RESPIRE

Radon real time monitoring system

LIFE16 ENV/IT/000553

LIFE RESPIRE

FINAL ENVIRONMENTAL REPORT

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Summary

List of Abbreviations

EF – Environmental Footprint

ELCD – European reference Life Cycle Database

HDPE, LDPE and LLDPE - high density, low density, and linear low density polyethylene

ISO – International Standardisation Organisation

ILCD - International Life Cycle Data system

JRC – Joint Research Centre of the European Commission

LCA - Life Cycle Assessment

LCI – Life Cycle Inventory

LCIA – Life Cycle Impact Assessment

R3S – RESPIRE Radon Remediation System

1. INTRODUCTION

Life Cycle Assessment (LCA) considers the entire life cycle of a product, from raw material extraction and acquisition, through energy and material production and manufacturing, to use and end of life treatment. Through such a systematic overview and perspective, the shifting of a potential environmental burden between life cycle stages or individual processes can be identified and possibly avoided (ISO 14040).

The increased awareness of the importance of environmental protection, and the possible impacts associated with products, both manufactured and consumed, has increased interest in the development of methods to better understand and address these impacts. One of the techniques being developed for this purpose is LCA.

LCA can assist in:

- identifying opportunities to improve the environmental performance of products at various points in their life cycle,
- informing decision-makers in industry, government or non-government organizations (e.g. for the purpose of strategic planning, priority setting, product or process design or redesign),
- the selection of relevant indicators of environmental performance, including measurement techniques, and
- marketing (e.g. implementing an ecolabelling scheme, making an environmental claim, or producing an environmental product declaration).

The LCA methodology comprises three basic steps (ISO 14040). The first is to set the goals and scope of the study. This is an important step because it sets the stage for the inventory analysis (second step) and the impact analysis (third step). An additional step is the interpretation of the results, which compares the LCA results of different products (Figure 1).

LCA analysis can help improve the production strategies in the industrial sector, leading to the right balance between production process impact and effectiveness of the remediation system; for this reason, results will be shared with the industrial partner of the Respire project.

ISO 14044 details the requirements for conducting an LCA. The three steps of ISO 14040 are presented here for the RESPIRE Radon Remediation System (R3S) prototypes produced by the project. In Section 2 ("goals and scope") the functional unit and the system boundaries for the R3S unit are defined. In Section 3 ("inventory analysis") the resources (raw materials and energy) consumed, and the emissions produced during production and operation of the R3S are presented. Section 4 ("impact analysis") links the resource consumption in the inventory analysis to the potential impacts on the environment, namely emissions affecting climate change (equivalent emissions of carbon dioxide, CO_2), acidification (equivalent emissions of sulphur dioxide, SO_2) and ozone formation (equivalent emissions of ethene or ethylene, C_2H_4). Sections 5, 6, and 7 describe the results.

The LCA analysis presented in this deliverable has been performed using the open-source software package "Open LCA" (https://www.openlca.org/), which permits all ISO 14040 steps to be followed using freely available databases.

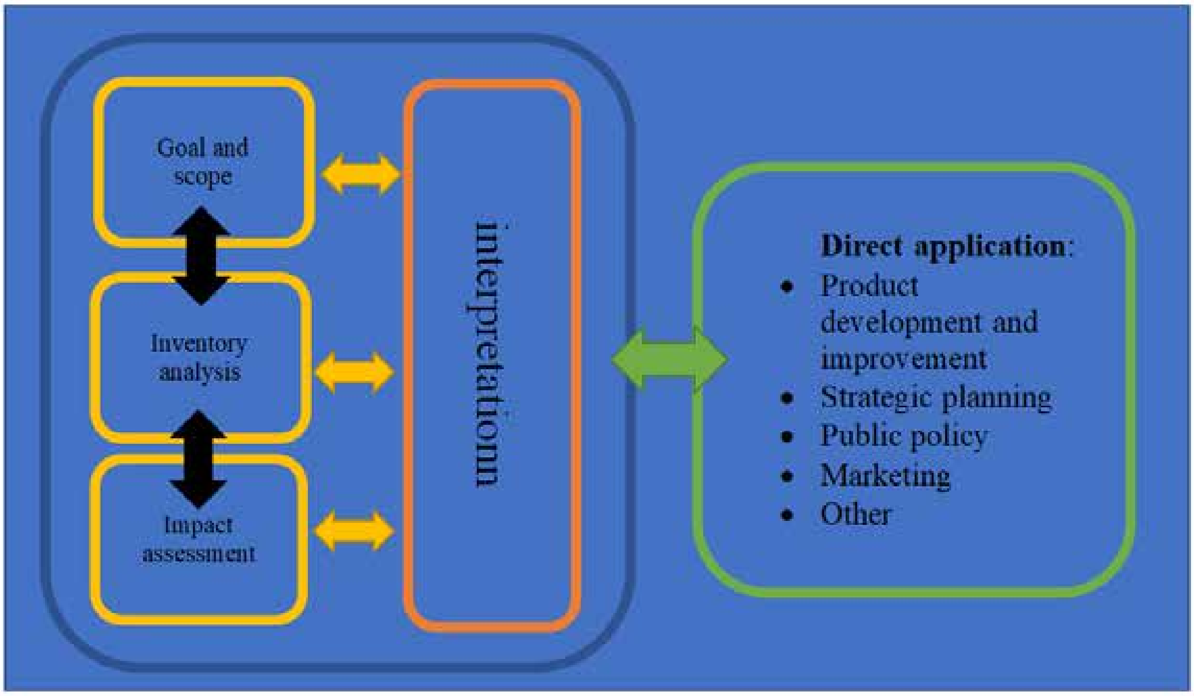


Figure 1. Stages of an LCA (modified from ISO 14040).

2. SUMMARY

Life Cycle Analysis considers the entire life cycle of a product, from raw material extraction and acquisition, through energy and material production and manufacturing, to use and end of life treatment. This kind of analysis allows one to identify life cycle stages or individual processes that may have an environmental impact and that can be avoided. LCA can in fact assist in decisions on: (i) improvement of the environmental performance of products at various points in their life cycle, (ii) informing decision-makers in industry, government or non-government organizations, (iii) the selection of relevant indicators of environmental performance, (vi) marketing.

The LCA analysis has been performed using the open-source software Open LCA (https://www.openlca.org/) that incorporates all the steps provided by ISO 14040, using freely available databases. Following these main four steps the functional units and systems boundaries were defined in the session Goals and scope. For the LIFE RESPIRE project, the main goal of this work was to provide the project's industrial partner, Elica, with information regarding the environmental impact of the two prototypes produced during the project.

The Life Respire project aims to develop a low-cost and low-energy–consuming remediation system that can reduce indoor radon concentrations, based on the new approach of continuous indoor radon monitoring. The RESPIRE remediation system operates only when the measured radon indoor values exceed a previously imposed threshold value. Two different prototypes were produced during the project with different results during the operation phase. The first one was built by connecting an extraction fan, the SNAP, already produced by Elica, to the sensor. After installation, the monitored dwellings showed a strong indoor decompression and a substantial inefficiency of the system; for this prototype, the best results were obtained where the fan was installed in the basement, creating a depression beneath the living area that prevented radon entry, as in the case of replication installed in Belgium. In the second prototype the extraction fan was replaced with a heat recovery unit, able to keep the indoor pressure more constant. The experimental phase showed better results were obtained, especially in those cases where installation and a correct sizing was supported by numerical modelling. These new ventilation systems comprise several different suppliers (two heat recovery units, one heat exchange unit), including the prototype provided by the industrial partner of the project which is not yet in production. These ventilation systems are represented in the second functional units by a generic Heat Recovery (HR) unit (considering that all the heat apparatus use the same materials) . The two systems have obtained several results in performance to reduce indoor radon. The system with HR is better and manages to reach, where properly sized, satisfactory results. For this reason, the LCA has dedicated itself to understanding whether the two systems, with their different levels of radon reduction effectiveness, have similar or different impacts during the construction and use phase.

Starting from these two main functional units, one with the SNAP (named RESPIRE remediation system) and the other with the generic heat recovery (HR) (named RESPIRE2 remediation system), the LCA was performed three times:

a) Using the IMPACT 2000+ method
b) Using the Environmental footprint method
c) Using the ILCD method (performed at mid and end point)

In this way, a complete comparison between the two main functional units was performed in terms of environmental impact, to provide the company with n evaluation of the potential of its own heat recovery prototype with respect to the SNAP extraction fan already on the market as a potential product for indoor Radon remediation.

In Step 2 “inventory analysis”, the resources (raw materials and energy) consumed, and the emissions produced during production and operation of the R3S are evaluated. For the two RESPIRE remediation systems the functional units are composed by three parts that constitute the three main components of the systems:

- Ventilation apparatus (fan or heat recovery)
- Radon sensor
- Control and data transmission system

The ventilation system is the part that changes between the two prototypes. The transport (in terms of type of transport and consumed fuel) has been added considering the prototype assembly location as the final destination (CERI-Sapienza Laboratory, Rome, Italy) and the energy consumed for one day of activity (considered at maximum power).

Step 3 “impact analysis” links the resource consumption in the inventory analysis to the potential impacts on the environment, namely emissions affecting climate change (equivalent emissions of carbon dioxide, CO_2), acidification (equivalent emissions of sulfur dioxide, SO_2) and ozone formation (equivalent emissions of ethene or ethylene, C_2H_4). Different impact categories are provided by the different methods, but in general, the results indicate higher values in the same or equivalent impact categories.

The two methods used (Impact 2020 and Environmental Footprints) indicate the main environmental categories that are impacted by the production process of the two prototypes (Fig. 3 and 4), which are aquatic toxicity, non-renewable energy consumption and, the R3S terrestrial toxicity; results show that these categories are overlapping almost completely.

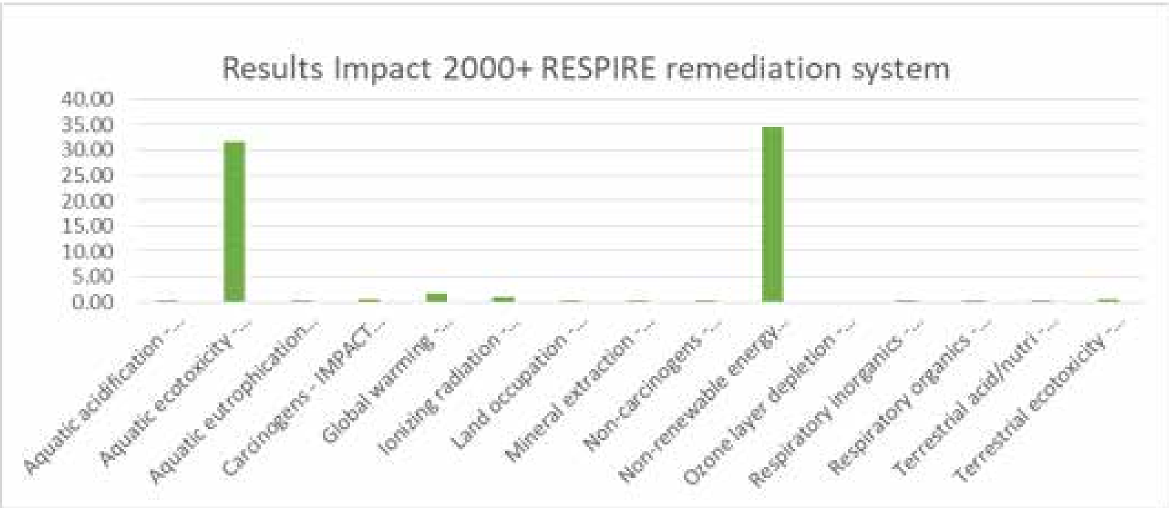


Figure 2- results of the Impact2000 for the respire remediation system 1 (SNAP)

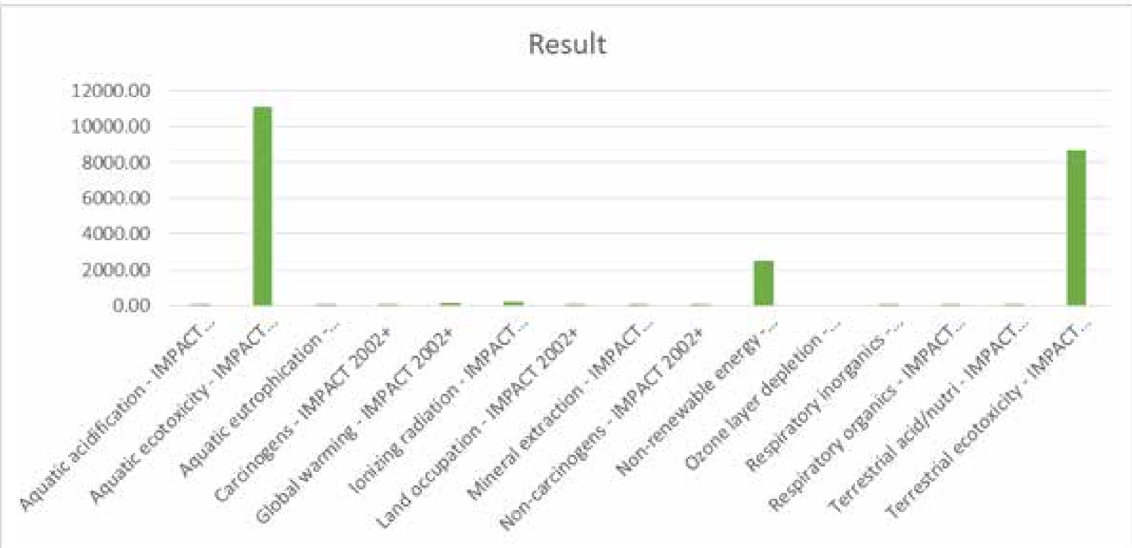
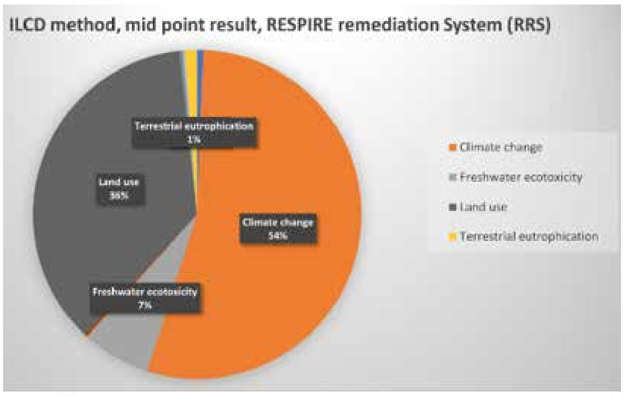


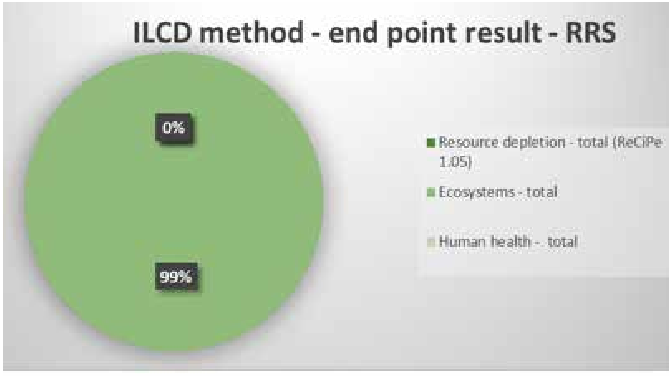
Figure 3- results of the Impact 2000 for the respire remediation system 2 (R3S)

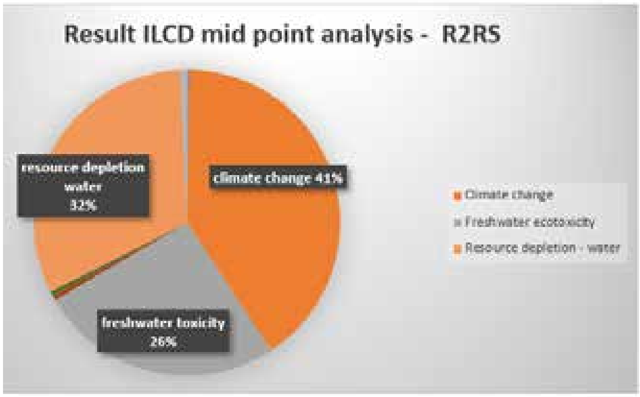
The main impact is always the use of fossil fuels. It is mainly due to transport (by lorry or plane) and by the production and use of several plastic materials (such as ABS). In the case of the R3S remediation system, that include the use of a ventilation unit including ceramic materials, the production of silicon and its associated fossil fuel use assume an important impact (also evidenced by the impact on terrestrial resource). Moreover, considering the category of climate change, which indicates the CO_2 equivalent produced during the production process, construction of the SNAP-Rn prototype produces 5.98 kg while construction of the R3S prototype produces 4.57 kg. These are relatively low values compared to, for example, a TV (160 kg), a smartphone (47 kg) or a pair of shoes (19 kg) (source: https://economiacircolare.com).

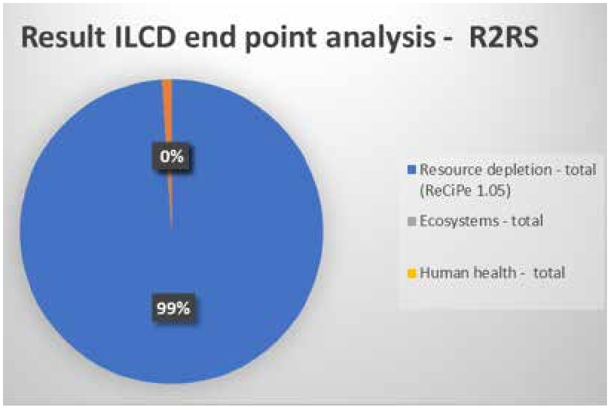
In addition to the interpretation based on mid-point categories, an evaluation was conducted of the whole environmental impacts of the different substances counted in the life cycle inventory. Among these, non-renewable resource depletion, ecotoxicity, acidification, indoor pollutants and photochemical oxidant formation were evaluated. To cross-compare the shares of the individual impact categories with reference to the damage categories, the impact assessment was at the endpoint level. This environmental impact analysis has been conducted using the ILCD methods (JRC, 2012) provided in Open LCA. The midpoint method is a characterisation method that provides indicators for comparison of environmental interventions at a level of cause-effect chain between emissions/(resource consumption) towards endpoint level. The analysis has been performed for both the prototypes at the mid point and end point levels (covering 100 years). For the end point, values are provided for each category and also as total impact on human health, the environment and resources The ILCD method uses several categories to define the impact in the next 100 years. In the ILCD method, the source for characterization factors for climate change at the midpoint was the IPCC 2007 report for a 100 year period.

Considering the mid-point analysis results, four categories show some impact, confirming the results obtained by other methods. These categories (highlighted in the graph) are land use (including depletion of water) for about the 30 %, terrestrial eutrophication, freshwater toxicity (which regards the depletion of natural resource for about 20 %) and climate change (CO2 production equivalent) for about the 40%. The results show that the main impact is still concentrated on the resource categories, on fossil fuel energy and water, both largely used in the production process. This impact is also shown in the long-term analysis, where it constitute 99% of the total impact. This means in relative terms that the production process do not impact significatively on the pollution and contamination through the production of nocive material.









The main impact is always the use of fossil fuels. It is mainly due to transport (by lorry or plane) and by the production and use of several plastic materials (such as ABS). In the case of the RESPIRE2 remediation system, the production of silicon carbide (used for heat management in the heat recovery ventilator) and its associated fossil fuel use is important. This impact is maintained even in the end point analysis and is comparable with the one obtained in other similar LCA. It is connected to the results in the climate change categories that are present in the EF analysis but in low value. In the categories related to acidification and toxicity (expressed in SO2 equivalent), the RESPIRE remediation system show some impact in aquatic and terrestrial toxicity that are again due to lorry transportation. In the EF analysis impact in the land use category is due to the production of plastic material and silicon carbide.

The comparison between the two systems show that the two systems present substantially the same impacts. They are substantially equal, low impact of both, especially due to energy consumption for construction. The consumption of energy for use does not really affect the analysis and in any case, it would be even lower because the system is not expected to always be turned on (as assumed for these analyses) but only when it is needed.

Combining the LCA results with the experimental results of the two systems, the indication for Elica is to continue experimentation based on heat recovery ventilation that has the same environmental impact as the SNAP extraction fan but shows better results in reducing indoor radon concentrations.

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