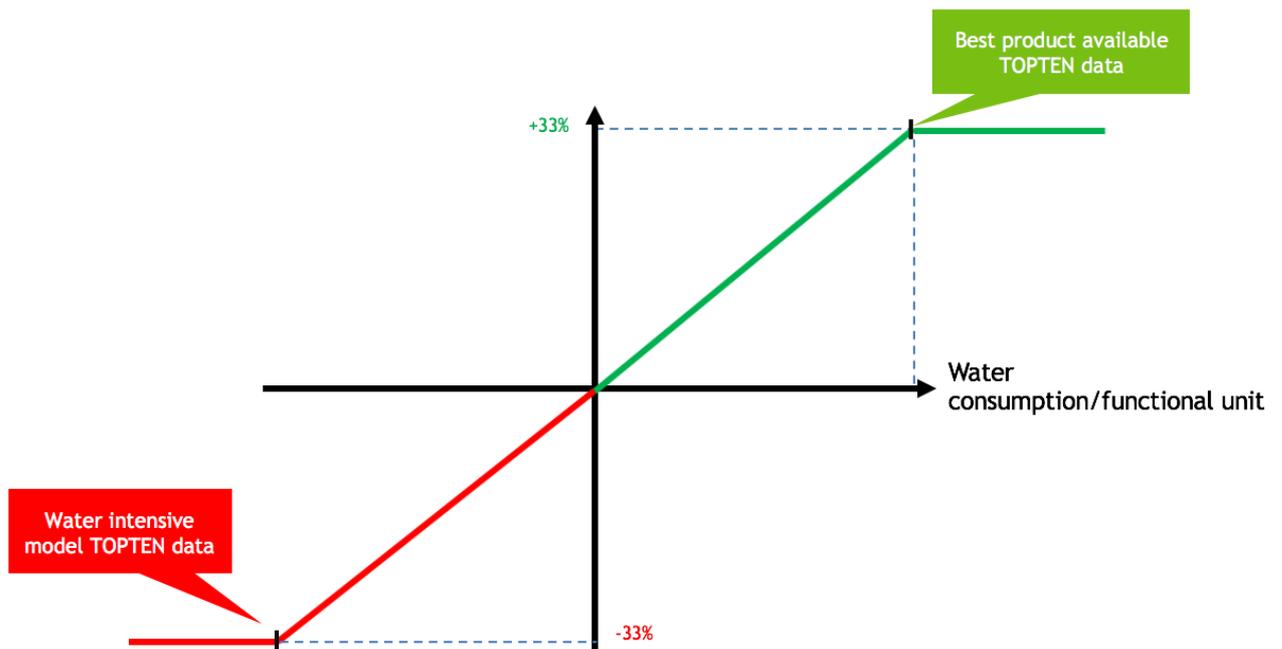
In this example, appliances are grouped by category, which can be further split using the number of references.

4.2. Water component

The water component calculation for large water-consuming appliances (dishwashers and washing machines) follows the same rationale as electricity consumption. The highest/lowest **water consumption/functional unit** ratios are determined based on EU Topten data. The functional unit is number of servings for a dishwasher, and kg of clothes for a washing machine.

Water consumption and functional unit are included in the mandatory disclosures on a product’s environmental labeling, therefore available at product level.

If a product does not have use-phase related water consumption, this component is not applicable.



Data availability and practical tips

Collecting product-specific energy consumption data may be time-consuming but is the only way to reflect product performance without reliable company-level data. Product environmental data is collected from commercial websites that follow the same format.

Example:



Environmental labelling of a washing machine, Electrolux website

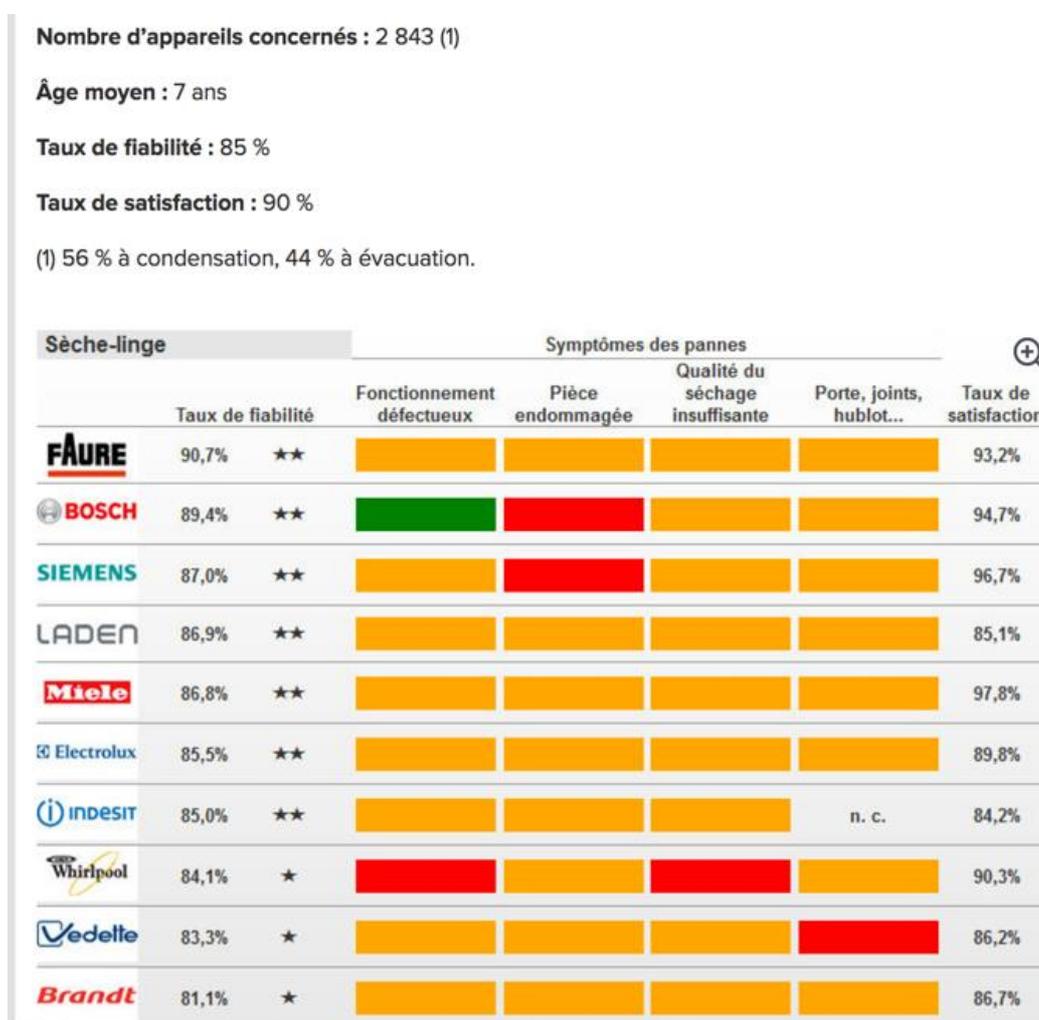
Even though water consumption data may vary within an energy label (not all A++ products have the same consumption), several references may have the same water consumption and functional unit and can be entered on a single line by completing the "number of references" column.

Revenue breakdown by product category can be found in a company report. When provided data is not granular enough, approximate the breakdown by counting the **number of references** for each product type.

4.3. Business practices component

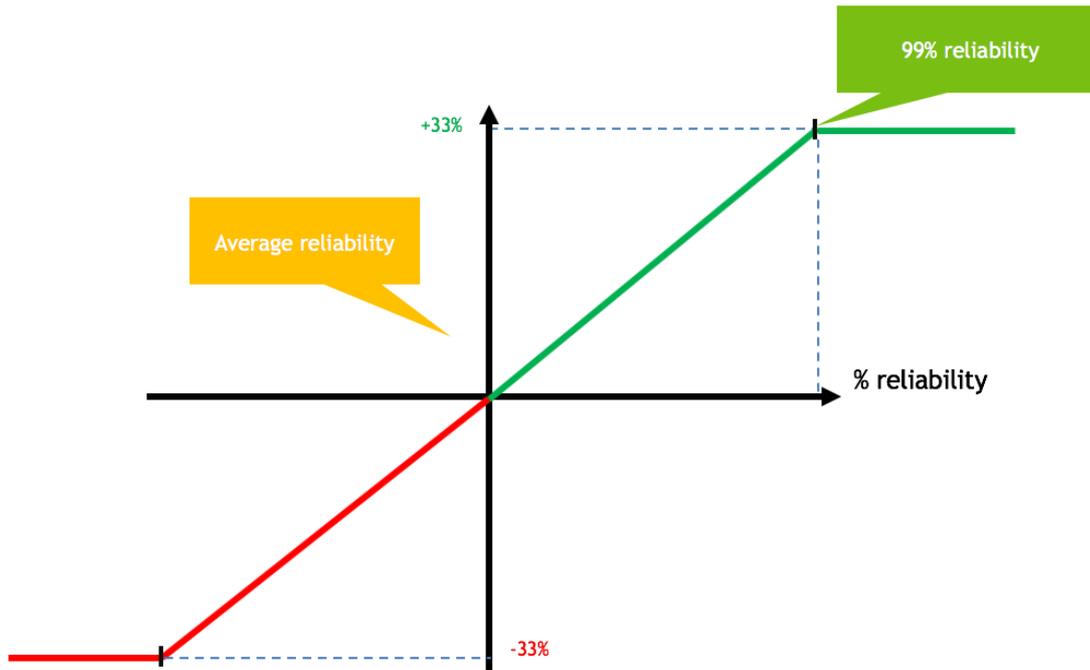
The **business practice** scale used to calculate this indicator is similar to calculations used in the furniture framework. It ranks companies by **product quality/lifespan** and examines **product warranty conditions** compared to estimated lifetimes as proxies of a company’s product quality. Average lifetimes for several domestic appliance types are provided in the Excel tool.

This framework also considers the **reliability** of a company’s products, based on testing data aggregated by “UFC- Que Choisir”. This independent French organization tested for each large domestic appliance type the reliability of each brand and average product reliability.



Source: UFC Que Choisir website

The optimal product reliability (the eco-solution point) has been set at 99%, estimated to match high quality professional equipment reliability and based on the assumption that 100% reliable products are not realistic. These two points define the business practice component NEC scale for each appliance type, with results then averaged at company level.



Data availability and practical tips

Warranty practices are usually disclosed on a company's commercial website. Warranty conditions can be complex (e.g. only cover certain product parts) so the most representative duration needs to be identified by the user.

Example:

La durée de garantie en France pour les appareils électroménagers Seb commercialisés jusqu'au 31 décembre 2015 est de 1 an, et de 2 ans sur les appareils commercialisés à compter du 1er janvier 2016.

Seb website, 2017

The information above provides the standard warranty period for Seb's domestic appliances.

Some information like a product's reparability is also relevant, but cannot be integrated in the rating. (This is better captured by a company's qualitative ESG assessments.).

Example:



Seb program for products' reparability, company website

5. Main limits

The main benefit of this approach is the focus on product consumption during use phase, the most significant phase of the lifecycle by far in terms of environmental impact. The framework examines both electricity and water consumption, two major impacts of daily household activities. It also considers performance of products currently sold, when available.

The main limitation is the difficulty to aggregate product-level information at company level, and the lack of information for products not subject to environmental labelling such as small domestic appliances. Also, product performance evolves extremely quickly in some segments, which makes an “eco-solution point” difficult to capture, and average market data difficult to obtain.

This methodology could be enhanced by looking at material recyclability to account for the important amount of waste generated by the sector. However, this would require even further product-level analysis.

6. Key data sources

| Data | Sources |
|--|---|
| Domestic Appliances European Market Monitoring | ADEME's market report 2016: http://www.topten.eu/uploads/File/Market-Monitoring-2016-EN-Topten.eu.pdf |
| European environmental labelling details | ADEME's guidance on environmental labelling http://www.ademe.fr/sites/default/files/assets/documents/fiche-les-etiquettes-environnementales.pdf |
| EU sales per energy performance label | Topten's market data http://www.topten.eu/uploads/File/Market-Monitoring-2016-EN-Topten.eu.pdf |
| Average lifespan per domestic appliance type | http://www.gifam.fr/article/etude-tns-sofres-sur-la-durabilite-des-gros-appareils-menagers.html http://ademe.typepad.fr/files/dur%C3%A9e-de-vie-des-eee.pdf http://www.universconso.com/Duree-de-vie_475.html |
| Product reliability by brand | <ul style="list-style-type: none">- UFC Que Choisir website (2013 data)- https://www.quechoisir.org |



The holistic metric
guiding environmental
action

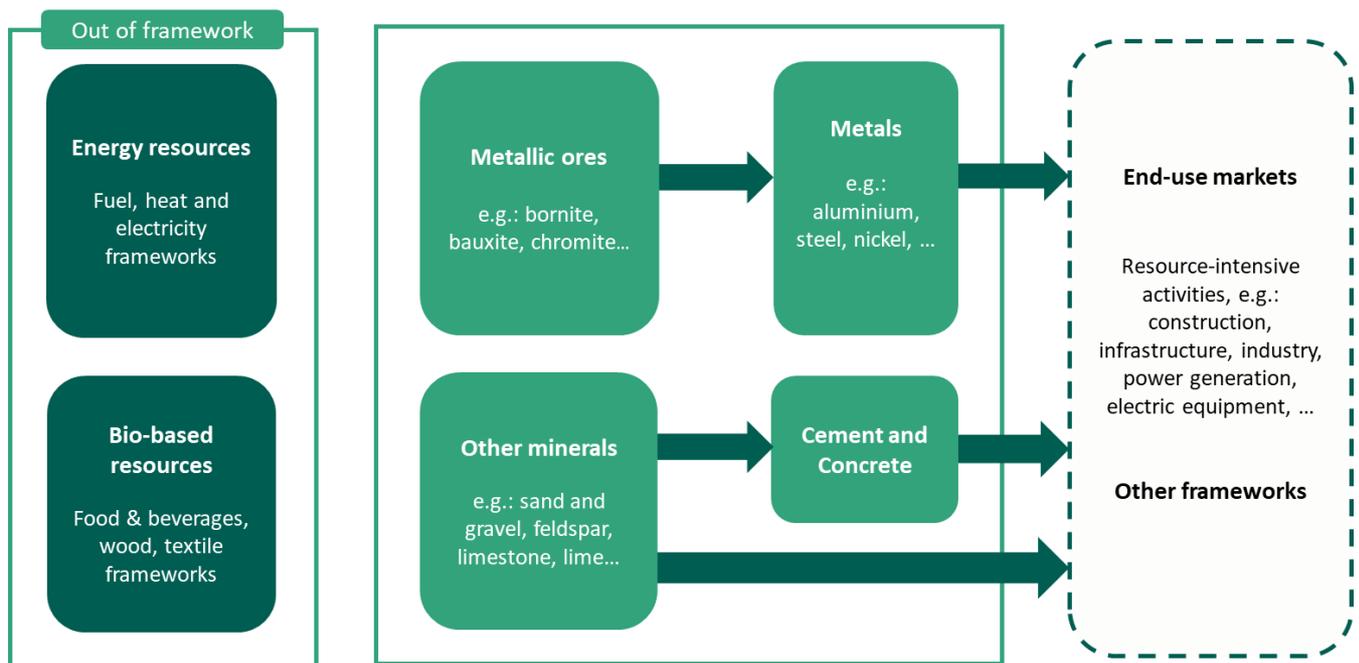
BASIC MATERIALS FRAMEWORK

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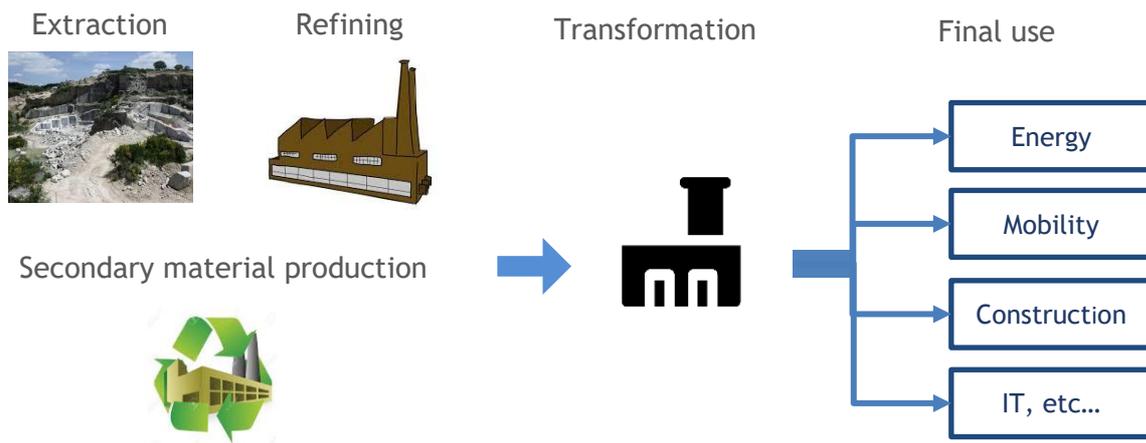
1. Introduction

The basic materials framework covers activities involved in the discovery, development and processing of raw materials. It enables to calculate the NEC for metals, metallic ores, other minerals, cement and concrete, which are used in resource-intensive industries such as construction, aeronautics, automobile manufacturing or power generation. This framework does not cover energy, chemicals and bio-based resources.



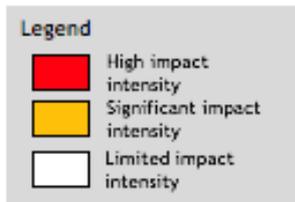
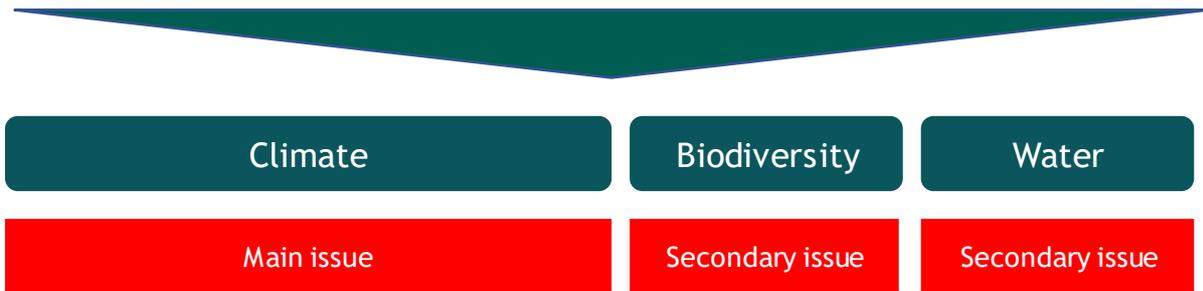
2. Metals and metallic ores

Mining has always had a large-scale impact on the global environment, not only locally by harming biodiversity and ecosystems, soil and water, but also worldwide by causing significant GHG emissions and resource depletion. In recent decades however, increasing norms and regulations have helped limit these harmful effects. While far from transparent, companies nowadays are more willing or obligated to disclose their sustainability policies and results. As for mining, metal transformation also has a significant ecological footprint, as it generates more than 4% of world GHG through energy-intensive plants. For instance, producing one ton of pure aluminum consumes more than 15 MWh of electricity.



2.1. Main environmental issues

| Environmental stake | | Relevance along the value chain | | | Comments |
|---------------------|-----------------------------|---------------------------------|------------|------------------------|---|
| | | Upstream (extraction) | Production | Downstream (use phase) | |
| Climate | Climate change | Yellow | Red | | Direct GHG emissions from mining activities contribute 36% of direct GHG emissions from industry. Mining sector is thus a significant contributor to climate change. However, in some cases, basic materials can have a positive impact on climate change because of their key role as critical components in the climate transition (e.g. Neodymium in wind turbines). |
| | Use of energy resources | Yellow | Red | | Metals refining and transformation consume significant amounts of energy. For instance, producing one ton of pure aluminum consumes more than 15 MWh of electricity. |
| Air quality | Air quality deterioration | Yellow | Yellow | Yellow | Mining emits metals into the atmosphere, including a significant direct impact through the generation of dust & particles. Direct impact is significant but metals also represent key enablers for depollution (e.g. catalytic converters). |
| Water | Water consumption | Red | Yellow | | Mining activities require significant quantities of water, in particular for waste treatment. Large industry and manufacturing (excluding energy) use about 4% of the world's total water withdrawal. |
| | Water pollution | Yellow | Yellow | | Heavy metal pollutions (cadmium, copper, zinc) have disastrous effects on both water quality and water availability in the pit zone. Mining sector is thus a serious contributor to water pollution. |
| Biodiversity | Soil pollution | Yellow | Yellow | | Mining causes only 3% of the contamination found in European soils overall. However, UK Environment Protection Agency estimates that more than 90% of soils near rivers are contaminated by heavy metals due to nearby mining activity. Based on these two facts, contribution of this sector to soil pollution is considered to be significant. |
| | Land use | Red | | | Land use changes are mainly due to forestry, agriculture expansion and mining. |
| Resources & waste | Use of non-energy resources | Red | Red | | Use of secondary materials and recycling activities are means to limit depletion. Resource depletion linked to metal transformation is substantial: for instance, more than five tons of bauxite is needed to yield one ton of pure aluminum. |
| | Waste | Yellow | Yellow | | Metals sector produces 3.1 million tons of waste each year, comprised of 77% of non-hazardous waste and 23% of hazardous waste. |



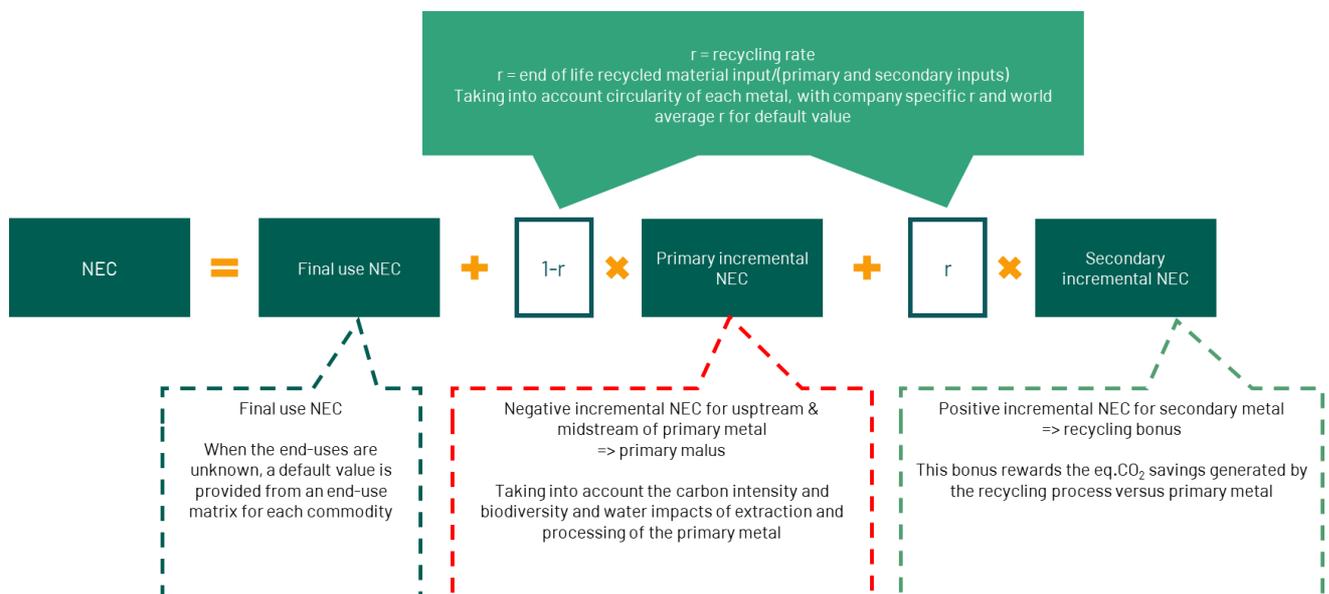
The main environmental issues that are both key for the sector and measurable at company level are:

- **Climate:** GHG emissions are key due to their role in climate change and because they represent much of the ecological footprint in metal transformation.
- **Biodiversity issue:** the biodiversity impact is greatest in mining's upstream operations, but still presents a secondary threat downstream mining and metals industry.
- **Water issue:** the water issue is relevant for both mining and metal transformation but, compared to climate, is considered secondary. The water issue depends more on the local situation (water stress area).

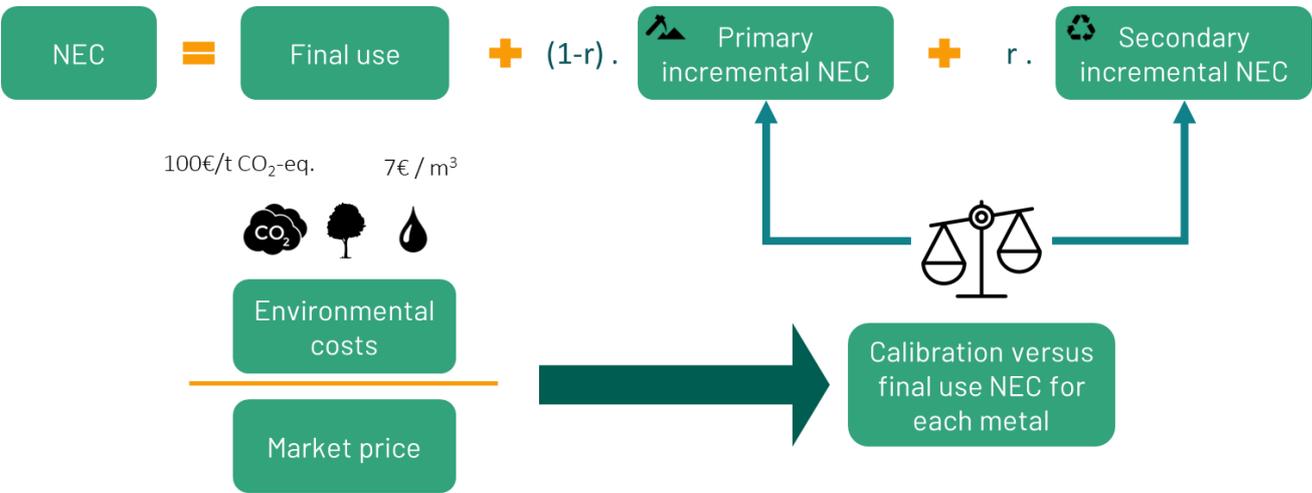
2.2. Environmental performance indicators

The following indicators have been selected to measure the Net Environmental Contribution (NEC) of the metals and metallic ores sector:

- **Final use:** via the NEC of the materials' end uses (usage matrix)
- **Primary incremental NEC:** upstream and midstream malus for primary metals production
- **Secondary incremental NEC:** recycling bonus
- **Recycling rate, r:** end of life recycled material input / primary and secondary inputs



The approach is based on the principle that it does not make sense to compare a ton of gold with a ton of steel, as these materials do not have the same function in society and economy. To step back from the methodological deadlock specific to life cycle analysis, which uses the functional unit to compare environmental impacts, an economical approach has been used. Thus, environmental impacts are monetized using the 2017 Environmental Prices Handbook from Delft University and compared to the economic utility measured by the average market price downstream (close to the final users) and over a significant time frame (10 to 20 years). The higher the ratio, the higher the primary and secondary incremental NECs.



Final use NEC

The final use NEC is calculated by commodity through a uses matrix that lists the end uses for each metal. This component quantifies the alignment with the environmental transition and is fed by multiple sources to establish these uses matrices, such as the Mineral Commodity Summaries from USGS, the global yearly study of Cyclope as well as numerous specialized studies on commodities.

Final use adjustments

The default uses matrix can be modified when the company discloses its end-use applications. In this case, the final use NEC derives from the company-specific split and the calculation can be facilitated by the Excel model, NEC 1.0 metals - template vdef, the tab template, column G, by selecting “adjusted” in the final use option, column F.

| | a. Type of material | b. Data | c. Turnover / EBITDA (m€ / m\$) / Prod. | % of Turnover / % of EBITDA | d. Final use option | e. Final use adjusted | d. EoL-RR | e. CO ₂ -eq. emissions (scope 1 & 2) in kg CO ₂ / kg | EoL-RR by default | CO ₂ -eq. emissions by default (scope 1 & 2) in kg CO ₂ / kg |
|--------------------|---------------------|---------------------|---|-----------------------------|---------------------|-----------------------|-----------|--|-------------------|--|
| Basic materials 1 | Steel | both data available | | #DIV/0! | by default | | 45% | 1,66 | 60% | 1,45 |
| Basic materials 2 | | | | ✓ | | | | | 0% | 0,00 |
| Basic materials 3 | | | | ✓ | | | | | 0% | 0,00 |
| Basic materials 4 | | | | ✓ | | | | | 0% | 0,00 |
| Basic materials 5 | | | | ✓ | | | | | 0% | 0,00 |
| Basic materials 6 | | | | ✓ | | | | | 0% | 0,00 |
| Basic materials 7 | | | | ✓ | | | | | 0% | 0,00 |
| Basic materials 8 | | | | ✓ | | | | | 0% | 0,00 |
| Basic materials 9 | | | | ✓ | | | | | 0% | 0,00 |
| Basic materials 10 | | | | ✓ | | | | | 0% | 0,00 |
| Total | | | 0,00 | #DIV/0! | | | | | 0% | 0,00 |

Calibration of incremental NEC

The incremental NEC calibration aims at defining a realistic weighting of the final use NEC and the incremental NECs. By comparing environmental costs with average long-term market prices, a proxy of the exposure of environmental risks has been determined. If the environmental costs exceed the market price, it means that the market of the corresponding commodity will be significantly exposed to a transition risk as soon as the companies are forced to pay the prices of their externalities.

The calibration is based on physical units derived from the life cycle analysis of four environmental stakes:

- Climate: kg CO₂-eq. / kg extracted
- Acidification: kg SO₂ / kg extracted
- Eutrophication: kg P-eq. / kg extracted
- Water consumption: m³ / kg extracted

These physical units are converted into economical values to be compared with the economic utility delivered by the metal to the economy. Data provided by Delft University have been used to set a price for each unit of pollutant:

- Greenhouse gas: 100€ / kg CO₂-eq.
- Terrestrial acidification: 5 394€ / kg SO₂
- Freshwater eutrophication: 1 898€ / kg P-eq.
- Water consumption: 7€ / m³

The resulting economical values enable to consistently weight the final use NEC, the primary incremental NEC and the secondary incremental NEC. The calibration derives from other frameworks for which a life-cycle carbon footprint per million € of economic value could be calculated for different NEC points. Only greenhouse gas emissions are widespread enough, across a wide range of activities, to perform this calibration. The resulting average order of magnitude for 100 NEC % points was 3 200 tCO₂-eq. / m€. Using this benchmark, the corresponding NEC are calibrated for each commodity with their long-term market prices and their carbon intensity.

Primary incremental NEC

The primary incremental NEC captures the impact of upstream (extraction/mining) and midstream (refining/metal transformation) within the metal production. A default value of primary incremental NEC has been calculated for each commodity, based on the world average of carbon intensity (using Ecoinvent LCA). The model is built to be adjusted according to activity/company performance, enabling activity/company specific NEC calculation based on the disclosed carbon intensity.

The LCA scope usually stands from cradle to gate: scopes 1, 2 and 3 (upstream and downstream to gate). However, as companies often disclose scopes 1 and 2 only, it is useful in practice to adjust performance on the basis of just scopes 1 and 2. If the company discloses scope 3, it is important to ensure that the data includes the extraction phase in order to be consistent with the LCA scope used in the NEC calculator. In that case, the value of LCA for scopes 1 to 3 can directly be adjusted in the model, providing the adjusted primary incremental NEC.

Example of Primary Incremental NEC with BlueScope Steel

The company discloses its carbon intensity in its 2018 sustainability report for scopes 1 and 2:

| BlueScope sustainability scorecard | | | |
|--|--------|-------------------|--------|
| Metric | FY2018 | FY2017 | Change |
| Raw steel produced (000 tonne) | 5,971 | 5,868 | 1.8% |
| Percentage of female employees (%) | 19 | 17 | 11% |
| Percentage of women in operator roles (%) | 8.4 | 6.1 | 38% |
| Lost time injury frequency rate (LTIFR) | 0.62 | 0.80 | -23% |
| Medically treated injury frequency rate (MTIFR) | 5.4 | 5.6 | -3.6% |
| GHG emissions intensity of steelmaking facilities (tCO ₂ -e/t) ² | 1.66 | 1.68 ¹ | -1.2% |
| Energy intensity of steelmaking facilities (GJ/t) ³ | 17.1 | 17.2 ¹ | -0.6% |
| Fresh water consumption (ML) | 22,940 | 29,907 | -23% |
| Fresh water intensity of steelmaking facilities (ML/t) ⁴ | 2.40 | 2.29 ¹ | 4.8% |

■ Improvement in performance metric
 ■ Decline in performance metric

The Excel template “NEC 1.0 metals - template vdef” is used to update the primary incremental NEC and calculate the resulting NEC. In the tab “template”, column B “type of material”, the corresponding commodity can be selected in the menu. The next column shows the level of detail provided by the company from “by default” for no information to “both data available” when the company discloses both the carbon intensity and the recycled content. Next, enter the disclosed value of carbon intensity in column I “CO₂-eq. emissions (scope 1 & 2) in kg CO₂ / kg”. The unit is also disclosed by companies in tCO₂-eq. / t. If the company produces various commodities, enter the turnover by commodity in column D.

| | a. Type of material | b. Data | c. Turnover / EBITDA (m€ / m\$) / Prod. | % of Turnover / % of EBITDA | d. Final use option | e. Final use adjusted | d. EoL-RR | e. CO ₂ -eq. emissions (scope 1 & 2) in kg CO ₂ / kg | EoL-RR by default | CO ₂ -eq. emissions by default (scope 1 & 2) in kg CO ₂ / kg |
|--------------------|---------------------|---------------------|---|-----------------------------|---------------------|-----------------------|-----------|--|-------------------|--|
| Basic materials 1 | Steel | both data available | | #DIV/0! | by default | | 45% | 1,66 | 60% | 1,45 |
| Basic materials 2 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 3 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 4 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 5 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 6 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 7 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 8 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 9 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 10 | | | | #DIV/0! | | | | | 0% | 0,00 |
| Total | | | 0,00 | #DIV/0! | | | | | | |

Secondary incremental NEC

The secondary incremental NEC captures the circular economy dimension. The more recycle content into the production process, the higher is the recycling bonus. The recycling rate, r , is the end-of-life recycling rate (EoL-RR). As a result, the share of production waste that is recycled within the activity, division or company, the internal recycling rate, is not integrated in the r calculation.

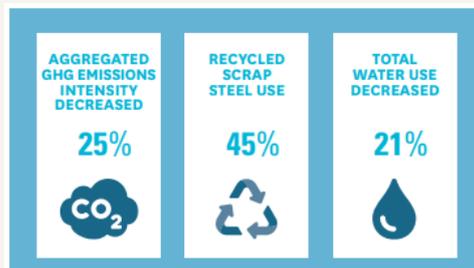
The secondary incremental NEC also depends on CO₂ savings related to the recycling process versus the primary metal transformation. The sources for average end-of-life recycling rate and corresponding CO₂ savings are UNEP studies and European Commission data on critical raw materials.

A default value of secondary incremental value was calculated for each commodity based on average of end-of-life recycling rates (worldwide or European depending on the source) and world average CO₂ savings per commodity. The model is built to be adjusted according to activity/company performance, enabling activity/company specific NEC calculation based on the disclosed carbon intensity.

In practice, calculation requires underlying assumptions. In particular, it was assumed that the recycling process delivers the same efficiency gains (in order of magnitude for all players) and that CO₂ savings are the same per commodity. Hence an efficient company that produces steel with only 1,2t CO₂/t of steel will achieve the same CO₂ savings (68%) as a company that produces steel with more than 2 t CO₂/t of steel in the model.

Example of Secondary Incremental NEC with BlueScope Steel

The company discloses its recycled content in its 2018 sustainability report:



The model "NEC 1.0 metals - template vdef" can be adjusted in the column H, "EoL-RR" as shown in the chart below:

| a. Type of material | b. Data | c. Turnover / EBITDA (m€ / m\$) / Prod. | % of Turnover / % of EBITDA | d. Final use option | e. Final use adjusted | d. EoL-RR | e. CO ₂ -eq. emissions (scope 1 & 2) in kg CO ₂ / kg | EoL-RR by default | CO ₂ -eq. emissions by default (scope 1 & 2) in kg CO ₂ / kg |
|---------------------|---------|---|-----------------------------|---------------------|-----------------------|-----------|--|-------------------|--|
| Basic materials 1 | Steel | both data available | #DIV/0! | by default | | 45% | 1,66 | 60% | 1,45 |
| Basic materials 2 | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 3 | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 4 | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 5 | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 6 | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 7 | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 8 | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 9 | | | #DIV/0! | | | | | 0% | 0,00 |
| Basic materials 10 | | | #DIV/0! | | | | | 0% | 0,00 |
| Total | | 0,00 | #DIV/0! | | | | | | |

The resulting adjusted NEC is calculated in column S with details on NEC components - final use, primary and secondary incremental - respectively in column M, N and O. The carbon intensity effect and the recycling effect are specified in comparison with default values. Aggregating these effects provides the activity or company-specific NEC.

| Company NEC | | | | | NEC Company | default NEC | | | |
|---------------|-------------------------|---------------------------|-------------------------|------------------|-------------|---------------|----------------------------|-----------------|-------------|
| NEC final use | Primary NEC incremental | Secondary NEC incremental | Carbon intensity effect | Recycling effect | | NEC final use | Malus upstream / midstream | Bonus Recycling | default NEC |
| 1% | -52% | 32% | -1,9% | -12,7% | -13,3% | 1% | -48% | 32% | 1,3% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | 0,0% | 0% | 0% | 0% | 0,0% |
| 0% | 0% | 0% | 0,0% | 0,0% | -13,3% | 0% | 0% | 0% | 0,0% |
| | | | | | -13,3% | | | | 1% |

2.3. Default values for metals

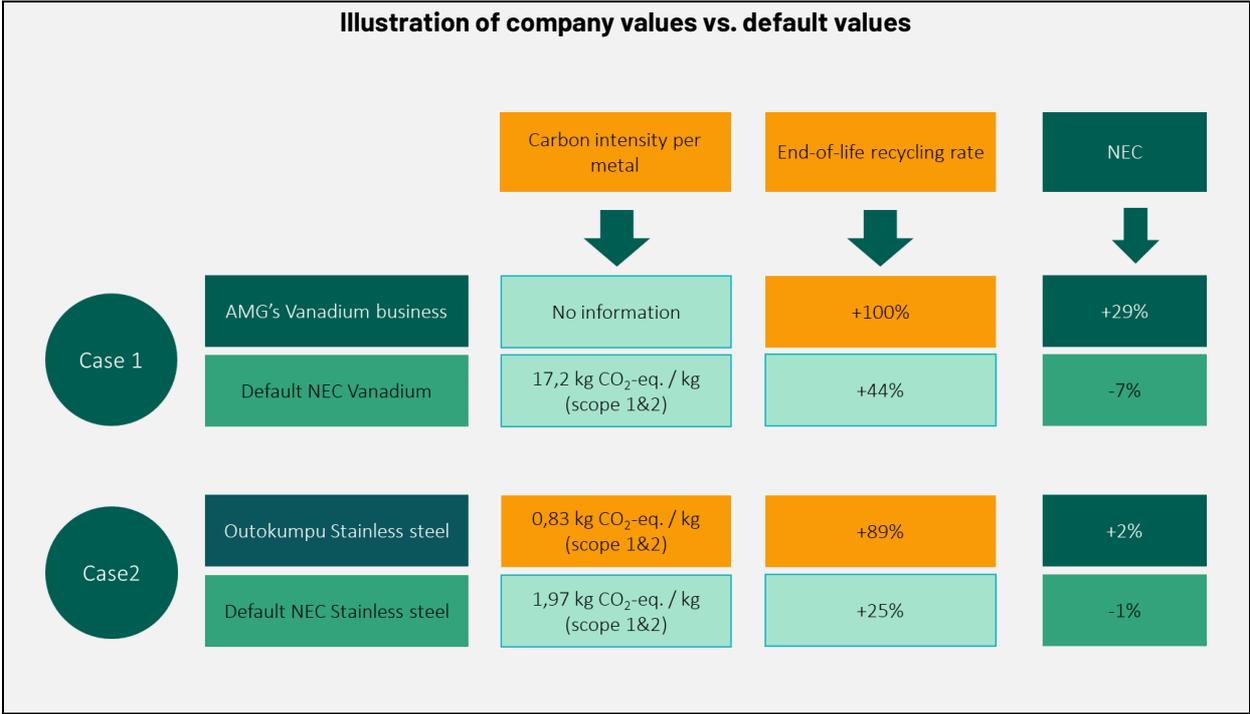
The default values for 54 commodities have been calculated and the 15 most frequently used are shown in the following table. These values may be used if the company does not disclose any additional information regarding carbon intensity or recycled content.

| | Final Use NEC | Default recycling rate | Incremental NECs | | |
|-----------------------|---------------|------------------------|------------------|-------------|------------|
| | | | primary | secondary | |
| Steel | 0% | 60% | -48% | +32% | +1% |
| Stainless steel | 0% | 25% | -3% | +2% | -1% |
| Pig iron | 0% | 38% | -87% | +59% | -31% |
| Aluminum | 13% | 32% | -93% | +87% | -22% |
| Copper | 8% | 55% | -14% | +13% | +9% |
| Manganese | 0% | 12% | -1% | +1% | -1% |
| Zinc | 1% | 31% | -21% | +14% | -10% |
| Lead | 16% | 75% | -6% | +5% | +18% |
| Nickel | 2% | 34% | -11% | +10% | -2% |
| Cobalt | 7% | 35% | 0% | 0% | +7% |
| Rare earth | 8% | 2% | -55% | +43% | -43% |
| Lithium | 11% | 0% | 0% | 0% | +11% |
| Silver | 6% | 55% | -4% | +4% | +6% |
| Neodymium | 25% | 1% | -1% | +1% | +24% |
| Gold | 0% | 30% | -2% | +2% | -1% |
| Average metals | 2% | 42% | -42% | +30% | -7% |

For iron as a chemical element, Fe, the default NEC results from the volume weighted NEC of the 3 main forms of iron: pig iron, steel and stainless steel. The weighted sum for iron, Fe, is -12%.

2.4. Company-specific adjustments

As presented in the primary and secondary incremental NEC description, default values can be adjusted via two variables: carbon intensity and recycled content (r , end-of-life recycling rate). These adjustments can have a significant impact on NEC results.

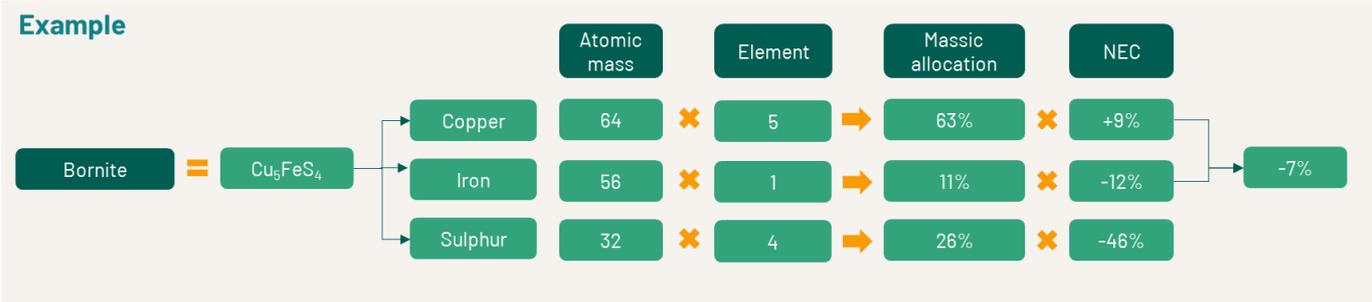


2.5. Metallic ores

In practice, companies' disclosure are metals-oriented rather than metallic ores-oriented. When this information is available, metallic ores' NECs are calculated using the following principle:

Metallic ores NEC = weighted sum of material NECs

Material NECs come from the present framework and when no NEC value is available, as for O, C or H, a 0% default value is used. Weight is based on the ore's atomic mass and chemical formula as shown in the example of bornite below:



The resulting default values for metallic ores are listed below:

| Metallic ores | Formula | NEC |
|---------------|--------------------|------|
| Chalcocite | Cu ₂ S | -2% |
| Chalcopyrite | CuFeS ₂ | -16% |

| | | |
|-----------------------|--|------|
| Bornite | Cu_5FeS_4 | -7% |
| Tetrahedrite | $(\text{Cu}, \text{Fe})_{12}\text{Sb}_4\text{S}_{13}$ | -20% |
| Galena | PbS | 10% |
| Cobaltite | CoAsS | -12% |
| Molybdenite | MoS_2 | -22% |
| Pentlandite | $(\text{Fe}, \text{Ni})_9\text{S}_8$ | -20% |
| Stibnite | Sb_2S_3 | -39% |
| Bauxite | $\text{Al}(\text{OH})_3$ | -22% |
| Cuprite | Cu_2O | 9% |
| Chromite | FeCr_2O_4 | -6% |
| Columbite | $\text{Mn}_{0.5}\text{Fe}_{0.5}\text{Nb}_{1.4}\text{Ta}_{0.6}\text{Ti}_{0.1}\text{O}_6$ | -58% |
| Tantalite | $\text{Mg}_{0.56}\text{Fe}_{0.4}\text{Mn}_{0.05}\text{Ta}_{1.2}\text{Nb}_{0.78}\text{Ti}_{0.02}\text{O}_6$ | -38% |
| Smithsonite | ZnCO_3 | -10% |
| Average metallic ores | | -7% |

Adjustments for specific company practices are generally less material

Because the impact of the extraction phase is limited compared to that of metal processing, the default NEC can be broadly used as the activity NEC, unless the company proves quantified, material benefits of specific climate, biodiversity and water actions.

2.6. Main limits

The main database is based on the study "Nuss et al 2014 - Life Cycle Assessment of Metals A Scientific Synthesis" which in turn is based on LCA Ecoinvent database; these sources should be updated in the coming years in order to take into consideration improvements in the assessment of environmental impacts.

The lack of data is a barrier to take into account potentially material environmental factors such as land use, water pollution or soil contamination. Consequently, the current assessment undoubtedly underestimates environmental impacts on biodiversity and water.

Moreover, complete information was not available for all 54 assessed metals and semi-metals. Thus, a weighted average has been used for some of them. For instance, regarding water consumption, a weighted average based on production volume has been used by sorting the metals for which data by categories from Mendeleïev's periodic table (transition metals, actinides, metalloid, alkali metal, etc.) were available.

2.7. Key data sources

| | |
|-----------------------------|---|
| LCA databases and resources | Ecoinvent database, ReCiPe 2016 (E,A) approach, Ecosystem quality endpoint |
| | Nuss et al 2014 - Life Cycle Assessment of Metals A Scientific Synthesis |
| | IMPACT 2002+, A Life Cycle Impact Assessment Methodology, Characterization factors for water withdrawal (version Q2.22) |
| Recycling data | European Commission 2017 - Critical raw materials and the circular economy |
| | UNEP 2013 - Environmental risks and challenges of anthropogenic metals flows and cycles |
| | UNEP 2013 - Metal recycling opportunities limits infrastructures |
| Energy savings | UNEP 2013 - Environmental risks and challenges of anthropogenic metals flows and cycles |
| Metal prices | USGS 2013 - Metal prices in the United States through 2010 |
| | USGS 2018 - Mineral commodity summaries |
| | Cyclope 2017 - les marchés mondiaux |
| Final use | Cyclope 2017 - les marchés mondiaux |
| Volumes | USGS 2018 - Mineral commodity summaries |
| Costs of externalities | CE Delft 2018 - Environmental Prices Handbook 2017 |

3. Cement, concrete and other minerals

3.1. Main environmental issues

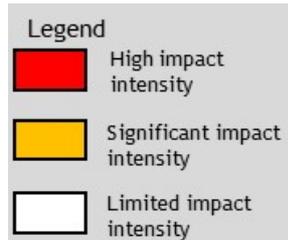
| Environmental stake | | Relevance along the value chain | | | Comments |
|---------------------|-----------------------------|---------------------------------|----------------------------------|------------------------|---|
| | | Upstream (extraction) | Production (cement and concrete) | Downstream (use phase) | |
| Climate | Climate change | Yellow | Red | | Worldwide, cementitious materials make up more than half of all materials and account for approximately 8% of global GHG emissions. Cement production in particular generates 5% of GHG emissions. |
| | Use of energy resources | Yellow | Red | | The production of clinker and cement is energy intensive. |
| Air quality | Air quality deterioration | Yellow | Yellow | | Pits and quarries emit dust & particles into the atmosphere. Direct impact from cement production is also significant. |
| Water | Water consumption | Red | Yellow | | Mining activities require a massive quantity of water, particularly for waste treatment. Heavy industry and manufacturing (excluding energy) use about 4% of the world's total water withdrawal. |
| | Water pollution | Yellow | Yellow | | Pits and quarries disrupt the existing movement of surface water and groundwater; they interrupt natural water replenishment and can lead to reduced quantity and quality of drinking water for both humans and wildlife near and downstream from quarry sites. |
| Biodiversity | Soil pollution | Yellow | Yellow | | Creating pits and quarries requires the removal of virtually all natural vegetation, top soil and subsoil. Not only does this lead to a loss of animal wildlife, it also severely reduces biodiversity as plants and aquatic habitats are destroyed. Moreover, adjacent eco-systems are affected by noise, dust, pollution and contaminated water. |
| | Land Use | Red | | | Land use changes are mainly due to forestry, agriculture and mining. |
| Resources & waste | Use of non-energy resources | Red | Red | | Recycled concrete represents only 6 to 8% of total concrete in Europe. Most recycled concrete is used as aggregates in road subbase, most commonly in unbound form. The percentage of recycled concrete in new concrete is very low. Resource depletion linked to construction materials such as sand and gravel is substantial: sand and gravel are among the most consumed non-renewable resources in the world (more than 11 billion metric tons in 2017). |
| | Waste | Yellow | Yellow | Red | About 1,300 million metric tons of waste are generated in Europe each year, of which about 40%, or 510 million metric tons, comes from construction and demolition (C&DW). The USA produce about 325 million metric tons and Japan about 77 million. Given that China and India now both produce and use over 50% of the world's concrete, their waste generation is also very significant and growing fast. |

For cement and concrete

Climate

Main issue

GHG footprint significantly outweighs other environmental issues for cement and concrete producers, so climate is the primary environmental issue to analyze these activities.



For other minerals

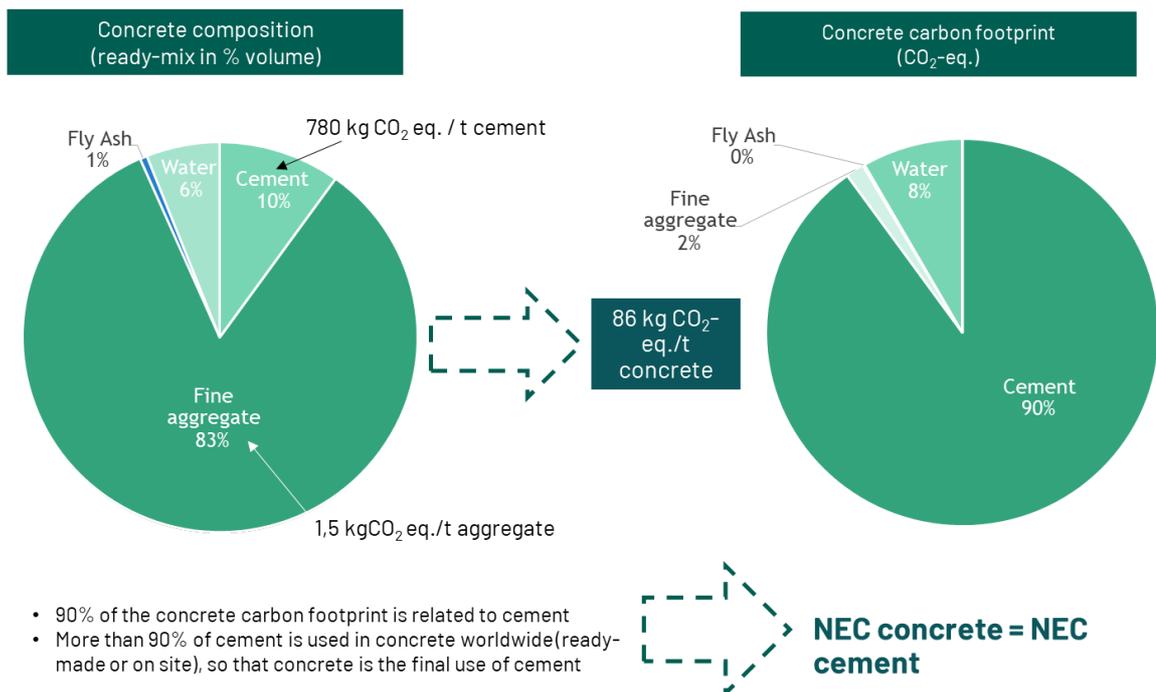
Climate Biodiversity Water

Main issue Secondary issue Secondary issue

For other minerals, the primary environmental issues are the same as those for metals and metallic ores.

3.2. Cement and concrete

Analysis of cement and concrete value chain



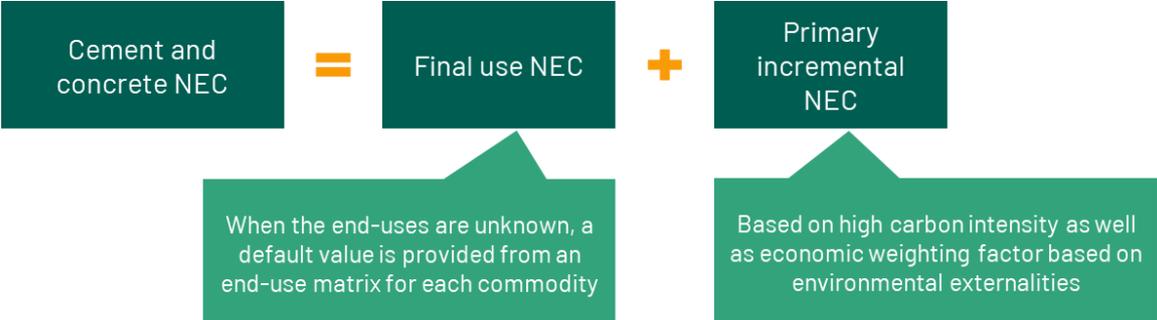
Cement, aggregates and admixture materials are combined to make concrete for the construction industry. These processes, including the extraction of natural aggregates and the production of clinker and cement, cause numerous environmental impacts.

While aggregates make up the bulk of concrete, the intermediary process of cement production is responsible for 90% of the ill effects due to the fact that cement production is energy intensive, and consequently generates significant quantities of CO₂-eq.

As the effects of cement production both dominate concrete and are embedded in it, the NEC of concrete has been considered equal to the NEC of cement:

NEC concrete = NEC cement

Environmental performance indicators

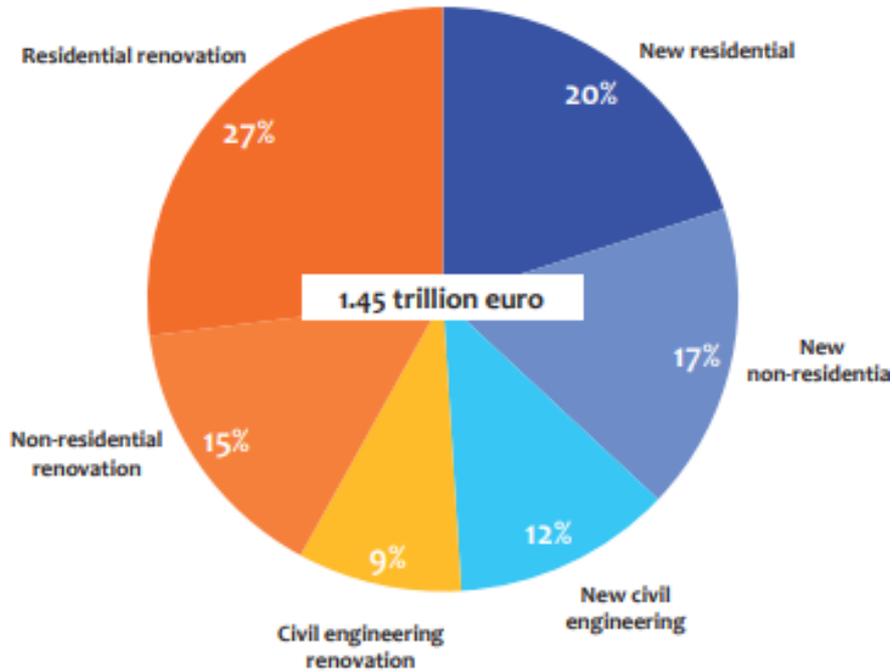


The same approach as for metals and metallic ores has been adopted with a NEC that is split between final use and primary incremental NEC. The calibration method of the primary incremental NEC is similar too. Nevertheless, the secondary incremental NEC has not been considered as it is not significant enough. Recycled concrete represents only 6 to 8% of the total concrete used in Europe. Most recycled concrete is used as aggregate in road subbase, most commonly in unbound form. The percentage of recycled concrete in new concrete is very low. Furthermore, recycling concrete is CO₂ neutral, which means that there are no significant energy savings in recycling versus new concrete. As a result, no recycling bonus is required.

Final use NEC

The uses matrix for concrete shows applications of concrete and cement from construction market statistics provided by CEM Bureau. As renovation represents 51% of the total market, to which is applied the 20% of NEC in the building & real estate framework, the resulting final-use NEC for cement and concrete is amounting +10%.

Construction market by segments in 2016
 37% account for new buildings, 42% for building renovation



Source: Euroconstruct (November 2017)

© ifo Institute

Primary incremental NEC

To be consistent with the method for metals and metallic ores, the same environmental factors of climate, terrestrial acidification, freshwater eutrophication and water consumption have been used. For more details on the calculation of the economic ratios and the determination of primary NEC incremental please refer to the above section on calibration of incremental NEC.

The Life Cycle Assessment of concrete estimates the cement footprint by taking the average data of cement types CEM II/A and B (LCA Ecovinent), the most prevalent cement worldwide. Other scientific studies consider individual composition for each type of concrete and its specific environmental footprint (Nisbet et al. 2002 - Environmental Life Cycle Inventory of Portland Cement Concrete and Taehyoung Kim et al 2016 - Analysis of Environmental Impact for Concrete).

Adjustment for companies

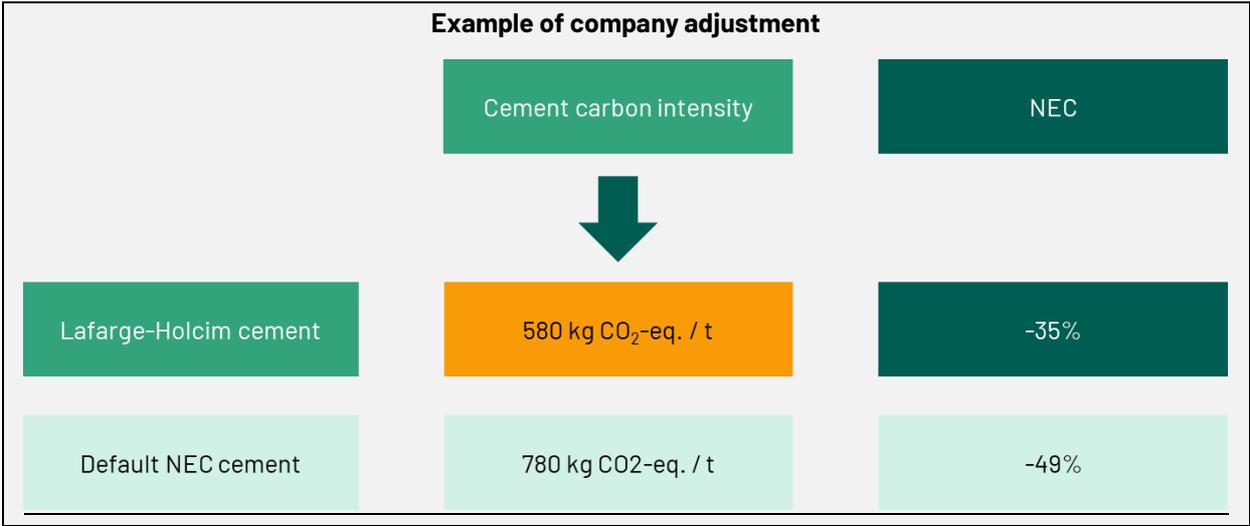
To calculate the NEC of a company's cement and concrete segment, the disclosed carbon intensity of its cement production is used in the template, named "NEC 1.0 cement and concrete - template vdef". When the carbon intensity of the cement is entered in column B, the template automatically calculates the NEC.

| a. Type of material | e. CO ₂ -eq. emissions (scope 1 & 2) in kg CO ₂ / kg | CO ₂ -eq. emissions by default (scope 1 & 2) in kg CO ₂ / kg |
|---------------------|--|--|
| Cement | | 0,78 |
| Cement and concrete | | 0,09 |

Default values

When a company does not disclose its carbon intensity, the default value based on average data worldwide (LCA database) is used:

| Default NEC Cement and concrete | Final use NEC | Primary incremental NEC |
|---------------------------------|---------------|-------------------------|
| -49% | 10% | -59% |

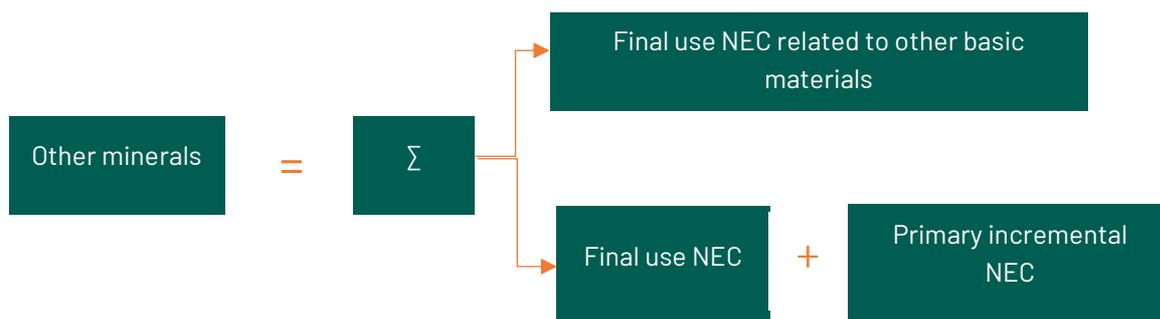


3.3. Other minerals

Other minerals include two categories:

- Minerals that are considered intermediary in cement and concrete;
- Minerals unrelated to other basic materials, which are directly used in end markets.

For some minerals such as sand and gravel, their final use can be split between these two categories, and each category has its own approach, weighted by their share in the final use allocation. Minerals that are related to other basic materials will integrate the upstream and midstream impact through final use. For instance, 44% of sand and gravel is used to produce concrete, so 44% of its final use NEC will be the NEC of concrete with its upstream and midstream impacts. No primary incremental NEC is applied as it is already included in the final use. The remaining final use NEC is determined by the other end uses, which generally do not include the upstream and midstream impacts. As a result, for the 56% of other final uses the default final use NEC as well as a primary incremental NEC are integrated in order to take into account the upstream and midstream impacts.



Environmental performance indicators

The approach is similar to metals, metallic ores, cement & concrete with two main components, the final use NEC and the primary incremental NEC:

$$\text{NEC} = \text{NEC Final use} + \text{Primary incremental NEC}$$

The same key environmental performance indicators are used as for other categories with climate, terrestrial acidification, freshwater eutrophication and water consumption.

The final use NEC is calculated via a uses matrix by commodity that lists the end uses for each mineral and that uses various sources such as the Mineral Commodity Summaries from USGS and more specialized studies.

For the primary incremental NEC, the approach is similar to that of previous sections covering climate, terrestrial acidification, freshwater eutrophication and water consumption. For more detail on the calculation of economic ratios and the determination of primary NEC incremental, please refer to the above section on calibration of incremental NEC.

Adjustments for specific company practices are generally less material

The primary incremental NEC for other minerals is generally insignificant, except for a few materials such as kaolin, sulfur and phosphorus. As a result, it is unnecessary to adjust the default value as it would not have a significant impact on the resulting NEC. Moreover, companies rarely disclose the carbon intensity for other minerals as their production mainly affects biodiversity and water.

Default values

As company adjustments are generally not possible or not worth calculating, the default values presented below are broadly used:

| | Final use NEC | Primary incremental NEC | NEC |
|------------------------|------------------|----------------------------|------|
| Kaolin | 0% | -12% | -12% |
| Feldspar | 0% | -1% | -1% |
| Gypsum | -7% | 0% | -7% |
| Lime | 3% | 0% | +3% |
| Silica | -2% | -3% | -5% |
| Sand and gravel | -16% | -1% | -17% |
| Limestone | -5% | 0% | -5% |
| Sulfur | -15% | -31% | -46% |
| Phosphorus | -23% | -54% | -77% |
| Graphite | 0% | 0% | 0% |
| Metallurgical coal | 1% | 0% | +1% |
| Perlite | 0% | 0% | 0% |
| Vermiculite | 0% | 0% | 0% |
| Bentonite | 0% | 0% | 0% |
| Average other minerals | -4% | -3% | -7% |

3.4. Main limits

Similarly to metals and metallic ores, the lack of data doesn't enable to take into account potentially significant environmental factors such as land use, water pollution or soil contamination. The current 1.0 framework undoubtedly underestimates environmental impacts on biodiversity and water.

Moreover, fundamental data regarding the composition of materials is likely to be revised in the near future in order to take into consideration improvements in alternative materials with low-carbon features.

For other minerals, the NEC calculation is currently mainly limited in its capacity to incorporate company-specific performance to mitigate impact on biodiversity and water due to the lack of disclosure. Both more extensive data from updated sources and from companies will improve its relevance.

3.5. Key data sources

For cement and concrete

| | |
|-----------------------------|---|
| LCA databases and resources | Taehyoung Kim et al 2016 – Analysis of Environmental Impact for Concrete |
| | Nisbet et al. 2002 – Environmental Life Cycle Inventory of Portland Cement Concrete |
| Material prices | USGS 2018 – Mineral commodities summaries |
| | Cyclope 2017 – les marchés mondiaux |
| Final use | CEM Bureau – Activity report 2017 https://cembureau.eu/media/1716/activity-report-2017.pdf |
| Volumes | CSI 2016 – Recycling concrete 2019 |
| | Freedonia Group – World Aggregates Market http://www.rockproducts.com/features/13045-world-aggregates-market.html#.W5jucugzaUk |
| Costs of externalities | CE Delft 2018 – Environmental Prices Handbook 2017 |

For other minerals

| | |
|---|---|
| LCA databases and resources Recycling data | Ecoinvent database, ReCiPe 2016 (E,A) approach, Ecosystem quality endpoint |
| | Nuss et al 2014 – Life Cycle Assessment of Metals A Scientific Synthesis |
| | IMPACT 2002+, A Life Cycle Impact Assessment Methodology, Characterization factors for water withdrawal (version Q2.22) |
| | Gypsum Association 2013 – Life Cycle Assessment Summary |
| | Gypsum Association 2016 – An Industry Average Cradle-to-Gate Life Cycle Assessment of Glass Mat Gypsum Panels for the USA |
| | IMA Europe – Environmental Footprint of some selected industrial minerals |
| | IMA Europe 2013 – Life Cycle Inventory |
| Mineral prices | LCA of North American gypsum boards |
| | Wrap 2009 – Life Cycle Assessment of Aggregates |
| | USGS 2013 – Metal prices in the United States through 2010 |
| Final use | USGS 2018 – Mineral commodity summaries |
| | Cyclope 2017 – les marchés mondiaux |
| | Cyclope 2017 – les marchés mondiaux |
| Volumes | USGS 2018 – Mineral commodity summaries |
| | USGS 2018 – Mineral commodity summaries |
| | CSI 2016 – Recycling concrete 2019 |
| Costs of externalities | Freedonia Group – World Aggregates Market http://www.rockproducts.com/features/13045-world-aggregates-market.html#.W5jucugezUk |
| | CE Delft 2018 – Environmental Prices Handbook 2017 |

BUILDING AND REAL ESTATE FRAMEWORK

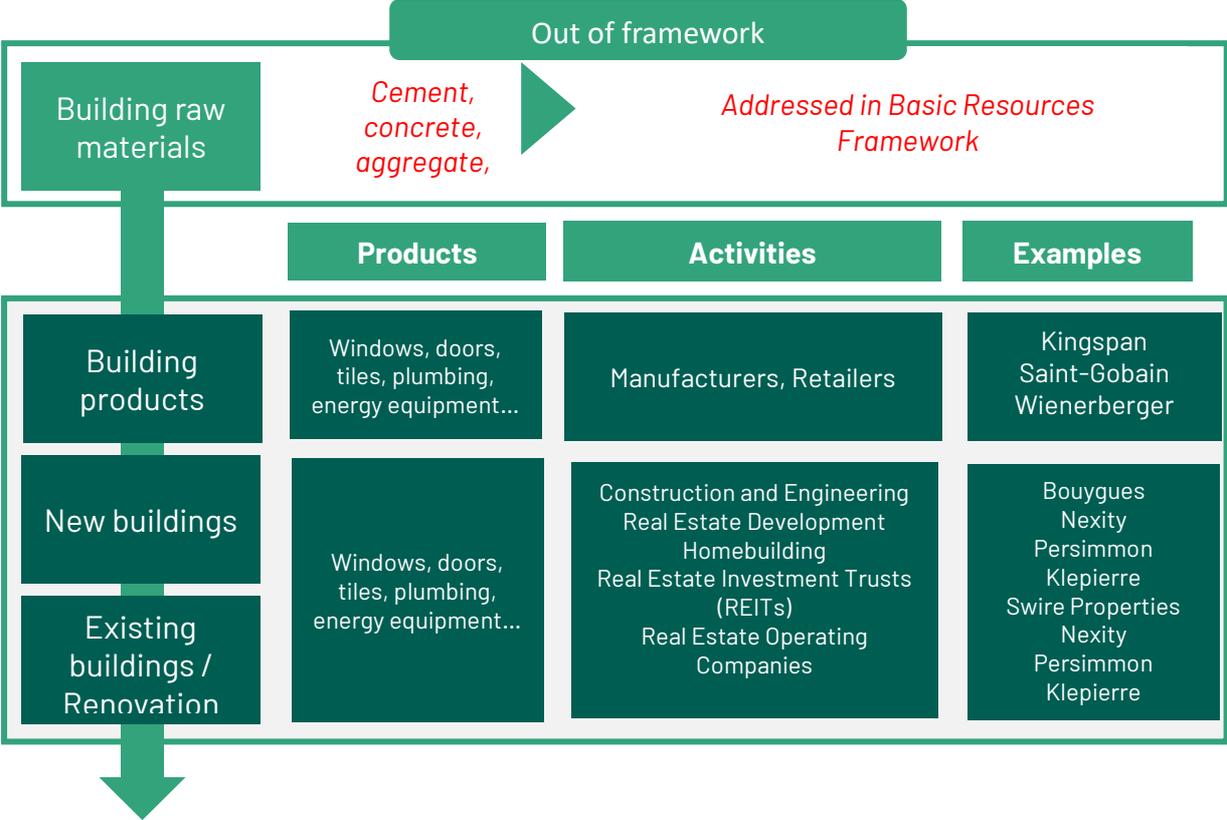
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1. Introduction

The building and real estate framework encompasses many activities of the construction value chain: building products (finished building materials as well as energy equipment), manufacturing and distribution, building construction and renovation, real estate development and renting, as well as civil engineering or inspection. As illustrated below, raw building materials are addressed in the Basic Resources framework.

Figure 1: Scope of Building & Real Estate framework, NEC 1.0.



The building and real estate sector is responsible for about 18% of total global greenhouse gas (GHG) emissions¹. The sector also faces issues such as resource depletion and indoor air quality. The life cycle analysis below demonstrates that the most impactful lifecycle phases are **construction (materials production)** and **use (energy consumption)**.

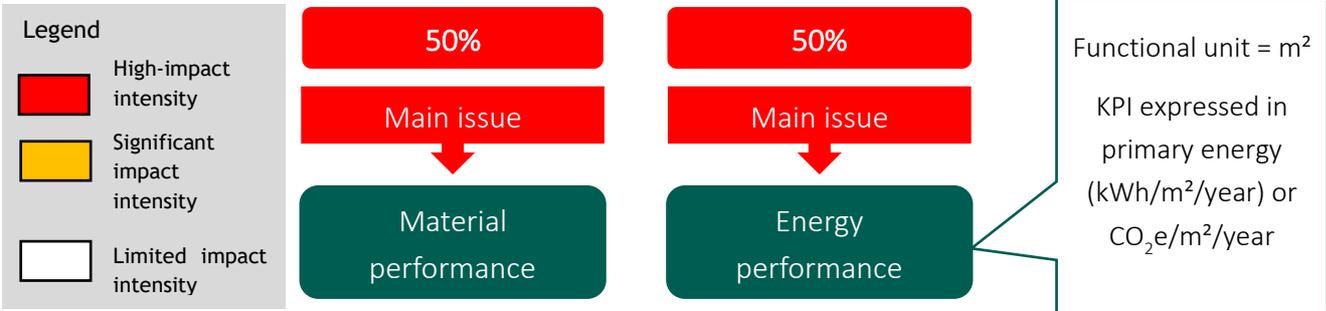


¹ Direct emissions: 6%; indirect emissions: 12% according to IGCC report n°5, 2014.

Around the world, the construction sector is gradually shifting away from older buildings with high operation/use impacts, mainly due to energy consumption, to more energy-efficient ones whose impacts are limited to embodied energy. Therefore, the framework focuses on the construction and use phases, as they concentrate the most salient impacts.

2. Main environmental issues

| Environmental stake | | Relevance along value chain | | Comments | Data availability |
|---------------------|-----------------------------|------------------------------------|------------------------------|--|--|
| | | Manufacturing / construction phase | Use phase | | |
| Climate | Climate Change | High-impact intensity | High-impact intensity | Both construction and use phase contribute significantly to climate change – mainly use phase for low energy efficiency building and materials in thermic renovation | GHG emissions per material manufacturing + labels requirements |
| | Use of energy resources | High-impact intensity | High-impact intensity | idem | Labels requirements |
| Air Quality | Air quality deterioration | Limited impact intensity | Significant impact intensity | Interior air quality issue for some specific materials | |
| Water | Water consumption | High-impact intensity | Limited impact intensity | Some construction materials and practices can be highly water intensive. Typical concrete mix ratio = 40% water + 60% cement | Labels requirements |
| | Water pollution | Significant impact intensity | Limited impact intensity | Limited issue for direct & use phase | |
| Biodiversity | Soil pollution | Limited impact intensity | Limited impact intensity | | |
| | Land use | Significant impact intensity | Significant impact intensity | Limited issue for direct & use phases | |
| Resources & Waste | Use of non-energy resources | Significant impact intensity | Limited impact intensity | Mostly abundant resources, including bio-sourced materials | Labels requirements |
| | Waste | High-impact intensity | High-impact intensity | Disposal & recycling of construction materials is a key issue | Labels requirements |

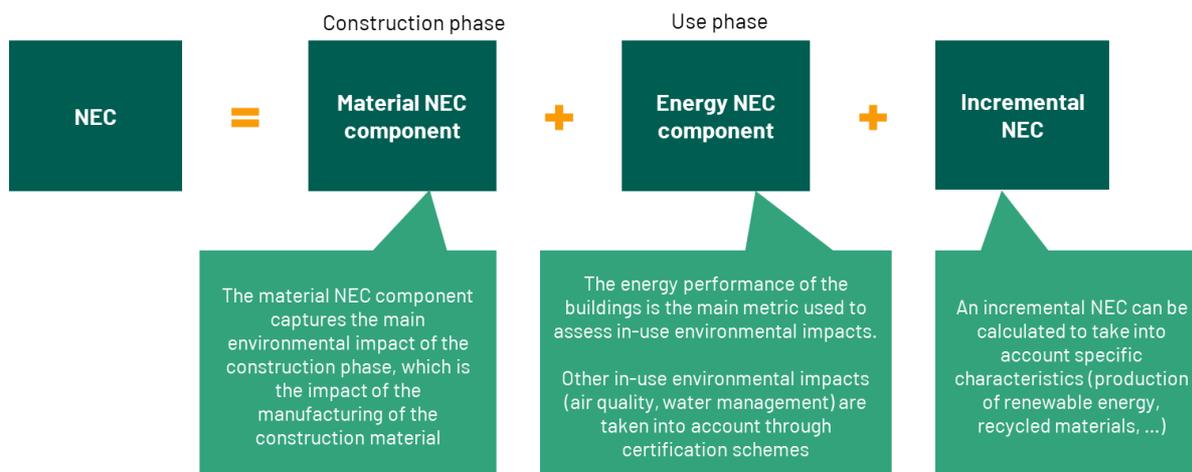


While many environmental issues are at stake, this framework considers the largest impacts that are measurable at the activity or company level. This multicriteria, qualitative rating approach includes the following indicators, also covered by building certifications: climate change, energy resource depletion, water withdrawal, waste management and material resource depletion.

3. Environmental performance indicators

The general equation for Net Environmental Contribution (NEC) is based on the sum of two NEC components: material NEC component of the construction phase and energy NEC component of the use phase, each calibrated on a -50%/+50% scale. An optional incremental NEC can always be added to account for specific characteristics, also calibrated on a -50%/+50% scale as it amends one of the two

previous components, such as production of renewable energy (linked to energy performance) or recycled materials (linked to material performance).



This general equation applies to the three main economic activities identified in this framework:

- Building products
- New buildings (construction and development)
- Existing buildings (renovation and real estate)

In practice, the Material NEC component is based on the building labelling/certification and/or the building material structure, as a proxy for building material performance:

- Building structure: the most common structures – wood, cement and steel – are assessed and differentiated.
- Labelling **or certification**: when benchmarking existing certifications or labels guaranteeing a given construction environmental performance, two features are screened:
 - Biosourced materials: is the incorporation rate of biosourced materials taken into account?
 - Excellence: what is the label requirement level?
- NB: if both information sources are available, the label-based rating, which is generally more complete or accurate, is preferred.

In practice, the Energy NEC component is based on effective energy intensity or on use-phase certifications.

Thanks to upgraded construction norms, insulation and energy performance, use phase impacts are decreasing each decade, especially in countries with advanced regulations, as often met among the OECD members. Thus, for new high-performance buildings, the use phase can have a negligible influence on final environmental impact. However, it is still not negligible in most cases.

More buildings are using a modeling system that tracks the building's energy consumption minute by minute or even plans its evolution. For this reason, information on a building's effective energy performance may be available in kWh of primary energy /m²/year. More broadly, energy uses are generally characterized by primary energy needs, widely available data often mentioned in the criteria required for certification. By comparing primary energy use requirements, labels can be ranked. A score of 0% is attributed to the average European house's primary energy needs, and a score of +50% is attributed to passive housing and building.

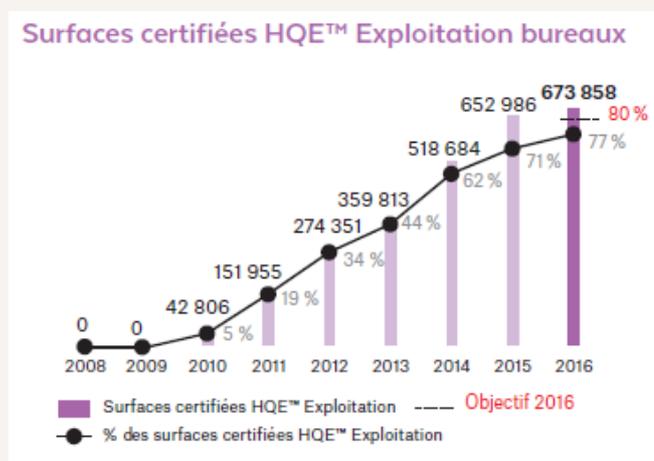
Data availability and practical tips

Information needed: breakdown per type of label building in the company turnover

The activity report of a company contains information concerning turnover breakdown. A company describes its activities and, in most cases, its labelling goals. For instance, after describing the breakdown between residential and tertiary building activities, this Gecina Activity Report focuses on environmental goals in the chapter "Responsibility and CSR performance". The following information can be found:

Gecina has three main types of rentals: offices, residential buildings and student residences,

77% of its offices are HQE certified. Out of 15 student residences, five are BBC certified and one is HQE certified.



A final NEC can be calculated based on this labelling split.

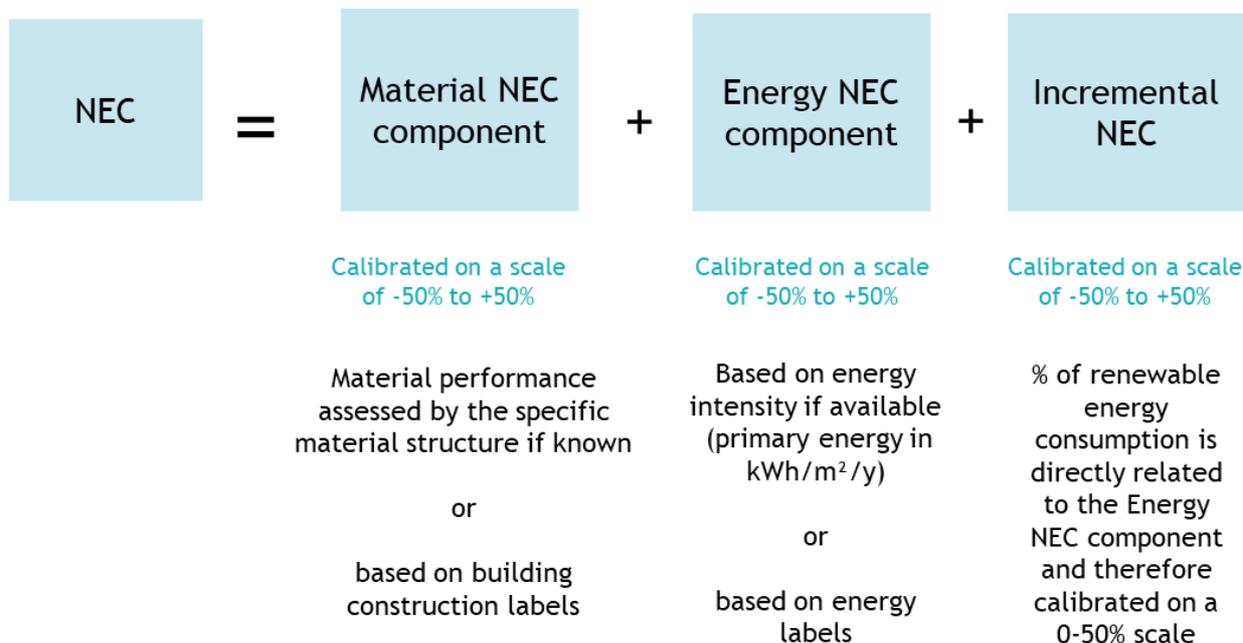
In brief, the environmental Key Performance Indicators used are:

- For materials performance in the construction phase: building products type, building structure type and certifications
- For energy performance in the use phase: primary energy intensity in kWh/m²/year and operation-related certifications

4. NEC calculation

4.1. New buildings

The NEC for construction and real estate development activities, i.e. new buildings, is split between material performance and energy performance with an optional incremental NEC.



4.1.1. Material NEC component

Labelling is often the best information source for a building's environmental performance in terms of materials. Certifications may cover many indicators and several requirement levels. The following table summarizes different construction method labels and their characteristics:

| | Is there a condition on embodied energy of construction materials? | Requirement level (on a scale of 0 to 10; 10 being the highest mark) | NEC |
|---------------------------------------|--|--|------------|
| HQE construction | | 0 | 0% |
| BREEAM | X | 1 | 1% |
| LEED | X | 1 | 1% |
| Label BBCA standard | X | 2 | 2% |
| Label BBCA performance | X | 3 | 3% |
| Certification Habitat & Environnement | X | 4 | 4% |
| Label BBCA excellence | X | 4 | 4% |
| Label E+C- | X | 6 | 7% |
| Label bâtiment biosourcé niveau 1 | X | 8 | 9% |
| Label bâtiment biosourcé niveau 2 | X | 9 | 10% |
| Label bâtiment biosourcé niveau 3 | X | 10 | 11% |

Most recent labels have a condition for materials performance, but requirement levels may differ. For instance, the French *Haute Qualité Environnementale*, HQE, is scored 0% because it has no condition for the incorporation rate of biosourced materials. LEED is scored 1% because there is a "materials and resources" category in which materials must have recycled content and be sourced locally. The corresponding requirement level is 1 (on a scale of 0 to 10, 10 being the highest mark).

As wood is the best material structure in environmental terms (as a renewable material with low carbon impact and carbon sequestration capacity), it is scored +50%. Considering that a wood structure contains 170 kg/m² of biosourced material (wood), various labels are modelled. For instance, the French label *bâtiment biosourcé niveau 3* has a biosourced material incorporation rate of 36 kg/m² and a NEC of 12%. Building solutions covering both labels and types of structures are ranked and summarized below:

| | NEC |
|---------------------------------------|------------|
| Steel structure | 0% |
| HQE construction | 0% |
| BREEAM | 1% |
| LEED | 1% |
| Label BBCA standard | 2% |
| Label BBCA performance | 3% |
| Certification Habitat & Environnement | 4% |
| Label BBCA excellence | 4% |
| Label E+C- | 7% |
| Label bâtiment biosourcé niveau 1 | 9% |
| Label bâtiment biosourcé niveau 2 | 10% |
| Label bâtiment biosourcé niveau 3 | 11% |
| Wood structure | 50% |

4.1.2. Energy NEC component

Energy performance information is given by energy intensity in kWh/m²/year or energy label. If both energy elements are available, two calculations can be performed and compared: NEC energy and NEC label energy, with NEC energy preferred.

If no information is available, average NEC is taken depending on the location of the assets (OECD versus non-OECD), OECD membership been used as a proxy of more stringent construction and energy norms.

Practical tips and traps on energy consumption quantification

Energy intensity characteristics:
 Energy intensity is given in primary energy and covers five regulated consuming functions (heating, cooling, air conditioning, interior lighting, hot water) for a whole building (e.g. If commercial real estate only takes into account shared spaces like corridors and car parks, the data is irrelevant).

Calculation of primary energy:
 Change between final energy and primary energy corresponds to energy loss in the system from production source to final usage. If a company does not report primary energy, data is converted using the following formula:
 Primary energy = 2.58*[% of electricity use] + 1*[% of the rest (gas, fuel) use]
 If the mix is unknown for the portfolio, the country energy mix is used (AIE data).

Both energy label and energy intensity are positioned in the diagram below:

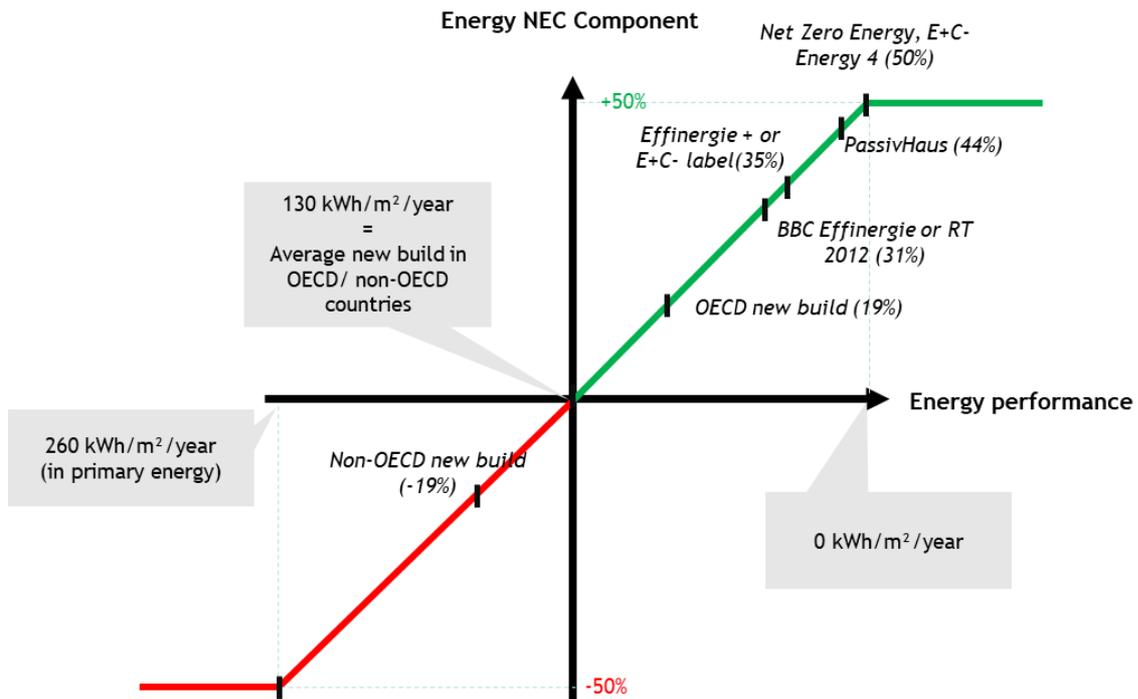
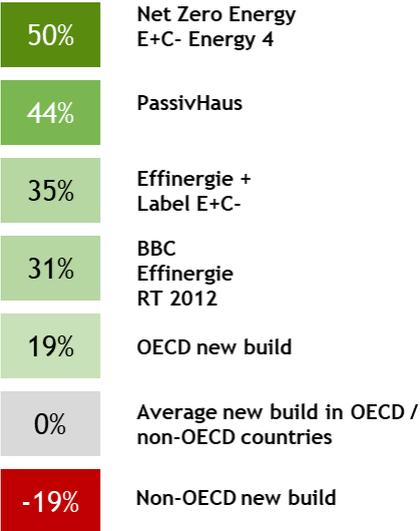


Figure 2: Energy NEC component for new constructions

A linear relationship is used for primary energy intensity data using the 3 following points:

| | |
|------|-----------------|
| 50% | 0 kWh/m²/year |
| 0% | 130 kWh/m²/year |
| -50% | 260 kWh/m²/year |

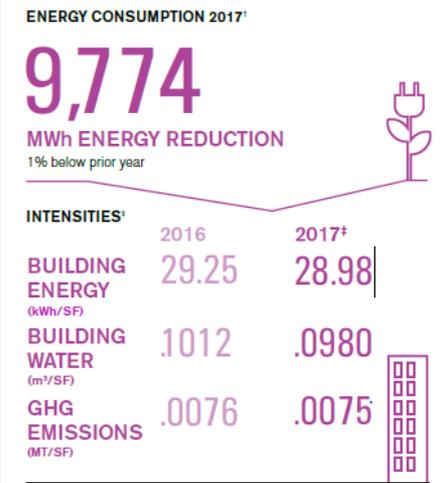
The same linear relationship is used to rank energy certifications as illustrated below:



Data availability and practical tips

Information needed: total energy consumption in kWh/m²/year (primary energy), type of construction (existing or new)

Vornado is an office real estate investment trust in the USA following GRI standards and disclosing energy consumption in its sustainability report.



Vornado operates only one type of assets: offices. Energy intensity is given in kWh/square foot/year:

- Data covers assets under management (there are no development projects)
- Data is assumed to be primary energy.
- The data is then converted into kWh/m²/year
- Energy intensity obtained is 312 kWh/m²/year, granting a NEC of +18%

A final NEC can be calculated based on these different splits.

4.1.3. Incremental NEC and renewable energy bonus

As renewable energy integration and on-site consumption are two key factors boosting building energy performance, a positive incremental NEC or bonus can be attributed to assets and activities incorporating a quantified level of renewable energy in their consumption.

- ▶ If renewable energy is produced on-site (added-value on energy performance and on land urbanization)

$$X\% = (\text{Renewable energy produced} / \text{Total energy consumed}) / 2$$

Maximum score : 50%

- ▶ If renewable energy is consumed (added-value on energy performance, but green certificates' robustness is variable and is lower than effective physical renewable energy supply)

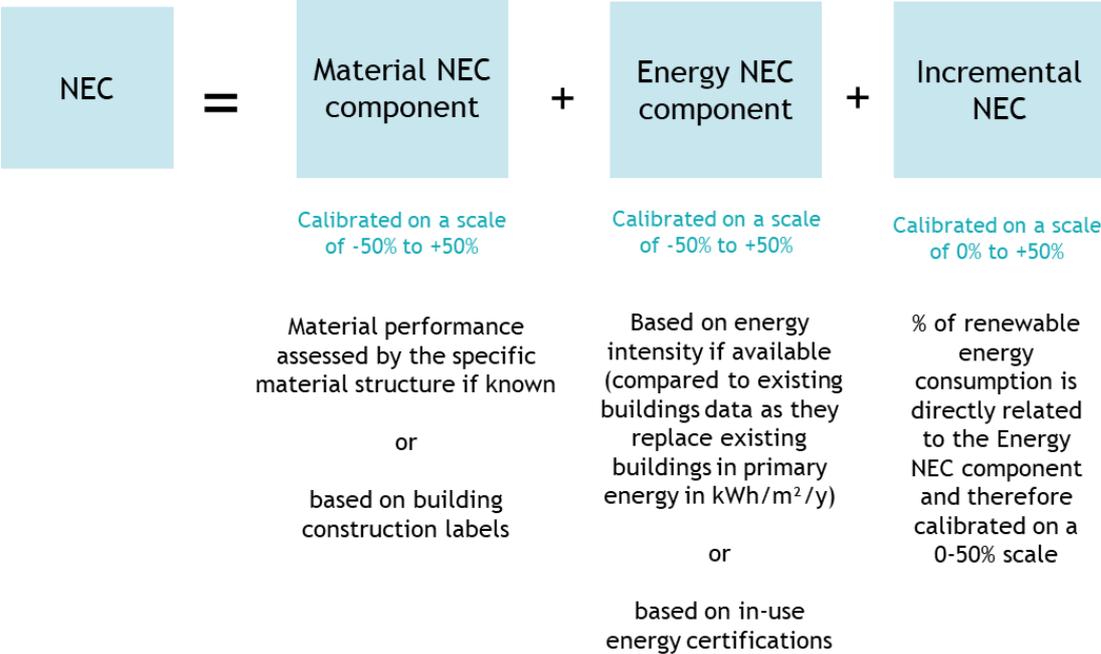
$$X\% = (\text{Renewable energy bought} / \text{Total energy consumed}) / 4$$

Maximum score : 25%

This Incremental NEC enhances in-use energy performance and is therefore calibrated on a 0% to +50% scale. Other incremental NEC are possible as soon as they are quantified, robust and consistent with the NEC frameworks.

4.2. Existing buildings and renovation

Similarly to new building NECs, the NEC for existing buildings and renovation is based 50% on materials performance and 50% on energy performance, with an incremental energy bonus for renewable energy consumption or production.



4.2.1. Material NEC component, same calculation as new buildings

Similarly to new buildings, the NEC for construction and real estate activities is based 50% on materials performance and 50% on energy performance, with an incremental energy bonus for renewable energy consumption or production. Labelling (for new construction or heavy rehabilitation only) is often the best source of information available on the environmental performance of building materials. Refer to the new buildings section 4.1.1, as the calculation method is the same.

4.2.2. Energy NEC component, different calculation from new buildings

The calculation for existing buildings and rehabilitation is different from the new buildings’ one, but uses the same logic. There are indeed different energy labels for new and rehabilitated buildings. Moreover, in-use energy performance is not as demanding (quantitatively speaking) for rehabilitated buildings than for new buildings, as already-installed bases of existing buildings have lower energy performance than new buildings. Both energy label and intensity are positioned in the diagram below:

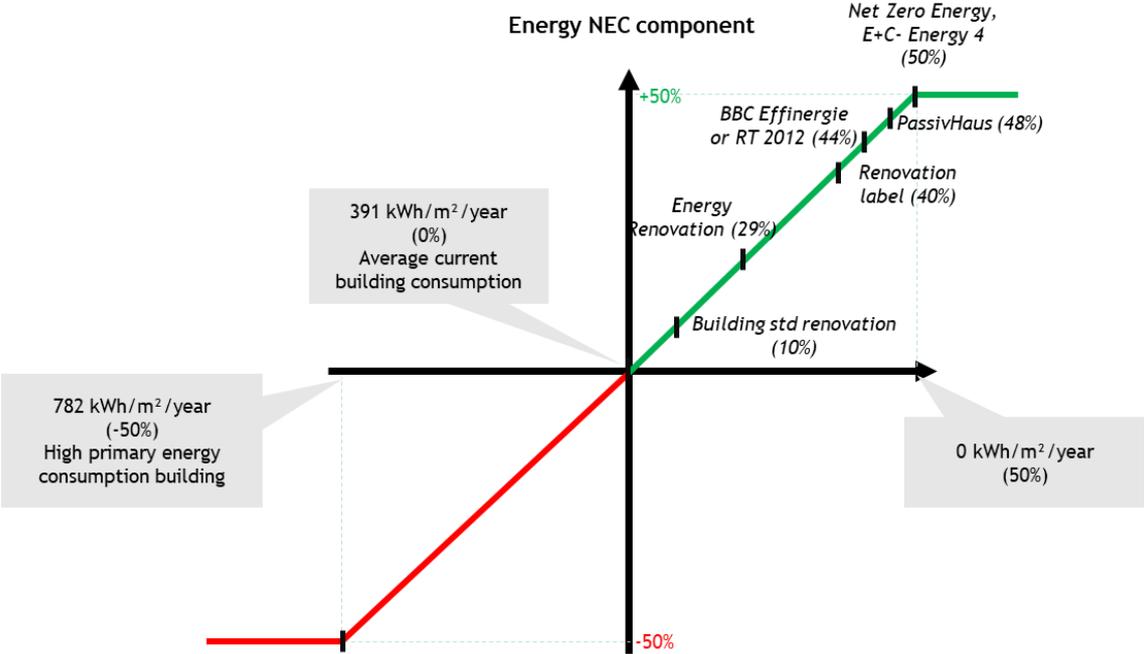


Figure 3: Energy NEC component for existing buildings/rehabilitation

When available, energy performance information is given by energy intensity in kWh/m²/year or energy label. If both sources are available, two calculations can be performed and compared. The most valuable source is preferred. Practical tips and traps on energy consumption quantification are the same as for new buildings.

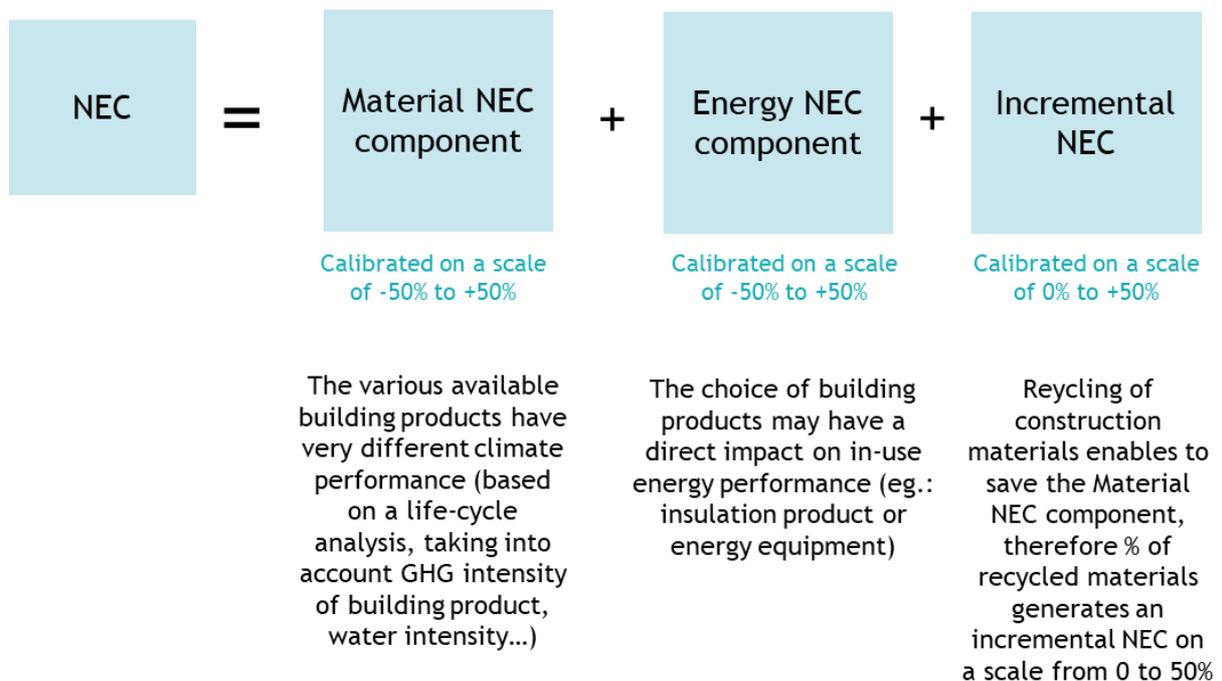
If no information is available, average NEC is used, depending on the location of the assets (OECD versus non-OECD), OECD membership been used as a proxy of more stringent construction and energy norms.

4.2.3. Incremental NEC and renewable energy bonus

Refer to the new buildings section 4.1.3, as the calculation method is the same.

4.3. Building products

The NEC for building products is based 50% on material performance and 50% on energy performance, with an incremental energy bonus for percentage of recycled materials.



4.3.1. Material NEC component

The material NEC component consists of an order of magnitude and a contribution intensity specific to each raw material:

- Order of magnitude: as the proportion of low carbon materials impacts the resulting NEC of construction systems, the NEC scale is set from -50% to +50%
- Contribution intensity of each raw material is summarized below. Concrete and cement are used in all types of buildings, even in low carbon construction systems at a lower proportion. Assuming the repartition of concrete use per construction system, an average of -25% for concrete and cement is estimated; same for general wood on the opposite with a +25% NEC. Dedicated structure wood has a NEC of +50% as solely used in wood-based construction systems.
- This scale is consistent also with the wood & paper framework, where wood used in construction has an average +25% value, and with the basic materials framework, where concrete has an average default value close to -50%.



Figure 4: Material NEC component for building products

4.3.2. Energy NEC component

The energy NEC component integrates the impact of the settled building products on final use, i.e. on the energy performance induced for the building use phase. It is estimated via the following categories:

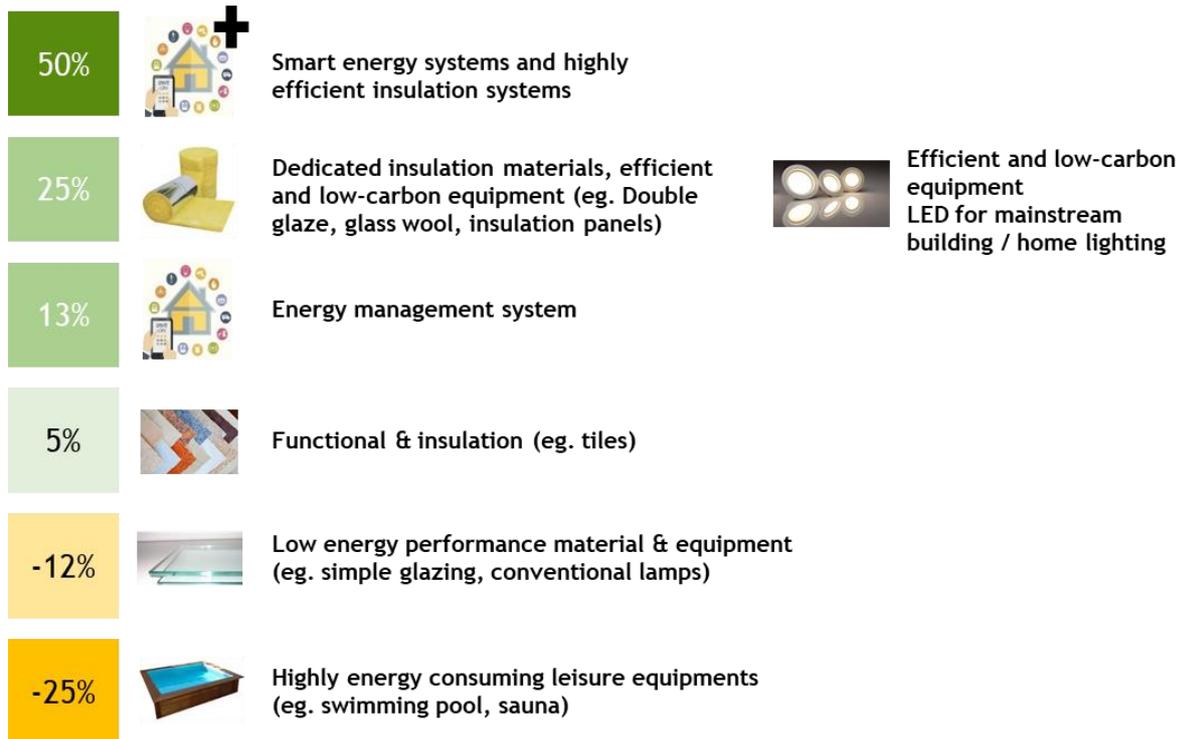


Figure 5: Energy NEC component for building products

4.3.3. Incremental NEC with share of recycled products

As recycling products consumes less resource than producing products from virgin raw materials, a positive incremental NEC or bonus can be attributed to assets and activities incorporating a quantified level of recycled products using the following ratio:

$$1\% \text{ of recycled materials} = 0.5\% \text{ of incremental NEC}$$

This Incremental NEC enhances material performance and is calibrated on a 0% to +50% scale.

4.4. Generic building services and other default values

Building services, when generic, are built using average default values summarized below.

| | | Default NEC | = | Material NEC component | + | Energy NEC component |
|---------------------------------|---------------------|-------------|---|------------------------|---|----------------------|
| New buildings | OECD | 19% | | 0% | | 19% |
| | Non-OECD | -19% | | 0% | | -19% |
| | All | 0% | | 0% | | 0% |
| Existing buildings / Renovation | Standard renovation | 10% | | 0% | | 10% |
| | Energy renovation | 29% | | 0% | | 29% |
| Generic renovation services | | 10% | | 0% | | 10% |
| Generic new building services | | 0% | | 0% | | 0% |
| Generic Building services | | 5% | | 0% | | 5% |

Some generic building services such as consulting, inspection or engineering may be directly responsible for the environmental performance of the buildings. Therefore, they can be get by incremental NEC derived from the environmental benefits they cause:

- If services help obtain a particular label, they get the label's NEC.
- If services help generic building activities, they get the average activity NEC:
 - o Generic renovation services have a +10% NEC – like standard renovation
 - o Generic new buildings services have a 0% NEC – like new buildings
 - o Generic building services are evenly divided between generic renovation and new buildings services and have a +5% default NEC.

If an audit is neutral regarding environmental performance, the associated NEC is 0%.

Using the same logic, additional default values for building activities are:

- Other building work, such as decorative renovation or interior design: 0%
- Incremental NEC for low Volatile Organic Compound, VOC, and phthalate-free materials: 12.5% (+25% incremental for air quality improvement, weighted 50% as it concerns only the operation/use phase)

5. Main limits

This method encompasses a multicriteria approach that covers several environmental key performance indicators (KPI). based on different types of frequently available input data (certification, type of building structure or energy consumption).

Lack of quantitative data and certification parameters limit the NEC assessments. Moreover, the selected KPIs may evolve over time, requiring the incorporation of new certifications and updates to current ones referenced.

The methodology offers only one level for each certification (BREEAM/LEED), whereas there are several in reality that could be taken into account when updating the methodology.

When rating materials performance, quantitative and precise data is lacking for many indicators, and ranking often remains qualitative. Also, data concerning energy consumption is not always similarly disclosed from one company to another, which can make comparisons difficult.

6. Key data sources

| Data | Sources |
|---|---|
| Certification/ label characteristics and requirement levels | https://www.certivea.fr/offres/label-batiment-biosource : Label "Bâtiment biosourcé" (version of March 2014) www.batimentbas carbone.org : Label « BBCA » www.constructiondurable.com www.projetvert.fr : label BBC www.cequami.fr : different labels comparison Energy in the Residential Sector, 2013 Report, SEAI www.projetvert.fr : label BBC www.cequami.fr : label "Effinergie" et RT www.lamaisonpassive.fr : label "PassivHaus" www.logement.gouv.fr : label "E+C-" www.minergie.fr : label "Minergie" https://www.researchgate.net/publication/318302908_A_critical_comparison_of_green_building_rating_systems www.certivea.fr : label « HPE » www.cequami.fr : different labels comparison Journal of Cleaner Production: Key credit criteria among international green building rating tools |
| Energy data | Energy Consumption in the European built environment - The role of cooling, by M. Santanamouris, UCL, 2016 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Consumption_of_energy/fr&oldid=396952 : Building energy consumption in the European Union |
| GHG emissions factors | http://www.bilans-ges.ademe.fr : ADEME - Bilan GES |

CHEMISTRY FRAMEWORK

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1. Introduction

Environmental impacts of the chemistry value chain are of high importance, particularly due to the fossil resources required as raw materials, and the pollution generated (water pollution and air pollution) by processing them and by their end-of-life disposal. A growing trend in the chemistry value chain is emerging, consisting for instance of using bio-based raw materials to replace fossil resources, thus improving the value chain's impacts on environment. Chemistry industry supplies key elements to an extremely wide range of activities and can contribute to the environmental transition directly or thanks to

compounds, ingredients, catalysts or products, indirectly reducing vehicles' emissions or improving pollution control, wastewater treatment, etc.

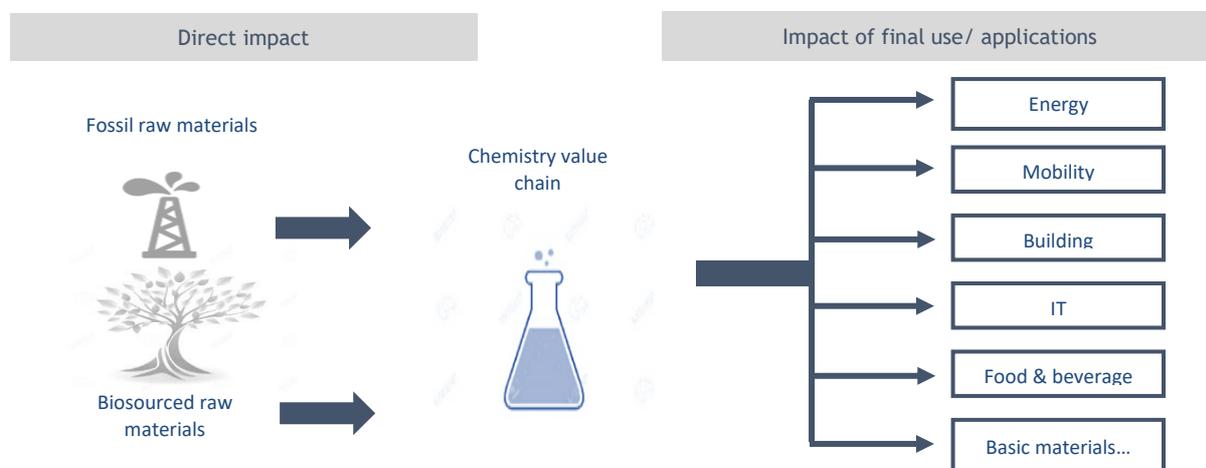


Figure 1: Scope of Chemistry framework, NEC 1.0.

2. Main environmental issues

| Environmental stake | | Relevance along value chain | | | Comments | Data availability |
|---------------------------|--|-----------------------------|------------|-----------|--|---|
| | | Raw materials | Processing | Final use | | |
| Climate | Climate Change | Yellow | Red | Red | The chemicals value chain is responsible for 1.52 GtCO ₂ eq (6% of GHG emissions), which is a significant share. But chemical products can also be key contributors to climate transition | Heterogeneity of the chemicals value chain makes it very difficult to have benchmarks |
| | Use efficiency of Energy Resources | Yellow | Red | Red | The chemicals value chain is energy intensive, e.g. fertilizers production | Heterogeneity of the chemicals value chain makes it very difficult to have benchmarks |
| Air Quality | Air quality deterioration | | Yellow | | In developed countries, environmental regulations have drastically reduced the emissions of pollutants | |
| Water | Water consumption | | Yellow | | Chemicals production can require significant water consumption (ex: Petrochemicals) | Heterogeneity of the chemicals value chain makes it very difficult to have benchmarks |
| | Water pollution | | Yellow | Yellow | Chemical use can generate downstream water impacts, e.g. nitrogenous fertilizers use generate water eutrophication, chemical uses in textile etc. | |
| Ecosystems & biodiversity | Soil Pollution | | Yellow | Yellow | Chemical use can generate downstream soil impacts, e.g. nitrogenous fertilizers generate soil eutrophication | |
| | Land Use | | | | Low land use per unit of product | |
| Resources & waste | Use Efficiency of Non-Energy resources | Red | | | Even if fossil raw materials are predominantly used, bio-based raw materials are more and more considered and can be a part of the solutions for climate transition | Companies communicate on their bio-sourcing share |
| | Waste | | Yellow | Red | The main issue is the waste generated during the final use phase and its potential mismanagement | It is very difficult to hierarchize chemical products based on waste generation |

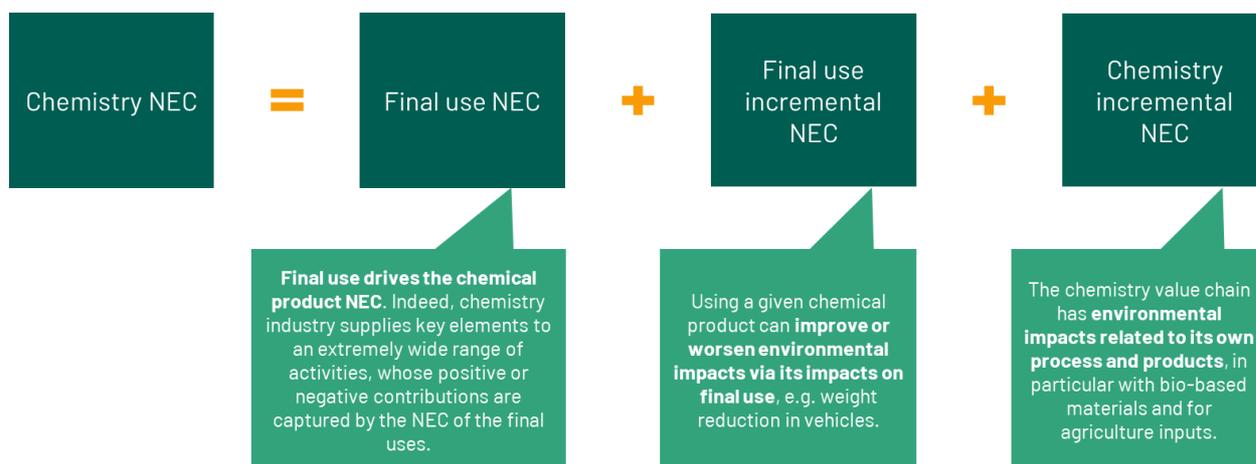
Environmental impacts are very diverse, heterogeneous and chemicals specific. They first rely on final use and on type of chemicals. The framework is then driven by final uses and by product specificities which can worsen or improve the environmental impacts. These specificities can concern both final use impacts and process-based upstream and midstream impacts. As soon as a significant share of an activity is identified to serve a specific application or sector (automobile, oil refining...), the end-market default NEC is applied.

As a result, this 1.0 framework is based on all other sectorial frameworks using their default NEC value and is completed by specific incremental NEC components.

3. Environmental performance indicators

The following indicators to determine the Net Environmental Contribution have been selected:

- **Final use NEC**
- **Incremental final use NEC**
- **Chemistry incremental NEC**

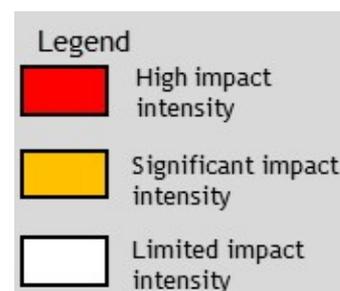


3.1. Final use NEC

Final use NEC = sum of [Product final use breakdown x product final use NEC]

The calculation is based on the final uses of the different products and their economic breakdown. Due to the wide range of uses of chemical products, the final use has to be analyzed upon their incorporation into a specific value chain. Therefore, the final use NEC has to be attributed depending on the scoring of the activities in the relevant framework. For instance, standard cosmetic products have a default NEC -12% according to Home and Personal Care framework, whereas solar panels get the default NEC +65% from the Electricity framework.

More than 300 default values NEC covering all the NEC methodology frameworks are listed in an excel tool. A sample of default final use NECs is presented here below:



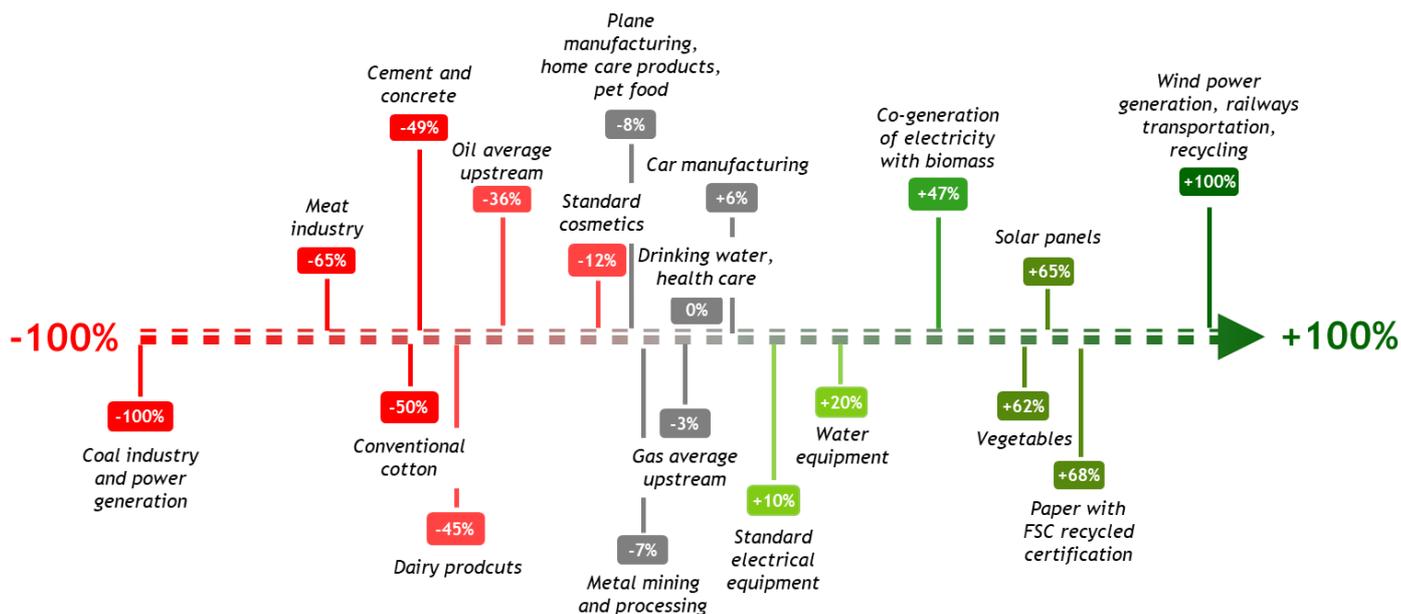


Figure 2: Default NEC values from other frameworks, NEC 1.0.

Data availability and practical tips

Needed information: Breakdown per products; for each product, breakdown per use

The product categories can be found in the annual report. However, chemicals are covering very wide and heterogeneous product ranges and end-markets. Moreover, companies reporting practices are extremely heterogeneous too, as illustrated below with reporting structure:

| ARKEMA reporting | CRODA reporting |
|---------------------------|----------------------|
| Filtration and absorption | Personal Care |
| Technical polymers | Health care |
| Organic peroxydes | Crop care |
| PMMA | Lubricants |
| Thiochemical | Coatings & Polymers |
| Fluorinated chemicals | Polymer Additives |
| Oxygenated | Geo Technologies |
| Acrylics | Home Care |
| Resins | Industrial chemicals |
| Additives | |

Figure 3: Example of product's categories of Arkema and CRODA

That is why, based on company information often disclosed in their annual report, each product category has to be associated with a final use NEC, which can be found in the Excel file. When it is only possible to know that one product category has several different final uses, without knowing the breakdown, it is possible to consider that each final use has an equal weighting for the product's category.

3.2. Final use incremental NEC

Chemistry products can also bring a positive or negative contribution to the final use of the product. For instance, a chemical product that adds preservative properties to the final product can be considered as a positive contribution by reducing food waste and could therefore be attributed a positive final use

incremental NEC, if a significant environmental benefit can be reliably quantified. On the other side, an additive helping to transform a plastic packaging into a non-recyclable item, e.g. perfume caps overweighed with metals, may get a negative incremental NEC.

3.2.1. For transport activities and batteries

In the mobility sector, chemistry plays a role at different levels: the refining of more or less efficient fuels, the fabrication of plastic's parts which can reduce the weight of vehicles, or the production of catalytic converters that decrease the emission of air pollutants. As a result, consistent with Mobility and Transport framework, final use incremental NECs are:

| Type of increment on final use | | Final use incremental NEC | Comments |
|--|--|---------------------------|---|
| Fuel efficiency gain | Default value for all transportation means | +1% => +1.5% | Car and truck driven, as main vehicles |
| | Car | +1% => +1.5% | |
| | Truck | +1% => +1.5% | |
| | Coach & Bus | +1% => +0.8% | |
| | Plane | +1% => +1.2% | |
| | Sea vessel | +1% => +1% | |
| Vehicle weight reduction | | -1% => +1.5% | |
| Catalysts for automotive, commercial vehicles & trucks' pollution control | | +25% | Apart from heavy industry, other applications of catalysts have a default NEC of 0% |

At this stage of the NEC methodology development, batteries are considered as commodities feeding their related final applications, which can be roughly summarized into:

- Renewable energy management and electric mobility applications, stationary and vehicle batteries (bicycles, passenger cars, etc.): average NEC of +75% deriving from mobility and electricity frameworks
- For other applications (electronic equipment, healthcare devices, toys, etc.): NEC +0%
- Battery for undifferentiated final use: NEC +50%

3.2.2. For other activities

Catalysts can also apply to heavy industries like activities related to Fuel, Electricity, Heat and Basic Materials frameworks. As soon as a quantified benefit from the catalyst (e.g. energy and/or raw material savings) can be reasonably estimated, an incremental NEC can be integrated. In practice, a default value for this incremental NEC has been set at +10%. For other applications of catalysts, when no quantified benefit or drawback can be estimated, there is no final use incremental NEC.

In general, chemical products can contribute to **save energy** in the final product life cycle footprint, which can be rewarded with the following incremental NEC calculation method, as soon as the quantification is reliable:

- For high-impact intensity frameworks: +1% NEC by percentage point of energy efficiency gain
- For moderate-impact intensity frameworks: +0.3% NEC by percentage point of energy efficiency gain

Food conservatives: chemical ingredients, such as conservatives, used in food and beverages can lengthen a product's life and thus reduce food waste. In practice, a default value for this incremental NEC is set at +5% when the environmental benefits are clear.

3.3. Chemistry incremental NEC

Apart from final use impacts, the chemistry value chain has various environmental impacts related to its own process. The chemistry incremental NEC is a way of assessing how the company increases/reduces these issues. NEC values are listed here below for some chemical products.

3.3.1. Bio-based materials

A default chemistry incremental NEC can be used for bio-based materials, only when none of the available NEC frameworks provides a certification ranking, such as wood or home and personal care frameworks, and when reliable LCA analysis are not available. The generic rule below can be used:

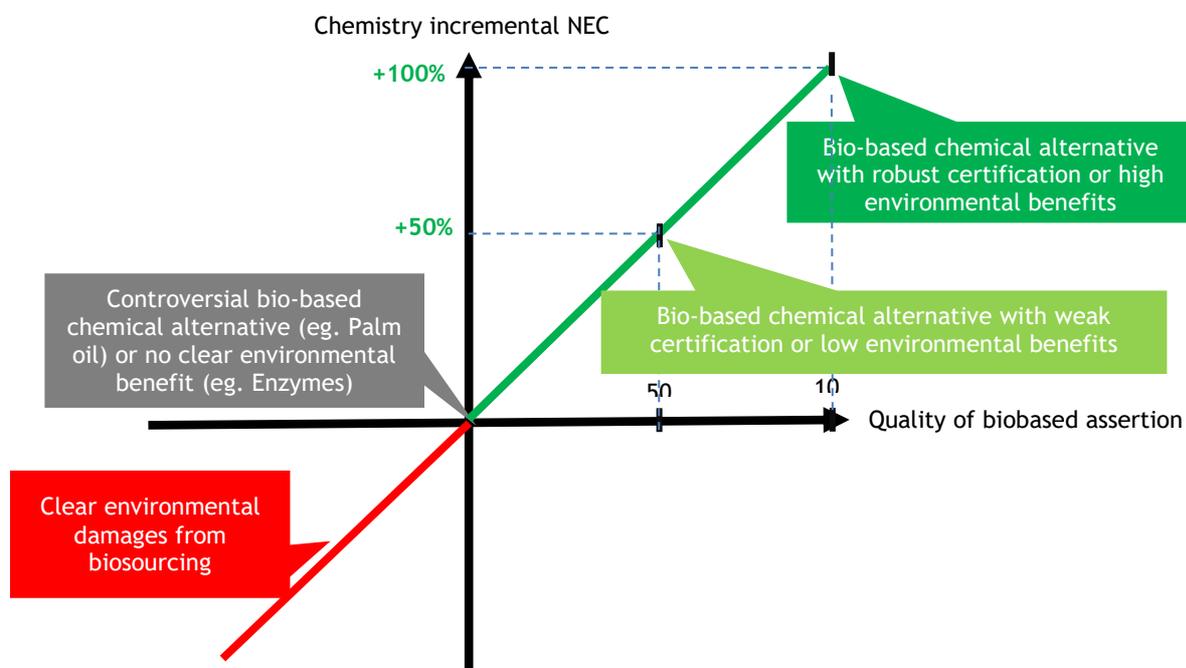


Figure 4: Chemistry incremental NEC for bio-based materials in high-impact intensity activities, NEC 1.0.

These NEC values apply only to final products of high-impact intensity frameworks. For the moderate-impact intensity frameworks (Home and Personal Care, Appliances and IT), chemistry incremental NEC values must be divided by 3, which gives the potential values of NEC +33%, NEC +16% or NEC 0% and down to NEC -33%.

3.3.2. Agriculture inputs

Data availability and practical tips

Needed information: breakdown per material, % of bio-based raw material

Data can be found in the company annual report or in the company's Sustainability Report. The data is most of the time available without distinction between products (for instance, in 2016, "Croda uses 62% of bio-sourced raw materials for its production"). To calculate the indicator, it is considered that each category uses the same amount of bio-sourced raw materials and the overall percentage is allocated to each category.

It is then assumed that the % of bio-sourced raw materials corresponds to the % turnover of products with bio-sourced raw materials.

Thus, the calculation table is filled as bellow for CRODA:

| Company | Activity characterization | Activity's NEC | Key hypothesis |
|---------|---------------------------|----------------|--|
| CRODA | Personal Care | +31% | Share of bio-based chemicals x 50% (weak certification) |
| CRODA | Health care | +31% | Share of bio-based chemicals x 50% (weak certification) |
| CRODA | Crop care | +31% | Share of bio-based chemicals x 50% (weak certification) |

Figure 5: Example of filled calculation table (Tab "CRODA") for NEC contribution to circular economy (Croda)

Specific NECs are attributed for pesticides, fertilizers and organic agriculture inputs:

- Pesticides** or phytosanitary products have negative impacts, on human health or on the environment. These impacts are not only felt by species targeted by the pesticides, but also by non-targeted species. ~98% of insecticides sprayed over crops reach other species than the ones targeted initially. Pesticides concern several environmental issues:
 - Air quality: pesticides can release chemical substances that can react with other chemical products, thus creating a pollutant called tropospheric ozone
 - Water quality: many pesticide residues can be found in water streams, notably because of water runoffs or soil erosions. The presence of pesticides in water has a significant impact on aquatic biodiversity
 - Biodiversity: the presence of pesticides has both an impact of vegetation and animals. First, nitrogen fixation, necessary to vegetation growth is impeded by the presence of pesticides in the ground. By contributing to the death of bees, pesticides are involved in the decline of pollinators, and thus to the decline of species depending on pollinators. Pesticides also have a direct negative impact on plants, including leaf yellowing or plants growth reduction. Animals can be poisoned by pesticides residues that can be found in food, as wild animals entering crops.
- Fertilizers:** fertilizer products are used in agriculture to improve soils quality, including their structure, and to fertilize cultivated plants. Several environmental issues are linked to the use of fertilizers, depending on the type of fertilizers used. The use of inorganic nitrogen fertilizers notably generates nitrogen cycle disruption, which results in eutrophication effects and ecosystems disruption.
- Organic agriculture inputs:** organic inputs for agriculture substitute pesticides and inorganic/mineral fertilizers, which have a NEC ranging from 0% to -100%. Compared to mineral fertilizers, organic inputs are on average less impactful in terms of GHG emissions associated with their production, and generate a lower environmental impact on water, soils and local ecosystems. Due to this substitution effect, a default NEC is set at +50% for these products. As a specific case, in the Waste framework, organic valorization of non-hazardous waste into fertilizers has a NEC of +75%, and therefore agriculture inputs from waste valorization achieve the same NEC.

Therefore, the following NEC are applied to agricultural chemistry products:

| Products | Types | Chemistry incremental NEC |
|-----------------------------------|--|---------------------------|
| Pesticides | Non selective pesticides | -100% |
| | Selective pesticides | -75% |
| Fertilizers | Nitrogenous fertilizers | -50% |
| | Mineral fertilizers (excluding nitrogen) | -25% |
| | Other fertilizers | 0% |
| Organic agriculture inputs | Default value for organic agriculture inputs | +50% |
| | Inputs from waste valorization (e.g. from compost) | +75% |

4. Main limits

The approach can capture and integrate the order of magnitude of impacts when the information about product specificities and final use are available. When these data can be estimated, the calculations are then relying on the other NEC frameworks for final use NEC and on comparative Life Cycle Assessment or impact studies for incremental NEC.

Plastics are an important output of chemistry industry. Their main environmental impacts considerably vary upon its application, especially regarding waste and the growing plastics leakage issue. Indeed, plastic can find long-lasting applications like in some construction products, while plastic cutlery is thrown away after one single use. Therefore, as any other chemical output, plastic has to be assessed based on its final use. Moreover, many specific applications are treated in other frameworks where they are compared to other existing alternatives: plastic packaging are widely used in food, beverage, household products, personal care products, thermoplastics can be found in construction materials, plastics fibers in clothes and shoes, etc.

After the full scale test achieved in 2017, the most frequently met limits were the width of products range, the diversity of the final applications and the heterogeneity of the reporting granularity and taxonomy. Facing this diversity and the limited disclosed information, a dialog with the company is generally required.

5. Key data sources

This framework is based on the other NEC 1.0 frameworks and on the following sources.

| Data | Sources |
|--|---|
| More details on fertilizing waste | https://www6.paris.inra.fr/depe/content/download/3833/36412/version/1/file/Mafor8p_anglais_VF.pdf |
| More details on organic fertilizers benefits | https://www.ademe.fr/sites/default/files/assets/documents/3-optimiser-la-fertilisation-azotee-reference-ademe-8183.pdf (in French) |
| More details on nitrogen fertilizers overuse impacts | https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31788-4/fulltext |

ELECTRICITY FRAMEWORK

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1. Introduction

The electricity industry is one of the world’s heaviest contributors to greenhouse gas emissions because it still relies substantially on fossil fuels. Currently, 35% of worldwide greenhouse gas emissions come from the generation and transmission of electricity, as two-thirds of the global mix of electricity production¹ is fuelled by coal (39%), natural gas (22%) and oil (5%). Global demand for electricity is constantly increasing because it parallels the growth of the world population and of the rising living standards in developing countries.

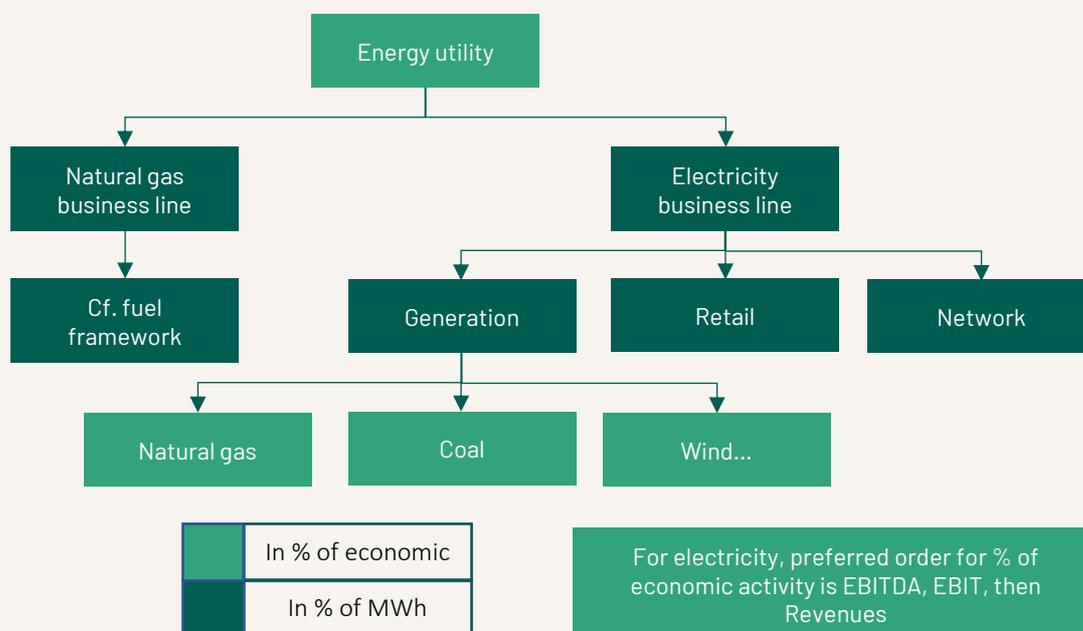
The following diagram shows a simplified three-step value chain, from upstream to downstream. Step two, electricity generation, has the largest environmental impact.



¹ 2014 Data of world electricity production from The Shift Project Data Portal.

Practical tips for Energy Utilities

Energy utilities often manage several types of energy, such as gaseous, liquid and solid fuels and biofuels. The Electricity framework is completed by two other energy frameworks: Fuel and Heat. For instance, gas-fired power plants are covered by this framework, as natural gas exploration, extraction, network operation and retail is covered by the Fuel framework. Thus, the analysis focuses on the business lines that deal with electricity.



The electricity business can be divided into three activities, with distinct environmental impacts:

- **Electricity generation:** an electric utility company often runs its own power plants. The generated electricity can be either commercialized directly to the final customer (e.g. corporate Power Purchase Agreement, PPA, or sold to the grid/network).
- **Retail:** the activity of selling electricity (either produced by the utility or purchased on the wholesale market) to the end-user.
- **Network operation:** power transmission, grid operation and distribution operation is a distinct business.

Each activity is rated on a scale from -100% to +100%. The final electric utility NEC is the sum of each activity's NEC multiplied by the weight of its economic activity:

$$\text{Electric Utility NEC} = \% \text{ Generation} \times \text{NEC generation} + \% \text{ Retail} \times \text{NEC retail} + \% \text{ Network} \times \text{NEC network}$$

In practice, the share of each economic activity (% generation, % retail, etc...) is based on EBITDA, EBIT or Revenues, in order of preference.

2. Main environmental issues

| Environmental stake | | Relevance along value chain | | | Comments | Data availability |
|---------------------|-----------------------------|-----------------------------|------------|------------|---|---|
| | | Upstream | Production | Downstream | | |
| Climate | Climate change | Yellow | Red | White | High climate impact intensity during fuel combustion (power generation), whereas for nuclear and renewable electricity, significant impact intensity for plant construction (upstream) | Emission factor of each technology |
| | Use of energy resources | Red | Red | Yellow | High-impact intensity regarding energy consumption in upstream phase (extraction of energy resources) as well as in production phase (energy conversion). Energy efficiency is also a significant issue in power transmission and distribution (downstream) | |
| Air Quality | Air quality deterioration | White | Red | White | Electricity production based on fossil fuels and biomass is an important contributor to air pollution (power generation sector accounts for 45% of total SO _x emissions) | Air pollution index of each technology |
| Water | Water consumption | White | Red | White | Significant impact intensity in production phase, mainly for temperature regulation reasons (13% of global freshwater consumption for power generation) | |
| | Water pollution | Yellow | Red | White | Significant impact intensity in upstream phase (fuel extraction phase) as well as in production phase (risk of water temperature increase and pollutants but usually regulated) | |
| Biodiversity | Soil pollution | Red | Red | White | High-impact intensity in material and fuel extraction phases (upstream) while intensity of impact during electricity production phase could be significant but usually regulated | Pollution index of each technology (LCA) |
| | Land use | Red | Red | Yellow | Land use transformation during production phase highly dependent on technologies: high for hydro and ground PV, significant for other technologies. High upstream impact intensity related to plant construction or fuel extraction, whereas significant downstream intensity related to habitat disturbance and fragmentation effect of electricity network. | Land use index of each technology (LCA) |
| Resources & Waste | Use of non-energy resources | Red | Yellow | Yellow | High-impact intensity in upstream phase due to the required use of minerals and metals for electricity plant construction. This use of non-energy resources is higher for renewable technologies than for fossil fuel power generation. | |
| | Waste | Yellow | Red | White | High-impact intensity related to production phase, especially for nuclear, and significant for lower yield technologies such as solar PV. Significant impact intensity in upstream phase related to construction waste. | Waste production index of each technology (LCA) |

The three main environmental stakes that stand out both as key for generation activity and assessable at company level are:

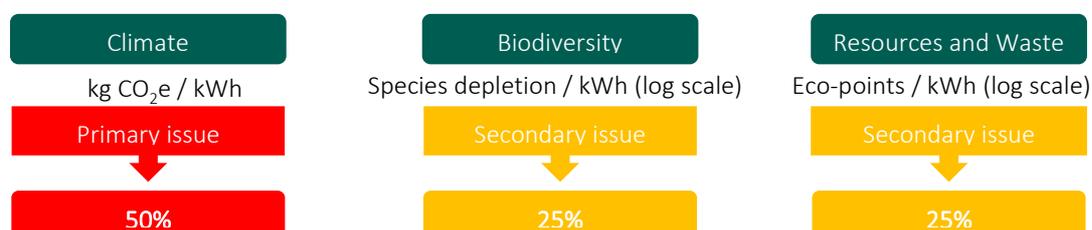
- **Climate:** as previously mentioned, the electricity production sector still relies heavily on fossil fuels as its primary source of energy. The fuel combustion reaction releases quantities of CO₂ that are proportional to the carbon content of each type of fuel. Coal has the highest carbon content, while natural gas (methane, CH₄) has the lowest carbon content of all fossil fuels.
- **Biodiversity:** electricity production can severely degrade the local habitat of living species. These impacts are mainly concentrated in the production phase of primary fossil and nuclear fuels (coal, oil, natural gas and, to a lesser extent, uranium extraction and treatment) as well as the power plant construction phase (especially for large hydro-dams that flood large swaths of ecosystems in order to retain required quantities of water). These impacts are starting to be quantified through the recent generalization of Life Cycle Assessment methods.

- **Resources and waste:** although electricity production essentially transforms energy (which should theoretically produce only heat and emissions), the sector still produces specific of waste:
 - o During the primary production phase for fossil fuels (by-products of coal, oil and natural gas extraction and treatment)
 - o During the component construction phase for renewable energies (e.g. photovoltaic panels and wind turbines) as well as during the dismantlement phase of the electric power plant
 - o During electricity production phase mainly for nuclear (radioactive nuclear waste and irradiated components) and for geothermal (deep earth components caught inside the steam)

3. Environmental performance indicators

To quantify the impact of each of the environmental issues, the following set of performance indicators (KPI) has been selected:

| Environmental stakes | Selected KPI |
|----------------------|--|
| Climate | Electricity Emissions Factor (kg CO ₂ e/kWh) |
| Biodiversity | Species depletion (points/kWh on a Log scale) |
| Resources & waste | Ecological impact of waste (eco-points/kWh on a Log scale) |



The Net Environmental Contribution (NEC) is a weighted sum of these three KPIs. Based on experts' consultations, as climate change mitigation is one of the most challenging issues of the 21st century with roots embedded in the electricity production system, a weight of 50% has been set to the **climate** issue. The remaining weight is split between **biodiversity** and **resources and waste** with 25% each.

4. NEC components

Electricity generation does not always generate external revenues, as produced electricity can be sold internally to other business units. Detailed production and sales mix are rarely disclosed, but can be estimated based on information gleaned from annual reports and 10-Ks.

4.1. Climate component

The climate impact of electricity production is proportional to the quantity of greenhouse gases emitted per kWh of produced electricity. GHG emissions are expressed in equivalent CO₂ emissions factors. In fact, the average emission factor, expressed in kgCO₂e/MWh or g CO₂e/kWh (similar) of each generation technology varies little among countries and companies. We therefore established a technology-specific emissions database that is incorporated into the Excel file.

Considered greenhouse gas emissions are those generated directly by electricity production as well as indirectly from upstream activities such as fuel production and power plant components manufacturing. The technology-specific emissions factors correspond to a world average Global Warming Potential over 100 years expressed in kg CO₂e/MWh as given by the IPCC (2013). The table below represents the final CO₂ equivalent emissions factors used in the NEC calculation.

| Production technology | Total emissions factor (kg CO ₂ e/MWh) | Environmental performance climate component |
|--|---|---|
| Hydroelectric, run-of-river | 4 | 100% |
| Waste incineration co-generation | 5 | 100% |
| Nuclear powerplant | 23 | 97% |
| Wind turbines | 28 | 97% |
| Hydroelectric, dam in mild climate | 31 | 96% |
| Biomass co-generation powerplant | 60 | 92% |
| Hydroelectric, dam in tropical climate | 74 | 91% |
| Geothermal powerplant | 80 | 90% |
| Rooftop solar PV | 86 | 89% |
| Ground solar PV | 88 | 89% |
| EU green taxonomy threshold as of 2019 | 100 | 87% |
| Natural gas co-generation powerplant | 569 | 23% |
| Natural gas powerplant | 635 | 15% |
| Fuel oil powerplant | 1194 | -61% |
| Coal co-generation powerplant | 1215 | -64% |
| Coal | 1308 | -77% |

Source: Ecoinvent Database version 3. Calculated Average GWP 100a indicators (IPCC 2013) of all query sheets for each production technology

To transform the emissions factors into an environmental performance, each factor is placed on a scale from -100% to +100%, where +100% corresponds to the lowest CO₂ emissions factor (Hydro, run-of-river), and 0% corresponds to the world average electricity emissions factor. The global emissions factor is calculated by weighting each technology emissions factor by its global share; this worldwide weighted average is 740 kg CO₂e/MWh.

4.2. Biodiversity component

In order to evaluate the impact of each production technology on the ecosystem and biodiversity, the endpoint (or Damage level) indicators of the Impact2002+ LCA method (2012) has been chosen. This indicator takes into account the following impacts:

- Land occupation
- Aquatic toxicity
- Terrestrial acidification & nitrification
- Terrestrial ecotoxicity

The following table represents the IMPACT2002+ points for each technology:

| Production technology | Biodiversity metric (Species depletion/kWh on log scale) | Environmental performance biodiversity component |
|----------------------------------|--|--|
| Waste incineration co-generation | 1 | 108% |
| Hydro, run-of-river | 1 | 100% |
| Hydro dam, mild climate | 2 | 89% |
| Hydro dam, tropical climate | 2 | 89% |
| Natural gas | 17 | 13% |
| Natural gas co-generation | 21 | 7% |
| Wind | 22 | 5% |
| Rooftop solar | 37 | -11% |
| Fuel oil | 44 | -17% |
| Ground solar | 55 | -23% |
| Nuclear | 98 | -41% |
| Geothermal | 291 | -75% |
| Coal co-generation | 656 | -101% |
| Biomass co-generation | 933 | -112% |
| Coal | 949 | -112% |

Source: Ecoinvent Database version 3. IMPACT 2002+ (Endpoint), Total of Ecosystem Quality indicators, World average

In order to transform the biodiversity indicator into an environmental performance, each factor is placed on a scale from -100% to +100%, where +100% corresponds to the lowest impact value of a scalable technology (Hydro, run of river), and the 0% corresponds to the world average electricity impact. The global biodiversity impact is calculated by weighting each technology impact by its global share.

4.3. Waste component

In order to assess the ecological impact of waste produced in the electricity generation process, the Ecological Scarcity 2013 LCA method has been chosen. The following table represents the impact of the radioactive and non-radioactive waste of each production technology, expressed in eco-points.

| Production technology | Impact of radioactive waste (Eco-points / kWh on a log scale) | Impact of non-radioactive waste (Eco-points / kWh on a log scale) | Environmental performance, Resource and waste component (equally weighted) |
|--|---|---|--|
| Hydroelectric, run of river | 0.07 | 0.01 | 100% |
| Hydroelectric, dam in tropical climate | 0.12 | 0.02 | 85% |
| Hydroelectric, dam in mild climate | 0.12 | 0.02 | 85% |
| Wind turbines | 0.63 | 0.86 | 14% |
| Biomass co-generation | 0.71 | 0.29 | 26% |
| Waste incineration co-generation | 0.03 | 1.09 | 22% |
| Coal co-generation | 0.71 | 0.76 | 14% |
| Natural gas co-generation | 1.25 | 0.44 | 10% |
| Coal-fired power plant | 1.28 | 0.82 | 3% |
| Natural gas power plant | 2.52 | 0.29 | -6% |
| Geothermal | 4.10 | 0.70 | -22% |
| Ground solar PV | 2.81 | 2.00 | -22% |
| Rooftop solar PV | 2.91 | 2.11 | -23% |
| Fuel-oil powerplant | 1.88 | 0.27 | 2% |
| Nuclear powerplant | 287.36 | 0.06 | -145% |

Source: Ecoinvent Database version 3. Ecological Scarcity 2013

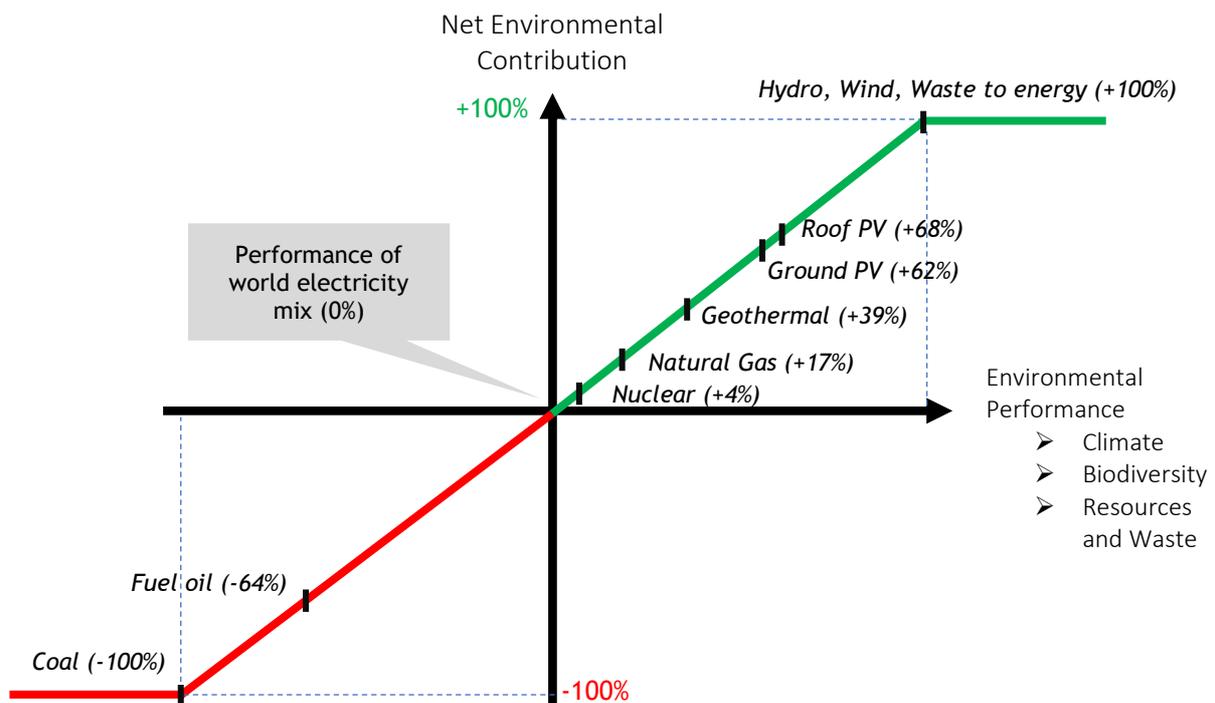
As for the other two KPIs, waste indicator is turned into an environmental performance using a -100% to +100% scale, hydro run-of-river being the +100% point. The 0% point is a worldwide weighted average. The global waste impact is calculated by weighting each technology impact by its global share.

After the consolidation calculation, we decided to recalibrate by moving the +100% point to wind power technology, which appears in the ranking as the first truly scalable technology (hydro and co-generation being linked to local and specific opportunities) with a key role in environmental transition.

4.4. Resulting NEC by generation technology

The final generation scores are presented in the following table:

| Weight | 50% | 25% | 25% | | |
|-----------------------------|-------------------|------------------------|-------------------------------|---------------------------|-------|
| Production technology | Climate component | Biodiversity component | Resources and waste component | Environmental performance | NEC |
| Hydro, run-of-river | 100% | 100% | 100% | 100% | 100% |
| Hydro dam, mild climate | 96% | 89% | 85% | 92% | 100% |
| Hydro dam, tropical climate | 91% | 89% | 85% | 89% | 100% |
| Waste co-generation | 100% | 108% | 22% | 83% | 100% |
| Wind | 97% | 5% | 14% | 53% | 100% |
| Rooftop solar | 89% | -11% | -23% | 36% | 68% |
| Ground solar | 89% | -23% | -22% | 33% | 62% |
| Biomass co-generation | 92% | -112% | 26% | 25% | 47% |
| Geothermal | 90% | -75% | -22% | 21% | 39% |
| Natural gas co-generation | 23% | 7% | 10% | 16% | 30% |
| Natural gas | 15% | 13% | -6% | 9% | 17% |
| Nuclear | 97% | -41% | -145% | 2% | 4% |
| Fuel oil | -61% | -17% | 2% | -34% | -64% |
| Coal co-generation | -64% | -101% | 14% | -54% | -100% |
| Coal | -77% | -112% | 3% | -66% | -100% |



Minimum data required for electric utilities

Utilities' environmental impacts are mainly technology- and country-specific and company-specific to a smaller extent. The key data is the electricity generation **breakdown by technology**. This information can usually be found in the first pages of company's annual reports or company presentations, as illustrated below:

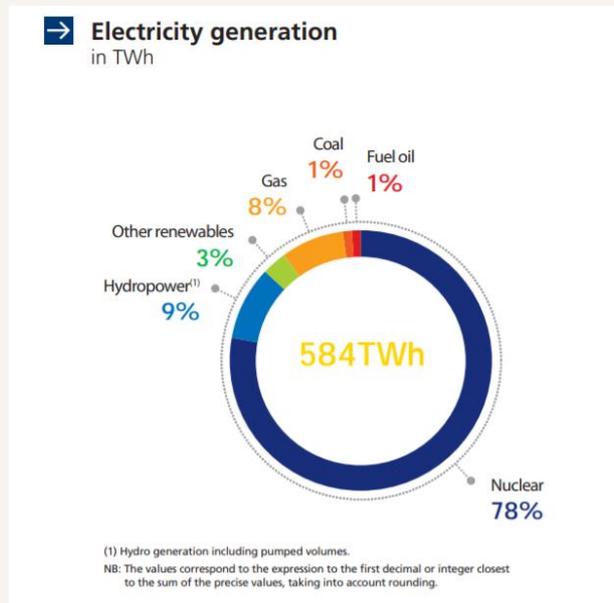


Figure 1: Electricity production split of EDF, source: Reference document 2018, page 5.

US companies often report their annual production of electricity by technology in the 10-K form. This information is usually presented in table form, where the unit is MWh:

Dominion Generation Operating Segment—Virginia Power

Presented below is a summary of Virginia Power's actual system output by energy source:

| Source | 2014 | 2013 | 2012 |
|------------------------|-------------|-------------|-------------|
| Nuclear ⁽¹⁾ | 33% | 33% | 33% |
| Purchased power, net | 19 | 21 | 27 |
| Coal ⁽²⁾ | 30 | 29 | 22 |
| Natural gas | 15 | 16 | 17 |
| Other ⁽³⁾ | 3 | 1 | 1 |
| Total | 100% | 100% | 100% |

(1) Excludes ODEC's 11.6% ownership interest in North Anna.

(2) Excludes ODEC's 50.0% ownership interest in the Clover power station. The average cost of coal for 2014 Virginia in-system generation was \$35.30 per MWh.

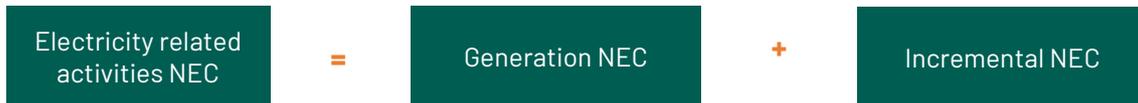
(3) Includes oil, hydro and biomass.

Figure 2: Dominion generation split, source: Dominion form 10-K

4.5. NEC of electricity-related activities

4.5.1. Generic equation

In order to rate the NEC of electricity-related activities, the NEC generic equation - Final use NEC+ Incremental NEC - is used:

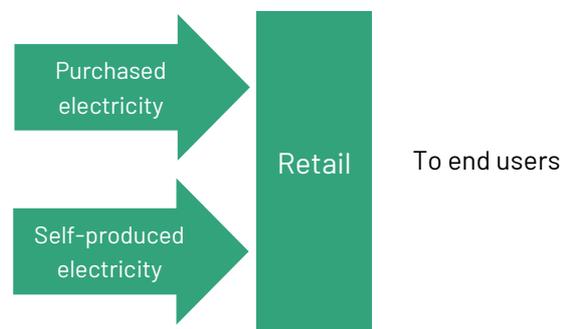


Based on an estimation of NEC-converted environmental benefits, the following two practical tips enable to estimate the incremental NEC:

- **1% of additional energy efficiency percentage point is equivalent to +1% NEC**
- **1% of additional renewable energy percentage point is equivalent to +1% NEC**

4.5.2. Retail activities

Retail activity consists of selling electricity directly to end users. The electricity can come from the company's own power plants or be purchased from the network (the most frequent case) or from another producer.



It is often not possible to trace the origins of the electricity sold to end users, as most utilities simultaneously buy and sell electricity on the market to and from other producers and do not disclose the breakdown. Moreover, some companies don't even report the turnover of their retail activity separately. As a consequence, the NEC of the utility's retail activities can be evaluated as follows:

- **If quantity (MWh) of produced electricity > quantity (MWh) electricity sold in retail** it can reasonably be assumed that all electricity sold in retail comes from internal generation. All of electricity activity is therefore rated using the generation NEC:

$$\text{Retail NEC} = \text{generation NEC}$$

- **If quantity (MWh) of sold electricity in retail > quantity (MWh) of produced** the production is rated as before using generation mix NEC and the incremental amount (net externally purchased = sold via retail - produced) is estimated:
 - Using the disclosed mix of purchased energy (e.g. Direct Energie, now a Total's affiliate);

- Or, when there is no information on purchased mix, using the geographical mix of the company (national or regional).

$$\text{Retail NEC} = \% \text{ internally sourced power} \times \text{company generation NEC} + \% \text{ externally sourced power} \times \text{net purchased electricity NEC}$$

The electricity NEC of the major countries and zones have been calculated in the dedicated Excel file, Electricity NEC per country.xlsx.

| Energy Mix | NEC |
|------------|------|
| Austria | 100% |
| Belgium | 24% |
| Denmark | 38% |
| Estonia | -44% |
| Finland | 45% |
| France | 26% |
| Germany | -18% |
| Iceland | 100% |
| Ireland | 12% |
| Italy | 35% |

| Energy Mix | NEC |
|----------------|-------|
| Kosovo | -100% |
| Luxembourg | 100% |
| Netherlands | -19% |
| Norway | 100% |
| Poland | -78% |
| Portugal | 33% |
| Spain | 22% |
| Sweden | 99% |
| United Kingdom | 7% |
| Switzerland | 100% |

| Energy Mix | NEC |
|---------------|------|
| China | -44% |
| India | -62% |
| Russia | 25% |
| Brazil | 100% |
| United States | -20% |
| Australia | -51% |
| Canada | 98% |

...

4.5.3. Network activities

Network activities include all activities that transport electricity to end users. They can be broken down into three main components:

- Transmission grid: a high voltage grid used to convey large amounts of electricity over long distances, it connects large-scale power plants to a distribution grid using transmission substations
- The distribution grid: a low voltage dense grid that conveys electricity from the transmission grid to end-users over short distances
- Grid balancing: consumption and production management that ensure grid's stability and may include storage

The NEC generic equation - Final use NEC+ Incremental NEC - is used:



Where:

- **The country NEC** is derived from each country electricity mix
- **Incremental NEC of standard grid operations is 10%**, as electricity grid enables the optimization of the production of electricity across the grid
- **Incremental NEC of advanced smart grids is 15%**, as advanced smart grids enable the increase of the share of renewables in the electricity mix and more efficient power management

Tips on data collection

In their annual reports, companies typically break down revenues, EBITDA or EBIT by source, such as electricity sales, network activity, gas sales, etc. as illustrated in the table below with Enel's revenues. The publicly available information enables to break out electricity related revenues from the company's total revenues (in this case, electricity related revenues represent 75% of Enel's total revenues (46 638 + 9 911 = 56 549 m€, out of 75 658 m€).

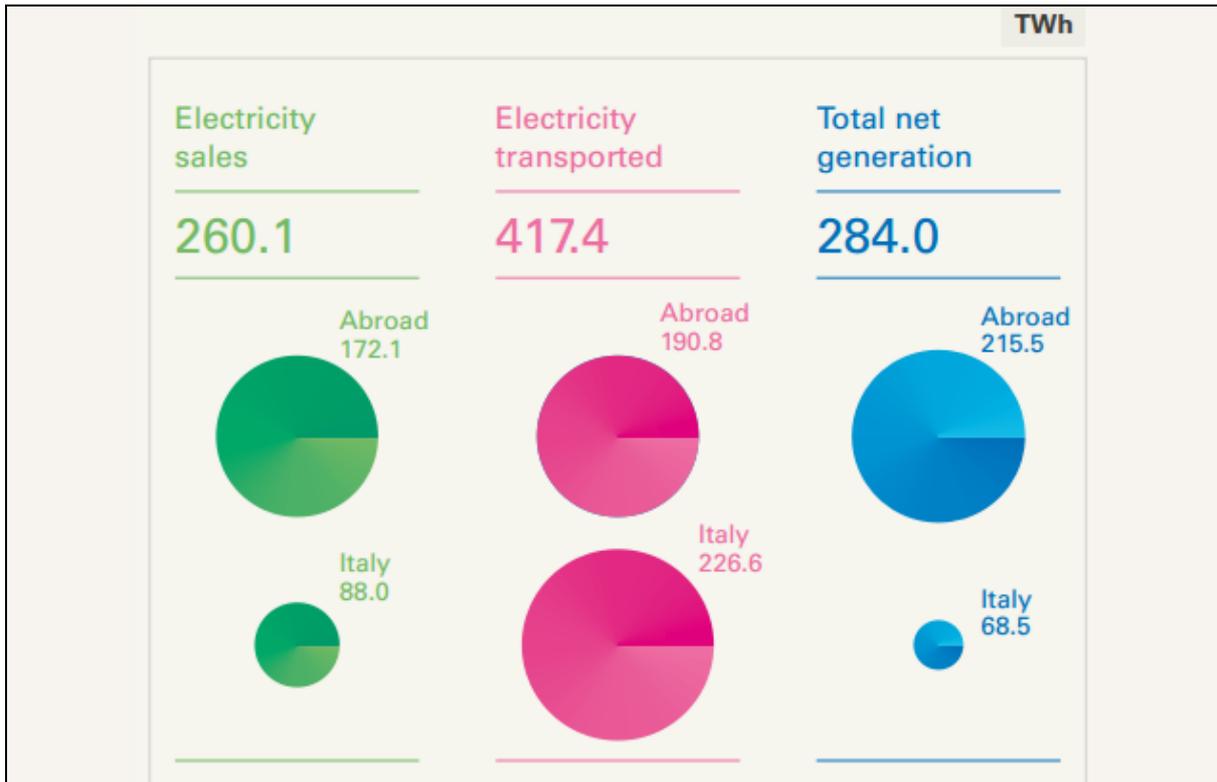
Revenue

Millions of euro

| | 2015 | 2014 | Change | |
|--|---------------|---------------|--------------|--------------|
| Revenue from the sale of electricity | 46,638 | 48,062 | (1,424) | -3.0% |
| Revenue from the transport of electricity | 9,911 | 9,142 | 769 | 8.4% |
| Fees from network operators | 826 | 783 | 43 | 5.5% |
| Transfers from equalization funds, market operators and energy services operators | 1,152 | 1,857 | (705) | -38.0% |
| Revenue from the sale of gas | 4,045 | 3,628 | 417 | 11.5% |
| Revenue from the transport of gas | 509 | 459 | 50 | 10.9% |
| Gains on disposal and negative goodwill on acquisitions of subsidiaries, associates, joint ventures, joint operations and non-current assets held for sale | 313 | 292 | 21 | 7.2% |
| Remeasurement at fair value after changes in control | 80 | 82 | (2) | -2.4% |
| Gains on the disposal of property, plant and equipment and intangible assets | 52 | 32 | 20 | 62.5% |
| Other sales, services and revenue | 12,132 | 11,454 | 678 | 5.9% |
| Total | 75,658 | 75,791 | (133) | -0.2% |

The analysis of Retail versus Generation activity is facilitated by the disclosure of amount of electricity (TWh) in both sales and generation activities: in this particular case, Enel is in excess of electricity abroad (generated electricity > retailed electricity) and in deficit of electricity in the Italian market (generated electricity < retailed electricity), which means that the NEC of the purchased electricity on the Italian market has to be taken into account (based on Italy Electricity NEC).

The NEC of the Network activity will be based on the country mix of transported electricity (in that case Italy and a mix of abroad countries).



Enel discloses the split of generated electricity by technology, enabling the calculation of the electricity generation NEC

Total net generation by resource TWh

284.0



Net generation by renewable resource TWh

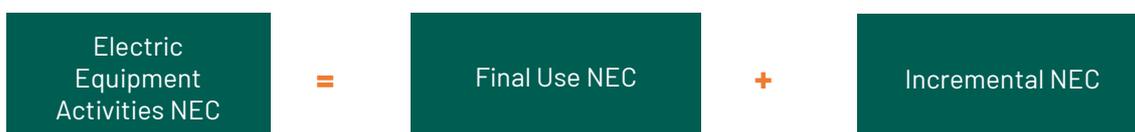
89.3



4.5.4. Electric Equipment activities

An Original Equipment Manufacturer (OEM) is a company that makes a part or a subsystem that is used in another company's end product. Regarding the electricity sector, an OEM mostly manufactures power equipment, such as power plants, cables, substations and switches.

The NEC generic equation - Final use NEC+ Incremental NEC - is used:



- **The Final use NEC** is the NEC of the managed electricity (gas, renewables, etc).
- Regarding network equipment:
 - o Equipment related to **Standard Network equipment** (such as cables, meters, energy management): **Incremental NEC of +10%**
 - o Equipment related to **Smart Energy System**, such as advanced smart grids: **Incremental NEC of +15%**

Example of Vestas

Vestas designs, manufactures, installs and services wind turbines. The NEC of electricity produced by wind is +100%. Vestas has a resulting NEC of +100%.

Tips on LED

LEDs use only 20%-25% of the energy of traditional incandescent bulbs and halogen lights and at least 8 times longer. As such they provide clear environmental benefits, in particular via drastic electricity consumption reduction. See building & real estate framework.

5. Main limits

The KPI chosen to reflect climate change (worldwide CO₂ equivalent emissions factors) is a robust indicator issued by the IPCC that has been reviewed by many parties.

Regarding Waste and Biodiversity KPIs, the use of LCA indicators is deemed pertinent because they are normalized indicators, which enables the comparison between production technologies based on different criteria. However, several renowned LCA methods exist, each having a slightly different approach. Therefore, final scoring may vary from one LCA method to another. The LCA methods selected here have been estimated to be the most relevant in the NEC context.

The 1.0 framework does not take into consideration fugitive methane emissions as they are not yet adequately covered by existing LCA methods. However, these emissions could be taken into account as soon as the methods are upgraded accordingly.

Eventually, the current framework does not integrate the negative over carbon budget incremental NEC (or 2°C malus) that is part of the fuel framework. The question of integrating a 1.5°C or 2°C malus in all energy frameworks appears relevant for the next update.

6. Key data sources

| Data | Sources |
|---|---|
| Global energy statistics | - 2014 world electricity production data from The Shift Project Data Portal: http://www.tsp-data-portal.org/ |
| Share of each production technology in the global electricity mix | - IEA 2014 world electricity and heat production: http://www.iea.org/statistics/statisticssearch/report/?country=WORLD&product=electricityandheat&year=2014 |
| CO ₂ emissions factors | - Ecoinvent Database version 3. Average GWP 100a indicators (IPCC 2013) of production technology query sheets |
| Ecosystem and biodiversity LCA indicators | - Ecoinvent Database version 3, IMPACT 2002+ (Endpoint), Total of Ecosystem Quality indicators, world average |
| Waste LCA indicator | - Ecoinvent Database version 3, Ecological Scarcity 2013, sum of radioactive and non-radioactive waste to deposit, world average |
| EU Green taxonomy threshold | - EU green taxonomy as of June 2019 at https://ec.europa.eu/info/publications/sustainable-finance-teg-taxonomy_en#190618 |



The holistic metric
guiding environmental
action

FOOD & BEVERAGE FRAMEWORK

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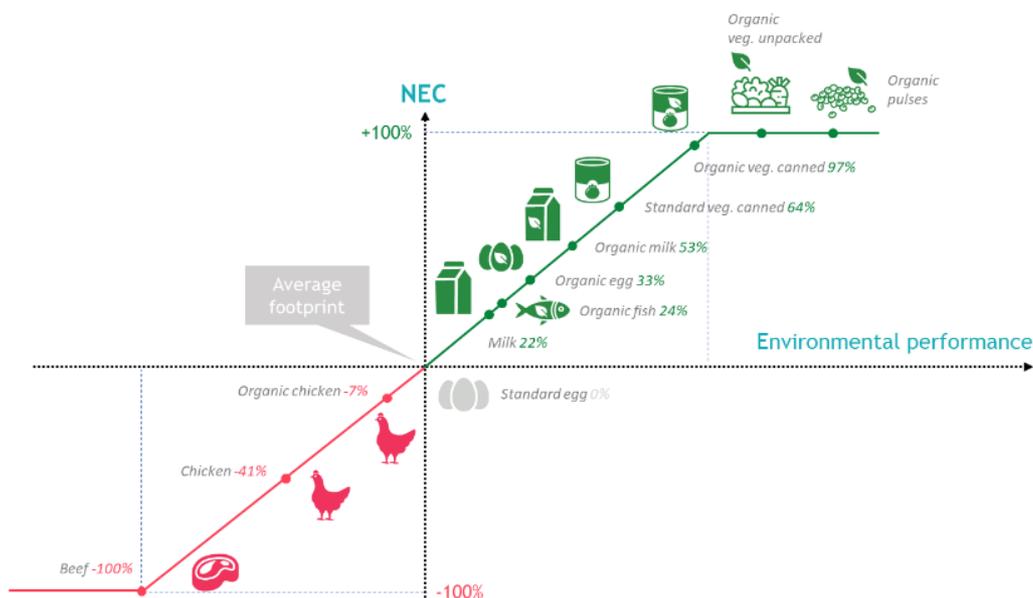
1. Introduction

The food & beverage sector includes companies involved in producing, transforming and retailing edible and drinkable goods. The framework is classified as a high environmental impact intensity framework in the NEC metric because the agricultural supply chain and production phase has a strong impact on the affected ecosystems and on climate.

Food & Beverage production includes agriculture, fishing, ingredients and animal farming. Transformation includes meat and dairy processing and the fabrication of processed goods. Distribution includes transportation and food & beverage retailers, such as grocery stores and restaurants. This sector is also responsible for 70% of fresh water consumption worldwide. Most companies contributing to this value chain are agricultural raw material providers, food transformers, packaging providers and retailers, with different degrees of vertical integration.



The environmental impact of food & beverage predominantly occurs in its agricultural upstream supply chain, where the production phase has a strong impact on the affected ecosystems and on climate. As global demand is increasing due to a growing global population and rising living standards, the management of the environmental impacts generated by this sector are a crucial component of the environmental transition. An overview of some NECs by product type are shown here:



2. Main environmental issues

| Environmental stake | | Relevance along value chain | | Comments | Data availability |
|---------------------|-----------------------------|-----------------------------|------------------------------|--|---|
| | | Production | transformation | | |
| Climate | Climate Change | High impact intensity | Significant impact intensity | Agriculture is a major contributor to anthropogenic GHG emissions, many drink categories require agriculture inputs (cereals, fruits...) | GHG emissions per food types have been computed in the ADEME's FOODGES database |
| | Use of Energy Resources | Limited impact intensity | Significant impact intensity | Energy intensity of transformation processes | Packaging's footprint is covered by FOODGES |
| Air Quality | Air quality deterioration | Limited impact intensity | Limited impact intensity | Considered marginal | |
| Water | Water consumption | High impact intensity | Limited impact intensity | Agriculture's irrigation is the primary source of human water consumption | Water footprint per food & beverage type is provided by the Hoekstra study |
| | Water pollution | High impact intensity | Limited impact intensity | Use of fertilizers/ chemicals to increase yields | Not available, excluded as not applicable across food and beverage types |
| Biodiversity | Soil Pollution | High impact intensity | Limited impact intensity | Use of fertilizers/chemicals to increase yields | Not available, has to be qualitative |
| | Land Use | High impact intensity | Limited impact intensity | Agriculture and farming occupy 40% of global land | Not available, has to be qualitative |
| Resources & Waste | Use of non-energy resources | Limited impact intensity | Significant impact intensity | Packaging's material consumption | No direct availability on resources but data on collection rate |
| | Waste | Limited impact intensity | Significant impact intensity | Food & Beverage packaging generates significant amount of waste | Waste treatment is geography specific and cannot be accounted for per company |

| Legend | |
|---------------------------------------|------------------------------|
| ■ | High impact intensity |
| ■ | Significant impact intensity |
| ■ | Limited impact intensity |

The three main environmental issues that arise as both key for the food sector and measurable at product category level are:

- **Climate change issue:** According to the IPCC¹, agriculture accounts for almost a fourth of global anthropogenic GHG emissions, which has a direct accelerating impact on climate change. Methane (CH₄) emissions from livestock ranching account for a significant share which illustrates the fact that different food types may have highly different GHG footprints. It is thus necessary to "qualify" food types for comparison purposes. Moreover, the production of food packaging puts further weight on the GHG footprint of finished products and should be accounted for.
- **Water consumption issue:** Agricultural and animal products may have a significant water footprint in production phase. The amount of water necessary to grow agricultural crops (or crops for livestock feed) puts significant pressure on local water resources, as a major consumer of water. Irrigation accounts for approximately 70% of water taken from rivers and groundwater sources² worldwide, but regions show various levels of water scarcity. Water consumption is thus another major environmental impact generated by the food value chain.

¹ Climate Change 2014 : mitigation of climate change, IPCC 2014

² <http://www.lennotech.com/water-food-agriculture.htm>

- **Biodiversity issue:** the impact of agriculture, fishing and animal farming on local ecosystems and biodiversity, (soil and water pollution, high land use for agriculture for instance) is highly dependent on the practices implemented during the production phase. Organic agriculture relies on a lower input of chemicals and hence a lower amount of pollutants outflow. Even though the particular practices associated with food products cannot be precisely tracked, this major distinction between conventional, sustainable and organic practices needs to be reflected on companies' NEC calculations.

For beverage products with agricultural inputs, the distribution of issues is in line with the food sector, due to the climate change and water impact of agriculture. As for the food sector the ADEME's database provides **GHG intensity per liter** for several beverages types, and the Global Footprint Network provides data on their **water intensity per liter**. Packaging types have an average **GHG footprint per unit of product** provided by standard LCA databases (mainly Ecoinvent), which can also be factored into the assessment.

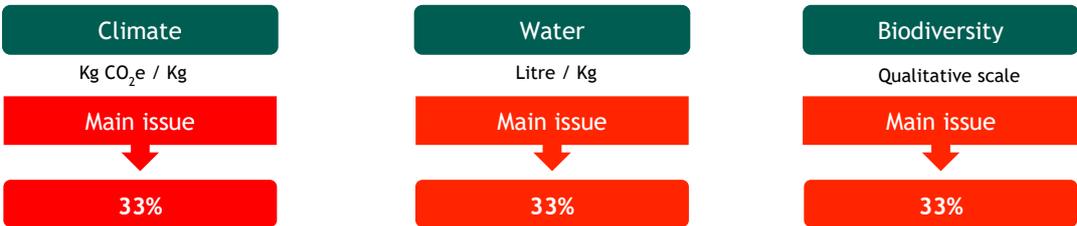
The Global Footprint Network (GFN) provides water footprint data for beverages on the same scopes as for food, distinguishing blue, green and grey water footprint (see the food section for more details on this approach). As for the food sector, the water footprint indicator is based on **beverages' blue water footprint**, which accounts for the freshwater actually consumed during the production phase.

The impact of certain culture types on local ecosystems also makes **biodiversity** assessments relevant for beverages with agricultural inputs.

3. Environmental performance indicators

In order to quantify the impact of each of the environmental issues, the following set of performance indicators (KPI) have been selected:

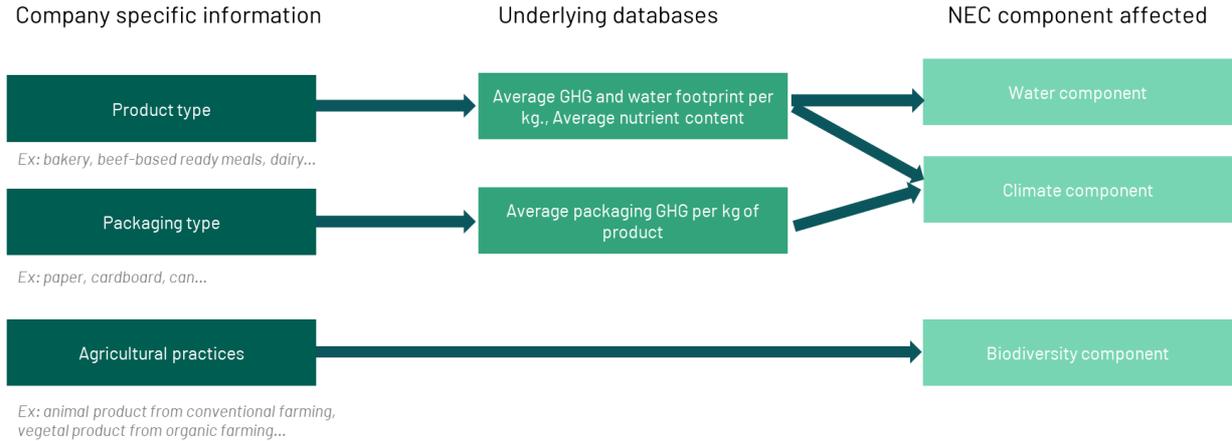
| Components | Selected KPI |
|--------------|--|
| Climate | GHG Emissions Factor (kg CO ₂ e/kg) |
| Water | Water consumption Factor (litre/kg) |
| Biodiversity | Biodiversity assessment scale (qualitative) |



The Net Environmental Contribution (NEC) is a weighted sum of these three components. By default, those three indicators have been equally weighted as these all represent major environmental issues on a global scale.

4. Food NEC calculation

The calculation of Food products' NEC relies on underlying databases to evaluate the 3 NEC components. As illustrated by the figures below, the required input data are **products** and **packaging types**, as well as **agricultural practices** associated with the food production (conventional or organic agriculture).



A database of GHG and water footprint for different food types has been computed to automatize the NEC calculation for food groups or specific food products

The calculation of each component, based on these input data, is detailed below.

4.1. Climate component

The data provided by ADEME allows the comparison of both food products and packaging types based on their GHG footprint. The FOODGES database indeed provides the GHG emissions associated with various primary and transformed food products, from their production to the retailer's gate (consumer use like cooking or storage is excluded). The transformed products' footprint (like transformed dishes) has been calculated as a combination of various primary products. The functional unit used to express the GHG intensity of products is by **kilogram of final product**.

However, the **limited substitutability of food types** (a kilogram of meat and a kilogram of candy do not fulfil the same functional unit) does not allow a simple comparison of food types' GHG footprint per kilo. A comparison per calorie (the common energy unit for all food types) would also provide results difficult to interpret: Products containing more calories, especially lipids, would have their intensity decreased without being possibly considered as "eco-solutions" as these can't provide the same "service" as other food types.

Hence the necessity to reflect the **variety of services provided by food**: food products should be compared to other food products providing equivalent **nutritional services**. The best level of granularity to obtain both representative and manageable results is the nutrient category level: Food essentially provides **proteins, lipids and carbohydrates** in various proportions. Other food contents such as vitamins have been excluded to remain within a manageable level of complexity.

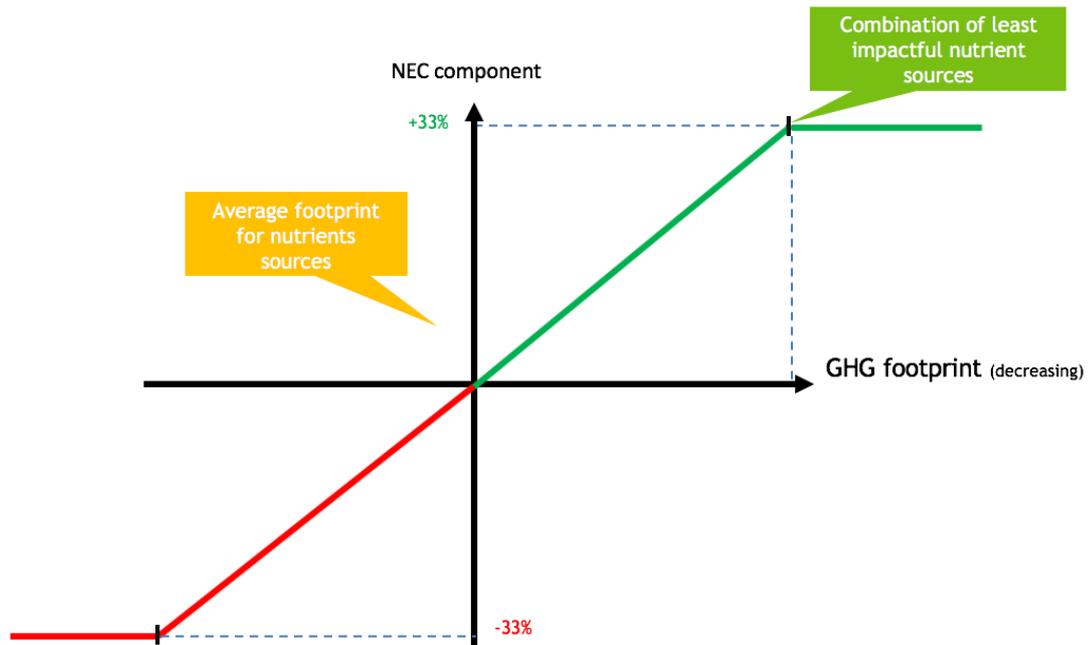


Different food groups with limited substitutability, as they provide different nutrients

This lack of common functional unit requires an approach specific to the **combination of nutrients** provided by the food product under analysis. For each food product, the proportion of proteins, lipids and carbohydrates has thus been calculated. In order to compare these food products to a relevant global average, the global consumption of each nutrient types (ex: the proteins consumed globally are mostly from wheat, pork meat etc.) has been obtained from the FAO database (FAOSTAT). This database also allowed to identify the **most efficient source of nutrient for each category**, which is defined as the food product that is both a significant provider of the nutrient and has the lowest GHG footprint possible.

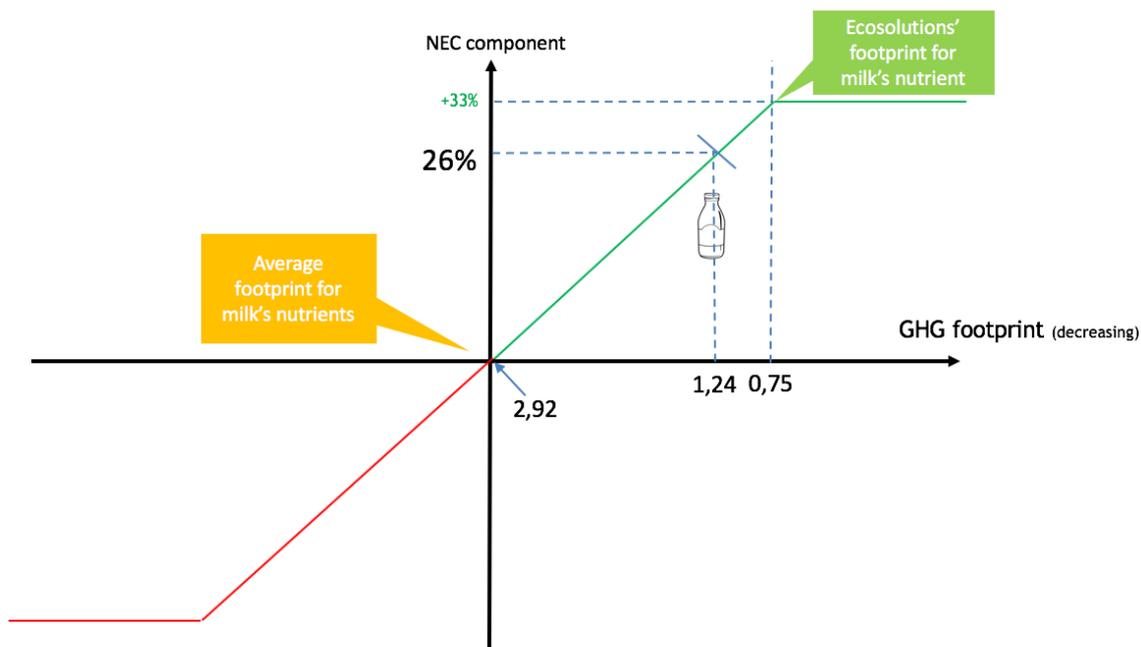
| Nutrient category | Average GHG footprint (kgCO ₂ e/kg) | Eco-solution identified | Eco-solution's average GHG footprint (kgCO ₂ e/kg) |
|-------------------|--|-------------------------|---|
| Proteins | 3,91 | Pulses | 0,88 |
| Lipids | 4,34 | Nuts | 0,66 |
| Carbohydrates | 1,72 | Fruits (avg.) | 0,69 |

These data points allow the comparison of a particular food product with the **average footprint for the nutrients it provides** and the **optimized footprint for the nutrients it provides**.



For instance, semi-skimmed Milk is on average composed of 49% carbohydrates, 35% proteins and 16% lipids, and its GHG footprint (PET packaging included) is 1,24 kgCO₂e/kg.

- The average point (in yellow on the graph above) is $(49\% \cdot \text{average GHG footprint carbohydrates}) + (35\% \cdot \text{average GHG footprint proteins}) + (16\% \cdot \text{average GHG footprint lipids}) = 2,7 \text{ kgCO}_2\text{e/kg}$,
- The optimized point (in green on the graph above) is $(49\% \cdot \text{Eco-solution carbohydrates GHG footprint}) + (35\% \cdot \text{Eco-solution proteins GHG footprint}) + (16\% \cdot \text{average GHG footprint lipids}) = 0,8 \text{ kgCO}_2\text{e/kg}$,
- Hence milk is more efficient than average for the nutrients it provides, and achieves a GHG NEC component of 26% (79% times the component weighting).

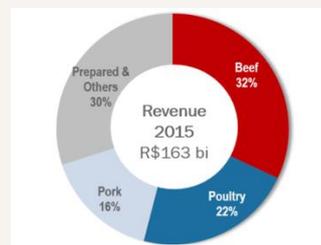


Data availability and practical tips

The Excel tool integrates a module to automatically calculate the NEC associated with a particular category of products. The key aspect is thus to be able to break down the company's revenues by product categories.

Example from JBS, Annual report 2015

When the data is not available, it can be approximated by splitting segments between product types (Ex: JBS' prepared segment can be split between pork, poultry and beef-based dishes). Also, a product category is widely available in different packaging types, the segment can be split to reflect this nuance.

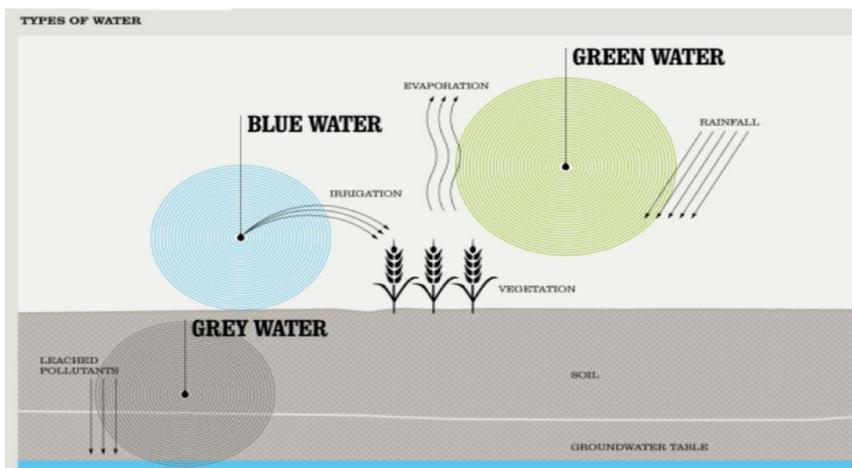


When information is available on a more granular level than the general categories proposed in the NEC FOOD tab, it is possible to look for a more precise representative product in the list of products covered by the FOODGES database. This dataset has around 200 food products covered with further granularity (ex: distinction between soft and hard cheese's footprints).

4.2. Water component

The underlying database used to estimate food products' water footprint is also the FOODGES database, to which specific water intensity factors have been added from the Global Footprint Network (GFN). This allows consistency in the way transformed food products are aggregated from primary products' footprint.

The calculation of products' water footprint is highly dependent on the analysis' scope. As conceptualized by AY Hoekstra, The GFN distinguishes **blue, green and grey water footprints**, as illustrated in the snapshot below:



- Green water is rainfall water, that irrigates the product and is then evaporated back into the atmosphere. It is thus not consumed but rather in a “closed loop” system, even though its quality can be downgraded by agricultural practices;
- Blue water is the water abstracted from water bodies (rivers, lakes, groundwater): This water is strictly consumed as it does not return to its abstraction point;
- Grey water is a more complex category that accounts for the water volume necessary to dilute the pollutants emitted by the production process.

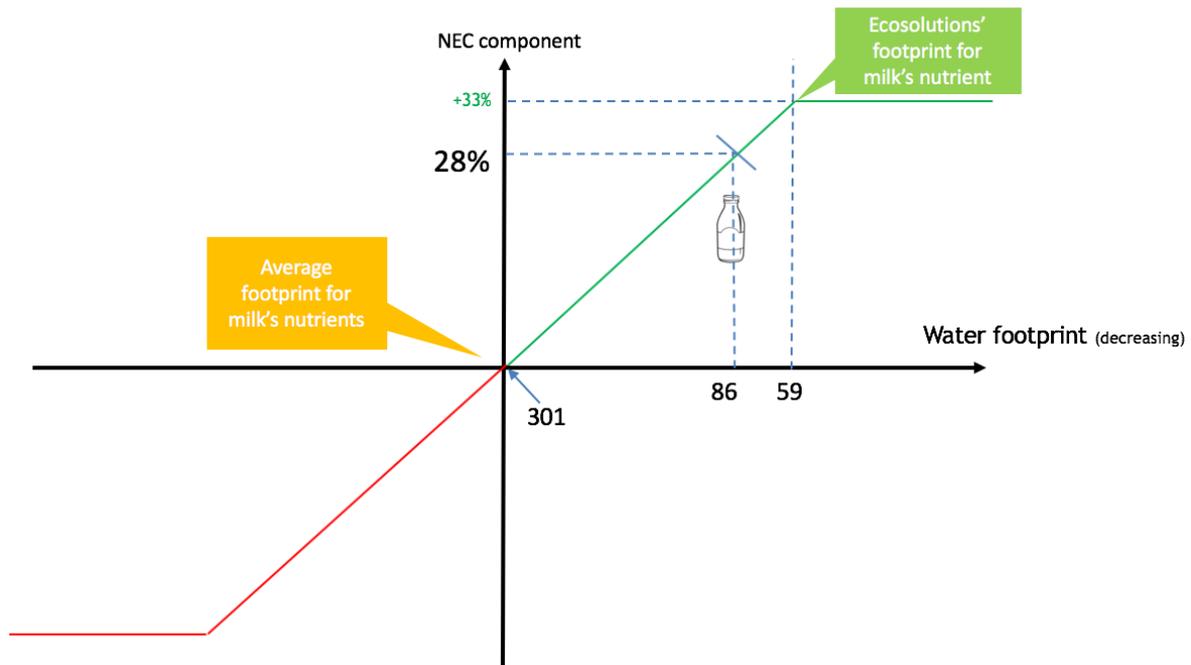
To remain robust and rely on comparable data, the indicator is based on **products’ blue water footprint**.

The approach for this indicator is identical to the GHG indicator’s approach: food products’ water footprint is compared to the other sources of the nutrients the products provide. The **average water footprint per nutrient** and **most efficient source of nutrient** from a water perspective have also been identified.

| Nutrient category | Average water footprint (l/kg) | Eco-solution identified | Eco-solution’s average water footprint (l/kg) |
|-------------------|--------------------------------|-------------------------|---|
| Proteins | 310 | Pulses | 57 |
| Lipids | 380 | Soy oil | 137 |
| Carbohydrates | 268 | Root crop | 33 |

For instance, Milk is on average composed of 49% carbohydrates, 35% proteins and 16% lipids, and its water footprint is 86 l/kg.

- The average point (in yellow on the graph above) is $(49\% \times \text{average water footprint carbohydrates}) + (35\% \times \text{average water footprint proteins}) + (16\% \times \text{average water footprint lipids}) = 301 \text{ l/kg}$;
- The optimized point (in green on the graph above) is $(49\% \times \text{Eco-solution carbohydrates water footprint}) + (35\% \times \text{Eco-solution proteins water footprint}) + (16\% \times \text{average water footprint lipids}) = 59 \text{ l/kg}$;
- Hence milk is more efficient than average for the nutrients it provides, and achieves a water NEC component of 28% (89% times the component weighting).



Data availability and practical tips

The company's products water footprint and water component NEC is calculated alongside the GHG calculation, hence there is no further manipulation to make for this indicator.

Of note, the packaging type has a marginal impact on water footprint and is thus not included in the GFN figures nor in the study's scope. Hence the same product with 2 different packaging types will have the same estimated water footprint.

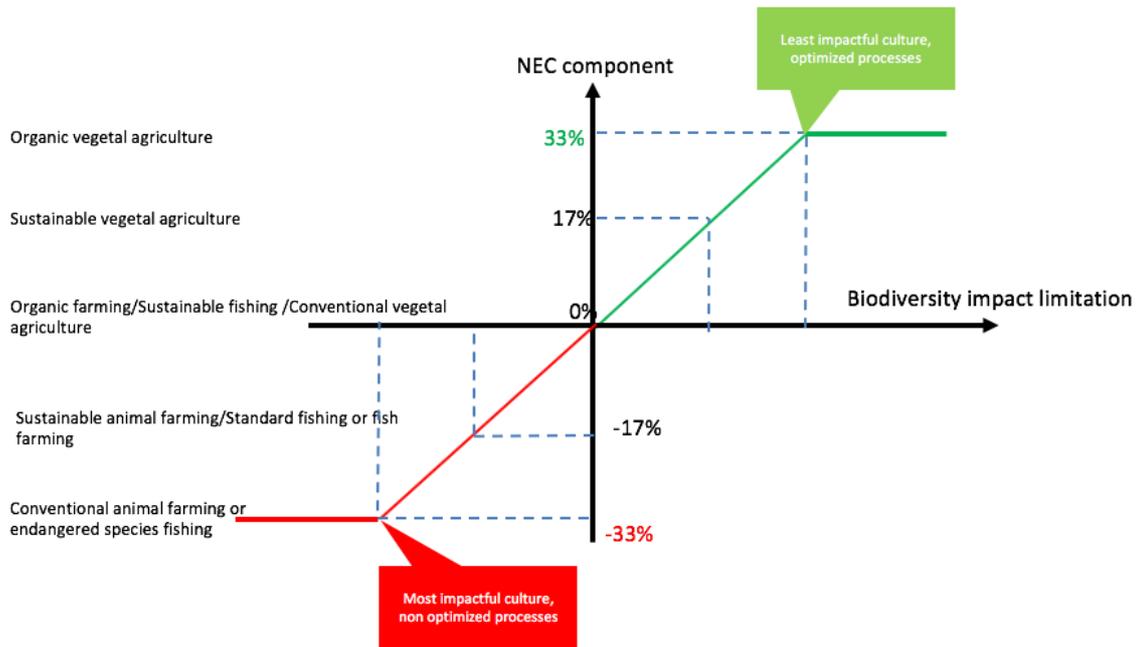
4.3. Biodiversity component

The impact of agricultural products on the local ecosystems they interact with can be very diverse depending on the practices implemented for their production: the use of fertilizers or phytosanitary products to increase agricultural yields has a direct impact on local water and soil pollution, or unsustainable fishing techniques can have a destructive impact on local ecosystems for instance.

Due to the lack of transparency in food companies' supply chain (impossibility to track primary products to their production location, impossibility to assess precise production techniques), a simpler scale has been defined to reflect two key nuances in food products' impact on biodiversity:

1. Animal products have on average a higher land use per kg than vegetal products, which means that the surface occupied to produce these, and the potential impact on biodiversity is higher
2. in terms of local pollution, some broad categories can be identified to distinguish **conventional practices**, when the company does not provide proof of efforts to lower its agricultural supply chain's footprint, **sustainable practices**

The combination of these 2 dimensions is summed up in the figure below:



Data availability and practical tips

The scoring of this indicator is done in the NEC FOOD tab, as for the GHG and water indicators.

The qualification of animal vs. vegetal is inherent to product types, and organic products are certified by specific labels. The qualification of sustainable practices cannot be normalized given the diversity of underlying environmental impacts.

The relevance of information provided by the company has to be assessed by the analyst to determine whether the company's practices can be classified as "sustainable": sustainability policy addressing supply chain impacts, engagement with suppliers to reduce impacts. Relevant labels can be relied on to certify sustainable practices. These include MSC for marine fish products, ASC for fish farming, or Rainforest Alliance for food.

4.4. Default values and specific cases

As partially shown in the first graph of this chapter, there is a single default value for each food product group such as bakery, pizza, fruits or vegetables. Those values can be found in the Excel tool. In case of more specific products, the most appropriate proxy can be chosen from a large list of products available in the tool.

Upstream

The specific impact of **Food import/export activities** can be reflected by counting a malus equivalent to the impact of transportation in food products' footprint. This malus is equivalent to counting twice transportation footprint, to reflect the fact that these are "optimizable" emissions. The malus only affects the GHG indicator and can be estimated to be on average 0.5 kgCO₂e/kg for boat transportation and of 20 kgCO₂e/kg for plane transportation (for the whole transportation). These can be added manually in the Excel's food calculator.

For example, assessing the importation of fruits, the average footprint for fruits is 0.7 kgCO₂e/kg, which results in a product NEC of +50%. When applying the malus by double counting the transportation footprint, the product NEC is downgraded to +37%.

Non-human nutrition products

The production/sale of animal feed has been analyzed through the final products approach: the different outputs from animal farming (milk, meat, leather...) have been quantified based on FAO data and their calculated average NEC is -8%. Concerning pet food, even though there is no end product analysis possible as for animal feed, the same default value (-8%) is used to reflect the impact of this meat-intensive diet.

Food retail

For **food retailers**, the impact of products sold represents 100% of the NEC, with bonus/malus for the stores' electricity consumption and retail channels. When the product mix is not clearly defined (for a general food retailer), a 100% NEC is given to products that are both **organic** and **local**, or **organic** and **seasonal**.

The figure below, from the EU's Organization Environmental Footprint (OEF) guidance, shows the environmental impacts distribution for an average generalist retailer and illustrates the prevalence of the

production and use phases for a general retailer on all environmental impacts

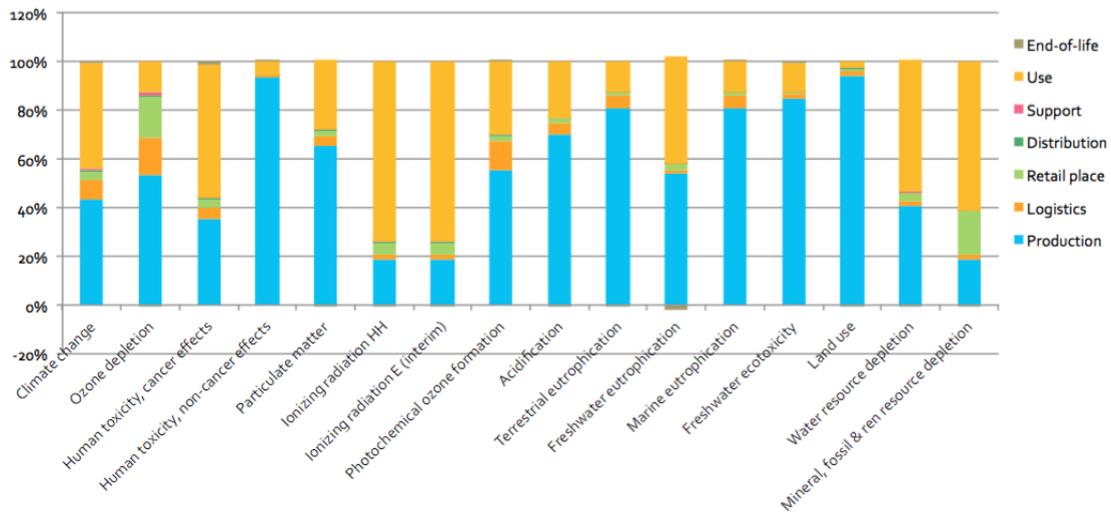


Figure 2: Contribution to the different impact categories for our virtual retailer, over the full OEF

Two retail-specific NEC increments have been defined:

1. Retail format increment

Even though the actual product’s footprint can vary greatly from one retailer to another, especially depending on geographical sourcing choices, the store formats deployed by the company can have a significant influence on upstream and downstream transportation. As underlined by the chart below, transportation upstream and downstream (dark orange) represents a non-neutral but marginal share of food retail emissions, hence the limited bonus magnitude.

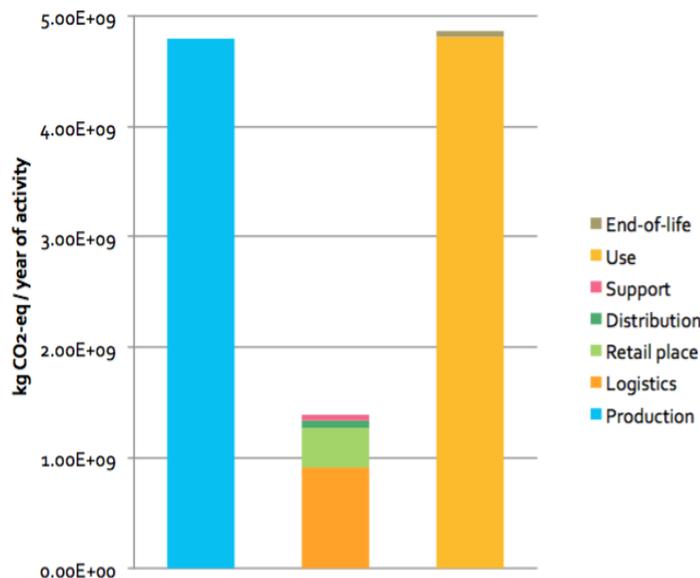
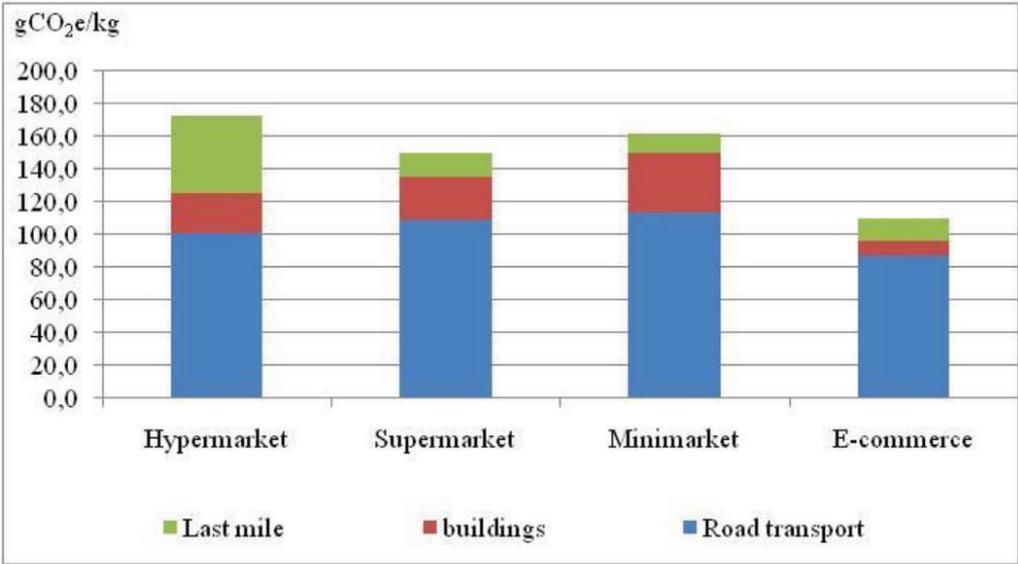


Figure 8: Impacts on climate change related to the retailer activity for one year

The footprint difference between the different retail formats can be normalized for a given product to express a percentage of difference. The graph below provides the average footprint for a kg of yogurt purchased in different retail store formats.



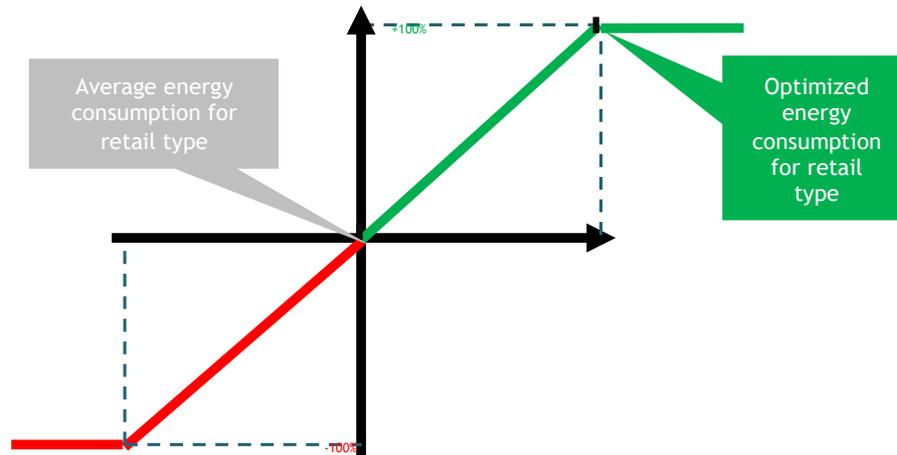
These results can be used as a proxy to estimate the “optimization” of retailers’ business model, based on their revenue distribution per store type (or area per store type), compared to the European average.

2. Energy consumption increment

Stores’ energy consumption can be greatly optimized by energy efficiency measures on HVAC systems, refrigeration processes etc. even though it may be marginal compared to products’ production footprint. The energy intensity is expressed in kWh per square meter per year and is primarily affected by the type of food conservation required for food products, as illustrated by the European Commission footprint guidance for the retail sector:

| Retail type | Average Energy consumption kWh/m ² /year) |
|-----------------------------|--|
| General nonfood | 150 |
| Standard food and beverages | 400 |
| Chilled food/beverages | 1900 |
| Frozen food | 2700 |

The energy consumption disclosed by the company can therefore be benchmarked against these averages depending on the type of product sold (food vs non-food). The eco-solution has been defined as being 50% better than the disclosed average, as the improvement potential in this sector is significant.

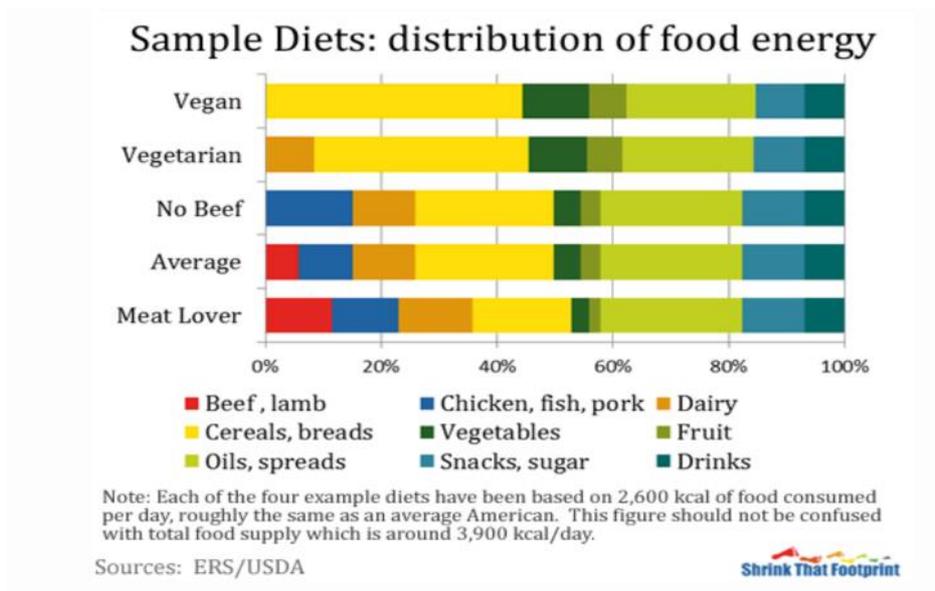


Given that these parameters influence the value chain's footprint marginally compared to food products' production, these are both given a **10% weighting**.



Other downstream activities

For **Restaurants**, the NEC of several average diets have been calculated (see table below). For restaurants focusing on one particular food type (ex: Pizza), the average NEC for this product can be applied.



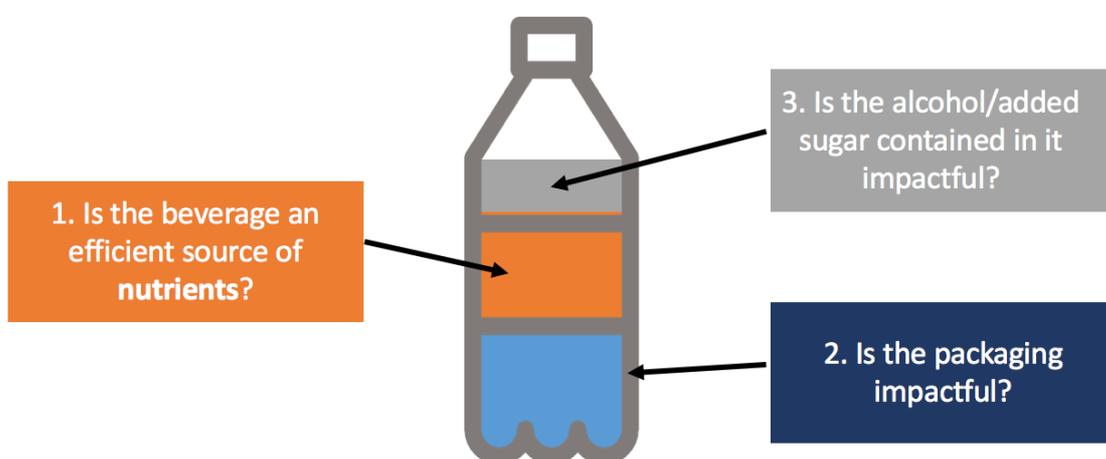
| Restaurant type | NEC |
|------------------------|--------------------|
| Specialized | Product assessment |
| General | 0% |
| Organic/local/seasonal | +100% |
| Vegetarian | +69% |
| Vegan | +100% |
| Meat focused | -63% |

5. Beverage NEC calculation

The framework also includes companies involved in producing and retailing alcoholic and non-alcoholic beverages for human consumption. Combined with the complexity of impacts on climate, water and biodiversity, as with food, other key factors have been integrated for beverages:

- They substitute tap-water, a low-impact solution, rather broadly available;
- They provide hydration;
- They may provide nutrients but also “empty calories” from alcohol or added sugar.

For example, water does not deliver any nutrients, but fruit juice does. Hence, they are assessed on separate scales using these types of questions.



5.1. Beverage additional functions & KPI

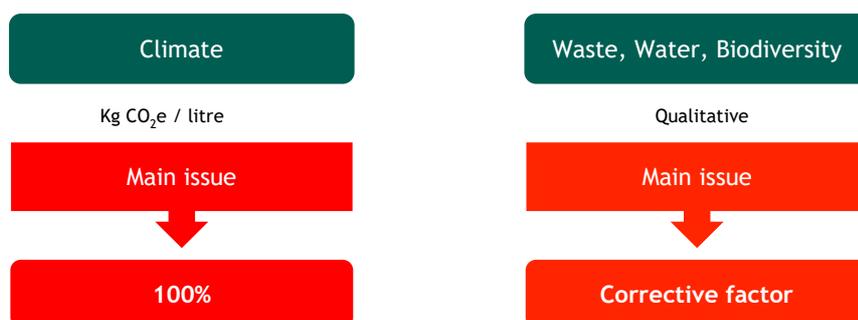
Apportioning the environmental impacts of beverages per liter of beverage may appear like the “natural” functional unit for this value chain, as this is applicable to all beverage types. However, this does not fully reflect the **various functions** beverages can fulfil. 3 main functions have been identified and been treated separately in the approach:

- **Hydration/Providing water:** each beverage contains a proportion of water, which fulfils the function of hydrating the human body. Even though the product itself is the same (drinkable water), this function can be delivered in various types of packaging.
- **Providing nutrients:** Some beverages contain nutrients (carbohydrates mainly) and therefore fulfil a function equivalent to food products.
- **Providing “empty calories”:** alcohol and added sugars do not contribute to the hydration nor nutrition function and are thus assessed on a separate “negative” scale

These functions are not substitutable (one does not drink water to get nutrients and partly drinks fruit juice for that purpose) and are thus assessed on separate scales. The 3 functions are assessed based on the following indicators enabling to calculate incremental NEC:

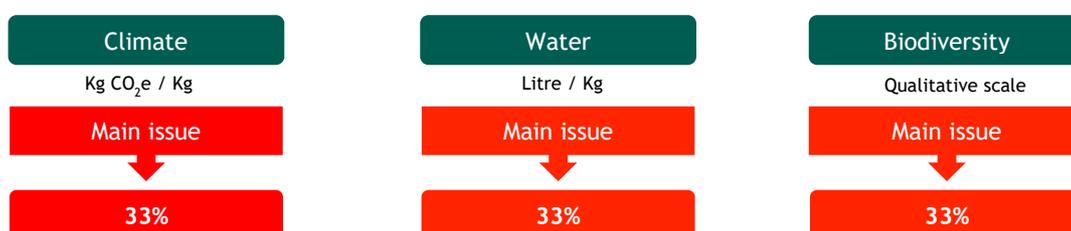
Hydration/packaged water function

This function’s impact mainly comes down to packaging impacts, which are measured through the average GHG footprint of different packaging types. This indicator is corrected through a specific consideration on plastic wastes impacting ecosystems as well as water quality.



Nutrition function

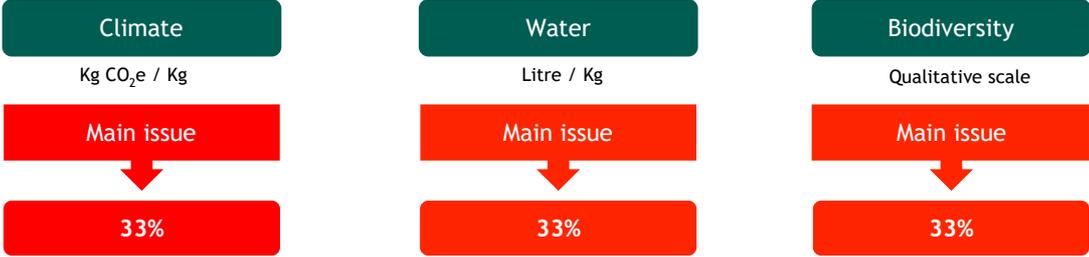
Coherently with the approach for food products, the potential nutrition share of beverages is evaluated over its climate change, water and biodiversity impacts.



Empty calories function

Coherently with the approach for food products, the alcoholic and added sugar shares of beverages are evaluated over its climate change, water and biodiversity impacts. However, given the lack of “positive”

function for these elements, these are considered on a negative increment (scale -100% to 0%) because they just add a useless environmental footprint with no contribution to useful nutrient supply.



These 3 NEC are combined based on the relative weight of each function for a given beverage.

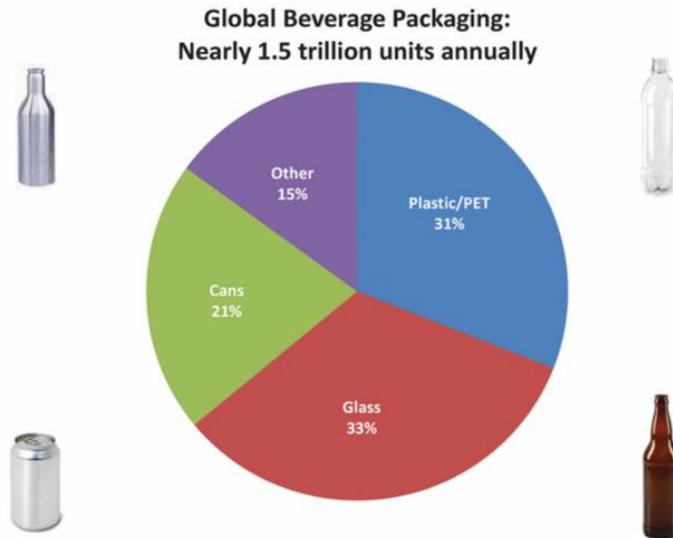


5.2. Hydration/providing water function

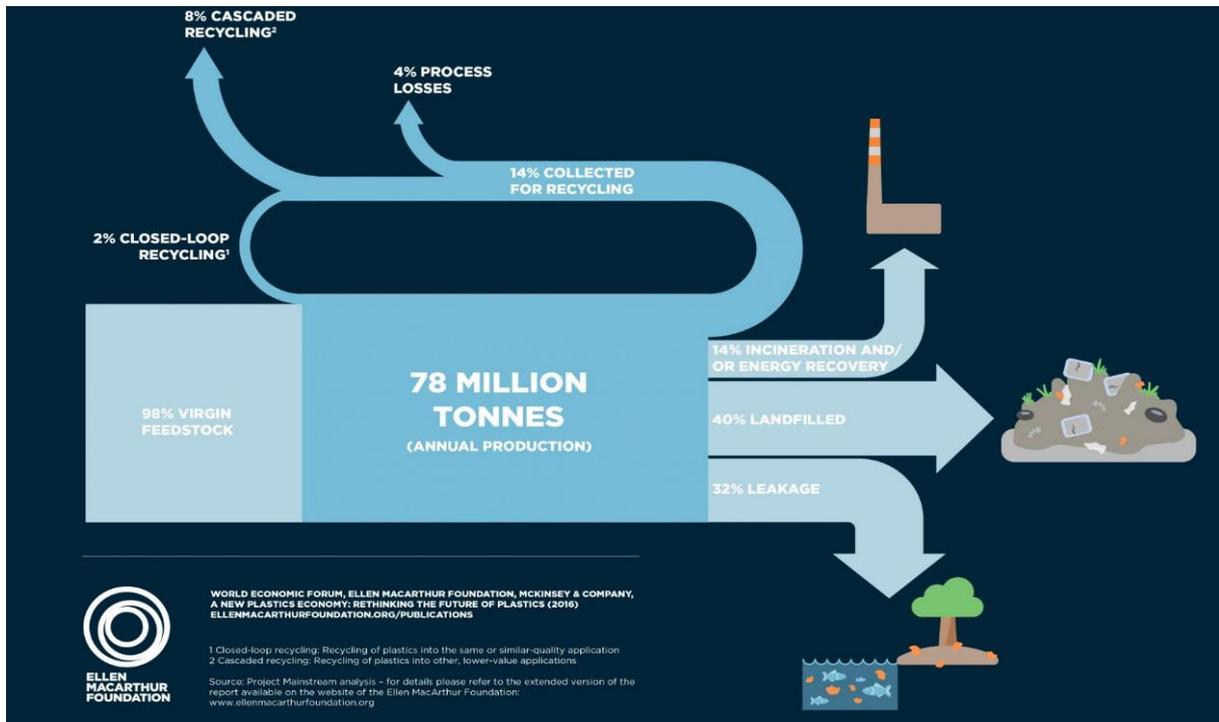
A common function to all beverage products is to provide water within a packaging (apart from tap water). In order to evaluate how "efficiently" this function is fulfilled, the average packaging GHG footprint of different packaging options has been extracted from LCA databases and compared to the global average of packaging used in the beverages industry:

| Packaging type | Packaging GHG/ litre of beverage |
|----------------|----------------------------------|
| PET bottle | 0,10 |
| Brick | 0,15 |
| Glass bottle | 0,44 |
| Aluminium can | 0,18 |
| Capsule | 1,59 |
| Beer keg | 0,12 |

Beverages packaging, global average



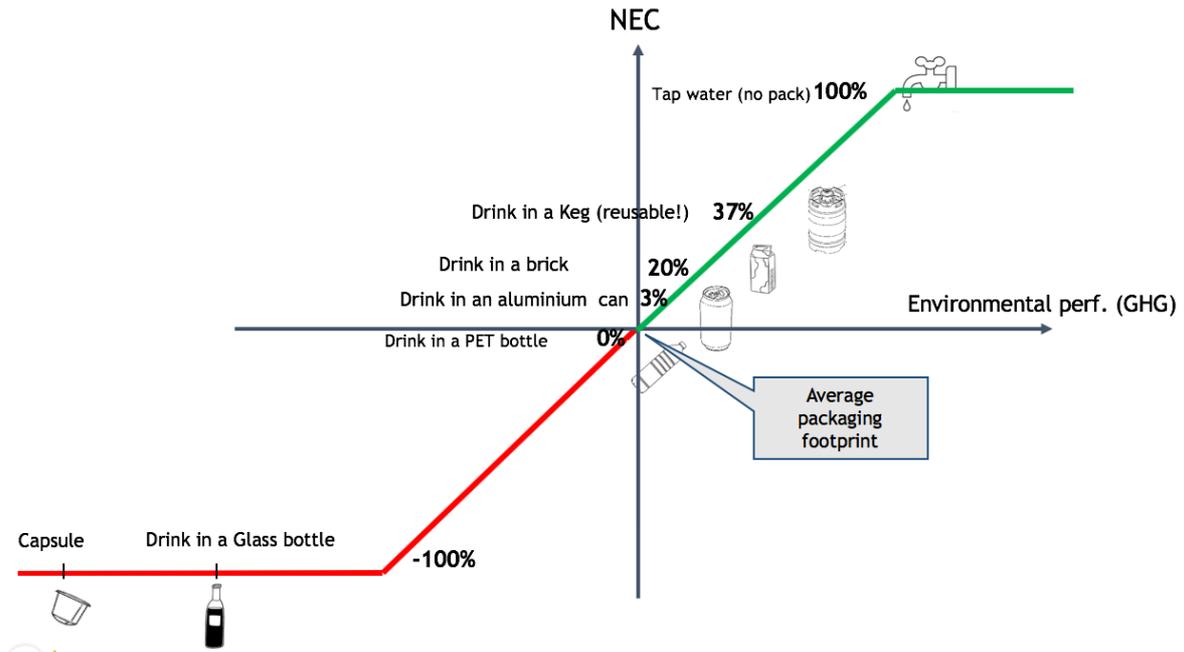
PET as a packaging materials is efficient from a production perspective, as the impact per unit produced is relatively low. However, it has a specific **negative impact further down in its lifecycle**: it generates important amount of waste, which partly ends up in natural environments and affect ecosystems (e.g. ocean plastics), as illustrated by the graph below.



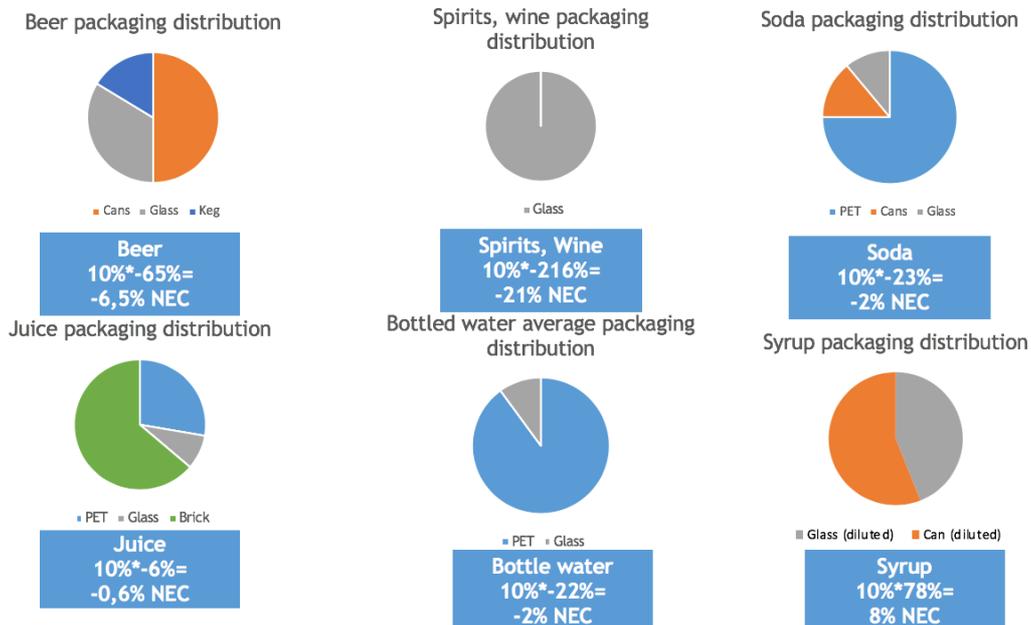
Source: Ellen McArthur Foundation

This specific “comparative disadvantage” for plastic packagings needs to be reflected. Therefore the hypothesis has been made that this aspect “cancels” out the comparative advantage of PET due to its lower production GHG footprint. PET’s NEC has been set at 0% (instead of 42% initially).

These data allowed the calculation of an average NEC per beverage packaging type:



For beverage categories such as soda or beer, an average packaging distribution has been researched. The associated NEC is presented below:



In order for this function to not be overrepresented in beverages' NEC, and to reflect its relative impact, its weight on the overall beverage footprint had to be estimated.

It has been estimated from GHG data that packaging accounts for an average of 1/3 of beverages footprint. In addition, this aspect only covers 1/3 of the relevant issues for this sector (does not cover water and biodiversity), and therefore this aspect has been given a **10% weighting factor**.

Data availability and practical tips

Some beverage manufacturers provide the breakdown of packaging types used for their products. Example:



Coca Cola, Annual report 2017

When the data is not available, the default value for each beverage type in the Excel tool can be used.

5.3. Nutrient function

Several beverages have nutritional contents, and therefore fulfil a function comparable to food products. Beer for instance provides a non-negligible amount of naturally-occurring carbohydrates (35g/l on average). These can be assessed through the food framework: based on the distribution of nutrients present in the beverage, the “environmental efficiency” of the product is assessed considering its GHG, water and biodiversity footprint (see food framework for further details).

Of note, added sugars are considered in the “empty calories” section.

Some beverages provide a significant amount of nutrients, while some others have marginal nutritional values. In order to determine a norm as to what is “a lot” of nutrients, milk has been used as a standard as it is commonly describe as an aliment rather than a beverage.

Milk provides on average 94g of nutrients per liter, which therefore has been set as 100% weight for the nutrient content. The table below shows the resulting nutrient weight for other beverages.

| Beverage type | Nutrients (g/l)* | Nutrition weight | Nutrient NEC | Incremental NEC |
|-----------------------|------------------|------------------|--------------|-----------------|
| Fruit juice | 100 | 100% | -6% | -6% |
| Fruit juice - Organic | 100 | 100% | 28% | 28% |
| Beer | 35 | 37% | 10% | 3,7% |
| Beer- Organic | 35 | 37% | 44% | 16,3% |
| Wine | 2 | 2% | 34% | 0,7% |
| Wine - Organic | 2 | 2% | 67% | 1,4% |
| Spirits | 0 | 0% | N/A | N/A |

5.4. Empty calories function

Even though it does provide calories, **Alcohol** is not a nutrient and does not provide any quantifiable services, aside of its recreational value. It is often described as “empty calories” for this reason. The same

goes for added sugars: Added sugars (from beetroot or sugar cane) are assimilated the same way as naturally occurring sugars by human organisms*.

However, these come **in excess** of naturally occurring sugars, as these are not associated with any vitamins, minerals etc. Therefore their nutritional function has to be challenged compared to naturally occurring sugars.

Therefore, **added sugars have been placed on a separate scale**, similarly to alcohol, in the empty calories section.

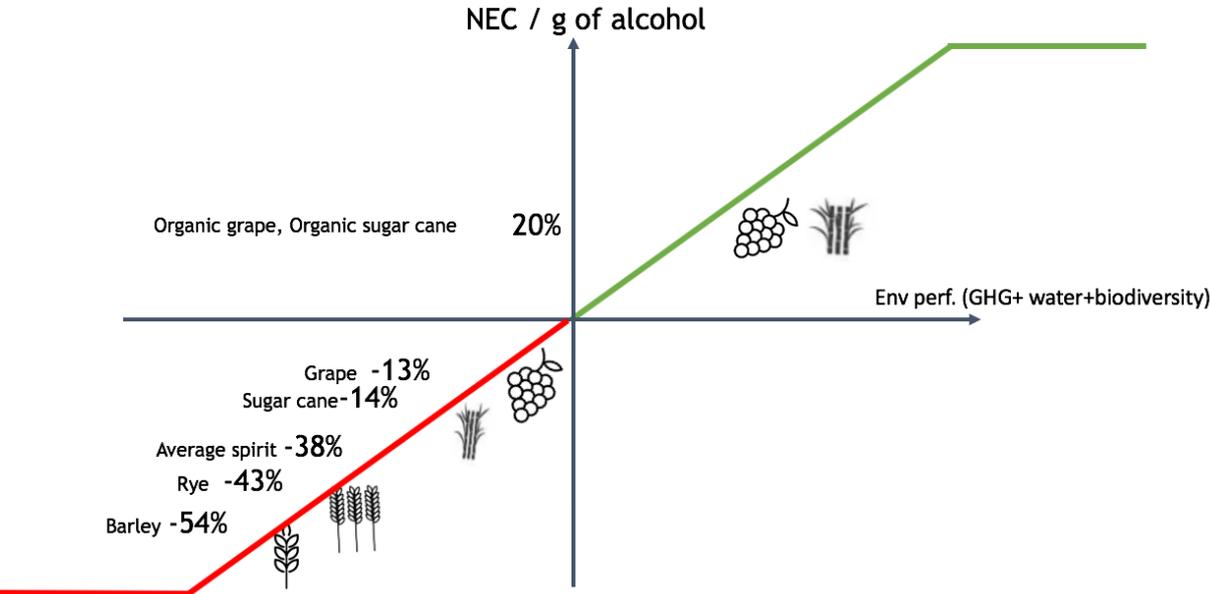
These two components are rated on a negative scale due to their lack of function:



In both cases, the different options are compared on the same parameters as food products, namely GHG, water and biodiversity footprint.

Alcohols NEC scale

| | Barley | Grape | Rye | Cane | Barley |
|--|---|-------|-------|------|--------|
| Main output | Beer | Wine | Vodka | Rum | Whisky |
| GHG footprint (kgCO _{2e} /kg) | 3,04 | 2,04 | 3,7 | 2,72 | 3,04 |
| Water footprint (m ³ /kg) | 0,6 | 0,41 | 0,38 | 0,29 | 0,6 |
| Biodiversity | Vegetal crop (0% intensive, 100% organic) | | | | |



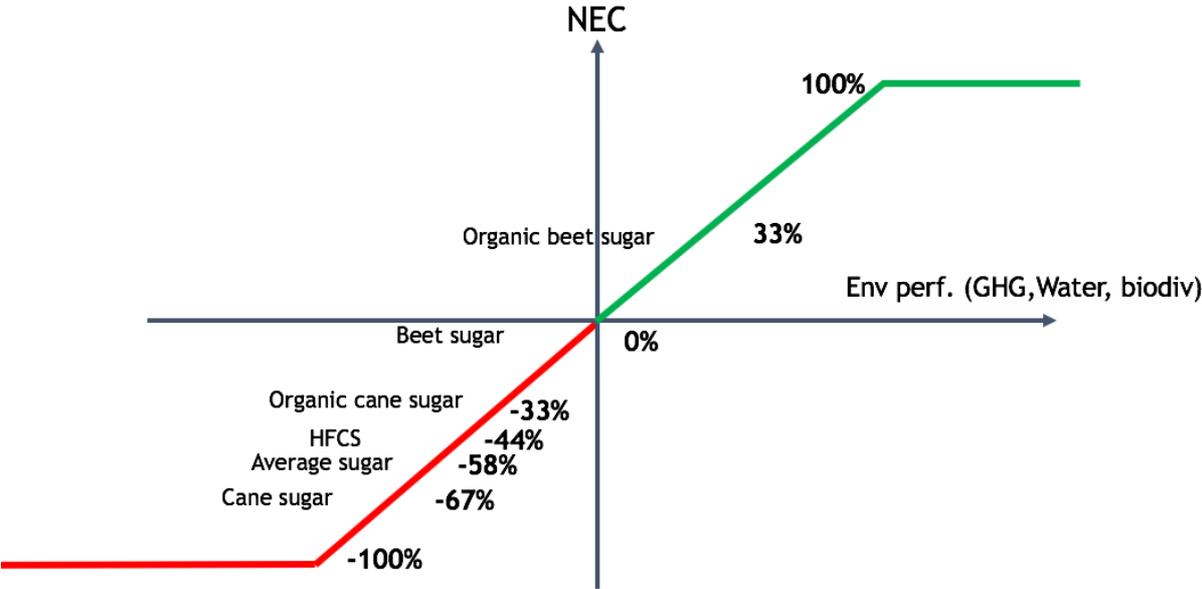
This NEC only applies to the **proportion of the final product that alcohol represents** (5% avg. for beer, 14% for wine etc.).

| Alcoholic beverage type | Pure ethanol NEC | Alcoholic content | Incremental NEC Alcohol per litre |
|-------------------------|------------------|-------------------|-----------------------------------|
| Beer | -54% | 5% | -3% |
| Wine | -13% | 14% | -2% |
| Rum | -14% | 40% | -6% |
| Whiskey | -54% | 40% | -21% |
| Average spirits | -38% | 40% | -15% |

Added sugars NEC scale

Added sugars are mainly produced from sugar cane, beet and corn (High Fructose Corn Syrup, HFCS).

| | Cane | Beet | HFCS (est.) |
|--|---|------|-------------|
| GHG footprint (kgCO _{2e} /kg) | 1,76 | 0,47 | 1,5 |
| Water footprint (l/kg) | 455 | 167 | 315 |
| Biodiversity | Vegetal crop (0% intensive, 100% organic) | | |



This NEC only applies to the **proportion of the final product that added sugars represent**: for instance, sodas contain an average of 110 g/l of added sugar, which is 11% of the final product.

| Beverage type | Sugar NEC | Added sugar content | Incremental NEC – Added sugar |
|--------------------------|-----------|---------------------|-------------------------------|
| Soda | -37% | 11% | -4% |
| Soda – Organic | -3% | 11% | 0% |
| Juice – with added sugar | -37% | 20% | -7% |
| Syrup | -58% | 8% | -5% |
| Syrup – Organic | -25% | 8% | -2% |

6. Main limits

The key advantage of this approach for the food sector is to account for the difference between the different nutrients provided by food, and to compare food products to an average of substitutable products. In this respect, it goes further than a “per calorie” or “per kilo” approach and allows the identification of efficient food types from both a GHG and a water perspective. The ADEME database also allows to have a rather granular vision on food product categories.

However, this approach cannot reflect all of the parameters that affect the environmental impacts of food products: a product that is consumed outside of its cropping season (i.e. that has been produced under other latitudes or in greenhouses for instance) can have a much higher GHG footprint, irrigation techniques can have a significant impact on water footprint etc. These distinctions would be really difficult to reflect in a company assessment, and even more difficult to reflect in an automatized calculation. Also, a key aspect of packaging’s footprint is the ratio between product mass and packaging mass, to account for the “over-packing” of certain food products. This aspect cannot be accounted for without significant further development (e.g. development of more packaging types like coffee capsules).

Regarding the beverage sector, the key advantage of this approach is to account for the major impacts of the different beverages and packaging types, and reflects the various functions fulfilled by beverages, notably to maximize alignment with the food framework.

As in the food sector, the issue of “sur-packing” (increasing ratio between quantity of product and quantity of packaging) hasn’t been reflected, as well as the different recyclability profiles of packaging materials. This can be seen as a limitation but is to some extent independent from companies’ business practices. Also, the specific impact that “captive” mineral water sources may have on local ecosystems, and the length of supply chains (amount of transportation in the supply chain) cannot be reflected in a systematic way.

A potential deepening of this approach could thus be to deepen the modelling of packaging types, and to further detail the biodiversity scale. Ideally, the geographic dimension (the distance between production and consumption points) should be reflected as well.

7. Key data sources

| Data | Sources |
|---|---|
| Food GHG footprint | ADEME's FOODGES database, based on EcolInvent data: http://www.bilans-ges.ademe.fr/fr/accueil/actualite/detail/id/23 |
| Food & Beverage water footprint | Global Footprint Network, based on Hoekstra et al. http://waterfootprint.org/media/downloads/Report-48-WaterFootprint-AnimalProducts-Vol1_1.pdf |
| Global consumption per nutrient types, animal farming outputs | FAOSTAT database http://www.fao.org/faostat/en/#home |
| Food types average nutrient content | http://www.monmenu.fr/s/calculer-calories.html |
| Food retail footprint breakdown | European Commission Organisation Environmental Footprint (OEF) guidance for retail http://ec.europa.eu/environment/eussd/smgp/pdf/OEFSR-Retail_15052018.pdf |
| Average EU non-alcoholic beverages consumption | http://www.bonial.fr/info/conso-boissons-sans-alcool-europe/ |
| Beverages nutritional values | https://fr.wikipedia.org/wiki/Composition_nutritionnelle_des_boissons |
| PET packagings environmental impacts | Ellen McArthur foundation |
| Average EU alcoholic beverages consumption | World Health Organization http://www.who.int/gho/alcohol/en/ |



The holistic metric
guiding environmental
action

FUEL FRAMEWORK

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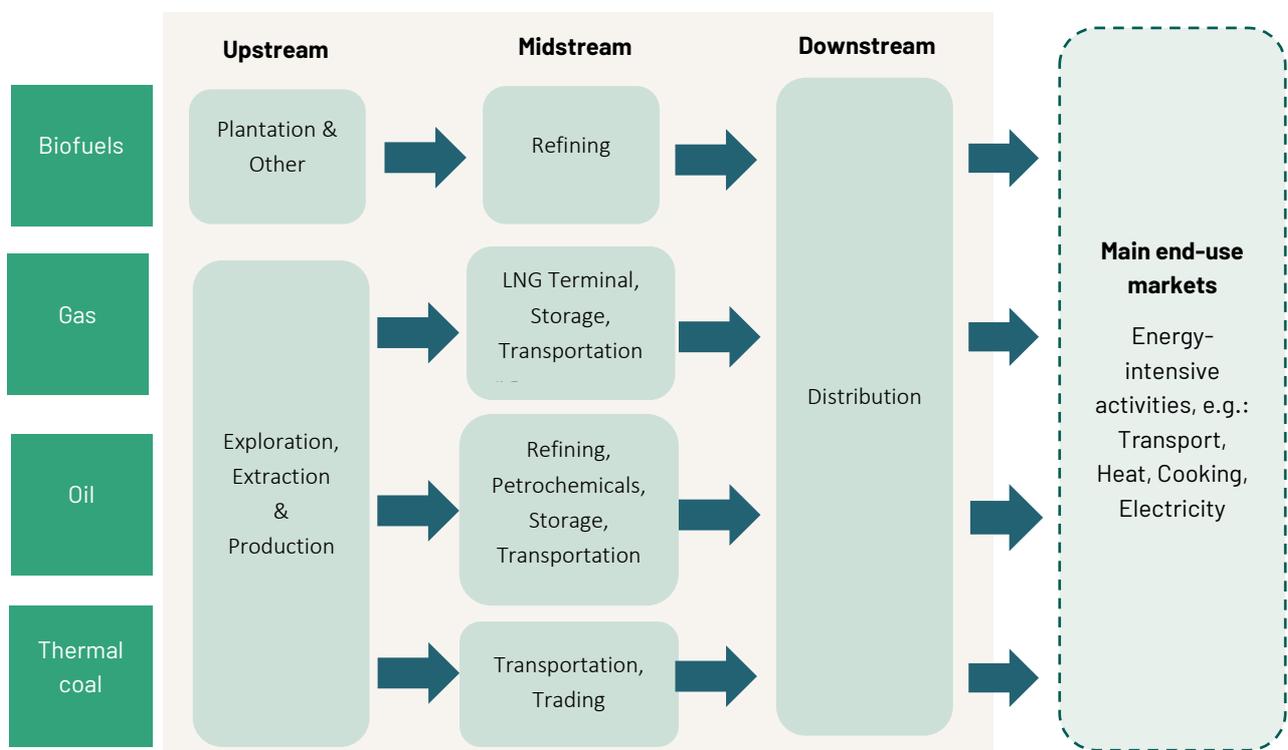
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1. Introduction

The fuel industry includes equipment manufacturers and service providers at all stages of the value chain, from fuel extraction or production, to storage, conversion, transportation and final use.

Likewise, this framework encompasses all stages of the value chain, and it is based on life cycle assessment (LCA) results of fossil and renewable fuels in all physical forms: solids (biomass, coal, waste-to-energy), liquids (crude oil, gasoline, diesel, biodiesel, liquified natural gas) and gasses (natural gas, biogas, hydrogen, methane, propane).

The life cycle of fuel products consists of three main phases: upstream, midstream and downstream. These phases are diagrammed below, and modelled separately in the framework.

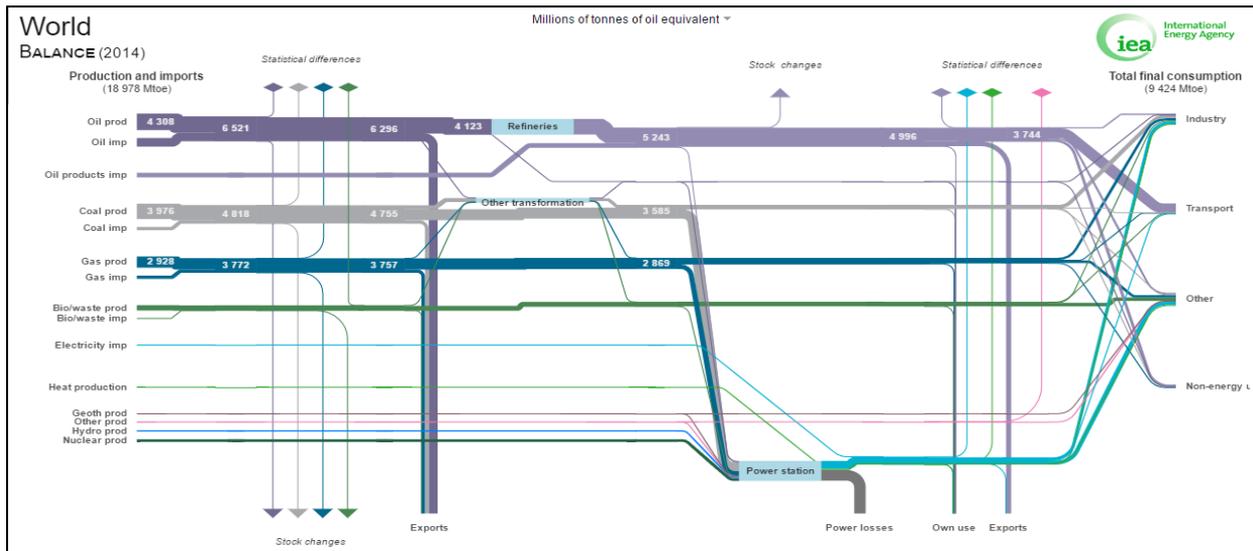


The upstream phase includes extraction & production activities. The midstream phase includes transformation & logistics activities like refining, Liquefied natural gas (LNG), petrochemistry, trading, and transportation by pipeline. The downstream phase includes distribution, retail and downstream uses. The underlying physical unit in all phases is energy, usually expressed in barrel of oil equivalent (BOE). Non-energy uses are not included in this scope; they are accounted for in the Chemistry and Basic Materials frameworks.

The fuel value chain is irrigating many sectors (e.g. industry and transport) as shown in the Sankey Diagram below.

Figure 1: World energy balance - from production and imports to final consumption (2014)

Source: IEA World Balance 2014



2. Main environmental issues

| Environmental stake | | Relevance along value chain | | Comments | Data availability |
|---------------------|-----------------------------|------------------------------|--------------------------|--|---|
| | | Upstream and Midstream | Downstream to final use | | |
| Climate | Climate change | High impact intensity | High impact intensity | Fossil fuels are a major contributor to climate change. They account for around 60% of total greenhouse gas (GHG) emissions. Fossil fuels emit GHG when burnt as part of daily activities, including transportation, electricity generation and residential and industrial heating. The extraction of natural gas also produces methane emissions – a more potent GHG than carbon dioxide – from drilling wells and pipeline transportation. | Carbon footprint available for most fuels |
| | Use of energy resources | Significant impact intensity | High impact intensity | Fossil fuels were created hundreds of millions of years ago when dead organic matter at the bottom of the sea was transformed by anaerobic digestion. A limited amount of fossil fuels remain in the ground, and current extraction rates are no longer sustainable. | Energy consumption available for most fuels |
| Air Quality | Air quality deterioration | Significant impact intensity | High impact intensity | The burning of fossil fuels is one of the main causes of air quality deterioration. Indeed, burning emits a number of air pollutants that are harmful to both the environment and public health, such as sulfur and nitrogen oxides. | Statistical average of NO _x and SO _x emitted available for most fuels |
| Water | Water consumption | High impact intensity | Limited impact intensity | Extraction may require important water consumption, especially for unconventional extraction techniques like hydraulic fracturing. Drilling and fracking shale gas formations typically requires 3 to 6 million gallons of water per well. In the United States, some fossil fuel and nuclear power plants withdraw the same amount of water as all farms, and more than four times the amount of water as all residences. | No direct data available: based on extraction types |
| | Water pollution | High impact intensity | Limited impact intensity | Extraction is a main risk factor for water quality, especially with unconventional fossil fuels. For instance, with hydraulic fracturing use, total amount of wastewater is amplified by the large volume of water and chemicals involved in the process. Furthermore, power plants that return water to nearby rivers, lakes or the ocean can harm wildlife through thermal pollution (the degradation of water quality as a result of changes in water temperature). | No direct data available: based on extraction types |
| Biodiversity | Soil pollution | High impact intensity | Limited impact intensity | Extraction is main source of soil pollution. During oil and natural gas production, "produced water" is the largest byproduct stream. Additionally, many oil and gas operations are augmented by the injection of hydraulic fracturing fluids into the ground. Both produced water and hydraulic fracturing fluids may contain hundreds of individual chemicals, including chemicals that are detrimental to public health and the environment. | No direct data available: based on extraction types |
| | Land use | High impact intensity | Limited impact intensity | A large amount of land is disturbed by drilling wells, access roads, processing facilities and pipelines connected to oil and gas drilling operations, coal mining and biofuel-related agriculture. | No direct data available: based on extraction types |
| Waste | Use of non-energy resources | Significant impact intensity | Limited impact intensity | The fuel industry depends mostly on energy resources. | No direct data available: based on extraction types |
| | Waste | Significant impact intensity | Limited impact intensity | The fuel industry is responsible for important coal mining residues, hazardous waste from refining activities and agricultural waste linked to biofuel production. | No direct data available: based on extraction types |

Legend

- High impact intensity
- Significant impact intensity
- Limited impact intensity

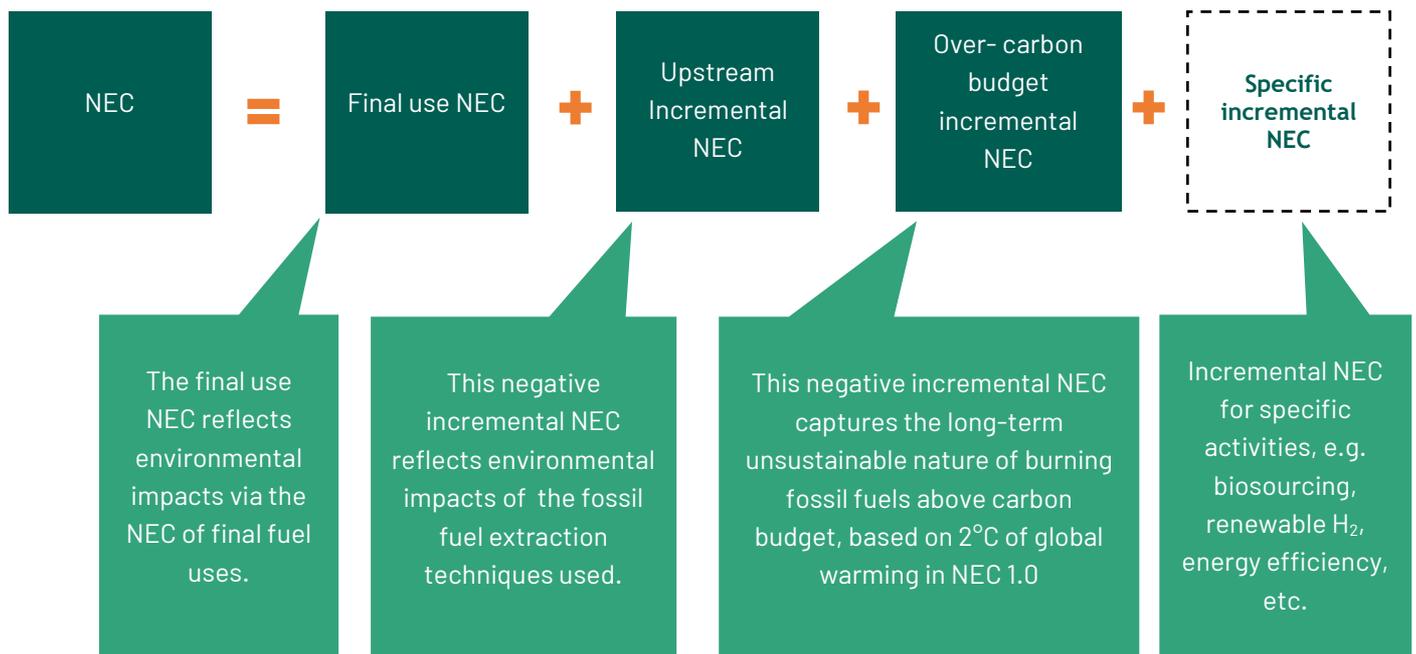
The fuel industry's environmental impacts are diverse, they are captured in the equation below.

Because fossil fuel usage is clearly identified as a primary and massive driver of climate change, negative incremental Net Environmental Contribution (NEC) is introduced to capture this environmentally non-sustainable nature, calibrated according to respective over-carbon budgets.

3. Environmental performance indicators

To quantify the impact of each environmental issue for all parts of the value chain, the NEC is calculated by summing four NEC components:

- Final use NEC: reflects environmental impacts related to the final use of fuel
- Upstream incremental NEC: reflects environmental impacts of the extraction technique used
- Over-carbon budget incremental NEC: A negative increment that captures the long-term unsustainable nature of burning fossil fuels.*
- Specific incremental NEC: added to capture additional specific positive or negative environmental impacts such as biosourcing, energy efficiency and renewable H₂



For biofuels, NEC = final use NEC + specific incremental NEC. No upstream incremental NEC and no over-carbon budget incremental NEC are applied.

*Because fossil fuel usage is clearly identified as a primary and massive driver of climate change, a negative incremental Net Environmental Contribution (NEC) is introduced to capture this environmentally non-sustainable nature, and it is calibrated according to respective over-carbon budgets.

3.1. Upstream rating

The upstream phase of the fuel sector life cycle covers the exploration, extraction and production phases. The NEC for the upstream phase is calculated using the same general equation (final use NEC + upstream incremental NEC + over-carbon budget incremental NEC + specific incremental NEC).

3.1.1. Final use NEC

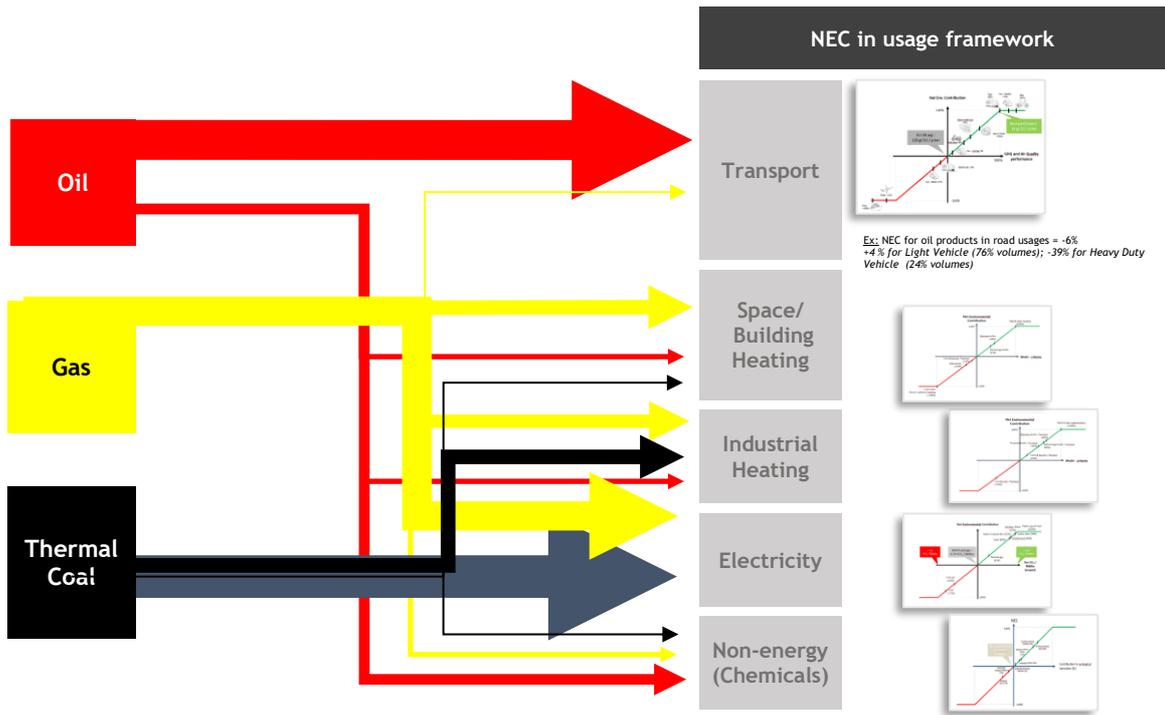


Figure 2: Main final use sectors of oil, gas and thermal coal products. Source: I Care & Consult analysis

When fuel is an upstream product in a value chain, its impact depends on how it's used (e.g. impacts are not the same for oil used for road transportation versus oil used for petrochemical products). Thus, the final use NEC of fuel is calculated based on the NEC provided by the other related frameworks – transport, heat, electricity and chemistry. The final use NEC of oil is calculated as the sum of each relevant use NEC weighted by the volume dedicated to each use.

$$\text{Final use NEC} = \sum \% \text{ volumes} \times \text{NEC of final use}$$

For instance, the NEC of oil products in road transportation is equal to -14%, with the knowledge that the NEC of a light vehicle is -6% for 76% of its volume, and the NEC of a heavy-duty vehicle is -39% for 24% of its volume. The table below presents calculations for oil, gas and thermal coal final use NEC.

| | Use framework | | Resulting NEC | Rationale |
|---------------------|---------------------|-------------|---------------|--|
| Gas matrix | Road transportation | 2% | 77% | |
| | Agriculture | 1% | 56% | Heat framework(gas boiler in space heating) |
| | Building | 24% | 33% | Heat framework(space heating) |
| | Industry | 22% | 60% | Heat framework(10% gas cogeneration, 90% gas boiler) |
| | Utility | 46% | 17% | Electricity framework(natural gas) |
| | Non-energy | 6% | 0% | |
| | Total | 100% | 30% | |
| Oil matrix | Road transportation | 49% | -14% | Hyp: 76% light vehicle, 24% heavy duty |
| | Aviation | 7% | -65% | Hyp: 87% Passenger, 13% freight |
| | Ship | 7% | 11% | Hyp: 10% passenger, 90% freight |
| | Rail | 1% | 100% | Hyp: 10% passenger, 90% freight |
| | Agriculture | 3% | 0% | |
| | Building | 8% | -10% | Heat framework |
| | Industry | 8% | 16% | Heat framework |
| | Utility | 1% | -64% | Electricity framework |
| | Non-energy | 16% | 0% | |
| | Total | 100% | -10% | |
| Thermal coal matrix | Agriculture | 1% | -55% | Heat framework |
| | Building | 3% | -100% | Heat framework |
| | Industry | 25% | -55% | Heat framework |
| | Utility | 69% | -100% | Electricity framework |
| | Non-energy | 2% | 0% | |
| | Total | 100% | -87% | |

Figure 3: Calculation details for oil, gas and thermal coal final use NEC. Source: I Care & Consult analysis

Final use NECs are:

- Thermal coal: -87%
- Oil: -10%
- Gas: +30%

Data availability and practical tips

Information needed: breakdown of production by raw material (oil, gas, thermal coal)

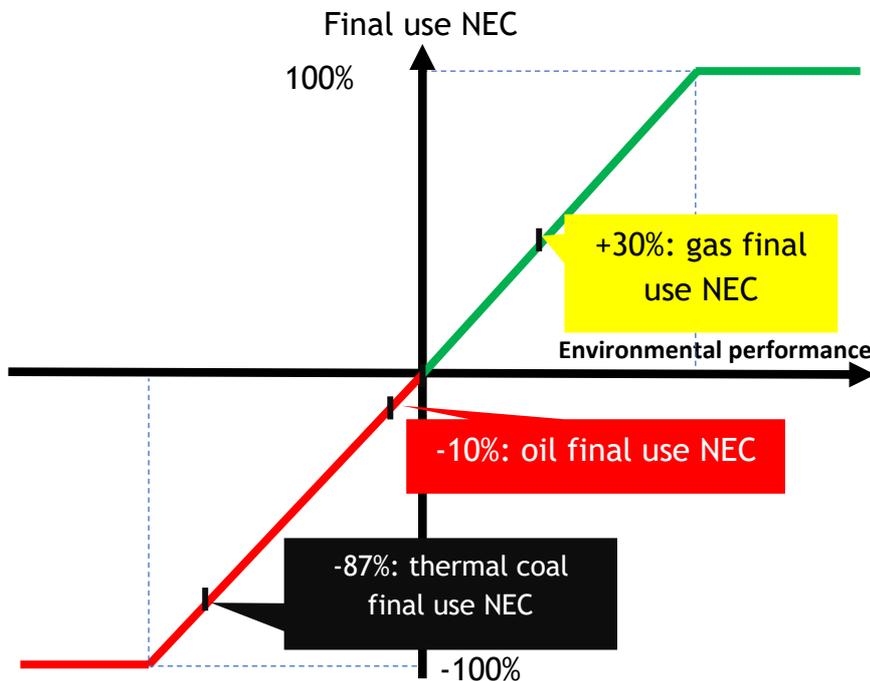
Fuel companies are fairly uncommunicative about their strategic data, including production volumes. However, breakdown of production by raw material can usually be found in a company's activity or sustainability reports.

For TOTAL, this figure is disclosed in the 2017 registration document in the "Business overview for fiscal year 2017" section below.

| Production | | | |
|------------------------------|-------|-------|-------|
| Hydrocarbon production | 2017 | 2016 | 2015 |
| Combined production (kboe/d) | 2,566 | 2,452 | 2,347 |
| Liquids (kbo/d) | 1,346 | 1,271 | 1,237 |
| Gas (Mcf/d) | 6,662 | 6,447 | 6,054 |

Figure 4: Average final use NEC for Oil, Gas and Thermal Coal. Source: I Care & Consult and Sycomore AM

Another useful source is the Shift Project Data Portal, which gives global worldwide energy data. The average global split is 60% oil and 40% gas.



3.1.2. Upstream incremental NEC

The upstream incremental NEC reflects the environmental impacts of fuel extraction. This incremental NEC is calculated using three studies from the European Commission. The first publication, dating back to 2012, covers human and environmental risks related to hydraulic fracturing techniques in Europe.¹ The second report, published in 2016, includes risk management and environmental impacts associated with the conventional oil & gas industry.² The third publication, a technical study from 2015, examines risks associated with unconventional oil & gas extraction techniques.³ These publications analyze diverse issues, including GHG emissions associated with extraction processes, water consumption and water stress risks, surface and underground water contamination risks, soil deterioration, air pollution, potential effects on health and seismic hazards. These analyses are summarised in a fourth report by Ernst & Young Norway, in partnership with KLP (Kommunal Landspensjonskasse)⁴. All four publications are summarised in the following matrix to show the environmental risks and assess the environmental impacts of each extraction technique.

¹European Commission, "Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe", 2012, <http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf>.

² European Commission, « Study on the management of environmental impacts and risks of conventional oil and gas », 412p., 2016, http://ec.europa.eu/environment/integration/energy/pdf/Study_on_the_management_of_environmental_impacts_and_risks_of_conventional_oil_and_gas%20.pdf.

³ European Commission, « Technical support for the risk of unconventional hydrocarbon extraction », 181p., 2015, http://ec.europa.eu/environment/integration/energy/pdf/study_management_ei.pdf.

⁴ Ernst & Young, KLP. « Unconventional Oil And Gas Carbon Constrained World », 59p., 2017, https://www.klp.no/polopoly_fs/1.38621.1509968953!/menu/standard/file/UnconventionalOilAndGasInaCarbonConstrainedWorld-September2017.pdf.

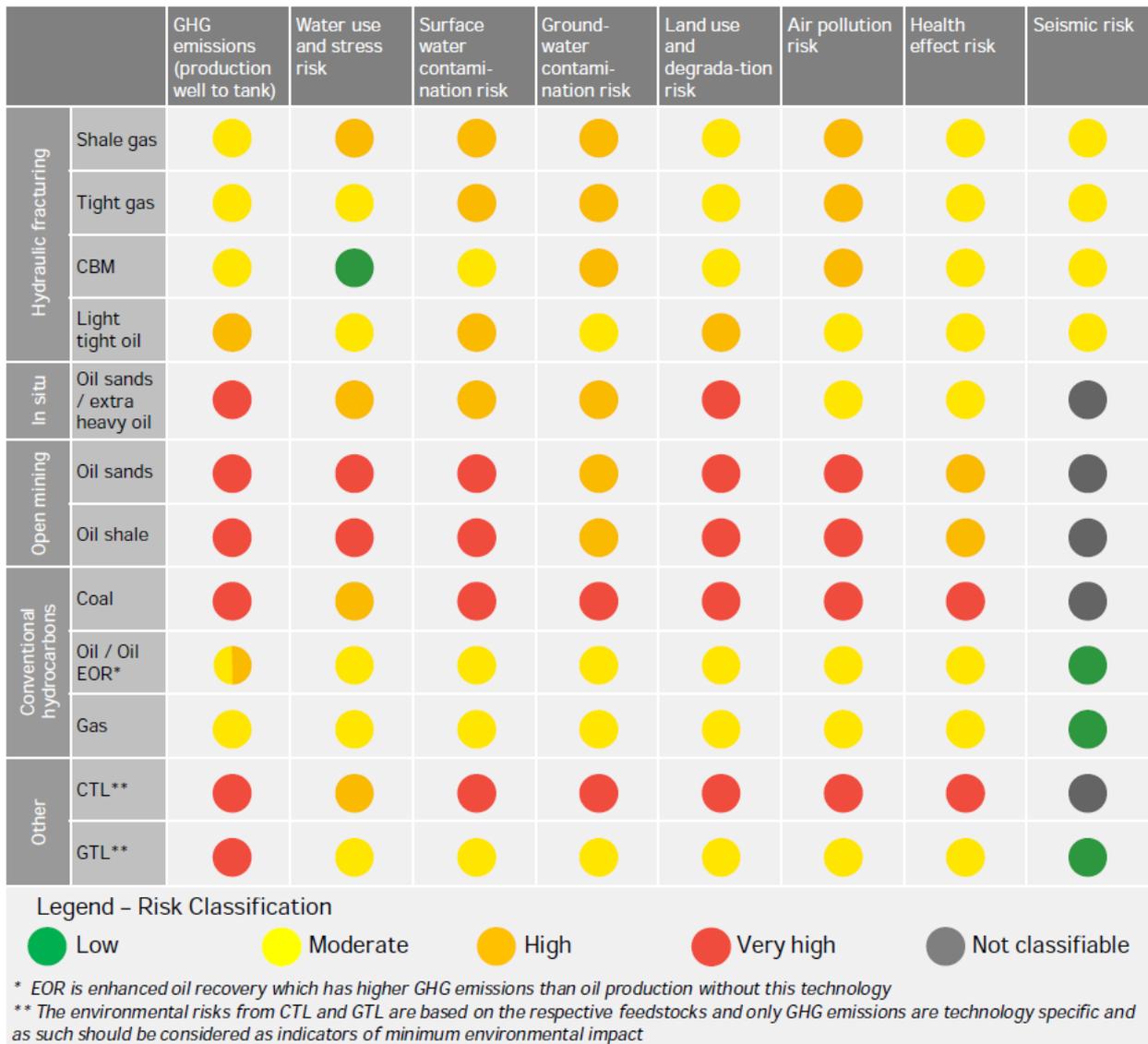


Figure 5: Risk Matrix showing key findings by environmental risk and production technology
 Source: "Unconventional Oil & Gas Carbon Constraint World", Ernst & Young Norway & Kommunal Landspensjonskasse, 2017

This data is converted using the following principles:

- Criteria scope: Only six strictly environmental criteria are included (risk to human health and seismic risk are not included).
- Criteria weighting:
 - The GHG emissions-related criterion is weighted at 33% to reflect the significant weight of the climate issue in the NEC across framework.
 - The three water-related criteria are aggregated into a single water issue also weighted at 33% since it is a significant area in the studies analysed: each item is weighted 11%.
 - The remaining two criteria related to land use and degradation (meaning biodiversity impacts) and air quality are weighted at 17% each.
- Point conversion: Each intensity level in the risk matrix is converted accordingly:
 - Low = 1
 - Moderate = 2
 - High = 3
 - Very high = 4

- Each extraction type is evaluated based on a score obtained by converting the intensity scale into points, then weighting points using the criteria above.
- Incremental NEC value conversion: The score distribution, which reflects the environmental impacts of different extraction techniques, is converted into NEC. In compliance with the NEC methodology, two reference points are defined to create a linear regression and assign each point a NEC value. The highest (and most impactful) value is designated as the most destructive natural capital value and assigned a NEC of -100%. To define the second reference point, the minimum level of impact is identified as conventional extraction (least impactful) and is assigned a NEC of -10%. However, these are two arbitrary hypotheses that could be the subject of further development and refinement.

Results are summarized below:

| | | GHG emissions | Water use and stress risk | Surface water contamination risk | Ground water contamination risk | Land use and degradation risk | Air pollution risk | Health Effect risk | Average | Upstream incremental NEC |
|---------------------------|---------------------------|---------------|---------------------------|----------------------------------|---------------------------------|-------------------------------|--------------------|--------------------|---------|--------------------------|
| Weighting | | 33% | 11% | 11% | 11% | 17% | 17% | 0% | 100% | |
| hydraulic fracturing | Shale gas | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2,50 | -34% |
| | Tight gas | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 2,39 | -29% |
| | Coal Bed Methane | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 2,17 | -18% |
| | Light tight oil | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2,61 | -39% |
| In situ | Oil sands / extra heavy c | 4 | 3 | 3 | 3 | 4 | 2 | 2 | 3,33 | -73% |
| Open mining | Oil sands | 4 | 4 | 4 | 3 | 4 | 4 | 3 | 3,89 | -100% |
| | Oil shale | 4 | 4 | 4 | 3 | 4 | 4 | 3 | 3,89 | -100% |
| Conventional hydrocarbons | Coal | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3,89 | -100% |
| | Oil | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2,00 | -10% |
| | Gas | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2,00 | -10% |
| Other | Coal-to-Liquid | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3,89 | -100% |
| | Gas-to-Liquid | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2,66 | -41% |
| | Conventional LNG | 2,5 | 2 | 2 | 2 | 2 | 2 | 2 | 2,17 | -18% |
| | Malus for LNG | | | | | | | | | -8% |

Figure 6: Correspondence between the fuel environmental risk matrix and Upstream incremental NEC.
Source: Sycomore AM

A score for liquified natural gas (LNG) is calculated based on the methodology above and the following specificities:

- A 2.5 score for GHG emissions (between “moderate” and “high”) since LNG processes (liquefaction and regasification) are more GHG-intensive than pipeline transportation.
- A 2 score for other impacts (“moderate”) based on “conventional gas” rating
- This results in an -18% rating (versus -10% for conventional gas), meaning a -8% malus for LNG compared to liquified conventional gas or natural gas.

This figure summarizes which upstream incremental NEC to apply, in accordance with the extraction technique of a given fuel type.

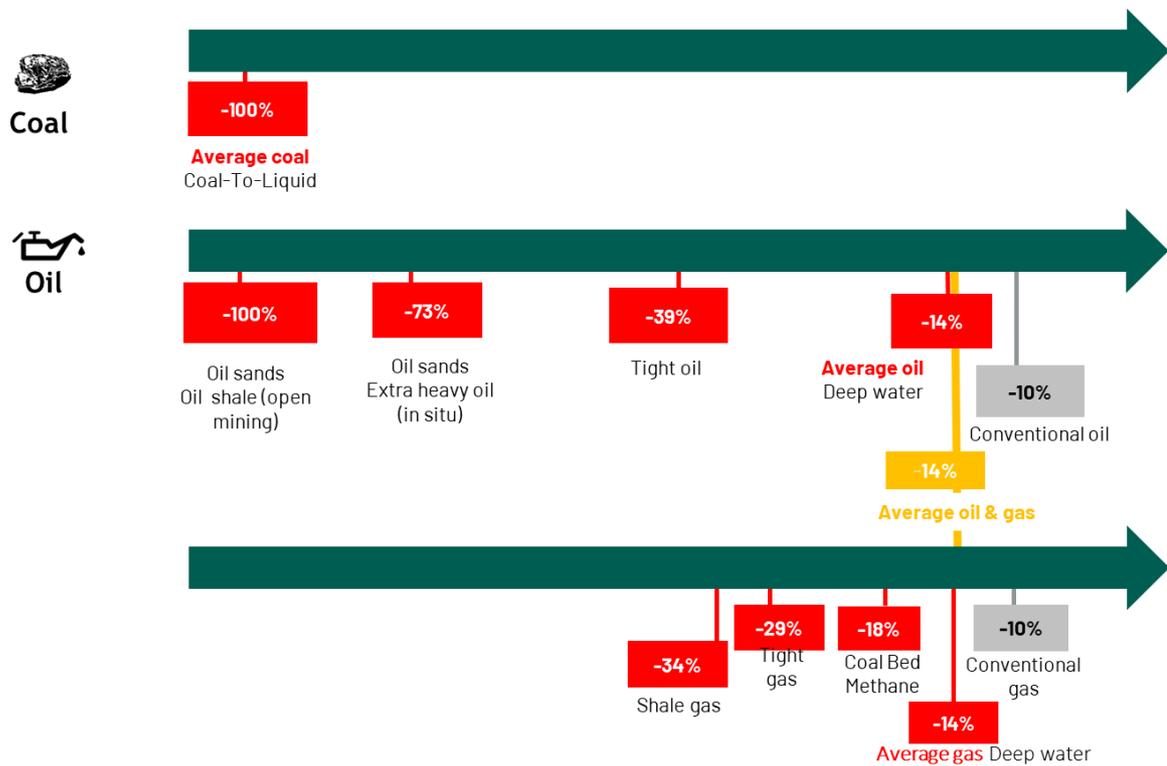


Figure 7: Upstream incremental NEC. Source: Sycomore AM and I Care & Consult analysis, 2018

3.1.3. Over-carbon budget incremental NEC

This negative incremental NEC takes into account a malus related to non-compliance with alignment objectives from the IPCC's 2° C scenario. In a 2015 study by McGlade & Ekins⁵, a model was developed to estimate the amount of oil and gas reserves that should remain in the ground based on constraints from the IPCC in keeping with their objective to keep average global warming below an average of 2°C. The discrimination of exploitable resources is based both on the production marginal cost of each extraction technique and on their carbon intensity. Thus, only the extraction techniques with the lowest carbon intensity and the lowest production marginal cost should be exploited.

The study determines what percentage of reserves (categorized by fuel type and extraction method) should not be extracted. McGlade and Ekins state that 33% of oil reserves, 52% of gas reserves and 88% of coal reserves need to remain in the ground in order to meet the IPCC carbon budget. They also provide detailed data categorized by extraction type.

The over-carbon budget incremental NEC is a malus that only reflects climate impact, unlike the upstream incremental NEC that covers multiple environmental impacts. Because this incremental only covers the climate criterion, weighted at 33% in the upstream incremental NEC, the over-carbon budget incremental NEC is equally weighted at 33%. The following table presents detailed results by extraction type.

5. Mcglade, C., & Ekins, P. (2015). The geographical distribution of fossil fuels unused when limiting global warming to 2 °C. *Nature*, 517, 187-190.

| | | % of reserves that must "remain in the ground" | Over carbon budget incremental NEC (% of reserves that must "remain in the ground" with a 33% weighting applied) |
|---------------------------|-----------------------------|--|---|
| hydraulic fracking | Shale gas | 82% | -27% |
| | Tight gas | 82% | -27% |
| | Coal Bed Methane | 82% | -27% |
| | Light tight oil | 52% | -17% |
| In situ | Oil sands / extra heavy oil | 99% | -33% |
| Open mining | Oil sands | 99% | -33% |
| | Oil shale | 100% | -33% |
| Conventional hydrocarbons | Thermal coal | 88% | -29% |
| | Oil | 33% | -11% |
| | Gas | 52% | -17% |
| Other | Coal-to-Liquid | 100% | -33% |
| | Gas-to-Liquid | 52% | -17% |

Figure 8: Summary table of over-carbon budget incremental NEC by extraction type. Source: Sycomore AM based on McGlade & Ekins study, 2015; and Julien Bouyssou's professional thesis ISIGE/Mines Paristech, 2018.

The following figures summarize the over-carbon budget incremental NEC that is applied according to the extraction technique for a given fuel type.

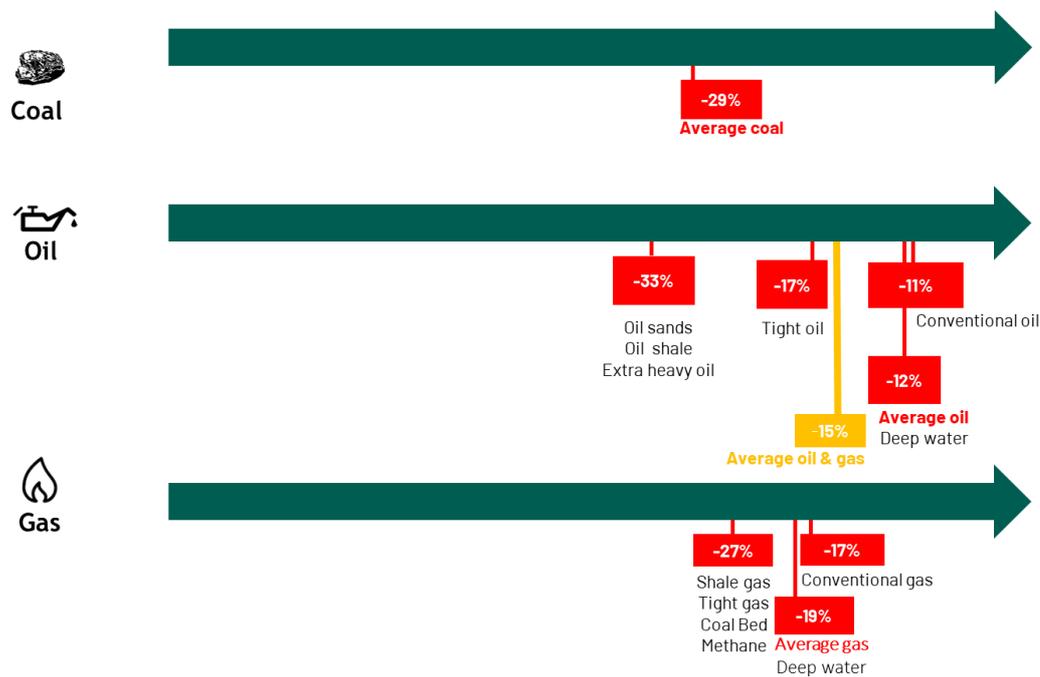


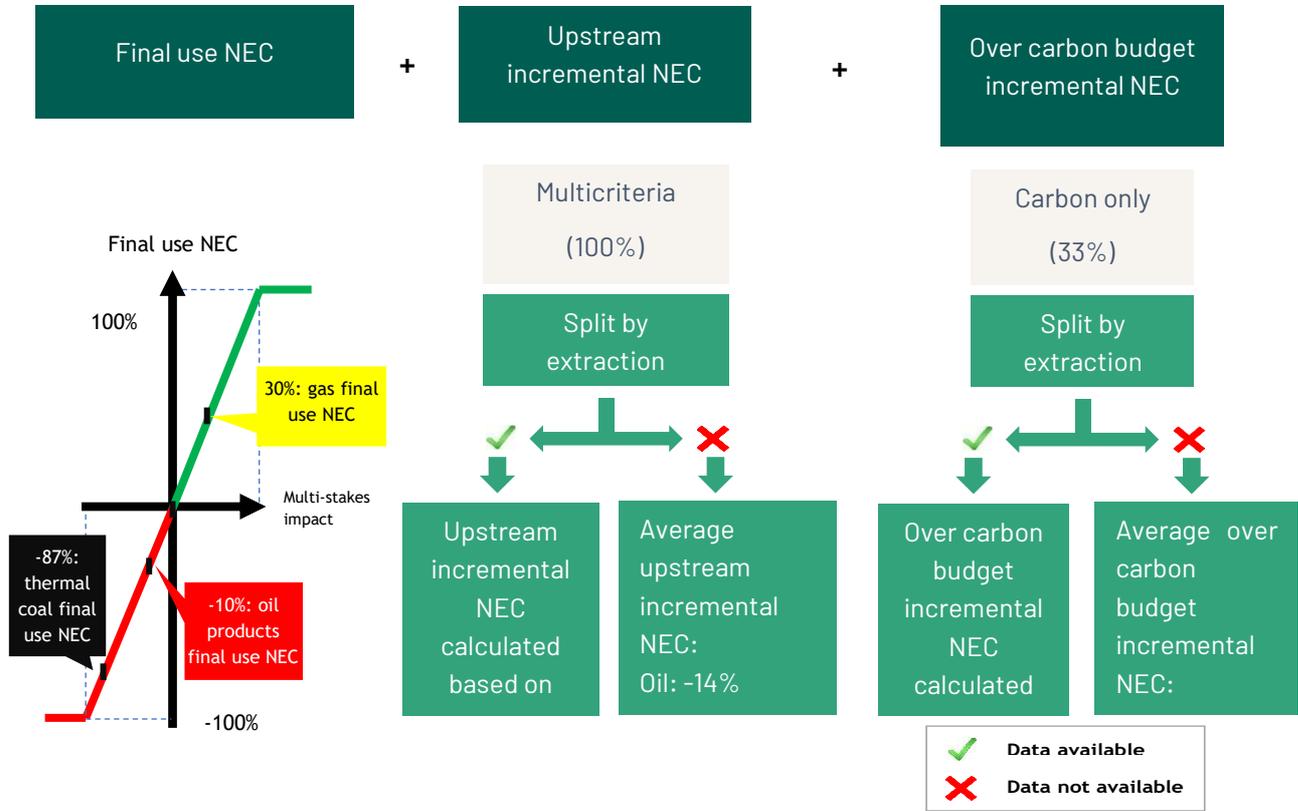
Figure 9: over-carbon budget incremental NEC by extraction type. Source: Sycomore AM based on McGlade & Ekins study, 2015; and Julien Bouyssou's professional thesis ISIGE/Mines Paristech, 2018.

The following table presents final use NEC and both incremental NECs for each extraction type, resulting in a final NEC.

| | | Final use NEC | Upstream incremental NEC | Over-carbon budget incremental NEC | Resulting NEC sum |
|---------------------------|----------------------------------|---------------|--------------------------|------------------------------------|-------------------|
| hydraulic fracking | Shale gas | 30% | -34% | -27% | -31% |
| | Tight gas | 30% | -29% | -27% | -26% |
| | Coal bed methane | 30% | -18% | -27% | -15% |
| | Light tight oil | -10% | -39% | -17% | -66% |
| In situ | Oil sands/extra heavy oil | -10% | -73% | -33% | -116% |
| Open mining | Oil sands | -10% | -100% | -33% | -143% |
| | Oil shale | -10% | -100% | -33% | -143% |
| Conventional hydrocarbons | Thermal coal | -87% | -100% | -29% | -216% |
| | Oil | -10% | -10% | -11% | -31% |
| | Gas | 30% | -10% | -17% | 3% |
| Other | Coal-to-liquid | -10% | -100% | -33% | -143% |
| | Gas-to-liquid | 30% | -41% | -17% | -29% |
| Deep water | Deep water/ultra deep water oil | -10% | -14% | -12% | -36% |
| | Deep water/ ultra deep water gas | 30% | -14% | -19% | -3% |

Table 3: Summary table of final use NEC, upstream incremental NEC and over-carbon budget incremental NEC by extraction type; Sycomore AM and I Care&Consult analysis, 2018

The calculation of both incremental NECs depends on the data available, described in the table below. If no company information is available, average incremental NEC is proposed as a default value.



3.2. Midstream rating

The midstream phase of the fuel sector covers transformation and logistics activities, including refining, production of petrochemicals and specialty chemicals, storage, transportation, pipelines and trading. The NEC for the midstream phase is calculated using the same generic equation.

3.2.1. Final use NEC

This indicator represents the impacts of a product's final uses, and is split into two parts:

- Refining sales: final use NEC of -10%.
- Petrochemical sales & specialty chemicals: final use NEC of 0% related to the Chemistry framework.

3.2.2. Incremental NECs

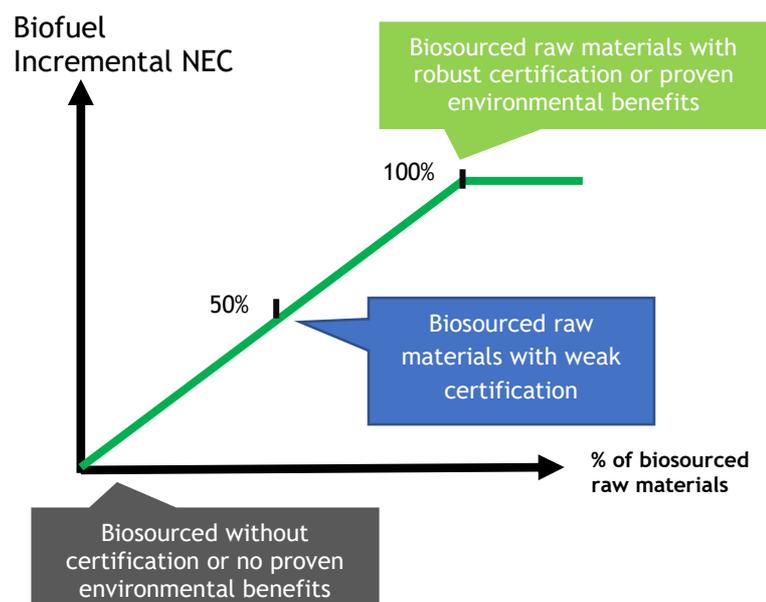
The two fossil-negative incremental NECs - upstream and over-carbon budget - apply to refining sales, since fuels are the largest output volume of refining and since the fossil share is predominant. The average default incremental NEC is generally used, unless specific information is available.

Fuels can also contribute to the IPCC 2°C scenario via:

- Biosourcing
- Energy efficient products or services
- Highly recycled materials
- Renewable H₂

Thus, a positive specific incremental NEC for biosourcing can be incorporated. Since biosourcing is a complex issue and can also be a source of significant negative environmental impacts, the specific incremental NEC must be based on comparative LCA or third-party quantified environmental benefits.

When this information is lacking, a +100% incremental NEC is used for biosourced materials with robust certification, and a +50% incremental NEC is used when biosourcing is supported by a weak certification. A 0% specific incremental NEC is used when the environmental benefit is unclear or when there is no certification.



3.2.3. Specific non-energy uses

- Petrochemicals and specialty chemicals NEC are included in the Chemistry framework with a 0% default NEC;
- Other non-energy uses (metallurgical coal, chemical commodities such as CH₄ or H₂) have a 0% default NEC.

3.3. Downstream rating

The downstream phase of the fuel sector covers retail and final uses. The NEC for the downstream phase is calculated using the same generic equation with the following specificities.

3.3.1. Incremental NECs

Average upstream and over-carbon budget incremental NECs are applied to downstream ratings to offer a consistent approach for the overall fuel value chain. If more specific information on extraction types is available, the corresponding rating is applied, as described in the upstream rating section.

3.3.2. Specific incremental NEC

A specific incremental NEC can be added depending on a retailer's efforts, as described below:

- Gas retail: -5% to +5%, depending on a retailer's efforts to boost energy control
- Oil retail: -10% to +10%, depending on a retailer's efforts to control energy and offer greener products (H₂, bio-sourced, etc.)
- Biogas: Just like the midstream phase, a positive incremental NEC can be added for biosourcing:
 - Biogas with robust certification or proven environmental benefits has a specific incremental NEC of +100%.
 - Biogas with weak certification has a +50% specific incremental NEC.

- Biogas with no certification or no proven environmental benefits has no specific incremental NEC.

3.3.3. Default values

The figures below represent a split in overall production by extraction type. Based on these values, default NECs are calculated for oil and gas, respecting the current production mix. For LNG, gas split is taken into consideration.

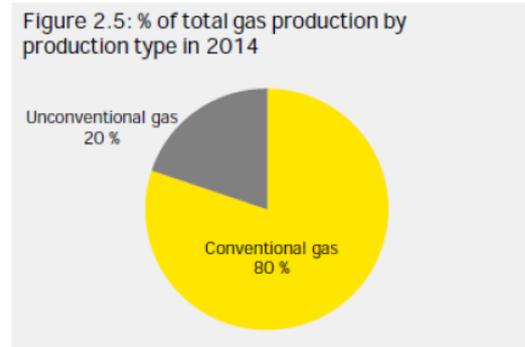
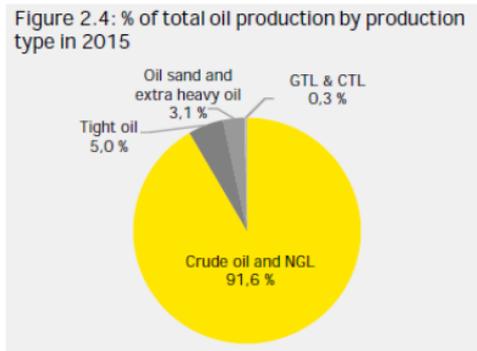


Figure 9: Distribution of oil and gas production by extraction type
Source: Ernst & Young (2017)

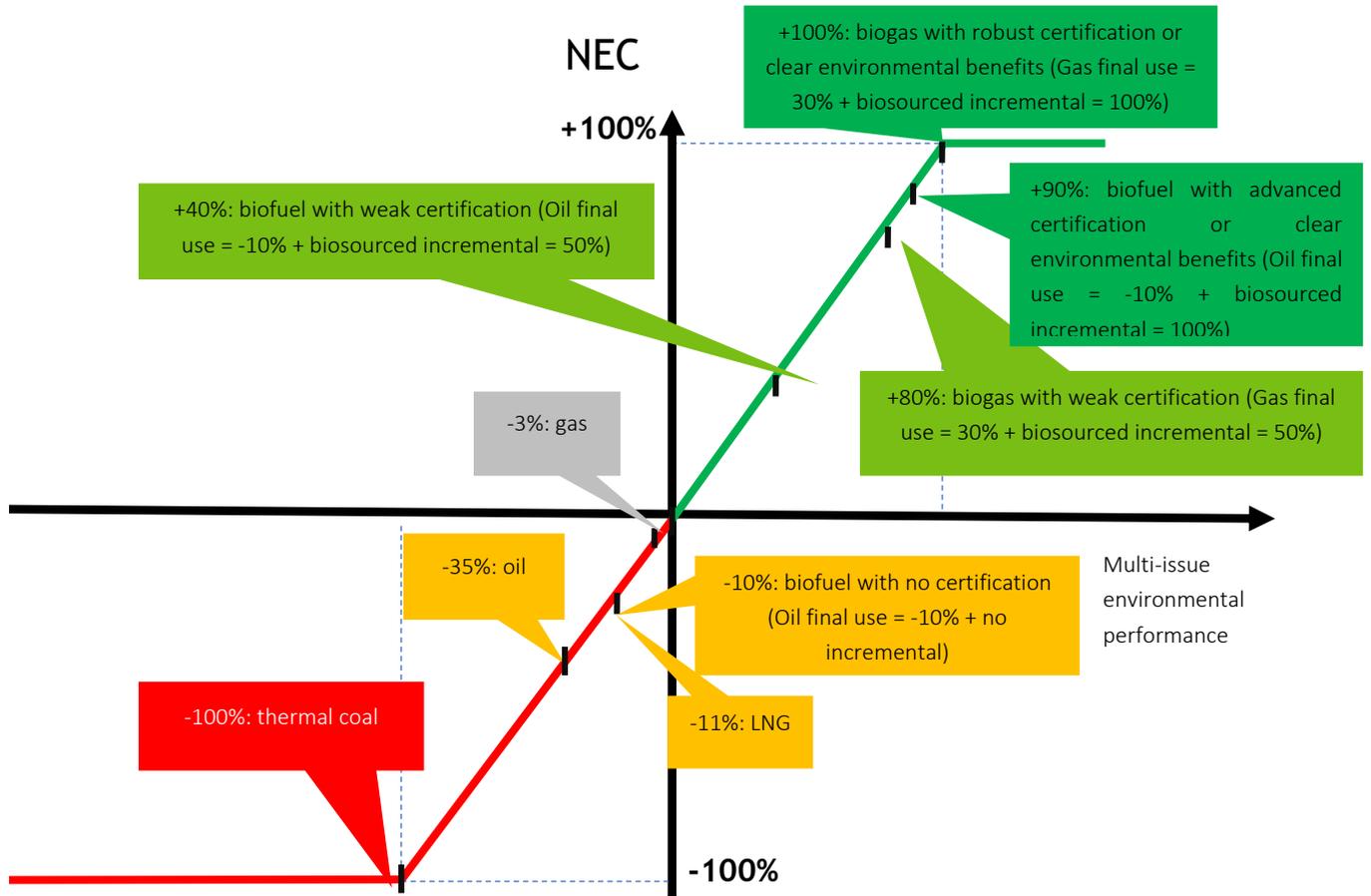
Based on this data and data from the 2017 BP Statistical Review of World Energy that gives the share of oil and gas at 58% and 42% respectively (tons of oil equivalent), the following default values are calculated:

| | Final use NEC | Upstream incremental NEC | Over-carbon budget incremental NEC | NEC |
|--------------|---------------|--------------------------|------------------------------------|-------|
| Oil | -10% | -14% | -12% | -36% |
| Gas | +30% | -14% | -19% | -3% |
| Oil and gas | +7% | -14% | -15% | -22% |
| LNG | +30% | -22% | -19% | -11% |
| Thermal coal | -87% | -100% | -29% | -100% |

Default values for generic undifferentiated use are summarized below:

- Thermal coal: -100%
- Oil distribution: -36%
- Gas distribution: -3%
- Upstream & midstream with no split oil/gas: -22%
- Oil & gas downstream (retail) with no split oil/gas: -22%
- Oil (mix of conventional/unconventional): -36%

- Gas (mix of conventional/unconventional): -3%
- LNG (mix of conventional/unconventional): -11%
- Biogas: 80% to 100%
- Petrochemicals and specialty chemicals NEC: 0%
- Other non-energy uses (metallurgical coal, chemical commodities, such as CH₄ or H₂): 0%



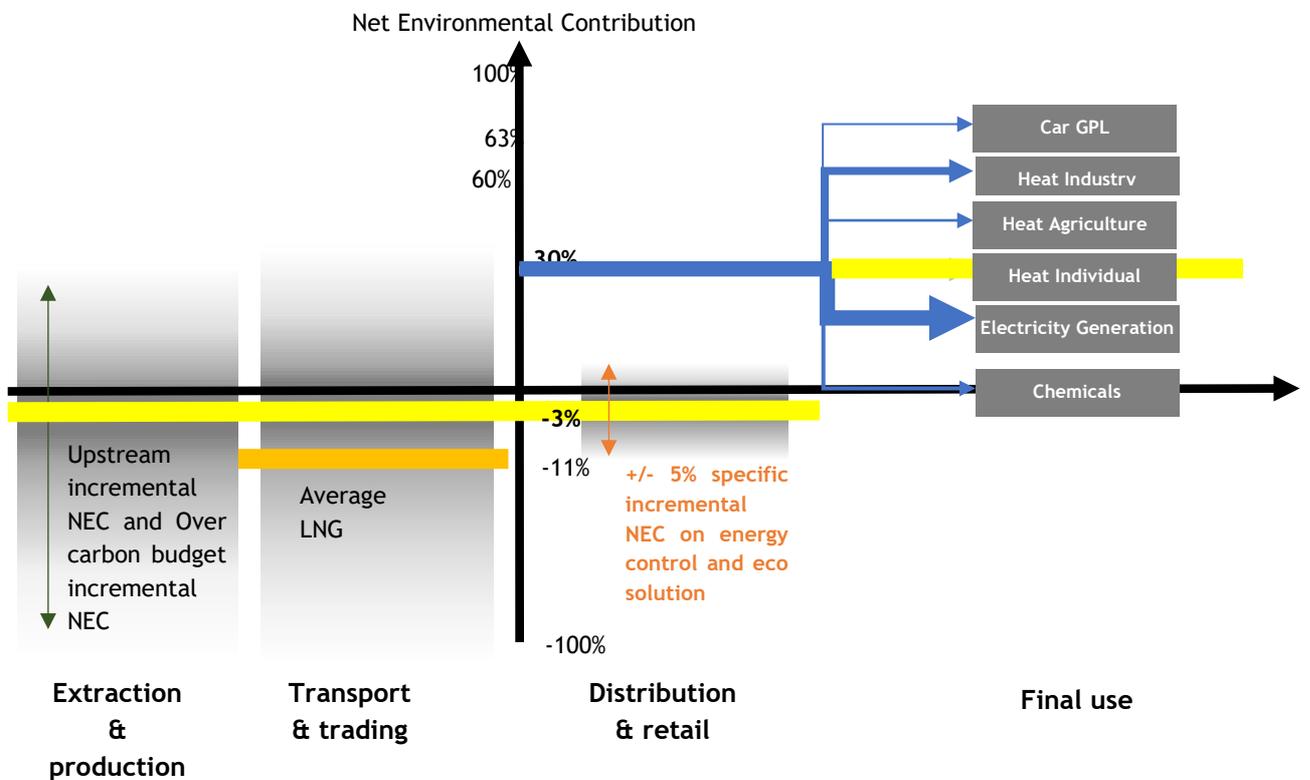
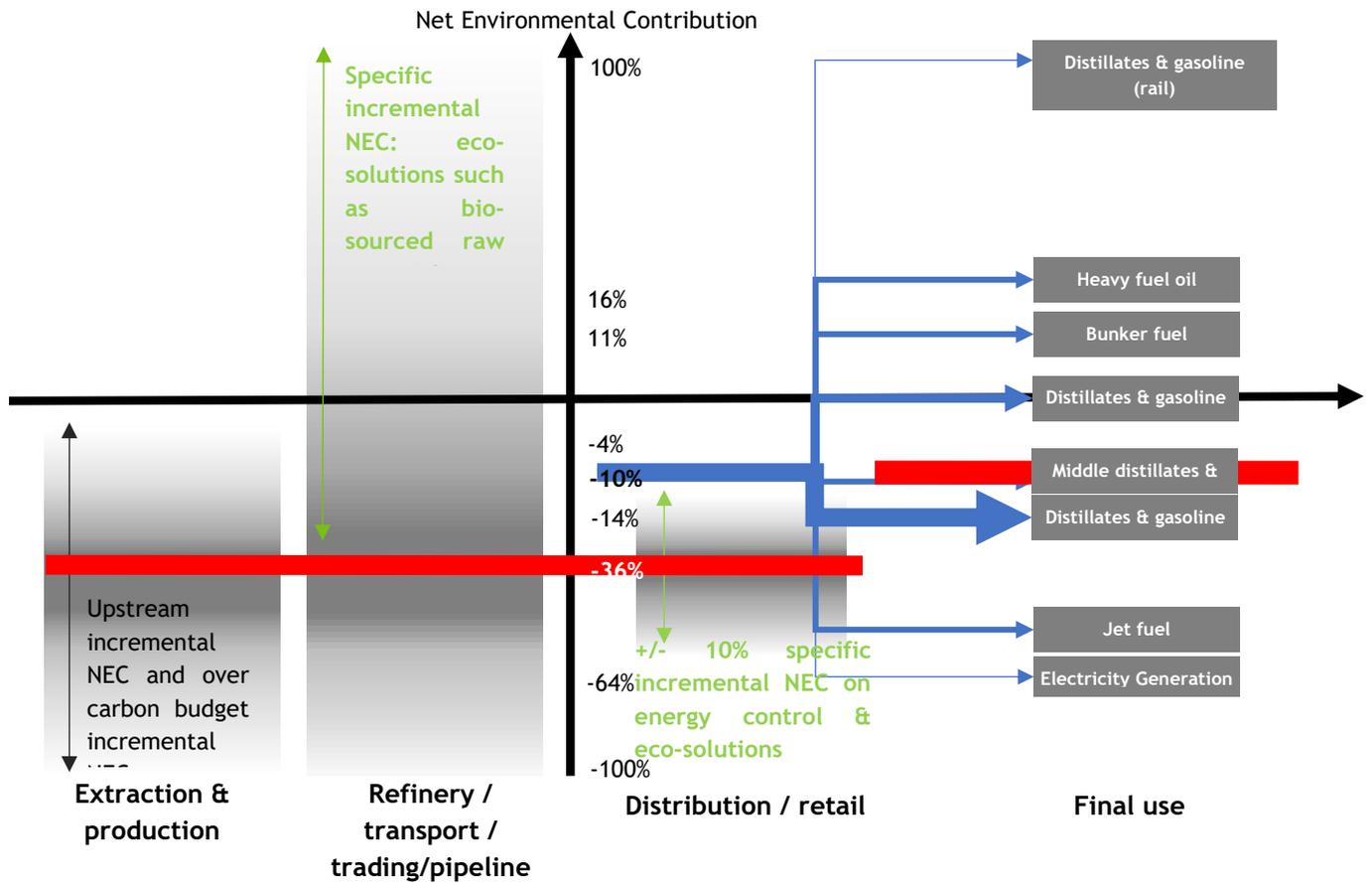
4. Main limits

There are several key advantages of this approach. The framework takes into account the entire fuel value chain, offering a wide range of lenses to evaluate and compare companies on different environmental issues. Since strategic data from oil and gas companies is often not disclosed, the framework allows the user to differentiate companies using a limited data set essentially based on oil/gas/coal/biogas/biofuel mixes and environmental policies' specificities.

However, the first limitation of the method is the lack of data concerning certain extraction types, particularly unconventional oil and unconventional gas. Generally speaking, the share of unconventional volume from total extracted volume and type of unconventional fuel (shale gas, shale oil, arctic, tar sands) is not disclosed, nor accessible. The share of unconventional reserve 1P, 2P CAPEX dedicated to unconventional or LNG investments may be available occasionally.

The second limitation is that the environmental benefits and damages of bio-fuels are generally not well-documented and could be better disclosed and assessed.

The two diagrams below are one perspective on oil and gas value chains' ratings, respectively. While NEC ratings are consistent from upstream to downstream, there is a disconnect between downstream NEC of the fuel framework and end use NEC in other frameworks (e.g. Electricity, Heating). The consistency of the entire value chain could be addressed in a subsequent update of the Fuel framework and of the related downstream-connected frameworks, such as electricity, heat or transportation. It is probably worthwhile to question the design of the 2°C based over-carbon-budget malus, e.g. what if a 1.5°C target is preferred, or could the fossil malus be extended to the downstream-connected frameworks?



5. Key data sources

| Data | Sources |
|--|---|
| Global energy and climate statistics | <p>The Shift Project's data portal website: http://www.tsp-data-portal.org/</p> <p>International Energy Agency, « Key World energy statistics 2017 », 97p., May 2018, https://www.iea.org/publications/freepublications/publication/KeyWorld2017.pdf</p> <p>BP statistical review of world energy, 11p., 2018, https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf.</p> <p>Enerdata, «Global Energy Trends», 39p., 2018, https://www.enerdata.net/system/files/publications/global-energy-trends-2018-edition-enerdata.pdf</p> <p>International Energy Agency World Balance 2014</p> |
| Unconventional Oil and Gas Carbon Constraint World | <p>Ernst & Young, KLP. «Unconventional Oil And Gas Carbon Constrained World», 59p., 2017, https://www.klp.no/polopoly_fs/1.38621.1509968953!/menu/standard/file/UnconventionalOilAndGasInaCarbonConstrainedWorld-September2017.pdf.</p> |
| Productivity of different uses of oil | <p>Carbon Productivity website: www.carbonproductivity.com</p> |
| Environmental risks related to oil & gas extraction techniques | <p>European Commission, "Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe". 2012, http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf.</p> <p>European Commission, «Study on the management of environmental impacts and risks of conventional oil and gas», 2016, http://ec.europa.eu/environment/integration/energy/pdf/Study_on_the_management_of_environmental_impacts_and_risks_of_conventional_oil_and_gas%20.pdf</p> <p>European Commission, «Technical support for the risk of unconventional hydrocarbon extraction », 2015, http://ec.europa.eu/environment/integration/energy/pdf/study_management_ei.pdf</p> <p>AEA, «Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe »: 292p., 2012. http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf.</p> |
| Biofuels | <p>Gagnepain Bruno. «Biocarburants», Techniques de l'ingénieur, Energies / Ressources énergétiques et stockage, 30p., 2016.</p> |
| Over-carbon budget | <p>Mcglade, C., & Ekins, P., 2015, The geographical distribution of fossil fuels unused when limiting global warming to 2 °C, Nature, 517, 187-190.</p> |



The holistic metric
guiding environmental
action

HEAT FRAMEWORK

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1.Introduction

The heat framework encompasses the different activities of the heat generation value chain: heat equipment, heat generation and distribution. Space heating and industrial heating are two different ways of producing heat, the former referring to small decentralized heating systems exclusively used in buildings and houses, while the latter covers centralized heat production units for industrial use or district heating.

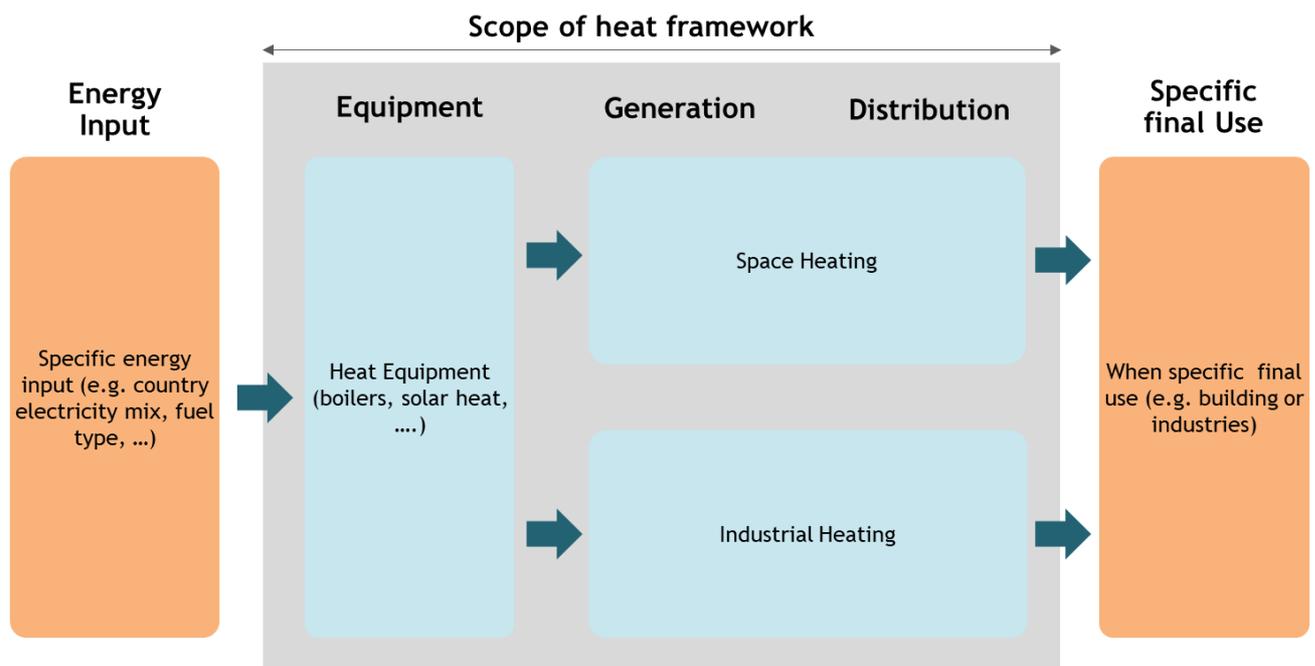


Figure 1: Scope of Heat framework, NEC 1.0.

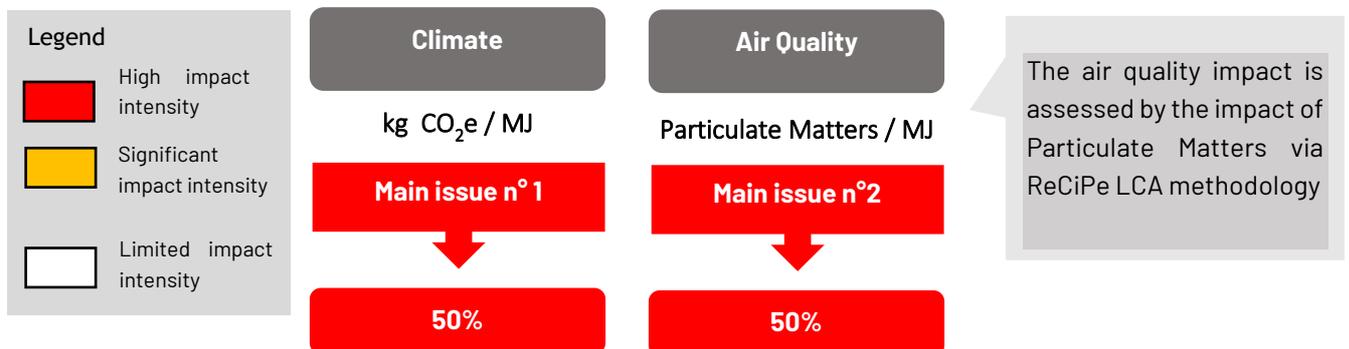
Along with electricity, heat is one of the most used forms of energy in the world. The main sources of energy used for heat production are coal and gas (both fossil fuels), electricity (whose fossil content depends on the electricity mix being used), and biomass, which is renewable. New types of energy have emerged in the past decades with decreased environmental impacts; of which geothermal and heat pumps are the most performant thanks to high efficiency levels, expressed in COP, Coefficient Of Performance.

Heat is mostly produced onsite by consumers themselves, both on industrial sites and in the heated buildings. It can also be provided via urban heat networks where heat production is centralized at industrial scale and then distributed locally by a district network. Heat providers are mostly:

- District heating companies: As for electricity, heat can be produced in centralized plants and conveyed to final consumers via heat networks. However, heat transport is much less efficient and more expensive than electricity transport. Indeed, it requires heavily insulated corrosion-resistant pipes, as well a great deal of pumps and valves. Therefore, heat distribution networks only exist in heavily populated urban areas and dense industrial areas.
- Energy services companies: These companies manage heating and cooling systems at the clients' sites: mainly industrial production sites, public utilities, offices and hospitals. In some cases, heat consumers decide to fully subcontract the heat production phase to a third party which designs, builds and operates the thermal plants onsite.

2. Main environmental issues

| Environmental stake | | Relevance along value chain | | Comments |
|---------------------|-----------------------------|-----------------------------|---------------------------|--|
| | | Upstream | Production & distribution | |
| Climate | Climate Change | High | High | For fossil heat generation: high climate impact intensity during fuel combustion. For electricity-based heat generation/ (heat pump), significant impact intensity in upstream phase (equipment construction and electricity generation). |
| | Energy Resources Efficiency | High | High | High impact intensity regarding energy consumption in upstream phase (extraction of energy resources) as well as in production phase (energy conversion). |
| Air Quality | Air quality deterioration | Limited | High | An important contributor to air pollution at generation level. In fact, the combustion of fossil fuel, and biomass (one of the main heating energies in the world), has a negative impact on air quality especially because of particulate matter. |
| Water | Water consumption | Limited | High | Local and city-wide district heating uses water mainly as a heat transfer fluid. Consumption is mainly due to filling and replenishing leaking networks. |
| | Water pollution | Limited | High | The water used in the heat transfer networks are treated with chemical additives (i.e. Glycol antifreeze), and thus require treatment for proper disposal. |
| Biodiversity | Soil Pollution | High | Limited | Significant impact on soil during the fuel production phase. |
| | Land Use | High | Limited | Significant transformation of land during biomass production. Minimal impact in production phase as heat plants have relatively small footprints. |
| Resources & Waste | Use of non-energy resources | High | Limited | Limited amount of materials used in the heat plant construction phase compared to the amount of heat produced over lifetime. |
| | Waste | Limited | Limited | No significant impact |



This framework considers the two main environmental impacts that are measurable at the activity or company level:

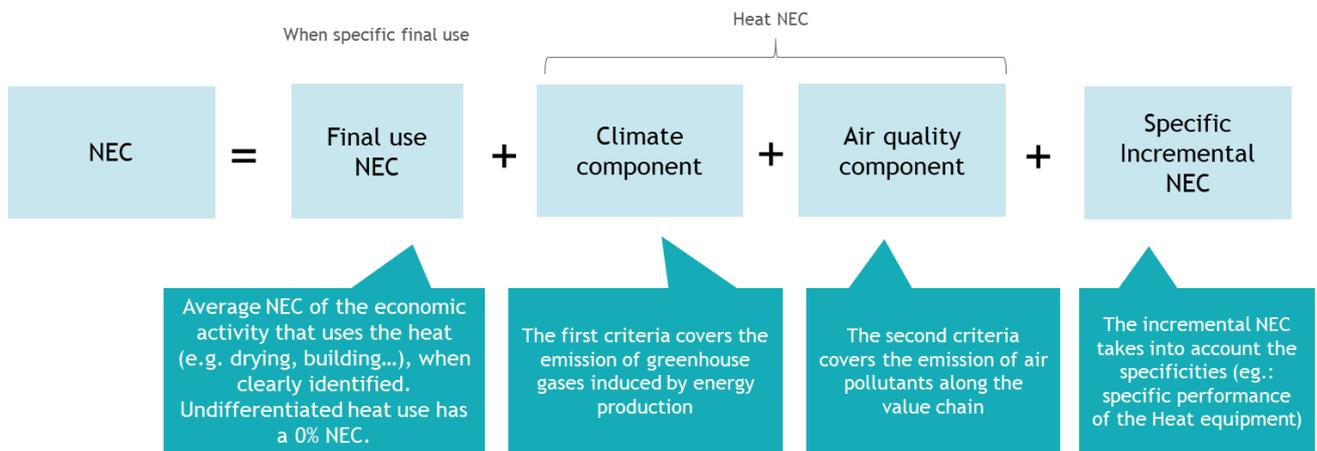
- Climate change:** The heat production sector still relies heavily on fossil fuels as a source of energy. The fuel combustion reaction releases quantities of CO₂ that are proportional to the carbon content of each type of fuel. Coal has the highest carbon content, while natural gas (methane, CH₄) has the lowest carbon content of all fossil fuels.

- **Air quality deterioration:** In addition to CO₂, fuel combustion releases airborne pollutants such as SO_x, NO_x, CO, volatile organic compounds (VOC) and particulate matters. These compounds cause significant damage to living species including humankind.

3. Environmental performance indicators

The general equation for Net Environmental Contribution (NEC) is based on the sum of different factors

- Final use NEC: average NEC of the economic activity that uses the heat (if undifferentiated: 0%)
- Heat NEC with 2 NEC components: Climate component and Air Quality component
- Specific incremental NEC to take account specificities such as specific energy or pollutant performance of heat equipment



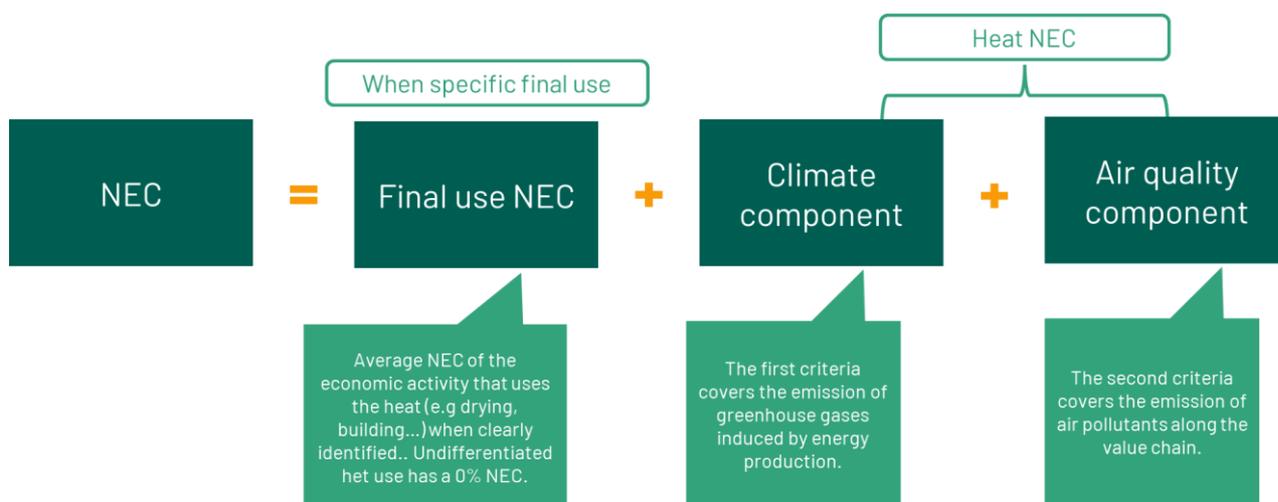
This general equation applies to the two main economic activities identified in this framework:

- Heat generation and distribution
- Heat equipment

4. NEC calculation

4.1. Heat generation and distribution

The NEC for heat generation and distribution is the sum of two NEC components: Climate NEC and Air Quality NEC. If there is a specific final use, a final use NEC can be added.



4.1.1. Climate component

The climate change impact of heat production is proportional to the quantity of greenhouse gases emitted per unit of produced heat. Each generation technology has an emission factor (expressed in kg CO₂eq/MJ). To that extent, a technology-specific emissions database has been established and is incorporated into the calculation Excel file.

Scope of GHG emission factors covers GHG emissions generated directly from heat production as well as indirectly from upstream activities such as fuel production and plant components manufacturing. The technology specific emissions factors correspond to a Global Warming Potential over 100 years (expressed in kg CO₂eq / MJ) given by the IPCC (2013). The table below represents the final CO₂ equivalent emissions factor used in the Excel file.

In order to transform the emissions factors into a Climate component, each factor is placed on a scale from -100% to +100%, where +100% corresponds to the lowest CO₂ emissions factor (biomass boiler for both industrial use and space heating), and the 0% corresponds to the world average heat emissions factor. This average heat emission factor is calculated by weighting each technology's emissions factor by its global share (the global share of fuels for heat production has been derived from the world energy balance tool of the IEA for 2014).

| Industrial heating technology | Total emissions factor (kg CO ₂ eq/MJ) | Climate component |
|-------------------------------|---|-------------------|
| Biomass boiler/furnace | 0,014 | 100% |
| Natural gas cogeneration | 0,031 | 82% |
| Natural gas boiler/furnace | 0,068 | 41% |
| Propane boiler/furnace | 0,086 | 21% |
| Fuel oil boiler/furnace | 0,095 | 12% |
| Coal boiler/furnace | 0,155 | -53% |

| Space heating technology | Total emissions factor (kg CO ₂ eq/MJ) | Climate component |
|--------------------------|--|-------------------|
| Hybrid solar heating | 0,021 | 100% |
| Natural gas boiler | 0,048 | 41% |
| Fuel oil boiler | 0,055 | 24% |
| Biomass boiler | 0,080 | -30% |
| Heat pump | 0,093 | -58% |
| Coal boiler | 0,2 | -100% |
| Radiative heating | 0,187 | -100% |

Source: Ecoinvent Database version 3. Calculated Average GWP 100a indicators (IPCC 2013) of all query sheets for each production technology

4.1.2. Air quality component

In order to evaluate the impact of each heat production technology on air quality, the endpoint (or damage level on human health) indicator of the ReCiPe LCA method for particulate matter emissions has been used, as particulate matter has one of the greatest impacts on human health amongst all pollutants. Particulate matter emissions are thus used as a proxy of air quality deterioration. The following table represents the impact of air quality expressed in point/MJ.

As for Climate component, the impact of air quality has been converted into an Air Quality component by placing each technology's impact on a -100% to +100% scale, +100% being the score of the technology with the lowest air pollution impact (natural gas cogeneration for industrial use and hybrid solar heating for space heating), and 0% corresponding to the world average heat air pollution impact. This average air pollution impact is calculated by weighting each technology's air pollution impact by its global share (the global share of fuels for heat production has been derived from the world energy balance tool of the IEA for 2014).

| Industrial heating technology | ReCiPe points x10 ⁶ / MJ | Air quality component |
|-------------------------------|-------------------------------------|-----------------------|
| Natural gas cogeneration | 61 | 100% |
| Natural gas boiler/furnace | 126 | 61% |
| Propane boiler/furnace | 130 | 59% |
| Fuel oil boiler/furnace | 282 | 18% |
| Biomass boiler/furnace | 331 | 9% |
| Coal boiler/furnace | 938 | -47% |

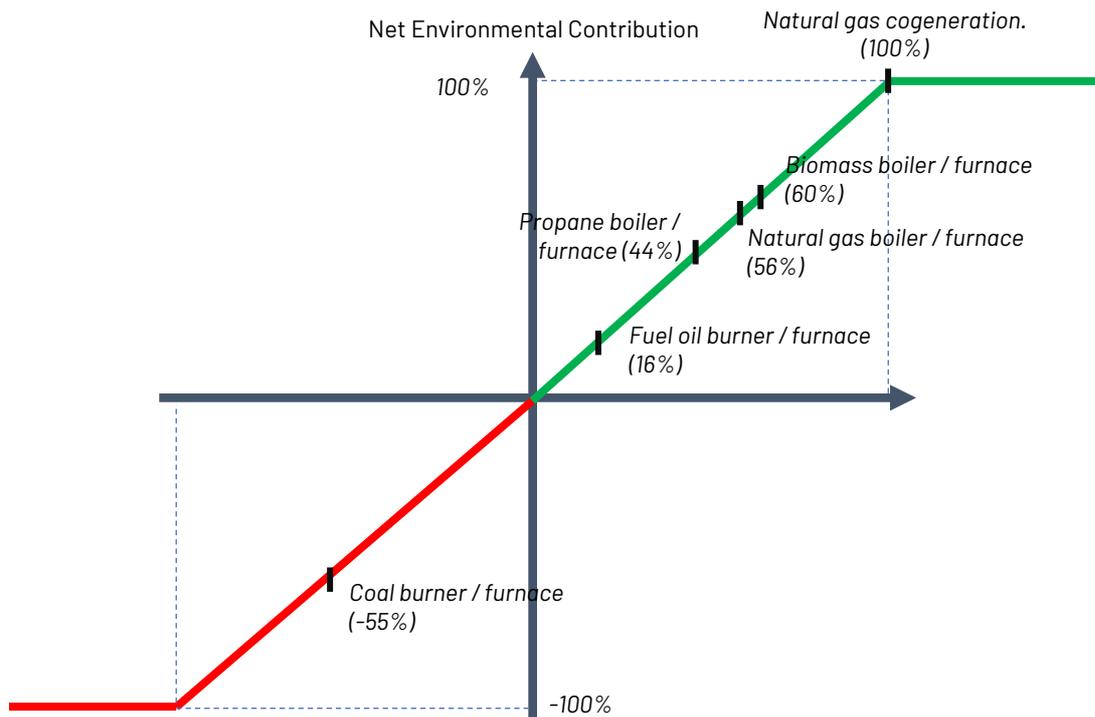
| Space heating technology | ReCiPe points x 10 ⁶ / MJ | Air quality component |
|--------------------------|--------------------------------------|-----------------------|
| Hybrid solar heating | 95 | 100% |
| Natural gas boiler | 121 | 76% |
| Fuel oil boiler | 167 | 44% |
| Biomass boiler | 379 | -37% |
| Heat pump | 474 | -59% |
| Coal boiler | 741 | -100% |
| Radiative heating | 2 196 | -100% |

Source: Ecoinvent Database version 3. IMPACT 2002+ (Endpoint), Total of Ecosystem Quality indicators, World average

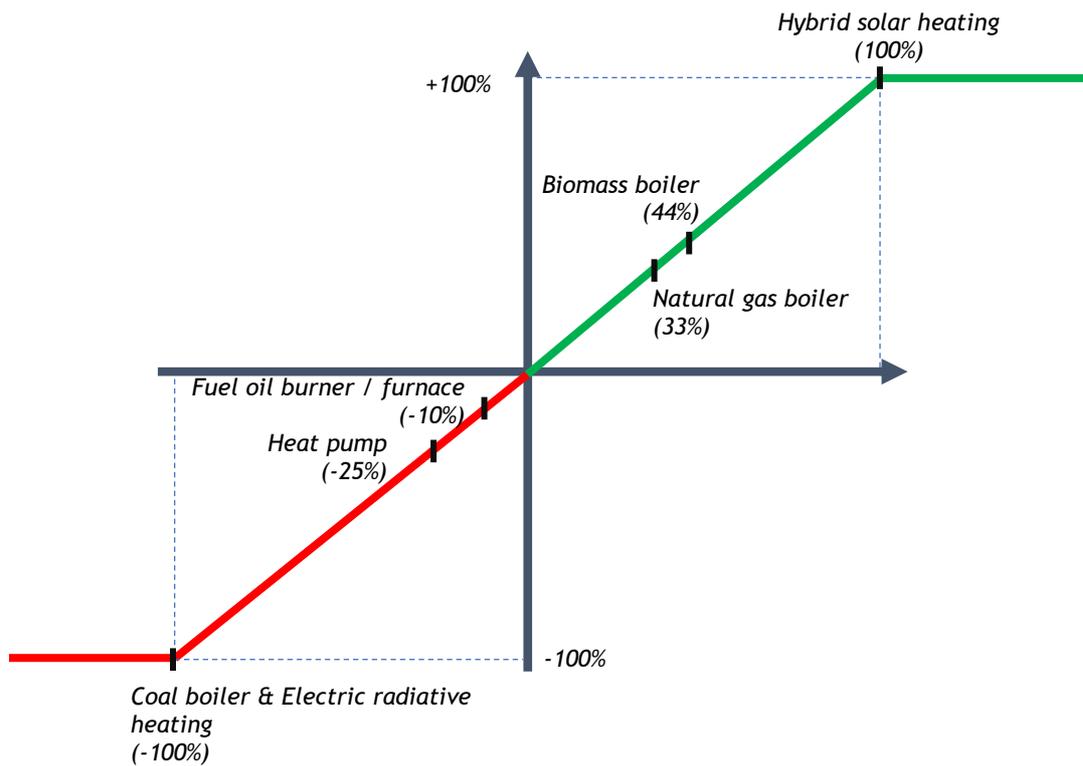
4.1.3. Average heat technology NEC

The average environmental performance for each heat technology is calculated by averaging the Climate component and the Air quality component. The resulting NEC derives from this aggregated environmental performance after setting the eco-solution point (+100% NEC) to the natural gas level for industrial use and to solar heating for space heating. This provides the two tables below.

| Weight | 50% | 50% | | |
|-------------------------------|-------------------|-----------------------|---------------------------|-------------|
| Industrial heating technology | Climate component | Air quality component | Environmental performance | NEC |
| Natural gas cogeneration | 82% | 100% | 91% | 100% |
| Biomass boiler/furnace | 100% | 9% | 54% | 60% |
| Natural gas boiler/furnace | 41% | 61% | 51% | 56% |
| Propane boiler/furnace | 21% | 59% | 40% | 44% |
| Fuel oil boiler/furnace | 12% | 18% | 15% | 16% |
| Coal boiler/furnace | -53% | -47% | -50% | -55% |

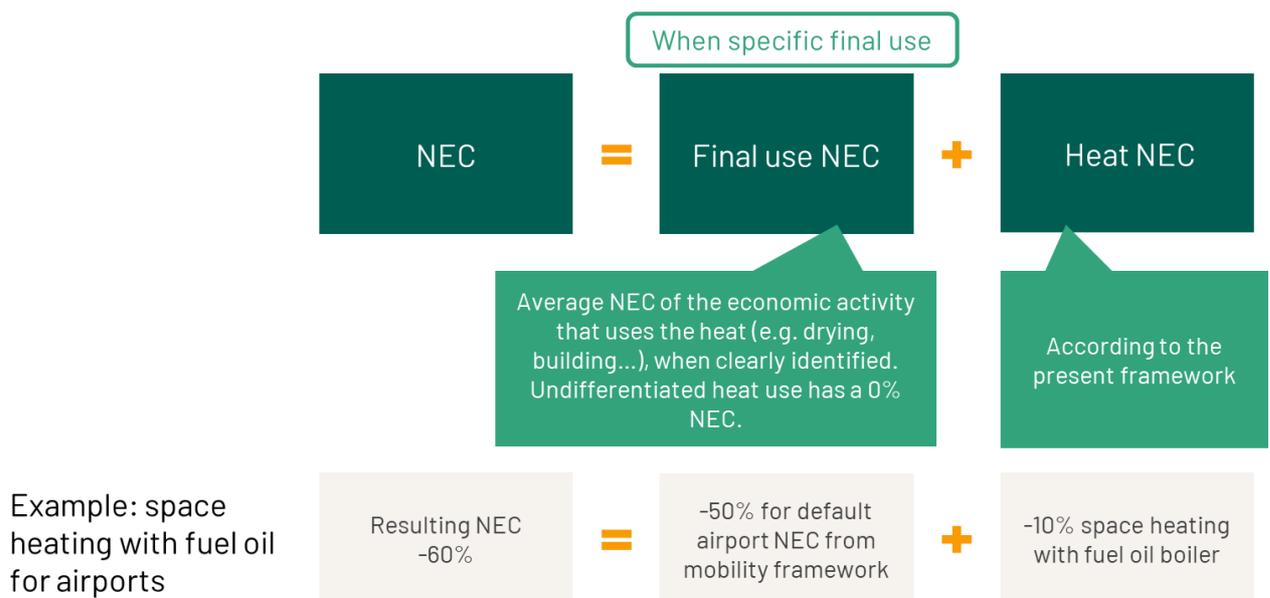


| Weight | 50% | 50% | | |
|----------------------------|-------------------|-----------------------|---------------------------|--------------|
| Space heating technology | Climate component | Air quality component | Environmental performance | NEC |
| Hybrid Solar heating | 41% | 100% | 71% | 100% |
| Biomass boiler | 100% | -37% | 31% | 44% |
| Natural gas boiler | -30% | 76% | 23% | 33% |
| Fuel oil boiler | -58% | 44% | -7% | -10% |
| Heat pump | 24% | -59% | -18% | -25% |
| Coal boiler | -290% | -104% | -197% | -100% |
| Electric radiative heating | -261% | -212% | -237% | -100% |



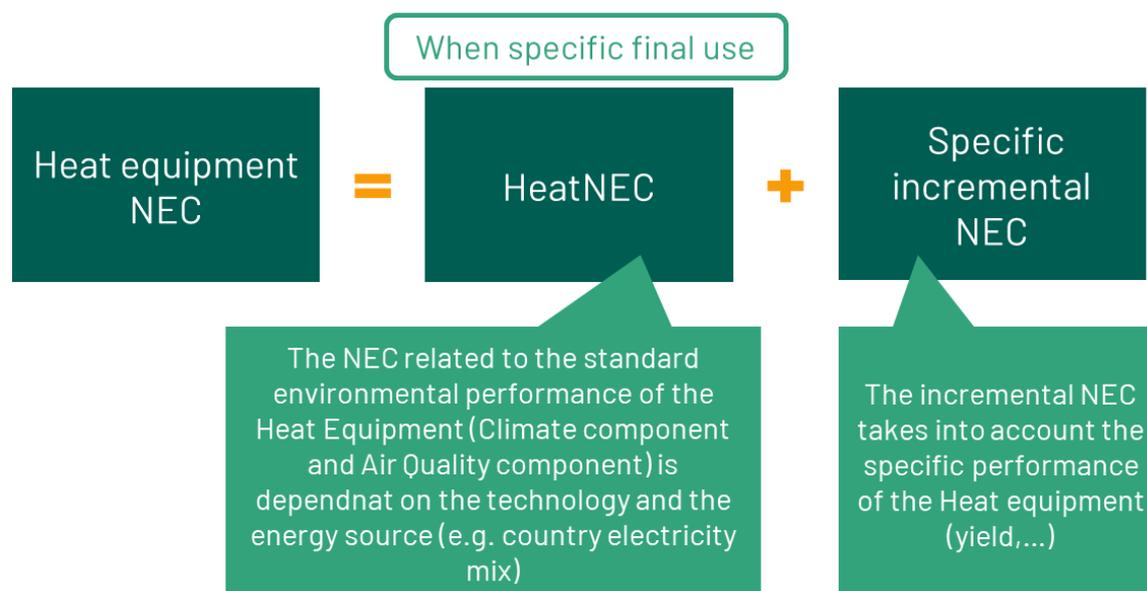
4.1.4. Specific final use NEC

In case of specific final use, a final use NEC can be added to the Heat NEC. In the example below, space heating for airports integrates a final use NEC of -50% as the default NEC of airport activity (Mobility framework).



4.2. Heat equipment

Following the generic equation, Heat Equipment NEC is the sum of the Heat NEC (with its two components) and of a Specific Incremental NEC.



An illustrative case of the calculation of Heat Equipment NEC is the case of heat pumps. A heat pump is a device that transfers thermal energy from external air or underground water bodies by pumping it into the living spaces. Given that heat pumps consume only electricity, their environmental impact is actually dependent on the environmental impact of this electricity. The average heat pump technology NEC of -25% calculated above takes into account the world electricity mix. This average NEC can be adapted to the different countries, using the electricity mix of each country. The following table shows that Heat Pump NEC can be either very positive or very negative, depending on the country electricity mix.

| Heat pump | Final NEC |
|-------------|-----------|
| Albania | 100% |
| Paraguay | 100% |
| Iceland | 100% |
| Norway | 100% |
| Switzerland | 100% |
| Sweden | 100% |
| France | 100% |
| Luxembourg | 100% |
| Peru | 100% |
| Canada | 100% |
| Austria | 100% |
| Uruguay | 100% |
| Brazil | 100% |
| Latvia | 100% |
| Belgium | 99% |
| Slovakia | 95% |
| Colombia | 94% |
| Lithuania | 93% |
| Venezuela | 93% |
| Finland | 82% |
| Moldova | 69% |
| Bahrain | 66% |
| Croatia | 59% |
| Hungary | 55% |
| Argentina | 50% |
| Russia | 45% |
| Slovenia | 38% |
| Spain | 38% |
| Denmark | 35% |
| Ecuador | 32% |

| Heat pump | Final NEC |
|--------------------|-----------|
| Romania | 31% |
| Italy | 29% |
| United Kingdom | 26% |
| Mexico | 19% |
| Ukraine | 17% |
| Portugal | 13% |
| Ireland | 4% |
| Turkey | 3% |
| Chile | -16% |
| Bulgaria | -17% |
| United States | -21% |
| Germany | -24% |
| Montenegro | -25% |
| Netherlands | -33% |
| Japan | -37% |
| Czech Republic | -37% |
| Malaysia | -47% |
| Greece | -47% |
| Macedonia | -56% |
| Dominican republic | -66% |
| Serbia | -80% |
| Australia | -84% |
| China | -87% |
| Estonia | -87% |
| Cuba | -90% |
| Cyprus | -98% |
| India | -98% |
| Malta | -100% |
| Poland | -100% |
| Kosovo | -100% |

| Heat pump | Final NEC |
|-----------------|-----------|
| South America | 90% |
| EU-28 | 28% |
| OECD Total | 6% |
| North America | -6% |
| Middle East | -10% |
| World average | -25% |
| Africa | -34% |
| Asia w/o China | -67% |
| Asia with China | -76% |

5. Main limits

The chosen key performance indicators reflect the two major environmental impacts of heat, i.e. on climate and air quality. When significant impacts are coming from the electricity source being used, it can be integrated by interfacing with the electricity framework, as illustrated for heat pumps. Both heat and electricity frameworks feed the fuel framework. As all three energy frameworks are interlinked, and as the current heat framework does not integrate the negative over-carbon-budget incremental NEC (or 2°C malus) that is part of the fuel framework, the question of integrating a 1.5°C or 2°C malus in all energy frameworks appears to be relevant for the next update.

Moreover, the 1.0 framework does not explicitly address urban heat networks, which can be considered as an industrial application to a centralized heating system. A more detailed analysis and NEC calibration of the most widely spread heating solutions could be included in the next update.

6. Key data sources

| Data | Sources |
|---|--|
| Global information on energy statistics | 2014 Data of world electricity production in 2014 from The Shift Project Data Portal: http://www.tsp-data-portal.org/ |
| Share of each production technology in the global heat energy mix | IEA world energy balance for 2014, presented in the form of Sankey diagram: https://www.iea.org/Sankey/ |
| Share of each production technology in the global electricity mix (used for heat pumps) | IEA world electricity and heat production in 2014: http://www.iea.org/statistics/statisticssearch/report/?country=WORLD&product=electricityandheat&year=2014 |
| GHG emissions factors electricity production technologies | Ecoinvent Database version 3. Average GWP 100a indicators (IPCC 2013) of all query sheets for each production technology |
| GHG emissions factors for heat production technologies | Ecoinvent Database version 3. Average GWP 100a indicators (IPCC 2013) of each production technology sheet |
| Air pollution | Ecoinvent Database version 3. ReCiPe (endpoint), Particulate matter formation indicator of each production technology sheet |



The holistic metric
guiding environmental
action

HOUSEHOLD & PERSONAL CARE FRAMEWORK

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1. Introduction

The environmental impacts of Household and Personal Care (HPC) industry are mainly due to the use of heated water, the release of chemicals into the environment during use and the sourcing of ingredients, such as palm oil, contributing to deforestation and biodiversity loss.

This industry encompasses a wide range of products with different functions. Cosmetic products can be split between rinse-off and non-rinse-off products, with different environmental impacts across product lifecycles. Household care products such as cleaning or laundry detergents have similar profiles to cosmetic rinse-off products, with impacts mainly concentrated in the release of chemicals to the environment as a consequence of the use phase.



This moderate-impact intensity NEC framework encompasses the whole household and personal care value chain of cosmetic and cleaning products, from raw material sourcing, chemical production and product manufacturing, to packaging and retail activity, all the way to the product’s end-use.

2. Main environmental issues

| Environmental stake | | Relevance along value chain | | | Comments | Data availability |
|---------------------|-----------------------------|-----------------------------|------------|------------------|--|---|
| | | Upstream | Production | Downstream (use) | | |
| Climate | Climate change | | | | Use of heated water for rinse-off cosmetics | Qualitative, included in certifications |
| | Use of energy resources | | | | Use of heated water for rinse-off cosmetics | Qualitative, included in certifications |
| Air Quality | Air quality deterioration | | | | Considered marginal (some impacts from transportation) | |
| Water | Water consumption | | | | Use of water for rinse-off cosmetics | Qualitative, included in certifications |
| | Water pollution | | | | Detergent products | Qualitative, included in certifications |
| Biodiversity | Soil pollution | | | | Considered marginal | |
| | Land use | | | | HPC industry accounts for 25% of global palm oil consumption | Good, through RSPO reporting |
| Resources & Waste | Use of non-energy resources | | | | Packaging materials | Qualitative, included in certifications |
| | Waste | | | | Packaging waste | Qualitative, included in certifications |

| Legend | |
|--------|------------------------------|
| | High impact intensity |
| | Significant impact intensity |
| | Limited impact intensity |

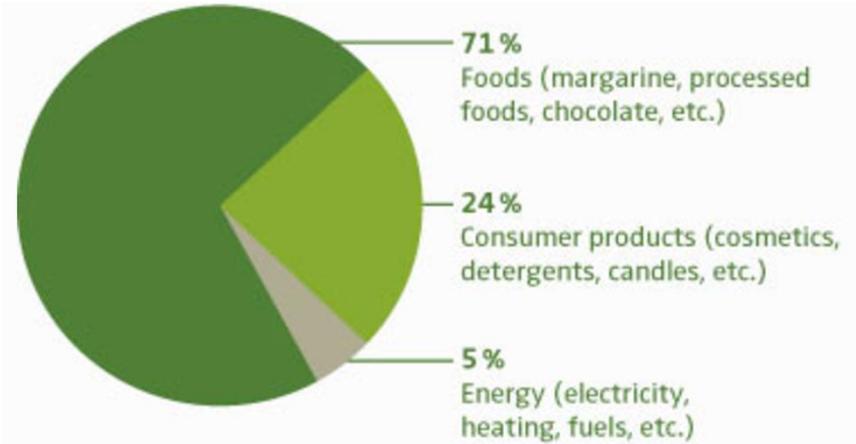
Rinse-off HPC products use important volumes of water to achieve the service these have been designed for. In European standards, this is quantified as the **critical dilution volume** for each product, which captures water use efficiency. For cosmetic products, water is usually heated, with the energy required to heat the water accounting for more than 80% of a product’s lifecycle climate change impact. However, apart from customers’ awareness raising policies, it appears very difficult to assess players over this

issue, as in most cases this information is unavailable and products and companies cannot be differentiated on this dimension. As a consequence, this dimension has not been incorporated within the 1.0 framework.

Moreover, a product’s negative impact on the environment can be measured through its **biodegradability**. Establishing a company hierarchy related to this issue requires an extremely detailed assessment of product composition and relative efficiency, which is not included in the scope of this assessment. This data is also highly competitive, and precise product formulas are not publicly reported.

Therefore, companies in this sector are assessed against transparent and comparable parameters. One key aspect in the HPC supply chain is the massive use of **palm oil**, for both cosmetics (e.g. creams, soap and shampoo) and household care products (e.g. laundry, cleaning products) - the consumer products

sector alone accounts for around 25% of global palm oil consumption. The global success of palm oil cultivation is a major source of deforestation, especially in Indonesia and Malaysia where growth is concentrated.



Worldwide palm oil consumption by use. Source: AGEB

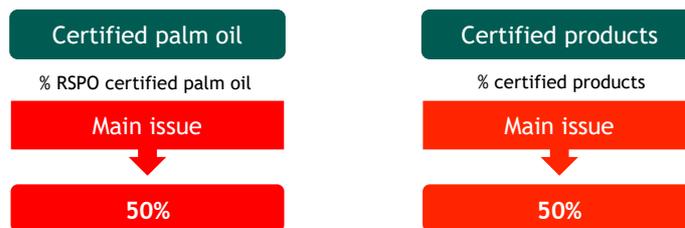
The WWF’s Roundtable on Sustainable Palm Oil (RSPO) aggregates corporate disclosures on palm oil use, thus serving as a useful source of information.

Regarding packaging and formula optimization, the best way to identify eco-friendly products is to analyze **external certifications**. Several certifications like the EU Ecolabel provide assurance about a product’s eco-design, using parameters such as packaging reduction, aquatic toxicity, product biodegradability and fitness for use. These certifications are the best way to normalize a company’s capacity to optimize the environmental footprint of their products.

3. Environmental performance indicators

To quantify the impact of each of the environmental issues, the two sets of performance indicators (KPI) have been selected:

| Components | Selected KPI |
|---------------------------------|---|
| Responsible sourcing - palm oil | Share of each responsibly-sourced palm oil (RSPO) certification level |
| Ecodesign - certified products | Share of certified products and level of certification |



Despite the non-negligible environmental issues associated with the HPC value chain, the environmental impact magnitude is much smaller than other high-impact value chains (oil & gas, power, food etc.). As a result, the HPC value chain has a considerably **moderate-impact intensity**, with NEC values calibrated (**divided by 3**) to reflect this. The HPC value chain NEC values therefore range from -33% to +33% unless their final use is specifically associated with one of the most impactful value chains.

The palm oil component is only scored from -33% to 0%, while certified product component is scored from 0% to 33%. Indeed, having palm oil-free products is not a sufficient condition to define a product as eco-friendly given that alternative oils may be even more environmentally impactful.

Consistent with the general methodological principles, if a product has a **final use** specifically dedicated to a given function or value chain (e.g. a cleaning product specific to cars), it will have the **same NEC value as that final use**, amended by the HPC-specific components.

4. NEC equation

The application of NEC principles to HPC companies relies on the following equation:



This equation has to be applied at **brand or company level**, and requires the collection of **Palm oil consumption data**, usually from company's RSPO reporting, and environmental **certification details** which can be found in company's reporting.

The calculation of each component, based on these input data, is detailed below.

4.1. Palm oil component

Widely used in the HPC industry due to its adaptability (texture, no smell etc.), palm oil cultivation correlates directly with deforestation. Its economic viability, concentrated mainly in Malaysia and Indonesia, makes it a major factor in land use change from tropical forests to palm oil cultivation, resulting in significant impacts on local ecosystems. Forest areas cleared for palm oil are also carbon sinks, whose destruction releases important amounts of CO₂.

In order to relevantly apply this parameter, the average proportion of palm oil integrated into a product formula is estimated at **70% for personal care products** and **50% for household care products**. Therefore, the parameter only applies to these proportions of relevant products.

The RSPO initiative certifies the use of “sustainable palm oil”. The initiative tracks production from sustainable palm oil plantations (that haven’t generated land use change) and allows companies to purchase sustainable palm oil, with different levels of assurance over the actual oil source.

The **book and claim** system is the lowest level of certification and consists of purchasing credits from sustainable palm oil plantations without linking palm oil actually used by the company to a particular plantation, thus providing only limited assurance that the oil was cropped sustainably. The **mass balance** system mixes sustainable and non-sustainable palm oil, with an assurance that at least 50% is sustainable. The **segregated** level of certification ensures that all palm oil has been cropped responsibly, but cannot be tracked to a particular plantation. Finally, the **identity preserved** certification allows a purchaser to track sustainable palm oil to its original plantation, thus providing the highest level of sustainability assurance. These levels are scored in the following table.

| RSPO certification | Underlying policy | Risk of associated deforestation | NEC component |
|--------------------|--|----------------------------------|---------------|
| No certification | None | Very high | -33% |
| Book and claim | No traceability for palm oil, "compensation" scheme | Very high | -25% |
| Mass balance | Minimum of 50% sustainable palm oil | High | -17% |
| Segregated | Sustainable palm oil is separated but not linked to particular plant | Moderate | -8% |
| Identity preserved | Sustainable palm oil is separated and can be tracked back to plant | No direct deforestation | 0% |

Data availability and practical tips to calculate indicator

RSPO membership includes an annual update on sustainable palm oil use that is also publicly available on rspo.org under the “membership/annual communications on progress” section.

The relevant information is found in questions 2.2.5 (total volume of all palm oil products you sold in the year) and 2.3 (palm oil volume per certification type)

Example:

2.3 Palm oil volume sold in the year in your own brands that is sourced through RSPO-certified physical supply chains: In Your Own Brand

| No | Description | Refined palm oil/Refined, bleached, and deodorized (RBD) oil palm (Tonnes) | Palm Kernel Oil (Tonnes) | Palm based derivatives or fractions (Tonnes) | Volume of Palm Kernel Expeller used / processed and/or traded in the year (Tonnes) |
|----|--|--|--------------------------|--|--|
| 1 | Book & Claim | | | | |
| 2 | Mass Balance | | | 34,000.00 | |
| 3 | Segregated | | | | |
| 4 | Identity Preserved | | | | |
| 5 | Total volume of oil palm products that is RSPO-certified | | | 34,000.00 | |

Henkel 2015 communication on progress, RSPO website

A company’s sustainable palm oil score is determined on this basis. To date, the RSPO is the only widely accepted label to certify sustainable palm oil.

Of note, question 2.4.1 of the RSPO reporting identifies which product lines include palm oil.

4.2. Certification component

A significant number of external certifications exist to assure stakeholders (especially consumers) that HPC products reflect specific environmental norms. Since qualitative information from companies is difficult to assess in a systematic way, this is the best signal companies can provide about product sustainability.

Existing labels vary widely in scope (whether they integrate the entire product lifecycle or not) and level of performance required. An analysis of the EU Ecolabel parameters provides a good overview of key environmental impacts considered in a product’s lifecycle assessment.

| Label criteria coverage | Criteria robustness | NEC Component |
|----------------------------|--|---------------|
| Partial (formula only) | LESS STRICT: equal or below 70% of organic ingredients or other less demanding criteria | +8% |
| Partial (formula only) | STRICT: at least 95% of natural ingredients are organic | +17% |
| Full (packaging + formula) | LESS STRICT: less than 95% of natural ingredients are organic, which constitutes less than 10% of the total formula or other less demanding criteria | +25% |
| Full (packaging + formula) | STRICT: at least 95% of natural ingredients are organic, which constitutes at least 10% of the total formula | +33% |

The label's NEC component is entered directly into the Excel tool based on the user's review of each label criteria.

| Data availability and practical tips to calculate indicator |
|--|
| <p>Data on certified products is usually well-advertised by companies. The challenge is identifying what share of a company's products is actually certified. When certification applies to a single product or a given range of products in a diversified company, certification is considered residual and the indicator is scored at 0%.</p> <p>If the certification applies to a significant number of products for the company, the user should approximate the share of revenues from certified products, potentially by number of references. If there is no information on certified products, then this indicator is considered not relevant (not scored 0%).</p> |

4.3. Default values

As Household and personal care companies may have limited disclosure on their products' sustainability (including no RSPO reporting and no information on products' certifications), a default NEC value can be defined for each of the two subsectors.

It is based on the average proportion of products including palm oil in their formulation, and the assumption that palm oil accounts for half of the ingredients:

- **Personal care products:** with 70% of uncertified palm-based products, the by-default raw NEC is -35%, which results in a -12% NEC once sector calibration ($\frac{1}{3}$) has been applied.

$$\frac{70\% \times 50\% \text{ content} \times -100\% \text{ NEC (not certified PO)}}{3 \text{ (moderate impact)}} = -12\%$$

- **Household care products:** with 50% of uncertified palm-based products, the by-default raw NEC is -25%, which results in a -8% NEC once sector calibration ($\frac{1}{3}$) has been applied.

$$\frac{50\% \times 50\% \text{ content} \times -100\% \text{ NEC (not certified PO)}}{3 \text{ (moderate impact)}} = -8\%$$

5. Main limits

The key advantage of this approach is that it reflects a major environmental impact of the HPC supply chain (palm oil cultivation and associated potential for deforestation) and accounts for quantifiable efforts by companies to incorporate lifecycle thinking into the product design process.

However, a lack of company-level data on product packaging and formulas makes it difficult to identify over/underperforming companies. A company's qualitative description of its eco-design activities provides a hint as to their level of advancement (target setting, new chemicals development etc.), but does not allow a quantitative assessment in line with the approach adopted for other sectors.

Our methodology would benefit from increased transparency on product-level environmental performance in order to sort companies based on the aquatic toxicity or biodegradability impacts of their products.

6. Key data sources

| Data | Sources |
|---|---|
| Palm oil used by companies | Roundtable on Sustainable Palm Oil (RSPO): https://www.rspo.org/members/acop |
| Average proportion of palm oil products | Personal care: http://eur.rspo.org/chris-sayner-croda/ Household care: http://saynotopalmoil.com/Whats_the_issue.php |
| Ecolabel criteria per category | http://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html |

INFORMATION TECHNOLOGY FRAMEWORK

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1. Introduction

Information Technology (IT) related activities have significantly spread into the economy over the last decades, boosted by the fast expansion of internet and digital services, and the mass production of computers, communication devices and data centers. In 2014, digital services were already using 10% of global electricity production, and this share keeps increasing year after year. Inevitably, the IT sector is a huge contributor to greenhouse gases emissions, representing already more than air transport. IT share in global GHG emissions is growing fast and could reach 10% by 2030, mainly due to the growing volume of data. Carbon intensity (in tCO₂e/€m) of the sector’s revenue is growing at 4% per year, which is huge compared to other economic sectors.

The IT industry is also using growing amounts of metals, rare earths, plastics and minerals. According to a 2018 dedicated study of the French Environmental Agency, ADEME, a 2-kg computer requires 800 kg of raw materials and emits on its whole life-cycle 169 kg CO₂e, where 124 kg CO₂e or 73% are coming from sourcing and manufacturing phases.

| | Products / Services | Examples of companies |
|--|---|------------------------------------|
| Hardware, devices and other electronic equipment | Manufacturing and retail of computers, smartphones, electronic instruments, data center equipment, semiconductors, repair services... | Samsung, Apple, Soitec |
| Data center activities | Data center design and build, data center management, cloud services | Equinix, 2CRSI |
| Software and IT services | Application software, home entertainment software, online services, data processing, IT consulting... | Google, Amadeus, Microsoft, Criteo |



The various types of activities across the IT industry have been categorized as follows:

Figure 1: Scope of IT framework, NEC 1.0.

IT devices, data centers and infrastructures are highly energy and resource intensive. As many tools and devices, they can be a significant to high threat to environmental sustainability as well as key enablers of the green transition solutions, such as energy efficiency, decentralized renewable energy generation, smart grid or intermodal transportation.

The IT framework includes semiconductors, hardwares, electronic components, communication devices, software as well as IT services along the whole value chain, from component manufacturers to technology retailers and service providers.

2. Main environmental issues

| Environmental stake | | Relevance along value chain | | | Comments | Data availability |
|---------------------|-----------------------------|------------------------------|---------------------------------|------------------------------|---|---|
| | | Manufacturing | Use and end-of-life of hardware | Final use of software | | |
| Climate | Climate change | Significant impact intensity | High impact intensity | Significant impact intensity | GHG emissions mainly occur during the use of hardware because of the electricity required, but the climate impact of device / hardware manufacturing is also significant. Impact related to the final use of the software might be also important (negative or positive) but very dependent of the final use of software/service (optimization of energy systems, avoided transport emissions or pure advertising). | Not directly available for use of hardware, % final use for use of software |
| | Use of energy resources | Significant impact intensity | High impact intensity | Significant impact intensity | Mainly intensive electricity consumption during the use of the hardware | PUE for datacenters and % of renewable in electricity supply |
| Air Quality | Air quality deterioration | Limited impact intensity | Limited impact intensity | Significant impact intensity | Potential impact dependent of the final use of the software/service | % final use for use of software |
| Water | Water consumption | Significant impact intensity | Significant impact intensity | Significant impact intensity | Water consumption during hardware manufacturing (and associated material extraction) as well as during data center management (for cooling) | Not directly available |
| | Water pollution | Significant impact intensity | Significant impact intensity | Limited impact intensity | Potential water pollution during hardware manufacturing (and associated material extraction) | Not directly available |
| Biodiversity | Soil pollution | Significant impact intensity | Limited impact intensity | Limited impact intensity | Potential soil pollution during hardware manufacturing (and associated material extraction) | Not directly available |
| | Land use | Significant impact intensity | Limited impact intensity | Limited impact intensity | Potential significant land use during hardware manufacturing (and associated material extraction) | Not directly available |
| Resources & Waste | Use of non-energy resources | High impact intensity | Limited impact intensity | Limited impact intensity | High material intensity of hardware, related to specific metals for electronic devices (strategic metals, rare earths...). Limited reuse so far of recycled components or materials. | Material score embedded on global device environmental score % of reused components |
| | Waste | High impact intensity | High impact intensity | Limited impact intensity | High replacement rate of product and difficulty to treat electronic waste | tons of products collected per year |

Legend

- High impact intensity
- Significant impact intensity
- Limited impact intensity

The two main environmental stakes that appears to be both key and measurable at company or activity level are related to the energy and resource intensity of IT: Climate and Resources & Waste issues.

- **Climate:** as previously mentioned, the electricity consumption of the IT sector is strongly growing, driven by the more complex functions of IT software and services which imply a growing volume of data. This growing GHG footprint is not likely offset by the final use impact related to smart IT services reducing the GHG emissions of their sector of application (transport, building, ...) although there are some benefits to be analysed;
- **Resources and waste:** the increasingly complex and powerful electronic hardware (computers, devices...) require significant mineral resources (with the associated environmental impacts) and generate electronic waste which is complex to recycle. Efforts for more circular economy (collection of reuse of hardware/devices) is therefore a strong lever of environmental contribution to analyse at company level.

3. Environmental performance indicators

Consistently with the generic NEC methodology, IT activities are rated as follows:



Final use drives the NEC of IT products and services. Indeed, all sectors require technological solutions, either specific to the business or generic. When a specific final use is identified, for instance a software for air traffic management, the default NEC of the final use is applied. In case of undifferentiated use, final use NEC is 0%.

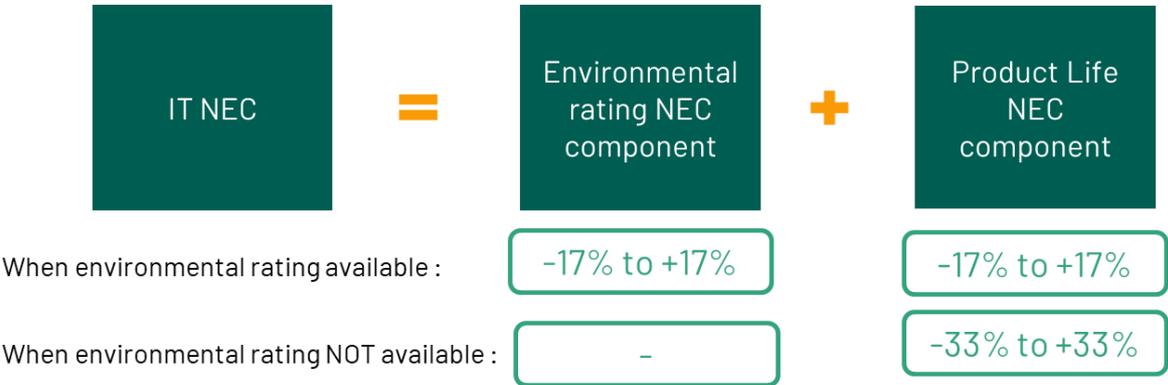
Moreover, IT products and services can contribute to reduce or increase environmental impacts of the final use: this corresponds to the final use incremental NEC. For example, this incremental NEC is applied when an IT service increases energy efficiency or improve passenger cars' load factor by car sharing services. In both case, NEC values have to be found in the other frameworks.

The IT NEC component captures the environmental impacts specific to the IT value chain. Their intensity is very significant but smaller than high-impact value chains such as oil & gas, power generation, transport or food. As a result, the IT framework and its IT NEC components belong to the moderate-impact intensity category and their NEC values are ranging from -33% to +33%.

3.1. Hardware, devices, and other electronic equipment

This section encompasses the manufacturing and retail of computers, smartphones, electronic instruments, data center equipment, semiconductors and other electronic compounds. Repair, resale or rental of IT products are also included.

Two equally weighted components make up the NEC calculation, but in case of unavailability of environmental rating, Product life NEC component is double counted as a proxy for Environmental rating NEC component.



3.1.1. Third-party rating NEC component

Product-based environmental ratings assess and aggregate impacts. When they are provided by robust third-parties, they can be converted into NEC. Among existing ratings, the FNAC environmental rating is used as an illustrative example of integration of a third-party rating.

The FNAC environmental rating covers 4 types of IT products: tablets, smartphones, TV and notebooks. It is based on a life cycle analysis (LCA) for all equipment (data originated from suppliers or disassembled equipment analysis) which takes into account 5 stages of the life cycle: raw materials, manufacturing, transport, use phase and end of life. It generates 2 sub-indicators:

- Impact on climate change, measured in greenhouse gases released in the atmosphere (kg CO₂ e)
- Impact on abiotic resource depletion, i.e. the constraints applied to non-renewable natural resources such as metals and rare earths, measured in kg of Antimony, Sb, equivalent (kg Sb eq)

Eventually, the global environmental performance of a product is rated on a scale from A to E (A being the best) and is transposed into a NEC value:

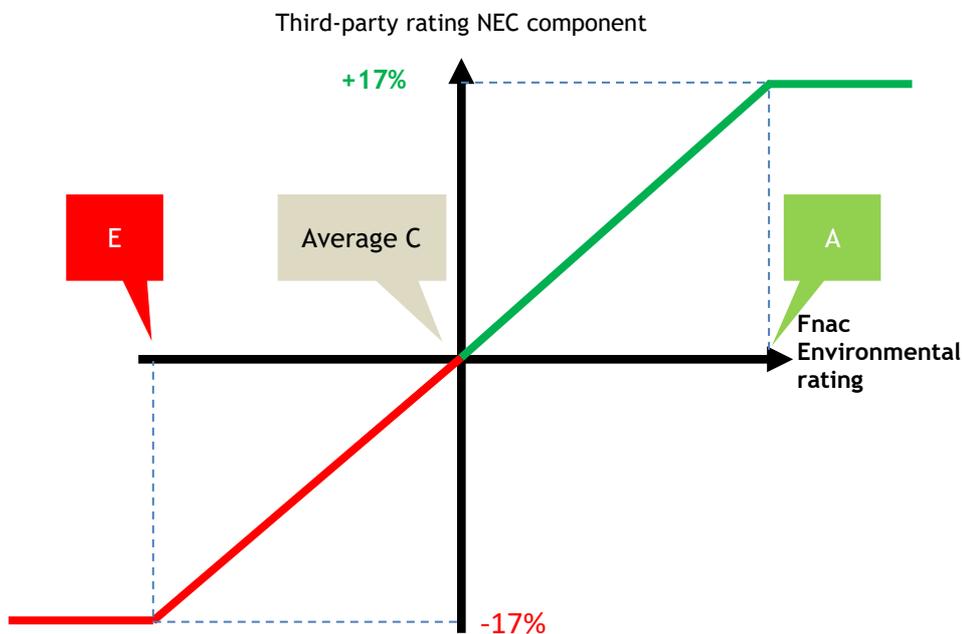
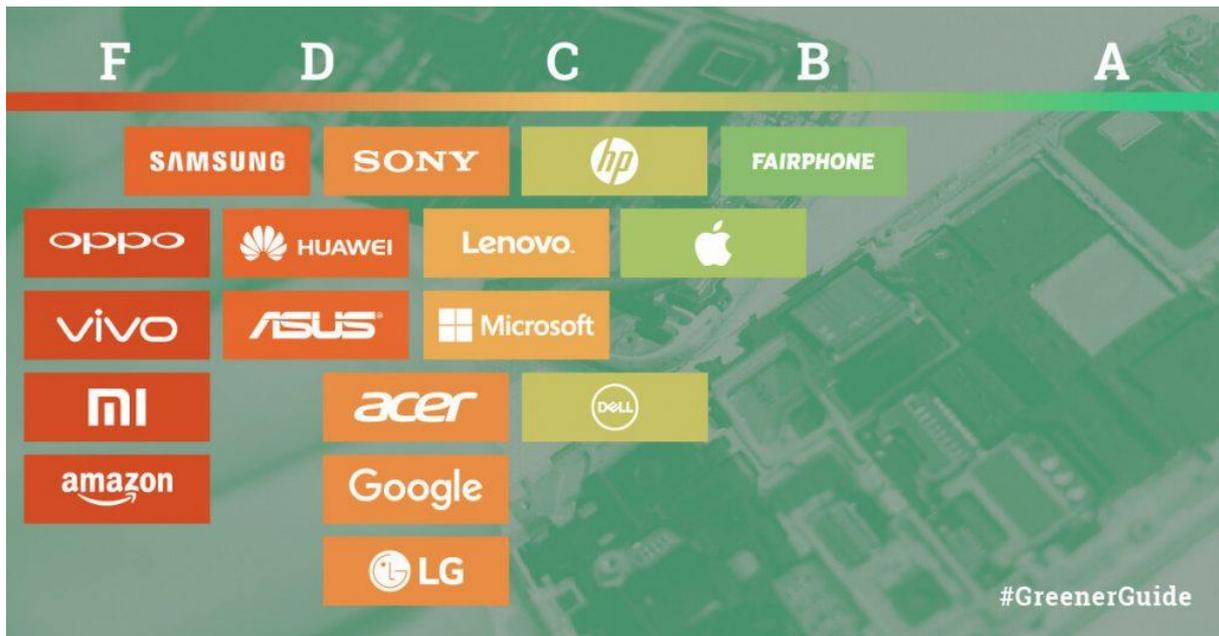


Figure 2: Third-party rating NEC component applied to the FNAC environmental rating, NEC 1.0.

Other environmental ratings and comparative studies, can be used, providing that their assessment methodology is robust and independent, such as Greenflex's EcoGuide IT or Greenpeace's Guide to Greener Electronics, illustrated below:



Data availability and practical tips

Find the most representative products in terms of sales of each main segment of the company (flagship product). The breakdown of the turnover per segment can usually be found in the annual report of the company.

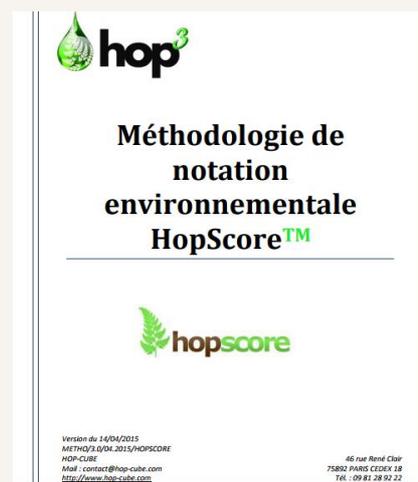
Once the flagship products are selected, look for their FNAC environmental rating in the fnac.com website. The "NOTE ENVIRONNEMENTALE" can be found among the detailed characteristics of the product.

Examples:

- Apple iPhone 8, 64 Go, 4.7":



- Apple iPhone 7+, 32Go, 5.5":



NOTE ENVIRONNEMENTALE



- Apple MacBook Air 13.3" LED 128 Go SSD 8 Go RAM Intel Core i5:

NOTE ENVIRONNEMENTALE



Fnac.com

3.1.2. Product life NEC component

This component focuses on products' lifespan and end-of-life management. It captures environmental impacts of products on resource depletion's pace and waste generation.

It relies on a qualitative assessment of companies' business practices and products characteristics. For instance, planned obsolescence or low reparability are given a NEC malus for reducing products' lifespan. On the contrary end-of-cycle management practices, high product's reliability, or leasing models are given a positive NEC.

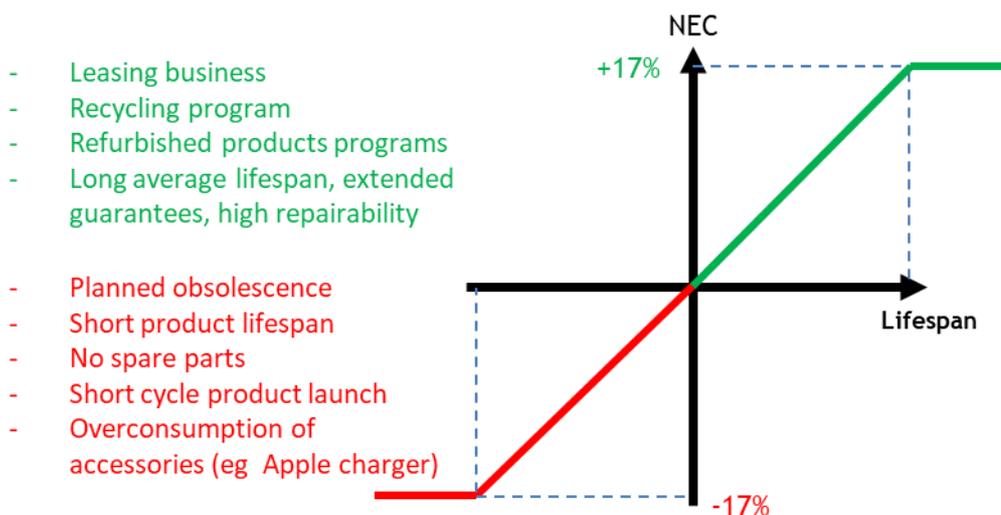


Figure 3: Product life NEC component, NEC 1.0.

Hardware IT products have different lifespan depending on the segment to which they belong. Consequently, each product has to be compared with the average lifespan of its segment.

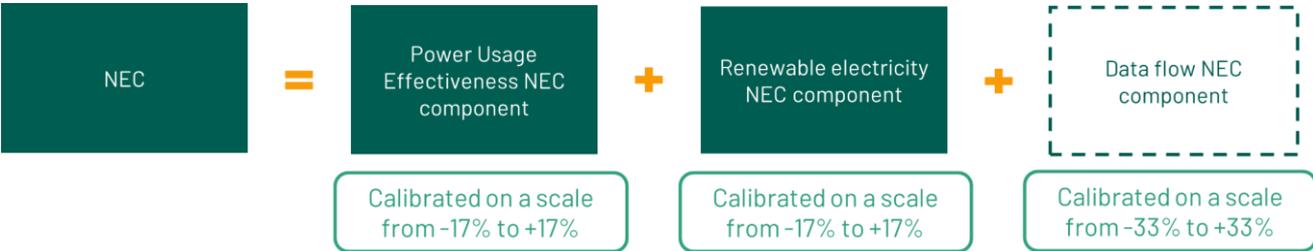
Figure 4: comparison of average products lifetime of Samsung, Apple and Blackberry, NEC 1.0.



3.2. Data center activities

Energy use is a key issue for data centers, in operation 24/7 and requiring constant temperature control. Two main components for data center activities NEC calculation, equally weighted, tackle the sourcing of energy, whether it is renewable or not, and its efficient or inefficient use.

Data center impacts can also be worsened by generation of digital pollution, or may enable data flow reduction. This dimension is captured, when possible, by the data flow NEC component. The resulting IT NEC equation is:



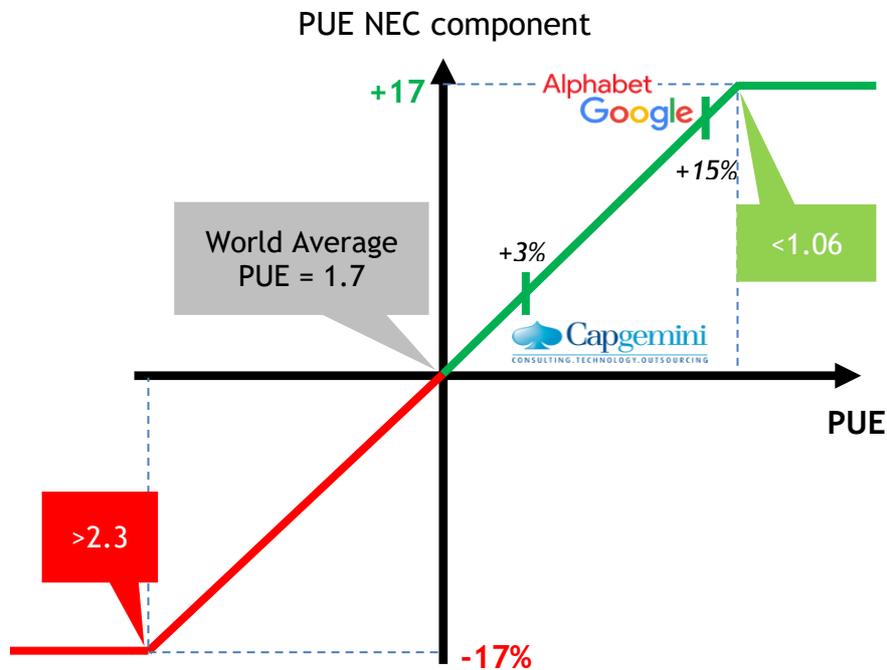
3.2.1. Power Usage Effectiveness NEC component

The **Power Usage Effectiveness** (PUE) is the main indicator of energy efficiency in data centers:

$$PUE = \frac{\text{Total energy consumed by the data center}}{\text{Energy consumed by the computer systems}}$$

The closer to 1, the better the PUE. PUE of 1 is achieved when the entire energy consumption of the data center is dedicated to run the computer systems. However, other electrical equipment is required such as air conditioning systems for servers. The best performance in terms of PUE is around 1.06, while average PUE is currently around 1.7.

Figure 5: Power Usage Effectiveness NEC component, NEC 1.0.



Data availability and practical tips

Usually the PUE is a widely available data for Software IT companies, this information can be found either in the company's CSR report or on the operator's website. Example:

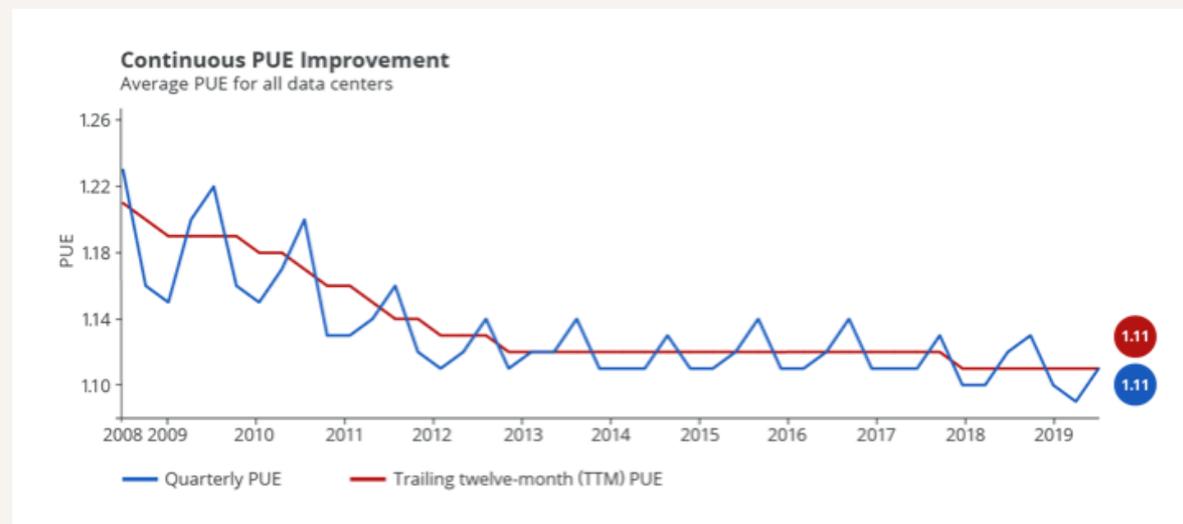


Figure 6: Google's data centers PUE from 2018 to 2019, <https://www.google.com/about/datacenters/efficiency/internal/>

When the data is not directly available, additional research on the internet may be required, the company may have presented their PUE in an IT conferences, a press conference, etc.

If a company only discloses its PUE on a limited scope, then its PUE should be recalculated by taking into account the representativeness of the disclosed scope and by using prudent hypothesis on the remaining scope.

3.2.2. Renewable electricity NEC component

To evaluate the climate/energy performance of a data center, it is also possible to analyze the share of renewable electricity consumed.

$$\% \text{ renewable electricity} = \frac{\text{Consumed electricity from renewable sources}}{\text{Total of electricity consumed}}$$

A company or activity which consumes mostly renewable electricity will have a much lower contribution to global warming.

The NEC assessment relies on the robustness of the renewable power supply. For physical direct renewable electricity supply, e.g. solar panels on a data center, which corresponds to the maximum robustness, the NEC component is directly related to the share of renewable electricity as presented on the graph below.

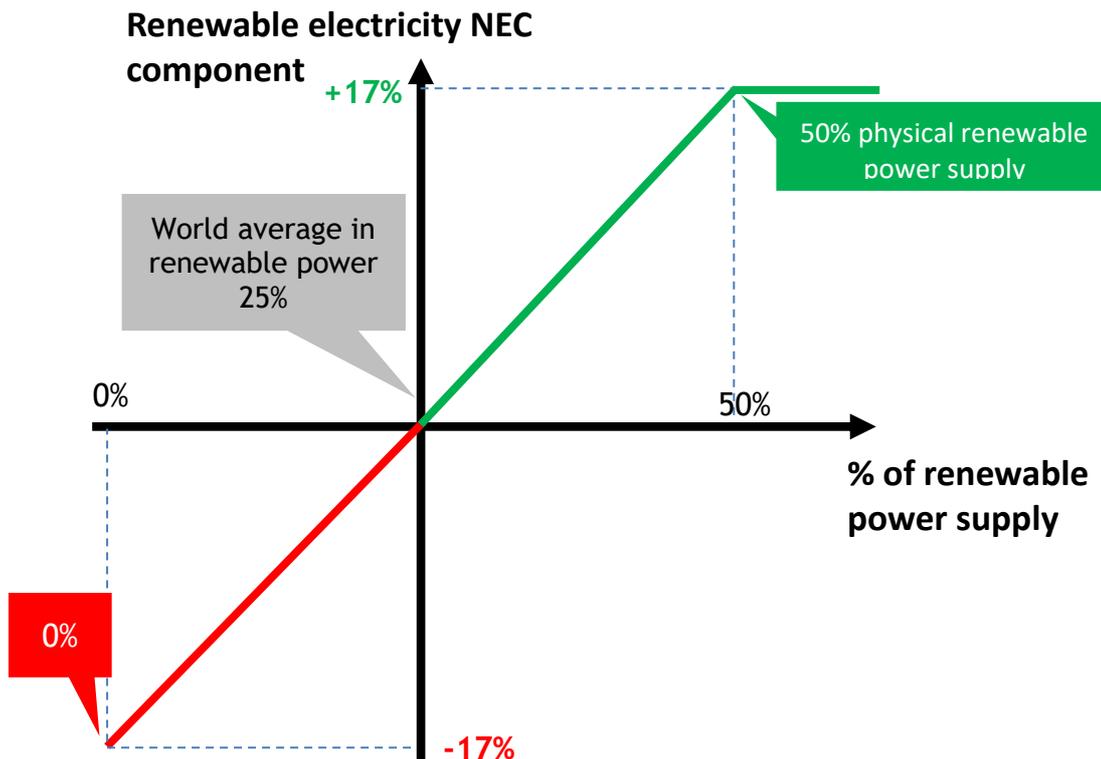


Figure 7: Renewable electricity NEC component, NEC 1.0.

However, in practice, green certificates, and to a larger extent virtual power purchasing agreement or compensation schemes certificates, have lower proven environmental benefits than direct physical renewable power supply. Therefore, in these cases, the qualification of renewable power supply implies to make some downward adjustments of the NEC rating.

The average (NEC = 0%) corresponds to the renewable share of the world electricity mix. Indeed, most of the time, the source of the electricity consumed corresponds to the local electricity mix.

Data availability and practical tips

The percentage of renewable electricity can be easily found in CSR reports or companies' website. Sometimes, the percentage is not directly available but it is possible to deduce it from the quantity of renewable electricity and the total electricity consumed.

Example:

| Energy consumption 2015 | |
|-------------------------|----------|
| Electricity | 7.4m MWh |
| Fossil Fuels | 0.5m MWh |
| Fuels vehicle fleet | 0.7m MWh |
| District heating | 0.2m MWh |

| in MWh | 2015 |
|--------------------------|-----------|
| Renewable energy (total) | 2 402 780 |

Figure 8: energy consumption of the Deutsche Telekom, CSR report 2015

If the percentage of renewable electricity is not available, an approximation can be made by using the electricity mix of the countries where the company operates.

3.2.3. Company specific guidelines

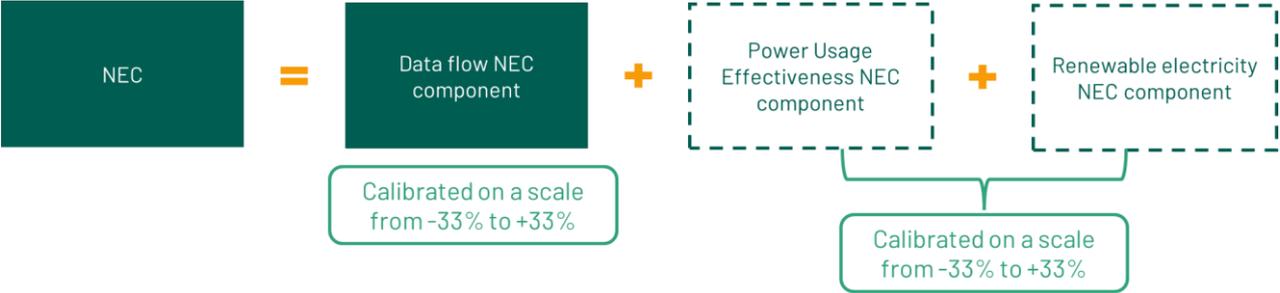
Depending on the type of activities, the importance of data center in the business model varies. Consequently, data center activities NEC has to be applied proportionally to the data center exposure of the company.

| Type of company | Examples | Data center exposure |
|---|-----------------------------|----------------------|
| Pure data center player | Equinix | 100% |
| Data center player | Amazon, Microsoft | 85% |
| More diversified player | Google | 70% |
| Mixed business model | Atos, IBM, DXC | 50% |
| IT consultancy and services with small dependency to data centers | Capgemini, Sopra, Accenture | 15% |

3.3. Software and IT services

Main impacts of software and IT services happen during use phase. The Data flow NEC component covers those impacts.

If software and IT services rely on identified data centers, and if enough information is available, these components adjust the IT NEC. Otherwise, they are set at 0% NEC. See Data center activities NEC calculations and specific company guidelines.



3.3.1. Data flow NEC component

Software may be a strong asset to reduce environmental impacts and manage energy. On the other hand, the exponential increase of data traffic and data storage has a growing negative impact on the environment. Depending on the business model of a company, its activities may generate a large amount of data. As this data has to be transferred and stored in servers, the more digital information is created, exchanged and stored, the more energy and servers has to be used to follow the growth.

This NEC component is based on a qualitative assessment of the contribution to data flow increase or optimization.

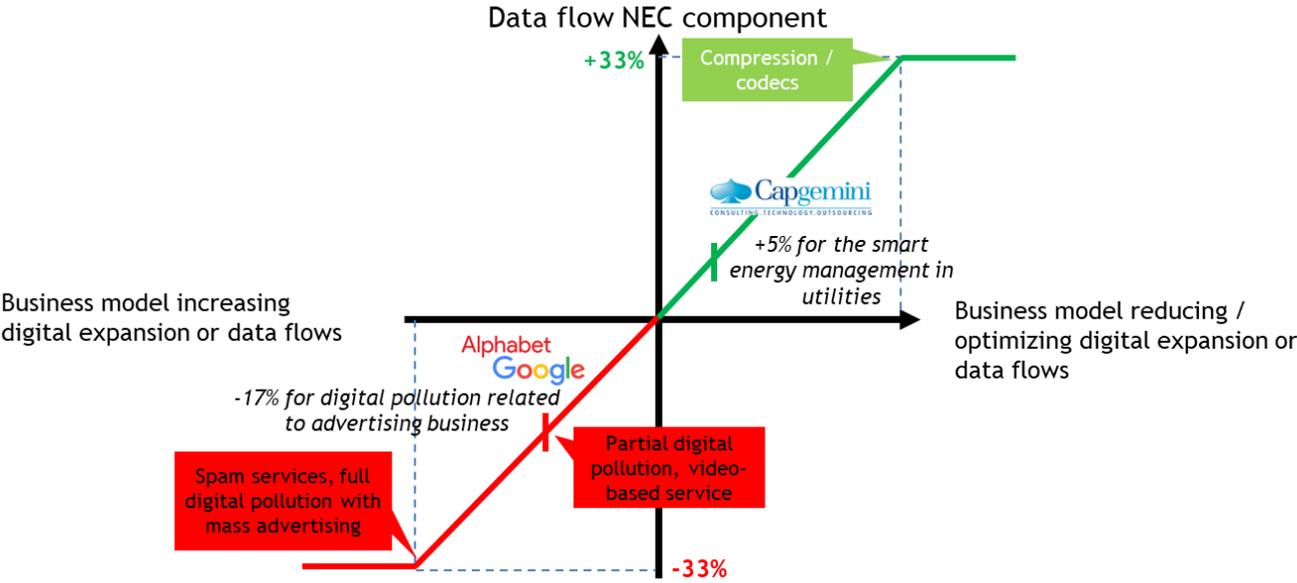


Figure 9: Data flow NEC component, NEC 1.0.

4. Main limits

The first limit is the quantification of the IT value chain's impacts. This framework has been classified as a moderate-impact intensity framework, which could be later reconsidered due to the growing energy and resource consumption of the sector, and the fast increase of electronic waste.

The second limit is the lack of quantified data, and the need to rely on qualitative assessment. For data center activities, both NEC component are based on usually reliable and easily available data. However, the evaluation of the Data flow NEC component is uneasy and may be subjective. It is difficult to capture whether an IT solution really contributes to the environmental transition or only creates additional data without fulfilling an essential function. Regarding the Product life NEC component, data about devices' lifespan is generally lacking and transparency on business practices is low. The coverage of third-party ratings, feeding the related NEC component, is very limited too. For example, the FNAC rating covers only 4 types of IT products (tablets, smartphones, TV and notebooks) and many IT devices such as printers, servers or storage equipment, are not or poorly rated.

The framework usability is thus limited by these lacks of measurable information.

5. Key data sources

| Data | Sources |
|---|--|
| IT environmental impact | In French : « Guide pratique, la face cachée du numérique », ADEME, November 2018, https://www.ademe.fr/sites/default/files/assets/documents/guide-pratique-face-cachee-numerique.pdf |
| PUE | Best PUE: https://www.supermicro.com/newsroom/pressreleases/2017/press170206_MicroBlade_Key_Win.cfm Average PUE: http://www.datacenterknowledge.com/archives/2014/06/02/survey-industry-average-data-center-pue-stays-nearly-flat-four-years/ |
| % renewable energy | Key world energy statistics, IEA, 2016. The Shift Project data portal: http://www.tsp-data-portal.org/Breakdown-of-Electricity-Generation-by-Energy-Source#tsp0vAbout |
| Business Model increasing / reducing digital expansion or pollution | http://www.novethic.fr/empreinte-terre/pollution/isr-rse/pollution-numerique-l-impact-sur-l-environnement-n-est-pas-virtuel-143921.html http://www.cigref.fr/wp/wp-content/uploads/2016/04/Benchmark-GreenIT-CIGREF-synthese-2016.pdf |
| Environmental rating | FNAC environmental rating methodology: http://apiae.hopscore.com/static/docs/Methodologie-HopScore.pdf EcoGuide IT, by Greenflex: http://www.ecoguide-it.com/en/ Greenpeace guide to greener electronics, 2017: https://www.greenpeace.org/usa/reports/greener-electronics-2017/ |

| Data | Sources |
|-----------------|--|
| Device lifespan | <p>Estimated Life Expectancy of Tech Product Categories:</p> <p>http://smartphones.specout.com/stories/9635/average-lifespan-tech-products</p> <p>https://www.statista.com/statistics/619788/average-smartphone-life/</p> <p>https://www.statista.com/statistics/267473/average-tablet-life/</p> <p>http://www.consoglobe.com/obsolescence-programmee-appareils-cg</p> <p>Product replacement rate (smartphones):</p> <p>https://www.kantarworldpanel.com/global/News/Apples-Replacement-Opportunity-is-Far-From-Over</p> |



The holistic metric
guiding environmental
action

MOBILITY & TRANSPORT FRAMEWORK

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1. Introduction

The mobility & transport framework covers the entire value chain of both passenger transport and freight across all modes: by sea, road, rail and air. It includes auto parts and vehicle manufacturers, transport infrastructure, and operators of transport services (e.g. leasers, transporters, logisticians).

The mobility & transport sector accounts for a growing share of total energy consumption (29% in 2016 compared to 23% in 1971) and represents 65% of oil product consumption in 2016.

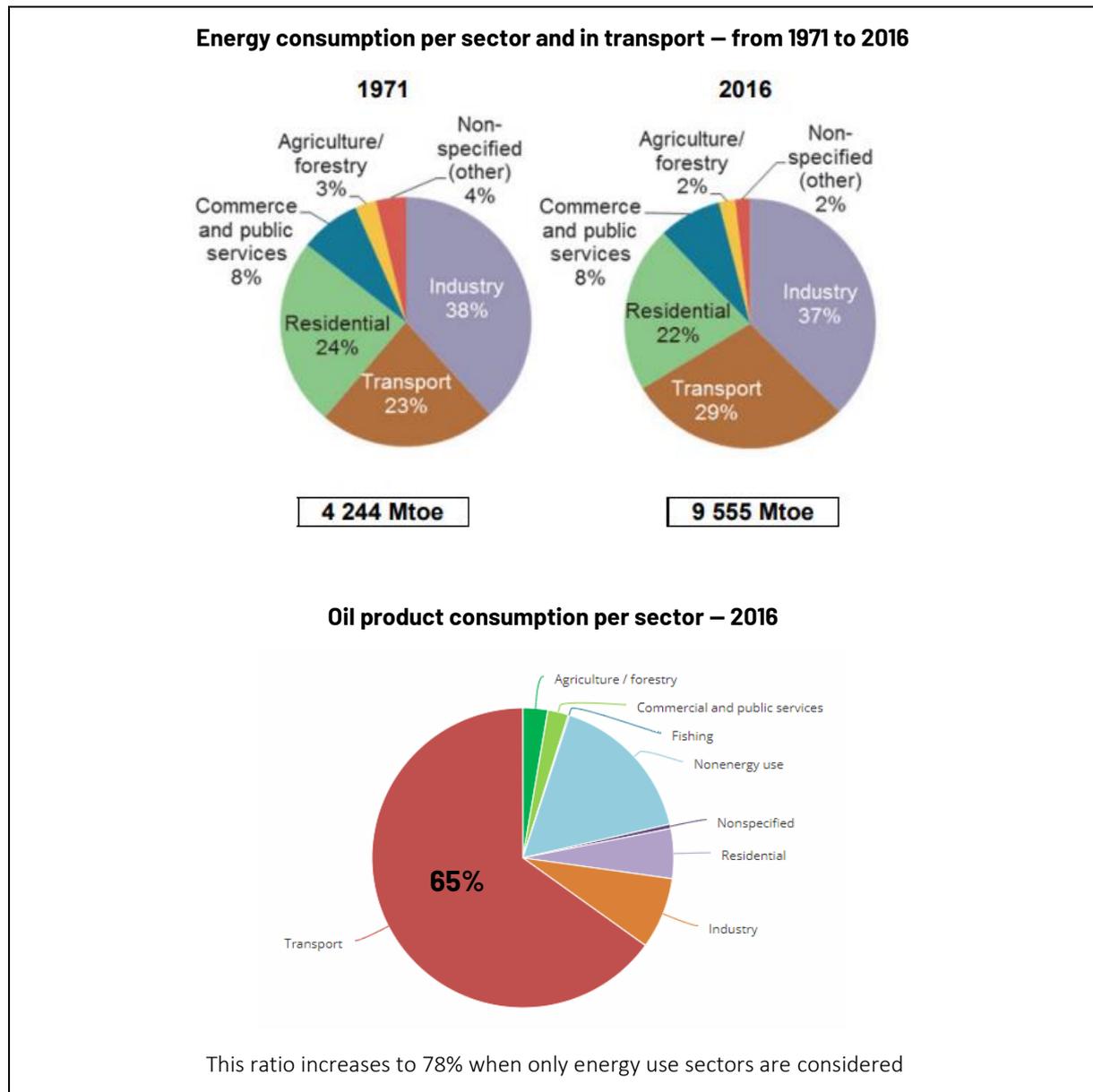


Figure 1: Energy consumption per sector, IEA World Energy Balances 2018

Much of transport services' environmental impacts are concentrated in use phase: more than 70% of greenhouse gas (GHG) and air pollutant emissions occur in use phase for passenger cars, and more than

80% for heavy duty vehicles. Concentration is even greater for aircraft since, from an LCA point of view, the manufacturing phase represents less than 1% of aircraft climate change impacts¹.

The transport sector is a driver of economic growth and international trade as demand for services continues to grow. Following a “business as usual” scenario, passenger transport volume between 2015 and 2050 will double – and more than triple in terms of freight volume².

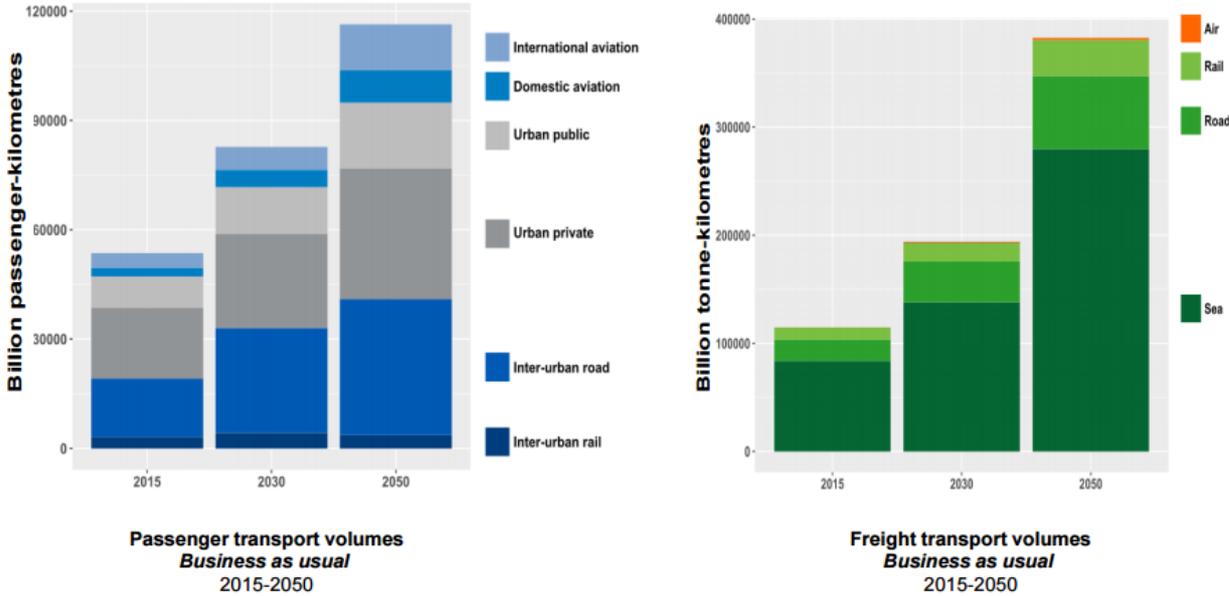


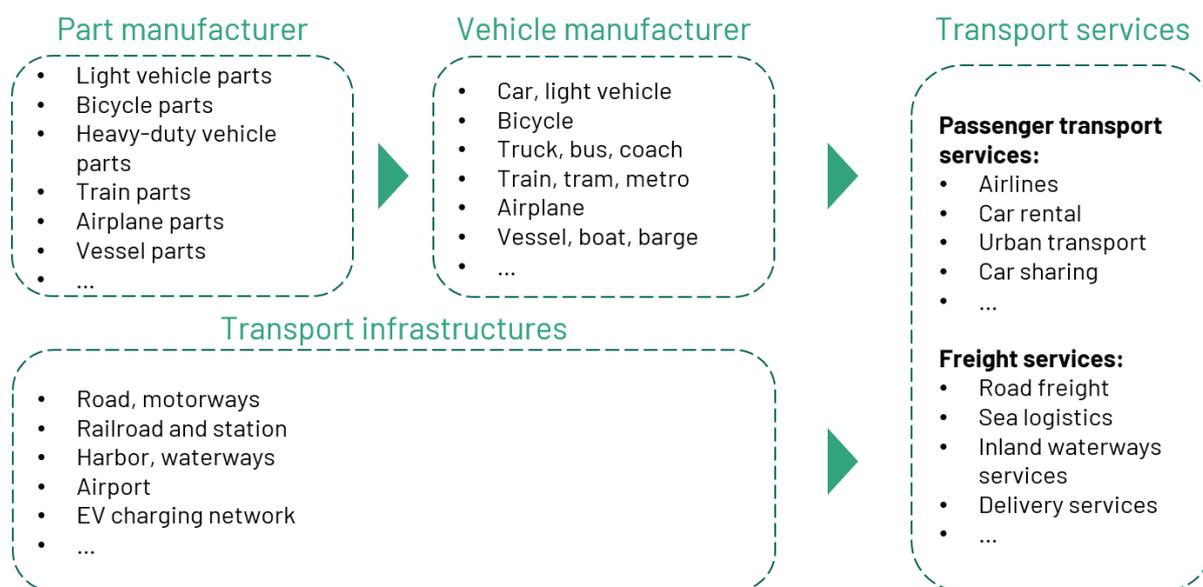
Figure 2: Passenger and freight transport volume forecast, from International Transport Forum – Decarbonising Transport, an ITF project to help achieve carbon-neutral mobility, 2016.

This high-impact intensity framework addresses any kind of transport. The common underlying physical unit is the distance in km for one transported unit, expressed in passenger.km for human mobility and ton.km for goods transport.

As illustrated below, the mobility & transport framework scope consists of four main sub-sectors: parts manufacturing, vehicle manufacturing, infrastructures and transport services.

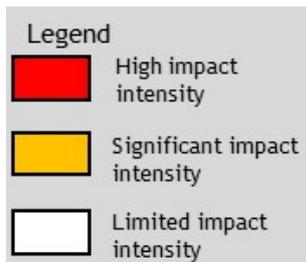
¹ Wojciench Jemiolo - Life cycle assessment of current and future passenger air transport in Switzerland, 2015
² International Transport Forum - Decarbonising Transport, an ITF project to help achieve carbon-neutral mobility, 2016

Underlying physical functional unit: passenger.km for passenger transport and ton.km for freight



2. Main environmental issues

| Environmental stake | | Relevance along value chain | | | Comments | Data availability |
|---------------------|-----------------------------|-----------------------------|--------------------------|-----------|---|--|
| | | Parts | Manufacturing / building | Use phase | | |
| Climate | Climate change | Red | Yellow | Red | Transport vehicles account for 14% of global GHG emissions. Additionally, transport infrastructure needs GHG-intensive materials. | Statistics per type of vehicle for use phase + specific data for manufacturers |
| | Use of energy resources | Red | Yellow | Red | Fossil fuels are by far the main energy source for transport, which accounts for 65% of world oil consumption. | Statistics per type of vehicle for use phase |
| Air Quality | Air quality deterioration | Yellow | Yellow | Red | One of the main sources of air pollution in urban areas | Data per type of vehicle |
| Water | Water consumption | Yellow | Yellow | Yellow | Water needed for infrastructure construction and metal extraction | |
| | Water pollution | Yellow | | | Risk of water pollution, mainly for maritime transport | Qualitative info per type of transport |
| Biodiversity | Soil pollution | Yellow | | | Legacy of polluted sites | Qualitative info per type of transport |
| | Land use | Yellow | Yellow | | Transport infrastructure is the main cause of land fragmentation. | Qualitative info per type of transport |
| Resources & Waste | Use of non-energy resources | Yellow | | | Some rare earths and strategic metals are key for vehicle manufacturing (ICE and EV) | No vehicle or company specific data |
| | Waste | | Yellow | Yellow | Waste is an issue for traditional & alternative vehicles, as well as for infrastructure construction. | No vehicle or company specific data |



The main environmental stakes that stand out as key for the transportation and mobility sector and that are measurable at activity level are climate and air quality.

Climate

The transport sector is a main contributor of GHG emissions, with fossil fuel use accounting for 14% of global emissions. Fuels are mainly used for road transport (gasoline and diesel), marine transport (heavy fuel oil) and air transport (jet fuel).

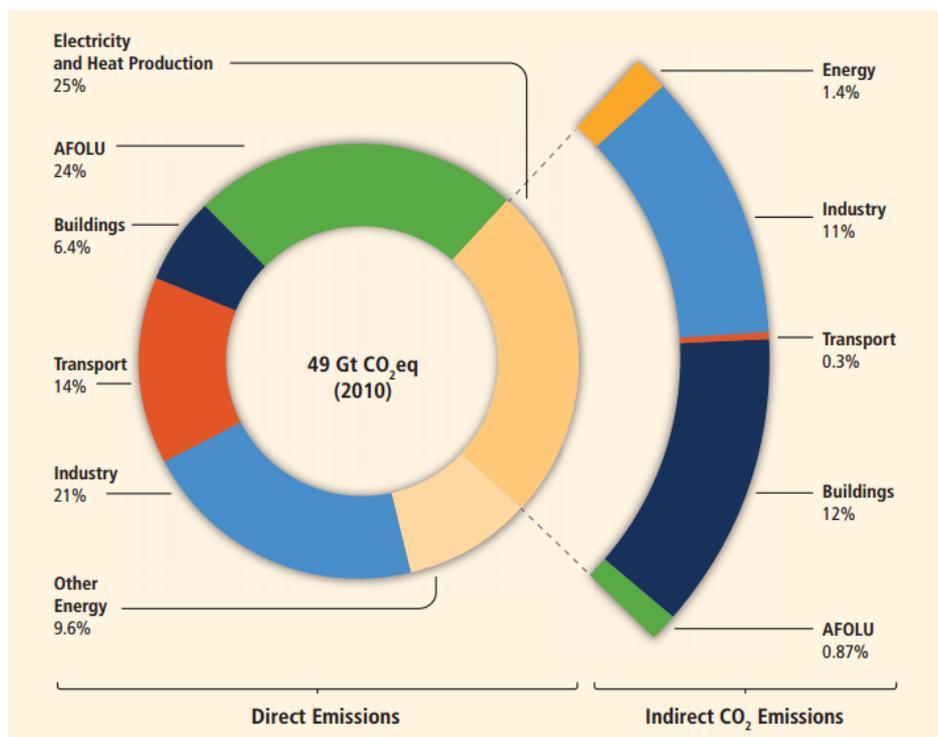


Figure 3: Breakdown of global GHG emission per sector
 Source: Summary for Policymakers (AFOLU = agriculture, forestry and other land use), IPCC, 2014

Air quality

Despite tightening standards for pollutant emissions (especially particulate matter and nitrogen oxides), road transport is still a main contributor (56% of NO_x and 12% of PM 10 in France) to outdoor air quality issues, especially diesel engines.

Nitrogen dioxide, NO₂, belongs to the nitrogen oxide family which, because of their irritant nature, create health risks, especially asthma attacks and respiratory issues. NO₂ is the result of oxidation when oxygen comes into contact with nitrogen monoxide, NO, emitted during combustion at high temperatures, and is mainly emitted by the road transport sector. The term NO_x gathers the three air pollutants NO, NO₂ and N₂O.

Fine particles have both natural and anthropic origins and can be derived from direct emissions or from secondary physicochemical processes. Depending on their size, fine particles carrying various harmful

substances (e.g. pollen, metals, etc.) penetrate differently into the pulmonary tree, altering respiratory function.

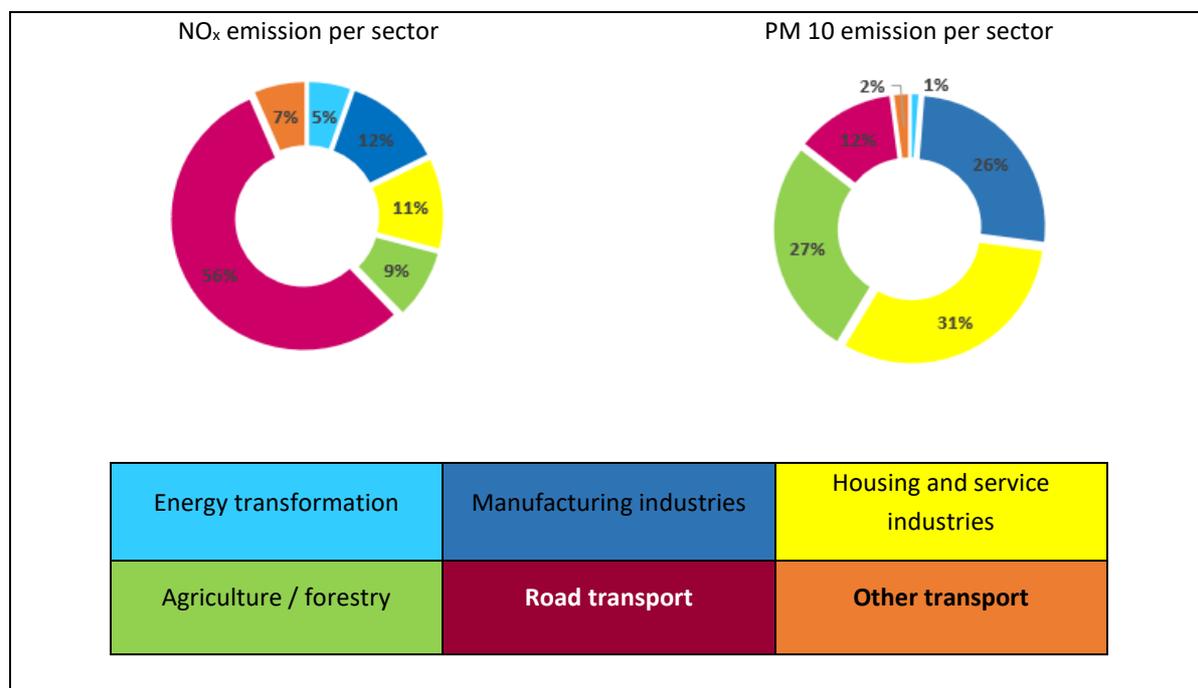


Figure 4: Breakdown French NO_x and PM 10 per sector, in 2016, CITEPA / Format SECTEN - 2017

In urban areas, the percentage of NO_x and PM 10 emissions from road transport is much higher.

There is also a clear gap between normalized pollutant and GHG emissions and actual vehicle emissions. Until September 2018, new vehicle emission approval testing in Europe was carried out on a motor test bench, the NEDC, for New European Driving Cycle. However, these tests designed to measure field use conditions were avoided by car manufacturers which calibrated vehicles specifically for laboratory testing³. Therefore, deviation from standardized emissions was common when measuring vehicle emissions in real-life conditions, with a more than 40% gap between official and real-life CO₂ emission values⁴.

The same deviation exists for NO_x emissions. For example, various NGOs monitoring the transport sector estimated that, on average, diesel vehicles emitted five times more pollutants under actual use conditions than norms in place, and that only one European vehicle out of 10 met the Euro 6 Standard. In 2016, Emission Analytics⁵ tested more than 250 Euro 5 and Euro 6 vehicles and concluded that only one out of 201 Euro 5 diesels (0,5%) and seven out of 62 Euro 6 diesels (11%) were under emission limits. The average NO_x deviation for diesel cars was 380%. New globally recognized vehicle emission approval tests (Light Vehicle Test procedures) are now more representative of actual modern driving conditions. These tests are run in parallel with real drive emissions tests (on-road tests) that verify legislative caps for pollutants are not exceeded during use.

³ Transport & Environment, 2015, "Don't breathe here, beware the invisible killer", *Tackling air pollution from vehicles*, p. 18.

⁴ ICCT, 2017, "From laboratory to road: A 2017 update"

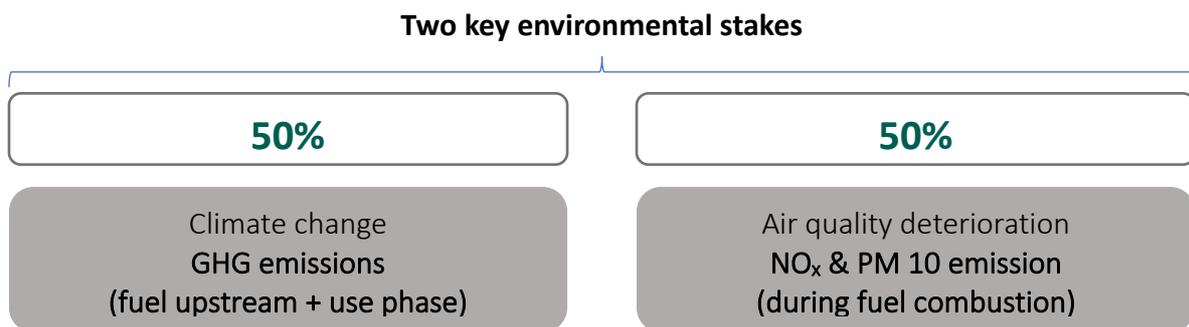
⁵ <http://equaindex.com/equa-air-quality-index/>

3. Environmental performance indicators

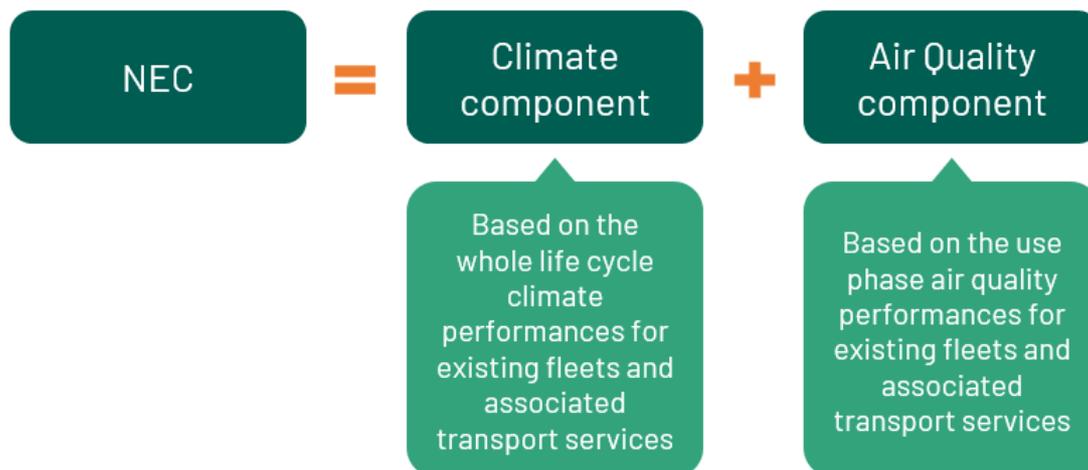
To quantify the impact of each of the two main environmental issues – climate change and air quality – the following set of key performance indicators have been selected. They are expressed per functional unit, which is the distance in km for one transported unit, passenger.km for human mobility and ton.km for goods transport:

- **level of GHG emissions during upstream and use phases per functional unit**
- **level of NO_x and PM 10 emissions during use phase per functional unit**

Following expert consultation, the two NEC components have been equally weighted:



The resulting equation is:



The present framework is divided into 4 parts or sub-frameworks:

- Transport services
- Vehicle manufacturing
- Parts manufacturing
- Infrastructures

Even though some transport modes are generally more efficient, the impact of vehicle type (among the same mode of transport) is also a key factor to determine transport efficiency (i.e. small size electric vehicle versus diesel SUV). Consequently, the intrinsic characteristics of manufactured vehicles are also essential. Part manufacturers bring another efficiency factor, as they provide the bricks that allow vehicle manufacturers to reduce vehicle emissions.

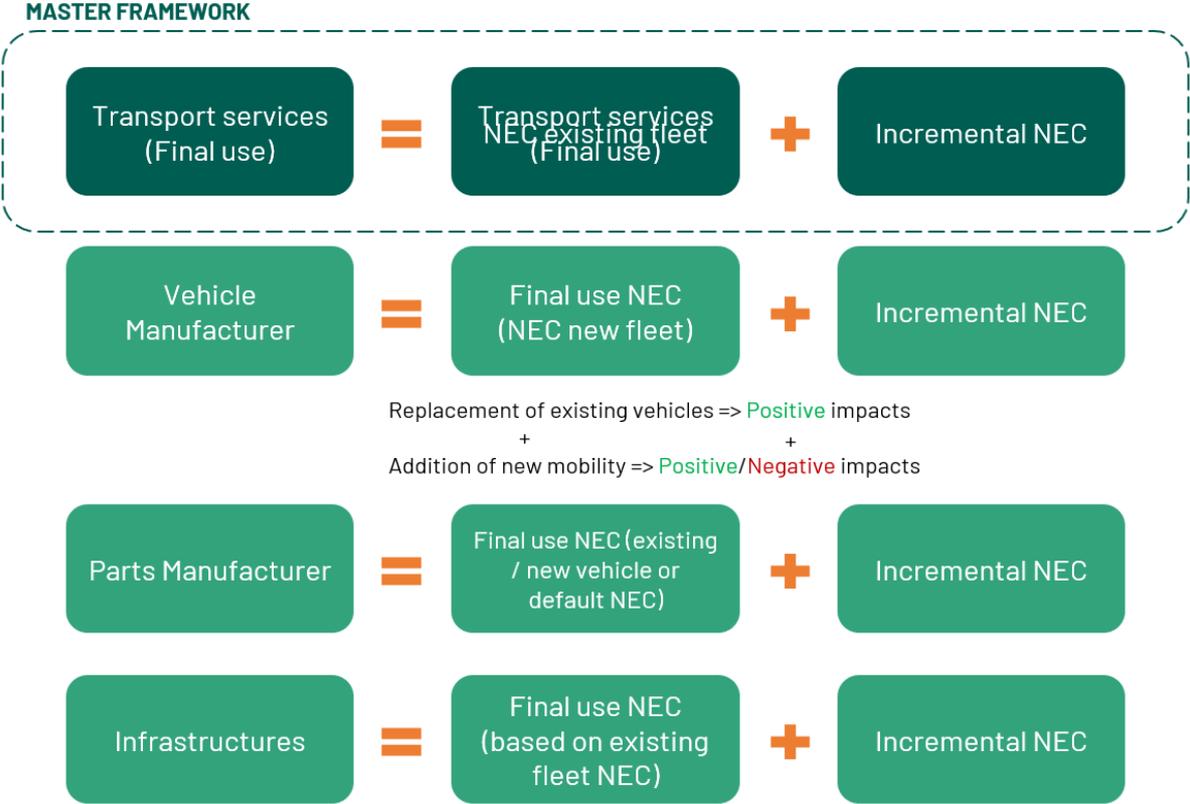
When evaluating transport-related activities, two types of fleets are considered, as they have very different characteristics:

- Existing fleets, comprising all vehicle types used effectively in transport services, with highly heterogeneous levels of GHG and air quality performances and a wide range of vehicle age;
- New fleets, comprising the newly manufactured vehicles, usually with better GHG and air quality performance than existing fleets thanks to more stringent regulations and improvement of vehicle performances.

Each part of the framework is related to existing or new fleets as follows:

| Part of the NEC framework | Related fleets |
|---------------------------|---|
| Transport services | Existing |
| Vehicle manufacturer | New |
| Parts manufacturer | New for vehicle manufacturing Existing for spare parts |
| Infrastructures | Existing |

For each sub-framework, an incremental NEC can be calculated to account for activity or company's specific contributions to global value chain environmental performance. The generic NEC equation stands as follow per the rating sub-framework:



The NEC of each fleet relies on the type of transport mode and on the type of vehicle (among the same mode of transport, e.g. small size electric vehicle versus diesel SUV).

4. Passenger transport services

Calculating the relative performance of various means of passenger transport requires the following KPIs:

- **g CO₂ / passenger.km** (GHG emissions per passenger transported over 1 km, fuel upstream and use phase)
- **mg NO_x / passenger.km and mg PM 10 / passenger.km** equally weighted

The total consolidated performance of these three KPIs results in:

| Modal mix | Mean of transport (existing fleet) | Environmental performance (aggregated climate and air pollution KPI) | NEC |
|-----------|---------------------------------------|---|-------|
| 60.0% | Car | -4,6% | -6% |
| 24.8% | Car - Diesel | -43% | -59% |
| 33.3% | Car - Gasoline | 21% | +28% |
| 0.1% | Car - Electric | 83% | +100% |
| 0.2% | Car - Hybrid Gasoline | 49% | +67% |
| 1.6% | Car - LPG | 57% | +77% |
| 1.6% | Motorbike | 11% | +15% |
| 0.7% | Bike | 120% | +100% |
| 6.6% | Bus and Coaches | 37% | +50% |
| 3.3% | Bus - Diesel | 17% | +23% |
| 3.3% | Coaches | 56% | +77% |
| 1.3% | Tram and Metro | 93% | +100% |
| 5.4% | Train | 74% | +100% |
| 1.5% | Train - Diesel | -12% | -17% |
| 3.9% | Train - Electric | 107% | +100% |
| 15.2% | Plane | -44% | -60% |
| 2.5% | Plane - Short haul | -125% | -100% |
| 5.1% | Plane - Medium haul | -51% | -70% |
| 7.6% | Plane - Long haul | -13% | -17% |
| 0.0% | Inland waterways | 22% | +29% |
| 0.6% | Sea | -1477% | -100% |
| 8.6% | Walking | 120% | +100% |
| 100% | Europe Average | 0% | 0% |

The +100% NEC, eco-solution point, has been set for the train average, as it is a widely scalable solution that can transport a large number of people over long distances.

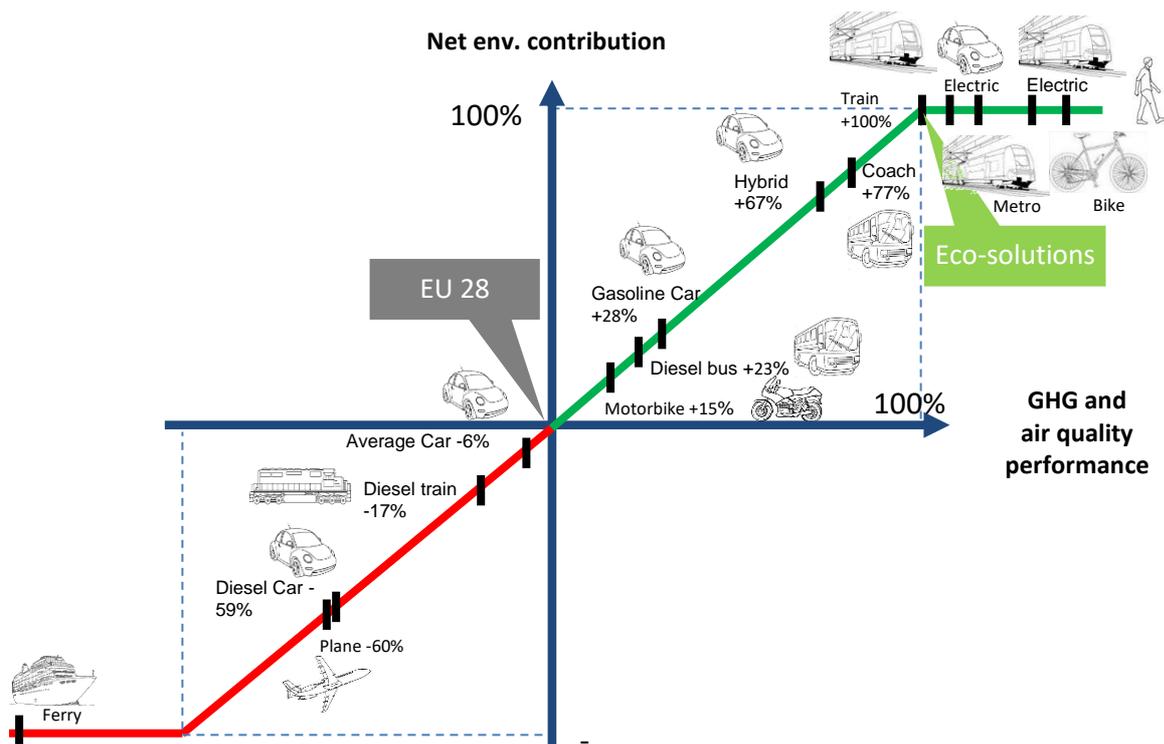


Figure 5: Average NEC per means of transport for passenger transport
 Source: I Care & Consult and Sycomore AM, 2017

4.1. Climate component

Evaluating GHG performance of the passenger transport sector is done through analyzing efficiency using **GHG emissions per passenger transported over 1 km**. Evaluating this indicator on a global scale would be more relevant; however, as global data is lacking, only a European-based framework can be robustly used, as illustrated below.

| | Europe | USA, Asia, emerging countries |
|--|--|--|
| Modal mix | ✓ • European statistics (Eurostat) | ✓ • No consolidated data, statistics available per mode only |
| Emission factors of transportation means | ✓ • European average available per mode | ✗ • No emission factor for every country • No world average per mode |
| Emission factors of automotive manufactures | ✓ • Standardized value per manufacturer | ✗ • Non-comparable values • Lack of availability for each zone |
| Difference between diesel and gasoline emissions | ✓ • French and European statistics and EURO standards | ✗ • Non-comparable values • Lack of availability for each zone |

Figure 6: Availability of GHG performance data for different means of transportation and car manufacturers by markets

The European modal mix (in billion passenger.km) with “walking” integrated has been used. Even if this 1.0 framework is not necessarily representative of world GHG performance across the world, it was the best option given available data. As a European-based framework, the French “Base Carbone” is used for the fuel upstream and several sources such as the “European Environment Agency”, IEA and ICCT.org for use phase, to obtain CO₂ emission per transport mode. The following adjustments have been designed to fill the gaps between actual and theoretical emissions for all means of transport, which are very high for cars and planes.

| Passenger | Existing fleet CO ₂ adjustment | New fleet CO ₂ adjustment |
|------------------|--|---|
| Car | +15% | +40% |
| Plane | +60% (15% efficiency adjustment+ 45% radiative forcing uplift) | +60% (15% efficiency adjustment + 45% radiative forcing uplift) |
| Motorbike | +15% | +15% |
| Coach | +15% | +15% |
| Bus | +15% | +15% |
| Bus & coach | +15% | +15% |
| Train | +15% | +15% |
| Inland waterways | +15% | +15% |
| Sea ferry | +15% | +15% |

Finally, different modes of transport are classified according to GHG performance below based on the modal split of passenger transport in Europe:

| Modal mix | Mean of transport (existing fleet) | Fuel Upstream gCO ₂ / p.km | Fuel Usage gCO ₂ / p.km | Total gCO ₂ /p.km | Climate component |
|---------------|------------------------------------|---------------------------------------|------------------------------------|------------------------------|-------------------|
| 60.0% | Car | 30 | 123 | 153 | -18% |
| 24.8% | Car — diesel | 32 | 120 | 152 | -16% |
| 33.3% | Car — gasoline | 30 | 127 | 157 | -22% |
| 0.1% | Car — electric | 72 | 0 | 72 | 65% |
| 0.2% | Car — hybrid gasoline | 21 | 91 | 112 | 25% |
| 1.6% | Car — LPG | 17 | 102 | 118 | 18% |
| 1.6% | Motorbike | 22 | 96 | 119 | 18% |
| 0.7% | Bike | 0 | 0 | 0 | 140% |
| 6.6% | Bus and coaches | 18 | 70 | 88 | 49% |
| 3.3% | Bus — diesel | 23 | 86 | 109 | 28% |
| 3.3% | Coaches | 14 | 53 | 67 | 71% |
| 1.3% | Tram and metro | 52 | 0 | 52 | 86% |
| 5.4% | Train | 22 | 16 | 39 | 100% |
| 1.5% | Train — diesel | 15 | 59 | 74 | 63% |
| 3.9% | Train — electric | 25 | 0 | 25 | 114% |
| 15.2% | Plane | 23 | 110 | 182 | -47% |
| 2.5% | Plane — short-haul | 33 | 157 | 260 | -128% |
| 5.1% | Plane — medium-haul | 23 | 108 | 179 | -45% |
| 7.6% | Plane — long-haul | 20 | 95 | 158 | -22% |
| 0.0% | Inland waterway | 15 | 59 | 74 | 64% |
| 0.6% | Sea | 158 | 737 | 895 | -783% |
| 8.6% | Walking | 0 | 0 | 0 | 140% |
| 100.0% | Europe average | 26 | 102 | 136 | 0% |

Among the five car categories, electric, hybrid and LPG vehicles have better ratings than traditional pure internal combustion engine cars. Electricity carbon content is based on the European mix which is favoring pure EV compared to a world average carbon content of electricity.

4.2. Air quality component

To evaluate air quality performance of the passenger transportation sector, **NO_x and PM 10 emissions per passenger transported over 1 km** are evaluated.

The following adjustments compensate for gaps between actual and theoretical emissions for all means of transport — especially for cars and motorbikes.

| Passenger | Existing fleet NO _x adjustment | New fleet NO _x adjustment |
|-----------|---|--------------------------------------|
| Car | +100% on diesel | +380% on diesel |
| Plane | +15% | +15% |
| Motorbike | +100% | +15% |

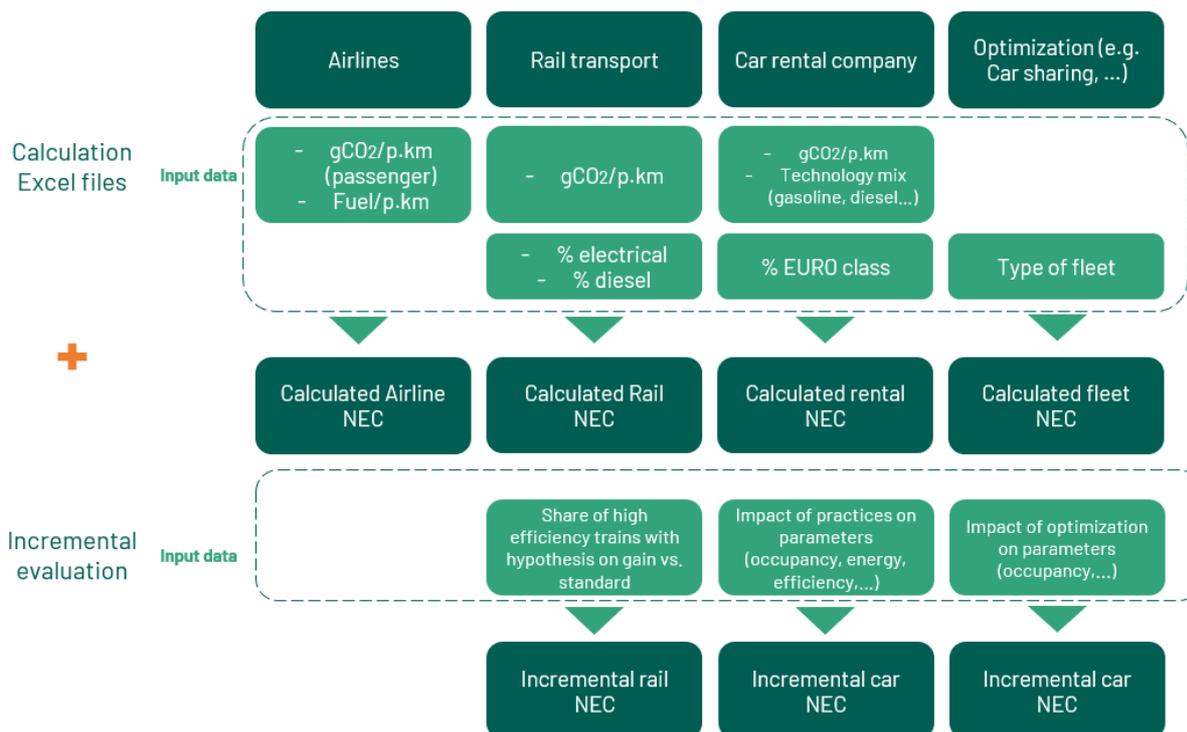
| | | |
|------------------|------|------|
| Coach | +15% | +15% |
| Bus | +15% | +15% |
| Bus & coach | +15% | +15% |
| Train | +15% | +15% |
| Inland waterways | +15% | +15% |
| Sea ferry | +15% | +15% |

Modal split of passenger transport in Europe and average of NO_x and PM 10 emissions

| Modal mix | Mean of transport (existing fleet) | PM 10 emission mg/p.km | NO _x emission mg/p.km | Air quality component |
|-----------|------------------------------------|------------------------|----------------------------------|-----------------------|
| 60.0% | Car — average | 3.1 | 141.5 | 9% |
| 24.8% | Car — diesel | 3.2 | 274.3 | -70% |
| 33.3% | Car — gasoline | 3.2 | 49.3 | 63% |
| 0.1% | Car — electric | 0.0 | 0.0 | 100% |
| 0.2% | Car — hybrid | 2.3 | 35.7 | 74% |
| 1.6% | Car — LPG | 0.1 | 24.6 | 95% |
| 1.6% | Motorbike | 10.0 | 83.6 | 4% |
| 0.7% | Bike | 0.0 | 0.0 | 100% |
| 6.6% | Bus & coach — average | 0.3 | 95.7 | 24% |
| 3.3% | Bus — diesel | 0.4 | 148.7 | 6% |
| 3.3% | Coach — diesel | 0.3 | 42.7 | 42% |
| 1.3% | Tram & metro | 0.0 | 0.0 | 100% |
| 5.4% | Train — average | 0.4 | 50.4 | 47% |
| 1.5% | Train — diesel | 1.3 | 180.0 | -88% |
| 3.9% | Train — electric | 0.0 | 0.0 | 100% |
| 15.2% | Plane | 1.1 | 332.4 | -41% |
| 2.5% | Plane — short-haul | 1.3 | 367.0 | -121% |
| 5.1% | Plane — medium-haul | 1.1 | 313.8 | -58% |
| 7.6% | Plane — long-haul | 1.1 | 333.2 | -3% |
| 0.0% | Inland waterway | 1.7 | 227.4 | -20% |
| 0.6% | Ferry | 23.9 | 3 287.3 | -2171% |
| 8.6% | Walking | 0.0 | 0.0 | 100% |
| 100.0% | Europe Average | 10 | 264 | 0% |

4.3. NEC calculation

To calculate a passenger transport activity or company's NEC, GHG intensity per passenger km is used. Depending on the transport mode, other information may also be required (e.g. type of fuel for a train — diesel or electricity). To account for company specificities through an incremental NEC, other information such as load factor is used. For each transport service, a dedicated user-friendly calculation Excel file is used to easily obtain a company's NEC.



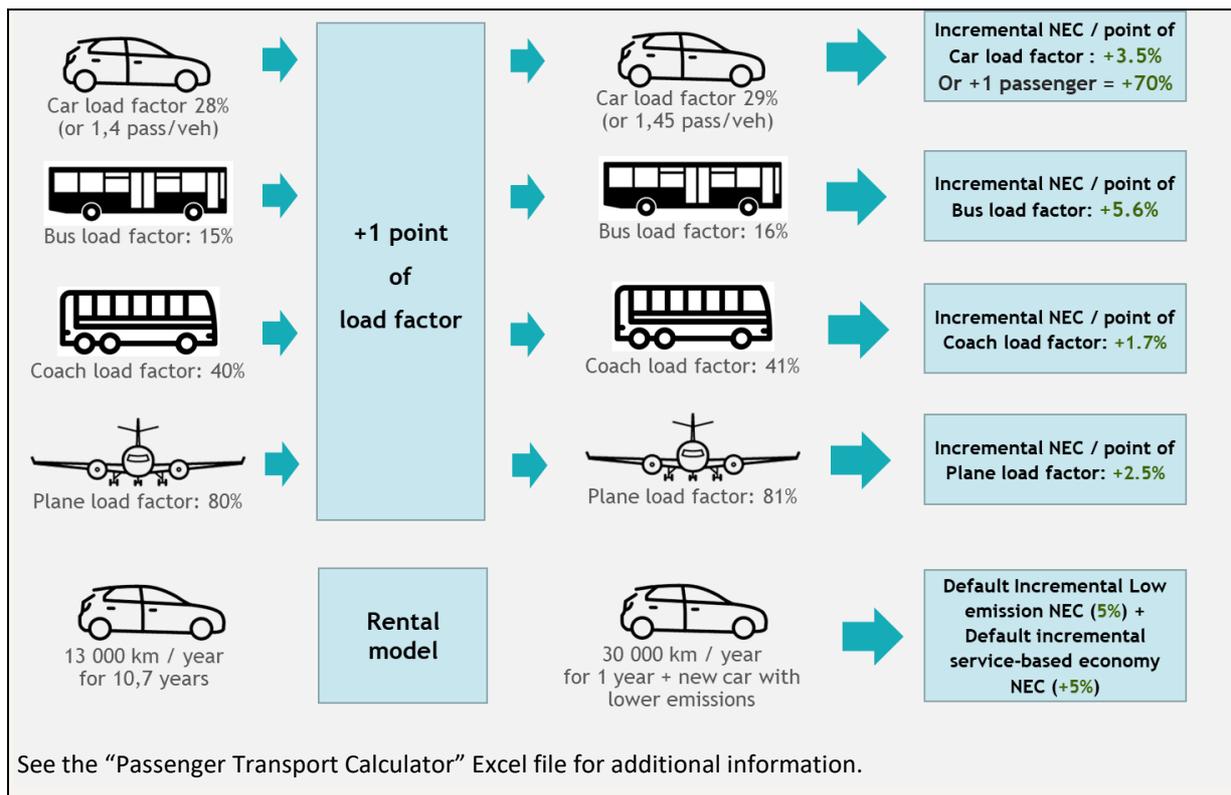
Data availability and practical tips

When evaluating a passenger transport company, the KPI assessed is gCO₂ / p.km.

When this is not directly available, the company's business model indicates what transport segment it's in (air, road, rail, maritime).

An incremental NEC can be added to the calculated NEC if a company presents specific information such as improved occupancy and fuel efficiency.

Here are a few rating guidelines to calculate incremental NEC:



Incremental NEC calculation tips for the car rental model

Considering that most rental cars are relatively new and that this service is adding mobility, the methodology for auto manufacturers is applied when evaluating a car rental company. With a fleet that is not 100% brand new, the associated NEC is ca. 5% (slightly lower than the 6% score for default auto manufacturers). This is the default incremental low emission NEC.

From a usage point of view, rental cars are driven longer distances in the first three years of their lifetimes, resulting in a higher depreciation of the vehicle manufacturing environmental footprint per passenger.km. The calculation results in a ca. 5% NEC increase. This is the default incremental service-based economy NEC.

Given the above, rental cars have a 10% default incremental NEC. If average GHG fleet efficiency (gCO₂/vehicle km) of a car rental company is available, then only the default incremental service-based economy NEC is added.

See the "Car Rental Calculator" Excel file for additional information.

5. Freight services

Freight activities are evaluated following the same principles as passenger transport, the transport unit being replaced by the transported ton over 1 km. KPIs are:

- **g CO₂ / ton.km** (GHG emissions - fuel upstream + use phase - per ton transported over 1 km)
- **mg NO_x / ton.km and mg PM 10 / ton.km**

The +100% or eco-solution point has been set for railways, consistently with passenger transport and the total consolidated performance of these three KPIs results in:

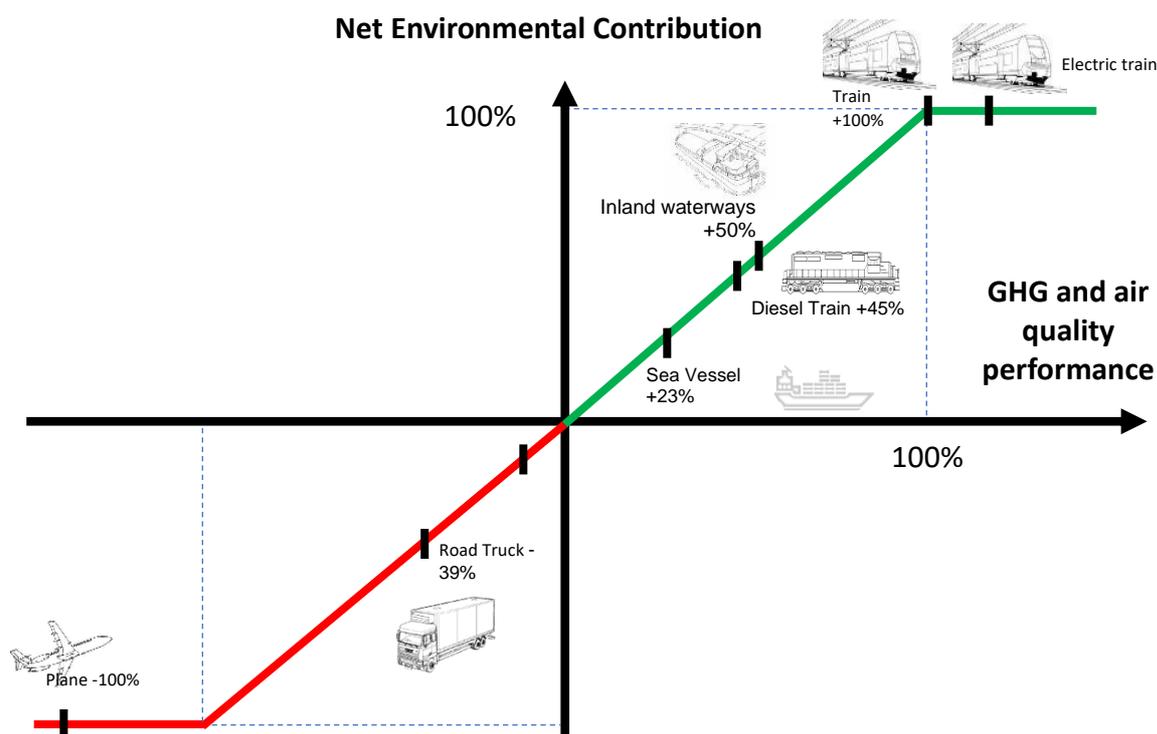


Figure 7: Average NEC per means of transport for freight transport
Source: I Care & Consult and Sycomore A, 2017

| Modal mix | Mean of transport (existing fleet) | Environmental performance (aggregated climate and air pollution KPI) | NEC |
|-----------|------------------------------------|--|-------|
| 51.1% | Road transport (truck) | -30% | -39% |
| 11.9% | Train | 78% | +100% |
| 3.3% | - Diesel | 35% | +45% |
| 8.6% | - Electric | 95% | +100% |
| 0.1% | Plane | -1638% | -100% |
| 4.7% | Inland waterways | 39% | +50% |
| 32.2% | Sea | 18% | +23% |

5.1. Climate component

When comparing carbon performance of different means of transport, note first that there are large performance variations within each mode depending on vehicle category: for road transportation, performance varies between 22–112 g CO₂ / t.km depending on type of vehicle chosen (trucks versus light duty vehicles).

Air transport has the worst performance (average value of 1 332 gCO₂ / t.km), while electric rail transport (average of 17 gCO₂ / t.km) and maritime transport (average of 12 gCO₂ / t.km) have the best performances.

Distribution of freight transport modes in Europe and their gCO₂ / t.km performance

| Freight transport | Modal mix | Fuel upstream g CO ₂ / t.km | Fuel usage g CO ₂ / t.km | Total g CO ₂ / t.km | Climate component |
|-----------------------|---------------|---|--|-----------------------------------|----------------------|
| Road transport | 51.1% | 23 | 89 | 112 | -81% |
| Train | 11.9% | 14 | 8 | 22 | 81% |
| - Diesel | 1.4% | 7 | 28 | 35 | 57% |
| - Electric | 10.5% | 17 | 0 | 17 | 90% |
| Plane | 0.1% | 169 | 802 | 1 332 | -2279% |
| Inland waterways | 4.7% | 9 | 33 | 42 | 45% |
| Sea | 32.2% | 2 | 9 | 12 | 100% |
| Europe Average | 100.0% | 15 | 52 | 67 | 0% |

Using the modal distribution of freight in Europe, average carbon performance is **67 g CO₂ / t.km**.

To evaluate a freight company's NEC, the average emission of gCO₂ / ton.km of transport is considered. When this data is not directly available, the modal mix of means of transport used is evaluated instead. Note that modal mix may differ from a company's own fleet, and that freight services purchased from subcontractors are also included.

5.2. Air quality component

NO_x and PM 10 emissions per ton transported over 1 km are used to evaluate air quality performance of the freight service.

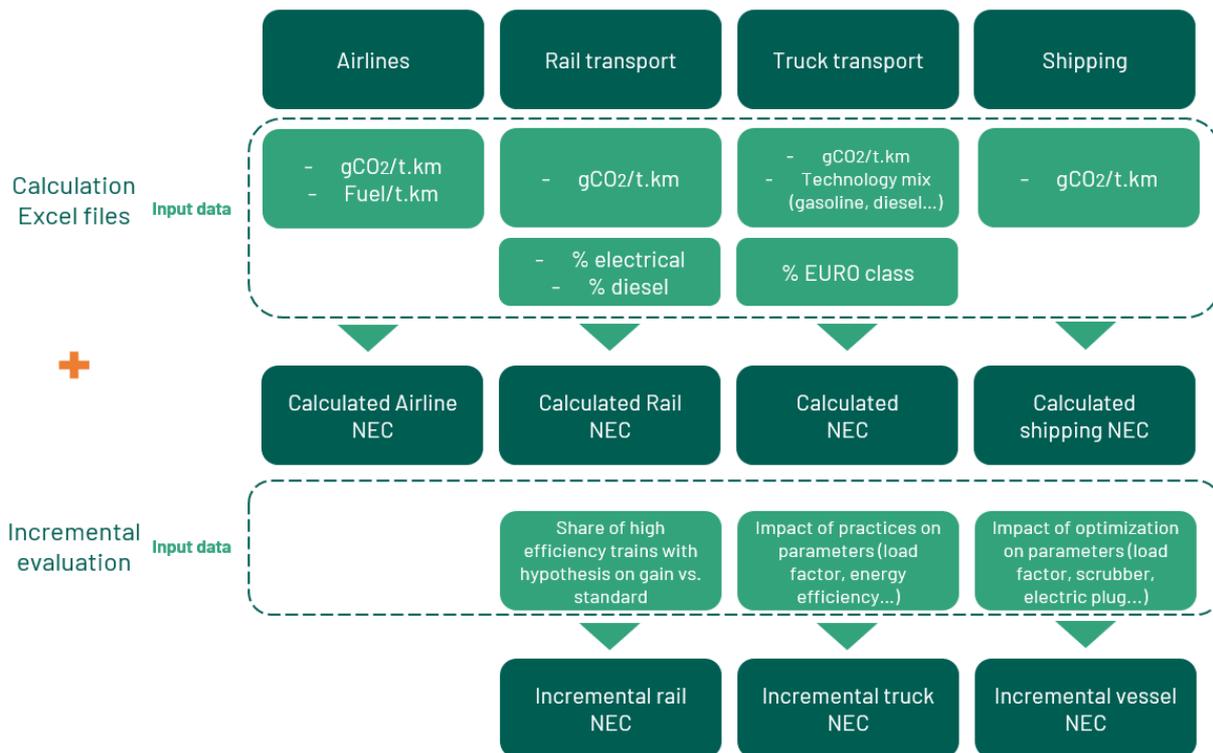
Modal split of freight in Europe and average PM 10 and NO_x emission

| Freight means | Modal mix | PM 10 emission mg/t.km | NO _x emission mg/t.km | PM 10 component | NO _x component | Air quality component |
|-----------------------|-----------|------------------------|----------------------------------|-----------------|---------------------------|-----------------------|
| Road transport | 51.1% | 4 | 358 | 56% | -13% | 21% |
| Train | 11.9% | 3 | 64 | 71% | 80% | 76% |
| Train - diesel | 1.4% | 10 | 230 | -2% | 27% | 13% |
| Train - electric | 10.5% | 0 | 0 | 100% | 100% | 100% |
| Plane | 0.1% | 47 | 5 429 | -377% | -1617% | -997% |
| Inland waterway | 4.7% | 8 | 176 | 22% | 44% | 33% |
| Sea | 32.2% | 21 | 347 | -117% | -10% | -63% |
| Europe average | 100.0% | 10 | 316 | | | |

5.3. NEC calculation

To calculate a freight company's NEC, GHG intensity per ton.km is used. Depending on transport mode, other information may also be required (e.g. type of fuel for train: diesel or electricity). To account for company specificities or to compensate for a lack of data, other information such as share of high-energy efficiency vehicles or load factor is used to calculate an incremental NEC.

For each freight service, a dedicated user-friendly calculation Excel file is used to easily obtain a company's NEC.



Data availability and practical tips

When evaluating a freight company, the KPI assessed is gCO₂ / ton.km.

This information can be found in a company's annual report, CSR or sustainability report, or CDP report (<https://www.cdp.net/fr/companies>).

When this data is not available, look at the modal mix of a company (air, road, rail, maritime) in terms of revenue, then apply the average emissions of each transportation mode.

Here is a rating guideline to calculate incremental NEC:



See the calculation Excel file for additional information.

Postal services

Postal services companies are regarded as freight companies and rated according to average emission of gCO₂ / ton.km or by modal mix split in terms of revenue. When no information is available, an average NEC of -15% is applied (see rationale below).

| | Road | Rail | Water | Air |
|---|-------------------------------|------|-------|-----|
| Average modal mix (in t.km) for seven selected postal service companies | 50% | 8% | 27% | 7% |
| NEC per modal mix | -39% | 100% | -100% | 23% |
| Resulting NEC | -15.9% rounded to -15% | | | |

6. Vehicle manufacturer

A new vehicle either replaces an old vehicle or adds mobility. When it replaces an old vehicle, compare with existing fleet performance; when it adds mobility, compare with new fleet performance. A vehicle manufacturer's NEC is the average of its production performance in the existing and new fleet framework. Below are the NEC by mode of transport:

| Passenger | New vehicle NEC in existing fleet framework | New vehicle NEC in new fleet framework | Vehicle Manufacturer NEC | |
|------------------|---|--|--------------------------|-----|
| Car | 33% | -22% | 6% | |
| Car diesel | 19% | -46% | -13% | |
| Car gasoline | 40% | -9% | 16% | |
| Car electric | 100% | 100% | 100% | |
| Car hybrid | 74% | 33% | 54% | |
| Car LPG | 80% | 58% | 69% | |
| Plane | 32% | -21% | 6% | 87% |
| Motorbike | 50% | -55% | -3% | |
| Coach | 100% | 99% | 100% | |
| Bus | 90% | 56% | 73% | |
| Bus&Coach | 100% | 78% | 89% | 13% |
| Train | 100% | 100% | 100% | |
| Inland waterways | 93% | 43% | 68% | |
| Ferry | -100% | -100% | -100% | |

| Freight | New vehicle NEC in existing fleet referential | New vehicle NEC in new fleet framework | Vehicle Manufacturer NEC | |
|------------------|---|--|--------------------------|--|
| Road | 10% | -26% | -8% | |
| Rail | 100% | 100% | 100% | |
| Plane | -100% | -100% | -100% | |
| Inland Waterways | 57% | 44% | 51% | |
| Sea logistics | 67% | 3% | 35% | |

| |
|------------------------|
| Plane NEC: -8% |
| Train NEC: 100% |

Car manufacturers are a key for the sector as **car transport represents more than 72% of the European modal mix in passenger.km**. Thus, manufacturers share a major responsibility for passenger transport CO₂ emissions. Strong commitments from automotive manufacturers may result in greater impacts from CO₂ reduction.

Air quality criteria is most relevant for existing fleets and vehicles sold under Euro5 norms. As of September 2015, every new passenger vehicle must abide by the EURO6b pollutant emission limitations, with a smaller difference between diesel and gasoline NO_x emissions compared to EURO5 limitations (EURO6b: 80 mg/km vs 60 mg/km; EURO5: 180 mg/km vs 60 mg/km). PM limitations under EURO6b are the same for diesel or gasoline cars⁶.

The following information is required:

⁶ More precisely, they are the same for direct injection gasoline and diesel cars.

- Turnover related to passenger car segments and others (e.g. truck, bus, motorbike)
- Average reported direct CO₂ emissions per km of sold vehicle fleets
- Car sales split per type of fuel (e.g. gasoline, diesel, hybrid...)

The weighted average of turnover per segment and each segment's NEC results in the auto manufacturer rating.

Data availability and practical tips

When applicable NEC calculation should be completed using sectorial specific referential

- automotive manufacturer **passenger segment**
- **freight segment**

Otherwise, data can also be directly provided by a manufacturer:

1.3.1.1.3. CO₂ emissions policy

The PSA group is committed to reducing CO₂ emissions

At the end of 2016, the PSA group is the leader in Europe with an average of 102.4 g of CO₂/km (104.4 g/mm in 2015) – data from AAA DATA – the average for the European market being 118.2g. The group has been consolidating a gradual decrease of its CO₂ emissions by around 35g since 2008.

Source: DDR Peugeot 2016, p.10

Otherwise, the **global average CO₂ emissions** of each automotive manufacturer are found at https://www.eea.europa.eu/data-and-maps/daviz/cars-co2-emissions-trends-by-manufacturer-4#tab-chart_2

The second piece of information to look for is **turnover or number of cars sold** per segment:

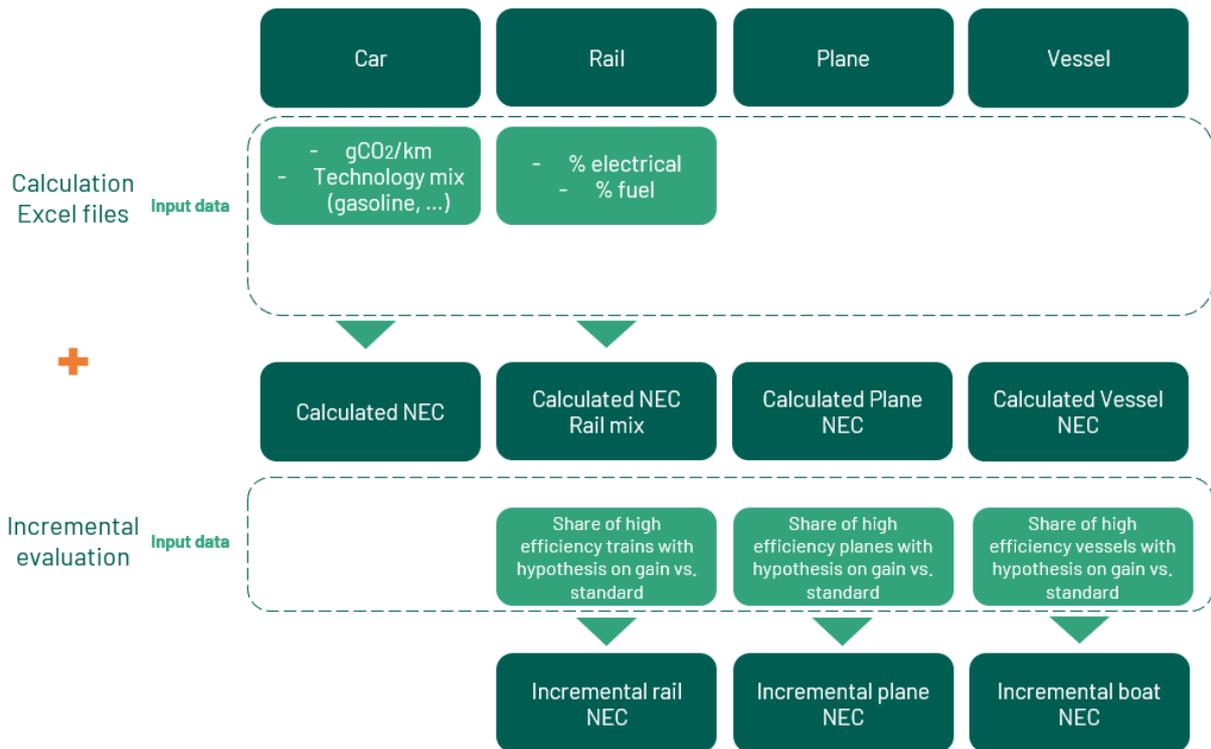
| | | |
|------------------------|--------------------------|------------------|
| TOTAL | | 102 300 |
| PSA | Passenger cars (PC) | 2 577 900 |
| | Commercial vehicles (CV) | 395 100 |
| | PC+CV of which: | |
| | Gasoline | 1 543 200 |
| | GPL | 2 600 |
| | Electric | 3 600 |
| | Diesel | 1 417 700 |
| | Hybrid | 5 800 |
| TOTAL PSA group | | 2 973 000 |

This data, imputed in the calculation file, calculates a car manufacturer's NEC.

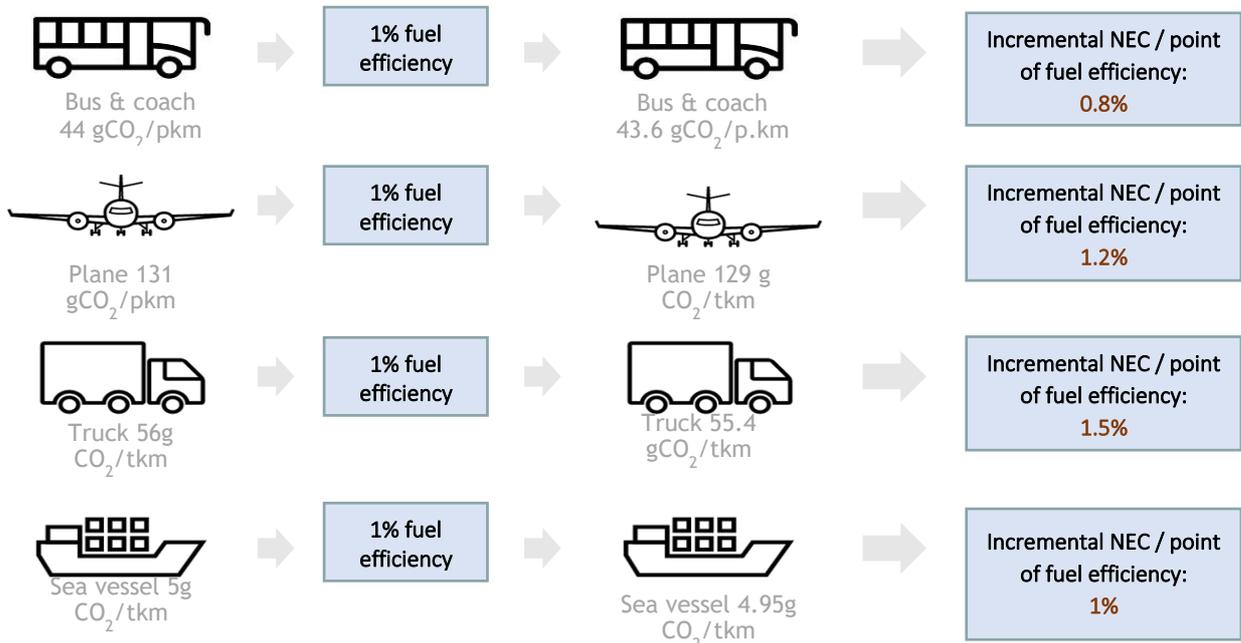
Other vehicle manufacturers (e.g. specific vehicle type, bus, truck, train, plane) are rated using the **final use NEC + incremental NEC** equation.

6.1. NEC calculation

To calculate the vehicle manufacturer NEC, GHG intensity per km (for cars) or type of fuel (for trains) is used. To account for company specificities or a lack of data, other information such as share of high efficiency vehicles is used. For each transport service, a dedicated user-friendly calculation Excel file is used to easily obtain a company's NEC.



For Incremental NEC, a few rating guidelines are below:



Additionally:

- Forklift NEC depends on motorization:

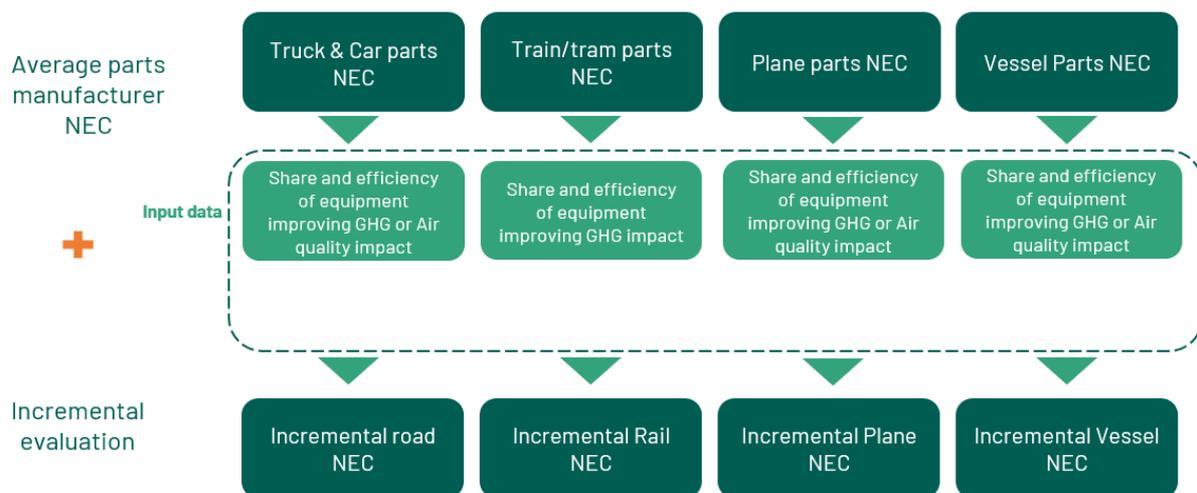
| Diesel | Gasoline | Gas | Electric / hydrogen | Default |
|--------|----------|------|---------------------|---------|
| -50% | -25% | +25% | +50% | 0% |

- Caravan or camping car NEC is 0% by default because of multiple final uses. Sole analysis from a mobility perspective would introduce bias, as caravan and camping-cars also serve accommodation purposes (related to the construction value chain).
- Helicopter default NEC is -100% due to poor fuel efficiency.
- Defense-related mobility NEC is 0% by default.

7. Parts manufacturer

Part manufacturers produce vehicle components such as brakes, seats and emission reduction systems.

Parts manufacturing is considered an upstream activity in relation to vehicle manufacturing, the main activity. Therefore, part manufacturer NEC calculations are directly related to the related transportation NEC. A part manufacturer's NEC is evaluated using the **final use NEC + incremental NEC** generic equation.

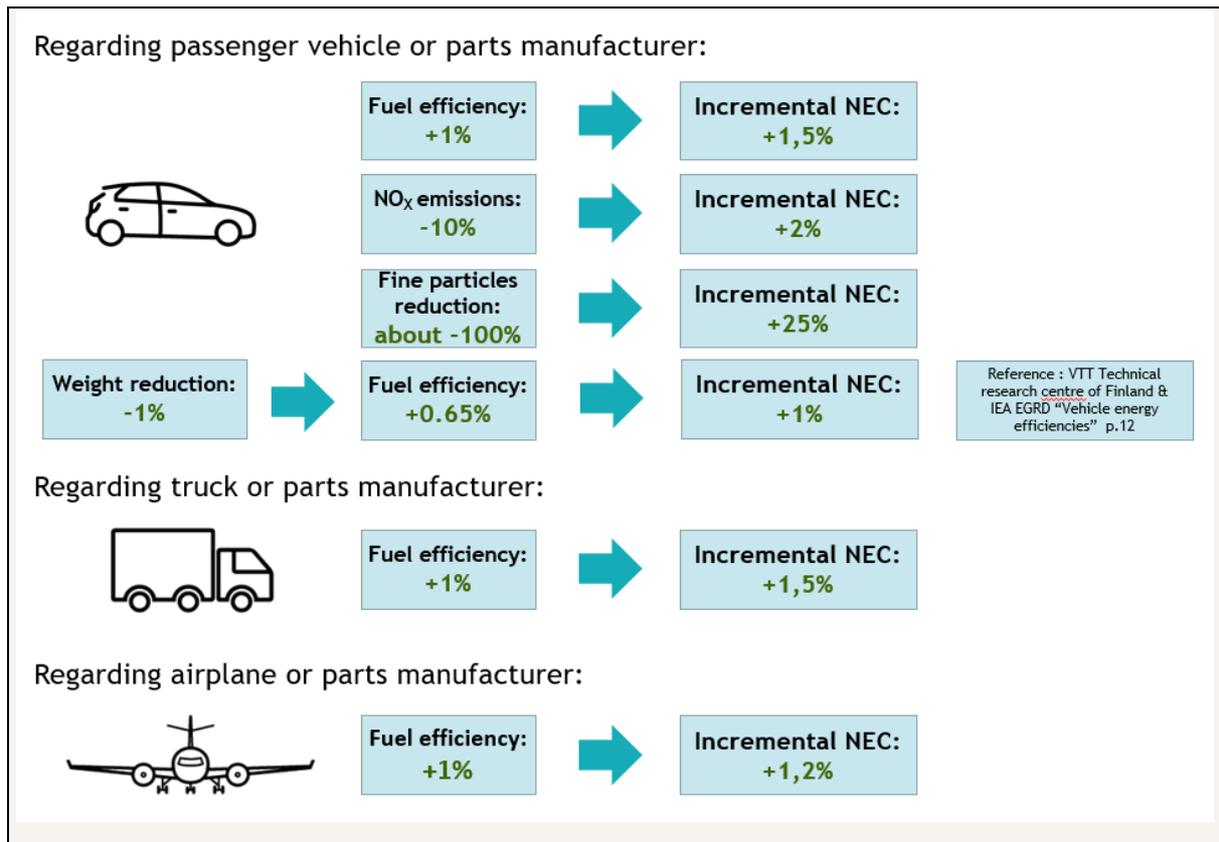


Data availability and practical tips

First, determine which modes of transportation relate to a part manufacturer, as well as related share of turnover. Below is a table for each mode of transportation:

| Vehicles | Existing fleet NEC | New fleet NEC | Original parts – manufacturer NEC (85% new fleet / 15% existing fleet) | Spare parts – vehicle component NEC (85% existing fleet / 15% new fleet) |
|-------------------------|--------------------|---------------|--|---|
| Car | -6% | 6% | 4% | -4% |
| Truck | -39% | -8% | -13% | -34% |
| Plane (pass. + freight) | -65% | -8% | -17% | -57% |
| Motorbike | +15% | -3% | 0% | +12% |
| Coach | +77% | +100% | +96% | +80% |
| Bus | +23% | +73% | +66% | +31% |
| Bus & coach | +50% | +89% | +83% | +56% |
| Train (pass. + freight) | +100% | +100% | +100% | +100% |
| Inland waterways | +29% | +68% | +62% | +35% |
| Ferry (passenger) | -100% | -100% | -100% | -100% |
| Cargo vessel (freight) | +23% | +35% | +33% | +25% |

If data is available, use the exact split between replacement and new vehicle parts to calculate part manufacturer's NEC. To calculate incremental NEC, the following rating guidelines may be useful:



8. Transport infrastructures

Transport infrastructure ratings are directly related to means of transportation served and the split between passenger and freight infrastructure use.

| Infrastructure | Default NEC |
|-------------------------------|-------------|
| Road (e.g. highways, tolls) | 0% |
| Rail (e.g. train stations) | +100% |
| Air (e.g. airports) | -50% |
| Sea (e.g. harbors, waterways) | +25% |

For airports, the combination of the different final uses gives the default value as follows:



A user-friendly calculation Excel file exists to easily obtain an airport's NEC.

9. Main limits

The 1.0 approach integrates GHG emissions in a life-cycle scope and two key emitted air pollutants, allowing comparison of many means of passenger and freight transportation. Existing fleet data is based on the European average normalized emissions adjusted to reflect real-life emissions versus company claims.

For an even more precise rating methodology, existing fleet and new fleet data should be updated yearly, preferably with identical sources for all means of transportation and a more accurate new fleet data average. Rating methods should be expanded to a global average. Finally, the methodology could be improved by taking into account other environmental impacts such as biodiversity or waste/resources.

10. Key data sources

Main sources of GHG emissions

| Mean of transport (existing fleet) | Sources | | | |
|------------------------------------|---|---|--|--------------|
| Transport | Modal Mix | Source Fuel Upstream CO ₂ / p.km | Fuel Usage CO ₂ / p.km | |
| Car - Average | European Commission Transport in figures 2016 (data 2014) | Base carbone (Fr) | Eur. Env. Agency (data 2014) | |
| Car - Diesel | | Base carbone (Fr) | Eur. Env. Agency (data 2014) recalculated | |
| Car - Gasoline | | IEA - EU28 | avere-france.org & estimation | |
| Car - Electric | | Base carbone (Fr) | Carlabelling.ademe.fr (Prius Euro 5) | |
| Car - Hybrid Gazoline | Coach and Bus treated as equal | Base carbone (Fr) | European Commission - WtoW Study | |
| Car - LPG | | Base carbone (Fr) | Eur. Env. Agency (data 2014) | |
| Motorbike | Plane: long haul modal mix extrapolated | Base carbone (Fr) | Eur. Env. Agency (data 2014) | |
| Bike | | | | |
| Bus & Coach - Average | | Base carbone (Fr) | Eur. Env. Agency (data 2014) | |
| Bus - Diesel | | Base carbone (Fr) | Eur. Env. Agency (data 2014), Ademe, Arafer recalculated | |
| Coach - Diesel | | Base carbone (Fr) | | |
| Tram & Metro | | Base carbone (Fr) | Base carbone (Fr) | |
| Train - Average | | IEA-IUC - Railway handbook 2015-16 | IEA-IUC - Railway handbook 2015-16 | |
| Train - Diesel | | IEA-IUC - Railway handbook 2015-16 | IEA-IUC - Railway handbook 2015-16 | |
| Train - Electric | | Base carbone (Wd) | DBEIS (2016) | |
| Plane | | Inland waterway and Ferry : estimated modal mix breakdown | Base carbone (Wd) | DBEIS (2016) |
| Short haul (< 1000 km) | | | | |
| Medium haul (1000-4000 km) | | | | |
| Long haul (> 4000 km) | Walking: nature.com 2017 | Base carbone (Fr) | Base carbone (Fr) | |
| Inland Waterways | | Base carbone (Fr) | Base carbone (Fr) | |
| Ferry | | Base carbone (Fr) | Base carbone (Fr) | |
| Walking | | | | |

| Mean of transport (existing fleet) | Source for GHG emissions | | |
|------------------------------------|---|--|---|
| Transport | Modal Mix | Fuel Upstream g CO ₂ / p.km | Fuel Usage (g CO ₂ / p.km) |
| Road transport | Railway handbook 2016 - based on EC (2015) and UIC (2015a) & Eurostat | Base Carbone | ICCT Roadmap - GCW 40t |
| Train | | | IEA - Railway handbook 2016 |
| - Diesel | | | |
| - Electric | | | http://eco-calculateur.aviation-civile.gouv.fr/decret.php |
| Plane | | | Eur. Energy Agency |
| Inland | | | |

| | | | |
|-----|--|--|--------------|
| Sea | | | ICCT Roadmap |
|-----|--|--|--------------|

Main sources of air quality data

| Mean of transportation (existing fleet) | Sources for air quality data |
|--|--|
| Car - Average | theicct.org (roadmap excel file) and calculation |
| Car - Diesel | |
| Car - Gasoline | |
| Car - Electric | |
| Car - Hybrid | |
| Car - LPG | |
| Motorbike | lcct.org |
| Bus & Coach - Average | theicct.org (roadmap excel file) and calculation |
| Bus - Diesel | |
| Coach - Diesel | |
| Tram & Metro | Base carbone (French) |
| Train - Average | Railway handbook 2015 |
| Train - Diesel | Railway handbook 2015 |
| Train - Electric | theicct.org |
| Plane | EMEP plane |
| Plane - Short haul | EMEP plane |
| Plane - Medium haul | EMEP plane |
| Plane - Long haul | EMEP plane |
| Inland waterway | STIF (environmental study) |
| Ferry | transportenvironment.org and calculation |



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WASTE FRAMEWORK

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1. Introduction

Waste is defined as unwanted material, substances or by-products. Global waste production is increasing with the growing population, the improvement of living standards and the globalisation of consumer society.

The waste framework is a high-impact intensity framework encompassing all types of non-radioactive waste and usually classified into three categories: hazardous or toxic, non-hazardous and inert:

- **Inert waste:** waste is recycled into new raw material, discharged in specific landfills, landfilled with other waste types or left untreated;
- **Non-hazardous waste:** waste is reused, recycled, treated for organic or energy recovery, discharged in a landfill or left untreated;
- **Hazardous waste:** waste is recycled, incinerated, inertized in specific landfills, landfilled with other waste types or left untreated.

The nuclear, radioactive waste issue is out of the present scope: it is integrated into the electricity framework. Waste management consists of the following steps:

- **Collection:** logistics, usually by truck
- **Sorting:** wide range of separation and preparation processes potentially supplying secondary raw materials producers or energy-intensive industries, such as cement production
- **Treatment:** wide range of solutions from reuse, recycling, and energy recovery to landfilling that may have positive impacts (e.g. recycled materials, saved energy) or negative ones (e.g. greenhouse gas emissions, land consumption, pollution of air, groundwater, aquifers or soil).



As illustrated above, the main environmental impacts of the waste industry occur after collection and largely depend on waste type and treatment category. Reuse and recycling contribute to the circular economy, reducing primary resource extraction and providing secondary materials. Landfilling with biogas recovery or incineration with energy recovery are both renewable sources of energy, but still contribute to GHG emissions. Landfilling without biogas recovery not only consumes land, but also generates significant amounts of GHG due to organic decomposition emitting large amounts of CH₄. Landfills can also be serious threats to ecosystems if not properly managed (risks include default in bottom barrier layer, lack of leachate treatment and more).

2. Main environmental issues

| Environmental stake | | Relevance along the value chain | | | Comments |
|---------------------|-----------------------------|---------------------------------|------------------------------|--------------------------|---|
| | | Upstream | Direct | Downstream | |
| Climate | Climate change | Significant impact intensity | High impact intensity | Limited impact intensity | GHG emissions are related to waste collection but to a limited extent. Half of incinerated waste is petrol-based (plastics). Landfill without biogas recovery has also a strong impact on climate change. |
| | Use of energy resources | Significant impact intensity | High impact intensity | Limited impact intensity | Waste collection energy. Fossil based material in landfills = worst case |
| Air quality | Air quality deterioration | Significant impact intensity | Significant impact intensity | Limited impact intensity | Diesel trucks for collection generate air pollutants, e.g. particulate matters. With stricter pollution regulations in developed countries, impact of waste incineration is reduced |
| Water | Water consumption | Limited impact intensity | Significant impact intensity | Limited impact intensity | Water is usually recovered |
| | Water pollution | Significant impact intensity | Significant impact intensity | Limited impact intensity | Pollution due to water runoff at any waste disposal |
| Biodiversity | Soil pollution | Limited impact intensity | Significant impact intensity | Limited impact intensity | Significant impact on soil on the landfill lifecycle or of smoke purification residues disposal |
| | Land use | Limited impact intensity | High impact intensity | Limited impact intensity | Significant for landfills |
| Resources & waste | Use of non-energy resources | High impact intensity | High impact intensity | Limited impact intensity | Directly related to the amount of materials that are not recovered |
| | Waste | High impact intensity | High impact intensity | Limited impact intensity | Inherent to the sector |

Legend

- High impact intensity
- Significant impact intensity
- Limited impact intensity

The three main environmental issues that arise for the waste industry are climate (GHG), resource (and waste itself) and biodiversity (land use and soil pollution). Nevertheless, the only accessible and measurable information are, in the best cases, geography, waste type and waste treatment category: a quantitative approach of waste treatment volumes is then combined with a qualitative approach of waste treatment category and geography.

3. Environmental performance indicators

The NEC methodology uses a norm-based, qualitative approach per geography and per treatment category for each waste type. The three commonly used types of non-radioactive waste are:

- **Inert waste:** waste that will not decompose or burn such as gravel, sand and stone
- **Non-hazardous waste:** non-inert and non-hazardous waste
- **Hazardous waste:** waste that has one or more hazardous properties as listed in Annex III of the Waste Framework European Directive¹:

| Hazardous properties | |
|----------------------|--|
| HP1 | Explosive |
| HP2 | Oxidising |
| HP3 | Flammable |
| HP4 | Irritant – skin irritation and eye damage |
| HP5 | Explosive |
| HP6 | Oxidising |
| HP7 | Flammable |
| HP8 | Irritant – skin irritation and eye damage |
| HP9 | Specific target organ toxicity (STOT)/aspiration toxicity |
| HP10 | Toxic for reproduction |
| HP11 | Mutagenic |
| HP12 | Release of an acute toxic gas |
| HP13 | Sensitising |
| HP14 | Ecotoxic |
| HP15 | Waste capable of exhibiting a hazardous property listed above not directly displayed by the original waste |

Waste treatment solutions are categorized following the European waste four-level hierarchy (from best to worst), to which a fifth level of non-compliance has been added:

1. **Reuse**
2. **Recycling or recovery of organic waste by return to the ground**
3. **Energy recovery**
4. **Disposal (landfill)**
5. **Non-compliant treatment, such as illegal storage or prohibited exportation**

Reuse and recycling are set as eco-solutions with a NEC of +100%, as they convert waste into secondary materials, thereby circumventing the greater environmental costs of raw material production.

Other waste treatment solutions are considered to have less of an impact if environmental actions like energy recovery are in place.

¹ Waste Framework Directive 2008/98/EC and 2014/955/EU: Commission Decision of 18 December 2014 amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC

For waste that is not recyclable such as many hazardous wastes and medical waste, the environmental challenge is to neutralize detrimental effects. Actions to treat these specific waste products are therefore considered significant contributors to the environmental transition, as well as upstream collection and regrouping activities.

A meaningful NEC calculation would require a breakdown of a company's turnover by segment, by type of treatment and by type of waste, as well as the resulting environmental benefits of each waste management step. As this kind of information is rarely disclosed or otherwise accessible, the approach mainly relies on default NEC values.

4. Default NEC per treatment solution

4.1. Inert Waste

As inert waste has a limited impact compared to no-inert, the NEC rating is limited to a -25% to +25% range with:

- **Reuse, Recycling : NEC = +25%.** Inert waste is transformed into raw material and contributes to the circular economy.
- **Landfilling in dedicated inert landfills:** NEC = 0%. This is most used way and stands for the 0% average. As many inert wastes can be reused directly or upon recycling, disposing of them directly into dedicated landfill is a lost opportunity cost (but still better than using non-dedicated landfill).
- **Landfilling in non-dedicated inert landfills:** NEC = -25%. Disposing inert waste in non-dedicated landfills is mixing them with non-hazardous or hazardous waste: it generates a waste of land and an extension of environmental damage potential.

4.2. Non-hazardous waste

The following table presents the breakdown of non-hazardous waste management solutions in Europe in 2014². Options are ranked according to the "Article 4 of Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives. The following waste hierarchy should be the priority order for waste prevention and management legislation and policy:

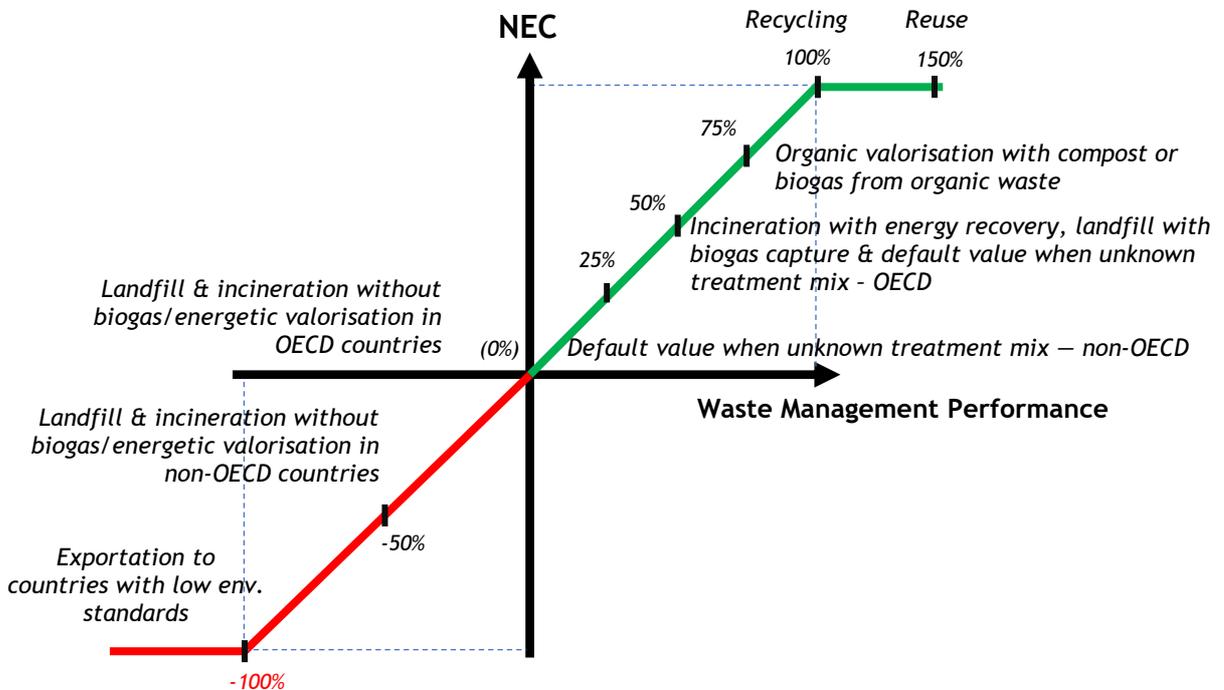
- (a) **Prevention**
- (b) **Preparing for re-use**
- (c) **Recycling**
- (d) **Other recovery (e.g. energy recovery)**
- (e) **Disposal**

The NEC scale is set with 100% assigned to prevention, waste reuse and recycling and 0% corresponding to the most commonly used treatment method – landfills. When the treatment solution mix is unknown, the default NEC is still positive, as waste treatment has a positive impact on the environment.

² Eurostat, Waste statistics, Waste treatment 2014.

| Treatment solution | Detailed type | Typical waste breakdown (in % of tons) ³ | NEC for high standard or OECD countries | NEC for non-OECD countries or unknown |
|-------------------------------------|--|---|---|---------------------------------------|
| Reuse | Reuse | ~ 0% | +100% | +100% |
| Recycling and organic valorisation | Recycling | 39% | +100% | +100% |
| | Organic valorisation (i.e. biogas, fertilizer) | 11% | +75% | +75% |
| Energy recovery | Incineration with energy recovery | 5% | +50% | +50% |
| Disposal/landfill | Landfill with biogas capture | 44% | +50% | +50% |
| | Landfill without biogas capture (by default) | | 0% | -50% |
| | Incineration without energy recovery | 2% | 0% | -50% |
| Non-compliant treatment | Any | | -100% | -100% |
| Collection or unknown treatment mix | Default value | | +50% | +25% |

Because standards in OECD countries are usually higher, activities occurring in OECD countries are used as a proxy for higher treatment performances. A lower default NEC is thus given to non-OECD countries, as environmental regulations regarding landfills and post-combustion fumes are usually less strict and/or less likely to be enforced.



Practical tip to get the split of waste treatment

When the required information is not directly available in a company's annual or sustainability report, a ratio may be calculated via the volumes table, as illustrated below for Suez's waste branch:

In the waste sector, in 2016, the Group treated nearly 41 million metric tons of waste. Through its waste collection activities, it served over 400,000 customers in services and industry and some 34 million people.

| TOTAL | | | | | | | | |
|---|--|----------------------|---------|------------|------------|------------|------------|------------|
| Total waste treated | | t | G4-EN23 | 44,403,767 | 40,587,456 | 40,776,345 | 39,403,953 | 41,411,826 |
| WASTE COLLECTION SERVICES | | | | | | | | |
| Number of inhabitants receiving collection services | | Number | G4-9 | 49,292,436 | 52,276,940 | 36,216,532 | 33,945,986 | 33,724,081 |
| Number of industrial and commercial customers receiving collection services | | Number | G4-9 | 466,275 | 417,349 | 410,077 | 400,227 | 397,922 |
| Total tonnage of household and similar waste collected | | t | G4-EN23 | 11,582,456 | 10,507,863 | 9,629,682 | 10,074,889 | 9,233,408 |
| Total tonnage of medical waste collected | | t | G4-EN23 | 159,954 | 149,847 | 134,704 | 134,992 | 149,018 |
| Total tonnage of industrial and commercial waste collected | | t | G4-EN23 | 14,002,761 | 11,988,447 | 11,425,490 | 10,617,434 | 11,203,284 |
| Tonnage of hazardous waste collected | | t | G4-EN23 | 1,186,878 | 1,083,568 | 1,186,399 | 1,083,570 | 1,688,645 |
| Total number of waste collection, cleaning, and wastewater treatment trucks | | Number | G4-EN30 | 12,174 | 12,545 | 12,271 | 11,967 | 11,448 |
| Percentage of the truck fleet running on alternative fuels | | % | G4-EN30 | 4.7 | 2.9 | 8 | 11 | 8.78 |
| Average diesel fuel consumption per truck ⁽¹⁾ | | m ³ /num. | G4-EN5 | 14.6 | 15 | 14.2 | 14.9 | 9.25 |
| Average diesel fuel consumption per ton collected | | l/t | G4-EN5 | 7.4 | 6.7 | 7.5 | 6 | 3.8 |
| SORTING AND RECYCLING BUSINESSES | | | | | | | | |
| Number of sites operating in the transfer of waste | | Number | G4-9 | 270 | 385 | 332 | 336 | 319 |
| Number of sites operating in sorting/recycling | | Number | G4-9 | 373 | 349 | 362 | 356 | 473 |
| Tonnage of recovered materials from sorting centres | | t | G4-EN23 | 8,781,841 | 8,568,410 | 7,954,843 | 10,468,000 | 10,377,442 |
| Volume of raw materials from recycling | | t | G4-EN23 | NC | 3,500,000 | 4,101,701 | 4,707,664 | 3,948,011 |
| COMPOSTING ACTIVITIES | | | | | | | | |
| Number of composting facilities | | Number | G4-9 | 128 | 123 | 127 | 121 | 107 |
| Incoming tonnage | | t | G4-EN23 | 2,081,652 | 2,209,965 | 2,041,291 | 1,786,805 | 2,222,970 |
| Tonnage of compost produced | | t | G4-EN23 | 847,401 | 901,538 | 916,963 | 853,797 | 792,079 |
| Tonnage of sewage sludge treated for material recovery | | t | G4-EN23 | 573,197 | 569,970 | 513,281 | 120,413 | 121,888 |
| NON-HAZARDOUS WASTE THERMAL TREATMENT ACTIVITIES | | | | | | | | |
| Number of urban waste incineration plants | | Number | G4-9 | 48 | 46 | 44 | 45 | 40 |
| Tonnage of waste incinerated ⁽¹⁾ | | xx | t | 6,662,964 | 6,225,817 | 6,762,114 | 6,975,291 | 7,049,368 |

Several ratios can be extracted, such as 7.95 million tons/41 million tons = 19.5% of the total treated waste to recycling or 2.04 million tons/41 million tons = 5.0% of the total treated waste to composting.

Source: Annual report, Suez Environnement, 2016.

4.3. Hazardous waste

The treatment of hazardous waste has a net positive impact, as it prevents harmful waste from being released into the environment without being treated. The following table presents the breakdown of hazardous waste management solutions in Europe in 2014³ and the default NEC per treatment solution.

| Treatment solutions | Detailed type | Typical breakdown of tons in % | Default NEC high standard or OECD countries | Default NEC non-OECD countries or unknown |
|--|--|--------------------------------|---|---|
| Recycling | Mainly recycling (oils, solvents, acids, other) | 37% | 100% | 100% |
| Energy recovery | Incineration with energy recovery/ alternative fuel for cement | 8% | 100% | 100% |
| Disposal/ landfilling | Landfill without biogas capture/ inertization/ disinfection/ other | 49% | 100% | 50% |
| | Incineration without energy recovery | 6% | 50% | 25% |
| Non-compliant treatment | | | -100% | -100% |
| Collection or unknown treatment mix | Default NEC value (the worst case is the base case) | | +50% | +25% |

Because standards for waste treatment are usually higher in OECD countries, the default value are higher for operations located in OECD countries.

4.4. Waste collection

The NEC for waste collection activities is equal to the NEC of the associated treatment mix, as the final use always drives the NEC. A default NEC is estimated when treatment mix data is not available for hazardous and non-hazardous waste:

- +50% in OECD countries
- +25% in non-OECD countries

Default non-inert waste collection NEC are considered to be positive, as the waste industry prevents waste from being directly released into the environment. As inert waste has far much lower impact, default value is set at 0%.

³ Eurostat, Waste statistics, Waste treatment 2014.

5. Main limits

The NEC methodology uses one metric to reflect several environmental stakes; however, the lack of publicly available information, especially regarding the breakdown of turnover by type of treatment, is a handicap. Non-compliant activities such as illegal storage or illegal exportation of waste are unlikely to be ever disclosed in companies' reporting. Stringent field control, reinforced waste regulation and engagement with companies are the best route to obtain the required data on the long term. Meanwhile, the main limitation is therefore lack of data from operators, which leads to the use of default NEC values in most assessments.

6. Key data sources

| Data | Sources |
|---|--|
| Global waste production | http://www.worldbank.org/en/news/feature/2012/06/06/report-shows-alarming-rise-in-amount-costs-of-garbage What a waste, the World Bank, 2012 |
| Waste treatment ranking | EU waste management law, Directive 2008/98/EC on waste -19/11/08 |
| Hazardous waste | Waste Framework Directive 2008/98/EC and 2014/955/EU: Commission Decision of 18 December 2014 amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC |
| European waste treatment breakdown per type | http://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics/fr http://www.statistiques.developpement-durable.gouv.fr/fileadmin/documents/Produits_editoriaux/Publications/Datalab_essentiel/2017/datalab-essentiel-98-bilan-2014-production-dechets-mars2017.pdf |
| Circular Economy | https://www.circle-economy.com/ |



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WATER FRAMEWORK

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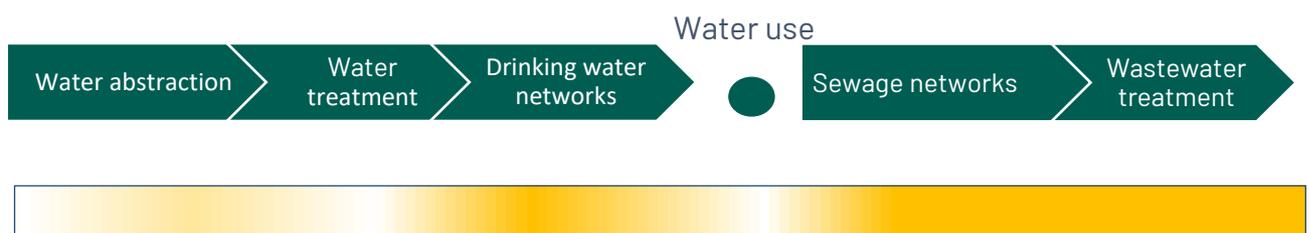
1.Introduction

Municipal and industrial water industry and more broadly water-related activities generate heavy freshwater abstraction but provide also water depollution solutions. This framework is a high impact category framework and is strongly related to biodiversity and water issues. The underlying physical unit is the cubic meter of water, m³.

Worldwide, agriculture accounts for 70% of all water consumption, compared to 20% for industry and 10% for domestic use¹. In industrialized nations, however, industrial and domestic uses consume more than half of the water available for human use. For instance, in Europe, more than 160 billion m³ of water are abstracted annually with an average breakdown of²:

- 44% for crop irrigation and livestock
- 41% for industry and energy production
- 15% for domestic use

The environmental impacts mainly occur upstream (water abstraction, management of land and water resource) and downstream (water discharge with impacts depending on the wastewater treatment performance, sludge treatment...).



¹ <https://www.worldometers.info/water/>

² Eurostat and <https://www.eea.europa.eu/themes/water/water-resources/water-use-by-sectors>

2. Main environmental issues

Main environmental impacts are assessed in the table below.

| Environmental stake | | Relevance along the value chain | | | Comments |
|---------------------|-----------------------------|---------------------------------|--------------------------|--------------------------|--|
| | | Upstream | Direct | Downstream | |
| Climate | Climate change | High impact intensity | High impact intensity | High impact intensity | Energy consuming processes and infrastructures |
| | Use of energy resources | Limited impact intensity | Limited impact intensity | Limited impact intensity | |
| Air Quality | Air quality deterioration | Limited impact intensity | Limited impact intensity | Limited impact intensity | |
| Water | Water consumption | High impact intensity | High impact intensity | Limited impact intensity | Water treatment plants abstract significant volumes of water from rivers and underground aquifers; water networks have leakages |
| | Water pollution | Limited impact intensity | High impact intensity | High impact intensity | Polluted water is treated before being released, with different quality standards |
| Biodiversity | Soil pollution | High impact intensity | Limited impact intensity | High impact intensity | In order to limit the degradation of the freshwater source, many water treatment companies try to convert their surrounding watershed farming into organic farming. Insufficient sludge treatment is a source of soil pollution. |
| | Land use | High impact intensity | High impact intensity | High impact intensity | Water treatment activities often occupy large areas |
| Resources & Waste | Use of non-energy resources | Limited impact intensity | Limited impact intensity | Limited impact intensity | |
| | Waste | High impact intensity | High impact intensity | High impact intensity | Important quantities of sludge (and other water and wastewater treatment effluents) have to be treated |

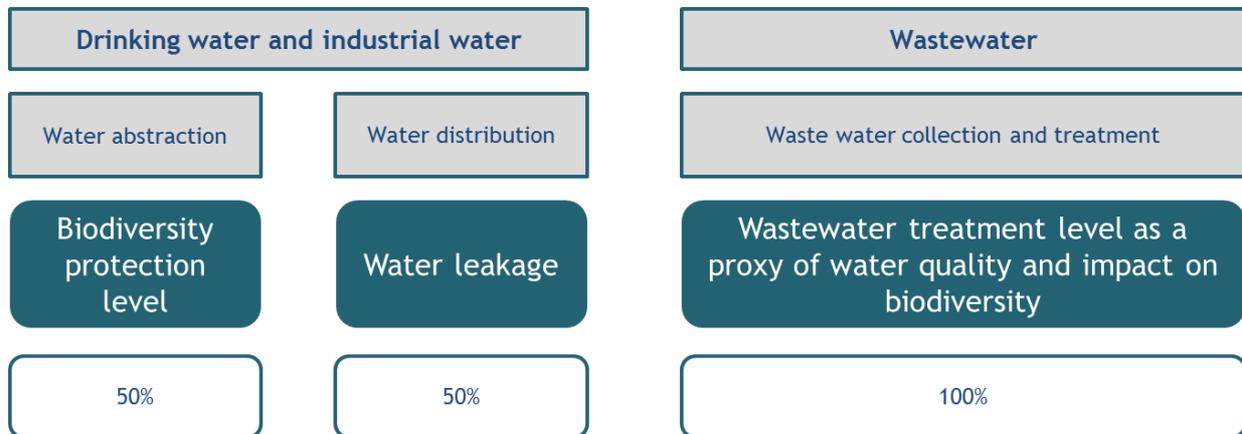
Climate change, water consumption, land use and waste management are the main environmental issues that are both key for the industry and measurable at company level. However, given the low level of company disclosure on environmental issues, **the water framework relies on a simplified, qualitative, norm-based approach.**

| Legend | |
|--|------------------------------|
| | High impact intensity |
| | Significant impact intensity |
| | Limited impact intensity |

3. Environmental performance indicators

Polluted water is a significant threat to ecosystems and biodiversity. Treating wastewater before releasing it back into the natural environment as well as protecting water extraction areas from pollution are both essential practices to preserve ecosystems and water quality. Both drinking and industrial water plants abstract considerable volumes of water from rivers and underground aquifers. Consequently the following indicators have been selected to measure the Net Environmental Contribution (NEC) of the water industry regarding these two activities:

- **Biodiversity protection** for withdrawal and production of drinking and industrial water
- **Water losses** for water distribution
- **Water quality and biodiversity** for wastewater treatment



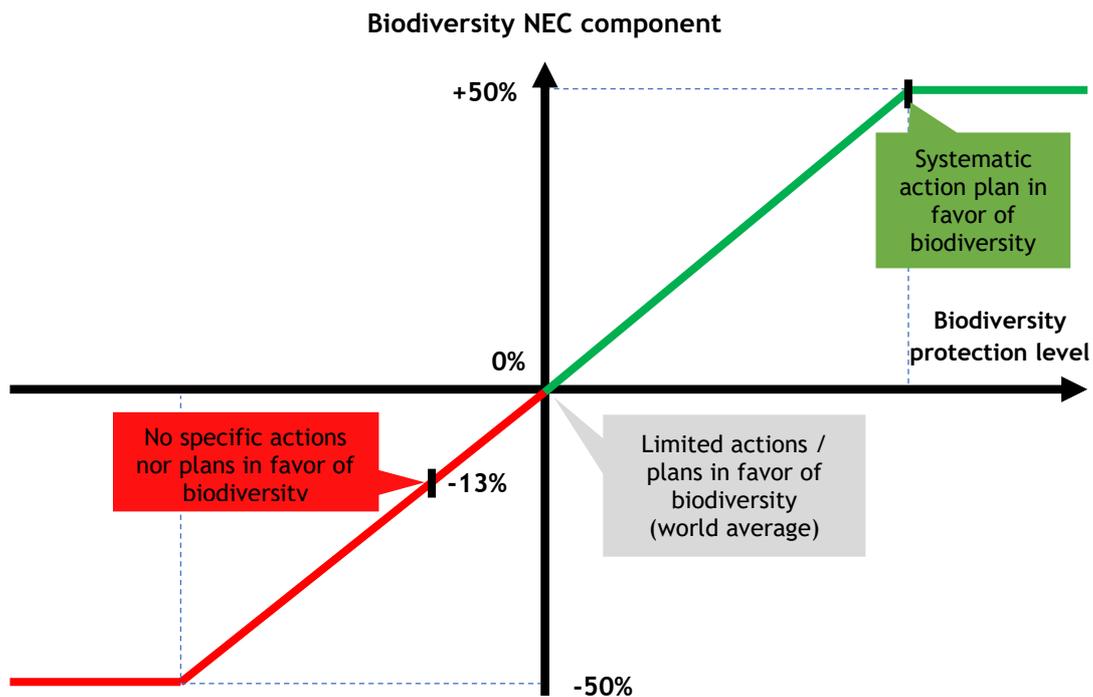
3.1. Specific water activities

3.1.1. Water abstraction

For water **withdrawal**, the main measurable environmental indicator is the level of biodiversity protection. Indeed, in order to reduce the costs of removing pesticides, nitrates and antibiotics, companies are encouraged to set up capture protection programs such as partnerships with farmers to develop organic agriculture, mechanical weeding, and more.

Consequently, the NEC Biodiversity component calculation is based on actions undertaken to protect ecosystems surrounding the abstraction point:

- **+50%** if a systematic action plan is set up to protect biodiversity, such as converting abstraction areas into organic farms or mechanical weeding
- **0%** if action plans are limited in scope or effective impact, which reflects the world average situation
- **-13%** if there is no specific action plan in place



Data availability and practical tips

Required information: Company action plan to protect biodiversity during water extraction

This information is often disclosed in a company's annual or sustainability reports. For instance, Suez devotes a section of its annual report to biodiversity and ecosystem protection, indicating that the company implements limited plans in favor of biodiversity but without any systematic actions. Consequently, their NEC component is set at 0%.

▶ 6.8.1.6 Protection of biodiversity and ecosystems

SUEZ acts to protect biodiversity for local authorities and industry. The Group's activities in offering water and waste treatment solutions limit the physical, chemical and biological impact that human activities would have on the environment, if not for the services provided by the Group. Furthermore, the Group is integrating in an increasingly systematic manner the issue of the conservation and enhancement of natural heritage into the environmental management processes of the sites it manages. This is accomplished through an inventory of the most sensitive sites in terms of biodiversity conservation, a

monitoring of the natural environment and the implementation of local action plans adapted to the features of the natural environment and the type of pressures exerted by facilities managed by the Group. SUEZ relies for this purpose on numerous expert partnerships with organizations specializing in natural protection; in France, this includes the *Muséum national d'histoire naturelle*, *France Nature Environnement*, and the *Ligue de Protection des Oiseaux*.

Commitment No. 3 of the 2012-2016 Group Sustainable Development Roadmap, "Improve the environmental footprint of our facilities and services", includes in its quantitative objectives "increasing the number of regulatory and voluntary action plans implemented at sensitive sites in or near protected areas".

Finally, SUEZ commitment plans for the National Biodiversity Strategy (NBS) were acknowledged by the French Minister of the Ecology, Sustainable Development and Energy in October 2014.

It is based on three objectives:

- ▶ promote a framework of internal actions that promote biodiversity;
- ▶ integrate biodiversity in Research and Innovation programs;
- ▶ share knowledge and contribute to public awareness campaigns.

The mid-term report on the Group's commitment for NBS was submitted to the Ministry in September 2016.

In addition, the Group is strongly committed to the subject of protection of the oceans and marine biodiversity through the formalization of a full-range offer for protecting coastlines, R&D work on processing micro-plastics in water treatment facilities and several expert partnerships, especially with UNESCO's International Oceanographic Commission.

Source: Suez Annual Report, 2016.

3.1.2. Water transport, storage and distribution

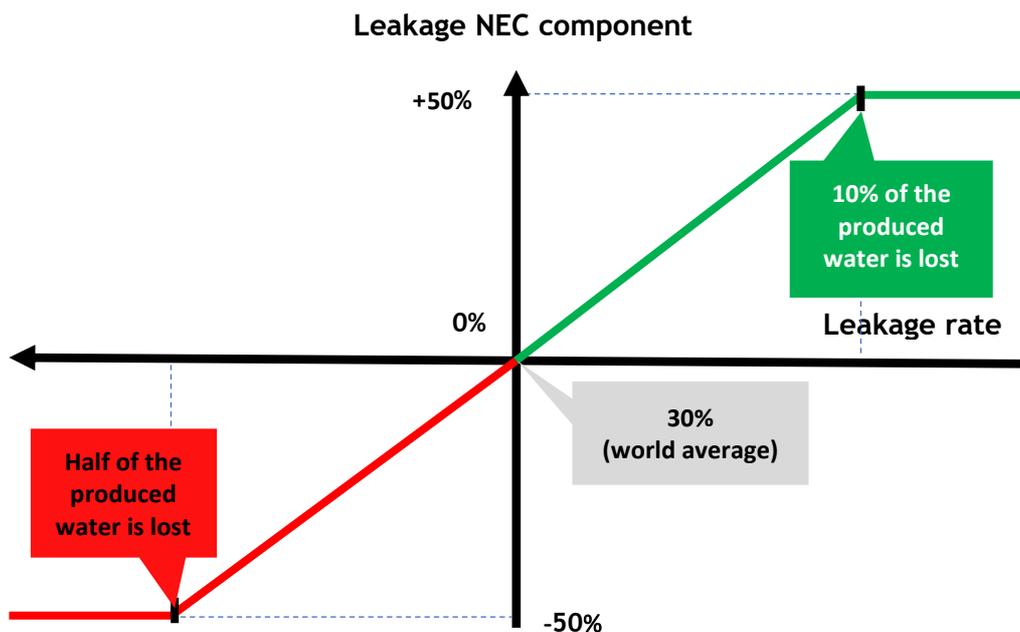
Concerning **water transport, storage and distribution**, the key performance indicator is preservation of the water resource in terms of quantity. Indeed, quality infrastructure and management can help limit water loss rate, thus contributing to the Energy and Environmental Transition by mitigating pressure on water resources. Water leakage is a substantial drain on network production, and can be reduced by promptly identifying leaks, repairing them and investing in network maintenance.

Consequently, the NEC Water Consumption Component is based on loss reduction efforts, as follows:

- **+50%** if the network loses water at a rate equal or less than 10%
- **0%** if the water leakage rate is equal to 30%, which reflects the world average
- **-50%** if the network loses water at a rate equal or greater than 50%

In practical terms, a leakage rate less than 5% is virtually impossible. Consequently, the +50% increment is attributed to companies with a leakage rate inferior to 10%.

Moreover, the World Bank estimates that, on average, 25-30% of a utility's water is lost in the network as non-revenue water (NRW). Consequently the 0% increment is set for a leakage rate of 30%, and the -50% increment to companies with a leakage rate inferior or equal to 50%.



Company data and practical tips

Required information: company's average water leakage rate

This information may be found in a company's annual or sustainability reports. Typically this information is not explicitly stated as the average water leakage rate but can be inferred from network performance rate.

For example, in Suez Environment's sustainability report (Integrated report, economic, environmental and social contribution), the company addresses the global environmental and technical performance of the drinking water networks of its four main subsidiaries.

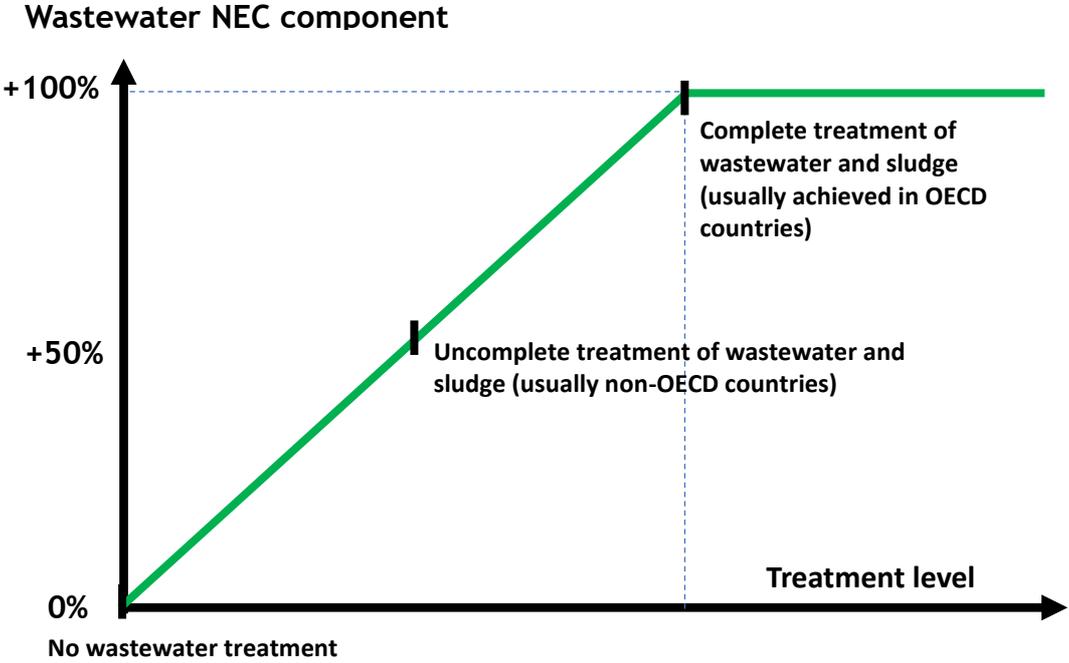
environmental performance at the heart of operational performance

In 2015, the Group's water activities made a significant contribution to the management efficiency of "smaller" urban water cycles. In terms of water supply, almost 1.7 million customers are now equipped with SMART meters, allowing them to control their usage; the overall technical performance of drinking water systems in the Group's four main subsidiaries (Water France, Agbar, SUEZ US and Lydec), despite the problems that arose on the Santiago de Chile distribution network, was once again above 77% for 2015, and the bacteriological compliance rate of water distributed continued at a level of excellence with regard to all local standards (in France it was 99.8%).

3.1.3. Waste water

Regarding **sanitation activities**, wastewater treatment is the key performance indicator concerning water quality and biodiversity. Whenever a company makes some efforts to collect and treat wastewater, it is considered as a positive contribution to the Environmental Transition as it preserves biodiversity and water quality; thus we assign a positive NEC. The more completely and consistently a company collects and treats wastewater and sludge, the higher its NEC. When poor or no treatment is provided, which is still often the case worldwide, there is no positive incremental NEC.

When specific information regarding wastewater management is not available, the level of wastewater management efficiency can be roughly approximated by distinguishing OECD from non-OECD countries, because in the latter, wastewater and sludge treatment level is lower.



Data availability and practical tips

Required information: performance of wastewater and sludge treatment or turnover in OECD countries

Wastewater and sludge treatment performance can be found in a company's annual or sustainability reports, as illustrated below from Veolia annual report 2016, where BOD₅ stands for Biological Oxygen Demand over 5 days and COD for Chemical Oxygen Demand.

Treatment efficiency of wastewater treatment plants with a population equivalent capacity of at least 100,000

| | 2014 | 2015 | 2016 | 2018 Objectives |
|---|-------|-------|----------|-----------------|
| BOD ₅ treatment efficiency (%) | 94.7% | 96.0% | 96.0%(√) | > 90% |
| COD treatment efficiency (%) | 90.2% | 91.4% | 91.5%(√) | > 85% |

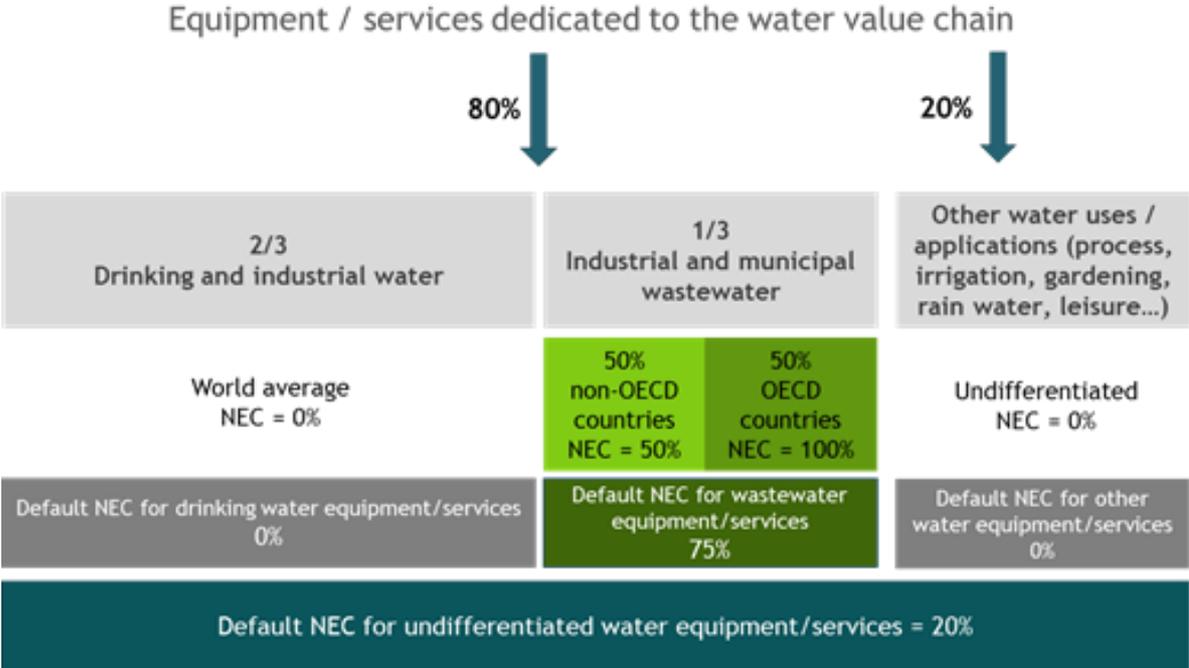
| SECTION | 2015 | 2016 |
|--|------|------|
| Percentage of sludge re-used (agricultural recovery) | 73 | 75 |

When performance indicators are not available or not usable, the default OECD and non-OECD NEC components are used.

3.1.4. Equipment manufacturers and service providers

For suppliers of equipment such as valves or pipes and services that do not provide a breakdown of end uses, it is assumed on world average that two-thirds of the equipment and services are used for drinking and industrial water and one-third are used in wastewater treatment. Based on this assumption, the default NEC are:

- For drinking and industrial water, NEC = 0% by definition
- For wastewater, NEC = 75%, as it is assumed that 50% is used in non-OECD countries with a default NEC of +50%, and 50% in OECD countries with a NEC of +100%.



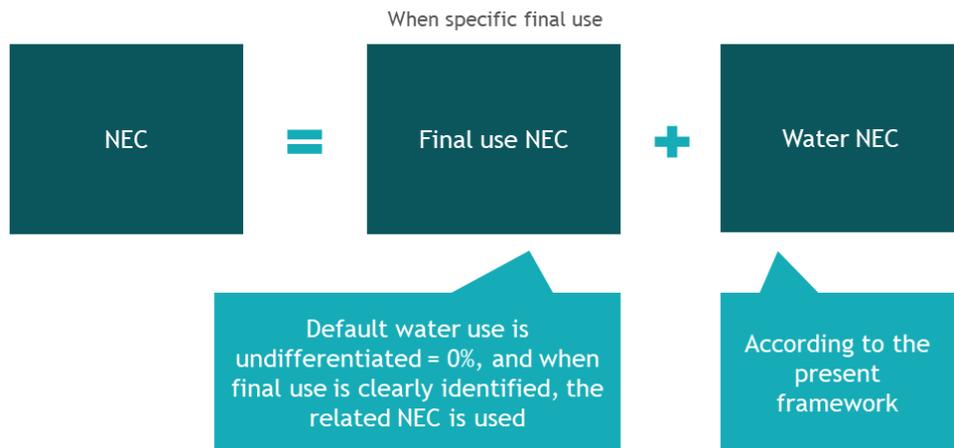
The default **NEC applied to equipment and service providers in the water value chain is therefore 20%** ((75%/3)*80%) for water-related equipment and services.

3.1.5. Water inside buildings

Providers of generic equipment and services that supply water to residential and non-residential buildings (i.e. for kitchens and bathrooms) are beyond the scope of the current methodology, as the quantification is generally uneasy and data are not available. Thus we apply a generic NEC of 0%, consistent with the building framework, unless there is sufficient information to quantify a significant environmental benefit (e.g. water or energy savings) or harm (overconsumption) and to convert into an incremental NEC.

3.1.6. Specific final use

For specific, well identified final uses, the NEC generic equation applies as illustrated below.



Example: industrial wastewater treatment of an oil refinery in a low water standard country



4. Main limits

The advantage of the 1.0 version is that it provides a rough, usable ranking of activities and companies operating in the drinking, industrial water and wastewater value chains despite the limited amount of publicly-available information.

Still, the ranking cannot be more than approximate unless companies disclose more usable and comparable data.

5. Key data sources

| Data | Sources |
|--------------------------------------|--|
| Water abstraction and use by sector | http://ec.europa.eu/eurostat/statistics-explained/index.php/Water_statistics/fr https://www.eea.europa.eu/themes/water/water-resources/water-use-by-sectors |
| Tokyo water leakage rate | C40 Cities, "Tokyo, World Leader in Stopping Water Leakage" http://www.c40.org/case_studies/tokyo-world-leader-in-stopping-water-leakage |
| Average utilities water leakage rate | Waste & Water International, "Water Leakage? Look to the clouds" http://www.waterworld.com/articles/wwi/print/volume-27/issue-2/editorial-focus/municipal-water-systems/water-leakage-look-to.html |

WOOD & PAPER FRAMEWORK

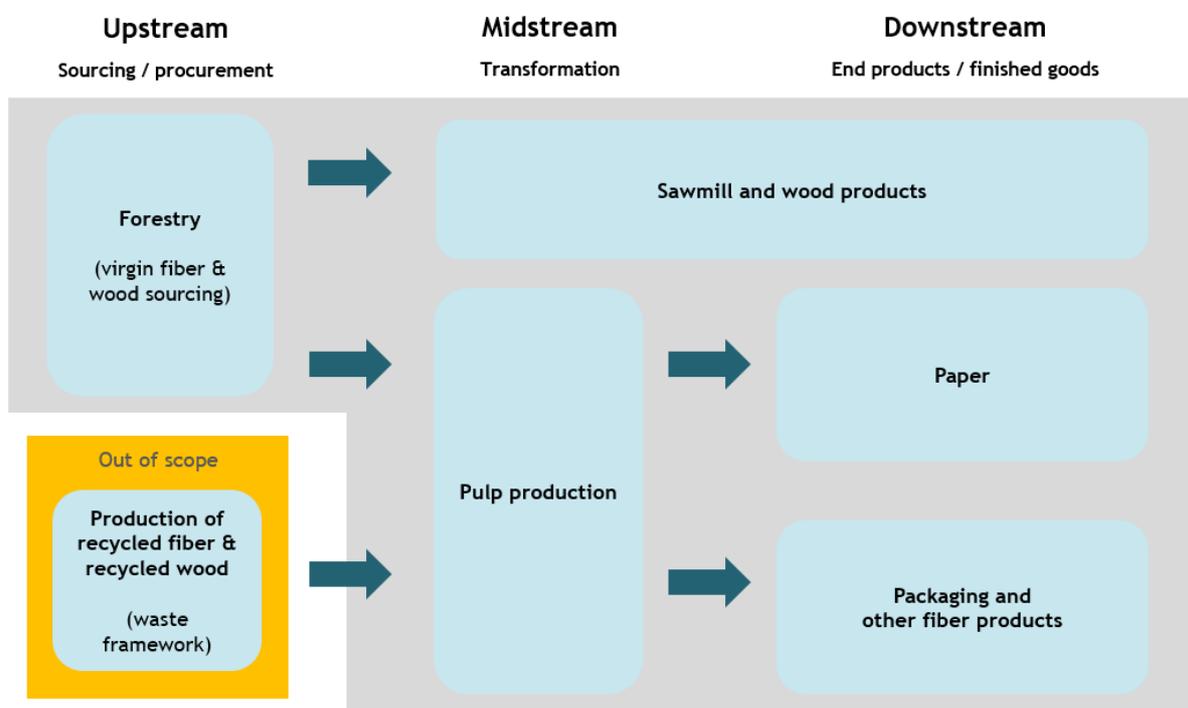
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1. Introduction

The wood & paper value chain has a significant global environmental impact, primarily due to the logging industry and the wood resources it requires. Logging significantly contributes to deforestation, particularly in tropical zones where forests are illegally exploited. Given this, certification is one method of monitoring and promoting sustainable forest management, even though only certifications account for only 2.3% of global forest area¹. For instance, the Forest Stewardship Council (FSC), the most globally recognised label, includes certified forests in 82 countries and more than 32 000 companies (e.g. forestry companies, industries and retailers), that guarantee traceability of their products.

Four main activities in the wood & paper value chain are included in this framework: forestry; pulp production and paper; sawmill and wood products; and packaging and other fiber products. However, only 12% of global wood-producing forests are certified, according to the WWF².



2. Main environmental issues

Environmental issues differ among the various activities in the wood & paper value chain. For instance:

- The logging industry is a major contributor to deforestation and, subsequently, to the degradation of ecosystems and biodiversity.
- Pulp and paper production requires high levels of water and energy consumption. Production uses two types of energy – electricity to power machinery, and heat for cooking or drying.

¹ Source: Office National des Forêts (French national forestry board)

² Source: WWF website (<https://www.wwf.fr/champs-daction/foret/approvisionnement-responsable/bois>)

- The fabrication process requires significant quantities of water, as water is the substrate of fibers during the fabrication process. Water pollution is also a major issue, with severe pollutants like chlorine historically used as bleaching agents. Today, new bleaching techniques use a derivative of chlorine or are chlorine-free, but still require the use of other additives (optical brighteners, halogenated products, etc.).

| Environmental stake | | Relevance along value chain | | | Comments | Data availability |
|---------------------|-----------------------------|------------------------------|------------------------------|------------|--|--|
| | | Upstream | Midstream | Downstream | | |
| Climate | Climate change | High impact intensity | High impact intensity | | The paper manufacturing industry is responsible for 1% of global greenhouse gas emissions and is also identified in the Science Based Targets Initiative as a carbon-intensive sector. Deforestation is also a potential threat if forest resources are not exploited in sustainable ways. 250 000 hectares of tropical forest disappear each week around the world. In France, 10% of used paper comes from suspicious sources. | Paper production GHG intensity often available, deforestation information mostly based on label requirements |
| | Use of energy resources | | Significant impact intensity | | Pulp & paper manufacturing is an energy-intensive process that uses both heat (usually own boilers) and electricity. | No available data |
| Air Quality | Air quality deterioration | | Significant impact intensity | | Combustion of fossil fuels for paper manufacturing potentially generates SO ₂ and NO _x emissions | No available data |
| Water | Water consumption | | High impact intensity | | Pulp and paper manufacturing is a water-intensive process; the paper industry is the second largest water consumer in Europe (<i>European Commission</i>). | Primarily based on label requirements |
| | Water pollution | | High impact intensity | | Pulp and paper manufacturing processes use chemical products (chlorine as a bleaching agent, for instance). | Primarily based on label requirements |
| Biodiversity | Soil pollution | | | | Limited impact | |
| | Land use | High impact intensity | | | Forests represent 80% of terrestrial biodiversity. 27 000 animal and vegetal species disappear each year because of deforestation (FAO). | No easily accessible data available |
| Resources & Waste | Use of non-energy resources | Significant impact intensity | Significant impact intensity | | Though wood is a renewable resource, deforestation may deplete the stock of wood essences and of biomass: recycling can help reduce this impact. | Primarily based on labels requirements |
| | Waste | | | | Limited impact | |

The primary environmental stakes that stand out as key and are modelled by certification schemes that include weight (in tonnes) as a physical unit are **Climate**, **Biodiversity** and **Water**.

| | |
|---|------------------------------|
|  | High impact intensity |
|  | Significant impact intensity |
|  | Limited impact intensity |

3. Environmental performance indicators

As introduced above, this framework encompasses four main activities in the value chain:

- **Forestry management performance**
- **Pulp production and paper**
- **Sawmill and wood products**
- **Packaging and other fiber products**

To quantify the impact of each of the environmental issues, the Net Environmental Contribution (NEC) is calculated using the sum of two NEC components:

- **Final use NEC:** reflects environmental impacts related to wood & paper final usage
- **Incremental NEC:** reflects environmental impacts of the production of wood, pulp production and paper, sawmill and wood products, packaging and other fiber products

Specific indicator values depend on the position in the wood & paper value chain and related environmental issues:



Focus on certification

Procurement is an issue across the entire wood & paper value chain, from forestry to fiber product manufacturing. Wood certifications are one of the most efficient ways to monitor sustainable forest management and procurement. Three main certifications are used for wood and wood products:

- **Forest Stewardship Council (FSC)**

- **Program for the Endorsement of Forest Certification (PEFC)**
- **Sustainable Forestry Initiative (SFI)³**

PEFC and SFI certifications are usually relatively close, with less stringent requirements than what is required for FSC certification.

All three certification systems can be applied to **forest management** or **chain of custody**.

- Forest management takes place **at the level of the forest itself, and monitors procurement issues related to forestry activities in the wood & paper value chain**. For instance, timber can earn a FSC label if an independent inspection guarantees the timber is from a well-managed forest, (i.e. it's compliant with the sustainable forest management criteria). PEFC/SFI and FSC differ slightly in their level of requirements:
 - FSC certification is more commonly given for exotic and distant woods, whereas PEFC/SFI is more prevalent for European/North American woods or temperate zones.
 - FSC certification and control criteria are more stringent. Notably, FSC certification requires an audit, whereas PEFC only requires a statement of intent.
- Chain of custody takes place **at the company level, the level used to rate procurement issues for other parts of the wood & paper value chain** and to ensure that timber products are followed through all stages of processing and distribution. It *“ensures that FSC materials and products have been checked at every stage of processing so that customers purchasing FSC labelled products can be confident that they are genuinely FSC certified”³*. There are several levels of certification, taking into account what proportion of recycled materials or percentage of fiber/wood is certified. When a company only discloses “chain of custody”, the weaker certification level is used. For instance, for “FSC chain of custody”, the FSC mix level is used.



(Sources: FSC, PEFC and SFI websites)

Figure 1: Forestry and wood procurement certifications, I Care & Consult analysis

³ Sources: FSC website (<https://www.fsc.org/>), PEFC website (<https://www.pefc.org/>), SFI website (<http://www.sfi-program.org>)

3.1. Forestry-related activities



3.1.1. Final use NEC

Wood is primarily used in four sectors: building; furniture; pulp, paper and packaging; and fuel (heat). A final use NEC for generic wood is calculated based on wood volumes (in tonnes) for each sector, multiplied by the final use NEC in the corresponding frameworks. For instance, the building sector uses 23%⁴ of wood volume (worldwide average in tonnes, 2016). In the building framework, generic wood structures are scored at 25% NEC. As shown in the graph below, the calculated generic NEC of wood is 22%. If no other information is available detailing the use of the wood produced by a company in the “forestry” segment, a 22% final use NEC is applied. Otherwise, if the specific final use is provided, a more accurate NEC is calculated via the split of final uses or end markets (e.g. forestry segment for construction → 25%).

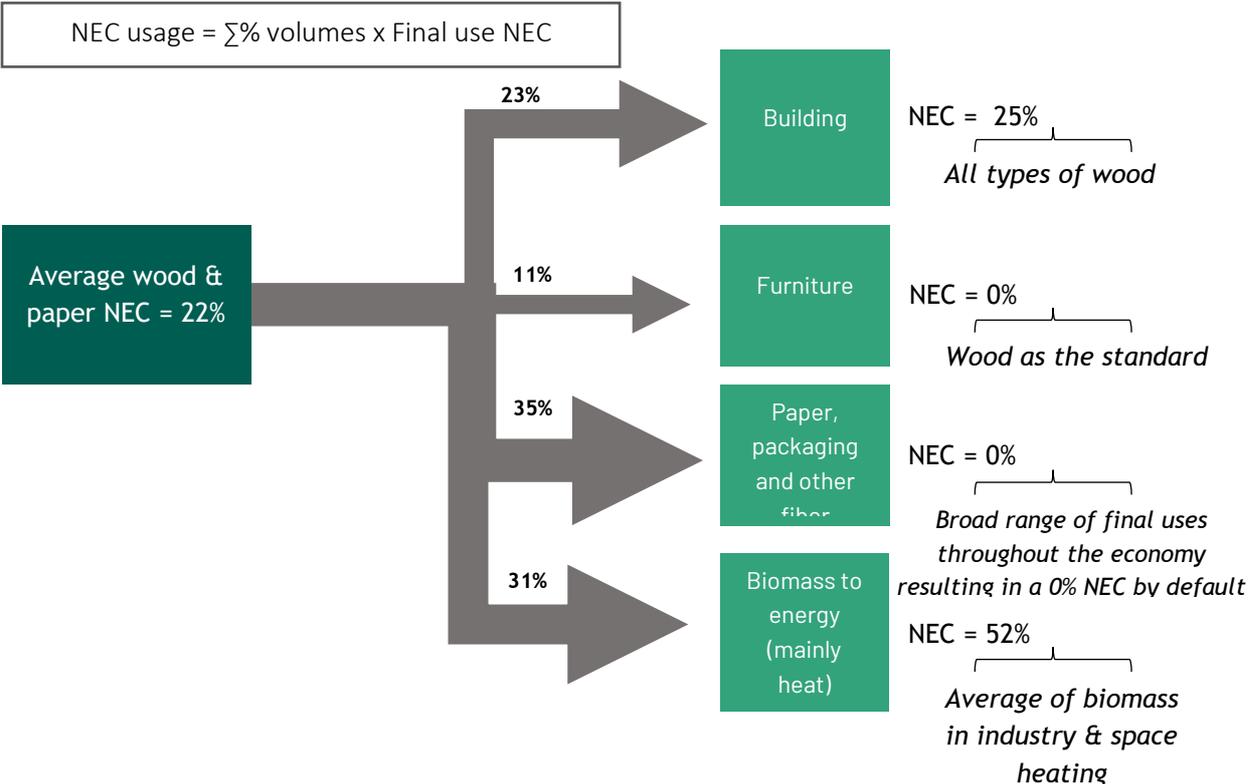


Figure 2: Wood & paper final use NEC calculation. Sources: FAOSTAT-Forestry 2016 database, I Care & Consult analysis

3.1.2. Incremental forestry management NEC

As previously explained, a proxy for forest management performance can be used for forest certifications. Performance levels are listed below:

- **FSC-certified forest:** FSC certification certifies forest management

⁴ Source: FAOSTAT-Forestry 2016 database (<http://www.fao.org/faostat/en/#data/FO>)

- **PEFC or SFI-certified forest:** like the FSC certification, SFI and PEFC certify forest management but are considered less stringent based on their requirements and have a lower NEC.
- **Certified controlled wood:** controlled wood is material from acceptable sources that can be included as part of a FSC mix label with other certified materials.
- **No certification:** if no certification is available for a company, country risk is analysed (described below). A company with no certification in standard countries is assigned a -50% NEC, whereas a company with no certification in risky countries is assigned a -100% NEC.
- A company whose forests are FSC certified and have additional guarantees related to forest management is assigned a 100% NEC.

For forestry management companies, country risk is assessed using the Global Forest Registry, a tool developed by FSC, Rainforest Alliance and NEPCo⁵. The registry covers more than 150 countries for parties that want to exercise due diligence when sourcing raw materials. The registry is based on the FSC Controlled Wood definition of unacceptable sources and provides information about risks for each of the five controlled wood categories. Completed FSC Controlled Wood National Risk Assessments are used as the basis for the Registry's risk categorisations.

Another tool launched in 2010 by the Forest Legality Alliance with support from the World Resources Institute (WRI), Environmental Investigation Agency (EIA) and the U.S. Agency for International Development (USAID) aims to reduce illegal logging. This Risk Tool⁶ helps users ask informed questions about where forest products are from and what issues buyers might encounter, with information about forest products and legality categorised by country and by species. The tool precisely details each country's issues and risks.

Primary high risk countries and regions are:

- Indonesia
- China
- West and Central Africa
- Asia (excepted Malaysia and Japan)
- Latin America

⁵ Source: <http://globalforestregistry.org/map> (a new registry is under construction)

⁶ Source: <http://www.forestlegality.org/risk-tool>

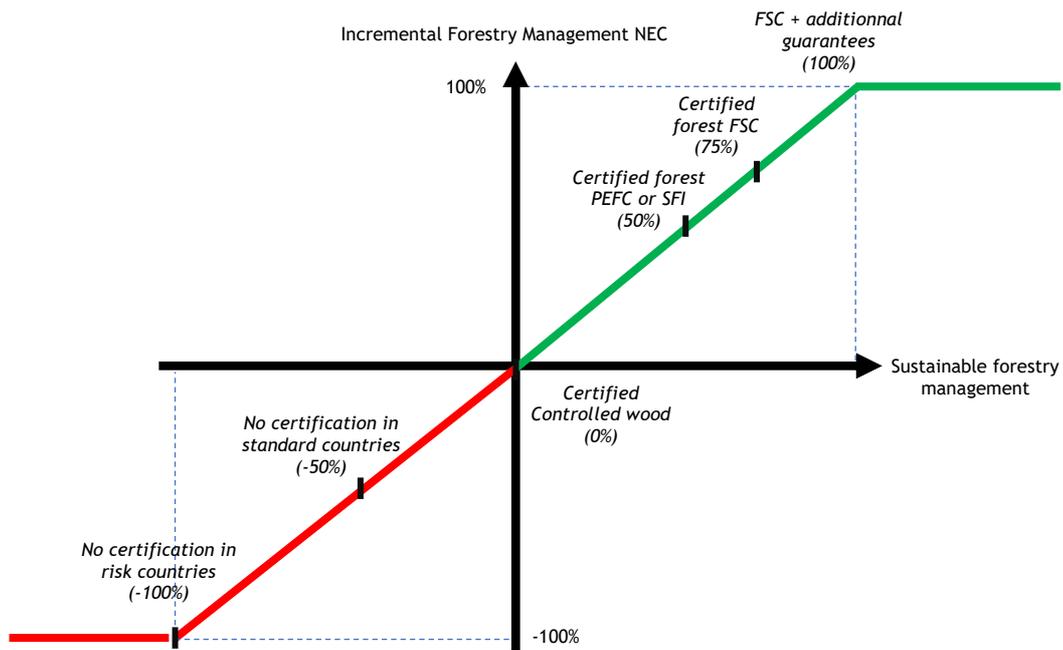


Figure 3: Incremental forestry management performance NEC

Data availability and practical tips

Information needed: breakdown of value chain sub-activities + country of wood production + certification

Breakdown of value chain sub-activities

This breakdown from Mondi, includes five sectors: packaging paper, fiber packaging, consumer packaging, uncoated fine paper, South Africa division. Since each sector's turnover is available, sub-sectors can easily be found as well as their respective breakdowns, assuming they have the same weight. Below is an example of information from Mondi's activity report:

| Packaging Paper | Fibre Packaging | Consumer Packaging | Uncoated Fine Paper | South Africa Division |
|-----------------|-----------------|--------------------|---------------------|-----------------------|
| Segment revenue | | | | |
| €2,056m | €1,929m | €1,562m | €1,246m | €594m |

Country of wood production and forest management certification:

Detailed country of wood production may be difficult to find; however, many companies describe any forest certification commitments with regards to risk countries in their sustainable development reports.

As an example, Mondi Group's 2016 sustainable development report describes:

"In 2016, 67% of our total procured wood was certified to FSC or PEFC™ (2015: 66%), with 81% of our externally procured pulp from FSC or PEFC™ certified sources (2015: 77%)."

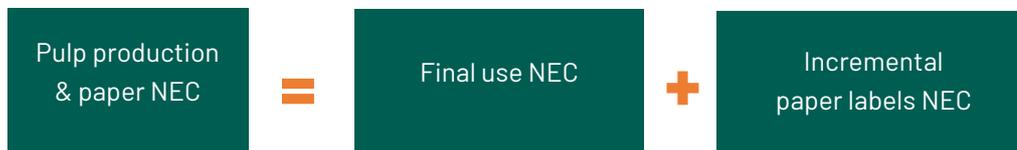
"We maintain FSC and ISO 14001 certification of all our owned and leased forests. For all wood that is not procured from our own forests, we prefer to source from credibly certified fiber and, where it's not possible, we ensure all non-certified wood and fiber products we procure comply with the standard for Controlled Wood (FSC-STD-40-005) as a minimum. This means that no wood or virgin fiber that we source, or that is contained in our products, comes from controversial sources, is harvested illegally or in violation of civil rights, or comes from forests with threatened

HCV areas or that are being converted to non-forest areas. In the countries we consider high-risk, we look to source wood from FSC certified forests.”

More precise values can be found in the consolidated performance data:

| | | | | | |
|---|-----------|-----------|-----------|-----------|-----------|
| Fibre use | 2012 | 2013 | 2014 | 2015 | 2016 |
| Wood (internal and external) (million m ³) | 16.2 | 16.4 | 16.3 | 16.4 | 16.6 |
| Pulp (externally procured) (million tonnes) | 0.5 | 0.4 | 0.4 | 0.3 | 0.4 |
| Paper for recycling (million tonnes) | 1.5 | 1.4 | 1.5 | 1.4 | 1.3 |
| Fibre procured from FSC or PEFC™ certified sources 2016 (%) | | | FSC | PEFC™ | Total |
| Wood | | | 46 | 21 | 67 |
| Pulp (procured externally) | | | 67 | 14 | 81 |
| Certified wood procured (%) | 2012 | 2013 | 2014 | 2015 | 2016 |
| FSC | 46 | 47 | 46 | 45 | 46 |
| PEFC™ | 19 | 19 | 20 | 21 | 21 |
| Total | 65 | 66 | 66 | 66 | 67 |

3.2. Pulp production & paper activities



3.2.1. Final use NEC

The final use NEC for paper is a 0% default NEC.

3.2.2. Incremental paper labels NEC

In the paper production process, environmental impacts include water pollution in addition to wood procurement issues. Sustainability also means eco-design choices: recycling plays an important role in the sector’s sustainability efforts, as paper can be recycled up to five times. Taking all of this into account, the scope of certifications available for paper is wider. Along with the three certifications described earlier, specific certifications like Blue Angel also exist for paper.

To responsibly choose a paper, then, certifications that both validate water measures (e.g. Blue Angel, European Ecolabel, Nordic Swan), as well as labels guaranteeing the use of recycled fibers or fibers from sustainably managed forests such as the FSC certification are favored. The NEC of these certifications is calculated based on three parameters that correspond to paper’s main environmental impacts:

- **Integration of recycled raw material:** recycled materials are considered as part of PEFC, SFI and FSC certification criteria, with « PEFC recycled », « SFI recycled » or « FSC recycled » levels of certification. NEC for each certification is based on requirement levels.
- **Forestry management:** NEC for each certification aligns with forestry management obligations. The best NEC is given to certifications that require conservation and/or restoration of ecosystems and that correct or limit negative environmental impacts (FSC 100%). If there is only a criterion for minimum wood quantity from certified forests, the NEC is 50%.

- **Water pollution:** certification requirements organized by limits on hazardous substances rejected during the manufacturing process are ranked below:

| Certification type | NEC |
|---|------|
| Non available | 0% |
| Means objectives | 25% |
| Results objectives: some substances forbidden or limited | 50% |
| Results and means: most dangerous substances are forbidden + limits (sometimes demanding ones) are placed on other substances | 75% |
| Results and means: highly demanding limits | 100% |

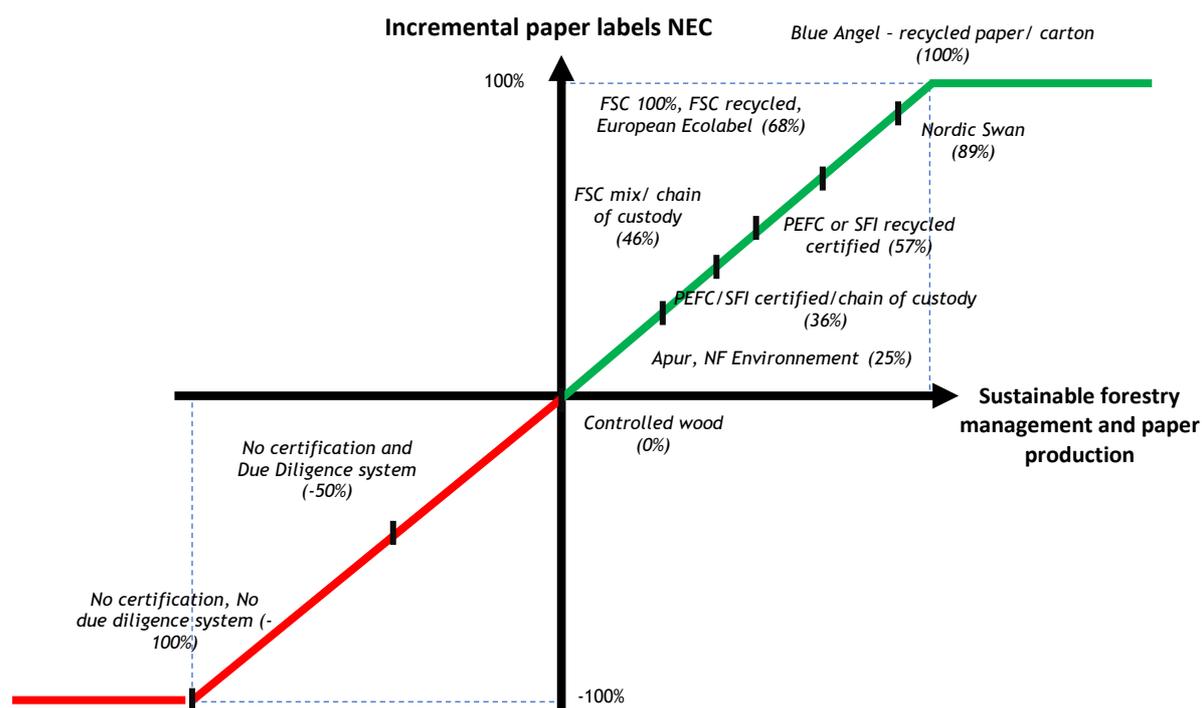
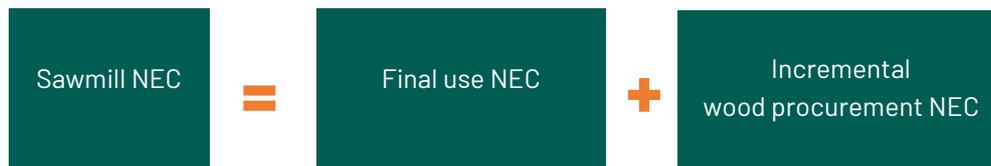


Figure 4: Incremental Paper labels NEC

The following products are covered under each certification scheme:

- **APUR:** paper only
- **Blue Angel:** recycled board, recycled paper, recycled toilet paper
- **European Ecolabel:**
 - Copier and graph paper
 - Newsprint
 - Printed paper
 - Transformed paper products
 - Hygienic protection paper
 - Wood, cork and bamboo flooring
- **Nordic Swan:**
 - Copier paper
 - Hygienic products
 - Furniture
 - Tissue

3.3. Sawmill and wood products-related activities



3.3.1. Final use NEC

The final use NEC of sawmill and wood products is 17%, as it is mainly used for building (a 25% NEC with a 68% weighting) and furniture (a 0% NEC with a 32% weighting).

3.3.2. Incremental Wood procurement NEC

The European Union Timber Regulation (2013)⁷ prohibits placing illegally harvested timber on the European market to discourage illegal logging around the world. It sets requirements that companies within the European Union must meet to minimise the risk of illegal timber being traded. More specifically, the Regulation requires companies placing timber or timber products on the European market (both imported and domestic) to implement a due diligence system (DDS). Apart from these legal requirements, companies can also choose to certify products. Several labels can be applied to wood products (see the “Focus on certifications” section above).

- If a product is made of “Controlled wood”, the NEC is 0%.
- If a product is PEFC or SFI certified, meaning at least 70% of wood is from PEFC-certified forests and wood from controlled sources, the NEC is 25% NEC.
- If a product, is FSC mix, meaning at least 70% of wood is FSC certified and remaining wood is made of controlled wood, the NEC is 50%.
- If a product is FSC 100%/FSC recycled, SFI recycled or PEFC recycled, the NEC is 75%.
- If a product is made of 100% recycled materials, the NEC is 100%.

⁷ Source: European Commission website: http://ec.europa.eu/environment/eutr2013/index_fr.htm

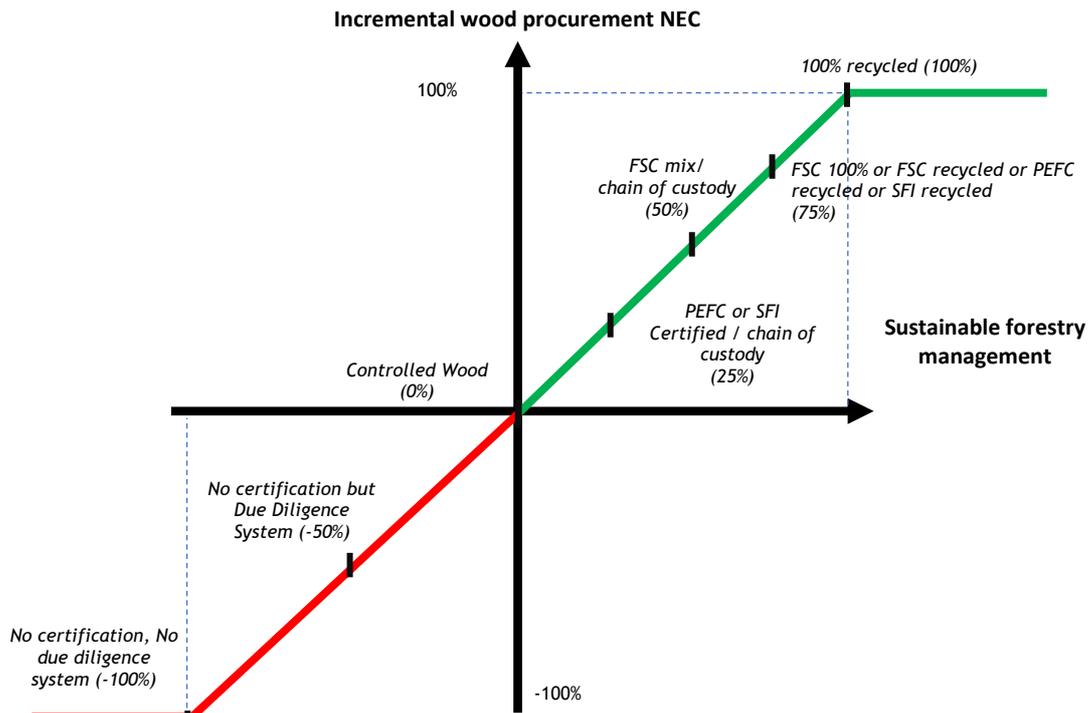
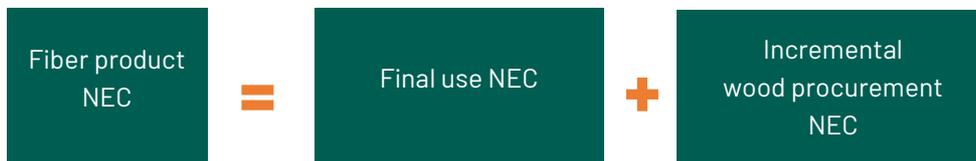


Figure 5: Incremental wood procurement NEC

3.4. Packaging and other fiber products-related activities

Fiber product manufacturing = Final use NEC + Incremental NEC (wood procurement)



3.4.1. Final use NEC

This indicator is calculated depending on the final use of the product based on recyclability and sustainable use:

- Uses that are ecological transition solutions (for example, a product that enables the loss of weight compared to a standard board) have the highest mark, 100%.
- Uses with significant positive impacts on environmental transition (such as a carton with a high recyclability rate or corrugated board) are marked 50%
- If no information is available or if product final uses are considered undifferentiated (such as tissue or toilet paper), products are marked 0%.
- Uses with significant negative impacts on environmental transition (single uses with no alternatives or scalable alternatives like kitchen paper) are marked -50%.
- All other uses with a significant negative impact are marked -100% (e.g. overpackaging or single use with an existing and scalable alternative, such as disposable tablecloth).

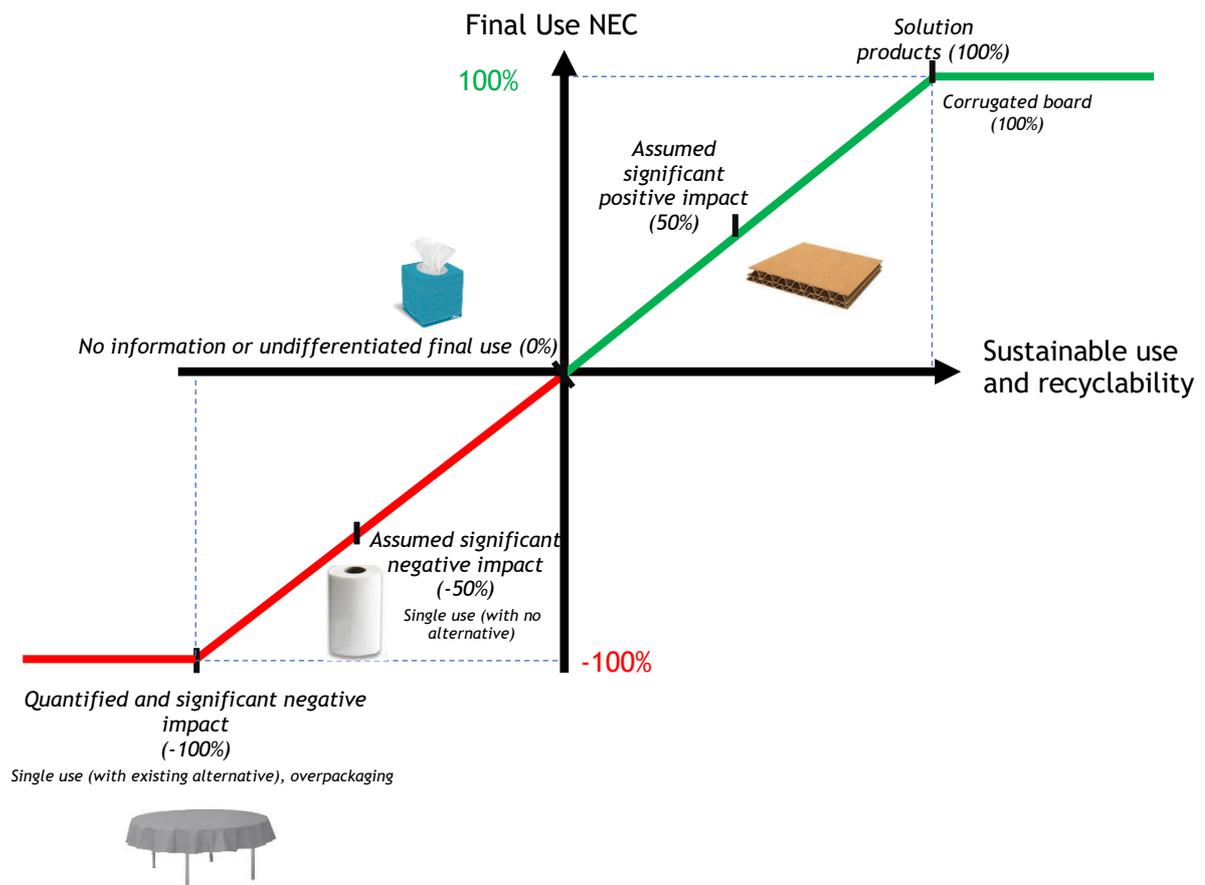


Figure 6: Final use NEC for fiber product manufacturing

3.4.2. Incremental wood procurement NEC

Fiber procurement companies use a DDS. The European Union Timber Regulation (2013) prohibits the placement of illegally harvested timber on the European market to discourage illegal logging. It also sets requirements that companies within the European Union must meet to minimise the risk of trading illegal timber, and requires companies placing timber or timber products in the European market (both imported and domestic) to implement a DDS.

Apart from legal requirements, companies can also certify products. As described earlier, several labels can be applied to wood products (refer to the “Sawmill and wood products” paragraph for more). We use the wood procurement scheme for incremental NEC of packaging instead of the pulp and paper scheme because the pulp and paper scheme includes paper-specific certifications that do not apply to packaging and other fiber products. Nonetheless, the European Ecolabel, which doesn’t apply to sawmill and wood products, can be found on some fiber products. It was assigned a NEC +75% due to a similar stringency to FSC 100% and FSC recycled certifications (see **pulp production and paper** incremental NEC).

Data availability and practical tips

Information needed: due diligence system and chain of custody certification

Data can be found in a company sustainability report, usually in the “Supply Chain” or “Sustainable Sourcing” chapters. In the 2016 Mondi Group’s report, for example, supply chain management is explained on page 64:

“All our mills – with the exception of our latest acquisition Pine Bluff (U.S.) – are certified to FSC and/or PEFC™ Chain-of-Custody standards. We plan to certify Pine Bluff in 2017. This provides assurance that all wood and virgin fiber used in our manufacturing processes can be traced back to a sustainably managed forest. Our due diligence system addresses the requirements of the European Union Timber Regulation (EUTR) and U.S. Lacey Act. None of our sourcing contributes to illegal logging or deforestation.”

4. Main limits

This framework presents several advantages. First, the entire wood & paper value chain can be rated by the user. This framework also takes into account various indicators dependent on the sub-sector considered and corresponding to several key environmental stakes, thus enhancing our analysis.

However, it could be argued that the framework is based on sector practices in taking labels into account, which comes with the disadvantage of not explicitly rating other environmental issues identified (climate, biodiversity, water).

5.Key data sources

| Data | Sources |
|--|---|
| Percentage of forest area certified | Office National des Forêts website (French national forestry board): http://www.onf.fr/gestion_durable/sommaire/milieu_vivant/patrimoine/forets_monde/20070926-112926-300942/@@index.html |
| Breakdown of wood usages | FAOSTAT-Forestry database: http://www.fao.org/faostat/en/#data/FO |
| Paper GHG emissions | From Dexia Asset Management (2007), quoted in « Impacts écologiques des Technologies de l'Information et de la Communication », Groupe EcoInfo, 2012 |
| Energy for a sheet of paper | "Energy Efficiency Improvement and Cost Saving Opportunities for the Pulp & Paper Industry", Berkeley Lab, 2009 |
| Forest data | Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/forestry/ijf2011/69186/en/ "We are destroying rainforests so quickly they may be gone in 100 years", J. Vidal, The Guardian, 2017 (https://www.theguardian.com/global-development-professionals-network/2017/jan/23/destroying-rainforests-quickly-gone-100-years-deforestation) |
| FSC, PEFC, SFI certifications | FSC website: https://www.fsc.org/ FSC Chain of custody: FSC UK website "FSC Chain of Custody Certification - Factsheet": http://www.fsc-uk.org/preview.fsc-chain-of-custody-certification-factsheet.a-196.pdf PEFC website: https://www.pefc.org/ SFI website: http://www.sfiprogram.org/ |
| Paper labels | Blue Angel: https://www.blauer-engel.de/en European Ecolabel: http://ec.europa.eu/ecat/category/en/35/printed-paper Nordic Swan: http://www.nordic-ecolabel.org/ |
| Global Forest Registry: list of risk countries | http://globalforestregistry.org/map |
| Forest Legality Alliance: list of risk countries | http://www.forestlegality.org/risk-tool |
| European Union Timber Regulation | European Commission website (2013): http://ec.europa.eu/environment/eutr2013/index_fr.htm |