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Organizational Life Cycle Assessment: methodological and practical insights from a pilot test in the packaging industry

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Abstract

This article presents and discusses the test implementation of Organizational Life Cycle Assessment (O-LCA) in the two Italian facilities (Aptar Italia), of a world leader group in the dispensing solutions niche of the packaging industry. This study was conducted in 2018 and was based on primary data and internal documentation provided by the company itself referring to 2017. The O-LCA test application revealed a number of environmental hotspots on which the organization should focus to undertake improvement actions, both internal and external, in particular related to the raw materials extraction and production that generate the major impact in terms of greenhouse gases (GHGs). The experience gained in the two facilities mentioned may also serve as a framework for the management of the environmental performance of the whole organization and for informing corporate sustainability reporting. The actions described in this article can be considered a significant example of the application of O-LCA in assessing the environmental impacts of a manufacturing company; the results can provide methodological and practical insights to scholars and practitioners in that field of activities.

Keywords: Corporate sustainability; Organizational Life Cycle Assessment; O-LCA; environmental assessment; packaging industry.

1. Introduction

Corporate sustainability implies the adoption of technological, organizational and managerial solutions aimed at increasing the environmental (and also economic and social) performances of a company (Yu and Chen, 2014; Wheelen and Hunger, 2012; White, 2009; Tukker and Jansen, 2006). At present, the most common methods for assessing the environmental impacts of product- and process-systems are focused on life-cycle-based approaches, in particular Life Cycle Assessment (LCA). The recent development of methodologies dedicated to entire organizations (e.g.: Organizational LCA – O-LCA) can widen the possibilities of representing all the aspects and activities related to their operation, improving the capabilities of i) evaluating and communicating the performances gained; ii) developing actions and sustainability strategies accordingly. O-LCA is a methodology capable of analysing entire organizations (i.e., organizational approach), also including upstream and downstream activities, besides the internal facilities (i.e., life cycle approach); it considers a set of relevant environmental aspects (i.e., multi-impact approach) and provides organizations with additional environmental understanding, supporting them effectively to improve their performance. Despite over fifteen years have elapsed since when the first attempts of life-cycle-based environmental analysis of organizations started to emerge, applications of O-LCA are not yet a common practice. With the aim of highlighting the potential (and the limitations) of that methodology, this article presents and discusses the test implementation of O-LCA at Aptar Italia (Aptar hereafter), a company belonging to Aptargroup, a world leader in the dispensing solutions niche of the packaging industry for beauty and home, pharmaceuticals, food and beverage products. After a short introduction and background about the O-LCA methodology, the main steps of its implementation within Aptar are described highlighting synergies and critical issues emerged from both the application and methodological point of view.

2. Methods

So far, two methodologies have been proposed to evaluate the environmental performance of organizations following a life cycle-based and multi-impact approach at an organizational level. These are the Organization Environmental Footprint (OEF) and the Organizational Life Cycle Assessment (O-LCA). The former was developed by the European Commission and is the subject of the Recommendation of the European Union on the Use of Common Methods to Measure and Communicate the Life Cycle Environmental Performance of Products and Organizations (European Commission, 2013). The latter was issued by the ISO/TS 14072 technical standard (ISO, 2014) and is the subject of the Guidance on Organizational Life Cycle Assessment developed by UNEP and SETAC (UNEP/SETAC, 2015). Considering the characteristics and requirements of those methodologies, it was decided to carry out the analysis following the O-LCA methodology, mainly for two main reasons: i) O-LCA is regulated by an international standard (this is particularly relevant since the organization under investigation is part of a multinational corporation operating worldwide); ii) O-LCA is more flexible as regards methodological choices.

The study was conducted in 2018 according to the ISO 14044 (ISO, 2006) and ISO/TS 14072 (ISO, 2014) standards and was based on primary data and internal documentation provided by Aptar for the two Italian production sites referring to 2017.

As recalled and suggested by the ISO/TS 14072 standard (ISO, 2014), the study was developed following the phases defined by the ISO 14044 standard (ISO, 2006): goal and scope definition, life cycle inventory analysis, life cycle impact assessment, interpretation of results. In the following, particular attention will be paid to the first phase since, with respect to what is foreseen for the product LCA, it is the one that most presents peculiarities when referring to an organization.

As for the conventional LCA procedure, the goal of the study must be clearly specified because it is decisive for all the phases of O-LCA that follow (UNEP/SETAC, 2015): the scope should be unique and sufficiently well-defined to ensure that the breadth, depth and detail of the study are compatible and sufficient to address the stated goals (ISO, 2006).

Some other features of the O-LCA differ from a conventional LCA procedure: they are specified hereafter.

According to the Guidance on Organizational Life Cycle Assessment (UNEP/SETAC, 2015), it is necessary to disaggregate the unit of analysis, i.e. the *reporting unit*, into two elements, which correspond to description (*reporting organization*) and quantification (*reporting flow*). The organization shall consolidate all its units or parts (e.g., business divisions, brands, facilities) following the control approach (operational or financial) or the equity share approach. It is necessary to set the reference period (i.e., the specific time period for which the organization is being studied), as the results are valid for that period, and this is recommended to be one operation cycle of the organization (in accordance to financial and other reporting schemes, one year is the preferred option). System boundary shall be defined to include direct as well as indirect resource use and emissions: the former occur within the reporting organization, while the latter take place throughout the value chain linked to organization's activities. Moreover, supporting activities should be included (e.g., marketing, stock storage, research and development, heating at the offices, etc.). The inventory analysis is the phase where an analogical model of reality is built to faithfully represent the exchanges between the single unitary operations that take place during the life cycle of the organization. It is the phase that requires more time and resources since it is the phase in which all the inputs and outputs of the activities included in the system boundaries must be identified and quantified, both inside and outside the company gates. A complete cradle-to-grave assessment should include the resource consumption and emissions of the use and the end-of-life phases (i.e., waste disposal and treatment) of the products sold in the reference period. However, if an organization has no influence on the use and end-of life stage of its products (e.g., via product design or recycling campaigns), it may select the cradle-to-gate perspective, (i.e., up to the gate of the reporting organization); thus, downstream stages are excluded. The latter situation is quite common for raw materials and intermediate products (UNEP/SETAC, 2015) and this is the case of Aptar, as dispensing systems represent a part of the final package. The quality of the data was evaluated based on the pedigree matrix presented in Table 1.

Tab. 1 – Pedigree matrix used to evaluate the quality of data
Source: https://www.greendelta.com/wp-content/uploads/2017/03/DF_pedigree.pdf

Indicator score	1	2	3	4	5 (default)
Reliability	Verified data based on measurements	Verified data partly based on assumptions ***or*** non-verified data based on measurements	Non-verified data partly based on qualified estimates	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate
Completeness	Representative data from all sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from >50% of the sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from only some sites (<<50%) relevant for the market considered ***or*** >50% of sites but from shorter periods	Representative data from only one site relevant for the market considered ***or*** some sites but from shorter periods	Representativeness unknown or data from a small number of sites ***and*** from shorter periods
Temporal correlation	Less than 3 years of difference to the time period of the dataset	Less than 6 years of difference to the time period of the dataset	Less than 10 years of difference to the time period of the dataset	Less than 15 years of difference to the time period of the dataset	Age of data unknown or more than 15 years of difference to the time period of the dataset
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown ***or*** distinctly different area (North America instead of Middle East, OECD-Europe instead of Russia)
Further technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study (i.e. identical technology) but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials	Data on related processes on laboratory scale ***or*** from different technology

The quality indicators that were taken into consideration were reliability, completeness, temporal correlation, geographical correlation and technological correlation. According to the matrix, a score of 1 to 5 is assigned, where 1 represents the maximum quality. A column was added to indicate whether the data is specific (S) or generic (G).

3. Results and Discussion

This section will present methodological and practical results related to the four phases of the O-LCA applied to the pilot test conducted.

Goal and scope definition

The main *goals* that the company decided to pursue carrying out the O-LCA study were i) gain insight into internal operation and the whole value chain, and ii) identify environmental hotspots, at different unit levels.

The *intended application* was to develop a model that, starting from the pilot test conducted in the Aptar Italia sites, would be extended in the near future to the other sites and divisions of the organization.

The *reporting organization* is composed of two facilities (Aptar Pescara and Aptar Chieti), both part of the "Beauty + Home" division, and manufactures and assembles dispensers and micro-pumps, which are meant to be part of finished products such as perfumes, soaps and lotions.

The *reporting flow* was the total amount of products manufactured during the year 2017.

The *consolidation method* selected was the operational control; therefore, all of the activities and related life-cycle processes of the reporting organization were considered, according to ISO/TS 14072.

The system boundary was defined following the cradle-to-gate approach. The reasons were mainly two:

i. the products sold by the organization are not directly sold to the end market: so, Aptar has no influence on the way they are distributed to the final consumer, used and disposed of;

ii. the use of the dispensing system itself does not generate any impacts on the environment.

Figure 1 shows the activities, both direct and indirect (upstream and downstream) ones, included in the system boundary.

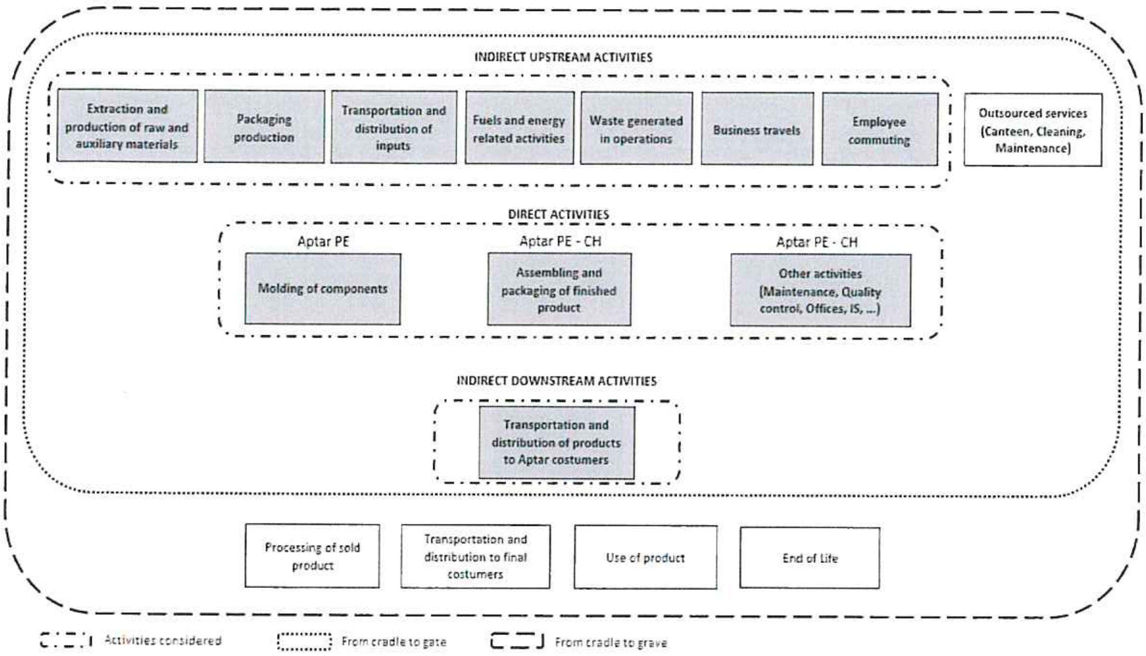

Fig. 1 – Activities included in the system boundary

The services performed by external organizations (such as the canteen service, the cleaning service and the maintenance of structural elements) do not fall within the scope of consolidation and, therefore, were excluded from the system boundary.

Life cycle inventory analysis

In order to carry out an exhaustive inventory of data and information required by an O-LCA analysis, multiple data collection forms were used (at least one for each activity), compiled with the information and data provided by the different Departments and by the various actors in the supply chain. A top-down approach was followed that considers the reporting organization as a whole and adds upstream and downstream models for inputs and outputs (UNEP/SETAC, 2015), and the data collected was, in almost all cases, specific data. No cut-offs were applied. Table 2 presents the results of the quality data assessment moving from the pedigree matrix showed in section 2.

Tab. 2 – Data quality assessment

Flow	Specific or Generic	Reliability	Completeness	Temporal correlation	Geographical correlation	Technological correlation
		INPUT				
Electrical energy						
Electrical energy from renewable sources	S	1	1	1	1	1
T&D losses	G	1*	2	1	3	2
Water						
Water	S	1	1	1	1	1
Materials and products						
Resins (for molding)	S	1	1	1	1	1
Resins (components)	S	2	1	1	1	1
Metals (components)	S	2	1	1	1	1
Auxiliary materials	S	1	1	1	1	1
Packaging	S	1	1	1	1	1
Maintenance products	S	1	5	1	1	1
Other products (e.g. for offices)	S	1	1	1	1	1
Fuels	S	2	1	1	1	1
Refrigerants	S	1	1	1	1	1
Trasport						
Incoming transport	S	2	1	1	1	1
Employee commuting	S	2	1	1	1	1
Business travels	S	1	2	1	1	1
Outbound transport	S	2	1	1	1	1
		OUTPUT				
Products and by-products						
Cartridges	S	1	1	1	1	1
Finished products	S	1	1	1	1	1
By-products	S	1	1	1	1	1
Waste						
Waste	S	1	1	1	1	1

*Third party certified (ISO 14025)

As is evident from Table 2 the quality of the data was more than satisfactory. In fact, the temporal, geographical and technological correlations always assume value 1 (with the exception of the data related to the losses of electricity due to distribution) since all the data collected were related to the reference period, to the sites under examination and to the technologies used. The reliability and completeness of the data also took on very positive values. It should be mentioned that in the future greater efforts will be needed to fully quantify the products used for maintenance activities; however, for the moment, this is not a great issue because the related emission factors are not yet available in the databases used.

Life cycle impact assessment

As previously mentioned, the O-LCA methodology follows a multi-criteria approach; therefore, the potential impact categories expected to be affected by the activities included in the system boundaries should be evaluated; however, in the pilot test conducted, according to another case study (UNEP and SETAC, 2015), only the category "Climate change - GWP100" was considered -in terms of tonnes of CO_2e - using the following midpoint LCIA methods: CML 2015; DEFRA 2017. The reason for this choice lies in the lack of information within the databases consulted: GaBi Professional Database (Thinkstep, 2018) and DEFRA Database (DEFRA, 2017). The LCIA results have been obtained by multiplying the quantities identified for each activity in the inventory phase and the related conversion factors using electronic spreadsheet. Below is an illustration of how the impact assessment phase was conducted.

- **Extraction and production of raw and auxiliary materials**: to quantify the potential impact of extraction and production of raw and auxiliary materials, conversion factors were identified from both the GaBi database (Thinkstep, 2018) and the DEFRA database (DEFRA, 2017); those relating to plastics and metals were identified from the former, while those referring to some auxiliary raw materials and to paper used in offices from the latter. As mentioned before, it was not possible to analyse the impacts of certain auxiliary materials and products used for maintenance.

- **Production of packaging**: the conversion factors used to analyse the environmental impacts related to the production of packaging were taken from the DEFRA database (DEFRA, 2017) and included:
  - Virgin raw materials: extraction, primary processing, production and transporting materials to the point of sale;
  - Secondary raw materials: sorting, processing, manufacturing and transporting of materials to the point of sale.

  These factors are useful for reporting efficiencies gained through reduced procurement of material or the benefit of procuring items that are the outcome of a previous recycling process.

- **Activities related to energy and fuels**: in order to calculate both upstream and core emissions related to electricity production and losses related to transport and distribution (downstream), the conversion factors from the EPD of the Vattenfall's hydroelectric plant - as representative of the clean(er) energy Aptar's suppliers (Vattenfall AB, 2017). To evaluate the impact of the production of fuels used to power the leasing cars and the emergency equipment, instead, reference was made to the DEFRA database (DEFRA, 2017) which shows the conversion factors that should be used for emissions associated with extraction, refining and transport of fuels to the site or to the organization's asset, prior to combustion. In addition, the impact related to the use of fuel was also calculated considering an additional conversion factor provided by DEFRA (2017).
- **Inbound transportation of raw materials, components, products and packaging and outbound transportation of finished products**: to assess the potential impact of inbound transportation of raw materials, components, products and packaging and of outbound transportation of finished products, conversion factors were taken from the DEFRA database (DEFRA, 2017). Precisely, those conversion factors come from the sheet dedicated to the "Freighting goods" (it is specified that these should be used specifically for shipments of goods by land, sea or air carried out by a third party organization, as is the case with Aptar).

- **Employee commuting and trips made with leased vehicles**: in order to calculate the impact generated by home-work journeys and travels between the two facilities, the conversion factors considered, taken from the DEFRA database (DEFRA, 2017), were identified based on the type of vehicle used each time. In fact, the database distinguishes the emission factors by market segment and by fuel.

- **Waste generated during the organization's activities**: the conversion factors to assess the impacts from the emissions related to the waste generated during the organization's activities were taken from the DEFRA database (DEFRA, 2017).
  - For landfill, the relevant factors include collection, transport and landfill emissions;
  - For recycling, the relevant factors include only transport to the facilities dedicated to these activities. This complies with the GHG Protocol Guidelines (WRI and WBCSD, 2004) and assigns emissions relative to the production activities of raw materials according to those who produce them.

The results are showed in Figure 2 and are expressed in terms of CO_2e since, in addition to CO_2, the other greenhouse gases covered by the Kyoto Protocol (CH_4, N_2O, HFC, PFC, SF_6) were also considered.

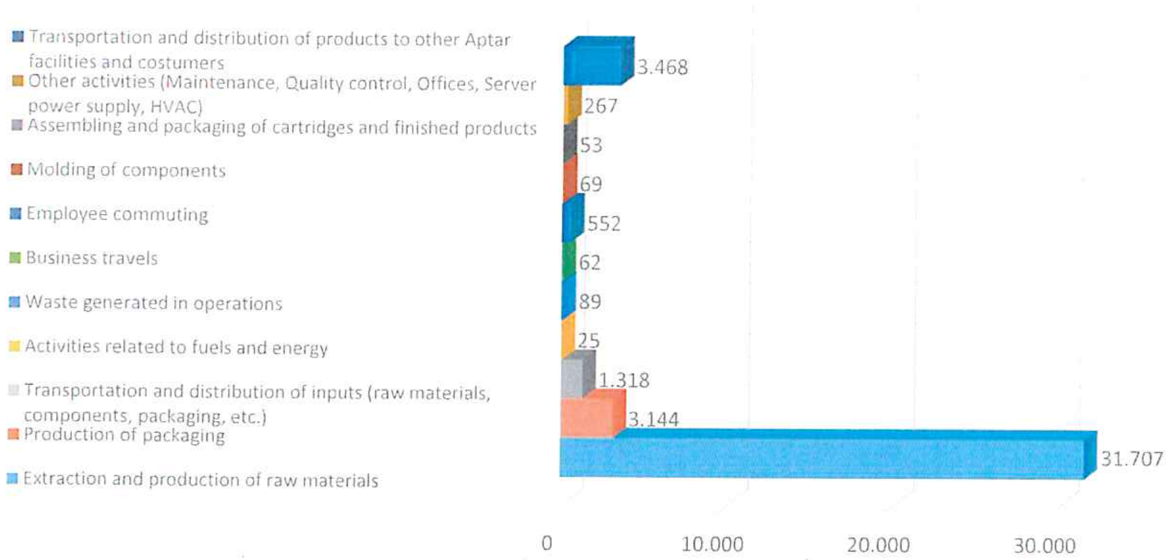

Fig. 2 – Assessment of the potential impact of Aptar on climate change, generated in 2017, expressed in tonnes of CO_2e

The potential impact generated by Aptar in 2017 was found to be 40755 tonnes of CO_2e.

Interpretation

The most impacting phase of the life cycle of the organization turned out to be the phase of extraction and production of raw and auxiliary materials (77.8%). This conclusion had already emerged from the products LCA carried out on the best-selling product of the company (Aptar Italia S.p.A., 2017a; Aptar Italia S.p.A., 2017b), and was confirmed here. It should be noted that the impact would be even more significant if the scraps deriving from the molding process were not internally re-used and reintroduced at that stage.

Next, the second most impactful phase was the transportation and distribution of products to all customers (8.5%). These are very numerous and located on all continents. Consequently, multiple shipments are carried out all over the world, often resorting to highly impactful means of transport, such as airplanes and heavy goods vehicles. Less frequently, shipments are by sea or rail, relatively less impacting.

The third most impacting phase was the production of packaging, mainly represented by boxes and pallets (7.7%). The former are made almost entirely from recycled paper and the latter are produced with wood from sustainably managed forests, FSC certified. The greatest impact, however, is to be attributed to the production of packaging made with virgin plastics, which, although used in smaller quantities, gives rise to a less sustainable production process, as evidenced by the conversion factors provided by the database used.

Of the total impact generated by the organization, approximately 99% is attributable to indirect activities, both upstream and downstream, and less than 1% derives from direct activities.

The core processes of Aptar, such as the molding of components and the assembly of semi-finished and finished products, require a considerable use of electricity; therefore, these activities could be expected to be the most impacting ones; however, it was not like this. The explanation lies in the source of the purchased electricity; indeed, this was from hydroelectric source instead of the grid mix. The two scenarios are compared in Table 3, considering also other activities carried out by the organization that require electricity.

Tab. 3 – Impacts related to the two electricity supply scenarios

Scenario A - Energy from renewable sources	Facility	kWh	Emission factor	t CO_2e
Molding	Pescara	9149335	7.50E-06	69
Assembling and packaging	Pescara	4692805	7.50E-06	35
Assembling and packaging	Chieti	2343866	7.50E-06	18
Subtotal core attivities		*16186006*		***121***
Other activities (Maintenance, Quality control, Offices, etc.)	Pescara	3931190	7.50E-06	29
Other activities (Maintenance, Quality control, Offices, etc.)	Chieti	2216781	7.50E-06	17
TOTAL				**168**

Scenario B - Energy from the grid	Facility	kWh	Emission factor	t CO_2e
Molding	Pescara	9149335	3.44E-04	3147
Assembling and packaging	Pescara	4692805	3.44E-04	1614
Assembling and packaging	Chieti	2343866	3.44E-04	806
Subtotal core attivities		*16186006*		***5568***
Other activities (Maintenance, Quality control, Offices, etc.)	Pescara	3931190	3.44E-04	1352
Other activities (Maintenance, Quality control, Offices, etc.)	Chieti	2216781	3.44E-04	763
TOTAL				**7683**

If we consider the current scenario, the impacts related to the consumption of energy generated from renewable sources amount to 121 tonnes of CO_2e for molding, assembling and packaging activities and to 168 tonnes of CO_2e if we consider all the activities carried out by the organization. Considering, instead, the alternative scenario, where reference is made to the national energy mix, the impacts would have been much greater, reaching 5568 tonnes of CO_2e for core activities only and 7683 tonnes of CO_2e for all activities. This shows that if Aptar had not used hydroelectric energy it would have generated a considerably greater potential environmental impact, attributable in particular to the main production processes.

Having clarified this aspect, another issue remains to be investigated in relation to waste. In fact, it was possible to verify that during the reference period, approximately 1478 tonnes of waste were generated and 89 tonnes of CO_2e were emitted to manage them. Considering the amount of waste produced, a greater impact could be expected from their management. Actually, Aptar sends to recycling at least 90% of the waste generated: as already mentioned in the impact assessment phase, for this process, we only considered the impact deriving from the transport to the recycling plants and not the emissions generated during the recycling process, which are allocated to the relevant recycling organization.

4. Conclusions

The results obtained from the pilot test conducted have allowed the company to reach multiple goals. Precisely, the organization i) has gained insight into internal operation and value chain, by understanding the relationship between the activities and processes and the environmental impacts of the product portfolio, thus enabling the design of efficient strategies for their reduction; ii) has identified additional environmental hotspots besides those that emerged from the previous product LCA; iii) has understood which areas are at risk, e.g. to generate large impacts or to violate any future legal requirements and has identified impact reduction opportunities, in order to support more informed and effective decisions; iv) has established a basis for environmental communication with stakeholders and reporting. The organization annually completes a sustainability report in compliance with the Global Reporting Initiative (GRI) and Carbon Disclosure Project (CDP) reporting standards and it could benefit from further information provided by the O-LCA application. In addition, the possibility of applying the O-LCA methodology to all group sites has been verified.

Nonetheless, limitations have also emerged.: i) it was not possible to quantify the amount of some products used to perform both preventive and extraordinary maintenance of capital goods (however, their impact is not expected to be significant, especially if compared to the use of mass and energy required by all other activities carried out by the organization); ii) the data relating to business travels only covered 61% of the total trips made in 2017 (however, even if the data on 100% of the trips were available, the result would not have changed significantly); iii) capital goods were not included since it was assumed that the plants, machinery and equipment used have a life extension such that the relevant share of environmental impacts to be allocated to a single reference period is not significant compared to other sources of impact.

Finally, based on the knowledge acquired through the analysis, it was possible to define impact reduction opportunities for the future. These are, first of all, testing alternative materials, such as bio-based or recycled resins, to be used as raw materials, increasing the share of transport carried out by rail -significantly less impacting than road transport- and increasing the reuse of packaging along the whole supply chain.

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