SELECTION OF ENVIRONMENTAL DATASETS AS GENERIC DATA: APPLICATION TO INSULATION MATERIALS WITHIN A NATIONAL CONTEXT

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Abstract

Purpose: The aim of this paper is to present the application of the NativeLCA methodology to the selection of Life Cycle Assessment (LCA) datasets of insulation materials to be used as generic data within a national context.

Method: NativeLCA is applied to the following products: stone wool (SW), polyurethane and insulation cork boards, expanded and extruded polystyrene, and lightweight expanded clay aggregates. Following the NativeLCA methodology, a review of available datasets for these insulation products is presented (i.e. generic LCA and Environmental Product Declaration databases). For each material (except SW), the aim was to verify the plausibility of LCA studies completed based on site-specific data, in order to use the latter as generic data within a national context.

Results and discussion: The case studies presented in this paper demonstrate the applicability and usefulness of using NativeLCA in the selection of a coherent dataset as generic data within a national context. Moreover, the application of this methodology to six case studies showed its feasibility, benefits, and limitations, while allowing the identification of some potential improvements.

Conclusion: NativeLCA relies on the selection of LCA data sets of construction products available in the European context to be used as generic for a national context. This is a straightforward approach, focused on the selection of a LCA data set to be directly used by LCA practitioners. The scope of NativeLCA was limited in this paper to insulation materials, but this methodology can be applied to other building products.

Keywords:
Data quality; EPD; Insulation materials; generic data; LCA

1 INTRODUCTION

The NativeLCA methodology guides the selection of representative Life Cycle Assessment (LCA) datasets of building products to be used as generic data for a national context [1]. This topic is particularly important because LCA studies of buildings require a large amount of data on building materials, products and processes. However, practitioners and developers of building LCA tools currently face practical issues when selecting data for the assessment of a building in a specific region [1].

This paper presents the application of NativeLCA to 5 insulation materials: stone wool (SW), polyurethane (PUR) and insulation cork boards (ICB), expanded (EPS) and extruded polystyrene (XPS), and lightweight expanded clay aggregate (LWA). The aim is to verify the plausibility of LCA studies completed in Portugal based on site-specific data ([2], following EN 15804:2012+A1:2013 and using Ecoinvent, ELCD and Plastics Europe for background data), in order to use these results as generic data within that national context. However, for SW, the aim is to select a coherent LCA dataset to be used

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as generic data for this product, since no LCA data is yet available in this country. A discussion on the insulation that presents lower environmental impact is out of the scope of this paper (a comparison of these results was already presented by the authors in other paper [2]).

2 THE NATIVELCA METHODOLOGY

First, a review of available datasets for these insulation products, such as generic LCA and Environmental Product Declarations (EPD) databases for both national (e.g. France, Germany, Spain, etc.) and European context, was completed. Then, appropriate generic datasets were chosen by means of a hybrid methodology: in the first step a meta-analysis is conducted on the sample of collected datasets from the literature. When relevant, product specific data (EPD of the different producers) are averaged to represent an average data (reference value - REVA), or existing generic data are adapted to be more suitable for the context. The use of data quality indicators then helps in selecting the relevant generic data for each context according to users' needs (Figure 1). However, the results from the meta-analysis can also be used to verify the plausibility of LCA studies completed based on site-specific data, in order to use the latter as generic data within a national context.

3 RESULTS AND DISCUSSION

3.1 Lightweight Expanded Clay Aggregate (LWA)

NativeLCA is used in this case for the comparison between LCA results for LWA (A1-A3 standardised product stage; for a bulk density of 297 kg/m^3 and 8-16 mm) of a Portuguese company [2], an individual EPD (from the Norwegian system) and a generic data set (from Ecoinvent). Figure 2 presents the relative differences between the Portuguese results and foreign data sets for the three most important impact categories after normalisation.

The Norwegian EPD is based on a 2007 study of the production process of LWA in bulk of a Norwegian company. The figures of this data set are very similar only to the Portuguese study in Global Warming Potential - GWP (the impact is only 5% higher), but are much lower in the remaining environmental categories (between 75% in AP - Acidification Potential, and 79% in PE-NRe - Non-Renewable Primary Energy consumption). The Portuguese plant does not yet use secondary fuels in the oven, but the Norwegian one already uses them. Considering the amount of secondary fuels used by the latter, 10% of the difference in NRe can be explained. Another parcel can be explained by the significant share of renewable energy in the Norwegian electricity mix. Taking into account the significant contribution of coke production to AP and NRe in the Portuguese case study, it is of paramount importance to know the characteristics and amount of fuels used in the oven in the Norwegian company to fully explain the differences found in both categories. However, this information is not provided in the corresponding EPD. Taking into account this absence of data, it is not possible to make more inferences concerning the causes of the differences found in NRe. However, the analysis of the remaining environmental impact categories shows that the Norwegian data set has a higher impact in Photochemical Ozone Creation Potential - POCP than the Portuguese one (57% more). This difference, along with an inverse difference in AP, can be related to the secondary fuels used only in the Norwegian plant that can lead to a different combination of air emissions resulting in a higher impact in POCP and a lower impact in AP.

The Ecoinvent data set for LWA production (ECO17 in Figure 2) includes packaging and therefore the comparison between this data set and the Portuguese results considered two hypotheses of LWA packaging (palletised Polyethylene (PE) bags and Polypropylene (PP) bags). The Ecoinvent data set has higher results than the Portuguese study only in GWP (between 20% and 31%) and lower results in the remaining environmental categories (between

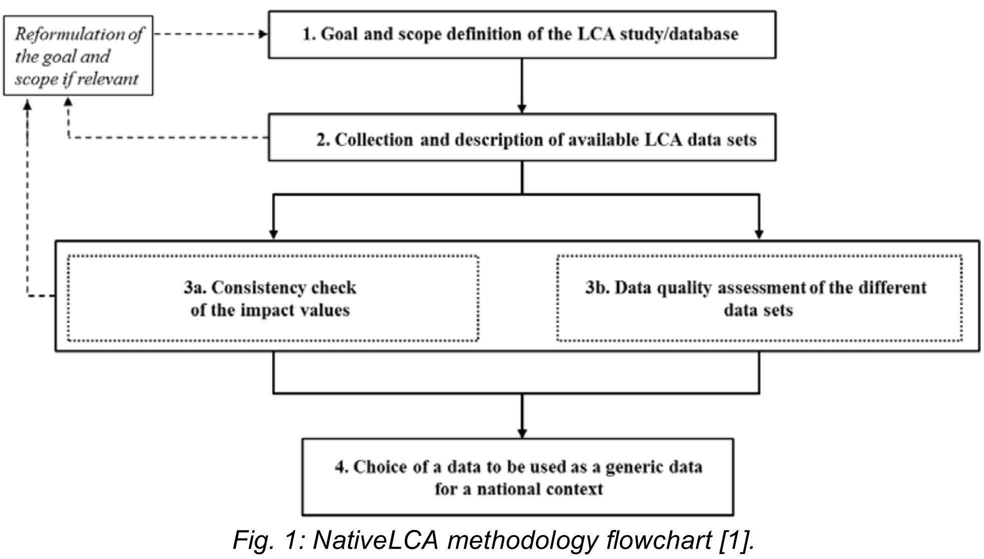

Fig. 1: NativeLCA methodology flowchart [1].

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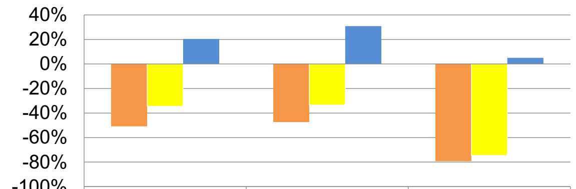
around 34% in AP and between 47% and 51% in PE-NRe). This data set is based on literature and on data from the period between 1995 and 2000. Along with these limitations of representativeness, it was found that the LWA production process uses around half of the electricity and less than 25% of fuels (and only heavy fuel oil, without considering petroleum coke) compared with the Portuguese case-study. Therefore, a trial was made with a “virtual” modification in the manufacturing of the LWA studied in Portugal: the same amount of electricity and heavy fuel of the Ecoinvent process. This “virtual” LWA tries to reproduce the latter, maintaining the other characteristics of the product studied (and also the air emissions from the Portuguese plant). Figure 3 shows the differences found between Ecoinvent and the “virtual” product described. It was confirmed that most of the differences in NRe and AP stemmed from the assumptions related to the lower quantity of fossil fuels and electric energy consumption of the Ecoinvent process. The “virtual” product indeed shows a lower difference to Ecoinvent in these categories (from 34% to around 21% in AP and from around 50% to ≤ 22% in NRe). However, in this case Ecoinvent has an even higher difference in GWP, which can be justified by the significant improvements of production technology in different sectors that have been made in order to reduce greenhouse gases between 1995 and 2012 (which can be confirmed by GWP figures of the Norwegian EPD and of the Portuguese case study).

Benchmarking of Portuguese results for LWA confirmed that these results are plausible and can be used in LCA of buildings in the Portuguese context, despite the lack of detailed data concerning the technology for LWA production in the Norwegian EPD and a poor temporal and geographical representativeness of the Ecoinvent data set.

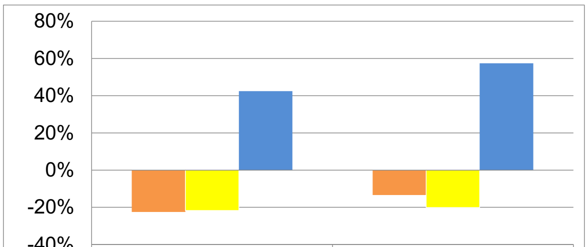
3.2 Extruded Polystyrene (XPS)

For XPS, 1 individual (from an Italian company from the International EPD system - ENV) and 2 joint (1 from 5 companies all over Europe and another one from 5 companies that sell in the German market, both available in the German system) EPD are available for XPS boards with characteristics similar to the ones studied. A European REVA was also calculated via an arithmetic mean according to the number of companies included in each data set. All these data sets correspond to the set of blowing agents used in the Portuguese plant for thicknesses ≤ 80 mm (dimethyl ether and carbon dioxide). For the other set of blowing agents (difluoroethane and ethanol, for thicknesses ≥ 80 mm), the only data set available is Ecoinvent (with 4 different data sets, depending on the set of blowing agents used). However, all Ecoinvent processes for XPS production consider polystyrene (PT) expandable beads as raw material, but this raw material is not used at XPS plants, rather in EPS plants. Instead, XPS production uses polystyrene pellets (General Purpose PT, GPPS). Thus, this comparison is only valid for XPS boards with thicknesses ≤ 80 mm.



	ECO17 vs LWA - palletized PE bags	ECO17 vs LWA - PP bags	NEPD4 - bulk
NRe	-51%	-47%	-79%
AP	-34%	-33%	-75%
GWP	20%	31%	5%

Fig. 2: Differences in PE-NRe, AP and GWP in the production of 1 kg of LWA between Portuguese site specific data and generic data set (Ecoinvent - ECO17) and individual EPD (NEPD).



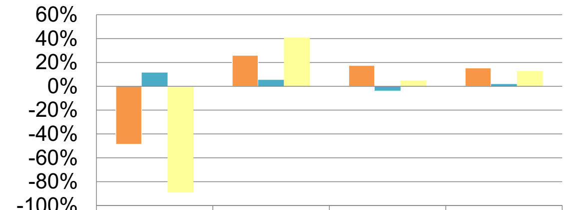
	ECO17 vs LECA - palletized PE bags	ECO17 vs LECA - PP bags
NRe	-22%	-13%
AP	-22%	-20%
GWP	42%	57%

Fig. 3: Differences in PE-NRe, AP and GWP in the production of 1 kg of LWA (A1-A3) between Portuguese site specific data and generic data set (Ecoinvent - ECO17) (from LWA with a modified manufacturing process).

The results achieved for the LCA of the Product stage (A1-A3) of XPS boards of a Portuguese company [2] were compared with the ones included in the 3 EPD and with the European REVA, and the relative differences found for 3 impact categories (Figure 4). This comparison was made considering the same thermal performance for the XPS boards represented by each data set (considering the thickness of each board necessary to achieve a thermal resistance of the layer of 1 $(m^2.°C)/W$, taking into account the corresponding density and thermal conductivity).

The main difference found in the comparison between Portuguese results and German joint EPD (IBU13 and IBU14 in Figure 4) is in POCP (between 5% and 41% higher in the EPD). POCP are, in the Portuguese study, mainly (94%) caused by the air emissions during manufacturing, namely due to the release of dimethyl ether during the extrusion process. Due to the lack of site specific data concerning the percentage of this blowing agent that is released during this stage, it was considered that 25% of the quantity of this compound initially included in the mixture is freely released to the atmosphere during the gate-to-gate stage.

This value was based on the Ecoinvent process for XPS because EPD do not quantify this percentage, despite referring to it. Therefore, it is probable that EPD consider a higher percentage of this blowing agent released during the manufacturing stage.



	ENV14	IBU13	IBU14	European MeVa - packed
NRe	-49%	26%	18%	15%
GWP	12%	5%	-4%	2%
POCP	-89%	41%	5%	13%

Fig. 4: Differences in PE-NRe, GWP, and POCP for XPS boards (A1-A3, with thickness ≤ 80 mm) with the same thermal performance between Portuguese site-specific data and European REVA and individual (ENV) and joint (IBU) EPD.

The joint EPD and Portuguese results are very similar in GWP (differences ≤ 5%) and are similar in NRe (difference between 18% and 26%). It must also be highlighted the higher similitude of the Portuguese figures with the joint EPD based on data from a higher number of plants (IBU14 in Figure 4, from 18 plants, while IBU13 is based on data from 5 plants) and with European REVA (corresponding to an average result of 24 plants), than with IBU13 or with the individual EPD. In fact, the individual EPD presents very different results from the other data sets in NRe and POCP (49% and 89% lower than the Portuguese results, respectively, and even lower than the joint EPD), despite having similar composition and physical characteristics. In terms of GWP, the difference is only 12%. Looking at the meta data of this EPD, the background database used to model PE pellets is not declared. This raw material has a high contribution to NRe and the use of a different background process to model its production can explain the differences found in this impact category (because the Portuguese case study and the joint EPD used the same background process). Concerning the differences found in POCP, the difference found has to rely on a much lower quantity of hazardous air emissions during manufacturing accounted for in the individual EPD.

The plausibility of the Portuguese LCA study of XPS production was checked through a benchmarking with European EPD. Despite the assumptions made concerning the release of the blowing agent during manufacturing, it can be considered that the results achieved for the Portuguese case study are plausible and can be used in LCA of building assemblies in the Portuguese context.

3.3 Expanded Polystyrene (EPS)

Two individual (from the French and ENV) and 1 joint (from 24 European companies, available in the German system) EPD are available for EPS boards with characteristics similar to the one studied. A European REVA was not calculated because it would be similar to the joint EPD that contributes with a 92% share (24/26 companies).

The results achieved for the Product stage (A1-A3) of EPS boards (site specific data from a LCA study of a Portuguese company [2]) were compared with the ones included in the 3 EPD, and the relative differences found for three important impact categories are presented in Figure 5. This comparison was made considering the same thermal performance for the EPS boards represented by each data set (similarly to the XPS case study). Concerning PE-NRe and GWP, it was found that the EPD present figures between 14% and 53% lower than Portuguese results. Two causes can justify this difference:

- Raw material production (A1) has a share of more than 65% in both categories in the Portuguese results and this life cycle stage was modelled using the ELCD database (the most recent data set for this process). If other databases were used to model this process in the EPD, this may have caused the differences found (the EPD do not declare the database used, except the joint EPD that refers that raw material production was based on the literature);
- The manufacturing has a share between 18% (in PE-NRe) and 25% (in GWP) in these categories. In the Portuguese case, these impacts are mainly due to the burning of naphtha in the boiler (e.g. 87% in GWP) to generate steam for the foaming process, which can be considered an "old" technology taking into account the age of this plant and of the equipment used in this process. Although no data is available in the EPD concerning the fuels or the processes used to generate steam for foaming, it is probable that a more recent technology can have an improved efficiency both in terms of naphtha (or other non-renewable fuel) consumption and greenhouse gas emissions.

Concerning POCP, EPD present figures between 59% and 187% higher than the Portuguese results. POCP are, in the Portuguese study, mainly (90%) caused by pentane and isopentane release during manufacturing. Due to the lack of site specific data concerning the percentage of the blowing agents that are released during this stage, a value of 30% was considered for the quantity initially included in PE expandable granulate that is freely released to the atmosphere during the gate-to-gate stage. This value was based on the Ecoinvent process for EPS (which was not included in this comparison because it corresponds to a board with twice the density of the one produced in Portugal) because the EPD do not quantify this percentage, despite referring to it. Therefore, it is probable that the EPD consider a

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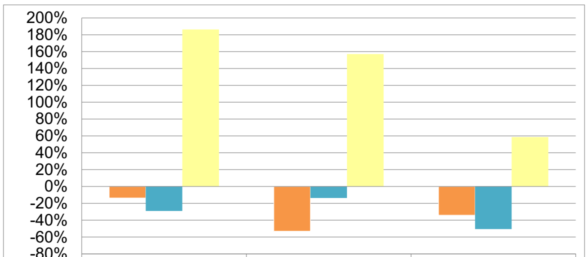
higher percentage of blowing agents released during the manufacturing stage.



	INIES_192	ENV11	IBU5
NRe	-14%	-53%	-34%
GWP	-29%	-14%	-51%
POCP	186%	157%	59%

Fig. 5: Differences in PE-NRe, GWP, and POCP for EPS boards (A1-A3) with the same thermal performance between individual (INIES and ENV) and joint (IBU) EPD and Portuguese site specific data.

Benchmarking of Portuguese results for EPS production was important to verify the validity and check the plausibility of this LCA study. Despite the lack of detailed data concerning the technology for EPS production represented in each EPD, and the assumptions made concerning the release of the blowing agent during this stage, it can be considered that the results achieved for the Portuguese case study are plausible and can be used in LCA of building assemblies in the Portuguese context.

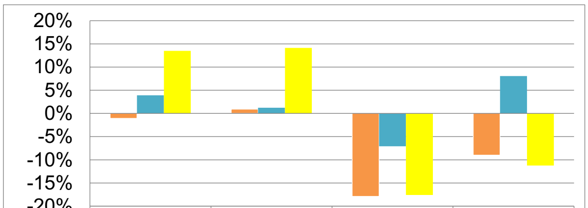
3.4 Polyurethane/Polyisocyanurate (PUR/PIR)

In this case, 1 joint EPD (from the German system, including 8 companies), 1 European average (from PU-Europe) and 2 generic (1 from Ecoinvent and another one from Plastics Europe, both not including the packaging of the boards) data sets are available for PUR/PIR boards with characteristics similar to the ones studied. A European REVA was not calculated because the European average data set does not refer to the number of companies included in the corresponding LCA study.

The results for the Product stage (A1-A3, not including the packaging material) of PUR/PIR boards produced in Portugal [2] were compared with the ones included in the referred data sets, and the relative differences found for three impact categories are presented in Figure 6. Figure 7 shows a similar comparison, but only including the European average data set and the joint EPD because generic data sets do not refer to the density or the thermal conductivity of the boards studied. This comparison was made considering the same thermal performance for the PUR/PIR boards represented by each data set (similarly to the XPS case study).

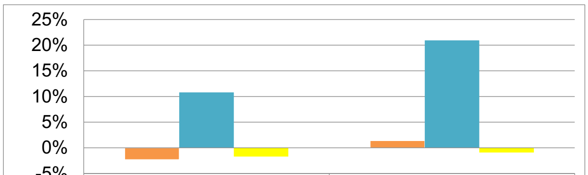
The results from the Portuguese producer are very similar to generic data sets in NRe and in GWP (1-4% differences). However, the difference is higher in AP, generic data sets presenting an impact around 14% higher than Portuguese results. This difference can be explained by the higher content of isocyanate in the products considered in generic data sets (4% more, on average, when compared with Portuguese boards). In fact, this component has a contribution of 78% to AP within raw materials, but a lower one for GWP (66%) and for NRe (62%).

Concerning the European average data set and the joint EPD (PUE and IBU in Figures 6 and 7, respectively), differences are not significant in the production of 1 kg of PUR/PIR boards for any environmental category relative to the Portuguese results (between 7% and 18%). These differences are even lower for NRe and AP when the comparison relies on the quantity of material necessary to achieve the same thermal performance (between 1% and 2%, which can be considered residual). This difference increases however in this second comparison for GWP, PUE and IBU presenting an impact 11% and 21% higher (respectively) to that of the Portuguese production. This increase is mainly explained by the better thermal performance (thermal conductivity 30% lower) of the PUR/PIR boards produced in Portugal.



	Eco_99	PE1	PUE1	IBU21
NRe	-1%	1%	-18%	-9%
GWP	4%	1%	-7%	8%
AP	13%	14%	-18%	-11%

Fig. 6: Differences in PE-NRe, GWP, and AP: production of 1 kg of PUR boards (A1-A3, wtt packaging material) between Portuguese site specific data and generic (Eco and PE) and European average (PUE) data sets and joint EPD (IBU).



	PUE1	IBU21
NRe	-2%	1%
GWP	11%	21%
AP	-2%	-1%

Fig. 7: Differences in PE-NRe, GWP, and AP: production of PUR boards (A1-A3, wtt packaging material) with the same thermal performance between Portuguese site specific data and a European average data set (PUE) and a joint EPD (IBU).

There is a higher similitude of the Portuguese figures with the European average data sets, which are based on the production of a higher number of companies than the other data sets and have a higher geographical representativeness. The plausibility of the Portuguese LCA study of the production of PUR/PIR boards was checked through a benchmarking with European data sets of similar products. Given the low significance of the differences found, it can be considered that the results

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achieved for the Portuguese case study are plausible and can be used in LCA of building assemblies in the Portuguese context.

3.5 Insulation Cork Boards (ICB)

ICB (or Agglomerate of Expanded Cork) is an insulation material produced in Portugal and in some other countries around the world, Portugal being the world's largest producer and exporter.

As described in detail in two other papers [2; 3], there is yet no other complete LCA study available worldwide concerning this insulation material, neither is any environmental declaration. Therefore, the LCA results achieved for the ICB boards can be used for the LCA of building assemblies or buildings at an international level.

3.6 Stone Wool insulation boards (SW)

For the production of 1 kg of SW (uncoated, produced using a synthetic binder, without packaging) with an average density of 89.64 kg/m^3 and an average thermal conductivity of 0.04 W/(m.ºC), a European REVA based on 7 individual EPD (6 French and 1 German) was considered (an arithmetic mean for each environmental indicator, since none of these datasets declare production volumes). This selection has been made after completing a data quality assessment to rank available datasets at the European level for this material. The results of this case study are described in detail in another paper [1].

4 CONCLUSION

NativeLCA relies on the selection of LCA data sets of construction materials (generic, average, EPD or site specific) available in Europe to be used as generic for a national context, after a comprehensive verification of their quality, consistency and representativeness (Figure 1). It is a straightforward approach; focused on the selection of a LCA data set to be used by practitioners depending on their goal and scope.

The six case studies presented in this paper demonstrate the applicability and usefulness of NativeLCA, namely in the selection of a coherent dataset as generic data within a national context. Moreover, the application of this methodology showed, in 4 of the case studies, its feasibility, benefits, and also some limitations and potential improvements, in the verification of the plausibility of LCA studies completed in Portugal based on site-specific data. The straightforwardness of its application was also proved, since it is not excessively time and resources demanding. This kind of scientifically-based aid to decision-making is very useful to LCA practitioners namely in EPD development or critical review.

The scope of NativeLCA was limited in this paper to insulation materials, but this methodology can be applied to other building products.

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