JRC TECHNICAL REPORT

JRC Ispra site Environmental Footprint (OEF)

Application of the Commission Recommendation 2013/179/EU and of the OEFSR Guidance v.6.3
- Reporting year 2015 -

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Abstract

This report represents the summary of a work carried out over the last few years involving different Units of the Joint Research Centre and a team of external consultants and reviewers. The OEF method (Organisation Environmental Footprint), together with the PEF method (Product Environmental Footprint), was developed by the JRC Life Cycle Assessment (LCA) Team (now in the Land Resources Unit, D3). Both methods were published in annex to the Commission Recommendation 2013/179/EU of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations.

The JRC Ispra is the 3rd largest site of the European Commission. The site is a combination of scientific activities and a broad set of supporting operations, ranging from power generation to water supply and wastewater treatment up to nuclear decommissioning. The site applies EMAS (the EU Environmental Management and Audit Scheme) to continuously improve its environmental performance and communicate it to the public. The application of the OEF, started in 2012 and reiterated over time, was a natural process and turned out to be quite beneficial for both tools. EMAS, in fact, has been getting complementary life cycle based information from the OEF while the latter has been gaining hands-on experience from EMAS in view of testing and possibly improving its methodological foundations. The JRC is therefore a unique field of play, a sort of "living-lab" where research and administration cooperate in a "win-win" perspective.

This third version of the OEF study was submitted to an external review panel of distinguished experts in the domain of environmental footprinting. We are happy to present the report to the external public and hope to encourage other organisations to follow our path towards sustainability.

Acknowledgements

The authors would like to thank all the people of JRC Ispra involved in this project for their availability and cooperation during the activities.

The application of the OEFSR Guidance to a complex reality such as the JRC Ispra site has been a stimulating experience and a good opportunity to share knowledge.

We wish also to thank the review panel for the help and the insights provided during the review of the study, which have significantly improved the scientific quality of the work.

Executive summary

Introduction

The Organisation Environmental Footprint (OEF) is a multi-criteria measure of the environmental performance of goods and services provided by an organisation from a life cycle perspective. OEF information is produced for the overarching purpose of seeking to reduce environmental impacts associated with organisational activities, taking into account supply chain activities. Specific applications of OEF studies may include: benchmarking and performance tracking, identification of environmental hot-spots, supply chain management and mitigation activities. Furthermore, the OEF is intended to provide complementary life-cycle based information in the context of environmental management systems, including the EU Eco-Management and Audit Scheme (EMAS).

The first application of the OEF methodology to the JRC Ispra site was performed in 2012 for the reporting period 2011. Afterwards, the study was updated every two years, i.e. for the reporting periods 2013 and 2015.

Building on the PEF pilot work, the JRC decided to update the latest version of the Ispra site OEF in order to comply with the applicable requirements of the OEFSR Guidance and replace as far as possible the existing secondary data with the new EF-compliant datasets. In addition, the JRC intended to make the document suitable for external communication.

This report documents therefore a new OEF assessment of the Ispra site, using the same activity data related to the reporting period 2015 but implementing the relevant provisions of the OEFSR Guidance 6.3 and the EF compliant database at the highest possible extent.

Goal and scope

The JRC Ispra Site OEF study is carried out:

— to achieve a comprehensive knowledge of environmental impacts due to site and related activities, taking a life cycle perspective;

— to identify footprint-based performance indicators to be integrated in the context of EMAS.

In addition to the reasons listed above, this edition of the study provides a case study for the application of the OEFSR Guidance 6.3, developed in the context of the Environmental Footprint pilot phase.

Two levels of system boundary definition are necessary for the OEF study:

— Organisational boundaries (in relation to the defined organisation)

— OEF boundaries (that specify which aspects of the supply chain are included in the analysis)

The environmental impacts have been assessed using the impact categories and models of the OEFSR Guidance 6.3 and applying normalization and weighting.

In accordance to the OEFSR Guidance, the three toxicity-related impact categories were subsequently excluded from the procedure to identify the most relevant impact categories, life cycle stages, processes and elementary flows.

Inventory analysis

The inventory section provides a description of inputs (resources, materials) and outputs (emissions) associated with the 31 activities identified in the OEF assessment.

All activity data have been collected on site. If not otherwise specified, they are related to the reporting period 2015.

Each inventory table includes, where applicable, input and output flows both elementary and non-elementary, along with information on the data source.

Generic data have been used to model all non-elementary flows and some elementary flows, both for inputs (e.g. materials supply chain) and outputs (e.g. waste management operations). These data have been sourced, as far as possible, from the EF database.

A complete description of the inventory modelling is reported in chapter 5.

Environmental footprint impact assessment and interpretation

JRC Ispra environmental footprint

Table 1 presents the comprehensive environmental footprint calculated for the whole set of Ispra site activities, expressed at the level of characterization, normalization (including toxicity categories) and weighted contribution of the total footprint (excluding toxicity indicators). Figure 1 shows the weighted impacts, subdivided by activity.

Table 1 – JRC Ispra environmental footprint. Results are presented at the characterization level, normalization and weighting (without the toxicity indicators).

Environmental impact indicator	Characterization		Normalization	Weighting	
	Unit	Value		Score	Share
Total	-	-	-	3.17	100.00%
Climate change	kg CO_2 eq	36,000,000	4,640	1.03	32.49%
Ozone depletion	kg CFC11 eq	0.96	41	2.76E-03	0.09%
Ionising radiation, HH	kBq U-235 eq	926,000	219	0.01	0.37%
Photochemical ozone formation, HH	kg NMVOC eq	59,800	1,470	0.08	2.37%
Respiratory inorganics	disease inc.	0.67	1,050	0.10	3.17%
Non-cancer human health effects	CTUh	2.1	4,340	-	-
Cancer human health effects	CTUh	0.14	3,750	-	-
Acidification	mol H+ eq	71,000	1,280	0.08	2.68%
Eutrophication freshwater	kg P eq	2,390	935	0.03	0.87%
Eutrophication marine	kg N eq	29,800	1,060	0.03	1.04%
Eutrophication terrestrial	mol N eq	227,000	1,280	0.05	1.58%
Ecotoxicity freshwater	CTUe	35,600,000	3,010	-	-
Land use	Pt	184,000,000	138	0.01	0.37%
Water use	m^3 depriv.	10,000,000	873	0.08	2.49%
Resource use, energy carriers	MJ	410,000,000	6,290	0.56	17.71%
Resource use, mineral and metals	kg Sb eq	789	13,600	1.10	34.78%

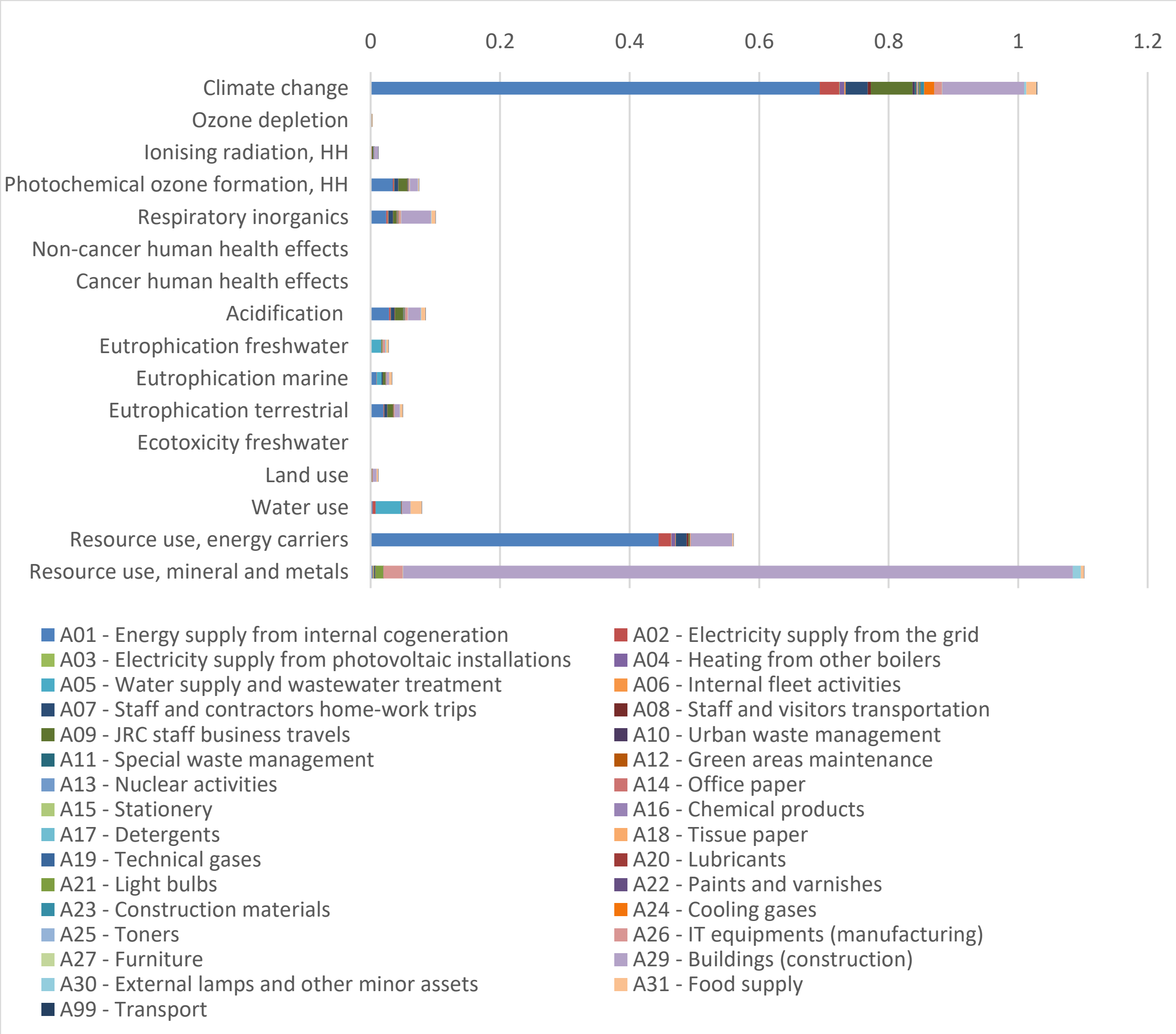

Figure 1 – JRC Ispra environmental footprint: weighted results (without toxicity indicators) subdivided by activities.

Identification of most relevant impact indicators, life cycle stages, processes and direct elementary flows (hotspot analysis)

Based on the weighted results, the most relevant impact categories (i.e. contributing to at least 80% of the impacts) are, in descending order:

— **Resource use, minerals and metals**: 35%

— **Climate change**: 33%

— **Resource use, energy carriers**: 18%

In addition to the most relevant ones, other three indicators have been added to the list:

— **Acidification**: 2.7%

— **Water use**: 2.5%

— **Ionizing radiation, HH**: 0.37%

The indicators listed above have been included in order to reach 90% of the overall weighted results. In addition, the chosen additional indicators are relevant to the direct elementary flows (NOx for acidification, water consumption for water use, air and water emissions from nuclear activities for ionizing radiation), are appropriate for communication as well as are suitable to derive indicators in support of EMAS. Other considerations on these aspects are provided in chapter 8.1 and Annex 4..

Table 2 – List of the most relevant processes contributing to at least 80% of each impacts (highlighted in orange) and the additional activities covering up to 90% of the overall impacts (highlighted in green) for all the most relevant impact indicators.

Impact indicator	Unit	Processes (activities)								
		A01	A02	A05	A07	A09	A13	A26	A29	A31
Climate change	kg CO2 eq	67%	2.9%	-	3.4%	6.3%	-	-	12%	-
Resource use, mineral and metals	kg Sb eq	-	-	-	-	-	-	-	94%	-
Resource use, energy carriers	MJ	79%	-	-	-	-	-	-	11%	-
Acidification	mol H+ eq	34%	-	-	6.5%	15%	-	4.4%	23%	7.5%
Water use	m3 depriv.	-	6.1%	49%	-	-	-	-	17%	22%
Ionizing radiation, HH	kBq U-235 eq	4.2%	12%	-	-	15%	11%	-	49%	-

A01 – Energy supply from internal cogeneration

A02 – Electricity supply from the grid

A05 – Water supply and wastewater treatment

A07 – JRC staff and contractors home-work trips

A09 – JRC staff business travels

A13 – Nuclear activities

A26 - IT equipment (manufacturing)

A29 - Buildings (construction

A31 - Food supply

It emerges from the analysis that only a few processes are material to the most relevant impact categories. Only 8 activities out of 32 are strictly included in the hotspot. Extending the coverage to 90% of the impacts only adds 1 more activity (A26 IT equipment). Processes related to energy supply and building construction are significant for most of the impact indicators. Water supply (A05) and nuclear activities (A13) are relevant only to the impact category of most influence, respectively water use and ionizing radiation. The application of the rules for the identification of the most relevant direct elementary flows confirms that the most relevant flows are the same already included in the company specific data from the previous studies. The most relevant direct elementary flows refer mostly to the electricity supply from internal cogeneration (A01), nuclear activities (A13) and water supply (A05).

For more details on the hotspot analysis, see chapter 7.1.

Conclusions

The OEF results after the application of the new requirements (OEFSR Guidance) are in line with the previous assessment and generally meaningful. This also taken into account the many assumptions and limitations.

According to the goals of the study, the results of the environmental footprint are intended for both internal use and external communication. The measure of the environmental footprint can support environmental improvement targets and performance tracking over time.

Differently from the previous versions of this study, the new method for the calculation of the impacts included a weighting step. Weighting allowed for the identification of the most relevant impact indicators, life cycle stages, processes and direct elementary flows, ensuring that the focus is put on those aspects that matter the most and for communication purposes.

A few impact categories and a few big main processes dominate the OEF. The most relevant impact indicators are Climate Change and the two indicators related to resource use (both mineral and metals and energy carriers). On the other hand, the most relevant processes are related to the energy supply from internal cogeneration and buildings construction.

Other relevant processes (and related impact indicator) are:

- Water supply (Water use)
- Business travels (climate change)
- Nuclear activities (ionizing radiation)
- Food supply (water use)
- Electricity purchased from the grid (ionizing radiation)

The footprint analysis has pointed out which activities were the most relevant in terms of potential environmental impacts during the reporting year 2015. This information should represent the baseline for setting environmental targets and actions for improvement as well as for reviewing and complementing existing actions.

1 Introduction

The Organisation Environmental Footprint (OEF) is a multi-criteria measure of the environmental performance of goods and services provided by an organisation from a life cycle perspective. OEF information is produced for the overarching purpose of seeking to reduce environmental impacts associated with organisational activities, taking into account supply chain activities. Specific applications of OEF studies may include: benchmarking and performance tracking, identification of environmental hot-spots, supply chain management and mitigation activities. Furthermore, the OEF is intended to provide complementary life-cycle based information in the context of environmental management systems, including the EU Eco-Management and Audit Scheme (EMAS).

The OEF method was developed by the Sustainability Assessment Unit of the JRC Institute for Environment and Sustainability (IES), upon mandate from DG Environment. The method applied in this study is the one in the Commission Recommendation 2013/179/EU of 9 April 2013 – Annex III "Organisation Environmental Footprint (OEF) Guide" (1).

The first application of the OEF methodology to the JRC Ispra site was performed in 2012 for the reporting period 2011 (3)(4). Afterwards, the study was updated every two years, i.e. for the reporting periods 2013 and 2015(5)(6). The study report was kept internally at the Commission because it did not undergo an independent review, which is a mandatory requirement for external communication. The outcomes of the study were however used to support the implementation of EMAS within the site through the supply of complementary life cycle based indicators to measure the site environmental performance and track it over time. A calculation tool was developed in 2017 to handle these OEF indicators, which will be updated on an annual basis. A description of these OEF indicators and OEF tool is provided in chapter 8.1.

In the meantime, the Commission initiated a pilot phase to test the Environmental Footprint methodologies[1], which was completed in April 2018. A fundamental output of the pilot phase was the publication of the OEF Sector Rules Guidance, which lays down specific requirements for the development of Organisation Environmental Footprint Sector Rules (OEFSR) (2) and introduces several modifications and clarifications to the original requirements of the OEF guide 2013. For instance, the OEFSR Guidance refers to a new list of impact assessment methods and models and to specific normalization and weighting factors. The latest version of the guidance is the 6.3 of January 2018.

Another important output of the pilot phase was the release of a database with a broad number of datasets meeting the Environmental Footprint requirements. This EF-compliant database can be used for environmental footprint applications of products and organisations belonging to product and sector groups addressed in the pilot phase. The use of common secondary data increases consistency, comparability and reproducibility across footprint studies.

Building on the above work, the JRC decided to update the latest version of the Ispra site OEF in order to comply with the applicable requirements of the OEFSR Guidance and replace as far as possible the existing secondary data with the new EF-compliant datasets. In addition, the JRC intended to make the document suitable for external communication.

This report documents therefore a new OEF assessment of the Ispra site, using the same activity data related to the reporting period 2015 but implementing the relevant provisions of the OEFSR Guidance 6.3 and the EF compliant database at the highest possible extent.

The task was carried out by the same working group involved in the previous OEF studies. The implementation of the OEFSR Guidance encountered some limitations in adapting the OEF model to the new requirements and in absence of OEFSR related to the sector under assessment. Such limitations are discussed throughout the report and summarized in chapter 2.2.

[1] http://ec.europa.eu/environment/eussd/smgp/policy_footprint.htm

2 Goal definition

2.1 Intended applications and reasons for carrying out the study

The JRC Ispra Site OEF study is carried out:

— to achieve a comprehensive knowledge of environmental impacts due to site and related activities, taking a life cycle perspective;

— to identify footprint-based performance indicators to be integrated in the context of EMAS.

In addition to the reasons listed above, this edition of the study provides a case study for the application of the OEFSR Guidance 6.3 (2), developed in the context of the Environmental Footprint pilot phase.

The OEF method provides a life-cycle based survey on the environmental performance of site activities, including the supply chain of products and materials used by the organisation. The OEF goal is to identify environmental hot-spots and to support decision making over environmental impacts reduction. The use of footprint data avoids the shifting of burdens across impact categories and organisational activities and allows focusing on real and measurable environmental improvements.

Due to the significant methodological changes and the use of the EF compliant database, the results of this study are not comparable with those from the previous applications.

This study has undergone an independent external review; therefore, it is suitable for external communication (see chapter 2.3).

2.2 Limitations/Assumptions

Based on the kind of products provided by the JRC (i.e. mainly intangible services), the study is limited to:

— site-level activities (direct activities carried out to provide JRC services);

— upstream activities (production of material and equipment supporting direct activities).

For more details related to the description of site activities, see chapter 3.3, System boundaries.

Downstream activities (goods/services use and end-of-life) are not relevant, hence they were excluded from this study.

The OEF method refers to Organisation Environmental Footprint Sector Rules (OEFSRs) for specific requirements to be applied in each activity sector. As OEFSRs for activities performed by the JRC Ispra site are currently not available, this study applies only the general OEF requirements and selected provisions of the OEFSR Guidance 6.3 (see Table 3). In case there is flexibility in applying some requirements, the approaches followed in this study have been explained and substantiated.

Other relevant limitations to this study:

— This study has been carried out using the version of the EF database and methods available in February 2018. Any difference from the published version is outside the scope of this application,

— EF compliant datasets were not available for all processes in the OEF boundaries. In case of data gaps, the datasets used in the previous study (mainly from Ecoinvent) were maintained.

- Some processes for which suitable EF compliant datasets were available were not updated, i.e. the original dataset was kept. Their contribution was carefully assessed throughout the study via an iterative process during the life cycle inventory to confirm that none of those processes were relevant to the hotspot analysis (i.e., the overall contribution to the weighted environmental impacts does not exceeds 20%). A comprehensive description of how and where the EF datasets were implemented in the model is provided in Annex 3
- The End of Life Formula (Annex V of the OEF Guide) was not applied in the previous versions of the JRC Ispra OEF due to the global irrelevance of processes and products sourced from secondary materials or recycled at the end of their life. The OEF boundaries do not include an end of life stage and do not require bulk input materials to deliver the expected services. Process waste arising from the site were modelled with a cut-off approach (no impacts from waste to recycling, yes impacts from recycling processes of secondary materials in input). In this study, the new Circular Footprint Formula (CFF) required in the OEFSR Guidance has been applied to buildings construction (A29) as sensitivity analysis (see chapter 7.2)
- Data and quality: since OEFSR are not available for JRC Ispra activities, the data quality assessment has been performed following the applicable requirements of the OEF Guidance. The assessment considers the most relevant processes only. Further details on the data quality assessment are reported in chapter 7.3.
- The classification and breakdown of the activities included in the OEF boundaries has not been changed since the first study of 2011, although some of them could have been merged or revised. The reason for that was to ensure consistency and comparability between different assessments over time. The same classification has been therefore maintained in this study, with the only exception of all transportation processes for materials and waste, which were moved and grouped in a new separate activity A99.
- Packaging has been included when clear information were available or when consistent assumptions could be made (e.g. PET bottles for water). In other cases packaging has been considered falling under the cut-off

  Having in the model datasets from Ecoinvent may cause inconsistencies when applying the EF method. Due to a different nomenclature of elementary flows, there may be uncharacterized flows that lead to inconsistent results. This aspect has been assessed to ensure that no significant flow is left out of characterization. In particular, an in-depth analysis has been carried out for the indicator resource use, energy carriers, as this indicator is the most affected by this issue among the most relevant impact categories. The results of this consistency check are reported in chapter 7.4
- The water use indicator may be highly uncertain for the copper dataset (especially due to potential mismatch in location related to water inputs and outputs). More details regarding the limitations for the indicator Water use are reported in chapter 3.5
- The climate change impacts of air travel may be underestimated due to the lack of consideration of the high altitude effect of carbon emissions in the OEF LCIA

The table below shows the list of provisions from the Guidance implemented in this study. Items not listed in the table were not directly addressed in this study.

Table 3 – List of OEFSR Guidance provisions implemented in this study.

Requirement (reference to the Guidance)	**Level of implementation**	**Comment**
EF Database	Partial	Not all the datasets from the PEFCR/OEFSR pilot phase were available. See above for main limitations

Requirement (reference to the Guidance)	Level of implementation	Comment
EF LCIA method	Complete	See above for main limitations
Identification of most relevant impact categories, life cycle stages, processes, direct elementary flows	Complete	
Cut-off	Partial	Same approach as for the previous OEF application was kept
Handling multifunctional processes	Complete	Same approach as for the previous OEF application was kept
Climate change modelling	Complete	
Electricity modelling	Complete, with assumptions	Supplier-specific mix used, but it was not possible to confirm the reliability of the contractual instrument
Transport modelling	Complete, with assumptions	Default distances used to model the transportation from producers to final suppliers
EoL modelling (CFF formula)	Sensitivity assessment only	Applied to A29 Buildings construction
Data and quality requirement	Partial	Data and quality requirements applied to most relevant processes only

Additional limitations and assumptions, where relevant, are further detailed throughout the report.

2.3 Target audience

This study is intended both for internal use and external communication. The Commission's internal target audiences are:

— JRC staff and DG Environment staff, responsible for the OEF development and diffusion;

— JRC Ispra staff responsible for the environmental management system and EMAS implementation.

— JRC staff of other units and scientific institutes in Ispra and other sites

The external communication is primarily addressed to LCA and footprint experts in the scientific community, but also to any other subject or party potentially interested in JRC activities and related potential impacts.

2.4 Commissioners of the study

The study has been commissioned by:

- Rana Pant (JRC Directorate D - Sustainable Resources, Bio-Economy unit D1)
- Philip Costeloe (JRC Department R.I Safety, Security & Site Management Ispra)

2.5 Executors of the study

Ugo Pretato

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With the contribution of:

Philip Costeloe, Valeria Borraccia (JRC Department R.I Safety, Security & Site Management Ispra)

Rana Pant, Luca Zampori (JRC Directorate D - Sustainable Resources, Land Resources Unit D3 (formerly Unit D1))

2.6 Critical review

Review panel:

- Paolo Masoni (chair)
- Sébastien Humbert
- Alessandra Zamagni

Review statement

The review panel has read the final version of the report "JRC Ispra site Environmental Footprint (OEF). Application of the Commission Recommendation 2013/179/EU and of the OEFSR Guidance v.6.3 - Reporting year 2015" rev.2 – Prepared by Ugo Pretato and Elia Rillo, Studio Fieschi e soci, 2018 and we are glad that the authors satisfactorily addressed all the elements that we have pointed out in our review.

With the modifications done to the report, the panel review considers this OEF study alligned to the possible extent in this time with the OEFSR Guidance v.6.3.

In particular:

- all applicable OEF methodological requirements, including the use of the predefined characterisation, normalisation and weighting factors, are fulfilled;
- the data and information used for the OEF study are consistent, reliable and traceable;
- the calculations performed do not – at our best knowledge - include mistakes;
- the OEF report is complete, consistent, and compliant with the OEF study template provided in the most recent version of the OEFSR Guidance;
- the information and data included are consistent, reliable and traceable;
- the mandatory information and sections are included and appropriately filled in;

- all the technical information that could be used for communication purposes, independently from the communication vehicle to be used, are included in the report.

The review panel, the authors and the commissioner of the study acknowledge that it was not possible to fulfil all the formal requirements in OEFSR Guidance at the moment of the study and with existing resource limitations. All the limitations and non-conformity have been adequately justified and documented in the report, and plans to overcome them in future revision of the study have been defined.

However, it is important to stress that this non-conformity does not reduce the value and usability of the study because its objectives have been satisfactorily achieved.

The review panel congratulate the authors for the interesting and complex study that we consider an important contribution also for improving the usability and relevance of the OEFSR Guidance.

Finally, the reviewers would like to thank the authors and commissioners for their constructive and always positive spirit.

The complete review report is available as a separate document.

3 Scope definition

Defining the scope of the OEF study refers to describing in detail the system to be evaluated along with the associated analytical specifications.

3.1 Organisation (unit of analysis)

Name: European Commission – Joint Research Centre

Kind of products: science and policy outputs (core activity), non-scientific supporting activities, nuclear decommissioning and waste management

Locations of operation: Ispra (Italy)

Main applicable NACE codes:

35.11 - Production of electricity;

35.30 - Steam and air conditioning supply;

36.00 - Water collection, treatment and supply;

37.00 - Sewerage;

71.20 - Technical tests and analysis;

72.11 - Research and experimental development on biotechnology;

72.20 - Research and experimental development on social sciences and humanities;

84.11 – General Public Administration activities;

99.00 - Activities of extraterritorial organisations and bodies.

The JRC organizational chart (as of December 2015) is shown in Annex 1.

3.2 Product Portfolio

"As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle. Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

According to the OEF Guide, the product portfolio is defined in terms of: "what" and "how much". If the use and end of life are considered, these are defined in terms of "how well" and "for how long".

<u>What</u>

The JRC Ispra site produces "scientific knowledge" in areas of life sciences, food, environment, agriculture, health, industrial competitiveness, nuclear safety and security. This output is provided in form of scientific papers, policy documents, technical reports, laboratory analysis but also verbal communication.

This core activity is supported by other non-scientific activities which include planning, design and maintenance/refurbishment of building installations, plant operations, infrastructure development and maintenance, asset management, distribution of electricity, water, telephony and IT cabling, firefighting, site health, safety and environmental protection.

Furthermore, the site carries out planning, design and implementation of nuclear decommissioning and nuclear waste management in its internal plants.

<u>How much</u>

The productivity of JRC is linked to the number of employed staff, permanent external contractors and total working hours spent during the reporting interval (1 year). This applies to both scientific and non-scientific activities.

As from 2015:

JRC employed staff = **1,831 people**
Contractors working permanently on site = **831 people**
Total staff**: 2,662 people**
Work time per person = 8 h/d * 211 d/y = 1,688 h/y
Total work time (staff + contractors) = 4,493,456 h/y

<u>How well</u>

How well relates to the quality performance of goods/services during use. This is not applicable to the present study, because use and end-of-life stages (downstream activities) are excluded.

(Ref. Limitations/assumptions)

<u>How long</u>

How long relates to products service life. This is not applicable to the present study, because use and end-of-life stages (downstream activities) are excluded.

(Ref. Limitations/assumptions)

<u>Year and reporting interval</u>

The reporting interval considered is one year, from 1 January 2015 to 31 December 2015. All activity data collected for evaluating the footprint refers to this interval. Any deviation from this rule has been motivated and documented.

3.3 System boundaries

Two levels of system boundary definition are necessary for the OEF study:

- organisational boundaries (in relation to the defined organisation);
- OEF boundaries (that specify which aspects of the supply chain are included in the analysis).

3.3.1 Organisational boundaries

Organisational boundaries for calculating the OEF shall encompass all of the facilities/activities that the organisation owns or operates (whether partially or in full) that contribute to producing the goods/services (or clearly defined subset thereof) that the organisation provides during the reporting interval.

The organisational boundaries are equal to the JRC-Ispra site geographical boundaries enclosed in the fence (167 ha) plus the other buildings and utilities outside the fence which directly or indirectly contribute to the service portfolio provision (Figure 2).

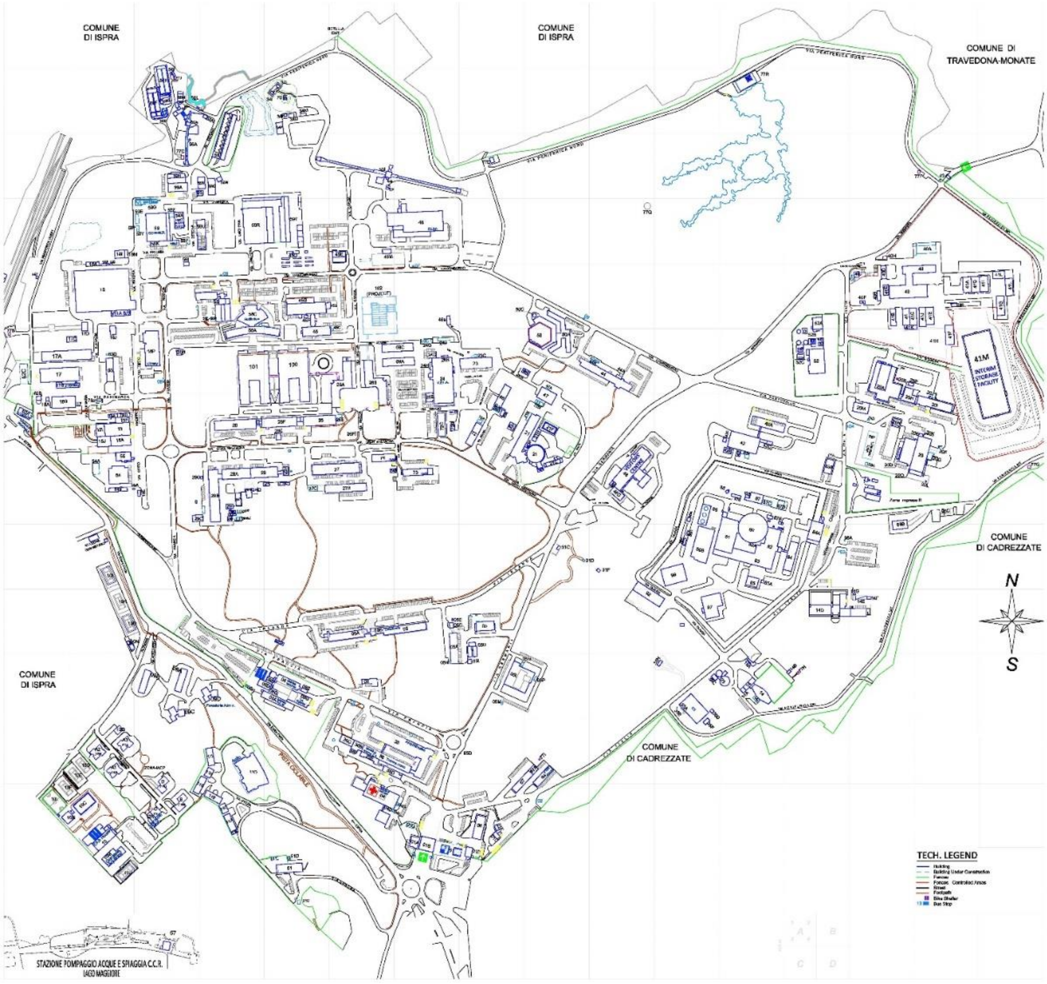


Figure 2 - JRC Ispra organisational boundaries

A detailed description of Site activities, buildings and plants which make up the organisational boundaries is available in the report "Ispra Site Initial Environmental Review (IER), rev 1.0, December 2008" (7), elaborated during the ISO 14001 implementation.

3.3.2 OEF boundaries

The OEF boundaries (Figure 3) are established in terms of directly and/or indirectly attributable activities occurring along the supply chains associated with Organisation's Product Portfolio. This shall include, at a minimum, site-level (direct) and upstream (indirect) activities. All environmentally significant processes within the defined OEF boundaries shall be considered.

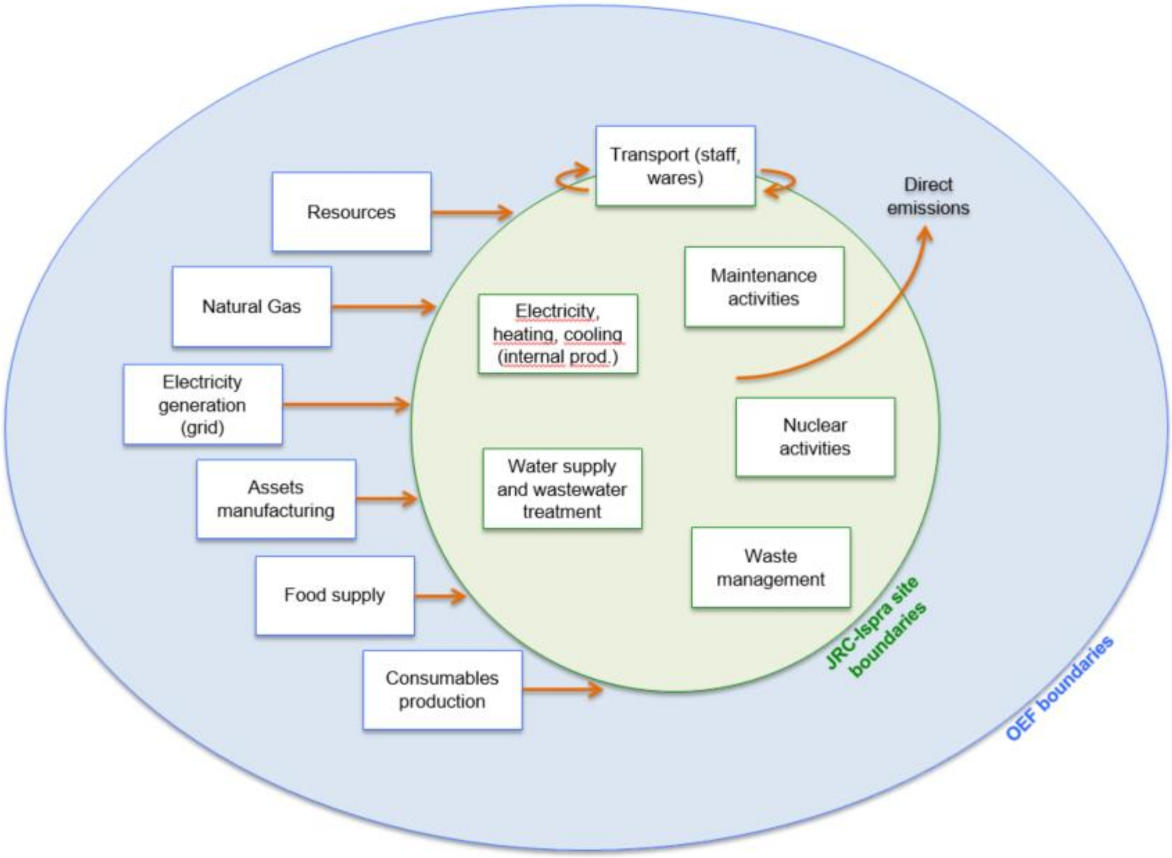


Figure 3 - OEF boundaries (exemplary)

Based on the organisational boundaries previously defined, the OEF activities considered in the study are listed below.

3.3.2.1 Direct site-level activities

Site-level activities refer to processes directly owned, operated or controlled by the organisation within its boundaries, i.e. for which the organisation can exert a direct control and, therefore, have an easier access to primary data.

Direct activities include:

A01 – Energy supply from internal cogeneration; A02 – Electricity supply from the grid; A03 – Electricity supply from photovoltaic installations; A04 – Heating from other boilers; A05 – Water supply and wastewater treatment; A06 – Internal fleet activities; A08 – JRC staff and visitors transportation; A09 – JRC staff business travels; A10 – Urban waste management; A11 – Special waste management; A12 – Green areas maintenance; A13 – Nuclear activities.

3.3.2.2 Indirect upstream activities

Upstream activities refer to impacts and processes along the supply chain of products associated with the organisation product portfolio. On these products the organisation may not exert a direct control, therefore data collection may be more demanding and, in some cases, it may be only possible by using secondary data. In the case of JRC, upstream activities include the supply chain of products, materials and equipment which are directly and indirectly used to support the provision of scientific and non-scientific outputs.

Indirect upstream activities include the supply chain of consumables and assets.

Consumables are products and materials with a life span generally shorter than 1 year. Their impact is totally assigned to the reporting interval of the OEF.

Assets are products and equipment with a life span exceeding the reporting interval and an acquisition value above a defined threshold which is currently fixed at 420.00 Euro. For management purposes, however, some sensitive goods are classified as assets even if their value is lower than the threshold (e.g. IT equipment).

The classification is regulated in the document "JRC Guidelines on tangible fixed assets, version 1.2, 2010" (8). For these items, the supply chain impacts are divided by the total number of life span years and attributed to each reporting interval with a linear approach.

The OEF Guide does not provide details on how modelling assets and capital equipment in the footprint analysis, it only recommends to consider their linear depreciation. In absence of guidance from specific sector rules (OEFSRs) an approach based on the designed service life has been adopted..

Such approach is based on the expected service life of the asset when it comes into use. In general, designed service lives are available for most types of assets in technical literature or can be estimated via expert judgement. This approach has been applied to all assets, i.e. *buildings, IT equipment, vehicles, furniture, external lamps and other minor assets.*
The total supply chain impacts of each asset shall be divided by its life span. The results provide the contribution to the environmental footprint of the reporting period (1 year).

Staff and contractors *home-work trips* using personal vehicles have been accounted among indirect activities, because JRC is not directly responsible for the means of transport and distance covered by the employees.

Next to the cited activities, the category includes the provision of *food and beverage* supplied in the JRC canteen and vending machines. According to the OEF Guide, all activities and processes which occur within the Organisational boundaries but which are not necessary for the functioning of the organisation shall be included in the analysis but reported separately. Impacts from food and beverage supply have hence been addressed as above.

The indirect upstream activities identified within the OEF boundaries are:

Consumables:
A14 - Office paper;
A15 - Stationery;
A16 - Chemical products;
A17 - Detergents;
A18 - Tissue paper;
A19 - Technical gases;
A20 - Lubricants;
A21 - Light bulbs;
A22 - Paints and varnishes;
A23 - Construction materials;
A24 - Cooling gases;
A25 - Toners.

Assets:
A26 - IT equipment (manufacturing);
A27 - Furniture (manufacturing);
A28 - Vehicles (manufacturing);
A29 - Buildings (construction);
A30 - External lamps and other minor assets (manufacturing).

Personnel commuting:
A07 – JRC staff and contractors home-work trips.

Other supporting activities:
A31 - Food supply.

The description of the above activities is provided in chapter 5.

3.4 Cut-off rules

According to the OEFSR Guidance, a 1% cut-off is allowed for all impact categories based on environmental significance, additionally to the cut-off already included in the background datasets.

No intentional cut-off has been applied, except for packaging. Packaging has been included when clear information were available or when consistent assumptions could be made (e.g. PET bottles for water). In other cases packaging has been considered falling under the cut-off.

Any data gaps have been filled with best available generic or extrapolated data.

In the present study the data quality requirements have been updated using the new OEF Guidance (2). For more details see chapter 4 and 7.3.

3.5 List of EF impact categories, normalisation factors and weighting factors

Table 4 reports the full list of impact categories used to calculate JRC Ispra site OEF.

In accordance with the OEFSR Guidance, the three toxicity-related impact categories were subsequently excluded from the procedure to identify the most relevant impact categories, life cycle stages, processes and elementary flows. The study includes and reports the characterised results for the three toxicity impact categories, but these results are not used for other communication purposes and for the identification of the most relevant life cycle stages, processes, and foreground direct elementary flows.

Table 4. List of recommended models at midpoint, together with their indicator, unit and source.

Recommendation at midpoint					
Impact category	**Indicator**	**Unit**	**Recommended default LCIA method**	**Source of CFs**	**Robustness**
Climate change[2]	Radiative forcing as Global Warming Potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)	EC-JRC, 2017[3]	I
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	Steady-state ODPs as in (WMO 1999)	EC-JRC, 2017	I
Human toxicity, cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)	EC-JRC, 2017	III/interim
Human toxicity, non-cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)	EC-JRC, 2017	III/interim
Particulate matter	Impact on human health	disease incidence	PM method recomm. by UNEP (UNEP 2016)	EC-JRC, 2017	I
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq U^{235} $_{eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	EC-JRC, 2017	II
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC $_{eq}$	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe 2008	EC-JRC, 2017	II
Acidification	Accumulated Exceedance (AE)	mol H+ $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006,	EC-JRC, 2017	II

[2] Three additional sub-indicators may be requested for reporting, depending on the OEFSR. For details refer to the OEFSR Guidance (2)

[3] The full list of characterization factors (EC-JRC, 2017a) is available at this link http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtm

Recommendation at midpoint					
Impact category	**Indicator**	**Unit**	**Recommended default LCIA method**	**Source of CFs**	**Robustness**
			Posch et al, 2008)		
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	EC-JRC, 2017	II
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P $_{eq}$	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	EC-JRC, 2017	II
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N $_{eq}$	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	EC-JRC, 2017	II
Ecotoxicity, freshwater*	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model, (Rosenbaum et al, 2008)	EC-JRC, 2017	III/interim
Land use	• Soil quality index[4] • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production • kg soil • m^3 water • m^3 groundwater	Soil quality index based on LANCA (De Laurentiis et al. 2019)	EC-JRC, 2017	III
Water use#	User deprivation potential (deprivation-weighted water consumption)	m^3 world $_{eq}$	Available WAter REmaining (AWARE) as recommended by UNEP, 2016	EC-JRC, 2017	III
Resource use[5], minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb $_{eq}$	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.		III
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)[6]	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002	EC-JRC, 2017	III

*Long-term emissions (occurring beyond 100 years) shall be excluded from the toxic impact categories. Toxicity emissions to this sub-compartment have a characterisation factor set to 0 in the EF LCIA (to ensure consistency).

#The results for water use might be overestimated and shall therefore be interpreted with caution. Some of the EF datasets tendered during the pilot phase and used in the PEFCR/OEFSRs development include inconsistencies in the regionalization and elementary

[4] This index is the result of the aggregation, performed by JRC, of the 4 indicators provided by LANCA model as indicators for land use

[5] The indicator "biotic resource intensity" was initially recommended under the additional environmental information. It will be further worked upon and explored during the transition phase.

[6] In the ILCD flow list, and for the current recommendation, Uranium is included in the list of energy carriers, and it is measured in MJ.

flow implementations. This problem has nothing to do with the impact assessment method or the implementability of EF methods, but occurred during the technical development of some of the datasets. The affected EF datasets will be corrected by mid-2019.

The list of normalization factors and weighting factors are available in Annex 2.

The full list of characterization factors (EC-JRC, 2017a) is available at this link http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtm

4 Data and quality requirements

Within the EF context, the data quality of each dataset and of the total EF study shall be calculated and reported. The calculation of the DQR shall be based on the following formula:

$$DQR = \frac{TeR + GR + TiR + P}{4}$$

where TeR is the Technological-Representativeness, GR is the Geographical-Representativeness, TiR is the Time-Representativeness, and P is the Precision/uncertainty. The representativeness (technological, geographical and time-related) characterises to what degree the processes and products selected are depicting the system analysed, while the precision indicates the way the data is derived and the related level of uncertainty.

Below are reported the tables with the criteria to be used for the semi-quantitative assessment of all parameters.

In the present study, the data quality requirements have been applied as follows:

— The data quality assessment has been performed only for the most relevant processes (see chapter 7.3)

— Company specific information: the approach set out in the Guidance §7.19.4.1. is followed. Table 5 reports the criteria followed to evaluate the parameters to calculate the DQR when using company specific information

— Processes in which secondary datasets are used: default DQR parameters as specified in the metadata information of the secondary dataset are used. If default DQR parameters are not available, the DQR is calculated based on the available metadata and following the criteria set out in the Guidance §7.19.4.1.

Table 5 - How to assign the values to parameters in the DQR formula when using company-specific information.

	P_{EF} and P_{AD}	Ti_{R-EF} and Ti_{R-AD}	Ti_{R-SD}	Te_{R-EF} and Te_{R-SD}	G_{R-EF} and G_{R-SD}
1	Measured/calculated and externally verified	The data refers to the most recent annual administration period with respect to the EF report publication date	The EF report publication date happens within the time validity of the dataset	The elementary flows and the secondary dataset reflect exactly the technology of the newly developed dataset	The data(set) reflects the exact geography where the process modelled in the newly created dataset takes place
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to maximum 2 annual administration periods with respect to the	The EF report publication date happens not later than 2	The elementary flows and the secondary dataset is a proxy of the	The data(set) partly reflects the geography where the process

	P_{EF} and P_{AD}	Ti_{R-EF} and Ti_{R-AD}	Ti_{R-SD}	Te_{R-EF} and Te_{R-SD}	G_{R-EF} and G_{R-SD}
		EF report publication date	years beyond the time validity of the dataset	technology of the newly developed dataset	modelled in the newly created dataset takes place
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data refers to maximum three annual administration periods with respect to the EF report publication date	Not applicable	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

P_{EF}: Precision for elementary flows; **P_{AD}**: Precision for activity data; **Ti_{R-EF}**: Time Representativeness for elementary flows; **Ti_{R-AD}**: Time representativeness for activity data; **Ti_{R-SD}**: Time representativeness for secondary datasets; **Te_{R-EF}**: Technology representativeness for elementary flows; **Te_{R-SD}**: Technology representativeness for secondary datasets**;** **G_{R-EF}**: Geographical representativeness for elementary flows; **G_{R-SD}:** Geographical representativeness for secondary datasets.

The results of the data quality assessment are summarized and reported in chapter 7.

5 Life cycle inventory analysis

This section provides a description of inputs (resources, materials) and outputs (emissions) associated with the 31 activities identified in the OEF assessment.

All activity data have been collected on site. If not otherwise specified, they are related to the reporting period 2015. Main sources for data collection have been the followings:

- JRC Ispra site, Register of measures and environmental indicators v1.0, 2016 (e.g. I-03.01 and others) (9);
- JRC Ispra site transport survey, 2016;
- JRC Ispra Site Initial Environmental Review (IER), Rev 1.0, December 2008;
- Information from relevant JRC Units and staff (e.g. R.I.3, R.I.4, etc.).

Each table presented below includes, where applicable, input and output flows both elementary and non-elementary, along with information on the data source. Furthermore, where appropriate, information on distances from the suppliers have been documented to evaluate transportation impacts of materials and equipment.

Elementary flows are (ISO 14040:2006, 3.12) "*material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation*." Elementary flows are e.g. resources taken from the nature or emissions into air, water, soil that are directly linked to the characterization factors of the EF impact categories.

Non-elementary (or complex) flows are all the remaining inputs (e.g. electricity, materials, transport processes) and outputs (e.g. waste, by-products) in a system that need further modelling efforts to be transformed into elementary flows.

Overall, it may be assumed that elementary flows correspond to *direct environmental aspects* as defined in EMAS, whereas non-elementary flows relate to *indirect environmental aspects*. The resource use and emissions profile, therefore, provides also a complete inventory of the organisation environmental aspects for EMAS purposes.

Generic data have been used to model all non-elementary flows and some elementary flows, both for inputs (e.g. materials supply chain) and outputs (e.g. waste management operations). These data have been sourced from internationally recognized LCI databases. The following priority scale has been applied:

- EF database: February 2018 (provided by JRC)
- Ecoinvent 3.2, 2015;
- European reference Life Cycle Database (ELCD), version II, 2009;
- Others (e.g. Agribalyse).

All generic data reported in the following sections are classified using acronyms according to the source database:

- **EF**: Environmental Footprint database
- **EI**: Ecoinvent
- **AG**: Agribalyse

Other cases are documented directly in the inventory tables.

In some cases, the generic data sources have been adapted to the specific context or combined to build more complex product systems. These modifications are highlighted in the data tables. The nomenclature adopted for modified generic data contains a heading which refers to the activity where these data have been used followed by a progressive number (e.g. A01.01, A01.02 etc.). Where relevant and feasible, EF compliant datasets have been also implemented in the sub-datasets. The full details are documented in Annex 5 – Sub-datasets.

Elementary flows that have been measured on site do not need association with generic data.

As stated in the limitations/assumptions chapter, not all of the inventory has been updated from Ecoinvent (or other databases) to the EF database. The checklist used for the overall update of the previous footprint model is reported in Annex 3.

Table 6 shows the key to read data related to the life cycle inventory.

Table 6 – LCI legend

Non-elementary flows	Material or energy entering the system or discarded into the environment, modified through technical processes
Elementary flows	Material or energy entering the system or discarded into the environment without being subject to human transformation
Unit	Unit of measurement
Value	Calculated or measured value representing the flow and referred to the unit of measurement
Distance	Distance between JRC-Ispra and the supplier/destination of the flow (e.g. chemicals suppliers, waste treatment plants, etc.)
Destination	Waste flows final treatment (only applicable to activities A10 and A11)
Weight	Weight of consumables (e.g. stationery) or assets (e.g. IT equipment)
Area	Floor area of buildings (only applicable to A29)
Volume	Volume of buildings (only applicable to A29)
Specific data	Data directly collected, measured on site or specifically referred to JRC-Ispra activities
Generic data	Data from literature or databases

5.1 A01 – Energy supply from internal cogeneration

Most of the energy required for the JRC Ispra site activities, in terms of electricity, heating and cooling, is produced by an internal cogeneration plant fuelled with natural gas and equipped with:

- 4 cogenerating units based on an otto-cycle engine;
- 2 absorption coolers, fed with steam and hot water;
- 4 hot water generators to supplement thermal energy supply in winter.

The plant works at an efficiency of around 80%, producing up to 6.2 MW of electrical power, 21.5 MW of thermal power and 5.8 MW of refrigerating power (10).

In 2015 the cogeneration plant production was:

- Electricity: 28,128 MWh (source I-03.07)
- Heating: 34,660 MWh (source I-03.16)
- Cooling: 12,839 MWh (source I-03.17)

Table 7 - A01 Energy supply from internal cogeneration

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Natural gas	Sm^3	9,708,132	included in the generic dataset	I-03.01	Natural gas mix| technology mix| consumption mix, to consumer| medium pressure level (< 1 bar) {IT} [LCI result]	EF
NaOH (30%)	kg	2,600	36.5	R.I.4	Sodium hydroxide production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]	EF
HCl (32%)	kg	2,300	36.5	R.I.4	Hydrochloric acid production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]	EF
Urea (expressed as N)	kg	81,213	36.5	R.I.4	Urea| as N| at plant| per kg N {EU-28+3} [LCI result]	EF
Polival M21 (Alkalinising additive)	kg	60	300	R.I.4	Melamine production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result] (Proxy for non hydrazinic anticorrosive)	EF
Kemtrol 211 (Hydrazine based anti-corrosion additive)	kg	275	300	R.I.4	A01.02 - Hydrazine EF	mixed

Dispersol TDX (antifouling)	kg	400	300	R.I.4	EDTA production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result] Proxy for average antifouling additive	EF
Biocide 420 (biocide)	kg	62	300	R.I.4	Alkylbenzene sulfonate production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result] Proxy for average anionic-tenside	EF
Biocide 404 (biocide)	kg	243	300	R.I.4	Alkylbenzene sulfonate production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result] Proxy for average anionic-tenside	EF
Bioxin 120 (anticorrosive)	kg	598	300	R.I.4	A01.02 - Hydrazine EF	mixed
Polival DH3 (anticorrosive)	kg	484	300	R.I.4	Melamine methylated| Technology mix| Production mix, at plant| {GLO} [LCI result] Proxy for non hydrazinic anticorrosive	EF
Alifos LS (antiscalant, anticorrosive)	kg	1,430	300	R.I.4	Fatty alcohols production| technology mix| production mix, at plant| 100% active substance {GLO} [LCI result] Proxy for average tenside	EF
Transport	tkm	4,209	-	-	See paragraph 5.32	-

OUTPUT					
Elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
CO_2	t	18,989	I-05.06	-	-
NOx	kg	16,384	I-05.01	-	-
CO	kg	20,212	I-05.01	-	-
SO_2	kg	179	-	-	-
PM<2.5	kg	179	-	-	-

Among the input flows, HCl and NaOH are used mainly for water demineralization in the district heating network. Similarly, the other substances are anticorrosives, antiscalants, antifoulings or biocides.

All transports have been calculated according to the average distance of the suppliers from the JRC Ispra site.

5.2 A02 – Electricity supply from the grid

Electricity needs of the JRC site are partly fulfilled (7.7% of the total site electricity supply) from the external grid. This energy is purchased directly from a supplier. Table 8**Error! Reference source not found.Error! Reference source not found.** reports the supplier-specific electricity mix sold to JRC (GALA) and the national grid mix. The supplier-specific mix for the year 2015 has been therefore considered in the footprint model.

Table 8 - JRC supplier electricity mix (2015).

Primary energy sources	Supplier (GALA)		National average	
	2014	2015	2014	2015
Renewable sources	43.71 %	39.43 %	43.10 %	41.60 %
Coal	18.57 %	20.23 %	19.00 %	19.60 %
Natural gas	30.07 %	30.90 %	28.60 %	28.30 %
Oil	0.98 %	1.36 %	1.00 %	1.30 %
Nuclear	2.79 %	4.83 %	4.60 %	5.10 %
Other sources	3.88 %	3.25 %	3.70 %	3.10 %

Table 9 – A02 Electricity supply from the grid.

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Electricity (high voltage)	MWh	2,382	I-03.08	Electricity, high voltage {IT}| (JRC) EF	Own modelling
Coal	%	20.23	GALA	Electricity from hard coal| AC, mix of direct and CHP, technology mix regarding firing and flue gas cleaning| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	EF
Natural gas	%	30.9	GALA	Electricity from natural gas| AC, mix of direct and CHP, technology mix regarding firing and flue gas cleaning| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	EF
Oil	%	1.36	GALA	Electricity from heavy fuel oil (HFO)| AC, mix of direct and CHP, technology mix regarding firing and flue gas cleaning| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	EF
Unspecified + waste	%	3.24	GALA	Electricity from fossil unspecified| AC, technology mix| production mix, at plant| 1kV - 60kV {IT} [LCI result]	EF
Nuclear	%	4.83	GALA	Electricity from nuclear| AC, technology mix of BWR and PWR| production mix, at power plant| 1kV - 60kV {FR} [LCI result]	EF
Geothermal*	%	2.00	GALA	Electricity from geothermal| AC, CHP, technology mix| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	EF
Hydro*	%	19.3	GALA	Electricity from storage and pump storage power plant| AC, storage and pump storage power| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	EF
Wind*	%	5.26	GALA	Electricity from wind power| AC, technology mix of onshore and offshore| production mix, at plant| 1kV - 60kV {IT} [LCI result]	EF
Solar (photovoltaic)*	%	7.62	GALA	Electricity from photovoltaic| AC, technology mix of CIS, CdTE, mono crystalline and multi crystalline| production mix, at plant| 1kV - 60kV {IT} [LCI result]	EF
Biogas*	%	3.96	GALA	Electricity from biogas| AC, mix of direct and CHP, technology mix regarding firing and flue gas cleaning| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	EF
Biomass*	%	1.3	GALA	Electricity from biomass (solid)| AC, mix of direct and CHP, technology mix regarding firing and flue gas cleaning| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	EF

*Shares of renewables from Thinkstep dataset "Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, to consumer| 1kV - 60kV {IT} [LCI result]"

5.3 A03 – Electricity supply from photovoltaic installations

In addition to energy supply from the trigenerator and from the external grid, a small amount of electricity is produced internally by a photovoltaic plant and entirely consumed on site.

The productivity has increased about six times from 2013 to 2015, because of the photovoltaic field on the top of the new buildings 100 and 101.

Table 10 – A03 Electricity supply from photovoltaic installations

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Electricity (photovoltaic)	MWh	378	I-03.09	Electricity from photovoltaic| AC, technology mix of CIS, CdTE, mono crystalline and multi crystalline| production mix, at plant| 1kV - 60kV {IT} [LCI result]	EF

5.4 A04 – Heating from other boilers

The JRC site canteens and a few other facilities outside the fence are not supplied by the trigeneration plant, but through dedicated natural gas boilers.

Table 11 – A04 Heating from other boilers.

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Natural Gas	Sm^3	97,802	I-03.02	Thermal energy from natural gas| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]	EF

5.5 A05 – Water supply and wastewater treatment

JRC site meets the need of drinking and industrial water by drawing it from Lake Maggiore with an average flow of about 250 m^3/h (in 2015). Water is made drinkable following a purification treatment with $NaClO_2$ and HCl.

About 740 m^3/h of industrial and civil wastewater is treated with a chemicals blend before being discharged into the Novellino River which flows into Lake Maggiore. The total amount of wastewater treated in 2015 was 5,659,332 m^3 (source I-02.01). This amount takes into account also significant contributions from rainwater and spring water, which are not accounted for (no data available) in the input section.

According to the impact method required in the OEF methodology for water depletion, only the consumptive use of water shall be considered in the calculation, namely uptake minus discharge. In agreement with JRC, the discharge has been estimated equal to 95% of the uptake (input water from Lake Maggiore), with the remaining 5% accounted as network losses and consequently as consumptive use.

It also has to be considered that about 20% of the treated water comes from the water drainage of Ispra households, commercial and small manufacturing activities. There is in fact an agreement between the JRC and the Municipality of Ispra by which the site provides treatment to the waste water released from municipal uses. Although such emissions are not generated by the JRC, the corresponding flows have been fully included in the assessment, in the assumption that the wastewater treatment plant (WWTP) is fully controlled by the JRC and therefore falls within the OEF boundaries (see System boundaries).

Table 12 – A05 Water supply and wastewater treatment.

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
$NaClO_2$ (25%)	kg	3,300	38	R.I.4	Sodium hypochlorite production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]	EF
HCl (32%)	kg	2,900	38	R.I.4	Hydrochloric acid production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]	EF
Polyelectrolyte Hydrofloc 385	kg	200	100	R.I.4	Cationic resin production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result] (proxy)	EF
$Ca(OH)_2$	kg	250	100	R.I.4	Lime, hydrated, packed {CH}| production | Alloc Def, U	EI
Enzymes	kg	50	100	R.I.4	Enzyme A - (confidential data)	-
Transport	tkm	286,000	-	-	See paragraph 5.32	-
Elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Water from Lake Maggiore	m^3	2,201,344	-	I-01.01	-	-

OUTPUT					
Elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Water, IT	m^3	2,091,277	R.I.4	-	-
Aluminium	kg	346	R.I.4	-	-

OUTPUT					
Elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Arsenic	kg	Not Detected	R.I.4	-	-
Barium	kg	95.4	R.I.4	-	-
Boron	kg	257.9	R.I.4	-	-
Cadmium	kg	Not Detected	R.I.4	-	-
Cyanide	kg	Not Detected	R.I.4	-	-
Chromium tot	kg	8.89	R.I.4	-	-
Hexavalent chromium	kg	Not Detected	R.I.4	-	-
Free available chlorine	kg	121	R.I.4	-	-
Iron	kg	1,327	R.I.4	-	-
Manganese	kg	102	R.I.4	-	-
Mercury	kg	0.89	R.I.4	-	-
Nickel	kg	30	R.I.4	-	-
Lead	kg	Not Detected	R.I.4	-	-
Copper	kg	171	R.I.4	-	-
Selenium	kg	Not Detected	R.I.4	-	-
Tin	kg	Not Detected	R.I.4	-	-
Zinc	kg	55.6	R.I.4	-	-
Sulphides	kg	Not Detected	R.I.4	-	-
Sulphites	kg	Not Detected	R.I.4	-	-
Sulphates	kg	91,173	R.I.4	-	-
Chlorides	kg	27,918	R.I.4	-	-
Fluorides	kg	493	R.I.4	-	-
Animal and vegetable fats and oils	kg	1,965	R.I.4	-	-
Hydrocarbons , mineral oils	kg	3,556	R.I.4	-	-
Phenols	kg	Not Detected	R.I.4	-	-

OUTPUT					
Elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Aldehydes	kg	Not Detected	R.I.4	-	-
Aromatic organic solvents	kg	2.51	R.I.4	-	-
Nitrogenated organic solvents	kg	Not Detected	R.I.4	-	-
Cationic surfactants	kg	2036	R.I.4	-	-
Anionic surfactants	kg	181	R.I.4	-	-
Surfactants tot	kg	526	R.I.4	-	-
Phosphorus pesticides	kg	Not Detected	R.I.4	-	-
Chlorinated solvents	kg	Not Detected	R.I.4	-	-
Aldrin	kg	Not Detected	R.I.4	-	-
Dieldrim	kg	Not Detected	R.I.4	-	-
Edrin	kg	Not Detected	R.I.4	-	-
Isodrin	kg	Not Detected	R.I.4	-	-
COD	kgO2	Not Detected	R.I.4	-	-
BOD5	kgO3	Not Detected	R.I.4	-	-
Suspended solids	kg	23,346	R.I.4	-	-
Phosphorus tot	kg	1,399	R.I.4	-	-
Ammonia nitrogen	kg	6,306	R.I.4	-	-
Nitrate nitrogen	kg	6,185	R.I.4	-	-
Nitrite nitrogen	kg	256	R.I.4	-	-

As agreed with JRC-R.I.4, data regarding emissions to water have been calculated as follows:

a. Calculation of the mass of substances coming in from the Lake Maggiore, based on Arpa water analyses. E.g.: Iron – mean $concentration_{IN}$: 0.11 kg/m^3_{IN} ➔ $Iron_{IN}$ = 2,201,344* 0.01 = 22,01 kg/year
b. Calculation of the mass of substances discharged into Novellino river, based on JRC analyses. E.g.: Iron – mean $concentration_{OUT}$: 0.238 kg/m^3_{OUT} ➔ $Iron_{OUT}$ = 5,659,332 * 0.238 = 1,550 kg/year
c. For each substance, calculation of the total amount of substance discharged into water directly coming from wastewater treatment activities, excluding the existing mass deriving from the Lake Maggiore input. E.g.: $Iron_{TOT}$ = $Iron_{OUT}$ – $Iron_{IN}$ = 1,550 – 22,01= 1,527.9 kg/year

This approach was applied to all substances accounted for in water analyses periodically carried out both on input and output flows and adopting the following assumptions:

- If a single raw monthly data registered a value "below the instrumental detection limit", that data was assumed as the lower detection limit for the evaluation of the annual average concentration (conservative assumption)
- In case all samples were below the detection limit, the substance was discarded from the emission profile.

Even so, the reported emissions resulted beneath Italian legal limits by one or two orders of magnitude, according to the legislative decree n. 152/2006, part III, annex 5.

In addition to the reported output flows, the wastewater treatment plant treated 16,840 kg of wastewater mud (CER 190812). Since it is a special waste, all related impacts are accounted in A11 - Special waste management.

Among the input flows, sodium chlorite and hydrochloric acid are used for drinking water purification. The other substances showed in the input table are employed in the wastewater treatment.

The distance from the final suppliers has been calculated for chemicals, based on data provided by R.I.4. Information on Hydrofloc 385, $Ca(OH)_2$ and Enzymes suppliers were not available, therefore a default distance of 100 km has been assumed.

5.6 A06 – Internal fleet activities

The JRC Ispra service fleet includes 122 cars and vans which are used for circulation within the site. In the original application of the study, this activity relates only to vehicles operations, represented by fuel consumption and distance covered. Using the EF database (LCI results available only), it is not possible to distinguish between operation and manufacturing impacts. Therefore, impacts of vehicles construction in A28 are put to 0 to avoid double counting.

Table 13 – A06 Internal fleet activities.

INPUT				
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**
Internal fleet activities	km	289,819	R.I.3	Passenger car, average| technology mix, gasoline and diesel driven, Euro 3-5, passenger car| consumption mix, to consumer| engine size from 1,4l up to >2l {GLO} [LCI result]

5.7 A07 – JRC staff and contractors home-work trips

The data used to characterize the commuting mode of JRC staff refer to a new transport survey performed in 2016.

A questionnaire was sent through to the personnel to get information about means of transport and distances.

As around 550 responses (21% of total JRC personnel) were received, the results were upscaled to the total number of people daily present on site at the time. The total amount of answers lead to the following summary:

Table 14 – JRC Ispra site transport survey results: overall distance travelled.

Travelled distance in 2015	
Travelled km (/day, average JRC ISPRA employee)	16.73
TOTAL distance travelled by JRC colleagues (km millions/year)	9.34

The total km travelled in 2015 are splitted up shaping the following table and figure. The weighted share for each transport mean takes into account the answers from all the interviewed employees regarding both the mean of transport used and the average distance cover from home to work (and back).

Table 15 – JRC Ispra site transport survey results: distances by mean of transportation.

SPLIT MODE: Mean of transport	Weighted share (travelled km)	Distance [km]
Car	55.84%	5,217,000
Carpool	5.62%	525,000
Motor	1.61%	151,000
Walk	1.71%	160,000
Bike	1.34%	125,000
Public transport	4.89%	456,500
JRC bus	29.00%	2,709,780*

*In the calculation model, this value (which represents the person-km travelled by JRC buses) has been substituted with the actual distance (km) travelled during the reporting year. More information in the paragraph "JRC buses" below.

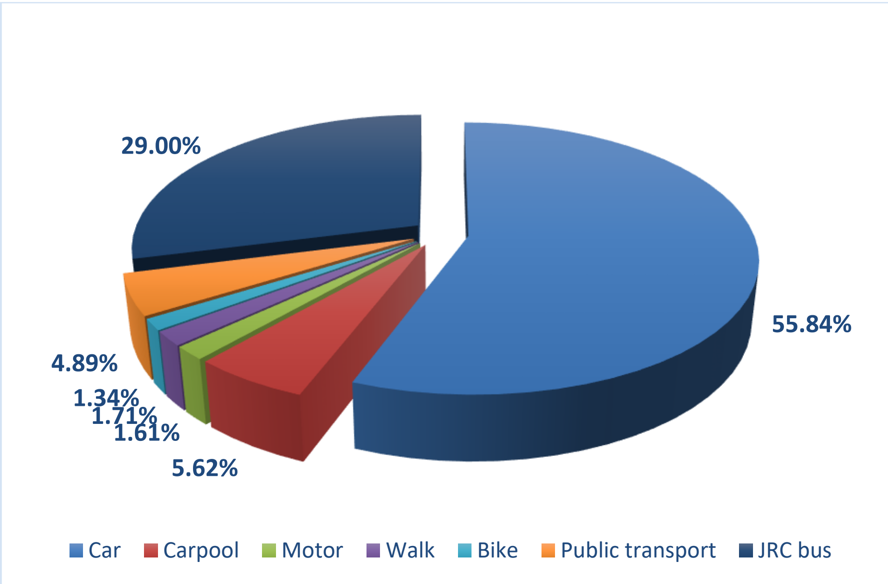


Figure 4 – JRC Ispra site transport survey results: travelled distances by mean of transport (weighted shares).

Car and carpool

Car and carpooling are analysed together. Carpooling considers an average of 3 people per car, while car considers a single driver. Therefore, the total carpooling kilometres need to be divided by the average people in a car. The km per car in carpooling mode have been added to the kilometres travelled by single driver cars.

The survey data provided the subdivision by fuel typology for the distances covered by car (see table below).

Table 16 – JRC Ispra site transport survey results: distances (cars) by fuel.

FUEL	Share	Distance [km]
Diesel	51.02%	2,751,000
Petrol	41.84%	2,256,000
Hybrid methane/petrol	2.04%	110,000
Hybrid LPG/petrol	4.08%	220,000
Electric	1.02%	55,000
TOT	100.00%	5,392,000

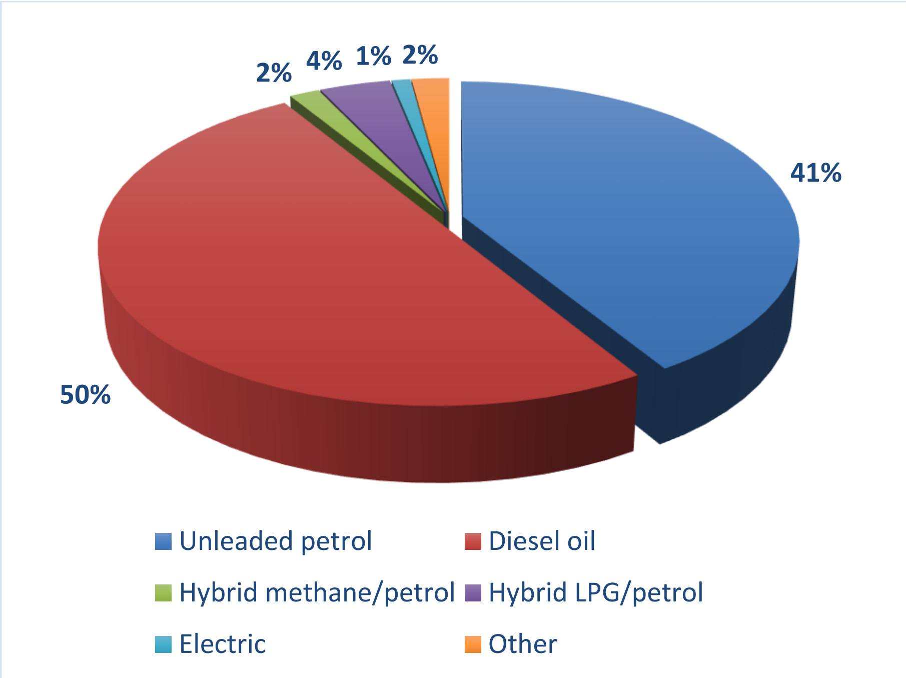


Figure 5 – JRC Ispra site transport survey results: fuel use (car).

Furthermore, the distances travelled by petrol and diesel vehicles have been subdivided by date of registry and EURO class (see the shares below, the distances are reported in the Input table at the end of this paragraph).

Table 17 – JRC Ispra site transport survey results: diesel and petrol cars by EURO class.

Date of registry	Class	Share
Before 1997	EURO 0/1	2.06%
Between 1997 and 2000	EURO 2	4.12%
Between 2001 and 2005	EURO 3	16.49%

Between 2006 and 2010	EURO 4	30.93%
Between 2011 and 2014	EURO 5	46.39%
After 2014		
TOT	-	100.00%

Public transport

The total km travelled by public transport have been further subdivided based on the answers to the survey (see table below).

Table 18 – JRC Ispra site transport survey results: public transportation by mean of transport.

Public transport	Share	Distance [km]
Train	57.65%	263,000*
Bus	37.65%	172,000*
Taxy	4.71%	21,500
TOT	100.00%	456,500

* These distances are expressed in person-km in the calculation model.

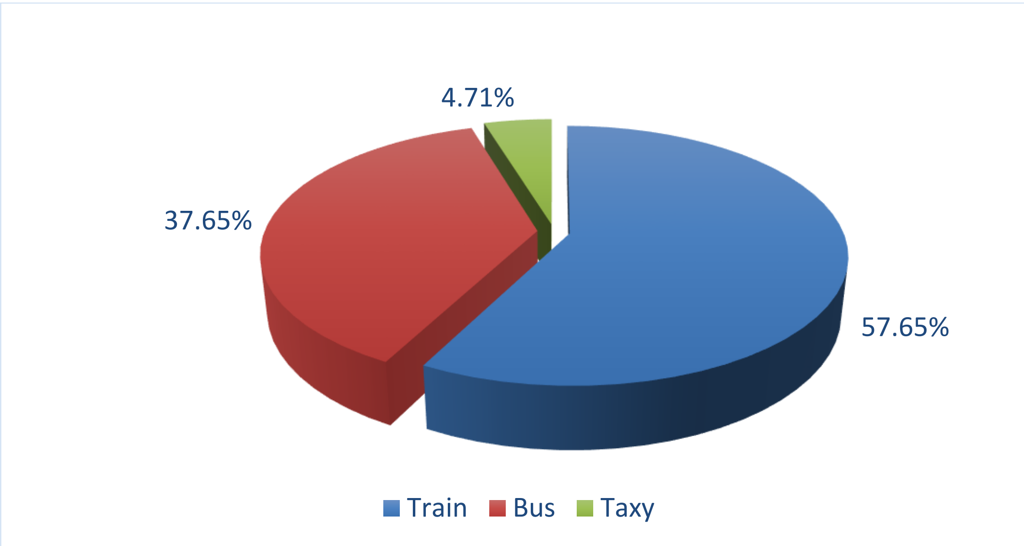


Figure 6 – JRC Ispra site transport survey results: Type of public transport used to get to work.

JRC buses

The transport survey performed in 2016 provides an estimation of the distances travelled by JRC buses based on the JRC personnel answers. The total travelled distance is 2,709,780 person-km. The metric km-person is used to express the combination of distance travelled and people carried. For example, 10 person-km equals to 10 people travelling 1 km or 1 person travelling 10 km. Referring to the survey results for JRC bus, and considering an average bus capacity of 30 people, the travelled distance equals to around 90,000 km.

However, JRC Human Resources provided the total actual distance covered by the JRC buses, accounting for 123,970 km. Since these data are of better quality, they have been preferred for the OEF calculation model over the survey data. The average fuel consumption was also provided, namely 0.26 l/km (Diesel). The emission profile for the JRC bus has been created adapting a generic bus dataset from Ecoinvent.

Summary table

The travelled km for all the transport means considered for the modelling of home-work trips are summarised below.

Table 19 A07 JRC staff and contractors home-work trips.

INPUT					
Non-elementary flows*	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Car (Diesel, pertrol, all emission classes	km	5,007,000	R.I.	Passenger car, average| technology mix, gasoline and diesel driven, Euro 3-5, passenger car| consumption mix, to consumer| engine size from 1,4l up to >2l {GLO} [LCI result]	EF
Hybrid methane/petrol	km	110,000	R.I.	Transport, passenger car, medium size, natural gas, EURO 4 {RER}| transport, passenger car, medium size, natural gas, EURO 4 | Alloc Def, U	EI
Hybrid LPG/petrol	km	220,000	R.I.	Transport, passenger car, medium size, liquefied petroleum gas, EURO 5 {GLO}| transport, passenger car, medium size, liquefied petroleum gas (LPG), EURO 5 | Alloc Def, U	EI
Electric	km	55,000	R.I.	Transport, passenger car, electric {IT}| processing | Alloc Rec, U	EI
Motor	person km	151,000	R.I.	Transport, passenger, motor scooter {CH}| processing | Alloc Def, U	EI
Train	person km	263,000	R.I.	Transport, passenger train {IT}| processing | Alloc Def, U	EI
Bus	person km	172,000	R.I.	Transport, passenger coach {CH}| processing | Alloc Def, U	EI
Taxy	km	21,500	R.I.	Passenger car, average| technology mix, gasoline and diesel driven, Euro 3-5, passenger car| consumption mix, to consumer| engine size from 1,4l up to >2l {GLO} [LCI result]	EF

INPUT					
Non-elementary flows*	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
JRC Bus	km	123,970	R.I.	Transport, JRC bus {CH}| processing | Alloc Def, U	EI

5.8 A08 – JRC transportation from Malpensa

A service provides daily transportation from and to the airport for staff and visitors.

Table 20 – A08 JRC transportation from Malpensa.

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Diesel van (Malpensa)	km	882,049	I-12.02	Passenger car, average| technology mix, gasoline and diesel driven, Euro 3-5, passenger car| consumption mix, to consumer| engine size from 1,4l up to >2l {GLO} [LCI result]	EF

5.9 A09 – JRC staff business travels

This activity includes all missions executed by JRC staff in the reference period, divided by modes of transport (coach, car, train, airplane).

Table 21 – A09 JRC staff business travels.

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Plane Short (<=3000 km)	personkm	8,240,932	PMO	Transport, passenger, aircraft {RER}| intracontinental | Alloc Def, U	EI
Plane Long (>3000 km)	personkm	6,238,840	PMO	Transport, passenger, aircraft {RER}| intercontinental | Alloc Def, U	EI
Train	personkm	623,939	PMO	Transport, passenger train {IT}| processing | Alloc Def, U	EI
Car	km	628,789	PMO	Passenger car, average| technology mix, gasoline and diesel driven, Euro 3-5, passenger car| consumption mix, to consumer| engine size from 1,4l up to >2l {GLO} [LCI result]	EF
Coach	personkm	49,848	PMO	Transport, passenger coach {CH}| processing | Alloc Def, U	EI

Data have been elaborated from mission records provided by the JRC Post Master Office (PMO) which document the city of departure, destination and transport means for each staff mission.

5.10 A10 – Urban waste management

Urban waste generated on site includes food waste and packaging waste from different materials, mainly paper, glass and plastics. This activity comprises also special waste that are assimilated to urban waste (RSAU).

During 2015, 68% of urban waste were separately collected and sent to recycling facilities. The remaining part was disposed in municipal landfills.

Table 22 – A10 Urban waste management

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Transport (recycling)	tkm	12,530	-	-	See paragraph 5.32	-
Transport (disposal)	tkm	6,716	-	-	See paragraph 5.32	-

OUTPUT							
Non-Elementary flows	**Unit**	**Value**	**Distance (km)**	**Destination**	**Specific data**	**Generic data**	**DB**
Plastic packaging (150102)	kg	27,430	40	Recycling	R.I	-	-
Glass packaging (150107)	kg	21,080	50	Recycling	R.I	-	-
Paper and cardboard (200101)	kg	113,600	25	Recycling	R.I	-	-
Biodegradable kitchen and canteen waste (200108)	kg	48,060	40	Recycling	R.I	-	-
Edible oil and fat (200125)	kg	2,542	50	Recycling	R.I	-	-
Street-cleaning (200303)	kg	137,240	40	Recycling	R.I	-	-
Mixed municipal waste (200301)	kg	167,890	40	Disposal	R.I	Municipal solid waste (waste treatment) {CH}| treatment of municipal solid waste, sanitary landfill | Alloc Def, U	EI

Waste to disposal has been modelled considering a sanitary landfill for municipal solid waste. The distance of the final treatment sites varies from 25 to 90 km and has been calculated upon information on the waste management companies under contract to JRC Ispra.

No impacts have been assigned to recycling processes, except for transportation to the recycling facilities.

5.11 A11 – Special waste management

The special waste produced on site accounted for 775 t, including many different hazardous and non-hazardous streams, ranging from exhausted oils, batteries, metal scraps, construction/demolition waste, electronic and chemical waste.

Waste disposal has been modelled with generic data considering different treatment processes. These depend on European Waste Codes (EWC) assigned to each flow.

In line with a cut-off modelling approach, no impacts have been assigned to recycling processes, except from transportation to the recycling facilities. This implies that no generic data have been associated to the waste streams sent to recycling. It has been assumed that both environmental credits of recycled materials and environmental burdens of recycling operations are borne by the user of the recycled material, which stands outside the study system boundaries.

Table 23 – A11 Special waste management.

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Transport (recycling)	tkm	25,550	-	-	See paragraph 5.32	-
Transport (disposal)	tkm	3,844	-	-	See paragraph 5.32	-

OUTPUT							
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Destination**	**Specific data**	**Generic data**	**DB**
Sludges from treatment of industrial waste water (190812)	kg	16,840	150	Recycling	R.I	-	-
Other batteries and accumulators (160605)	kg	704	90	Recycling	R.I	-	-
Lead batteries (160601*)	kg	11,100	70	Recycling	R.I	-	-
Waste printing toners (080318)	kg	2,114	30	Recycling	R.I	-	-
Mixed construction and demolition wastes (170904)	kg	29,780	17.5	Recycling	R.I	-	-
Iron and steel (170405)	kg	409,850	10	Recycling	R.I	-	-
Discarded equipment containing hazardous components (160213*)	kg	22,320	23	Recycling	R.I	-	-
Synthetic engine, gear and lubricating oils (130206*)	kg	538	50	Recycling	R.I	-	-
Fluorescent tubes and other waste	kg	174	50	Recycling	R.I	-	-

OUTPUT							
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Destination**	**Specific data**	**Generic data**	**DB**
containing mercury (200121*)							
Wood (200138)	kg	84,540	70	Recycling	R.I	-	-
Discarded equipment containing chlorofluorocarbons (200123*)	kg	2,520	60	Recycling	R.I	-	-
Others oil (130208*)	kg	1,215	90	Recycling	R.I	-	-
Chlorofluorocarbon, HCFC, HFC (140601*)	kg	90	90	Recycling	R.I	-	-
Cadmium batteries (160602*)	kg	384	90	Recycling	R.I	-	-
Cables (170411)	kg	6,140	90	Recycling	R.I	-	-
Oil filters (160107)	kg	36	90	Recycling	R.I	-	-
Alluminum (170402)	kg	110	90	Recycling	R.I	-	-
Waste from desanding (190802)	kg	112,900	90	Recycling	R.I	-	-
Aqueous rinsing liquids containing dangerous substances (110111*)	kg	82	90	Disposal	R.I	Hazardous waste, for incineration {CH}| treatment of hazardous waste, hazardous waste incineration | Alloc Def, U	EI
Laboratory chemicals, consisting of or containing dangerous substances, including mixtures of laborator-y chemicals- (160506*)-	kg	4,618	90	Disposal	R.I	Spent solvent mixture {CH}| treatment of, hazardous waste incineration | Alloc Def, U	EI
Wastes whose collection and disposal is subject to special requirements in order to prevent	kg	2,600	30	Disposal	R.I	Hazardous waste, for incineration {CH}| treatment of hazardous waste, hazardous waste incineration | Alloc Def, U	EI

OUTPUT							
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Destination**	**Specific data**	**Generic data**	**DB**
infection (180103*)							
Waste paint and varnish containing organic solvents or other dangerous substances (080111*)	kg	323	160	Disposal	R.I	Waste paint {CH}| treatment of, hazardous waste incineration | Alloc Def, U	EI
Machining emulsions and solutions free of halogens (120109*)	kg	7,529	50	Disposal	R.I	Spent solvent mixture {CH}| treatment of, hazardous waste incineration | Alloc Def, U	EI
Bulky waste (200307)	kg	46,490	40	Disposal	R.I	Municipal solid waste {CH}| treatment of, sanitary landfill | Alloc Def, U	EI
Packaging containing organic solvents or other dangerous substances (150110*)	kg	663	90	Disposal	R.I	Hazardous waste, for incineration {CH}| treatment of hazardous waste, hazardous waste incineration | Alloc Def, U	EI
Absorbents contaminated with dangerous substances (150202*)	kg	2,885	90	Disposal	R.I	Hazardous waste, for incineration {CH}| treatment of hazardous waste, hazardous waste incineration | Alloc Def, U	EI
insulating materials (170603*)	kg	114	90	Disposal	R.I	Hazardous waste, for incineration {CH}| treatment of hazardous waste, hazardous waste incineration | Alloc Def, U	EI
Ion exchange resins (190905)	kg	44	90	Disposal	R.I	Spent cation exchange resin from potable water production {CH}| treatment of, municipal incineration | Alloc Def, U	EI
Screening from sludges (190801)	kg	8,020	90	Disposal	R.I	Municipal solid waste {RoW}| treatment of, sanitary landfill | Alloc Def, U	EI

* hazardous waste

The distance of the final treatment sites varies from 10 to 160 km and has been calculated upon information on the waste management companies under contract to JRC Ispra. In 2015, 9% of special waste was sent to disposal while the recycled amount reached 91%.

5.12 A12 – Green areas maintenance

The extension of green areas within the JRC site is about 109 ha (65% of the total area). Maintenance activities consist of periodic meadow mowing and tree lopping. Fertilizers and pesticides are not used. Wood and biomass materials are usually composted on site, but not in 2015.

Table 24 – A12 Green areas maintenance

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Mown/cut area	ha	384	EMAS	Mowing, by motor mower {CH}| processing | Alloc Def, U	EI

Impacts from mowing and cutting have been modelled considering the use of agricultural machineries.

It is assumed that no land use changes occurred within the site in the last 20 years.

5.13 A13 – Nuclear activities

As JRC Ispra site was founded with nuclear research purposes, two nuclear reactors plus a third only for critical experiments were built within its borders, starting from 1959.

The older one, Ispra-1, is a 5MW power heavy water moderator; in 1965 ECO reactor 1kW power, heavy water moderator became operational. Lastly in 1968 a 25MW reactor became operational, the ESSOR (Essai ORGEL).

As Ispra-1 was shut down in 1977, ECO in 1980 and ESSOR in 1983, today all impacts from nuclear activities are due to internal operations of preparing nuclear decommissioning. Nuclear waste is currently stored on site in a dedicated area, awaiting the construction of the Italian National Nuclear Waste Repository. Emissions of radionuclides in atmosphere and water occurred in 2015 are attributable to the site footprint.

Annual data on radioactive substances emitted into air and water are communicated to the Italian reference authority for nuclear safety (I.S.P.R.A.).

At the moment the nuclear waste disposal resulting from decommissioning activities is not yet modelled, since such waste are still temporarily stored on site.

Table 25 – A13 Nuclear activities

OUTPUT					
Elementary flows (air)	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Hydrogen-3	MBq	$1.40*10^{5}$	G.III.9	-	-
Cs-137	MBq	0.007	G.III.9	-	-
Elementary flows (water)	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Hydrogen-3	MBq	28.46	G.III.9	-	-
Strontium-90	MBq	N.D.	G.III.9	-	-
Other alpha emitters (including Am-241)	MBq	N.D.	G.III.9	-	-
Other beta/gamma emitters (including Cs-137 and Co-60)	MBq	1.21	G.III.9	-	-

5.14 A14 – Office paper

This activity includes consumption of office paper having different sizes, weights and materials.

Table 26 – A14 Office paper

INPUT						
Non-elementary flows	**Unit**	**Value**	**Weight (kg)**	**Specific data**	**Generic data**	**DB**
A4 75	n.	7,540,000	35,438	I-11.01	Uncoated wood free paper| production mix| at plant| per kg wood free paper {EU-28+3} [LCI result]	EF
A3 75	n.	212,500	1,998	I-11.01	Uncoated wood free paper| production mix| at plant| per kg wood free paper {EU-28+3} [LCI result]	EF
A4 80	n.	80,000	400	I-11.01	Uncoated wood free paper| production mix| at plant| per kg wood free paper {EU-28+3} [LCI result]	EF
A3 80	n.	45,000	450	I-11.01	Uncoated wood free paper| production mix| at plant| per kg wood free paper {EU-28+3} [LCI result]	EF
A4 80 recycled	n.	247,500	1,238	I-11.01	Graphic paper| production mix| at plant| per kg graphic paper {EU-28+3} [LCI result]	EF

INPUT						
Non-elementary flows	**Unit**	**Value**	**Weight (kg)**	**Specific data**	**Generic data**	**DB**
A3 80 recycled	n.	20,000	200	I-11.01	Graphic paper| production mix| at plant| per kg graphic paper {EU-28+3} [LCI result]	EF
A4 100	n.	75,500	472	I-11.01	Kraft paper, unbleached| production mix| at plant| per kg paper {EU-28+3} [LCI result]	EF
A3 160	n.	30,000	600	I-11.01	Kraft paper, unbleached| production mix| at plant| per kg paper {EU-28+3} [LCI result]	EF
A4 160	n.	1,000	10	I-11.01	Kraft paper, unbleached| production mix| at plant| per kg paper {EU-28+3} [LCI result]	EF
A4 210	n.	1,000	13	I-11.01	Kraft paper, unbleached| production mix| at plant| per kg paper {EU-28+3} [LCI result]	EF
Transport	tkm	4,082	-	-	See paragraph 5.32	-

Sheets weight has been calculated based on the following information (I-11.01):

- 1000 sheets of A4 (80g): 5 kg
- 1000 sheets of A4 (75g): 4.7 kg
- 1000 sheets of A3 (80g): 10 kg
- 1000 sheets A3 (75g): 9.4 kg
- 1000 sheets of A4 (100g): 6.25 kg
- 1000 sheets of A3 (160g): 20 kg
- 1000 sheets of A4 (160g): 10 kg
- 1000 sheets A4 (210g): 13.125 kg

A transportation default distance of 100 km from the final supplier to the JRC site has been assumed.

5.15 A15 – Stationery

Data on stationery items include pens, pencils, markers, rubbers, envelopes and notebooks.

No data on rubbers were recorded, therefore a number of 0.5 rubbers/pencil has been assumed.

A transportation default distance of 100 km from the final supplier to the JRC site has been considered.

Table 27 – A15 Stationery

INPUT						
Non-elementary flows	**Unit**	**Value**	**Weight (kg)**	**Specific data**	**Generic data**	**DB**
Pens	n.	14,117	70.59	R.I.3	13- A15.01 - Pen	EI
Pencils	n.	2,484	8.45	R.I.3	13- A15.02 - Pencil	EI
Rubbers	n.	898	13.47	expert judgement	13- A15.03 - Rubber	EI
Markers	n.	3,341	76.84	R.I.3	13- A15.04 - Marker	EI
Envelopes	n.	129,465	906.26	R.I.3	Paper, woodfree, uncoated {RER}| market for | Alloc Def, U	EI
Notebooks	n.	2,212	829.50	R.I.3	- Paper, woodfree, uncoated {RER}| market for | Alloc Def, U - Solid unbleached board {RER}| production | Alloc Def, U	EI
Transport	tkm	196.04			See paragraph 5.32	-

The weights have been counted as follows:

- Pen: 5 g
- Pencil: 3.4 g
- Marker: 15 g
- Rubber: 23 g
- Envelope: 7 g
- Notebook: 375 g

The above data have been derived from public sources and information from the producers.

5.16 A16 – Chemical products

Chemical products are mainly used in laboratory activities and include a large variety of substances. Consumption data are not recorded, but a large inventory database (DAISY) provides data on current stocks.

A 10% of consumption per year of those amounts has been reasonably assumed.

Table 28 – A16 Chemicals products.

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Potassium chloride	kg	1.57	DAISY – expert judgement	Potassium chloride, as K2O {RER}| potassium chloride production | Alloc Def, U	EI
Sodium chloride	kg	542.33	DAISY – expert judgement	Sodium chloride, powder {RER}| production | Alloc Def, U	EI
Sodium hydroxide	kg	423.35	DAISY – expert judgement	Sodium hydroxide, without water, in 50% solution state {GLO}| market for | Alloc Def, U	EI
Nitric acid	kg	32.62	DAISY – expert judgement	Nitric acid, without water, in 50% solution state {RER}| nitric acid production, product in 50% solution state | Alloc Def, U	EI
Sulphuric acid	kg	13.28	DAISY – expert judgement	Sulfuric acid {RER}| production | Alloc Def, U	EI
Acetone	kg	49.57	DAISY – expert judgement	Acetone, liquid {RER}| production | Alloc Def, U	EI
Acetonitrile	kg	33.67	DAISY – expert judgement	Acetonitrile {RER}| Sohio process | Alloc Def, U	EI
Ethyl acetate	kg	11.48	DAISY – expert judgement	Ethyl acetate {RER}| production | Alloc Def, U	EI
n-Hexane	kg	26.05	DAISY – expert judgement	Hexane {RER}| molecular sieve separation of naphtha | Alloc Def, U	EI
Toluene	kg	0.09	DAISY – expert judgement	Toluene, liquid {RER}| production | Alloc Def, U	EI
Methanol	kg	24.60	DAISY – expert judgement	Methanol {GLO}| production | Alloc Def, U	EI
Transport	tkm	116	-	See paragraph 5.32	-

The consumption of organic and inorganic chemicals has been assumed based on the percentage of the most representative set of substances recorded in the DAISY database.

A transportation default distance of 100 km from the final supplier to the JRC site has been assumed.

5.17 A17 – Detergents

Detergents are used in toilet rooms, canteens and general cleaning activities.

Table 29 – A17 Detergents.

INPUT					
Non-elementary flows	**Unit**	**Weight**	**Specific data**	**Generic data**	**DB**
Detergents (floor, dishes, etc)	kg	4,540	R.I.3	A17.01 - Detergents	EI
Liquid soap (refills)	Kg	1,458	R.I.3	Soap {RER}| production | Alloc Def, U	EI
Transport	tkm	419.9	-	See paragraph 5.32	-

Data on weights and product characteristics are the same as reporting year 2013:

- 1 litre of detergent: 1.2 kg

A transportation distance of 70 km from the final supplier based in Milan has been considered.

5.18 A18 – Tissue paper

Tissue paper includes toilet paper, kitchen rolls and paper handkerchiefs used in toilet rooms and canteens.

Table 30 – A18 Tssue paper.

INPUT						
Non-elementary flows	**Unit**	**Value**	**Weight (kg)**	**Specific data**	**Generic data**	**DB**
Toilet paper rolls	n.	23,760	7,722	R.I.3	Sanitary and household papers (tissue paper)| production mix| at plant| per kg paper {EU-28+3} [LCI result]	EF
Hand towel rolls	n.	6,300	11,624	R.I.3	Sanitary and household papers (tissue paper)| production mix| at plant| per kg paper {EU-28+3} [LCI result]	EF
Paper handkerchiefs	n.	891,000	2,317	OIB	Sanitary and household papers (tissue paper)| production mix| at plant| per kg paper {EU-28+3} [LCI result]	EF
Transport	tkm	308		-	See paragraph 5.32	-

Data on weights and product characteristics have been collected from the producer:

- 1 toilet paper roll: 0.325 kg
- 1 hand towel roll: 1.845 kg
- 1 handkerchief: 0.0026 kg

A transportation distance of 14.2 km from the final supplier has been considered.

5.19 A19 – Technical gases

Like chemical products, technical gases are used to support laboratory activities. The most important gas is nitrogen liquid which is stored in four permanent tanks. Other gases are purchased in bottles, most of them are 50 litres 200 bars bottles.

Table 31 – A19 Technical gases .

INPUT					
Non-elementary flows	**Unit**	**Weight**	**Specific data**	**Generic data**	**DB**
Nitrogen liquid	kg	108,086	R.I.3	Nitrogen, liquid {RER}| air separation, cryogenic | Alloc Def, U	EI
Carbon dioxide	kg	2,200	R.I.3	Carbon dioxide, liquid {RER}| production | Alloc Def, U	EI
Argon	kg	854	R.I.3	Argon, liquid {RER}| production | Alloc Def, U	EI
Helium	kg	5,415	R.I.3	Helium, crude {GLO}| helium storage, crude | Alloc Def, U	EI
Hydrogen	kg	28	R.I.3	Hydrogen, liquid {GLO}| production mix | Alloc Def, U	EI
Propane/butane	kg	604	R.I.3	Liquefied petroleum gas {Europe without Switzerland}| petroleum refinery operation | Alloc Def, U	EI
Oxygen	kg	172	R.I.3	Oxygen, liquid {RER}| air separation, cryogenic | Alloc Def, U	EI
Compressed air	kg	760	R.I.3	Compressed air, 1000 kPa gauge {RER}| compressed air production, 1000 kPa gauge, <30kW, average generation | Alloc Def, U	EI
Transport	tkm	23,461	-	See paragraph 5.32	-

Gas bottles include several products, e.g. hydrogen, helium, carbon dioxide, argon, propane. A representative basket has been created based on actual consumption data.

To calculate the weights (and thus to calculate transport), the following assumptions have been made:

- Nitrogen liquid: 0.8098 kg/l
- Full bottle (gaseous): 40 kg (bottle) + 3 kg (gas)

- Full bottle (liquid): 40 kg (bottle) + 20 kg (liquid)

A transportation default distance of 100 km from the final supplier has been considered.

5.20 A20 – Lubricants

Lubricants are mostly used in the European Laboratory for Structural Assessment (ELSA) of the JRC Institute for the Protection and Security of Citizens (IPSC).

Table 32 – A20 Lubricants

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Lubricants	kg	80	100	IPSC ELSA	Lubricating oil {RER}| production | Alloc Def, U	EI
Transport	tkm	8	-	-	See paragraph 5.32	-

To calculate the transport impacts, a default distance of 100 km has been considered.

5.21 A21 – Light bulbs

This activity comprises all impacts resulting from the manufacturing of incandescent lamps, neon tubes and LED lamps for indoor lighting.

Table 33 – A21 Light bulbs.

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Incandescent lamps	n.	320	30	G.III.9	15 - A21.01 - Light bulbs	EI
Neon tubes	n.	3,540	30	G.III.9	15 - A21.01 - Light bulbs	EI
LED lamps	n.	670	30	G.III.9	15 - A21.02 - LED lamp	EI
Transport	tkm	16.31	-	-	See paragraph 5.32	-

Products come from a supplier in Varese, therefore a transportation distance of 30 km has been considered.

Total weight of the light bulbs has been approximated to an average weight of 120 g/unit for all lamps (public sources, expert judgement).

5.22 A22 – Paints and varnishes

Paint and varnishes are used in building maintenance activities.

Table 34 – A22 Paints and varnishes.

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Paint and varnishes	kg	8,000	35	R.I.4	A22.01 - Paints and varnishes	Mixed EF and EI*
Transport	tkm	280	-	-	See paragraph 5.32	-

*EF data for varnish, EI data for paint

Products come from suppliers in Arona (NO) and Cavallirio (NO), therefore an average transportation distance of 35 km has been considered.

5.23 A23 – Construction materials

This activity includes all materials used for buildings maintenance, but not impacts deriving from buildings construction which are described in A29.

Table 35 – A23 Construction materials.

INPUT						
Non-elementary flows	**Unit**	**Value**	**Weight (kg)**	**Specific data**	**Generic data**	**DB**
Glass windows	m^2	60	1,200	R.I.4	Glazing, double, U<1.1 W/m2K {RER}| production | Alloc Def, U	EI
Concrete	m^3	80	192,000	R.I.4	Cement, Portland {Europe without Switzerland}| production | Alloc Def, U	EI
Transport	tkm	5,796	-	-	See paragraph 5.32	-

The following weights have been considered:

- Glass windows: 20 kg/m^2
- Concrete: 2,400 kg/m^3

Products are supplied from the local market, therefore an average transportation distance of 30 km has been considered.

5.24 A24 – Cooling gases

Cooling gases include gas refilling of refrigeration equipment. During 2015, five types of HFC were consumed for refilling purposes.

To fulfil the mass balance, an equal amount of substances has been accounted as emitted into air.

Table 36 – A24 Cooling gases.

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
HFC (R404a)	kg	4.10	R.I	Tetrafluoroethane (R134a) | estimation | production mix, at plant | 102.03 g/mol Melting point -103.3 °C Boiling point -26.3 °C {DE} [LCI result] (proxy)	EF
HFC (R410a)	kg	6.45	R.I	Tetrafluoroethane (R134a) | estimation | production mix, at plant | 102.03 g/mol Melting point -103.3 °C Boiling point -26.3 °C {DE} [LCI result] (proxy)	EF
HC (R422D)	kg	4.00	R.I	Tetrafluoroethane (R134a) | estimation | production mix, at plant | 102.03 g/mol Melting point -103.3 °C Boiling point -26.3 °C {DE} [LCI result] (proxy)	EF
HFC (R23)	kg	30.00	R.I	Tetrafluoroethane (R134a) | estimation | production mix, at plant | 102.03 g/mol Melting point -103.3 °C Boiling point -26.3 °C {DE} [LCI result] (proxy)	EF
HFC (R508b)	kg	6.80	R.I	Tetrafluoroethane (R134a) | estimation | production mix, at plant | 102.03 g/mol Melting point -103.3 °C Boiling point -26.3 °C {DE} [LCI result] (proxy)	EF
Transport	tkm	5.14	-	See paragraph 5.32	-

OUTPUT					
Elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	kg	2.20	R.I	-	-
Ethane, pentafluoro-, HFC-125	kg	8.00	R.I	-	-
Ethane, 1,1,1-trifluoro-, HFC-143a	kg	2.13	R.I	-	-
Methane, difluoro-, HFC-32	kg	2.00	R.I	-	-
Butane (Pentane R601)	kg	0.22	R.I	-	-
Methane, trifluoro-, HFC-23	kg	33.13	R.I	-	-
Ethane, esafluoro-, HFC-116	kg	3.67	R.I	-	-

Output substances have been selected based on the composition in percentage of each gas. This approach was followed to ensure that all emissions were linked to characterization factors available in the OEF methods:

- HFC (R404a): 44% R125 + 52% R143a + 4% R134a
- HFC (R134a): 100% R134a
- HFC (R410a): 50% R32 + 50% R125
- HFC (R422-D): 31.5% R134a + 65.1% R125 + 3.4% R601
- HFC (R508b): 54% R116 + 46% R23

To calculate the transport impacts, a default distance of 100 km has been considered.

5.25 A25 – Toners

Toners consumption has been derived from data on waste management (waste printing toners – 080318).

A percentage of 30% of the overall amount has been assigned to colour toners, while 70% are black/white toners.

Table 37 – A25 Toners.

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Toners (b/w)	kg	1,480	30	I-04.01	Toner module, laser printer, black/white {GLO}| production | Alloc Def, U	EI
Toners (colour)	kg	634	30	I-04.02	Toner module, laser printer, colour {GLO}| production | Alloc Def, U	EI
Transport	tkm	63	-	-	See paragraph 5.32	-

An average weight of 1.14 kg has been considered for each toner.

A transportation distance of 30 km has been estimated, assuming that the supplier is involved in the whole waste toners treatment and supplying cycle.

5.26 A26 – IT equipment (manufacturing)

IT equipment consists of a broad range of products upholding the JRC staff activities. The data set has been obtained from the JRC assets database (ABAC).

Among the total equipment recorded in the database, the selection includes only active items, identified by the product codes 30, 31 and 32.

To consider impacts due to the production of IT equipment, a designed service life of 5 years has been assumed for all products, except for LCD and TV screens (10 years). Such values have been extrapolated from different sources, including suppliers' technical manuals and environmental performance reports.

This means that, for the reporting period, the impacts of each item account for the 20% of the total (10% for screens), according to a linear approach. Hence only 1/5 of impacts from the equipment manufacturing (1/10 for screens) contribute to the 2015 environmental footprint.

Based on the service life, the manufacturing of screens older than 2006 and the manufacturing of other equipment older than 2011 have not been considered. According to the modelling approach followed (see chapter 3.3), impacts of older items have been paid off prior to 2015.

The JRC assets database does not comprise copying machines, as the service is provided by an external company. For this reason, a number of 1 active machine, supposedly not older than 5 years, for every 10 staff members has been estimated.

ABAC does not include as well landline telephones because they are not considered as assets, therefore a number of 1 telephone per employee has been accounted, assuming that every telephone has not been purchased before 2011. In respect to 2013, ABAC includes now a number of tablets, which have been added to the system.

Generic data from Ecoinvent reported in the table below have been modified excluding use and end-of-life stages from the system.

Table 38 – A26 IT equipment (manufacturing)

INPUT						
Non-elementary flows	**Unit**	**Value**	**Weight (kg)**	**Specific data**	**Generic data**	**DB**
Desktops	n.	3,263 (/5)	8,810	ABAC	A26.01 Computer, desktop, without screen {GLO}| production | Alloc Def, U A26.02 Keyboard {GLO}| production | Alloc Def, U A26.03 Pointing device, optical mouse, with cable {GLO}| production | Alloc Def, U	EI
Laptops	n.	1,040 (/5)	728	ABAC	A26.04 Computer, laptop {GLO}| production | Alloc Def, U	EI
LCD and TV screens	n.	4,754 (/10)	1,901	ABAC	Display, liquid crystal, 17 inches {GLO}| production | Alloc Def, U	EI
Servers	n.	599 (/5)	2,396	ABAC	A26.09 Server - Computer, desktop, without screen {GLO}| production | Alloc Def, U	EI
Modems and routers	n.	93 (/5)	14.88	ABAC	Internet access equipment {CH}| production | Alloc Def, U	EI
Printers (B/W)	n.	42 (/5)	38.64	ABAC	A26.07 Printer, laser, black/white {GLO}| production | Alloc Def, U	EI
Printers (colour)	n.	82 (/5)	75.44	ABAC	A26.08 Printer, laser, colour {GLO}| production | Alloc Def, U	EI
Scanners (B/W)	n.	2 (/5)	1.84	ABAC	A26.10 - Scanner	EI
Scanners (colour)	n.	11 (/5)	10.12	ABAC	A26.10 - Scanner	EI
Mobile phones	n.	194 (/5)	11.10	ABAC	A26.11 - Mobile Phone	EI
Tablets	n.	38 (/5)	5.47	ABAC	A26.12 - Tablet	EI
Copying machines	n.	183 (/5)	1,831	Expert Judgement	A26.07 Printer, laser, black/white {GLO}| production | Alloc Def, U	EI
Telephones	n.	1,831 (/5)	122.7	Expert Judgement	A26.05 - Telephone	EI
Transport	tkm	13,874	-	-	See paragraph 5.32	-

The following average weights have been considered:

- Desktop: 13.5 kg
- Laptop: 3.5 kg
- LCD and TV screen: 4 kg
- Server: 20 kg
- Modem/router: 0.8 kg
- Printer (B/W): 4.6 kg
- Printer (colour): 4.6 kg
- Scanner (B/W): 4.6 kg
- Scanner (colour): 4.6 kg
- Fax: 3.5 kg
- Mobile phone (iPhone 6): 0.286 kg
- Copying machine: 50 kg
- Telephone: 0.335 kg
- Tablet (iPad): 0.72 kg

The above data have been derived from public sources and information from the producers.

In order to account for the transportation impacts, a default distance of 870 km from the final supplier has been assumed, since IT equipment is provided by suppliers in the Brussels's area. Previous transports from manufacturing countries (generally in Eastern Asia) to Europe are included in the generic datasets employed.

5.27 A27 – Furniture (manufacturing)

Data on furniture products have been extracted from the ABAC database. The total amount of active items is around 10,000 pieces, including furniture for offices, laboratories and residences. A designed service life of 10 years has been considered, based on expert judgement and supplier's information.

This means that 1/10 of the active items contributes to the environmental footprint in 2015 and all the accounted items have been acquired from 2004 onwards. The same methodological considerations made for IT equipment (see A26 description) applies here.

In respect to 2013 no data was available for ovens and refrigerators. Therefore they were not included.

Table 39 – A27 Furniture (manufacturing).

INPUT						
Non-elementary flows	**Unit**	**Value**	**Weight (kg)**	**Specific data**	**Generic data**	**DB**
Armoires	n.	810 (/10)	8,910	ABAC	A27.06 - Armoire/bookcase	EI

Tables	n.	124 (/10)	1,509	ABAC	A27.03 - Table	EI
Desks	n.	398 (/10)	2,082	ABAC	A27.02 - Desk	EI
Dressers	n.	72 (/10)	648	ABAC	A27.07 - Dresser	EI
Chairs	n.	297 (/10)	861	ABAC	A27.01 - Chair	EI
Transport	tkm	1,401	-	-	See paragraph 5.32	-

The following weights have been considered:

- Armoire: 110 kg
- Table: 121.7 kg
- Desk: 52.3 kg
- Dresser: 90 kg
- Chair: 29 kg

A transportation default distance of 100 km from the final supplier to the JRC site has been assumed.

5.28 A28 – Vehicles (manufacturing)

Included in A06 (see paragraph 5.6).

5.29 A29 – Buildings (construction)

Inside the JRC Ispra borders there are around 400 buildings accounting for a total volume of more than 1 million m^3 and covering an area of over 660,000 m^2.

The functions and characteristics of each building are widely different as there are many offices along with laboratories, residences, industrial structures and others.

This activity comprises also the JRC road network and technical galleries.

Most of the buildings and roads exist since the site became operational in 1959, while new ones have been built over time and others have been completely refurbished.

In order to evaluate the buildings construction impact, a design service life of 50 years has been considered. The constructions areas and volumes have been therefore divided by 50 to obtain their contribution to the environmental footprint for the reporting period. Only buildings with less than 50 years, i.e. built after 1965, still contributes to the OEF.

For instance, considering a building of 10,000 m^3 covering an area of 1,000 m^2, the impact of the construction phase assigned to the one-year reference period corresponds to a fraction of 200 m^3 and 20 m^2, i.e. 1/50 of the impact.

As most of the buildings and infrastructures have homogeneous characteristics, they have been grouped into classes according to the different functions and construction materials.

The generic data extracted from Ecoinvent have been modelled on the specific buildings categories without considering the end of life stage. Any waste from buildings demolitions in the reporting year are accounted in waste management activities.

The OEF 2015 includes the construction of the new buildings 100 and 101, which became operational in 2014.

Table 40 – A29 Buildings (construction).

INPUT					
Non-elementary flows	**Area (m^2)**	**Volume (m^3)**	**Specific data**	**Generic data**	**DB**
Offices and laboratories	136,568 (/50)	577,416 (/50)	ISBL	A29.01 - Building*	EF
Warehouses, technical	22,457 (/50)	62,666 (/50)	ISBL	A29.01 - Building*	EF
Security	21,832 (/50)	38,356 (/50)	ISBL	A29.01 - Building*	EF
Services	26,779 (/50)	73,654 (/50)	ISBL	A29.01 - Building*	EF
Cyclotron	3,970 (/50)	14,070 (/50)	ISBL	A29.01 - Building*	EF
Waste management	4,931 (/50)	23,255 (/50)	ISBL	A29.01 - Building*	EF
Water supply and wastewater treatment	105,774 (/50)	15,087 (/50)	ISBL	A29.01 - Building*	EF
Cogeneration	2,870 (/50)	26,297 (/50)	ISBL	A29.01 - Building*	EF
ESSOR	26,443 (/50)	134,063 (/50)	ISBL	A29.01 - Building*	EF
Ispra-1	80 (/50)	280 (/50)	ISBL	A29.01 - Building*	EF
Roads (m^2)	180,000 (m^2y)		Initial Environmental Review	Road (german average) | average road construction | production mix, at customer, installed | 1 km road constructed, material composition see table attached {DE} [Partly terminated system]	EF

Elementary Flows	Unit	Value	Specific data	Generic data	DB
Land occupation	m^{2}y**	345,543	ISBL	-	-

* For details regarding the bill of materials used for the modelling of buildings construction, see chapter 7.2, Table 53.

** The metric m^{2}y indicates the use of land over a period of time. 1 m^{2}y indicates the occupation of 1 m^2 for 1 year.

5.30 A30 – External lamps and other minor assets (manufacturing)

The JRC site hosts 1,075 external lighting equipment, with a designed service life of 50 years. This means that 1/50 of products contributes to the environmental footprint in 2015.

Minor assets comprise an estimation of all materials used for minor electronic and laboratory equipment and furniture (laboratory glassware, scales, microscopes, fume hoods, shelves, etc.). In this case an average designed service life of 10 years has been assumed.

Table 41 – A30 External lamps and other minor assets (manufacturing).

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
External lamps	n.	1,075 (/50)	IER + expert judgement	A30.01 – HPS/LED street lamp	EI
Minor assets	kg	100 (/10)	ABAC + expert judgement	A30.02 - Minor assets	EI
Transport	tkm	1,025.8	-	See paragraph 5.32	-

A sample of an external lighting equipment has been modelled for the screening exercise on 2010 data, which include lamp and housing and exclude pole. No relevant changes have been assumed for 2015. A weight of 12 kg for each lamp and a transportation distance of 100 km from the final supplier to the JRC site have been assumed for lamps and other assets.

5.31 A31 – Food supply

2015 data have been collected from the canteen warehouse database and complemented by expert judgement. The information covers all food and beverage categories supplied to the restaurant and coffee bar, as well as products from the vending machines located in offices. The latter were only roughly estimated in the previous assessments, because of data unavailability.

As food product flows are extremely diversified, they have been brought together in key relevant categories for which secondary data are available from LCI databases.

The transportation has been calculated based on information about the final suppliers provided by the canteen management. Other transports from producing countries are included in the generic datasets employed.

Table 42 – A31 Food supply.

INPUT						
Non-elementary flows	**Unit**	**Value**	**Distance (km)**	**Specific data**	**Generic data**	**DB**
Chicken, turkey	kg	7,863	374	JRC-Ispra canteen	Broiler| for slaughter| at farm| per kg live weight {EU-28+3} [LCI result]	EF
Pork	kg	8,191	374	JRC-Ispra canteen	Swine| for slaughter| at farm| per kg live weight {EU-28+3} [LCI result]	EF
Beef	kg	4,790	374	JRC-Ispra canteen	Beef cattle| for slaughter| at farm| per kg live weight {EU-28+3} [LCI result]	EF
Fish, seafood	kg	11,679	80	JRC-Ispra canteen	Large trout, 2-4kg, conventional, at farm gate/FR U Small trout, 250-350g, conventional, at farm gate/FR U Sea bass or sea bream, 200-500g, conventional, in cage, at farm gate/FR U	AG
Pasta	kg	11,756	91	JRC-Ispra canteen	A31.01 – Pasta	EF
Rice	kg	4,540	91	JRC-Ispra canteen	White rice| from dry milling| at plant| {CN} [LCI result]	EF
Eggs	kg	2,327	374	JRC-Ispra canteen	Eggs| production mix| at farm| per kg {EU-28+3} [LCI result]	EF
Milk	kg	10,760	91	JRC-Ispra canteen	Cow milk| production mix| at farm| per kg FPCM {EU-28+3} [LCI result]	EF
Butter	kg	682	91	JRC-Ispra canteen	A31.99 - Butter, from cow milk	Mixed EF/EI

Yoghurt, cream	kg	5,211	91	JRC-Ispra canteen	A31.98 - Cream, from cow milk {RoW}| yogurt production, from cow milk	Mixed EF/EI
Cheese	kg	10,283	91	JRC-Ispra canteen	Cheese, from cow milk, fresh, unripened {GLO}| market for | Alloc Rec, U	EF
Bread	kg	10,166	8	JRC-Ispra canteen	A31.97 - Bread, wheat, conventional, fresh	EF
Vegetables*	kg	80,329	6	JRC-Ispra canteen	- Aubergine {GLO}| production | Alloc Def, U -Broccoli {GLO}| production | Alloc Def, U -Cauliflower {GLO}| production | Alloc Def, U -Celery {GLO}| 675 production | Alloc Def, U -Fennel {GLO}| production | Alloc Def, U -Lettuce {GLO}| 360 production | Alloc Def, U -Spinach {GLO}| production | Alloc Def, U -Zucchini {GLO}| production | Alloc Def, U -Peas, from farm -Carrot, conventional, national average, at farm gate/FR U -Cucumber {GLO}| production | Alloc Def, U -Maize grain, Swiss integrated production {CH}| production | Alloc Def, U -Onion {GLO}| 855 production | Alloc Def, U -Potato, organic {RoW}| production | Alloc Def, U -Tomato {GLO}| production | Alloc Def, U -Fava bean, Swiss integrated production {CH}| fava bean production, Swiss integrated production, at farm | Alloc Def, U	Mixed EI/AG
Fruit*	kg	46,289	6	JRC-Ispra canteen	-Apple, production mix, national average, at orchard/FR U -Grape, integrated, variety mix, Languedoc-Roussillon, at vineyard/FR U	Mixed EI/AG/IE

					-Kiwi {GLO}| production | Alloc Def, U -Melon {GLO}| production | Alloc Def, U -Pear {GLO}| production | Alloc Def, U -Pineapple {GLO}| production | Alloc Def, U -Strawberry {GLO}| production | Alloc Def, U -Citrus {GLO}| production | Alloc Def, U -Banana {GLO}| production | Alloc Def, U	
Oil	kg	9,771	91	JRC-Ispra canteen	Rapeseed| technology mix, production mix| at farm| {EU+28} [LCI result]	EF
Vinegar	kg	869	91	JRC-Ispra canteen	A31.02 - Wine	Mixed EF/EI
Sauces	kg	1,092	91	JRC-Ispra canteen	A31.04 - Ketchup	Mixed EF/EI
Coffee, infusions	kg	11,157	91	JRC-Ispra canteen; JRC-Ispra vending machines	A31.03 - Coffee	EF
Salt	kg	2,536	91	JRC-Ispra canteen	Sodium chloride powder production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]	EF
Sugar	kg	1,120	91	JRC-Ispra canteen	Sugar, from sugar beet| from sugar production, production mix| at plant| {EU+28} [LCI result]	EF
Water (PET)	kg	224,322	32	JRC-Ispra canteen; JRC-Ispra vending machines	Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result] PET bottle, transparent| raw material production, blow moulding| production mix, at plant| 192.17 g/mol per repeating unit {EU-28+EFTA} [LCI result]	EF
Water (glass)	kg	3,732	32	JRC-Ispra canteen	Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result] Container glass, green colour| Green colour container glass (all sizes) to be used for glass bottles and food jars|	EF

					Production mix. Technology mix. EU-28 + EFTA| 1 kg of formed and finished container glass, Recycled Content 80% {EU-28+EFTA} [LCI result]	
Fruit juices	kg	11,611	32	JRC-Ispra canteen; JRC-Ispra vending machines	Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result] Sugar, from sugar beet| from sugar production, production mix| at plant| {EU+28} [LCI result] Beverage carton| precursor material processing, carton assembling and printing| production mix, at plant| grammage: 0.338 kg/m2 {EU-28+EFTA} [LCI result]	EF
Non-alcoholic beverages (PET)	kg	8,818	32	JRC-Ispra canteen; JRC-Ispra vending machines	Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result] Sugar, from sugar beet| from sugar production, production mix| at plant| {EU+28} [LCI result] PET bottle, transparent| raw material production, blow moulding| production mix, at plant| 192.17 g/mol per repeating unit {EU-28+EFTA} [LCI result]	EF
Alcoholic beverages (can)	kg	775	32	JRC-Ispra canteen	Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result] Aluminium foil| primary production| single route, at plant| 2.7 g/cm3 {EU-28+3} [LCI result]	EF
Non-alcoholic beverages (can)	kg	11,420	32	JRC-Ispra canteen; JRC-Ispra vending machines	Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result] Sugar, from sugar beet| from sugar production, production mix| at plant| {EU+28} [LCI result] Aluminium foil| primary production| single route, at plant| 2.7 g/cm3 {EU-28+3} [LCI result]	EF
Alcoholic beverages (glass)	kg	2,929	32	JRC-Ispra canteen	A31.02 – Wine Container glass, green colour| Green colour container glass (all sizes) to be used for glass bottles and food jars| Production mix. Technology mix. EU-28 + EFTA| 1 kg of formed and finished container glass, Recycled Content 80% {EU-28+EFTA} [LCI result]	Mixed EF/EI
Alcoholic beverages (keg)	kg	726	32	JRC-Ispra canteen	Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result] A31.02 – Wine	Mixed EF/EI

					Stainless steel hot rolled| hot rolling| production mix, at plant| stainless steel {ROW} [LCI result]	
transport	tkm	25,590	-	-	See paragraph 5.32	-

* For Vegetables and Fruit, a share to each dataset has been assigned based on equal mass allocation.

5.32 A99 – Transport

According to the OEFSR Guidance requirements for the identification of the most relevant processes (Guidance §7.4.3) the transport of materials (from supplier to end user) and waste have been moved from the activity processes into one general dataset.

Table 43 – A99 Transport (from final supplier to JRC Ispra site).

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
A01 Energy supply from internal cogeneration	tkm	4,209	-	Articulated lorry transport, total weight 7.5-12 t, mix Euro 0-5| diesel driven, Euro 0 - 5 mix, cargo| consumption mix, to consumer| 7,5 - 12t gross weight / 5t payload capacity {EU-28+3} [LCI result]	EF
A05 Water supply and wastewater treatment	tkm	286	-		
A10 Urban waste management (waste to recycling)	tkm	12,530	-		
A10 Urban waste management (waste to disposal)	tkm	6,716	-		
A11 Special waste management (waste to recycling)	tkm	25,550	-		
A11 Special waste management (waste to disposal)	tkm	3,844	-		

A14 Office paper	tkm	4,082	-		
A15 Stationery	tkm	196	-		
A16 Chemical products	tkm	116	-		
A17 Detergents	tkm	420	-		
A18 Tissue paper	tkm	308	-		
A19 Technical gases	tkm	23,461	-		
A20 Lubricants	tkm	8	-		
A21 Light bulbs	tkm	30	-		
A22 Paints and varnishes	tkm	280	-		
A23 Construction materials	tkm	5,796	-		
A24 Cooling gases	tkm	5	-		
A25 Toners	tkm	63	-		
A26 IT equipment (manufacturing)	tkm	13,874	-		
A27 Furniture	tkm	1,401	-		
A30 External lamps and other minor assets	tkm	1000	-		
A31 Food supply	tkm	25,590	-		
A29 Buildings*	tkm	212,322	-	Articulated lorry transport, total weight 20-26 t, mix Euro 0-5| diesel driven, Euro 0 - 5 mix, cargo| consumption mix, to consumer| 20 - 26t gross weight / 17,3t payload capacity {EU-28+3} [LCI result]	

*Includes transport of materials from producers to construction site.

In addition to the transport from final suppliers to JRC Ispra site, the transport of materials from the production plants to the distribution centres has been included.

Since no specific data for this part of transportation is available, the default distances and means of transportation from the Guidance have been considered. The following scenario applies:

- Food supply: suppliers located in Europe
    - 130 km by truck
    - 240 km by train

    - 270 km by ship
- All other materials listed in Table 44 (excluding A29): suppliers Outside Europe
    - 1’000 km by truck
    - 18’000 km by ship

Below are reported the data for transport of materials from the manufacturing plants to the distribution sites.

Table 44 – A99 Transport (from producer to final supplier).

INPUT					
Non-elementary flows	**Unit**	**Value**	**Specific data**	**Generic data**	**DB**
Truck (EU)	tkm	67,214	-	Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)| diesel driven, Euro 4, cargo| consumption mix, to consumer| more than 32t gross weight / 24,7t payload capacity {EU-28+3} [Unit process, single operation]	EF
Train (EU)	tkm	124,088	-	Freight train, average (without fuel)| technology mix, electricity and diesel driven, cargo| consumption mix, to consumer| average train, gross tonne weight 1000t / 726t payload capacity {EU-28+3} [Unit process, single operation]	EF
Ship (EU)	tkm	139,599	-	Barge| technology mix, diesel driven, cargo| consumption mix, to consumer| 1500 t payload capacity {EU-28+3} [LCI result]	EF
Truck (Extra EU)	tkm	649,000	-	Articulated lorry transport, Euro 4, Total weight >32 t (without fuel)| diesel driven, Euro 4, cargo| consumption mix, to consumer| more than 32t gross weight / 24,7t payload capacity {EU-28+3} [Unit process, single operation]	EF
Ship (Extra EU)	tkm	6,490,004	-	Transoceanic ship, containers| heavy fuel oil driven, cargo| consumption mix, to consumer| 27.500 dwt payload capacity, ocean going {GLO} [LCI result]	EF

6 Impact assessment

This chapter shows the results of the impact assessment for the JRC-Ispra activities during the reporting period 2015.

Below the following results:

— **Characterized results**: all impact categories, including toxicity, per each activity. Results are reported both in absolute values and relative to the contribution to each impact category

— **Normalized results:** reported both with and without toxicity indicators

— **Weighted results:** reported only without the toxicity indicators

The list of impact categories is available in chapter 3.5. Normalization and weighting factors are reported in Annex 2.

Climate change impacts are reported in aggregated form summing up together contributions arising from fossil carbon, biogenic carbon and direct land use change. Biogenic and land use change emissions represent less than 5% of total GHG emissions, therefore they have not been accounted separately.

The hotspot analysis is described in chapter 7.

6.1 CHARACTERIZATION

Below are reported the characterized results of the JRC Ispra site OEF, per each activity. Results are presented in absolute values (Table 45 and Table 46) and as contribution to the total environmental indicator (Table 47 and Table 48).

Table 45 - Characterization of impacts of the JRC Ispra site: absolute values (Part 1).

Part 1 **Unit of analysis: 1 year of activity**	**Environmental impact indicator**							
	Climate change	**Ozone depletion**	**Ionising radiation, HH**	**Photochemical ozone formation, HH**	**Respiratory inorganics**	**Non-cancer human health effects**	**Cancer human health effects**	**Acidification**
Activity	**kg CO2 eq**	**kg CFC11 eq**	**kBq U-235 eq**	**kg NMVOC eq**	**disease inc.**	**CTUh**	**CTUh**	**mol H+ eq**
A01 - Energy supply from internal cogeneration	24,300,000	1.47E-03	38,800	27,300	0.16	0.03	4.08E-03	23,800
A02 - Electricity supply from the grid	1,060,000	3.42E-04	114,000	1,360	0.02	-7.54E-03	8.31E-04	1,940
A03 - Electricity supply from photovoltaic installations	13,100	2.08E-06	1,990	37	2.46E-03	3.10E-03	1.06E-04	51
A04 - Heating from other boilers	254,000	2.32E-06	2,610	222	1.47E-03	3.03E-04	4.17E-05	193
A05 - Water supply and wastewater treatment	2,830	1.40E-03	603	6.5	1.69E-04	0.09	0.05	14
A06 - Internal fleet activities	54,200	1.29E-07	110	135	1.48E-03	2.20E-03	6.30E-04	170
A07 - Staff and contractors home-work trips	1,210,000	0.05	16,300	4,650	0.04	0.06	0.01	4,600
A08 - Staff and visitors transportation	165,000	3.92E-07	334	412	4.50E-03	6.70E-03	1.92E-03	518
A09 - JRC staff business travels	2,250,000	0.49	136,000	10,800	0.04	0.04	5.10E-03	10,900
A10 - Urban waste management	127,000	6.64E-04	448	56	3.13E-04	6.31E-04	3.52E-04	25
A11 - Special waste management	80,800	2.63E-03	642	44	7.09E-04	1.71E-03	9.62E-04	48
A12 - Green areas maintenance	8,090	1.37E-03	415	94	2.76E-04	0.02	1.11E-04	47
A13 - Nuclear activities	0	0	101,000	0	0	0	0	0
A14 - Office paper	34,100	1.12E-03	5,040	165	5.46E-03	0.03	8.17E-04	214

Part 1 Unit of analysis: 1 year of activity	Environmental impact indicator							
	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification
Activity	**kg CO2 eq**	**kg CFC11 eq**	**kBq U-235 eq**	**kg NMVOC eq**	**disease inc.**	**CTUh**	**CTUh**	**mol H+ eq**
A15 - Stationery	2,310	2.77E-04	143	9.9	3.58E-04	1.33E-03	4.56E-05	15
A16 - Chemical products	1,090	3.70E-04	58	3.1	5.31E-05	1.31E-04	1.09E-05	7.1
A17 - Detergents	16,400	2.33E-03	562	45	8.72E-04	1.50E-03	3.59E-04	83
A18 - Tissue paper	29,500	5.00E-04	3,590	58	1.20E-03	0.05	6.79E-04	88
A19 - Technical gases	54,900	0.01	5,600	169	2.52E-03	4.19E-03	4.83E-04	527
A20 - Lubricants	84	9.51E-05	28	1.2	4.05E-06	7.66E-06	9.57E-07	0.82
A21 - Light bulbs	69,900	5.39E-03	3,710	371	4.53E-03	0.04	1.07E-03	888
A22 - Paints and varnishes	32,100	3.19E-03	1,540	113	1.92E-03	2.04E-03	4.70E-03	313
A23 - Construction materials	170,000	5.96E-03	2,800	293	2.21E-03	7.12E-03	3.04E-04	399
A24 - Cooling gases	552,000	0.30	28	0.99	2.33E-04	8.48E-06	3.82E-06	2.0
A25 - Toners	6,260	5.93E-07	225	42	4.64E-04	4.68E-04	4.33E-05	54
A26 - IT equipments (manufacturing)	397,000	0.03	17,100	1,620	0.02	0.14	0.01	3,140
A27 - Furniture	27,500	2.27E-03	924	117	2.61E-03	9.18E-03	6.23E-03	177
A29 - Buildings (construction)	4,420,000	0.01	450,000	9,650	0.30	1.3	0.03	16,300
A30 - External lamps and other minor assets	110,000	8.14E-03	4,620	436	7.01E-03	0.05	5.93E-03	918
A31 - Food supply	559,000	0.02	16,400	1,350	0.04	0.23	8.76E-03	5,320
A99 - Transport	30,400	7.32E-08	86	197	1.22E-03	2.81E-03	1.96E-04	221
Total	*36,000,000*	*0.96*	*926,000*	*59,800*	*0.67*	*2.1*	*0.14*	*71,000*

Table 46 - Characterization of impacts of the JRC Ispra site: absolute values (Part 2)

Part 2 **Unit of analysis: 1 year of activity**	**Environmental impact indicator**							
	Eutrophication freshwater	**Eutrophication marine**	**Eutrophication terrestrial**	**Ecotoxicity freshwater**	**Land use**	**Water use**	**Resource use, energy carriers***	**Resource use, mineral and metals**
Activity	**kg P eq**	**kg N eq**	**mol N eq**	**CTUe**	**Pt**	**m3 depriv.**	**MJ**	**kg Sb eq**
A01 - Energy supply from internal cogeneration	11	7,960	90,300	208,000	3,380,000	362,000	326,000,000	2.1
A02 - Electricity supply from the grid	5.7	542	5,070	20,600	14,500,000	614,000	14,100,000	0.73
A03 - Electricity supply from photovoltaic installations	0.04	9.0	96	7,830	125,000	3,160	197,000	1.1
A04 - Heating from other boilers	0.02	62	684	2,120	50,700	1,340	4,080,000	0.01
A05 - Water supply and wastewater treatment	1,400	6,670	24	12,700,000	14,100	4,950,000	40,400	0.03
A06 - Internal fleet activities	0.28	59	707	11,800	276,000	4,920	714,000	4.03E-03
A07 - Staff and contractors home-work trips	13	1,620	18,800	535,000	6,290,000	91,600	12,400,000	1.00
A08 - Staff and visitors transportation	0.85	179	2,150	35,900	839,000	15,000	2,170,000	0.01
A09 - JRC staff business travels	8.7	3,600	39,600	306,000	2,750,000	25,500	1,550,000	0.17
A10 - Urban waste management	0.88	212	71	15,300	163,000	42	0	2.50E-03
A11 - Special waste management	0.97	78	119	33,800	164,000	140	0	8.07E-03
A12 - Green areas maintenance	0.41	12	136	12,200	114,000	54	0	0.07
A13 - Nuclear activities	0	0	0	0	0	0	0	0
A14 - Office paper	1.6	64	614	73,500	14,100,000	50,200	580,000	0.12
A15 - Stationery	0.16	3.4	34	4,020	604,000	104	0	3.92E-03
A16 - Chemical products	0.08	1.4	13	556	6,710	30	0	2.16E-03
A17 - Detergents	1.4	21	166	10,500	324,000	6,340	0	0.03
A18 - Tissue paper	0.95	34	250	66,300	1,350,000	11,600	377,000	0.06

Part 2 Unit of analysis: 1 year of activity	Environmental impact indicator							
	Eutrophication freshwater	**Eutrophication marine**	**Eutrophication terrestrial**	**Ecotoxicity freshwater**	**Land use**	**Water use**	**Resource use, energy carriers***	**Resource use, mineral and metals**
Activity	**kg P eq**	**kg N eq**	**mol N eq**	**CTUe**	**Pt**	**m3 depriv.**	**MJ**	**kg Sb eq**
A19 - Technical gases	3.7	35	374	40,800	402,000	3,280	0	0.04
A20 - Lubricants	4.45E-03	0.09	0.97	57	551	1.8	0	1.53E-04
A21 - Light bulbs	136	100	1,180	231,000	787,000	2,410	0	8.5
A22 - Paints and varnishes	2.4	48	305	185,000	328,000	7,130	103,000	0.19
A23 - Construction materials	1.9	99	1,150	13,000	250,000	989	0	0.03
A24 - Cooling gases	2.41E-03	0.30	3.2	50	3,720	15	7,650	1.27E-04
A25 - Toners	0.07	18	194	1,350	123,000	929	102,000	0.10
A26 - IT equipments (manufacturing)	335	953	5,700	868,000	3,990,000	10,000	0	21
A27 - Furniture	1.1	29	346	82,600	1,620,000	332	0	0.40
A29 - Buildings (construction)	21	3,310	35,700	16,300,000	91,200,000	1,660,000	46,600,000	740
A30 - External lamps and other minor assets	147	129	1,530	299,000	1,040,000	2,830	0	9.0
A31 - Food supply	292	3,890	20,300	3,560,000	38,400,000	2,180,000	1,490,000	3.5
A99 - Transport	0.19	106	1,150	5,160	334,000	1,160	413,000	1.76E-03
Total	*2,390*	*29,800*	*227,000*	*35,600,000*	*184,000,000*	*10,000,000*	*410,000,000*	*789*

* The non-available results for energy carriers arise from activities not addressed by the update to the EF database and are caused by inconsistencies between Ecoinvent and EF method substances nomenclature, as stated in the limitation of this study (chapter 2.2). An in-depth consistency analysis for this indicator is provided in chapter 7.4.

Table 47 - Characterization of impacts of the JRC Ispra site: contribution analysis (Part 1) (in RED impacts contributing more than 10% to the impact category, in YELLOW contributions between 10% and 5%, in GREEN contributions between 5% and 1%; lower contributions are not highlighted)

Part 1 **Unit of analysis: 1 year of activity**	**Environmental impact indicator**							
	Climate change	**Ozone depletion**	**Ionising radiation, HH**	**Photochemical ozone formation, HH**	**Respiratory inorganics**	**Non-cancer human health effects**	**Cancer human health effects**	**Acidification**
Activity	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
A01 - Energy supply from internal cogeneration	67.40%	0.15%	4.19%	45.66%	23.98%	1.25%	2.82%	33.53%
A02 - Electricity supply from the grid	2.94%	0.04%	12.28%	2.28%	2.38%	<0.01%	0.57%	2.74%
A03 - Electricity supply from photovoltaic installations	0.04%	<0.01%	0.21%	0.06%	0.37%	0.15%	0.07%	0.07%
A04 - Heating from other boilers	0.71%	<0.01%	0.28%	0.37%	0.22%	0.01%	0.03%	0.27%
A05 - Water supply and wastewater treatment	<0.01%	0.15%	0.07%	0.01%	0.03%	4.58%	33.61%	0.02%
A06 - Internal fleet activities	0.15%	<0.01%	0.01%	0.23%	0.22%	0.11%	0.44%	0.24%
A07 - Staff and contractors home-work trips	3.35%	5.43%	1.76%	7.78%	6.63%	2.73%	9.45%	6.48%
A08 - Staff and visitors transportation	0.46%	<0.01%	0.04%	0.69%	0.67%	0.33%	1.33%	0.73%
A09 - JRC staff business travels	6.25%	51.01%	14.73%	18.11%	5.35%	1.92%	3.53%	15.33%
A10 - Urban waste management	0.35%	0.07%	0.05%	0.09%	0.05%	0.03%	0.24%	0.04%
A11 - Special waste management	0.22%	0.28%	0.07%	0.07%	0.11%	0.08%	0.67%	0.07%
A12 - Green areas maintenance	0.02%	0.14%	0.04%	0.16%	0.04%	1.03%	0.08%	0.07%
A13 - Nuclear activities	<0.01%	<0.01%	10.92%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
A14 - Office paper	0.09%	0.12%	0.54%	0.28%	0.81%	1.33%	0.57%	0.30%
A15 - Stationery	<0.01%	0.03%	0.02%	0.02%	0.05%	0.06%	0.03%	0.02%
A16 - Chemical products	<0.01%	0.04%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
A17 - Detergents	0.05%	0.24%	0.06%	0.08%	0.13%	0.07%	0.25%	0.12%

Part 1 Unit of analysis: 1 year of activity	Environmental impact indicator							
	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification
Activity	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
A18 - Tissue paper	0.08%	0.05%	0.39%	0.10%	0.18%	2.28%	0.47%	0.12%
A19 - Technical gases	0.15%	1.38%	0.61%	0.28%	0.38%	0.20%	0.33%	0.74%
A20 - Lubricants	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
A21 - Light bulbs	0.19%	0.56%	0.40%	0.62%	0.68%	1.72%	0.74%	1.25%
A22 - Paints and varnishes	0.09%	0.33%	0.17%	0.19%	0.29%	0.10%	3.25%	0.44%
A23 - Construction materials	0.47%	0.62%	0.30%	0.49%	0.33%	0.35%	0.21%	0.56%
A24 - Cooling gases	1.54%	31.86%	<0.01%	<0.01%	0.03%	<0.01%	<0.01%	<0.01%
A25 - Toners	0.02%	<0.01%	0.02%	0.07%	0.07%	0.02%	0.03%	0.08%
A26 - IT equipments (manufacturing)	1.10%	3.11%	1.85%	2.70%	3.66%	6.72%	8.07%	4.43%
A27 - Furniture	0.08%	0.24%	0.10%	0.20%	0.39%	0.45%	4.31%	0.25%
A29 - Buildings (construction)	12.28%	1.12%	48.59%	16.14%	45.26%	61.10%	18.59%	22.99%
A30 - External lamps and other minor assets	0.31%	0.85%	0.50%	0.73%	1.05%	2.47%	4.10%	1.29%
A31 - Food supply	1.55%	2.16%	1.77%	2.26%	6.48%	11.11%	6.06%	7.50%
A99 - Transport	0.08%	<0.01%	<0.01%	0.33%	0.18%	0.14%	0.14%	0.31%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Table 48 - Characterization of impacts of the JRC Ispra site: contribution analysis (Part 2) (in RED impacts contributing more than 10% to the impact category, in YELLOW contributions between 10% and 5%, in GREEN contributions between 5% and 1%; lower contributions are not highlighted)

Part 2 **Unit of analysis: 1 year of activity**	**Environmental impact indicator**							
	Eutrophication freshwater	**Eutrophication marine**	**Eutrophication terrestrial**	**Ecotoxicity freshwater**	**Land use**	**Water use**	**Resource use, energy carriers**	**Resource use, mineral and metals**
Activity	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
A01 - Energy supply from internal cogeneration	0.45%	26.68%	39.83%	0.58%	1.84%	3.62%	79.32%	0.27%
A02 - Electricity supply from the grid	0.24%	1.82%	2.23%	0.06%	7.90%	6.13%	3.44%	0.09%
A03 - Electricity supply from photovoltaic installations	<0.01%	0.03%	0.04%	0.02%	0.07%	0.03%	0.05%	0.13%
A04 - Heating from other boilers	<0.01%	0.21%	0.30%	<0.01%	0.03%	0.01%	0.99%	<0.01%
A05 - Water supply and wastewater treatment	58.63%	22.36%	0.01%	35.60%	<0.01%	49.41%	<0.01%	<0.01%
A06 - Internal fleet activities	0.01%	0.20%	0.31%	0.03%	0.15%	0.05%	0.17%	<0.01%
A07 - Staff and contractors home-work trips	0.55%	5.42%	8.31%	1.50%	3.43%	0.91%	3.02%	0.13%
A08 - Staff and visitors transportation	0.04%	0.60%	0.95%	0.10%	0.46%	0.15%	0.53%	<0.01%
A09 - JRC staff business travels	0.36%	12.06%	17.45%	0.86%	1.50%	0.25%	0.38%	0.02%
A10 - Urban waste management	0.04%	0.71%	0.03%	0.04%	0.09%	<0.01%	<0.01%	<0.01%
A11 - Special waste management	0.04%	0.26%	0.05%	0.10%	0.09%	<0.01%	<0.01%	<0.01%
A12 - Green areas maintenance	0.02%	0.04%	0.06%	0.03%	0.06%	<0.01%	<0.01%	<0.01%
A13 - Nuclear activities	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
A14 - Office paper	0.07%	0.21%	0.27%	0.21%	7.69%	0.50%	0.14%	0.01%
A15 - Stationery	<0.01%	0.01%	0.01%	0.01%	0.33%	<0.01%	<0.01%	<0.01%
A16 - Chemical products	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
A17 - Detergents	0.06%	0.07%	0.07%	0.03%	0.18%	0.06%	<0.01%	<0.01%

A18 - Tissue paper	0.04%	0.11%	0.11%	0.19%	0.74%	0.12%	0.09%	<0.01%
A19 - Technical gases	0.16%	0.12%	0.17%	0.11%	0.22%	0.03%	<0.01%	<0.01%
A20 - Lubricants	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
A21 - Light bulbs	5.71%	0.33%	0.52%	0.65%	0.43%	0.02%	<0.01%	1.08%
A22 - Paints and varnishes	0.10%	0.16%	0.13%	0.52%	0.18%	0.07%	0.03%	0.02%
A23 - Construction materials	0.08%	0.33%	0.51%	0.04%	0.14%	<0.01%	<0.01%	<0.01%
A24 - Cooling gases	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
A25 - Toners	<0.01%	0.06%	0.09%	<0.01%	0.07%	<0.01%	0.02%	0.01%
A26 - IT equipments (manufacturing)	14.05%	3.19%	2.51%	2.44%	2.17%	0.10%	<0.01%	2.70%
A27 - Furniture	0.05%	0.10%	0.15%	0.23%	0.88%	<0.01%	<0.01%	0.05%
A29 - Buildings (construction)	0.86%	11.10%	15.74%	45.77%	49.68%	16.62%	11.34%	93.85%
A30 - External lamps and other minor assets	6.18%	0.43%	0.67%	0.84%	0.57%	0.03%	<0.01%	1.14%
A31 - Food supply	12.25%	13.02%	8.95%	10.01%	20.92%	21.83%	0.36%	0.45%
A99 - Transport	<0.01%	0.35%	0.51%	0.01%	0.18%	0.01%	0.10%	<0.01%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

6.2 NORMALIZATION

As a further optional step in the OEF impact assessment, the normalization of the results has been carried out (table 10 and figures 5-6).

Through the normalization step, the impact assessment results are multiplied by normalization factors in order to calculate and compare the magnitude of their contributions to the impact categories in relation to a reference unit, i.e. typically the pressure related to that category caused by a whole country or an average citizen over one year. As a result, normalized impact assessment figures are obtained and expressed in person-equivalents or other similar units. Normalized OEF results do not however indicate the severity/relevance of the respective impacts in absolute terms.

The normalization has been carried out considering the worldwide factors developed by the JRC and reported in Annex 2.

Table 49 - Normalization of impacts of the JRC Ispra site

Unit of analysis: 1 year of activity	**Environmental impact indicator**															
	Climate change	**Ozone depletion**	**Ionising radiation, HH**	**Photochemical ozone formation, HH**	**Respiratory inorganics**	**Non-cancer human health effects**	**Cancer human health effects**	**Acidification terrestrial and freshwater**	**Eutrophication freshwater**	**Eutrophication marine**	**Eutrophication terrestrial**	**Ecotoxicity freshwater**	**Land use**	**Water scarcity**	**Resource use, energy carriers**	**Resource use, mineral and metals**
Activity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A01 - Energy supply from internal cogeneration	3,130	0.06	9.2	672	253	54	106	428	4.2	282	511	18	2.5	32	4,990	37
A02 - Electricity supply from the grid*	136	0.01	27	34	25	-1.59E+01	22	35	2.2	19	29	1.7	11	54	216	13
A03 - Electricity supply from photovoltaic installations	1.7	8.91E-05	0.47	0.90	3.9	6.5	2.8	0.92	0.01	0.32	0.54	0.66	0.09	0.28	3.0	18

Unit of analysis: 1 year of activity	Environmental impact indicator															
	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification terrestrial and freshwater	Eutrophication freshwater	Eutrophication marine	Eutrophication terrestrial	Ecotoxicity freshwater	Land use	Water scarcity	Resource use, energy carriers	Resource use, mineral and metals
Activity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A04 - Heating from other boilers	33	9.94E-05	0.62	5.5	2.3	0.64	1.1	3.5	6.75E-03	2.2	3.9	0.18	0.04	0.12	62	0.18
A05 - Water supply and wastewater treatment	0.36	0.06	0.14	0.16	0.27	199	1,260	0.26	548	236	0.13	1,070	0.01	431	0.62	0.46
A06 - Internal fleet activities	7.0	5.52E-06	0.03	3.3	2.3	4.6	16	3.1	0.11	2.1	4.0	1.00	0.21	0.43	11	0.07
A07 - Staff and contractors home-work trips	156	2.2	3.9	115	70	118	355	83	5.2	57	106	45	4.7	8.0	190	17
A08 - Staff and visitors transportation	21	1.68E-05	0.08	10	7.1	14	50	9.3	0.33	6.3	12	3.0	0.63	1.3	33	0.21
A09 - JRC staff business travels	290	21	32	267	56	83	132	196	3.4	127	224	26	2.1	2.2	24	3.0
A10 - Urban waste management	16	0.03	0.11	1.4	0.49	1.3	9.1	0.46	0.34	7.5	0.40	1.3	0.12	3.69E-03	0	0.04
A11 - Special waste management	10	0.11	0.15	1.1	1.1	3.6	25	0.87	0.38	2.7	0.67	2.9	0.12	0.01	0	0.14

Unit of analysis: 1 year of activity	Environmental impact indicator															
	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification terrestrial and freshwater	Eutrophication freshwater	Eutrophication marine	Eutrophication terrestrial	Ecotoxicity freshwater	Land use	Water scarcity	Resource use, energy carriers	Resource use, mineral and metals
Activity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A12 - Green areas maintenance	1.0	0.06	0.10	2.3	0.43	44	2.9	0.84	0.16	0.43	0.77	1.0	0.09	4.70E-03	0	1.2
A13 - Nuclear activities	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0
A14 - Office paper	4.4	0.05	1.2	4.1	8.6	58	21	3.9	0.63	2.3	3.5	6.2	11	4.4	8.9	2.0
A15 - Stationery	0.30	0.01	0.03	0.24	0.56	2.8	1.2	0.27	0.06	0.12	0.19	0.34	0.45	9.03E-03	0	0.07
A16 - Chemical products	0.14	0.02	0.01	0.08	0.08	0.28	0.28	0.13	0.03	0.05	0.07	0.05	5.02E-03	2.60E-03	0	0.04
A17 - Detergents	2.1	0.10	0.13	1.1	1.4	3.2	9.3	1.5	0.56	0.73	0.94	0.89	0.24	0.55	0	0.48
A18 - Tissue paper	3.8	0.02	0.85	1.4	1.9	99	18	1.6	0.37	1.2	1.4	5.6	1.0	1.0	5.8	1.1
A19 - Technical gases	7.1	0.56	1.3	4.2	4.0	8.8	13	9.5	1.5	1.2	2.1	3.5	0.30	0.29	0	0.77
A20 - Lubricants	0.01	4.07E-03	6.60E-03	0.03	6.36E-03	0.02	0.02	0.01	1.75E-03	3.13E-03	5.51E-03	4.86E-03	4.13E-04	1.54E-04	0	2.64E-03
A21 - Light bulbs	9.0	0.23	0.88	9.1	7.1	75	28	16	53	3.5	6.7	20	0.59	0.21	0	147
A22 - Paints and varnishes	4.1	0.14	0.36	2.8	3.0	4.3	122	5.6	0.96	1.7	1.7	16	0.25	0.62	1.6	3.2
A23 - Construction materials	22	0.26	0.66	7.2	3.5	15	7.9	7.2	0.75	3.5	6.5	1.1	0.19	0.09	0	0.44

Unit of analysis: 1 year of activity	Environmental impact indicator															
	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification terrestrial and freshwater	Eutrophication freshwater	Eutrophication marine	Eutrophication terrestrial	Ecotoxicity freshwater	Land use	Water scarcity	Resource use, energy carriers	Resource use, mineral and metals
Activity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A24 - Cooling gases	71	13	6.70E-03	0.02	0.37	0.02	0.10	0.04	9.46E-04	0.01	0.02	4.21E-03	2.79E-03	1.34E-03	0.12	2.20E-03
A25 - Toners	0.81	2.54E-05	0.05	1.0	0.73	0.99	1.1	0.97	0.03	0.65	1.1	0.11	0.09	0.08	1.6	1.7
A26 - IT equipments (manufacturing)	51	1.3	4.1	40	39	292	303	57	131	34	32	73	3.0	0.87	0	368
A27 - Furniture	3.5	0.10	0.22	2.9	4.1	19	162	3.2	0.43	1.0	2.0	7.0	1.2	0.03	0	6.8
A29 - Buildings (construction)	569	0.46	107	238	477	2,650	698	294	8.1	117	202	1,380	68	145	713	12,800
A30 - External lamps and other minor assets	14	0.35	1.1	11	11	107	154	17	58	4.6	8.6	25	0.78	0.25	0	155
A31 - Food supply	72	0.88	3.9	33	68	482	228	96	115	137	115	302	29	190	23	61
A99 - Transport	3.9	3.13E-06	0.02	4.8	1.9	5.9	5.1	4.0	0.07	3.7	6.5	0.44	0.25	0.10	6.3	0.03
Total (per activity)	**4,640**	**41**	**219**	**1,470**	**1,050**	**4,340**	**3,750**	**1,280**	**935**	**1,060**	**1,280**	**3,010**	**138**	**873**	**6,290**	**13,600**

*Negative contribution to toxicity, human, non-cancer related to EF dataset "Electricity from biogas, IT".

Figure 7 – JRC Ispra site OEF Normalized results including toxicity indicators

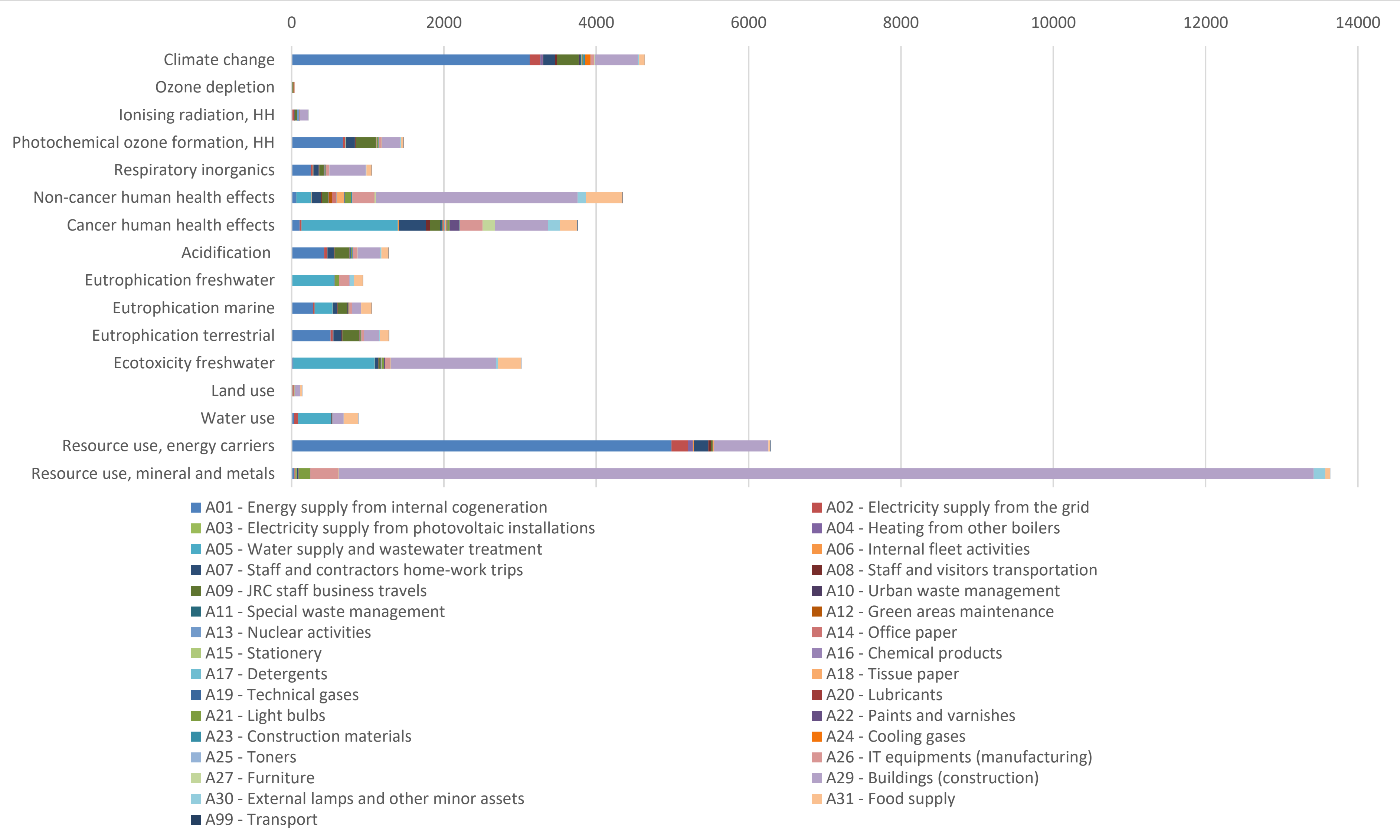
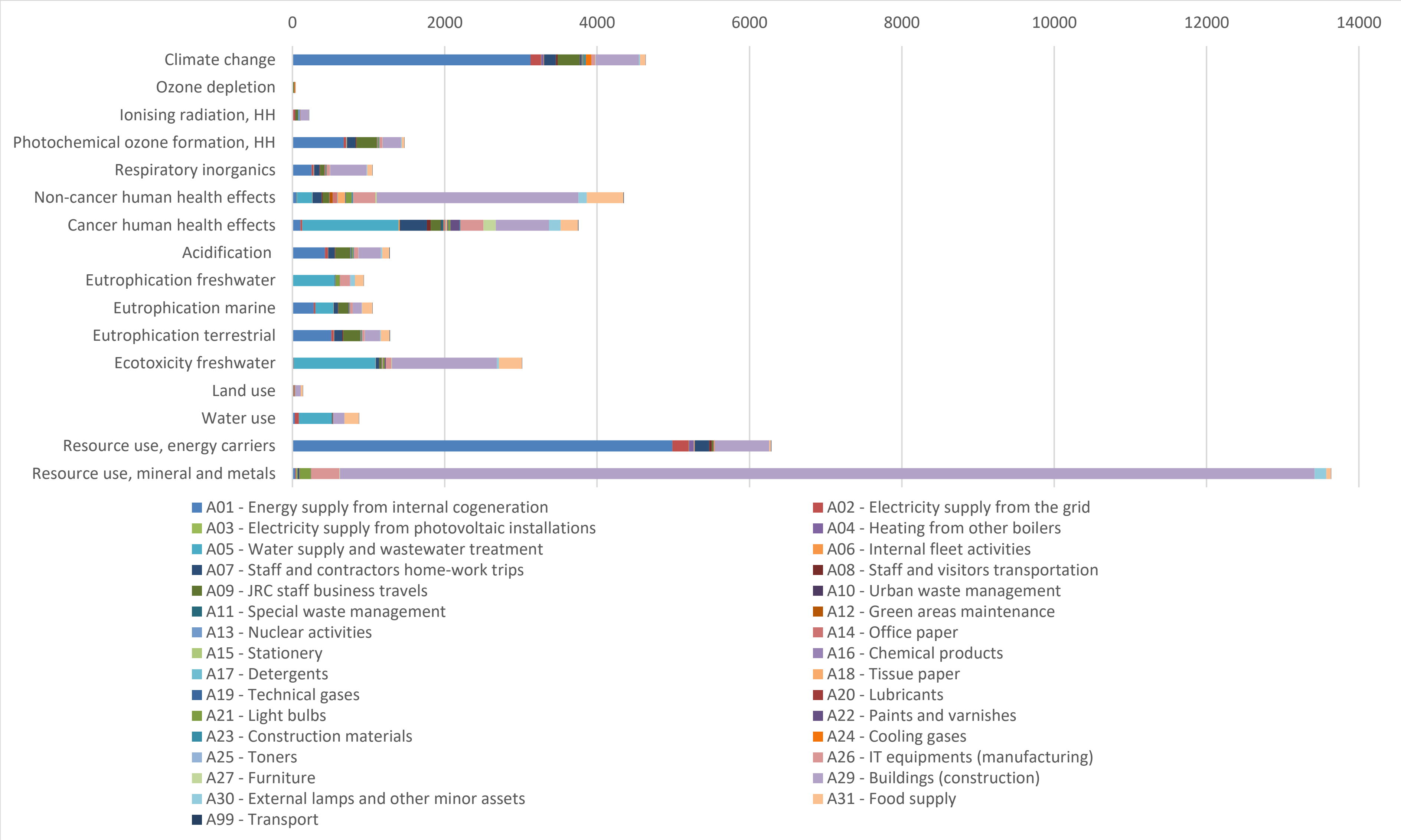


Figure 8 – JRC Ispra site OEF Normalized results excluding toxicity indicators



6.3 WEIGHTING

In Life Cycle Assessment (LCA), according to ISO 14044 (ISO 2006), normalisation and weighting are optional steps of Life Cycle Impact Assessment (LCIA). Those steps allow expressing LCA results aggregating the results (up to a single score), giving different weight to the different environmental impacts.

Weighting supports the identification of the most relevant impact categories, life cycle stages, process and resource consumptions or emissions to ensure that the focus is put on those aspects that matter the most and for communication purposes.

Any weighting scheme is not mainly natural science based but inherently involves value choices that will depend on policy, cultural and other preferences and value systems. No "consensus" on weighting seems to be achievable. This situation does not apply only to weighting in a LCA or Environmental Footprint context, but seems inevitable for many multicriteria approaches.

In this study we have applied the weighting factors referenced in the OEFSR Guidance and reported in Annex 2.

Below (Table 50 and Figure 9) are presented the weighted results of the JRC Ispra environmental footprint.

Table 50 - JRC Ispra site OEF Weighted results, excluding toxicity indicators

Environmental impact indicator	Value	Share
Total	3.17	100.00%
Climate change	1.03	32.49%
Ozone depletion	2.76E-03	0.09%
Ionising radiation, HH	0.01	0.37%
Photochemical ozone formation, HH	0.08	2.37%
Respiratory inorganics	0.10	3.17%
Non-cancer human health effects	-	-
Cancer human health effects	-	-
Acidification	0.08	2.68%
Eutrophication freshwater	0.03	0.87%
Eutrophication marine	0.03	1.04%
Eutrophication terrestrial	0.05	1.58%
Ecotoxicity freshwater	-	-
Land use	0.01	0.37%

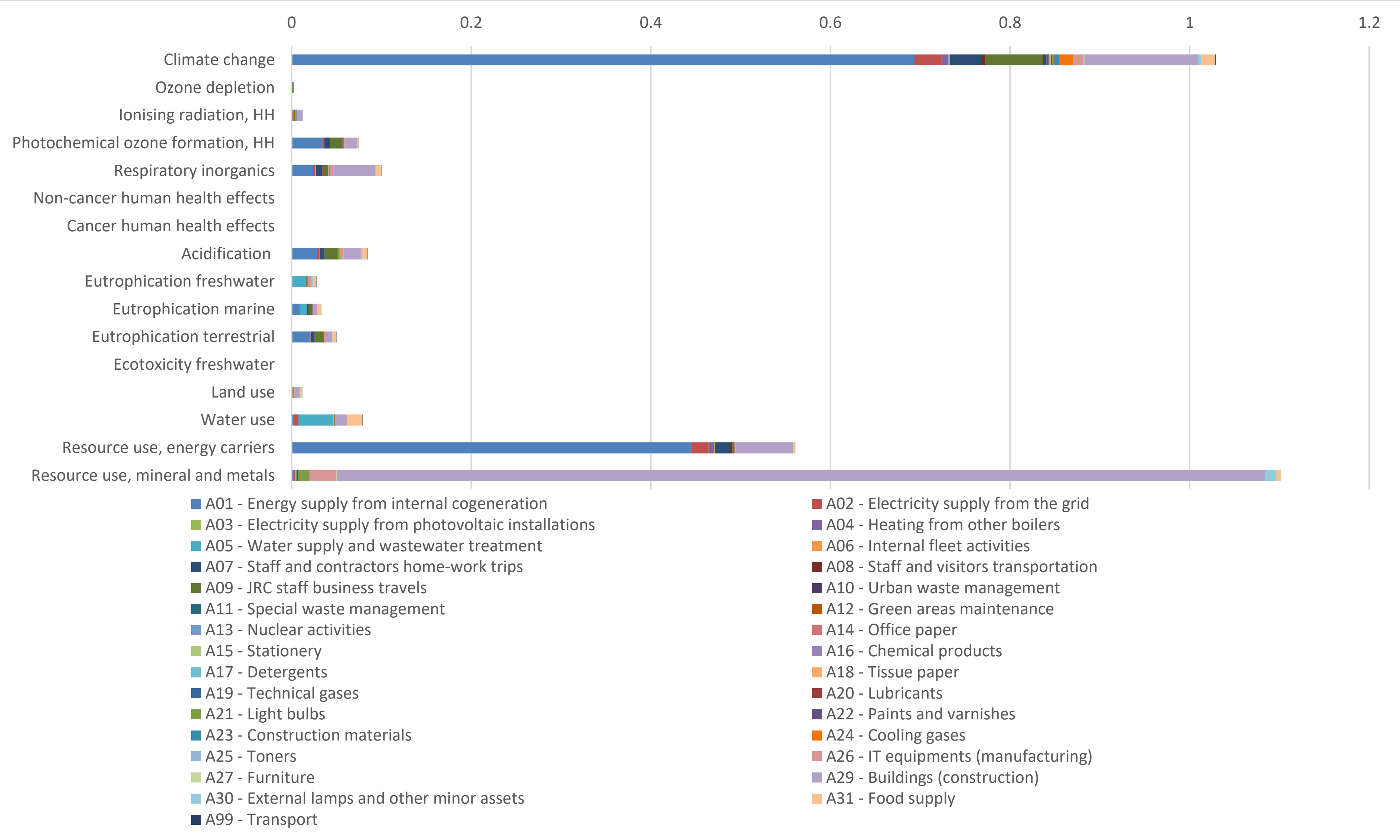
Environmental impact indicator	Value	Share
Water use	0.08	2.49%
Resource use, energy carriers	0.56	17.71%
Resource use, mineral and metals	1.10	34.78%

Based on the weighted results the most relevant impact categories are:

- **Resource use, minerals and metals**: the dominant contribution for this indicator comes from buildings construction (A29), due to the use of metals and mineral resources in the manufacturing of building materials
- **Climate change**: strongly influenced by the impacts from the energy generation in the cogeneration plant (A01). Other significant contributions come from buildings construction (A29) and people transportation (A09 and A07)
- **Resource use, energy carriers**: the biggest contribution to this indicator comes again from energy generation from the cogeneration plant (A01), due to the use of natural gas

The detailed assessment of the most relevant indicators and processes is described in the next chapter 7.

Figure 9 – JRC Ispra site OEF weighted results, excluding toxicity indicators



7 Interpretation

The purposes of the interpretation step are to ensure that the OEF modelling corresponds to the objectives and quality requirements defined for the study and to derive robust conclusions and recommendations in support of environmental improvements.

Based on the updated impact assessment results, it was possible to perform a hotspot analysis for the reporting year 2015, hereafter documented.

7.1 Identification of most relevant impact categories, life cycle stages, processes and direct elementary flows

The identification of the most relevant impact categories, life cycle stages, processes and elementary flows has been carried out following the OEF Guidance, §7.4. Any deviation from the Guidance is documented below.

7.1.1 Most relevant impact categories

Based on the weighted results, the most relevant impact categories (i.e. contributing to at least 80% of the impacts) are, in descending order:

- **Resource use, minerals and metals**: 34.78%
- **Climate change**: 32.49%
- **Resource use, energy carriers**: 17.71%

The three indicators are sufficient to cover the most relevant contributions according to the OEFSR Guidance v6.3.

The resource indicators should be interpreted keeping in mind that:

- The impacts related to the indicator resource use, minerals and metals generally arise from activities outside the control of the organization (in this the impacts related to the supply of construction materials for buildings). The limited influence of the organization to this share of impacts should be considered when performing the hotspot analysis
- In the case there is a large contribution to climate change from the combustion of a fossil fuel within the system boundaries, the indicator Resource use, energy carriers provides basically the same information as the climate change indicator. This could be seen as a double counting and cause a limitation to the identification of the most relevant impact categories

In addition to the most relevant ones, other indicators and impact categories have been added to the list:

- **Acidification**: 2.68%
- **Water use**: 2.49%
- **Ionizing radiation, HH**: 0.37%

The indicators listed above have been included in order to reach 90% of the overall weighted results. In addition, the chosen additional indicators are relevant to the direct elementary flows (NOx for acidification, water consumption for water use, air and water emissions from nuclear activities for ionizing radiation), are appropriate for communication as well as are suitable to derive indicators in support of EMAS. Other considerations on these aspects are provided in chapter 8.1 and Annex 4.

7.1.2 Most relevant life cycle stages

As explained at the beginning of this chapter, the typical subdivision in life cycle stages is not significant in relation to the JRC Ispra site. Therefore, for all the most relevant environmental indicators (see paragraph 7.1.1), **a subdivision in organizational boundaries (on-site activities) and OEF boundaries (upstream) is used**, and both stages are considered relevant as both are needed to obtain the needed threshold of 80% of any of the identified most relevant impact indicators.

7.1.3 Most relevant processes

Since use stage is not defined, the identification of the most relevant processes and elementary flows is performed considering the whole Organisational and OEF boundaries.

Below the identification of the most relevant processes for each of the identified most relevant impact indicator.

Table 51 – List of the most relevant processes contributing to at least 80% of each impact (highlighted in orange) and the additional activities covering up to 90% of the overall impacts (highlighted in green) for all the most relevant impact indicators.

Impact indicator	Unit	Processes (activities)								
		A01	A02	A05	A07	A09	A13	A26	A29	A31
Climate change	kg CO2 eq	67%	2.9%	-	3.4%	6.3%	-	-	12%	-
Resource use, mineral and metals	kg Sb eq	-	-	-	-	-	-	-	94%	-
Resource use, energy carriers	MJ	79%	-	-	-	-	-	-	11%	-
Acidification	mol H+ eq	34%	-	-	6.5%	15%	-	4.4%	23%	7.5%
Water use	m3 depriv.	-	6.1%	49%	-	-	-	-	17%	22%
Ionizing radiation, HH	kBq U-235 eq	4.2%	12%	-	-	15%	11%	-	49%	-

A01 – Energy supply from internal cogeneration

A02 – Electricity supply from the grid

A05 – Water supply and wastewater treatment

A07 – JRC staff and contractors home-work trips

A09 – JRC staff business travels

A13 – Nuclear activities

A26 - IT equipment (manufacturing)

A29 - Buildings (construction

A31 - Food supply

The identification of the most relevant processes has been done including:

— The activities contributing to at least 80% of the impacts for each impact category indicator (in orange in the table)

— Additional activities that contribute up to 90% of the impacts for each impact category indicator (in green in the table)

It emerges from the analysis that only a few processes are material to the most relevant impact categories. Only 8 activities out of 32 are strictly included in the hotspot. Extending the coverage to 90% of the impacts only adds 1 more activity (A26 IT equipment). Processes related to energy supply and building construction are significant for most of the impact indicators. Water supply (A05) and nuclear activities (A13) are relevant only to the impact category of most influence, respectively water use and ionizing radiation.

7.1.4 Most relevant direct elementary flows

For each most relevant process, the identification of the most relevant direct elementary flows is important to define which direct emissions or resources should be requested as company-specific data (i.e. the foreground elementary flows within the processes listed in the PEFCR as mandatory company-specific).

The most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with **80%** to the total impact of the direct elementary flows of the process, for each most relevant impact category. The analysis shall be limited to the direct emissions of the level-1 disaggregated datasets. This means that the 80% cumulative contribution shall be calculated against the impact caused by the direct emissions only, and not against the total impact of the process.

Due to the lack of specific OEFSR, the elementary flows taken into account in this phase are those already characterized with company-specific data in the previous applications of the study. Table 52 reports the most relevant elementary flows (orange cells).

Table 52 – Identification of the most relevant direct elementary flows

Indicator	Substance	Unit	Processes						
			A01 - Energy supply from internal cogeneration	A02 - Electricity supply from the grid	A05 - Water supply and wastewater treatment	A09 - JRC staff business travels	A13 - Nuclear activities	A29 - Buildings (construction)	A31 - Food supply
Climate change	Carbon dioxide, fossil	kg CO2 eq	99.83%	-	-	-	-	n.a.	-
	Carbon monoxide, fossil	kg CO2 eq	0.17%	-	-	-	-	n.a.	-
Resource use, mineral and metals	n.a.	kg Sb eq	-	-	-	-	-	n.a.	-
Resource use, energy carriers	n.a.	MJ	n.a.	-	-	-	-	n.a.	-
Acidification	Nitrogen oxides	mol H+ eq	60.69%	-	-	-	-	n.a.	-
	Sulfur dioxide	mol H+ eq	39.31%	-	-	-	-	n.a.	-
Water use	Water, lake, IT	m3 depriv.	-	-	100%	-	-	n.a.	n.a.
Ionizing radiation, HH	Hydrogen-3, Tritium	kBq U-235 eq	-	n.a.	-	n.a.	94.06%	n.a.	-

Indicator	Substance	Unit	Processes						
			A01 - Energy supply from internal cogeneration	A02 - Electricity supply from the grid	A05 - Water supply and wastewater treatment	A09 - JRC staff business travels	A13 - Nuclear activities	A29 - Buildings (construction)	A31 - Food supply
	Cesium-137	kBq U-235 eq	-	n.a.	-	n.a.	4.71%	n.a.	-
	Cobalt-60	kBq U-235 eq	-	n.a.	-	n.a.	1.24%	n.a.	-

The application of the rules for the identification of the most relevant direct elementary flows confirms that the most relevant flows are the same ones already included in the company specific data from the previous studies. The most relevant direct elementary flows refer mostly to the electricity supply from internal cogeneration (A01), nuclear activities (A13) and water supply (A05).

Based on the previous application of the study, below a list of possible additional elementary flows to be considered as mandatory company-specific data in future updates of the OEF assessment:

- A24: consumption of coolant/refrigerant gases, direct emissions from losses
- A04: other fuel uses on site; estimation of emissions based on fuel consumption
- A06: activity of the internal fleet; estimation of emissions based on fuel consumption
- A07: distances travelled by JRC staff for commuting; estimation of emissions based on fuel consumption

The additional proposed activities are relevant for the inclusion in the hotspot analysis for their communication significance and for the integration of OEF with EMAS.

Details related to the activities reported above are provided in chapter 5.

7.2 Sensitivity analysis – Application of the Circular Footprint Formula to A29 – Buildings construction

7.2.1 Introduction

Sensitivity checks are helpful to assess the influence of assumptions and methodological choices on the environmental footprint results. Moreover, they allow assessing the effect of implementing alternative choices where these are identifiable.

Sensitivity analysis is performed regarding the application of the CFF. The application is done on activity A29 Buildings (construction) for the following reasons:

- A29 contributes significantly to almost all impact categories included in the hotspot analysis
- The bill of materials[7] (BoM) used for buildings provides a good case study since it includes many different types of materials (building materials, metals, plastics, etc.)

7.2.2 Buildings construction - Bill of Materials

Below is reported the BoM for buildings construction, prior to the application of the CFF. **The reference flow is 1 m^3**. The same nomenclature used in chapter 5 applies.

Table 53 – Bill of materials for buildings construction and demolition, baseline scenario. In this scenario, all materials are virgin materials, and the waste goes to landfill (building materials and metals) or incineration (plastics).

INPUT				
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**
Bricks	kg	178	Bricks vertically perforated (EN15804 A1-A3) | technology mix | production mix, at plant | vertically perforated {EU-28} [LCI result]	EF
Concrete	kg	220	Concrete C20/25 (ready-mix concrete)| technology mix| production mix, at plant| C20/25 {DE} [LCI result]	EF
Cement mortar	kg	61.7	Cement mortar {CH}| production | Alloc Def, U	EI
Glass	kg	3.08	Flat glass, uncoated| production mix| at plant| per kg flat glass {EU-28+3} [LCI result]	EF
Insulation	kg	1.3	Glass fibres| production mix| at plant| per kg glass fibres {EU-28+3} [LCI result]	EF
Aluminium	kg	8.48	Aluminium ingot mix | primary production | consumption mix, to consumer | aluminium ingot product, primary production {EU-28+EFTA} [LCI result]	EF
Copper	kg	8.48	1 kg - Copper billet/slab (smelting and refining to produce primary copper cathode)| casting| single route, at plant| 8.92 g/cm3 {EU-28+EFTA} [LCI result] 3.25 kg - Copper Concentrate (Mining, mix technologies)| copper ore mining and processing| single route, at plant|	EF

[7] The BoM is derived from the Ecoinvent process "Building, multi-storey {RER}\| construction \| Alloc Def, U".

INPUT				
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**
			Copper - gold - silver - concentrate (28% Cu, 22.3 Au gpt, 37.3 Ag gpt) {GLO} [LCI result]	
Steel	kg	7.17	Hot rolled coil| hot rolling| production mix, at plant| carbon steel {EU-28+EFTA} [LCI result]	EF
Plastics (PVC)	kg	0.925	PVC granulates, low density| polymerisation of vinyl chloride| production mix, at plant| 62 g/mol per repeating unit {EU-28+EFTA} [LCI result] Pipes extrusion| pipe production by plastic extrusion| production mix, at plant| 3% loss (range 2- 8%), 2.2 MJ electricity (range 1.5- 8) {EU-28+EFTA} [LCI result]	EF
Plastics (LDPE)	kg	0.925	LDPE granulates| Polymerisation of ethylene| production mix, at plant| 0.91- 0.96 g/cm3, 28 g/mol per repeating unit {EU-28+EFTA} [LCI result] Pipes extrusion| pipe production by plastic extrusion| production mix, at plant| 3% loss (range 2- 8%), 2.2 MJ electricity (range 1.5- 8) {EU-28+EFTA} [LCI result]	EF
Wood	kg	0.0617	Sawn wood, softwood| planed, dried| at plant| per kg sawn wood {EU-28+3} [LCI result]	EF
Thermal energy (construction works)	MJ	15	Thermal energy from light fuel oil (LFO)| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]	EF
Electricity (construction works)	kWh	0.3	Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, to consumer| 1kV - 60kV {IT} [LCI result]	EF
Transport	tkm	11	See chapter 5.32	-

OUTPUT*				
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**
Landfill – Construction materials (incl. insulation)	kg	461	Landfill of inert (construction materials)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site| {EU-28+EFTA} [LCI result]	EF
Landfill - Glass	kg	3.08	Inert matter (Glass) on landfill | landfill | consumption mix, at consumer | {DE} [LCI result]	EF
Landfill – steel	kg	7.17	Landfill of inert (steel)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site| {EU-28+EFTA} [LCI result]	EI

OUTPUT*				
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**
Landfill – copper	kg	8.48	Landfill of inert material (other materials)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site {EU-28+EFTA} [LCI result]	EF
Landfill – Aluminium	kg	8.48	Landfill of inert (aluminium)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site| {EU-28+EFTA} [LCI result]	EF
Landfill - Wood	kg	0.0617	Landfill of untreated wood| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site {EU-28+EFTA} [LCI result]	EF
Incineration – PVC	kg	0.925	Waste incineration of PVC| waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| polyvinyl chloride waste {IT} [LCI result]	EF
Incineration - LDPE	kg	0.925	Waste incineration of PE| waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| polyethylene waste {IT} [LCI result]	EF

*Base scenario for end of life has been based on a precautionary approach: all materials sent to landfill except for plastics, sent to incineration.

7.2.3 Assumptions/limitations

The application of the CFF is done using the formula reported below.

Material $(1-R_1)E_V + R_1 \times \left(AE_{recycled} + (1-A)E_V \times \frac{Q_{Sin}}{Q_p}\right) + (1-A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$

Energy $(1-B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$

Disposal $(1-R_2-R_3) \times E_D$

General assumptions and limitations to the analysis:

— The default coefficients reported in the OEF Guidance, annex C, have been used if not specified otherwise

— A default scenario for end-of-life construction materials is not available. A precautionary approach has been assumed:

   - No recycled material in input (i.e. R1=0). This assumption represents the actual state of the infrastructure of JRC Ispra site, since most of the buildings are more than 40 years old. It is reasonable to assume that the amount of recycled materials is near zero

- Recycling rates taken from the Italian annual report for special waste management (10)
- Substitution of a lower value material on the market after recycling, such as aggregate for backfilling (modelled as gravel)

— Recycling processes datasets (ErecEoL) available only for metals: aluminium, copper and steel. This leads to an underestimation of the burdens. This shortcoming should not affect significantly the interpretation, since the missing data for recycling processes is expected to have low burdens if compared to metals recycling (e.g. crushing and sorting for construction materials)

— The datasets used may include already an implementation of the CFF. The analysis has been done to the best understanding possible, considering the availability of LCI datasets and the accompanying metadata

— CFF has not been implemented for insulation materials, since too little information was available in the EF database used to carry out the study (February 2018)

— The quantity of copper included in the BoM may be overestimated, hence causing an overestimation of the impacts of buildings construction

— The uncertainties related to copper datasets (e.g. regionalization of water flows, allocation to copper of elements such as molybdenum, silver, gold and others from mining) increase the uncertainty on the LCIA results for buildings construction

Table 54 reports in detail the coefficients used, assumptions and sources.

Table 54 – Coefficients for the application of the CFF to buildings construction.

Buildings construction BoM item	Coefficients											Comments
	A	B	R1	R2[1]	R3	$x_{er,heat}$[2]	$x_{er,elec}$[2]	LHV[3] [MJ/kg]	Ev=E*v	Qsin/Qp	Qsout/Qp	
Bricks	0.5	0	0	0.761	0	-	-	-	No (material substituted: backfilling for construction works)	-	-	- A: default value - R1: own assumption - R2: see note 1 to the table - Material substitution: own assumption
Concrete	0.5	0	0	0.761	0	-	-	-	No (material substituted: backfilling for construction works)	-	-	
Cement mortar	0.5	0	0	0.761	0	-	-	-	No (material substituted: backfilling for construction works)	-	-	
Glass	0.2	0	0	0.868	0	-	-	-	Yes	1	1	Default CFF parameters: - A, R1: glass-MATERIAL - Quality ratios assumed equal to packaging
Insulation	0.5	0	0.407	0	0	-	-	-	no	n.a.	-	Too few data available, only upstream impacts (Ev) considered

Buildings construction BoM item	Coefficients											Comments
	A	B	R1	R2[1]	R3	$x_{er,heat}$[2]	$x_{er,elec}$[2]	LHV[3] [MJ/kg]	Ev=E*v	Qsin/Qp	Qsout/Qp	
Aluminium	0.2	0	0	0.711	0	-	-	-	Yes	1	1	Default CFF parameters: - A, R1: Aluminium-MATERIAL - Quality ratios assumed equal to packaging
Copper	0.2	0	0.79	0.95	0	-	-	-	Yes	1	1	Default CFF parameters: - A, R1, R2: copper-building-pipes - Quality ratios assumed equal to packaging (other metals)
Steel	0.2	0	0.54	0.853	0	-	-	-	Yes	1	1	Default CFF parameters: - A, R1: Steel-building-sheet - Quality ratios assumed equal to packaging
Plastic 1 (PVC)	0.5	0	0	0.593	0.305[5]	0.285	0.158	18.5	Yes	0.9	0.9	Default CFF parameters: - A, R1: plastics-buildings and construction-PVC - R3: see note 4 to the table

Buildings construction BoM item	Coefficients											Comments
	A	B	R1	R2[1]	R3	$x_{er,heat}$[2]	$x_{er,elec}$[2]	LHV[3] [MJ/kg]	Ev=E*v	Qsin/Qp	Qsout/Qp	
												- Quality ratios assumed equal to packaging
Plastic 2 (LDPE)	0.5	0	0	0.593	0.30[5]	0.285	0.158	41.2	Yes	0.75	0.75	Default CFF parameters: - A, R1: plastics-buildings and construction-PVC - R3: see note 4 to the table - Quality ratios assumed equal to packaging
Wood	0.5	0	0	0.783	0	-	-	-	no	-	-	Low relevance to the BoM. Treated as a construction material. - A: default value - R1: own assumption - R2: see note 1 to the table - Material substitution: own assumption

1) Recycling rates for materials from construction works taken from Italian annual report on special waste management (10) except for copper.

2) Efficiencies for thermal energy and electricity production from waste incineration taken from Ecoinvent 3.2.

3) LHV for plastic waste taken from waste plastic incineration dataset included in the EF database.

4) Incineration of plastics estimated based on 2015 data of the end-of-life of plastic packaging in Italy.

7.2.4 Application of the CFF to the BoM

Below the updated BoM, after the application of the CFF. The formulas applied to the different datasets (Ev, Erec, etc.) are reported below in literal form and in numerical form in the table (column CFF).

$$E_V \times \left((1-R_1)+(1-A)\times R_1 \times \frac{Q_{Sin}}{Q_p}\right)$$

$$E_{recycled} \times A \times R_1$$

$$-E_V^* \times (1-A)R_2 \times \frac{Q_{Sout}}{Q_P}$$

$$E_{recyclingEoL} \times (1-A) \times R_2$$

$$E_D \times (1-R_2-R_3)$$

$$E_{ER} \times R_3{*}$$

*The energy part of CFF is applied to waste-to-energy processes that already include the benefits from energy recovery.

Table 55 - Application of the CFF to the BoM for buildings construction

INPUT					
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**	**CFF**
Bricks	kg	178	Bricks vertically perforated (EN15804 A1-A3) | technology mix | production mix, at plant | vertically perforated {EU-28} [LCI result]	EF	Ev 178*((1-0)+(1-0.5)*0)=178
Concrete	kg	220	Concrete C20/25 (ready-mix concrete)| technology mix| production mix, at plant| C20/25 {DE} [LCI result]	EF	Ev 220*((1-0)+(1-0.5)*0)=220
Cement mortar	kg	61.7	Cement mortar {CH}| production | Alloc Def, U	EI	Ev 61.7*((1-0)+(1-0.5)*0)=61.7
Glass	kg	3.08	Flat glass, uncoated| production mix| at plant| per kg flat glass {EU-28+3} [LCI result]	EF	Ev 3.08*((1-0)+(1-0.5)*0*1)=3.08
Insulation	kg	1.3	Glass fibres| production mix| at plant| per kg glass fibres {EU-28+3} [LCI result]	EF	Ev CFF not applied
Aluminium	kg	8.48	Aluminium ingot mix | primary production | consumption mix, to consumer | aluminium ingot product, primary production {EU-28+EFTA} [LCI result]	EF	Ev 8.48*((1-0)+(1-0.2)*0*1)=8.48
Copper	kg	7.14	1 kg - Copper billet/slab (smelting and refining to produce primary copper	EF	Ev 8.48*((1-0.79)+(1-0.2)*0.79*1)=7.14

INPUT					
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**	**CFF**
			cathode)| casting| single route, at plant| 8.92 g/cm3 {EU-28+EFTA} [LCI result] 3.25 kg - Copper Concentrate (Mining, mix technologies)| copper ore mining and processing| single route, at plant| Copper - gold - silver - concentrate (28% Cu, 22.3 Au gpt, 37.3 Ag gpt) {GLO} [LCI result]		
Steel	kg	6.39	Hot rolled coil| hot rolling| production mix, at plant| carbon steel {EU-28+EFTA} [LCI result]	EF	Ev 7.17*((1-0.54)+(1-0.2)*0.54*1)=6.39
Plastics (PVC)	kg	0.925	PVC granulates, low density| polymerisation of vinyl chloride| production mix, at plant| 62 g/mol per repeating unit {EU-28+EFTA} [LCI result] Pipes extrusion| pipe production by plastic extrusion| production mix, at plant| 3% loss (range 2- 8%), 2.2 MJ electricity (range 1.5- 8) {EU-28+EFTA} [LCI result]	EF	Ev 0.925*((1-0)+(1-0.5)*0*1)=0.925
Plastics (LDPE)	kg	0.925	LDPE granulates| Polymerisation of ethylene| production mix, at plant| 0.91-0.96 g/cm3, 28 g/mol per repeating unit {EU-28+EFTA} [LCI result] Pipes extrusion| pipe production by plastic extrusion| production mix, at plant| 3% loss (range 2- 8%), 2.2 MJ electricity (range 1.5- 8) {EU-28+EFTA} [LCI result]	EF	Ev 0.925*((1-0)+(1-0.5)*0*1)=0.925
Wood	Kg	0.0617	Sawn wood, softwood| planed, dried| at plant| per kg sawn wood {EU-28+3} [LCI result]	EF	Ev 0.0617*((1-0)+(1-0.5)*0*0.1)=0.0617
Aluminium	kg	0	Secondary aluminium ingot (zinc main solute)| secondary production, aluminium casting and alloying| single route, at plant| 2.7 g/cm3 {EU-28+3} [LCI result]	EF	Erec 8.48*0.2*0=0
Steel	kg	0.77	Steel cast part alloyed| electric arc furnace route, from steel scrap, secondary production| single route, at plant| carbon steel {EU-28+EFTA} [LCI result]	EF	Erec 7.17*0.2*0.54=0.77
Copper	kg	1.34	Secondary copper billet/slab (clean copper scrap)| copper scrap smelting and refining| single route, at plant| 8.92 g/cm3 {EU-28+EFTA} [LCI result]	EF	Erec 8.48*0.2*0.79=1.34
Construction materials	kg	-174.9	Gravel extraction | extraction | production mix, at quarry | {EU-28+EFTA} [LCI result]	EF	E*v 459.7*(1-0.5)*0.761*(-1)=-67.7

INPUT					
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**	**CFF**
Construction materials (wood)	kg	-0.024	Chips production| production mix| at plant| per kg wood or bark chips {EU-28+3} [LCI result]	EF	E*v 0.0617*(1-0.5)*0.783*(-1)=-0.024
Glass	kg	-2.14	Flat glass, uncoated| production mix| at plant| per kg flat glass {EU-28+3} [LCI result]	EF	E*v 3.08*(1-0.2)*0.868*(-1)= -2.14
Aluminium	kg	-4.82	Aluminium ingot mix | primary production | consumption mix, to consumer | aluminium ingot product, primary production {EU-28+EFTA} [LCI result]	EF	E*v 8.48*(1-0.2)*0.711*(-1)= -4.82
Copper	kg	-6.44	1 kg - Copper billet/slab (smelting and refining to produce primary copper cathode)| casting| single route, at plant| 8.92 g/cm3 {EU-28+EFTA} [LCI result] 3.25 kg - Copper Concentrate (Mining, mix technologies)| copper ore mining and processing| single route, at plant| Copper - gold - silver - concentrate (28% Cu, 22.3 Au gpt, 37.3 Ag gpt) {GLO} [LCI result]	EF	E*v 8,48*(1-0,2)*0,95*(-1)*1= -6,44
Steel	kg	-4.89	Hot rolled coil| hot rolling| production mix, at plant| carbon steel {EU-28+EFTA} [LCI result]	EF	E*v 7.17*(1-0.2)*0.853*(-1)= -4.89
Plastics (PVC)	kg	-0.247	PVC granulates, low density| polymerisation of vinyl chloride| production mix, at plant| 62 g/mol per repeating unit {EU-28+EFTA} [LCI result]	EF	E*v 0.925*(1-0.5)*0.593*(-1)*0.9= -0.247
Plastics (LDPE)	kg	-0.2	LDPE granulates| Polymerisation of ethylene| production mix, at plant| 0.91-0.96 g/cm3, 28 g/mol per repeating unit {EU-28+EFTA} [LCI result]	EF	E*v .925*(1-0.5)*0.593*(-1)*0.75= -0.20
Thermal energy (construction works)	MJ	15	Thermal energy from light fuel oil (LFO)| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]	EF	Not applicable
Electricity (construction works)	kWh	0.3	Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, to consumer| 1kV - 60kV {IT} [LCI result]	EF	Not applicable
Transport	tkm	11	See chapter 5.32	-	Not applicable

OUTPUT					
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**	**CFF**
Aluminium	kg	4.82	Recycling of aluminium into aluminium scrap - from post-consumer| collection, transport, pretreatment, remelting| production mix, at plant| aluminium waste, efficiency 90% {EU-28+EFTA} [LCI result]	EF	ErecEoL 8.48*(1-0.2)*0.711=4.82
Copper	kg	6.44	Recycling of copper from clean scrap| collection, transport, pretreatment| production mix, at plant| copper waste, efficiency 90% {EU-28+EFTA} [LCI result]	EF	ErecEoL 8.48*(1-0.2)*0.95=6.44
Steel	kg	4.89	Recycling of steel into steel scrap| collection, transport, pretreatment, remelting| production mix, at plant| steel waste, efficiency 95% {EU-28+EFTA} [LCI result]	EF	ErecEoL 7.17*(1-0.2)*0.853=4.89
Landfill – Construction materials (incl. insulation)	kg	110.2	Landfill of inert (construction materials)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site| {EU-28+EFTA} [LCI result]	EF	ED (178+220+61.7+1.3)*(1-0.761-0)= 110.2
Landfill - Glass	kg	0.41	Inert matter (Glass) on landfill | landfill | consumption mix, at consumer | {DE} [LCI result]	EF	ED 3.08*(1-0.868-0)= 0.41
Landfill – steel	kg	3.3	Landfill of inert (steel)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site| {EU-28+EFTA} [LCI result]	EI	ED 7.17*(1-0.54-0)=3.3
Landfill – copper	kg	8.48	Landfill of inert material (other materials)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site {EU-28+EFTA} [LCI result]	EF	ED 8.48*(1-0-0)=8.48
Landfill – Aluminium	kg	2.45	Landfill of inert (aluminium)| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site| {EU-28+EFTA} [LCI result]	EF	ED 8.48*(1-0.711-0)=2.45
Landfill - Wood	kg	0.013	Landfill of untreated wood| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific	EF	ED 0.0617*(1-0.783-0)= 0.013

OUTPUT					
Non-elementary flows	**Unit**	**Value**	**Generic data**	**DB**	**CFF**
			sites), at landfill site {EU-28+EFTA} [LCI result]		
Incineration – PVC	kg	0.28	Waste incineration of PVC| waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| polyvinyl chloride waste {IT} [LCI result]	EF	EER 0.925*0.30=0.28
Incineration - LDPE	kg	0.28	Waste incineration of PE| waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment| production mix, at consumer| polyethylene waste {IT} [LCI result]	EF	EER 0.925*0.30=0.28

7.2.5 Results

Results are provided as:

- Detailed results, per each type of material (table 17)
- A comparison with the dataset used for the baseline scenario (table 18 and figure 8)
- A global analysis on the effects on the global weighted OEF (table 19 and figure 9)

Results for the first two points are referred to the construction of 1 m^3 of building.

Table 56 – Impacts for the construction of 1 m^3 of building after the application of the CFF. Results are reported for each material included in the BoM and further subdivided in the contribution (positive and negative) from each dataset used to model the different elements of the CFF, i.e. Ev, Erec, E*v, etc.

Buildings construction BoM item	**Environmental impact indicator**															
	Climate change	**Ozone depletion**	**Ionising radiation, HH**	**Photochemical ozone formation, HH**	**Respiratory inorganics**	**Non-cancer human health effects**	**Cancer human health effects**	**Acidification**	**Eutrophication freshwater**	**Eutrophication marine**	**Eutrophication terrestrial**	**Ecotoxicity freshwater**	**Land use**	**Water use**	**Resource use, energy carriers**	**Resource use, mineral and metals**
	kg CO2 eq	**kg CFC11 eq**	**kBq U-235 eq**	**kg NMVOC eq**	**disease inc.**	**CTUh**	**CTUh**	**mol H+ eq**	**kg P eq**	**kg N eq**	**mol N eq**	**CTUe**	**Pt**	**m3 depriv.**	**MJ**	**kg Sb eq**
Aluminium	32.94	8.51E-09	8.65	0.05	1.04E-06	1.42E-06	6.80E-08	0.10	1.66E-05	0.01	0.16	2.02	55.51	2.05	461.10	5.90E-06
*E*v*	-3.98E+01	-1.12E-08	-1.14E+01	-5.45E-02	-1.31E-06	-1.77E-06	-8.54E-08	-1.27E-01	-1.92E-05	-1.75E-02	-1.89E-01	-2.52E+00	-6.90E+01	-2.66E+00	-5.56E+02	-7.63E-06
ED	0.07	1.11E-13	7.56E-04	3.17E-04	4.29E-09	2.96E-08	7.33E-10	3.92E-04	9.84E-07	1.20E-04	1.30E-03	0.01	0.32	5.15E-03	0.88	6.21E-09
ErecEoL	2.64	2.32E-11	0.03	3.60E-03	4.73E-08	4.42E-08	2.46E-09	4.60E-03	9.89E-07	1.16E-03	0.01	0.09	2.75	0.02	38.06	9.28E-08
Ev	70.05	1.97E-08	19.97	0.10	2.30E-06	3.12E-06	1.50E-07	0.22	3.38E-05	0.03	0.33	4.43	121.48	4.68	978.12	1.34E-05

Buildings construction BoM item	Environmental impact indicator															
	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification	Eutrophication freshwater	Eutrophication marine	Eutrophication terrestrial	Ecotoxicity freshwater	Land use	Water use	Resource use, energy carriers	Resource use, mineral and metals
	kg CO2 eq	kg CFC11 eq	kBq U-235 eq	kg NMVOC eq	disease inc.	CTUh	CTUh	mol H+ eq	kg P eq	kg N eq	mol N eq	CTUe	Pt	m3 depriv.	MJ	kg Sb eq
Construction materials	77.45	5.27E-07	1.76	0.12	1.18E-06	3.10E-06	1.15E-07	0.14	2.95E-04	0.04	0.46	4.89	413.54	4.16	416.86	7.79E-06
*E*v*	-1.29E-01	-2.86E-11	-3.20E-02	-9.55E-04	-1.58E-08	-4.87E-08	-5.58E-10	-8.46E-04	-8.17E-07	-3.51E-04	-3.77E-03	-2.48E-02	-5.70E+00	-1.08E-02	-1.99E+00	-3.16E-08
ED	3.02	5.01E-12	0.03	0.01	1.93E-07	1.33E-06	3.30E-08	0.02	4.43E-05	5.41E-03	0.06	0.52	14.38	0.23	39.73	2.79E-07
Ev	74.56	5.27E-07	1.76	0.11	1.01E-06	1.82E-06	8.24E-08	0.13	2.52E-04	0.04	0.41	4.39	404.86	3.94	379.11	7.54E-06
Copper	6.79	2.74E-10	0.11	0.02	1.54E-06	8.22E-06	1.28E-07	0.05	6.86E-05	8.83E-03	0.09	139.51	66.72	12.03	58.95	6.40E-03
*E*v*	-2.92E+01	-9.10E-10	-1.22E-01	-1.07E-01	-6.88E-06	-3.68E-05	-5.73E-07	-2.12E-01	-3.03E-04	-3.83E-02	-4.07E-01	-6.25E+02	-2.90E+02	-5.38E+01	-2.46E+02	-2.87E-02
ED	0.01	1.83E-14	1.30E-04	5.22E-05	7.31E-10	5.09E-09	1.24E-10	6.48E-05	1.68E-07	1.94E-05	2.09E-04	1.93E-03	0.05	8.76E-04	0.15	1.05E-09
Erec	3.38	1.16E-10	0.03	0.01	7.88E-07	4.20E-06	6.55E-08	0.02	3.46E-05	4.41E-03	0.05	71.60	33.52	6.16	28.67	3.28E-03
ErecEoL	0.22	5.86E-11	0.07	5.50E-04	7.06E-09	1.54E-08	5.02E-10	8.14E-04	8.20E-07	2.35E-04	2.48E-03	0.01	1.58	0.03	3.44	5.35E-08
Ev	32.42	1.01E-09	0.14	0.12	7.63E-06	4.08E-05	6.35E-07	0.23	3.36E-04	0.04	0.45	692.52	321.96	59.64	272.36	0.03
Glass	0.96	2.37E-10	0.03	4.36E-03	1.20E-07	3.93E-08	4.87E-09	9.38E-03	1.77E-05	1.50E-03	0.02	0.16	2.76	0.24	12.63	2.61E-06
*E*v*	-2.18E+00	-5.39E-10	-6.68E-02	-9.84E-03	-2.71E-07	-7.86E-08	-1.09E-08	-2.12E-02	-3.99E-05	-3.38E-03	-4.16E-02	-3.70E-01	-6.23E+00	-5.49E-01	-2.86E+01	-5.94E-06

Buildings construction BoM item	Environmental impact indicator															
	Climate change	Ozone depletion	Ionising radiation, HH	Photochemical ozone formation, HH	Respiratory inorganics	Non-cancer human health effects	Cancer human health effects	Acidification	Eutrophication freshwater	Eutrophication marine	Eutrophication terrestrial	Ecotoxicity freshwater	Land use	Water use	Resource use, energy carriers	Resource use, mineral and metals
	kg CO2 eq	**kg CFC11 eq**	**kBq U-235 eq**	**kg NMVOC eq**	**disease inc.**	**CTUh**	**CTUh**	**mol H+ eq**	**kg P eq**	**kg N eq**	**mol N eq**	**CTUe**	**Pt**	**m3 depriv.**	**MJ**	**kg Sb eq**
ED	6.76E-03	3.54E-15	1.14E-04	3.94E-05	5.97E-10	4.75E-09	7.39E-11	4.90E-05	1.41E-07	1.38E-05	1.44E-04	9.89E-04	0.02	5.05E-04	0.09	6.87E-10
Ev	3.14	7.76E-10	0.10	0.01	3.90E-07	1.13E-07	1.57E-08	0.03	5.75E-05	4.87E-03	0.06	0.53	8.97	0.79	41.09	8.56E-06
Insulation	3.11	4.95E-09	0.40	0.01	1.82E-07	1.08E-06	5.31E-08	0.02	4.55E-05	3.94E-03	0.04	4.99	10.78	0.77	46.54	1.53E-05
Ev	3.11	4.95E-09	0.40	0.01	1.82E-07	1.08E-06	5.31E-08	0.02	4.55E-05	3.94E-03	0.04	4.99	10.78	0.77	46.54	1.53E-05
Plastics	2.22	1.08E-09	0.32	0.01	6.43E-08	1.95E-07	2.89E-08	7.90E-03	4.33E-05	2.09E-03	0.02	0.74	8.46	1.12	100.69	7.70E-07
*E*v*	-9.61E-01	-3.69E-10	-9.38E-02	-3.05E-03	-1.79E-08	-6.15E-08	-8.61E-09	-2.18E-03	-1.25E-05	-6.11E-04	-6.05E-03	-2.16E-01	-2.74E+00	-3.12E-01	-2.86E+01	-1.58E-07
ED	6.80E-03	1.10E-14	8.93E-05	3.05E-05	4.10E-10	3.60E-09	1.74E-10	4.02E-05	3.47E-06	1.13E-05	1.21E-04	3.44E-03	0.03	5.33E-04	0.09	6.58E-10
EER+ESEheat+ESEelec	-7.98E-01	3.37E-11	0.03	5.30E-04	7.89E-09	-1.94E-08	4.31E-10	8.91E-04	6.97E-08	1.48E-04	1.10E-03	0.02	-1.33E-02	-1.57E-02	8.77	2.81E-07
Ev	3.97	1.42E-09	0.39	0.01	7.39E-08	2.73E-07	3.69E-08	9.15E-03	5.22E-05	2.54E-03	0.03	0.93	11.18	1.44	120.42	6.46E-07
Steel	7.17	7.12E-10	0.84	0.01	1.06E-06	1.08E-06	6.32E-08	0.02	9.23E-06	4.18E-03	0.04	1.23	22.86	1.03	84.54	1.09E-04
*E*v*	-1.27E+01	7.50E-11	0.05	-2.33E-02	-1.12E-06	-2.72E-06	-5.51E-08	-3.87E-02	-9.62E-06	-6.51E-03	-7.01E-02	-1.63E+00	-1.39E+01	-1.71E+00	-1.06E+02	-3.54E-04
ED	0.09	1.50E-13	1.02E-03	4.28E-04	5.78E-09	3.99E-08	9.87E-10	5.28E-04	1.33E-06	1.62E-04	1.75E-03	0.02	0.43	6.94E-03	1.19	8.36E-09

Buildings construction BoM item	Environmental impact indicator															
	Climate change	**Ozone depletion**	**Ionising radiation, HH**	**Photochemical ozone formation, HH**	**Respiratory inorganics**	**Non-cancer human health effects**	**Cancer human health effects**	**Acidification**	**Eutrophication freshwater**	**Eutrophication marine**	**Eutrophication terrestrial**	**Ecotoxicity freshwater**	**Land use**	**Water use**	**Resource use, energy carriers**	**Resource use, mineral and metals**
	kg CO2 eq	**kg CFC11 eq**	**kBq U-235 eq**	**kg NMVOC eq**	**disease inc.**	**CTUh**	**CTUh**	**mol H+ eq**	**kg P eq**	**kg N eq**	**mol N eq**	**CTUe**	**Pt**	**m3 depriv.**	**MJ**	**kg Sb eq**
Erec	1.39	3.36E-10	0.39	2.02E-03	6.13E-07	4.26E-08	4.31E-08	3.24E-03	2.03E-06	7.14E-04	7.41E-03	0.49	7.23	0.14	22.08	3.03E-07
ErecEoL	1.79	3.99E-10	0.46	4.14E-03	1.01E-07	1.58E-07	2.16E-09	7.44E-03	2.92E-06	1.31E-03	0.01	0.23	10.93	0.35	28.68	4.56E-07
Ev	16.58	-9.80E-11	-6.65E-02	0.03	1.47E-06	3.56E-06	7.20E-08	0.05	1.26E-05	8.50E-03	0.09	2.13	18.22	2.24	138.84	4.63E-04
Wood	0.03	1.63E-11	1.04E-03	7.16E-05	2.85E-09	3.20E-09	2.09E-10	4.75E-05	1.73E-07	1.81E-05	2.03E-04	4.64E-03	16.43	1.03E-03	0.10	4.56E-08
*E*v*	-1.97E-04	-1.39E-13	-2.41E-05	-6.75E-07	-4.37E-12	-7.85E-12	-2.00E-12	-6.43E-07	-7.80E-10	-2.21E-07	-2.41E-06	-3.89E-05	-7.49E-04	-7.77E-06	-2.91E-03	-1.99E-10
ED	0.02	-3.49E-13	-4.25E-04	1.28E-05	2.37E-11	2.06E-10	4.37E-12	2.76E-06	4.78E-08	2.13E-06	1.86E-05	3.58E-05	-2.89E-04	-1.74E-05	-7.09E-03	-1.14E-10
Ev	6.90E-03	1.67E-11	1.48E-03	5.95E-05	2.83E-09	3.01E-09	2.06E-10	4.54E-05	1.25E-07	1.62E-05	1.87E-04	4.64E-03	16.43	1.05E-03	0.11	4.59E-08
Other processes	2.01	2.17E-10	0.24	3.56E-03	3.42E-08	4.16E-08	9.07E-09	4.32E-03	2.06E-06	1.23E-03	0.01	0.20	6.06	0.11	29.65	2.87E-07
n.a.	2.01	2.17E-10	0.24	3.56E-03	3.42E-08	4.16E-08	9.07E-09	4.32E-03	2.06E-06	1.23E-03	0.01	0.20	6.06	0.11	29.65	2.87E-07
Total	132.68	5.43E-07	12.34	0.23	5.24E-06	1.52E-05	4.71E-07	0.36	4.98E-04	0.08	0.85	153.74	603.11	21.51	1,211	6.55E-03

Table 57 – Reduction of buildings construction impacts (characterization) after the application of the CFF.

Environmental impact indicator	Unit	Impacts W/O CFF	Impacts W CFF	Reduction of impacts
Climate change	kg CO2 eq	224.78	132.68	40.97%
Ozone depletion	kg CFC11 eq	5.55E-07	5.43E-07	2.21%
Ionising radiation, HH	kBq U-235 eq	23.18	12.34	46.75%
Photochemical ozone formation, HH	kg NMVOC eq	0.48	0.23	51.77%
Respiratory inorganics	disease inc.	1.56E-05	5.24E-06	66.37%
Non-cancer human health effects	CTUh	6.47E-05	1.52E-05	76.54%
Cancer human health effects	CTUh	1.33E-06	4.71E-07	64.61%
Acidification	mol H+ eq	0.83	0.36	57.07%
Eutrophication freshwater	kg P eq	1.05E-03	4.98E-04	52.68%
Eutrophication marine	kg N eq	0.17	0.08	52.25%
Eutrophication terrestrial	mol N eq	1.78	0.85	52.11%
Ecotoxicity freshwater	CTUe	842.72	153.74	81.76%
Land use	Pt	1,046	603.11	42.34%
Water use	m3 depriv.	86.05	21.51	75.01%
Resource use, energy carriers	MJ	2,279	1,211	46.85%
Resource use, mineral and metals	kg Sb eq	0.04	6.55E-03	82.93%

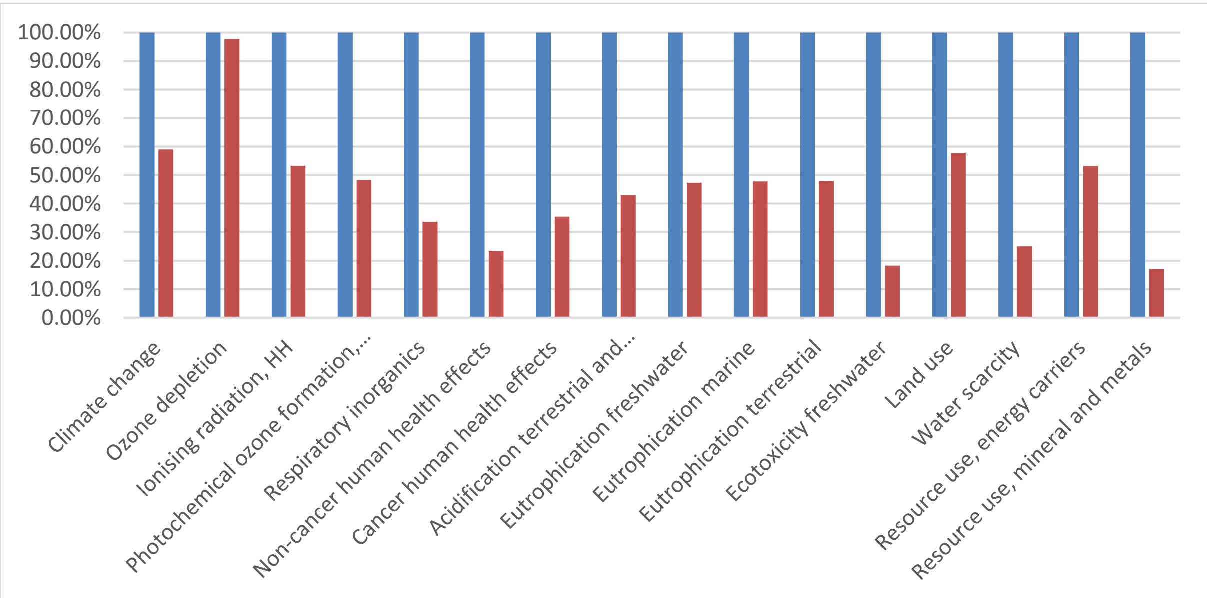


Figure 10 – Reduction of buildings construction impacts (characterization) after the application of the CFF

Table 58 - Reduction of the overall site impacts (weighted) with the application of the CFF to buildings construction.

Environmental impact indicator	JRC Ispra OEF results W/O CFF	JRC Ispra OEF results W CFF	Reduction of impacts (single indicator)	Reduction of impacts (overall)
Total	**3.17**	**2.17**	-	**31.64%**
Climate change	1.03	0.98	4.94%	1.61%
Ozone depletion	2.76E-03	2.76E-03	0.02%	<0.01%
Ionising radiation, HH	0.01	9.12E-03	22.60%	0.08%
Photochemical ozone formation, HH	0.08	0.07	8.10%	0.19%
Respiratory inorganics	0.10	0.07	29.75%	0.94%
Non-cancer human health effects	-	-	-	-
Cancer human health effects	-	-	-	-
Acidification	0.08	0.07	12.86%	0.34%
Eutrophication freshwater	0.03	0.03	0.45%	<0.01%
Eutrophication marine	0.03	0.03	5.59%	0.06%
Eutrophication terrestrial	0.05	0.05	7.90%	0.13%
Ecotoxicity freshwater	-	-	-	-
Land use	0.01	0.01	4.66%	0.02%
Water use	0.08	0.07	12.45%	0.31%
Resource use, energy carriers	0.56	0.53	5.02%	0.89%
Resource use, mineral and metals	1.10	0.24	77.83%	27.07%

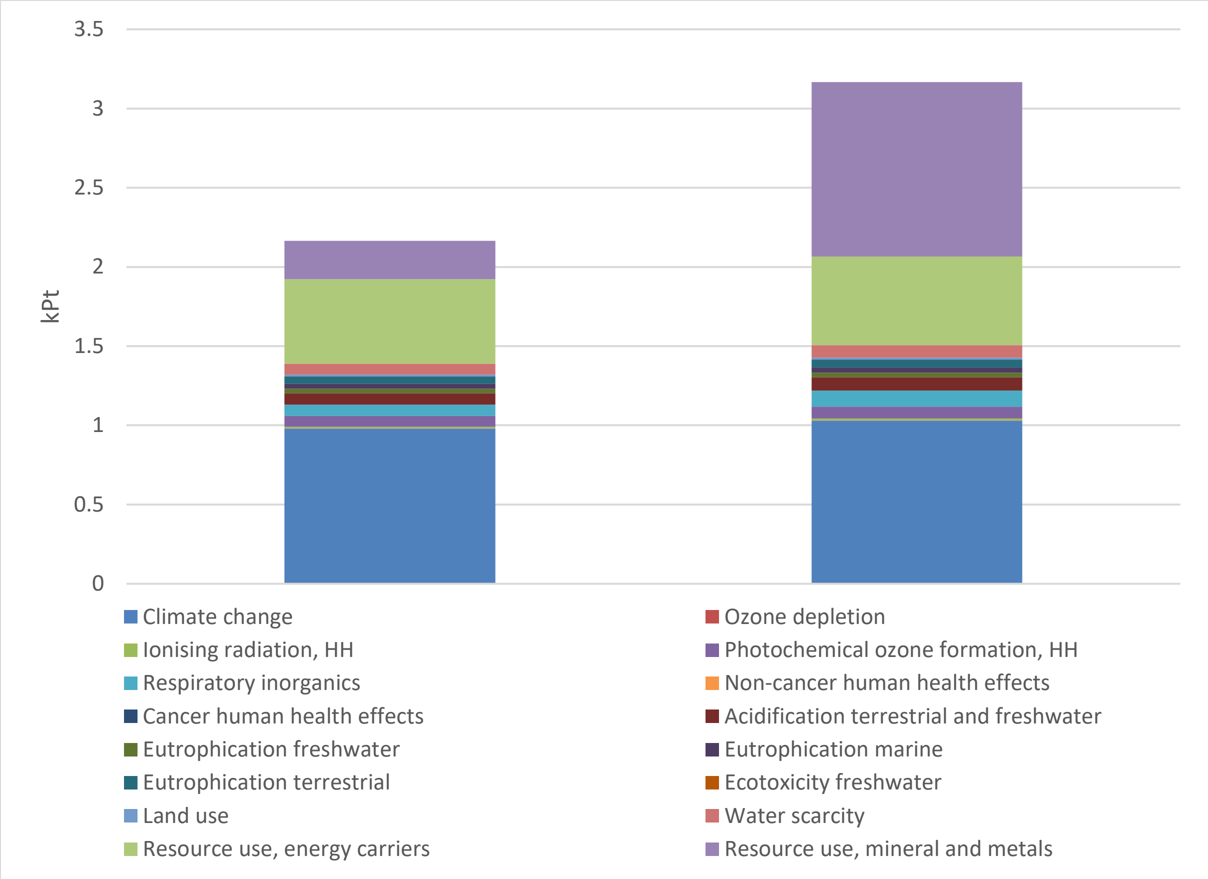


Figure 11 - Reduction of the overall site impacts (weighting) with the application of the CFF to buildings construction

7.2.6 Comments

The application of the CFF proved successful: most data from the EF database were available. However, since OEFSR for JRC activities are not developed, an effort has been made to create a realistic scenario, using the available default values included in Annex C of the OEF Guidance and complementing with literature values (e.g. recycling rates for waste from buildings construction).

The results show a notable reduction of impacts for all impact categories when applying the CFF, ranging from 2% to more than 80%. In particular, the resource use indicator sees a reduction of almost 83% of the impacts. The other most relevant indicators, Climate change and Resource use, energy carriers decrease their impact by around 41% and 46% respectively.

The hotspot analysis does not change after the application of the CFF, i.e. the most relevant indicators and processes are the same as before the application of the CFF. The weighted impacts decrease significantly (-32%) and the impact category resource use, minerals and fossils decreases in relevance (11% vs 35% prior to CFF application). Climate change and resource use, energy carriers, instead, gain relevance (70% vs 50% prior to CFF application).

The application of the CFF yielded meaningful results, even considering the limitations. The high relevance of the recycling rates at the materials end-of-life (i.e. the credit effect as reduction of the environmental impacts) suggests that relevant information may be obtained and integrated into EMAS from the CFF application.

The outcomes suggest that in future updates of OEF, the application of the CFF should be made more extensive and supported by more specific rules.

7.3 Data quality assessment

The data quality assessment has been carried out only for the most relevant processes, and provides the following outcomes:

— DQR for the most relevant processes (see chapter 7.1.3)

— DQR of the whole study

— Proposed list of mandatory company specific data for the processes included in the data quality assessment

The definition of the secondary datasets to be used for this type of OEF application (i.e. Public administration/research centers) is not addressed in this study.

For each of the most relevant processes, the DQR has been applied to the elementary flows, activity data and secondary datasets contributing to at least 80% of the weighted impacts of the analysed process.

Due to the limitations in the applicability of the OEFSR Guidance requirements to this study (see chapter 2.2), the following situations from the Data Needs Matrix (DNM) are addressed:

— Situation 1/option 1: for processes with a high level of control by the site (e.g. A01 – Energy supply from internal cogeneration)

— Situation 3/option 1: for processes with low to no control by the site (e.g. A29 – Buildings construction)

The DQR have been calculated applying the procedure for company-specific datasets included in the Guidance (§7.19.2). The parameters Ter, GR, TiR and P were evaluated for elementary flows and activity data. For secondary datasets, the default DQR included in the datasets metadata have been applied without any modification.

The rules established in §7.19.2 of the OEFSR Guidance to compute the DQR in case the datasets have most relevant processes covered by non-EF compliant datasets have been applied. The correction factors applied in such cases are reported at the bottom of Table 59.

Table 59 and Table 60 show the results of the data quality assessment.

Table 59 – DQR for the most relevant processes.

Most relevant process (OEF)	Situation /option	Elementary flow	Most relevant process (disaggregation level 1)	Contribution to weighted environmental impact [%]	Contribution to DQR [%]	DQR Elementary flows, activity data and secondary datasets					DQR most relevant process				
						TeR	GR	TiR	P	DQR	TeR	GR	TiR	P	DQR
A01	1/1	Carbon Dioxide, fossil	-	43.08%	44.40%	1.00	1.00	1.00	2.00	**1.25**	1.00	1.00	1.00	1.49	**1.12**
		Nitrogen oxides	-	4.87%	5.02%	1.00	1.00	1.00	2.00	**1.25**					
		-	Natural gas mix| technology mix| consumption mix, to consumer| medium pressure level (< 1 bar) {IT} [LCI result]	49.07%	50.58%	1.00	1.00	1.00	1.00	**1.00**					
A29	3/1	-	Copper JRC*	81.45%	100.00%	1.00	3.00	1.00	2.00	**1.75**	1.00	3.00	1.00	2.00	**1.75**
A05	1/1	Water, lake, IT	-	85.03%	100.00%	1.00	1.00	1.00	3.00	**1.50**	1.00	1.00	1.00	3.00	**1.50**
A31*	1/1	-	Broiler| for slaughter| at farm| per kg live weight {EU-28+3} [LCI result]	4.30%	13.00%	2.80	2.80	2.70	2.80	**2.78**	3.30	3.36	3.11	3.62	**3.35**
		-	Swine| for slaughter| at farm| per kg live weight {EU-28+3} [LCI result]	6.51%	19.70%	2.50	2.40	2.00	2.90	**2.45**					
		-	Beef cattle| for slaughter| at farm| per kg live weight {EU-28+3} [LCI result]	6.78%	20.50%	2.40	2.30	2.20	2.40	**2.33**					
		-	White rice| from dry milling| at plant| {CN} [LCI result]	2.52%	7.63%	1.40	1.80	1.80	2.30	**1.83**					

Most relevant process (OEF)	Situation /option	Elementary flow	Most relevant process (disaggregation level 1)	Contribution to weighted environmental impact [%]	Contribution to DQR [%]	DQR Elementary flows, activity data and secondary datasets					DQR most relevant process				
						TeR	GR	TiR	P	DQR	TeR	GR	TiR	P	DQR
		-	Eggs| production mix| at farm| per kg {EU-28+3} [LCI result]	1.34%	4.06%	2.00	2.80	1.60	2.20	**2.15**					
		-	Cow milk| production mix| at farm| per kg FPCM {EU-28+3} [LCI result]	1.65%	5.00%	2.40	2.30	2.20	2.40	**2.33**					
		-	Rapeseed| technology mix, production mix| at farm| {EU+28} [LCI result]	2.21%	6.67%	1.50	1.80	1.80	2.40	**1.88**					
		-	PET bottle, transparent| raw material production, blow moulding| production mix, at plant| 192.17 g/mol per repeating unit {EU-28+EFTA} [LCI result]	7.75%	23.45%	2.00	2.00	2.00	2.00	**2.00**					
A13	1/1	Hydrogen-3, Tritium	-	94.06%	100.00%	1.00	1.00	1.00	1.00	**1.00**	1.00	1.00	1.00	1.00	**1.00**
A09**	3/1	-	Passenger car, average| technology mix, gasoline and diesel driven, Euro 3-5, passenger car| consumption mix, to consumer| engine size from 1,4l up to >2l {GLO} [LCI result]	6.55%	100.00%	3.00	3.00	1.00	3.00	**2.50**	5.76	5.76	1.92	5.76	**4.80**

Most relevant process (OEF)	Situation /option	Elementary flow	Most relevant process (disaggregation level 1)	Contribution to weighted environmental impact [%]	Contribution to DQR [%]	DQR Elementary flows, activity data and secondary datasets					DQR most relevant process				
						TeR	**GR**	**TiR**	**P**	**DQR**	**TeR**	**GR**	**TiR**	**P**	**DQR**
A02	3/1	-	Electricity from hard coal| AC, mix of direct and CHP, technology mix regarding firing and flue gas cleaning| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	38.80%	43.88%	1.00	1.00	1.00	2.00	**1.25**	1.00	1.00	1.00	2.00	**1.25**
		-	Electricity from natural gas| AC, mix of direct and CHP, technology mix regarding firing and flue gas cleaning| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	33.90%	38.34%	1.00	1.00	1.00	2.00	**1.25**					
		-	Electricity from storage and pump storage power plant| AC, storage and pump storage power| production mix, at power plant| 1kV - 60kV {IT} [LCI result]	6.54%	7.40%	1.00	1.00	1.00	2.00	**1.25**					
		-	Electricity from nuclear| AC, technology mix of BWR and PWR| production mix, at power plant| 1kV -	4.71%	5.33%	1.00	1.00	1.00	2.00	**1.25**					

Most relevant process (OEF)	Situation /option	Elementary flow	Most relevant process (disaggregation level 1)	Contribution to weighted environmental impact [%]	Contribution to DQR [%]	DQR Elementary flows, activity data and secondary datasets					DQR most relevant process				
						TeR	GR	TiR	P	DQR	TeR	GR	TiR	P	DQR
			60kV {FR} [LCI result]												
		-	Electricity from fossil unspecified| AC, technology mix| production mix, at plant| 1kV - 60kV {IT} [LCI result]	4.47%	5.06%	1.00	1.00	1.00	2.00	**1.25**					

* Copper JRC is an auxiliary dataset made up by Copper concentrate and copper working. Since no DQR is available for the auxiliary dataset, the DQR for copper concentrate has been used as proxy (Process UUID: beacade4-7521-4844-a79d-18724142842f).

** The DQR for A31 are multiplied by 1.48, the correction factor for non EF datasets excluded from the data quality assessment (see chapter 5.31)

*** The DQR for A09 are multiplied by 1.92, the correction factor for non EF datasets excluded from the data quality assessment (see chapter 5.9)

Table 60 – DQR of the study

Most relevant process	Contribution to weighted environmental impact [%]	Contribution to DQR [%]	DQR Study				
			TeR	GR	TiR	P	DQR
A01	40.09%	43.57%	1.24	2.17	1.09	1.98	**1.62**
A02	2.10%	2.28%					
A05	1.46%	1.58%					
A09	3.59%	3.90%					
A13	0.04%	0.04%					
A29	42.53%	46.21%					
A31	2.21%	2.40%					

The application of the data quality requirements proved successful and it was possible to obtain a DQR for the study. Since most of the data used for this study are company-specific, the data quality of the study results very high. However, the history of the study, the lack of OEFSR and the high number of assumptions may generate some limitations to the overall consistency of the assessment.

Two of the most relevant processes, A31 (food supply) and A09 (business travels) are not fully covered by EF compliant datasets. Therefore, correction factors were needed. These factors lower significantly the data quality for these processes. However, their low relevance to the weighted environmental impacts make them marginal to the study DQR.

In accordance with the hotspot analysis, A01 (energy supply from internal cogeneration) and A29 (buildings construction) give the highest contribution to the overall score. They count alone for more than 80% of the overall DQR.

Below, the list of proposed mandatory company-specific data, as a result of the data quality assessment:

- A01 – Energy supply from internal cogeneration
  - Elementary flows: flue gas from combustion (CO2, CO, NOx, SOx)
  - Activity data: natural gas consumption and properties (composition, LHV, etc.)
- A02 – Electricity purchased by the grid
  - Elementary flows: not applicable
  - Activity data: electricity consumption from the grid and supplier electricity mix
- A05 – Water supply and wastewater treatment

    - Elementary flows: site water balance (total input and outputs, type of water used)
    - Activity data: not relevant
- A09 – JRC staff business travels
    - Elementary flows: not applicable
    - Activity data: km travelled by JRC Ispra site staff for business travels, categorized by mean of transport
- A13 – Nuclear activities
    - Elementary flows: measurements of ionizing radiation releases in air and water. The same measurements used to report to the national environmental control authority (ISPRA)
    - Activity data: not relevant
- A29 – Buildings constrution
    - Elementary flows: not relevant
    - Activity data: total volume of buildings located within the site. Specific BoMs for the most relevant types of buildings (e.g. offices, power plant, wastewater treatment plant, etc.)
- A31 – Food supply
    - Elementary flows: not relevant
    - Activity data: amounts of foods and beverages consumed in the canteen and in vending machines

The specifications for the unit of measure and other details related to the proposed list of mandatory company-specific data are reported in chapter 5.

7.4 Consistency analysis – Resource use, energy carriers indicator

The use of datasets from different databases, in particular Ecoinvent, having different nomenclature, may lead to inconsistencies in the results due to uncharacterized flows.

The use of EF datasets for the most relevant processes ensures full consistency with the EF methods for the most relevant processes and a good consistency overall.

A sensitivity check has been performed for all the most relevant indicators, through searching for big amounts of uncharacterized material/energy flows that could affect significantly the quantification of the impact indicators.

The resource use, energy carriers indicator has been identified as the most affected one by these inconsistencies, due to the differences in the characterized elementary flows in respect to other well known methods used to quantify the consumption of primary energy (e.g. CED).

The consistency assessment has been done comparing the results obtained with the EF method with the results obtained with the CED method, considering only the fossil and nuclear components. Since the CED method includes all the elementary flows included in the EF resource, the difference between the two results gives a reliable estimation of the uncharacterized energy flows. Table 61 shows the results of the consistency analysis.

Table 61 – Consistency analysis of the impact assessment performed on the impact indicator Resource use, energy carriers.

Activity	Impacts [MJ] using CED (fossil + nuclear	Impacts [MJ] using EF method	Difference per single activity*	Most relevant processes using CED method
A01 - Energy supply from internal cogeneration	325,565,620	325,565,620	0.00%	70.30%
A02 - Electricity supply from the grid	14,139,233	14,112,243	0.19%	3.05%
A03 - Electricity supply from photovoltaic installations	196,880	196,880	0.00%	0.04%
A04 - Heating from other boilers	4,079,391	4,079,391	0.00%	0.88%
A05 - Water supply and wastewater treatment	44,737	40,403	9.69%	0.01%
A06 - Internal fleet activities	713,751	713,751	0.00%	0.15%
A07 - Staff and contractors home-work trips	16,299,118	12,383,354	24.02%	3.52%
A08 - Staff and visitors transportation	2,172,265	2,172,265	0.00%	0.47%
A09 - JRC staff business travels	34,032,788	1,548,549	95.45%	7.35%
A10 - Urban waste management	59,943	0	100.00%	0.01%
A11 - Special waste management	127,166	0	100.00%	0.03%
A12 - Green areas maintenance	112,305	0	100.00%	0.02%
A13 - Nuclear activities	0	0		0.00%
A14 - Office paper	580,490	580,489	0.00%	0.13%
A15 - Stationery	40,431	0	100.00%	0.01%
A16 - Chemical products	19,047	0	100.00%	0.00%
A17 - Detergents	199,819	0	100.00%	0.04%
A18 - Tissue paper	376,723	376,722	0.00%	0.08%

Activity	Impacts [MJ] using CED (fossil + nuclear	Impacts [MJ] using EF method	Difference per single activity*	Most relevant processes using CED method
A19 - Technical gases	2,425,005	0	100.00%	0.52%
A20 - Lubricants	6,489	0	100.00%	0.00%
A21 - Light bulbs	916,475	0	100.00%	0.20%
A22 - Paints and varnishes	466,528	102,719	77.98%	0.10%
A23 - Construction materials	739,368	0	100.00%	0.16%
A24 - Cooling gases	7,652	7,652	0.00%	0.00%
A25 - Toners	101,860	101,860	0.00%	0.02%
A26 - IT equipments (manufacturing)	4,995,714	0	100.00%	1.08%
A27 - Furniture	418,472	0	100.00%	0.09%
A29 - Buildings (construction)	48,184,821	46,556,685	3.38%	10.41%
A30 - External lamps and other minor assets	1,607,698	0	100.00%	0.35%
A31 - Food supply	4,043,748	1,487,762	63.21%	0.87%
A99 - Transport	413,330	413,330	0.00%	0.09%
Total	**461,883,500**	**410,438,450**	**11.14%**	

* 0% difference means that there are no uncharacterized elementary energy flows using the EF method. 100% difference means that none of the elementary energy flows is characterized using the EF method.

The results using the CED method score 11.14% higher in respect to the impacts calculated with the EF method. Most of the activities not addressed in the update of the JRC Ispra OEF model are not characterized at all by the EF method. However, the most relevant processes (A01 and A29) are well characterized, ensuring the consistency of the impact assessment. Most of the uncharacterized activities would give minor contribution to the impacts. The most significant uncharacterized activities are related to people transportation, namely A09 – Business travels and A07 - Staff and contractors home-work trips.

Conclusively, the impact assessment, at least for the most relevant processes, proves good consistency.

8 Conclusions

According to the defined goal and scope, the environmental footprint analysis of the JRC Ispra site provides a detailed and comprehensive measure of the interactions between site activities and the environment, taking a life cycle perspective.

The study covered the whole operational processes carried out on site, along with the value chain of consumables and assets that support scientific and non-scientific activities. The system complexity and the great deal of data and information required a significant effort in the elaboration and modelling of the footprint. The results are however satisfactory and allowed the identification of the relevant activities, processes and products which contribute to the environmental footprint.

The OEF results after the application of the new requirements (OEFSR Guidance) are in line with the previous assessment and generally meaningful. This also taken into account the many assumptions and limitations.

According to the goals of the study, the results of the environmental footprint are intended for both internal use and external communication. The measure of the environmental footprint can support environmental improvement targets and performance tracking over time.

Differently from the previous versions of this study, the new method for the calculation of the impacts comprised a weighting step. Weighting allowed for the identification of the most relevant impact indicators, life cycle stages, processes and direct elementary flows, ensuring that the focus is put on those aspects that matter the most and for communication purposes.

A few impact categories and a few big main processes dominate the OEF. The most relevant impact indicators are Climate Change and the two indicators related to resource use (both mineral and metals and energy carriers). On the other hand, the most relevant processes are related to the energy supply from internal cogeneration and buildings construction.

Other relevant processes (and related impact indicator) are:

- Water supply (water use)
- Business travels (climate change)
- Nuclear activities (ionizing radiation)
- Food supply (water use)
- Electricity purchased from the grid (ionizing radiation)

The additional indicators have been selected based on their relevance to the direct site activities (data measured on site) and suitability for communication and EMAS.

The footprint analysis has pointed out which activities were the most relevant in terms of potential environmental impacts during the reporting year 2015. This information should represent the baseline for setting environmental targets and actions for improvement as well as for reviewing and complementing existing actions.

Defining the potential environmental improvements should however take into consideration the level of influence the site has over the relevant activities to the environmental impacts. For example, building construction has a high incidence on the environmental impacts, but it is a process where JRC has very limited influence, as well as other indirect activities.

The JRC Ispra environmental footprint has the goal to identify footprint-based performance indicators to be integrated in the context of EMAS. Hereafter the description of the work done so far for creating such indicators.

8.1 Supporting EMAS implementation with OEF information

Building on the outcomes of the present and past studies and further developing the suggestions laid down in the previous chapters, this final section includes a framework for integrating the OEF information into the Ispra site Environmental Management System. The purpose is to provide complementing life-cycle based-information and elements in support of EMAS implementation and to guide the future updates of the OEF assessment.

The previous OEF studies already documented the achievements obtained over time by the Ispra site in reducing the site EF both from performance-improvement actions (such as improving the energy generation efficiency) and management action (e.g. sustainable mobility policies).

In addition, the last OEF study (6) had a section dedicated to suggested action for further improvement, which are shown in table xx below

Table 62 – Suggested actions to reduce JRC Ispra OEF from the previous study

Target activity	Performance-improvement action	Management action	Target impact categories (2013 EF method)
A01 – Energy from cogeneration	Re-powering of the plant through the installation of new gas turbines	-	Climate change Particulate matter Photochemical ozone Acidification Terr. Eutrophication
	Further reduce natural gas consumption (supply-chain effects)		Climate change Particulate matter Photochemical ozone Acidification Terr. Eutrophication Ionizing radiation
	Fuel switch (to bio-gas)		Climate change (others to be assessed)
A02 – Electricity from the grid	Reducing the grid dependence through on-site generation from photovoltaic and other renewable sources	-	Climate change Particulate matter Photochemical ozone Acidification Terr. Eutrophication Ionizing radiation Water scarcity
	Purchase “green electricity” or GO certificates		
A05 – Water supply and wastewater	Further reduce water withdrawal from the lake	Perform a Water Footprint study according to ISO 14046:2014	Water scarcity
A07 – Staff commuting	-	Enhance sustainable mobility policies	Climate change Particulate matter Photochemical ozone Acidification Terr. Eutrophication
A09 – Business travels	Reduce travel needs through encouraging web/video conferences	-	Climate change Particulate matter Photochemical ozone Acidification Terr. Eutrophication
A31 – Food supply	Reduce meat consumption in the staff diet balance	-	Climate change Acidification Terr Eutrophication

Target activity	Performance-improvement action	Management action	Target impact categories (2013 EF method)
			Water Scarcity

The outputs of this new application of the OEF confirm the validity of the recommendations made in the previous study.

Given the high number of information delivered by an OEF study, it is necessary to select a limited but relevant subset of indicators to be integrated into EMAS. The evaluation is based on a set of criteria, namely:

- Method robustness
- OEF relevance,
- Good data availability,
- Strategic importance for Commission policies,
- Suitability for communication

Based on the previous application of the OEF to JRC Ispra site, the indicators reported in Table 63 were implemented in a dedicated tool (JRC Ispra OEF KPI Tool). A brief presentation of the tool is provided in Annex 4.

With the support of instruments such as the JRC Ispra OEF KPI Tool, new performance indicators may be added to the current set in use by the Ispra site (register of measures and environmental indicators). These new OEF indicators will enable the JRC to:

- Broadening the scope of the site EMS to an inclusive consideration of indirect environmental aspects,
- Measuring the effectiveness of the implemented actions in a life cycle perspective

Table 63 – Indicators included in the JRC Ispra OEF KPI Tool.

Indicator name	Scope	Calculation	Unit of measure
Total JRC site Carbon Footprint	GHG emissions arising from direct and indirect site activities, as defined in the OEF boundaries Corresponding to the full accounting of Scope1-2-3 emissions according to the GHG Protocol WBCSD/WRI	OEF 2013 methodology	t CO_2 eq.
JRC site Carbon footprint – direct emissions	GHG emissions arising from direct site activities Scope1 emissions according to the GHG Protocol	Sum of GHG emissions from: trigenerator, other boilers, internal fleet and cooling gases	t CO_2 eq.
JRC site Carbon footprint – indirect emissions	GHG emissions arising from the indirect site activities Scope2 emissions according to the GHG Protocol	GHG emissions arising from the consumption of electricity (emissions at power plant only)	t CO_2 eq.
JRC site Carbon footprint – indirect emissions	GHG emissions arising from the indirect site activities Scope3 emissions according to the GHG Protocol	Total CF – (scope 1 + scope 2)	t CO_2 eq.
Total Ionizing radiation emissions	Emissions arising from direct and indirect site activities, as defined in the OEF boundaries	OEF 2013 methodology	kBq U_{235} eq.

Indicator name	Scope	Calculation	Unit of measure
Ionizing radiation - direct emissions	Emissions arising from activity A13	Site measurements of emissions, as declared to ISPRA	kBq U_{235} eq.
Ionizing radiation – indirect emissions	Emissions arising from indirect site activities, as defined in the OEF boundaries	Difference between the above indicators	kBq U_{235} eq
Water Scarcity Footprint	Consumptive water use arising from direct and indirect site activities, as defined in the OEF boundaries	OEF 2013 methodology	m^3 water eq.

The new assessment documented in this study confirms the list of the indicators implemented in the OEF KPI tool:

— Climate change is confirmed as a relevant impact category,

— Water use is relevant for communication and mostly under the control of the organisation,

— Ionizing radiation is currently not significant, but it will probably become relevant in the future when the nuclear decommissioning will be fully implemented

At the moment, indicators related to resource use are not essential for the tool. This is due to:

— Minerals and metals: low influence of JRC on the processes contributing to this impact category, i.e. buildings construction

— Energy carriers: impacts are coupled with climate change impacts and therefore are already addressed in the tool(i.e. impacts arising from combustion of fossil fuels)

However, since both indicators have high relevance to the environmental footprint, future applications of the OEF should further investigate these indicators in order to provide more consistent information and a suitable methodology to integrate them in EMAS as well.

Other possible relevant indicators for the impact categories like acidification, photochemical ozone formation, and eutrophication are not essential as well for different reasons:

— They are also to a large extent correlated with the indicator for Climate Change, therefore obtaining a better performance for this category would affect positively the others,

— Improvement opportunities for these indicators are limited because high contributions to the environmental impacts are due to processes out of the range of influence of the JRC (e.g. mineral extraction, flue gases at power plants, etc.),

— The expansion of the indicators list should be initially limited to a few items in order not to increase excessively the workload of the JRC staff responsible for EMAS; other indicators may be added in future once the integration EMAS-OEF will be more consolidated.

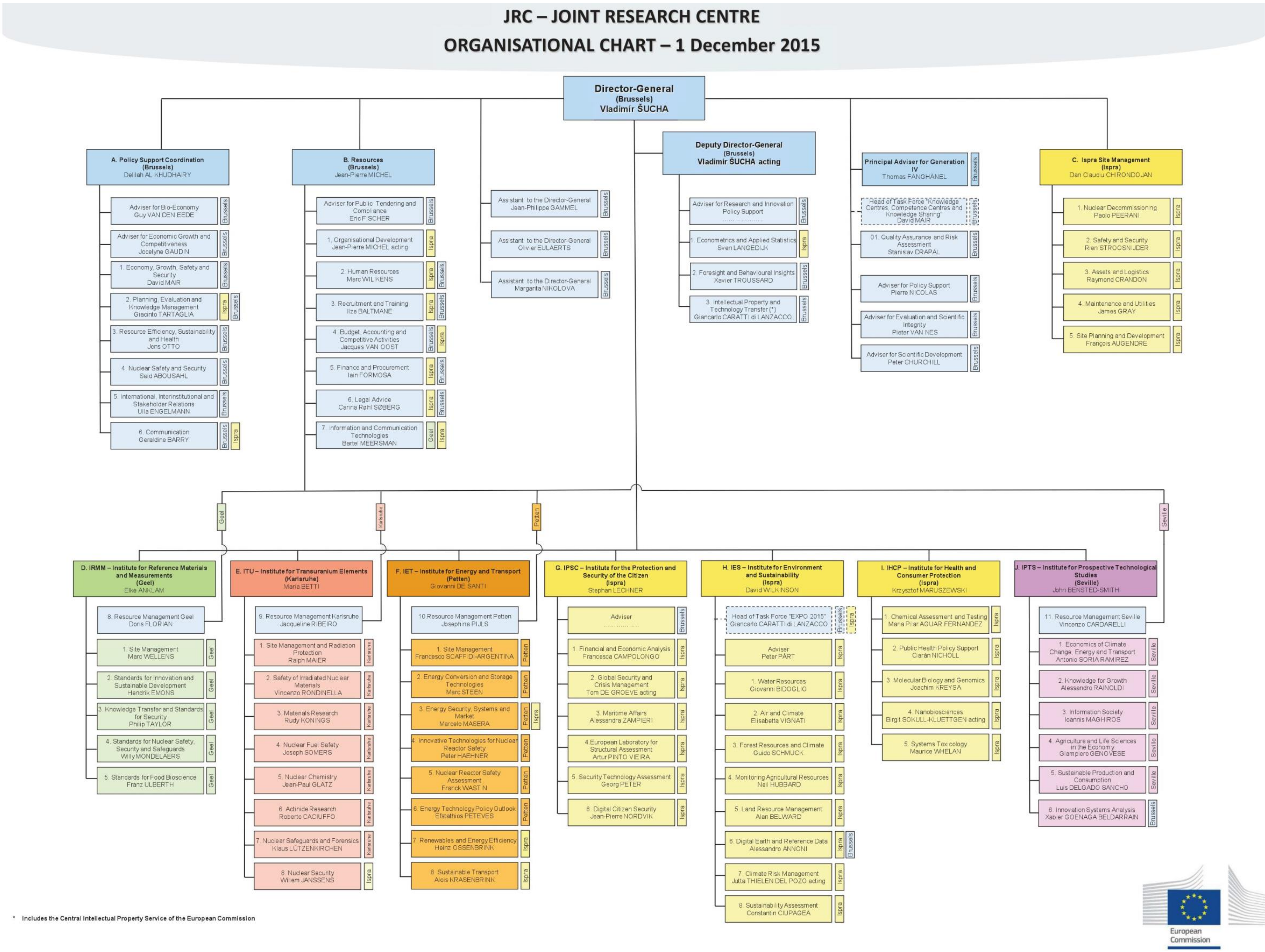
Additional metrics can be developed, for instance by referring the footprint data to specific parameters, such as staff number, on site annual presence, number of scientific and technical papers and publications and so forth.

References

1) European Commission, *Commission Recommendation 2013/179/EU of 9 April 2013 – Annex III "Organisation Environmental Footprint (OEF) Guide"*, 2013
2) JRC, *Product Environmental Footprint Category Rules Guidance – Version 6.3 – December 2017*, 2017
3) JRC Ispra Site Environmental Footprint, Reporting period 2011, final report – 2013
4) JRC Ispra Site Environmental Footprint, Reporting period 2011, final report – Secondary data and model update – 2014
5) JRC Ispra Site Environmental Footprint, Reporting period 2013, final report – 2015
6) JRC Ispra Site Environmental Footprint, Reporting period 2015, final report – 2017
7) Ispra Site Initial Environmental Review (IER), rev 1.0 – European Commission, JRC Environmental Management – 2008
8) JRC Guidelines on tangible fixed assets, version 1.2 – European Commission, JRC Budget Finance and Accounting Unit – 2010
9) JRC Ispra site, Register of Measures and Environmental Indicators v1.0 – 2016
10) Plant Operations Sector – Annual Report – Maintenance and Utilities Unit – 2011 and 2012
11) ISPRA, *Rapporto rifiuti speciali – Edizione 2017*, 2017

Annexes

Annex 1. JRC Organizational chart (December 2015)



Annex 2. List of normalization and weighting factors

Global normalisation factors for Environmental Footprint

Impact category	Model	Unit	global NFs for PEF	Person NF for PEF	Robustness of ILCD for the PEF impact assessment	Inventory coverage completeness	Inventory robustness	Comment
Climate change	IPCC, 2013	kg $CO_{2\ eq}$	5.35E +13	7.76E +03	I	II	I	
Ozone depletion	World Meteorological Organisation (WMO), 1999	kg CFC-11 $_{eq}$	1.61E +08	2.34E-02	I	III	II	
Human toxicity, cancer	USEtox (Rosenbaum et al., 2008)	CTUh	2.66E +05	3.85E-05	II/III	III	III	
Human toxicity, non-cancer	USEtox (Rosenbaum et al., 2008)	CTUh	3.27E +06	4.75E-04	II/III	III	III	
Particulate matter	UNEP, 2016	Disease incidence	4.39E +06	6.37E-04	I	I/II	I /II	NF calculation takes into account the emission height both in the emission inventory and in the impact assessment.
Ionising radiation, human health	Frischknecht et al., 2000	kBq $U^{235}{}_{-eq}$	2.91E +13	4.22E +03	II	II	III	
Photochemical ozone formation, human health	Van Zelm et al., 2008, as applied in ReCiPe, 2008	kg NMVOC $_{eq}$	2.80E +11	4.06E +01	II	III	I/II	
Acidification	Posch et al., 2008	mol H+ $_{eq}$	3.83E +11	5.55E +01	II	II	I/II	

Impact category	Model	Unit	global NFs for PEF	Person NF for PEF	Robustness of ILCD for the PEF impact assessment	Inventory coverage completeness	Inventory robustness	Comment
Eutrophication, terrestrial	Posch et al., 2008	mol N eq	1.22E +12	1.77E +02	II	II	I/II	
Eutrophication, freshwater	Struijs et al., 2009	kg P eq	1.76E +10	2.55E +00	II	II	III	
Eutrophication, marine	Struijs et al., 2009	kg N eq	1.95E +11	2.83E +01	II	II	II/III	
Land use	De Laurentiis et al. 2019, (based on Bos et al., 2016)	pt	9.20E +15	1.33E +06	III	II	I I	The NF is built by means of regionalised CFs.
Ecotoxicity, freshwater	USEtox (Rosenbaum et al., 2008)	CTUe	8.15E +13	1.18E +04	II/III	III	III	
Water use	AWARE 100 (based on; UNEP, 2016)	m^3 world eq	7.91E +13	1.15E +04	III	I	II	The NF is built by means of regionalised CFs.
Resource use, fossils	ADP fossils (van Oers et al., 2002)	MJ	4.50E +14	6.53E +04	III	I	II	
Resource use, minerals and metals	ADP ultimate reserve (van Oers et al., 2002)	kg Sb eq	3.99E +08	5.79E-02	III			

Weighting factors for Environmental Footprint

WITH TOX CATEGORIES (not applied in pilot phase)	Aggregated weighting set (50:50)	Robustness factors (scale 1-0.1)	Calculation	**Final weighting factors**
	A	B	C=A*B	C scaled to 100
Climate change	12.9	0.87	11.18	**21.06**
Ozone depletion	5.58	0.6	3.35	**6.31**
Human toxicity, cancer	6.8	0.17	1.13	**2.13**
Human toxicity, non-cancer	5.88	0.17	0.98	**1.84**
Particulate matter	5.49	0.87	4.76	**8.96**
Ionizing radiation, human health	5.7	0.47	2.66	**5.01**
Photochemical ozone formation, human health	4.76	0.53	2.54	**4.78**
Acidification	4.94	0.67	3.29	**6.2**
Eutrophication, terrestrial	2.95	0.67	1.97	**3.71**
Eutrophication, freshwater	3.19	0.47	1.49	**2.8**
Eutrophication, marine	2.94	0.53	1.57	**2.96**
Ecotoxicity, freshwater	6.12	0.17	1.02	**1.92**
Land use	9.04	0.47	4.22	**7.94**
Water use	9.69	0.47	4.52	**8.51**
Resource use, minerals and metals	6.68	0.6	4.01	**7.55**
Resource use, fossils	7.37	0.6	4.42	**8.32**

WITHOUT TOX CATEGORIES (applied in the pilot phase)	Aggregated weighting set (50:50)	Robustness factors (scale 1-0.1)	Calculation	**Final weighting factors**
	A	B	C=A*B	C scaled to 100
Climate change	15.75	0.87	13.65	**22.19**
Ozone depletion	6.92	0.6	4.15	**6.75**
Particulate matter	6.77	0.87	5.87	**9.54**
Ionizing radiation, human health	7.07	0.47	3.3	**5.37**
Photochemical ozone formation, human health	5.88	0.53	3.14	**5.1**
Acidification	6.13	0.67	4.08	**6.64**
Eutrophication, terrestrial	3.61	0.67	2.4	**3.91**
Eutrophication, freshwater	3.88	0.47	1.81	**2.95**
Eutrophication, marine	3.59	0.53	1.92	**3.12**
Land use	11.1	0.47	5.18	**8.42**
Water use	11.89	0.47	5.55	**9.03**
Resource use, minerals and metals	8.28	0.6	4.97	**8.08**
Resource use, fossils	9.14	0.6	5.48	**8.92**

Annex 3. JRC Ispra OEF model update checklist

Activity	Name	Availability of EF-compliant data	Data updated	Comments
A01	Energy supply from internal cogeneration	Yes	Yes	Primary data for direct emissions, EF datasets for natural gas and auxiliaries
A02	Electricity supply from the grid	Yes	Yes	Supplier mix 2015. Generation technology datasets from EF database
A03	Electricity supply from photovoltaic installations	Yes	Yes	Included for completeness (not included in hotspot)
A04	Heating from other boilers	Yes	Yes	Included for completeness (not included in hotspot)
A05	Water supply and wastewater treatment	Partial	Yes	Remodelled elementary flows to match ILCD nomenclature and available secondary data (products for water depuration)
A06	Internal fleet activities	Yes	Yes	Included for completeness (not included in hotspot)
A07	Staff and contractors home-work trips	Partial	Yes	EF dataset for car transport only (European mix)
A08	Staff and visitors transportation	Yes	Yes	Included for completeness (not included in hotspot)
A09	JRC staff business travels	Partial	Yes	EF dataset for car transport only (European mix)
A10	Urban waste management	Partial	No	Not relevant (screening on weighted results)
A11	Special waste management	Partial	No	Not relevant (screening on weighted results)
A12	Green areas maintenance	No	No	Not relevant (screening on weighted results)
A13	Nuclear activities	Yes	Yes	Remodelled elementary flows only, to match ILCD nomenclature (coherent with EF LCIA method). Other LCI datasets from Ecoinvent
A14	Office paper	Yes	Yes	Included for completeness (not included in hotspot)
A15	Stationery	No	No	Not relevant (screening on weighted results)
A16	Chemical products	Partial	No	Not relevant (screening on weighted results)
A17	Detergents	No	No	Not relevant (screening on weighted results)
A18	Tissue paper	Yes	Yes	Included for completeness (not included in hotspot)
A19	Technical gases	No	No	Not relevant (screening on weighted results)
A20	Lubricants	No	No	Not relevant (screening on weighted results)
A21	Light bulbs	No	No	Not relevant (screening on weighted results)
A22	Paints and varnishes	Partial	Yes	Included for completeness (not included in hotspot)
A23	Construction materials	Partial	No	Not relevant (screening on weighted results)

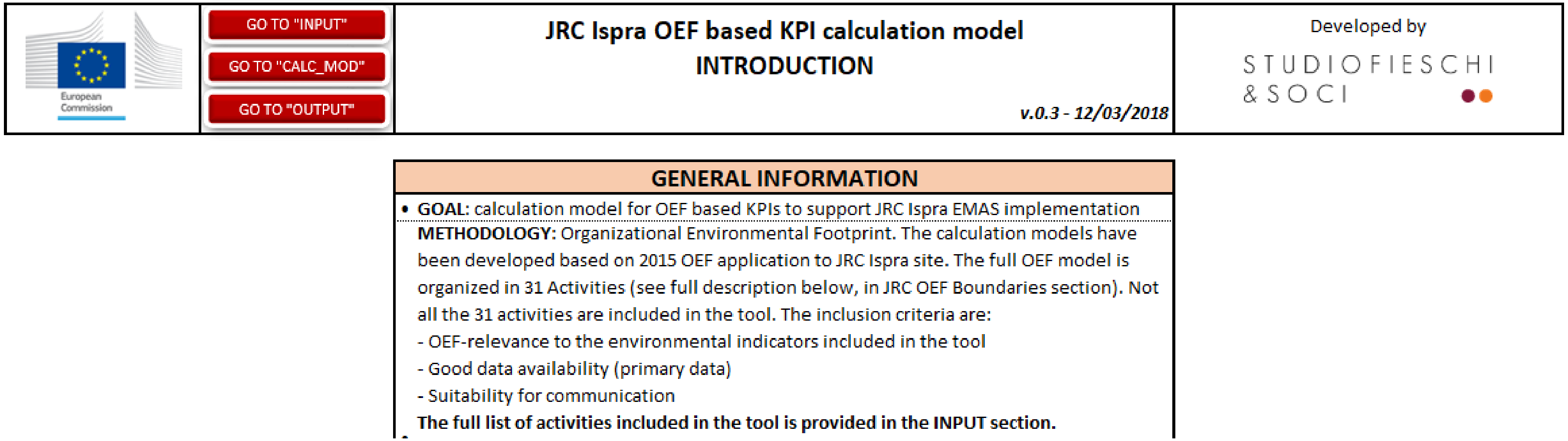
Activity	Name	Availability of EF-compliant data	Data updated	Comments
A24	Cooling gases	Yes	Yes	Included for completeness (not included in hotspot)
A25	Toners	Yes	Yes	Included for completeness (not included in hotspot)
A26	IT equipments (manufacturing)	No	No	Not relevant (screening on weighted results)
A27	Furniture	No	No	Not relevant (screening on weighted results)
A28	Vehicles (manufacturing)	No	No	Not relevant (screening on weighted results)
A29	Buildings (construction)	Partial	Yes	Missing part of the materials (e.g. cement mortar) needed to model the generic building. Data gaps filled using Ecoinvent data
A30	External lamps and other minor assets	Partial	No	Not relevant (screening on weighted results)
A31	Food supply	Partial	Yes	Previous study datasets substituted using (in hierarchical order): EF database AGRIBALYSE (v1.3) Ecoinvent (previous data maintained where new data was unavailable)

Annex 4. JRC Ispra OEF KPI Tool

Below a few screens taken from the tool.

All contents are provisional and do not represent an actual evaluation of the JRC Ispra environmental footprint.

Introduction: Description of the goal of the tool. Description of the methodology. Navigation buttons.



INPUT: the tool allows input for all the relevant activities to the characterized environmental indicators. The user fills in activity data (up to 2030), sources and assumptions.

A02 - Electricity from the grid

Back to top		Input name	Source	Other information	Unit	Year 2011	2012	2013	2014	2015	2016	2017
INPUT	2.1	Electricity (high voltage)	R.I.4/OIB I-03.08	Including EE for trigeneration support and for Residenze, Foresterie and ALER apartments and external area.	MWh			3,236	2,232	2,493	3,033	4,054
	2.2	Natural gas	Contractors I-03.19-a	in case of more contractors insert weighted average	%			33.00%	30.07%	30.69%	46.94%	31.31%
	2.3	Coal	Contractors I-03.19-a	in case of more contractors insert weighted average	%			19.00%	18.57%	20.08%	19.76%	13.07%
	2.4	Oil products	Contractors I-03.19-a	in case of more contractors insert weighted average	%			1.00%	0.98%	1.35%	1.00%	0.65%
	2.5	Nuclear	Contractors I-03.19-a	in case of more contractors insert weighted average	%			6.00%	2.79%	4.82%	4.56%	3.01%
	2.6	Renewables	Contractors I-03.19-a	in case of more contractors insert weighted average	%			37.00%	43.71%	39.83%	23.81%	49.35%
	2.7	Other	Contractors I-03.19-a	in case of more contractors insert weighted average	%			4.00%	3.88%	3.22%	3.93%	2.61%
	2.8	Total	-	Total must be 100%	%			100.00%	100.00%	100.00%	100.00%	100.00%

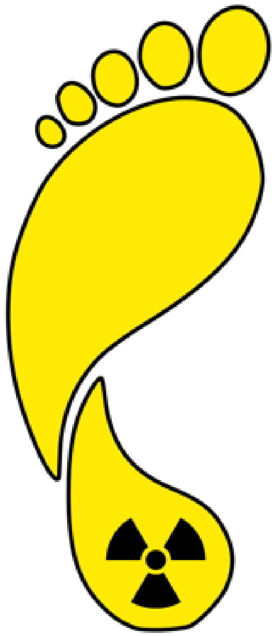
CALCULATION MODELS and CHARACTERIZATION FACTORS: the tool computes the environmental impacts applying to the inputs OEF based emission factors. The algorithms and the conversion factors are visible to the user for full disclosure of the methodology.

						Value						
		Input name	Algorithm	Comments	Unit	2011	2012	2013	2014	2015	2016	2017
INPUT	C2.1	Electricity (high voltage)	=sum(C2.2:C2.7)	-	kgCO$_2$ eq	0	0	1,780,632	1,165,253	1,367,411	2,013,249	1,890,307
	C2.2	Natural gas	=INPUT 2.1*INPUT 2.2*CHAR_F 2.1	Overall emissions (supply chain + power plant emissions + transmission and transformation losses)	kgCO$_2$ eq	0	0	887,839	558,007	636,247	1,183,464	1,055,105
	C2.3	Coal	=INPUT 2.1*INPUT 2.3*CHAR_F 2.2	Overall emissions (supply chain + power plant emissions + transmission and transformation losses)	kgCO$_2$ eq	0	0	738,476	497,829	601,477	719,949	636,175
	C2.4	Oil products	=INPUT 2.1*INPUT 2.4*CHAR_F 2.3	Overall emissions (supply chain + power plant emissions + transmission and transformation losses)	kgCO$_2$ eq	0	0	36,208	24,475	37,651	33,934	29,678
	C2.5	Nuclear	=INPUT 2.1*INPUT 2.5*CHAR_F 2.4	Overall emissions (supply chain + power plant emissions + transmission and transformation losses)	kgCO$_2$ eq	0	0	20,613	6,611	12,756	14,682	12,969
	C2.6	Renewables	=INPUT 2.1*INPUT 2.6*CHAR_F 2.5	Overall emissions (supply chain + power plant emissions + transmission and transformation losses)	kgCO$_2$ eq	0	0	89,872	73,230	74,549	54,202	150,158
	C2.7	Other	=INPUT 2.1*INPUT 2.7*CHAR_F 2.6	Overall emissions (supply chain + power plant emissions + transmission and transformation losses)	kgCO$_2$ eq	0	0	7,624	5,101	4,732	7,016	6,223
	C2.8	Electricity (high voltage)	=sum(C2.8:C2.14)	Electricity share	kWh	0	0	3,236,000	2,232,000	2,493,354	3,032,715	4,053,529
	C2.9	Natural gas	=INPUT 2.1*INPUT 2.2	Electricity share	kWh	0	0	1,067,880	671,162	765,269	1,423,454	1,269,065
	C2.10	Coal	=INPUT 2.1*INPUT 2.3	Electricity share	kWh	0	0	614,840	414,482	500,777	599,415	529,666
	C2.11	Oil products	=INPUT 2.1*INPUT 2.4	Electricity share	kWh	0	0	32,360	21,874	33,650	30,328	26,524
	C2.12	Nuclear	=INPUT 2.1*INPUT 2.5	Electricity share	kWh	0	0	194,160	62,273	120,148	138,296	122,156
	C2.13	Renewables	=INPUT 2.1*INPUT 2.6	Electricity share	kWh	0	0	1,197,320	975,607	993,172	722,111	2,000,474
	C2.14	Other	=INPUT 2.1*INPUT 2.7	Electricity share	kWh	0	0	129,440	86,602	80,337	119,110	105,644
	C99	Total activity impacts	=C2.1	-	kgCO$_2$ eq	0	0	1,780,632	1,165,253	1,367,411	2,013,249	1,890,307
	C89	Scope 1	-	-	kgCO$_2$ eq	-	-	-	-	-	-	-
	C88	Scope 2	=sum(C2.9*CHAR_F 2.9:C2.14*CHAR_F 2.14)	-	kgCO$_2$ eq	0	0	1,292,995	841,265	993,804	1,497,862	1,330,526
	C87	Scope 3	=C99-C88	-	kgCO$_2$ eq	0	0	487,637	323,988	373,607	515,387	559,781

RESULTS: the tool shows the results (characterization of the environmental impacts) with a level of aggregation suitable for JRC environmental reporting and communication (e.g. Scope1/2/3, etc.). Results are organized in tables and graphs.

The tool reports the environmental impacts for three impact categories: Climate change (**carbon footprint**), water scarcity (**water footprint**) and ionizing radiation (**atomic footprint**).

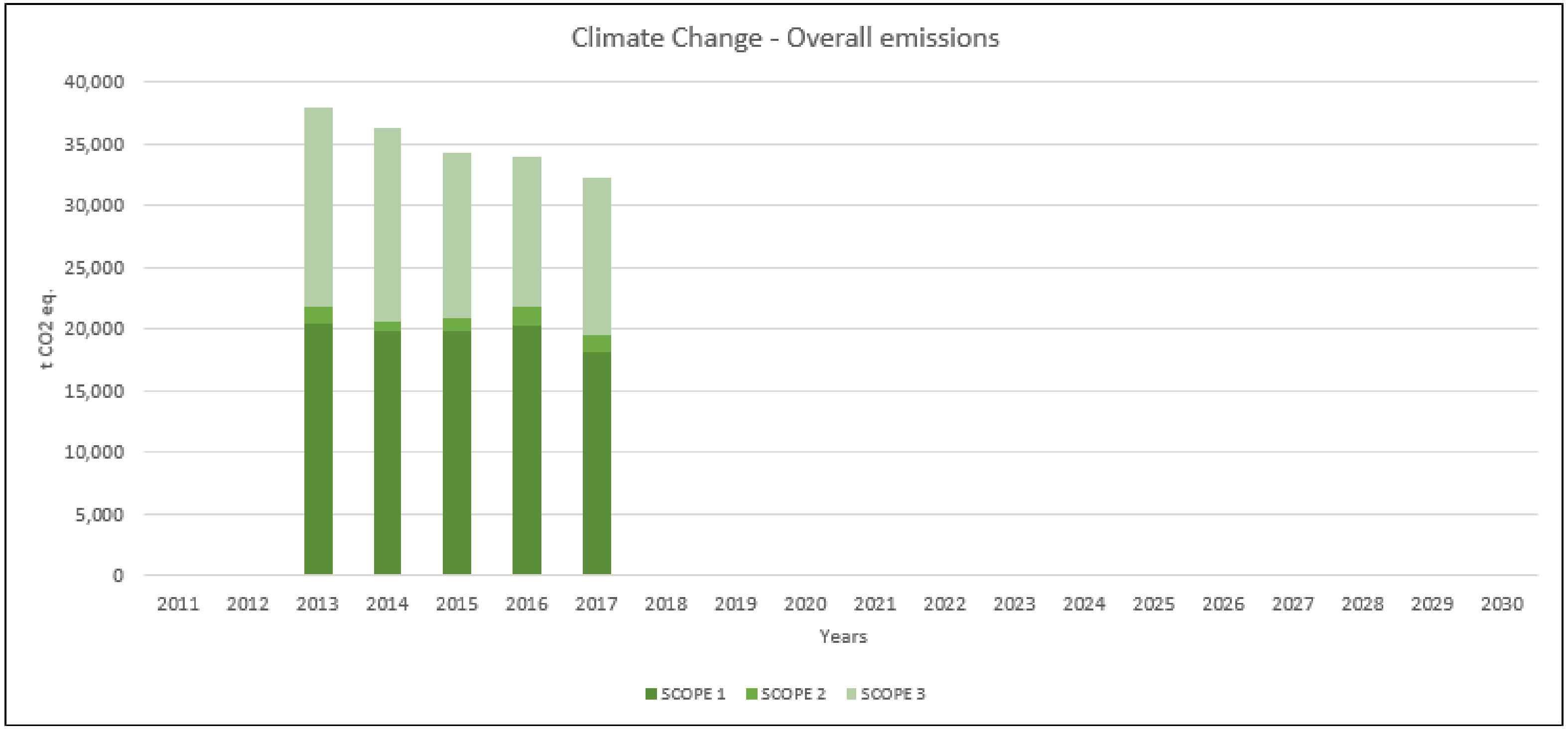
Carbon Footprint



Atomic Footprint

Water Footprint

				Year						
KPI	**Description**	**Comments**	**Unit**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Total JRC Ispra site Carbon Footprint	GHG emissions arising from direct and indirect site activities, as defined in the OEF boundaries Corresponding to the full accounting of Scope1-2-3 emissions according to the GHG Protocol WBCSD/WRI		tCO$_2$ eq.	**0**	**0**	**37,968**	**36,328**	**34,209**	**33,998**	**32,212**
			tCO$_2$ eq./p			**17.1**	**15.5**	**14.9**	**15.1**	**14.1**
SCOPE 1	Sum of GHG emissions from: trigenerator, other boilers, internal fleet and cooling gases		tCO$_2$ eq.	**0**	**0**	**20,463**	**19,772**	**19,847**	**20,318**	**18,143**
			tCO$_2$ eq./p			**9.2**	**8.5**	**8.6**	**9.0**	**8.0**
Fuels combustion	Sum of emissions from fuel combustion on site		tCO$_2$ eq.	0	0	20,230	19,615	19,181	18,158	17,939
			tCO$_2$ eq./p			9.1	8.4	8.4	8.0	7.9
of which natural gas	Natural gas consumption for heating boilers		*tCO$_2$ eq.*	*0*	*0*	*20,230*	*19,615*	*19,181*	*18,158*	*17,939*
			tCO$_2$ eq./p			*9.1*	*8.4*	*8.4*	*8.0*	*7.9*
of which diesel/petrols or other fuel	*[fill in description]*		*tCO$_2$ eq.*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
			tCO$_2$ eq./p			*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Owned/managed transport	GHG emissions from JRC Ispra internal fleet (A06)		tCO$_2$ eq.	0	0	59	56	62	47	38
			tCO$_2$ eq./p			0.0	0.0	0.0	0.0	0.0
Coolant/ Refrigerant leaks	Emissions from Coolant/ Refrigerant leaks		tCO$_2$ eq.	0	0	173	101	604	2,113	167
			tCO$_2$ eq./p			0.1	0.0	0.3	0.9	0.1
SCOPE 2	GHG emissions arising from the consumption of electricity (emissions at power plant only)		tCO$_2$ eq.	**0**	**0**	**1,293**	**841**	**994**	**1,498**	**1,331**
			tCO$_2$ eq./p			**0.6**	**0.4**	**0.4**	**0.7**	**0.6**
Electricity	Emissions from electricity purchased from the grid		tCO$_2$ eq.	0	0	1,293	841	994	1,498	1,331
			tCO$_2$ eq./p			0.6	0.4	0.4	0.7	0.6
SCOPE 3	GHG emissions arising from indirect activities (e.g. Business travels and commuting, food, etc.) and energy supply chain (e.g. fuel extraction and transportation)		tCO$_2$ eq.	**0**	**0**	**16,213**	**15,714**	**13,369**	**12,182**	**12,738**
			tCO$_2$ eq./p			**7.3**	**6.7**	**5.8**	**5.4**	**5.6**
Business travels	GHG emissions arising from JRC staff missions (activity A09)		tCO$_2$ eq.	0	0	2,212	2,455	2,222	1,828	1,872
			tCO$_2$ eq./p			1.0	1.1	1.0	0.8	0.8



Climate Change - Overall emissions
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
t CO2 eq.
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Years
SCOPE 1
SCOPE 2
SCOPE 3

Annex 5. Sub-processes

This section provides a list of the sub-process units obtained through the re-elaboration of pre-existing processes from LCA databases or built from scratch based on literature data or expert judgement.

Sub-process unit			
A01.02 – Hydrazine EF	3.2	kg	Approximation based on the Pechiney-Ugine-Kuhlmann reaction: $2NH_3 + H_2O_2 = N_2H_4 + 2H_2O$
Materials/fuels			
Ammonia, as 100% NH3 production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]	3.4	kg	
Hydrogen peroxide, 100% production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]	3.4	kg	

Sub-process unit			
A15.01 - Pen	1	p	
Materials/fuels			
Polypropylene, granulate {RER}| production | Alloc Def, U	3.8	g	
Injection moulding {RER}| processing | Alloc Def, U	3.8	g	
Printing ink, offset, without solvent, in 47.5% solution state {RER}| printing ink production, offset, product in 47.5% solution state | Alloc Def, U	0.3	g	

Steel, low-alloyed, hot rolled {RER}| production | Alloc Def, U	0.9	g	

Sub-process unit			
A15.02 - Pencil	1	p	
Materials/fuels			
Pine wood, timber, production mix, at saw mill, 40% water content DE S	2.4	g	
Graphite {RER}| production | Alloc Def, U	0.73	g	
Clay, at mine	0.27	g	

Sub-process unit			
A15.03 - Rubber	1	p	
Materials/fuels			
Polyvinylchloride, suspension polymerised {RER}| polyvinylchloride production, suspension polymerisation | Alloc Def, U	21	g	
Injection moulding {RER}| processing | Alloc Def, U	21	g	
Solid bleached board {RER}| production | Alloc Def, U	2	g	

Sub-process unit			
A15.04 - Marker	1	p	
Materials/fuels			
Polypropylene, granulate {RER}| production | Alloc Def, U	14.5	g	

Injection moulding {RER}| processing | Alloc Def, U	14.5	g	
Printing ink, offset, without solvent, in 47.5% solution state {RER}| printing ink production, offset, product in 47.5% solution state | Alloc Def, U	0.5	g	

Sub-process unit			
A17.01 - Detergents	1	kg	
Materials/fuels			
Sodium perborate, tetrahydrate, powder {RER}| production | Alloc Def, U	0.2	kg	
Sodium perborate, monohydrate, powder {RER}| production | Alloc Def, U	0.2	kg	
Sodium percarbonate, powder {RER}| production | Alloc Def, U	0.2	kg	
Fatty alcohol sulfate {RER}| market for | Alloc Def, U	0.2	kg	
Glycerine {RER}| production, from epichlorohydrin | Alloc Def, U	0.2	kg	

Sub-process unit			
A21.01 - Light bulbs	1	p	Data refer to a compact fluorescent lamp, extrapolated from article "The environmental impacts of compact fluorescent lamps and incandescent lamps for Australian conditions- Parsons D., 2006" • Bulb weight: 89.503 g • Packaging 30.7 g • Total weight = 120.203 g
Materials/fuels			

Tin {RER}| production | Alloc Def, U	1.7	g	Metal base, tinplate
Copper wire, technology mix, consumption mix, at plant, cross section 1 mm² EU-15 S	0.1	g	Base pins
Copper {GLO}| market for | Alloc Def, U	0.4	g	Base contacts
Soft solder, Sn97Cu3 {RER}| production | Alloc Def, U	0.2	g	Base contacts - solder
Packaging glass, brown {CH}| production | Alloc Def, U	6.2	g	Base insulation - black glass
Glass tube, borosilicate {DE}| production | Alloc Def, U	35.5	g	Tube glass
Mercury {GLO}| production | Alloc Def, U	0.003	g	Mercury as gas
Resistor, surface-mounted {GLO}| production | Alloc Def, U	26.2	g	Ballast - electronic assembly
Rosin size, for paper production {RER}| production | Alloc Def, U	3.6	g	Glue
Polyvinylchloride, at regional storage	15.16	g	Plastic base
Extrusion, plastic pipes {RER}| production | Alloc Def, U	15.16	g	for PVC: extrusion efficiency: 99.6%
Glass tube, borosilicate {DE}| production | Alloc Def, U	0.4	g	Electrode glass
Copper {GLO}| transformer production, low voltage use | Alloc Def, U	0.1	g	Electrode wires
A26.06 - Electronic processing	89.5	g	Assembly of electronic parts
Corrugated board box {RER}| production | Alloc Def, U	5	g	Paper for packaging
Polyethylene terephthalate, granulate, bottle grade {RER}| production | Alloc Def, U	26.33	g	PET for packaging
Extrusion, plastic film {RER}| production | Alloc Def, U	26.33	g	for PET: extrusion efficiency: 97.6%

Sub-process unit			
A21.02 – LED Lamps	1	p	Data refers to a LED lamp (LED lamp) "Life cycle assessment of Streetlight Technologies - Mascaro Center for Sustainable Innovation, Hartley D., Jurgens C., Zatcoff E., 2009"
Materials/fuels			
Printed wiring board, for surface mounting, Pb free surface {GLO}| production | Alloc Def, U	0.009	g	
Capacitor, film type, for through-hole mounting {GLO}| production | Alloc Def, U	18	g	
Diode, glass-, for through-hole mounting {GLO}| production | Alloc Def, U	0.6	g	
Resistor, surface-mounted {GLO}| production | Alloc Def, U	2	g	
Transformer, low voltage use {GLO}| production | Alloc Def, U	48	g	
Polystyrene, general purpose {RoW}| production | Alloc Def, U	26	g	
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	21	g	
Light emitting diode {GLO}| production | Alloc Def, U	28	g	
Silicon tetrachloride {GLO}| production | Alloc Def, U	4	g	
Aluminium alloy, AlMg3 {RER}| production | Alloc Def, U	23	g	
Corrugated board box {RER}| production | Alloc Def, U	3	g	

Polyethylene terephthalate, granulate, amorphous {RER}| production | Alloc Def, U	26.33	g	
Cable, unspecified {GLO}| production | Alloc Def, U	7	g	
Electricity, low voltage {IT}| market for | Alloc Def, U	0.029	kWh	

Sub-process unit			
A22.01 - Paints and varnishes	3	kg	
Materials/fuels			
Acrylic varnish, without water, in 87.5% solution state {RER}| acrylic varnish production, product in 87.5% solution state | Alloc Def, U	1	kg	
Alkyd paint, white, without water, in 60% solution state {RER}| alkyd paint production, white, water-based, product in 60% solution state | Alloc Def, U	1	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Alloc Def, U	1	kg	

Sub-process unit			
A26.01 Computer, desktop, without screen {GLO}| production | Alloc Def, U	1	p	Ecoinvent process have been modified excluding use and end-of-life stages from the system

Sub-process unit

A26.02 Keyboard {GLO}| production | Alloc Def, U	1	p	Ecoinvent process have been modified excluding use and end-of-life stages from the system

Sub-process unit			
A26.03 Pointing device, optical mouse, with cable {GLO}| production | Alloc Def, U	1	p	Ecoinvent process have been modified excluding use and end-of-life stages from the system

Sub-process unit			
A26.04 Computer, laptop {GLO}| production | Alloc Def, U	1	p	Ecoinvent process have been modified excluding use and end-of-life stages from the system

Sub-process unit			
A26.05 - Telephone	1	p	Inventory data extrapolated from "Telephone LCA - ME221 - LCA Rough Assign. II, Hsu J., Jachowski N., McArdle T., Rylander J." 3/13/09. Transport assumed from Taiwan to Bruxelles
Materials/fuels			
Acrylonitrile-butadiene-styrene granulate (ABS), production mix, at plant RER	0.23	kg	For ABS telephone parts
Injection moulding {RER}| processing | Alloc Def, U	0.23	kg	For ABS telephone parts
Steel, low-alloyed, hot rolled {GLO}| market for | Alloc Def, U	0.0409	kg	
Ethylvinylacetate, foil {RER}| production | Alloc Def, U	0.0297	kg	

Synthetic rubber {RER}| production | Alloc Def, U	0.018	kg	
Aluminium, primary, cast alloy slab from continuous casting {RoW}| production | Alloc Def, U	0.0009	kg	
Electronic component, active, unspecified {GLO}| production | Alloc Def, U	0.0716	kg	
Zinc {GLO}| primary production from concentrate | Alloc Def, U	0.0015	kg	
Copper wire, technology mix, consumption mix, at plant, cross section 1 mm² EU-15 S	0.0319	kg	
A26.06 - Electronic processing	0.3353	kg	

Sub-process unit			
A26.06 - Electronic processing	1	kg	
Materials/fuels			
Capacitor, auxilliaries and energy use {GLO}| production | Alloc Def, U	0,2	kg	
Diode, auxilliaries and energy use {GLO}| production | Alloc Def, U	0,2	kg	
Inductor, auxilliaries and energy use {GLO}| production | Alloc Def, U	0,2	kg	
Resistor, auxilliaries and energy use {GLO}| production | Alloc Def, U	0,2	kg	
Transistor, auxilliaries and energy use {GLO}| production | Alloc Def, U	0,2	kg	

Sub-process unit			
A26.07 Printer, laser, black/white {GLO}| production | Alloc Def, U	1	p	Ecoinvent process have been modified excluding use and end-of-life stages from the system

Sub-process unit			
A26.08 Printer, laser, colour {GLO}| production | Alloc Def, U	1	p	Ecoinvent process have been modified excluding use and end-of-life stages from the system

Sub-process unit			
A26.09 Server - Computer, desktop, without screen {GLO}| production | Alloc Def, U	1	p	Ecoinvent process have been modified excluding use and end-of-life stages from the system

Sub-process unit			
A26.10 - Scanner	1	p	Ecoinvent, modified
Resources			
Water, well, in ground	0.0227	m^3	
Materials/fuels			
Aluminium production mix World 2013 - Primary {GLO} and remelted ingots {RoW}	0.0199	kg	
Cable, connector for computer, without plugs {GLO}| production | Alloc Def, U	1.8	m	
Cable, printer cable, without plugs {GLO}| production | Alloc Def, U	1.8	m	

Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	1.286	kg	
Copper {GLO}| market for | Alloc Def, U	0.2081	kg	
Corrugated board box {RER}| production | Alloc Def, U	1.304	kg	
Electricity, medium voltage {IT}| market for | Alloc Def, U	1.6667	kWh	
Epoxy resin, liquid {RER}| production | Alloc Def, U	0.0202	kg	
Flat glass, uncoated {RER}| production | Alloc Def, U	0.00143	kg	
Injection moulding {RER}| processing | Alloc Def, U	2.8673	kg	
Magnesium {RER}| production | Alloc Def, U	0.0774	kg	
Magnesium-alloy, AZ91, diecast {RER}| magnesium-alloy production, AZ91, diecasting | Alloc Def, U	0.0774	kg	
Packaging film, low density polyethylene {RER}| production | Alloc Def, U	0.0352	kg	
Photovoltaic cell factory {DE}| construction | Alloc Def, U	1.33E-08	p	
Plug, inlet and outlet, for computer cable {GLO}| production | Alloc Def, U	1	p	
Plug, inlet and outlet, for printer cable {GLO}| production | Alloc Def, U	1	p	
Polyethylene, high density, granulate {RER}| production | Alloc Def, U	0.0626	kg	
Polystyrene foam slab {RER}| production | Alloc Def, U	0.2608	kg	
Polystyrene, high impact {RER}| production | Alloc Def, U	2.83	kg	

Section bar extrusion, aluminium {RER}| processing | Alloc Def, U	0.0199	kg	
Sheet rolling, copper {RER}| processing | Alloc Def, U	0.0516	kg	
Sheet rolling, steel {RER}| processing | Alloc Def, U	0.1199	kg	
Steel, low-alloyed, hot rolled {RER}| production | Alloc Def, U	0.0939	kg	
Stretch blow moulding {RER}| production | Alloc Def, U	0.0626	kg	
Synthetic rubber {RER}| production | Alloc Def, U	0.0171	kg	
Tap water {Europe without Switzerland}| market for | Alloc Def, U	24.8	kg	
Wire drawing, copper {RER}| processing | Alloc Def, U	0.1565	kg	

Sub-process unit			
A26.11 - Mobile phone (iPhone6)	1	p	Inventory data mainly extrapolated iPhone6 Environmental report 2015
Materials/fuels			
Aluminium alloy, AlMg3 {RER}| production | Alloc Def, U	26	g	
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	25	g	
Acrylonitrile-butadiene-styrene granulate (ABS), production mix, at plant RER	5	g	ABS parts
Injection moulding {RER}| processing | Alloc Def, U	5	g	ABS parts

Liquid crystal display, unmounted {GLO}| production | Alloc Def, U	28	g	Display+glass
Printed wiring board, surface mounted, unspecified, Pb free {GLO}| production | Alloc Def, U	115	g	
Battery, Li-ion, rechargeable, prismatic {GLO}| production | Alloc Def, U	27	g	
Synthetic rubber {RER}| production | Alloc Def, U	3	g	
Liquid packaging board container {RER}| production | Alloc Def, U	157	g	

Sub-process unit			
A26.12 - Tablet	1	p	Inventory data extrapolated mainly from iPad 2 mini Environmental report 2015
Materials/fuels			
Aluminium alloy, AlMg3 {RER}| production | Alloc Def, U	70	g	
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	17	g	
Acrylonitrile-butadiene-styrene granulate (ABS), production mix, at plant RER	14	g	ABS parts
Injection moulding {RER}| processing | Alloc Def, U	14	g	ABS parts
Liquid crystal display, unmounted {GLO}| production | Alloc Def, U	103	g	Display+glass
Printed wiring board, surface mounted, unspecified, Pb free {GLO}| production | Alloc Def, U	24	g	
Battery, Li-ion, rechargeable, prismatic {GLO}| production | Alloc Def, U	111	g	

Liquid packaging board container {RER}| production | Alloc Def, U	378	g	

Sub-process unit			
A27.01 - Chair	1	p	Data for office chair, table and desk with cabinet is extrapolated from: "Life-Cycle Assessment of Office Furniture Products - Final report on the study of three Steelcase office furniture - David V. Spitzley, Bernhard A. Dietz, and Gregory A. Keoleian, 2006"
Materials/fuels			
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	14.6	kg	
Polyethylene, high density, granulate {RER}| production | Alloc Def, U	6.6	kg	
Aluminium production mix World 2013 - Primary {GLO} and remelted ingots {RoW}	6	kg	

Sub-process unit			
A27.02 - Desk	1	p	Data for office chair, table and desk with cabinet is extrapolated from: "Life-Cycle Assessment of Office Furniture Products - Final report on the study of three Steelcase office furniture - David V. Spitzley, Bernhard A. Dietz, and Gregory A. Keoleian, 2006"
Materials/fuels			

Particle board, for indoor use {RER}| production | Alloc Def, S	0.096	m3	72.2 kg, density 750 kg/m3
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	23.9	kg	
Particle board, for indoor use {RER}| production | Alloc Def, U	0.031	m3	23.5 kg, density 750 kg/m3
Polyethylene, high density, granulate {RER}| production | Alloc Def, U	2.1	kg	

Sub-process unit			
A27.03 - Table	1	p	Data for office chair, table and desk with cabinet is extrapolated from: "Life-Cycle Assessment of Office Furniture Products - Final report on the study of three Steelcase office furniture - David V. Spitzley, Bernhard A. Dietz, and Gregory A. Keoleian, 2006"
Materials/fuels			
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	22.8	kg	
Particle board, for indoor use {RER}| production | Alloc Def, S	0.02	m3	15 kg, density 750 kg/m3
Aluminium production mix World 2013 - Primary {GLO} and remelted ingots {RoW}	12.7	kg	
Laminated timber element, transversally prestressed, for outdoor use {RER}| laminated timber element production, for outdoor use | Alloc Def, U	0.0014	m3	density 1000 kg/m3

Polyethylene, high density, granulate {RER}| production | Alloc Def, U	0.4	kg	

Sub-process unit			
A27.04 - Fridge/freezer	1	p	Data from Yuhta Alan Horie - 2004 - LC Optimization of Household Refrigerator-Freezer Replacement
Materials/fuels			
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	47.55	kg	
Cast iron {RER}| production | Alloc Def, U	4.56	kg	
Aluminium production mix World 2013 - Primary {GLO} and remelted ingots {RoW}	2.11	kg	
Copper {GLO}| market for | Alloc Def, U	2.7	kg	
Brass {CH}| production | Alloc Def, U	0.17	kg	
Synthetic rubber {RER}| production | Alloc Def, U	0.17	kg	
Paper, woodfree, uncoated {RER}| market for | Alloc Def, U	0.08	kg	
Polypropylene, granulate {RER}| production | Alloc Def, U	0.51	kg	
Polystyrene, general purpose {RER}| production | Alloc Def, U	3.125	kg	
Polystyrene, high impact {RER}| production | Alloc Def, U	3.125	kg	
Acrylonitrile-butadiene-styrene copolymer {RER}| production | Alloc Def, U	5.07	kg	

Polyvinylchloride, at regional storage	1.01	kg	
Polyurethane, rigid foam {RER}| production | Alloc Def, U	5.57	kg	
Glass fibre {RER}| production | Alloc Def, U	0.08	kg	
Flat glass, uncoated {RER}| production | Alloc Def, U	2.87	kg	
Refrigerant R134a {RER}| production | Alloc Def, U	0.08	kg	
Lubricating oil {RER}| production | Alloc Def, U	0.17	kg	

Sub-process unit			
A27.05 - Oven/stove	1	p	Data from Niels Jungbluth - 1997 - Life-Cycle-Assessment for Stoves and Ovens - UNS Working Paper No. 16
Materials/fuels			
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	43	kg	
Aluminium production mix World 2013 - Primary {GLO} and remelted ingots {RoW}	0.09	kg	
Copper {GLO}| market for | Alloc Def, U	0.18	kg	
Zinc {GLO}| market for | Alloc Def, U	0.2	kg	
Rock wool {CH}| production | Alloc Def, U	1.1	kg	
Flat glass, coated {RER}| production | Alloc Def, U	6	kg	
Polyvinylchloride, at regional storage	0.12	kg	
Polystyrene, expandable {RER}| production | Alloc Def, U	1	kg	

Corrugated board box {RER}| production | Alloc Def, U	4	kg	
Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | Alloc Def, U	7.2	kg	
Electricity/heat			
Electricity, medium voltage {IT}| market for | Alloc Def, U	65	kWh	

Sub-process unit			
A27.06 - Armoire/bookcase	1	p	
Materials/fuels			
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	11	kg	
Particle board, for indoor use {RER}| production | Alloc Def, U	0.117	m^3	88 kg, density 750 kg/m^3
Polyethylene, high density, granulate {RER}| production | Alloc Def, U	11	kg	

Sub-process unit			
A27.07 - Dresser	1	p	
Materials/fuels			
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	9	kg	
Particle board, for indoor use {RER}| production | Alloc Def, U	0.096	m^3	72 kg, density 750 kg/m3

Polyethylene, high density, granulate {RER}| production | Alloc Def, U	9	kg	

Sub-process unit			
A30.01 - HPS street lamp	1	p	Data refers to a high pressure sodium lamp (HPS lamp). Source: "Life cycle assessment of Streetlight Technologies - Mascaro Center for Sustainable Innovation, Hartley D., Jurgens C., Zatcoff E., 2009"
Materials/fuels			
Aluminium alloy, AlMg3 {RER}| production | Alloc Def, U	3,811.3	g	
Brass {CH}| production | Alloc Def, U	39.2	g	
Aluminium production mix World 2013 - Primary {GLO} and remelted ingots {RoW}	110.1	g	
Sanitary ceramics {CH}| production | Alloc Def, U	176.9	g	
Printed wiring board, through-hole mounted, unspecified, Pb free {GLO}| production | Alloc Def, U	40.8	g	
Copper {RoW}| treatment of metal part of electronics scrap, in blister-, by electrolytic refining | Alloc Def, U	5.0936	g	
Textile, jute {IN}| production | Alloc Def, U	2.867	g	
Steel hot rolled coil, blast furnace route, prod. mix, thickness 2-7 mm, width 600-2100 mm RER S	511.4674	g	
Flat glass, uncoated {RER}| production | Alloc Def, U	2,359	g	
Solid unbleached board {RER}| production | Alloc Def, U	1.2603	g	

Polystyrene (general purpose) granulate (GPPS), prod. mix, RER	196.8304	g	
Injection moulding {RER}| processing | Alloc Def, U	196.8304	g	
Stainless steel hot rolled coil, annealed & pickled, elec. arc furnace route, prod. mix, grade 304 RER S	18.5	g	
Capacitor, auxilliaries and energy use {GLO}| production | Alloc Def, U	228.0458	g	
Electronic component, active, unspecified {GLO}| production | Alloc Def, U	4,800	g	Ballast
Printed wiring board, through-hole mounted, unspecified, Pb free {GLO}| production | Alloc Def, U	5.7677	g	Circuit components
Light emitting diode {GLO}| production | Alloc Def, U	0.4275	g	
Steel rebar, blast furnace and electric arc furnace route, production mix, at plant GLO S	54.2	g	Screws
Copper {GLO}| market for | Alloc Def, U	60	g	
Metal working, average for metal product manufacturing {RER}| processing | Alloc Def, U	4,505.567	g	

Sub-process unit			
15 - A30.02 - Minor assets	1	t	
Materials/fuels			
Steel, chromium steel 18/8, hot rolled {RER}| production | Alloc Def, U	200	kg	20%
Aluminium production mix World 2013 - Primary {GLO} and remelted ingots {RoW}	100	kg	10%

Copper {GLO}| market for | Alloc Def, U	50	kg	5%
Polyethylene, high density, granulate {RER}| production | Alloc Def, U	150	kg	15%
Polyethylene, low density, granulate {RER}| production | Alloc Def, U	150	kg	15%
Acrylonitrile-butadiene-styrene copolymer {RER}| production | Alloc Def, U	150	kg	15%
Synthetic rubber {RER}| production | Alloc Def, U	100	kg	10%
Flat glass, uncoated {RER}| production | Alloc Def, U	50	kg	5%
Corrugated board box {RER}| production | Alloc Def, U	30	kg	3%
Kraft paper, unbleached {RER}| production | Alloc Def, U	20	kg	2%

Sub-process unit			
A31.01 – Pasta EF	1	kg	Assumptions and data from the EPD of Barilla durum wheat semolina dried pasta
Resources			
Water, unspecified natural origin, low water stress	1.66	l	
Materials/fuels			
Durum wheat grain| dried| at farm| per kg {IT} [LCI result]	1	kg	
Kraftliner | technology mix, by-products tall oil, turpentine, thermal energy sold/used externally | production mix, at plant | 0.35 kg waste paper input per kg Kraftliner {EU-28+EFTA} [LCI result]	30	g	

Sub-process unit			
A31.02 – Wine EF	1	l	Source: "Life Cycle Assessment of Wine Production Process: Finding Relevant Process Efficiency and Comparison to Eco-Wine Production", A. Gonzalez, A. Klimchuk, M. Martin, 2006
Resources			
Wood, unspecified, standing/kg	0.0454	kg	Grapes for winery (2 kg)
Water, unspecified natural origin/m3	2.5	l	Winery activities
Materials/fuels			
Fertilising, by broadcaster {CH}| processing | Alloc Def, U	0.00044	ha	Grapes for winery (2 kg)
Irrigation {CH}| processing | Alloc Def, U	0.00044	ha	Grapes for winery (2 kg)
Liquefied Petroleum Gas (LPG) (70% propane, 30% butane)| from crude oil| production mix, at refinery| mix of 70% propane and 30% butane {EU-28+3} [LCI result]	0.000213	kg	Grapes for winery (2 kg)
Gasoline (regular) at refinery| from crude oil| production mix, at refinery| 10 ppm sulphur {EU-27} [LCI result]	0.007752	kg	Grapes for winery (2 kg)
Diesel at refinery| from crude oil| production mix, at refinery| 10 ppm sulphur {EU-28+3} [LCI result]	0.02504	kg	Grapes for winery (2 kg)
Glyphosate| at plant| per kg of active ingredient {EU-28+3} [LCI result]	0.00604	kg	Grapes for winery (2 kg)
Ur Urea| as N| at plant| per kg N {EU-28+3} [LCI result] ea, as N {RER}| production | Alloc Def, U	0.03	kg	Grapes for winery (2 kg)

Potassium chloride| as K2O| at plant| per kg K2O {EU-28+3} [LCI result]	0.037	kg	Grapes for winery (2 kg)
Sulfur dioxide, liquid {RER}| production | Alloc Def, U	0.075	g	Winery activities
Sodium hydroxide, without water, production mix, at plant - SF	1.62	g	Winery activities
Liquefied Petroleum Gas (LPG) (70% propane, 30% butane)| from crude oil| production mix, at refinery| mix of 70% propane and 30% butane {EU-28+3} [LCI result]	0.007183	kg	Winery activities
Natural gas mix| technology mix| consumption mix, to consumer| medium pressure level (< 1 bar) {EU-27} [LCI result]	0.24648	MJ	Winery activities
Gasoline (regular) at refinery| from crude oil| production mix, at refinery| 10 ppm sulphur {EU-27} [LCI result]	0.008436	kg	Winery activities
Electricity/heat			
Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, at consumer| 1kV - 60kV {EU-28+3} [LCI result]	0.668	MJ	Grapes for winery (2 kg)
Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, at consumer| 1kV - 60kV {EU-28+3} [LCI result]	0.551	MJ	Winery activities
Emissions to air			
Carbon dioxide, fossil	0.43066	kg	Grapes for winery (2 kg)
Chlorinated fluorocarbons, soft	0.0003	kg	Grapes for winery (2 kg)
Hydrogen	0.176	g	Grapes for winery (2 kg)
Oxygen	0.0403	kg	Grapes for winery (2 kg)

Methane	0.0009	kg	Grapes for winery (2 kg)
Carbon dioxide, fossil	1.665	kg	Winery activities
Chlorinated fluorocarbons, soft	0.0059	kg	Winery activities
Hydrogen	0.000429	kg	Winery activities
Oxygen	0.257	kg	Winery activities
Methane	0.0016	kg	Winery activities
Waste to treatment			
Landfill of biodegradable waste| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site {EU-28+EFTA} [LCI result]	0.0232	kg	Grapes for winery (2 kg)
Landfill of municipal solid waste| landfill including leachate treatment and with transport without collection and pre-treatment| production mix (region specific sites), at landfill site {EU-28+EFTA} [LCI result]	0.0566	kg	Winery activities

Sub-process unit			
A31.03 – Coffee EF	1	kg	
Materials/fuels			
Soybean production| production mix, technology mix| at farm| {GLO} [LCI result]	0.81	kg	Assumption: as coffee beans
Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, at consumer| 1kV - 60kV {EU-28+3} [LCI result]	0.14	kWh	

Natural gas mix| technology mix| consumption mix, to consumer| medium pressure level (< 1 bar) {EU-27} [LCI result]	2.42	MJ	
Solid board box| Kraft Pulping Process, pulp pressing and drying| production mix, at plant| 280 g/m2 {EU-28+EFTA} [LCI result]	0.014	kg	
Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result]	0.26	kg	
Aluminium foil| primary production| single route, at plant| 2.7 g/cm3 {EU-28+3} [LCI result]	0.01	kg	Assumption: as laminate for packaging
HDPE granulates| Polymerisation of ethylene| production mix, at plant| 0.91- 0.96 g/cm3, 28 g/mol per repeating unit {EU-28+EFTA} [LCI result]	0.006	kg	Assumption: as laminate for packaging
Transoceanic ship, bulk| heavy fuel oil driven, cargo| consumption mix, to consumer| 100.000- 200.000 dwt payload capacity, ocean going {GLO} [LCI result]	7,160	kgkm	Assumption: from Fortaleza to Genoa

Sub-process unit			
A31.04 – Ketchup EF	1	kg	
Materials/fuels			
Tomato, standard	1	kg	
Onion, dried, stored and packed	0.25	kg	
Sodium chloride powder production| technology mix| production mix, at plant| 100% active substance {RER} [LCI result]	50	g	

Sugar, from sugar beet| from sugar production, production mix| at plant| {EU+28} [LCI result]	50	g	
Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result]	1	kg	
A31.02 – Wine EF	0.1	l	

Sub-process unit			
A31.97 - Bread, wheat, conventional, fresh	1	kg	Adaptation of LCA food inventory with EF secondary data.
Materials/fuels			
Wheat flour| from dry milling, production mix| at plant| {EU+28} [LCI result]	0.7	kg	
Tap water| technology mix| at user| per kg water {EU-28+3} [LCI result]	1.9	kg	
Electricity grid mix 1kV-60kV| AC, technology mix| consumption mix, at consumer| 1kV - 60kV {EU-28+3} [LCI result]	0.02	kWh	
Thermal energy from natural gas| technology mix regarding firing and flue gas cleaning| production mix, at heat plant| MJ, 100% efficiency {EU-28+3} [LCI result]	1	MJ	
Sub-process unit			
A31.98 - Cream, from cow milk {RoW}| yogurt production, from cow milk	1	kg	Adaptation of Ecoinvent inventory with EF secondary data.
Resources			
Water, unspecified natural origin, RoW	0.7	kg	
Materials/fuels			

Nitric acid, without water, in 50% solution state {GLO}| market for | Alloc Rec, U	1	MJ	
Refrigerant R134a {GLO}| market for | Alloc Rec, U	$7.25*10^{-9}$	kg	
Sodium hydroxide, without water, in 50% solution state {GLO}| market for | Alloc Rec, U	0.003	kg	
Evaporation of milk {GLO}| market for | Alloc Rec, U	0.1	kg	
Chemical factory, organics {GLO}| market for | Alloc Rec, U	$3.2*10^{-10}$	p	
EDTA, ethylenediaminetetraacetic acid {GLO}| market for | Alloc Rec, U	0.0002	kg	
Cow milk| production mix| at farm| per kg FPCM {EU-28+3} [LCI result]	1.3	kg	
Sodium hypochlorite, without water, in 15% solution state {GLO}| market for | Alloc Rec, U	$4.8*10^{-7}$	kg	
Spray-drying of milk {GLO}| market for | Alloc Rec, U	0.008	kg	
Wheat grain {GLO}| market for | Alloc Rec, U	0.002	kg	
Water, deionised, from tap water, at user {GLO}| market for | Alloc Rec, U	0.001	kg	
Tap water {GLO}| market group for | Alloc Rec, U	0.02	kg	
Whey {GLO}| market for | Alloc Rec, U	0.01	kg	
Sugar, from sugarcane {GLO}| market for | Alloc Rec, U	0.03	kg	
Sugar, from sugar beet {GLO}| market for | Alloc Rec, U	0.05	kg	
Strawberry {GLO}| market for | Alloc Rec, U	0.05	kg	

Soda ash, light, crystalline, heptahydrate {GLO}| market for | Alloc Rec, U	$3.1*10^{-6}$	kg	
Maize starch {GLO}| market for | Alloc Rec, U	0.025	kg	
Hydrogen peroxide, without water, in 50% solution state {GLO}| market for | Alloc Rec, U	0.0002	kg	
Chemical, organic {GLO}| market for | Alloc Rec, U	0.007	kg	
Propylene glycol, liquid {GLO}| market for | Alloc Rec, U	$6.5*10^{-6}$	kg	
Ammonia, liquid {RER}| market for | Alloc Rec, U	$1.8*10^{-7}$	kg	
Electricity, medium voltage {GLO}| market group for | Alloc Rec, U	0.26	kWh	
Heat, district or industrial, natural gas {GLO}| market group for | Alloc Rec, U	1	MJ	
Emissions to air			
Ammonia	$1.8*10^{-8}$	kg	
Methane, chlorodifluoro-, HCFC-22	$7.2*10^{-9}$	kg	
Waste to treatment			
Wastewater from potato starch production {GLO}| market for | Alloc Rec, U	0.005	m^3	
Municipal solid waste {CA-QC}| market for | Alloc Rec, U	$8.2*10^{-6}$	kg	
Municipal solid waste {CH}| market for | Alloc Rec, U	$1.1*10^{-5}$	kg	
Municipal solid waste {RoW}| market for | Alloc Rec, U	0.004	kg	

Sub-process unit			
A31.99 - Butter, from cow milk	1	kg	Adaptation of Ecoinvent inventory with EF secondary data.
Materials/fuels			
Sodium hydroxide, without water, in 50% solution state {GLO}| market for | Alloc Rec, U	0.002	kg	
Nitric acid, without water, in 50% solution state {GLO}| market for | Alloc Rec, U	0.003	kg	
Tap water {GLO}| market group for | Alloc Rec, U	3.8	kg	
Dairy {GLO}| market for | Alloc Rec, U	$6.2*10^{\wedge-5}$	kg	
Cow milk| production mix| at farm| per kg FPCM {EU-28+3} [LCI result]	5	kg	
Electricity, medium voltage {GLO}| market group for | Alloc Rec, U	0.28	kWh	
Heat, district or industrial, natural gas {GLO}| market group for | Alloc Rec, U	0.96	MJ	
Heat, district or industrial, other than natural gas {RoW}| heat production, heavy fuel oil, at industrial furnace 1MW | Alloc Rec, U	0.04	MJ	
Emissions to air			
Water/m3	0.0006	m^3	
Waste to treatment			
Wastewater from potato starch production {GLO}| market for | Alloc Rec, U	0.003	m^3	

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