TRANSPORTATION OF BUILDING MATERIALS: AN ENVIRONMENTAL ISSUE?

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ABSTRACT

In the context of sustainable design of buildings and selection of building materials, where reduction of environmental impact is a key issue, it's interesting to analyze the influence of the transportation on the environmental impact of building materials throughout its life cycle. Indeed, the life cycle analysis (LCA) [4] considers the transportation step between the extraction phase and manufacturing phase but rarely other steps. If this transportation step is undoubtedly the most important in terms of kilometers covered, the other steps are mainly by road (truck and van) and may have a significant environmental impact.

The present contribution aims to answer to a simple but current question: does the use of a local building material really reduce the environmental impact of transportation and thereby lower the environmental assessment of this building material? This work is performed by analyzing through different transportation scenarios based on seven specific distances, the influence of the distance covered and the influence of the means of transport.

Keywords: building material, transportation of building materials, environmental impact assessment of building materials

INTRODUCTION

Transportation is an inherent demand of the construction sector especially for the production and distribution of building materials. Transportation is a part of the life cycle of building materials. Each transportation step is characterized by the use of mode(s) of transport and a number of kilometres covered; but also by a demand of energy and by emission of atmospheric pollutants.

The environmental impact of transportation, mainly long distance, is often seen as a negative element in the overall environmental assessment of a building material or product. Indeed, in terms of sustainable choice of building materials, people, in building sector, argue for the short distance - building material locally produced rather than fare away - as a positive element to reduce the environmental impact and embodied energy requirement of a building material.

The paper aims to ensure the accuracy of this statement. If selecting building materials produced locally can meet specific and local climate and can promote local economy, is this selection really interesting in terms of energy requirement and environmental impact? Does it really reduce energy consumption? Does it significantly lower the environmental impact of building material?

METHOD

Goal and scope of the research

This contribution highlights the environmental impact of various modes of transport and tries to establish different transportation scenarios depending on the origin of the building material, the number of kilometers covered and the mode(s) of transport used. The environmental impact of various modes of transport and the results of the scenarios are assessed through five LCA indicators (see table 1).

Seven geographical areas have been selected (from 90 km to 10 000 km covered). For each area, various scenarios were proposed. The scenarios are based on transportation step between the manufacturing plant where building materials is produced and the building site where building material is implemented. The building site is located in the center of Brussels.

Environmental impact assessment of transportation modes

Modes of transport consume fossil energy resources and thereby have an impact on energy requirement and atmospheric air quality. Environmental impacts generated by the different modes are shown in the table 1. They are based on the ton-kilometers (tkm) through five mandatory LCA indicators: grey energy consumption, global warming, acidification potential, eutrophication and photochemical ozone creation potentials.

Mode of transport	Data base	Environmental impact				
		Grey energy *MJ/tkm*	Global warming *kCO_2/tkm*	Acidification *$kgSO_2$/tkm*	Eutrophication *$kgPO_4$/tkm*	Photochem. Ozone *kg C_2H_2/tkm*
truck 16t	Ecosoft	5,9	0,37	0,00264	0,00046	0,00009
	KBOB 2007	5,27	0,318	/	/	/
	ECOINVENT	5,511702	0,33384	0,0017912	0,0033337	0,000059612
	CLIMAT	5,511702	0,333840	0,001791	0,000460	0,000060
truck 28t	Ecosoft	3,7	0,22	0,0016	0,00027	0,00008
	KBOB 2007	3,76	0,223	/	/	/
	ECOINVENT	4,595289	0,19439	0,0010596	0,0019749	0,000037076
	CLIMAT	3,760000	0,212463	0,001059	0,000270	0,000037
truck 40t	Ecosoft	2,7	0,15	0,00108	0,00016	0,00007
	KBOB 2007	2,84	0,165	/	/	/
	ECOINVENT	1,977356	0,11727	0,00056487	0,0010044	0,000019357
	CLIMAT	2,700000	0,150000	0,000565	0,000160	0,000019
van (<3,5t)	Ecosoft	27,1	1,65	0,00844	0,00115	0,0014
	KBOB 2007	19,5	1,16	/	/	/
	ECOINVENT	/	1,5718	0,0056272	0,0072329	0,00079057
	CLIMAT	19,500000	1,571800	0,007356	0,001150	0,000791
freight train	Ecosoft	1,2	0,06	0,0004	0,00004	0,00001
	KBOB 2007	0,606	0,0138	/	/	/
	ECOINVENT	0,716884	0,039543	0,00021161	0,00022926	8,8767E-06
	CLIMAT	0,716884	0,039543	0,000212	0,000040	0,000009
inland waterway	Ecosoft	0,9	0,06	0,00041	0,00006	0,00001
	KBOB 2007	0,657	0,0457	/	/	/
	ECOINVENT	0,650593	0,046401	0,0003361	0,00061414	6,5004E-06
	CLIMAT	0,657	0,050700	0,000336	0,00006	0,000007
sea waterway	Ecosoft	0,1	0,01	0,00026	0,00001	0
	KBOB 2007	0,17	0,0106	/	/	/
	ECOINVENT	/	0,0090391	0,00022775	0,00017264	7,1141E-06
	CLIMAT	0,100000	0,010000	0,000228	0,000010	0,000000
freight plane - europe	Ecosoft	/	/	/	/	/
	KBOB 2007	/	/	/	/	/
	ECOINVENT	32,943769	1,6689	0,0064768	0,0085938	0,00027032
	CLIMAT	32,943769	1,668900	0,006477	0,008594	0,000270
freight plane - world	Ecosoft	/	/	/	/	/
	KBOB 2007	16,4	1,08	/	/	/
	ECOINVENT	16,334347	1,0675	0,0041314	0,0054769	0,00017271
	CLIMAT	16,3343465	1,0675	0,004131	0,005477	0,000173

Table 1: Environmental impact of transportation modes – five environmental indicators

Unlike other European countries, Belgium does not have database related to the environmental impact of products. Considering the difficulty of obtaining complete and valid data for all modes of transport, the author has used several databases [8 to 10].

Scenarios of transportation

Transportation steps considered

Transportation of building materials can consist, like the life cycle of a product, of several steps:

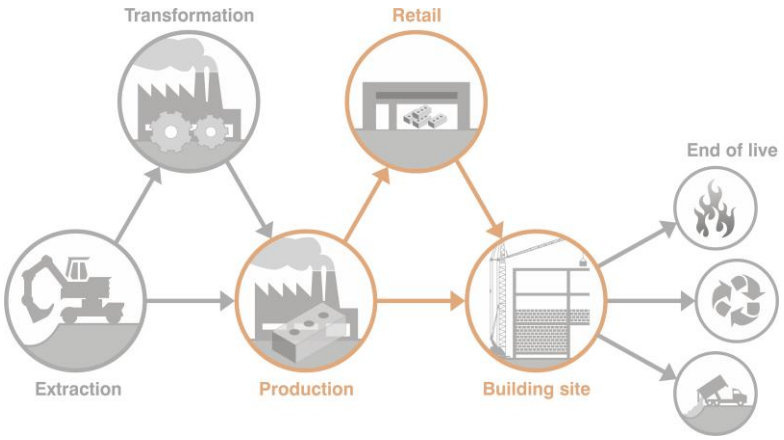

Figure 1: Steps of transportation in live cycle of building material

For the evaluation of environmental impact of transportation, the author only considered the transport step between the manufacturing plant and the building site, located in the center of Brussels.

If this phase transportation is not always the most important in terms of kilometers, it takes into account the transport of various materials such as certain types of wood, metals and certain raw materials. For this step of transportation, the author has considered two alternatives:

- Building materials are directly carried from the manufacturing plant to the building site ;
- Building materials go through a retailer before they are carried to the building site. In this case, an average distance of 30 km covered by van has been considered [5]. This alternative was included in the scenarios.

Geographical zoning

Seven geographical areas have been identified for the establishment of scenarios. These areas and distances covered should be considered as an estimation. It is obvious that some materials coming from China, Russia or from the rest of the world can travel higher distance than 10000 km. The seven areas and the average distance covered are presented below:

- **Area « Belgium »** with an average distance of 90 km to cover;
- **Area « Benelux »** with an average distance of 200 km to cover;
- **Area « Neighbouring regions »** with an average distance of 500 km to cover;
- **Area « Neighbouring countries»** with an average distance of 1000 km to cover;
- **Area « Nearby Europe »** with an average distance of 2000 km to cover;
- **Area « Enlarged Europe »** with an average distance of 4500 km to cover;
- **Area « World »** with an average distance of 10 000 km to cover.

Distribution of transportation modes

In terms of transportation, it is important to consider the mode or the different modes of transport used to cover a given distance. Indeed, over the same distance, the use of a truck, a freight train or inland waterway transport or a mix of them will not lead to the same amount of carried material, nor the same cost nor the same energy consumption, nor the same emission of air pollutants.

Except for the "Belgium" area where only two scenarios were established, over ten different scenarios were developed for each area, considering that the more the distance covered is important, the more the transportation by rail, by inland ou sea waterway are used. For example, scenarios selected for the "Neighboring countries" area are presented below, with the results for each scenario and an average score (green line on the graphs).

- **Area « Neighbouring countries »**

  scenario 1 : 100 % van
  scenario 2: 100 % truck 16t
  scenario 3: 100 % truck 28t
  scenario 4: 100 % truck 40t
  scenario 5: 100 % freight train
  scenario 6: 100 % inland waterway
  scenario 7: 95 % truck16t et 5 % van
  scenario 8: 95 % truck28t et 5 % van
  scenario 9: 95 % truck 40t et 5 % van
  scenario 10: 90 % freight train et 10 % truck 28t
  scenario 11: 90 % inland waterway et 10 % truck 28t
  scenario 12: 50 % freight train et 50 % truck 28t
  scenario 13: 50 % inland waterway et 50 % truck 28t
  scenario 14: 55 % inland waterway, 40 % truck 28 t et 5 % van

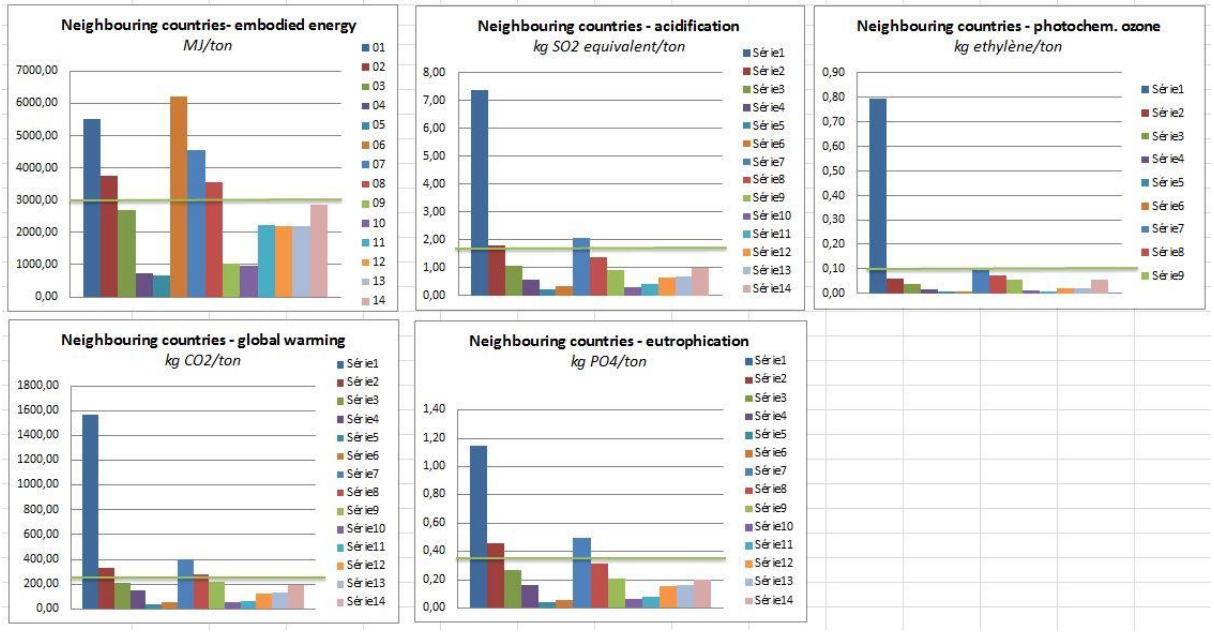

Figure 2: Environmental impact of scenarios – Neighbouring countries

Systems boundaries

This contribution only takes into account the step of transportation between the manufacturing plant and building site. It would be interesting to analyse the transport step between extraction and manufacturing plant but the kind of analysis can only be achieved for a specific building material as it requires knowledge of all the components (raw materials) and their origin.

An estimation of environmental impact of transport step between the building site and the treatment unit at the end of life has been achieved. This estimation has considered a distance of 35 km covered by 16t truck following a study of localization of processing units of

construction waste in Belgium [3]. In addition, to complement this first contribution, the environmental impact of a full transport cycle has been studied for two materials produced by Knauf and Knaufinsulation, in the area of Liege [3]. The results of this second study are not included here but have confirmed the results below.

RESULTS AND DISCUSSION

While those different scenarios are relatively rough, especially in the distribution of transportation modes and the estimated number of kilometers covered, they offer some interesting conclusions:

1. *Influence of the distance on the environmental impact*

More the distance covered is important, more the transportation phase will require energy and have higher impacts on the environment but the energy requirement and the environmental impact are not linear results: their increase is not proportional to the number of kilometers.

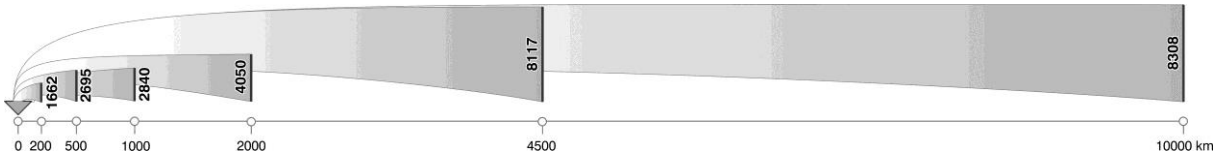

Figure 3: Consumption of grey energy for «1 ton x number of kilometers covered", calculated on the basis of the average of the scenarios for each geographic area - [MJ]

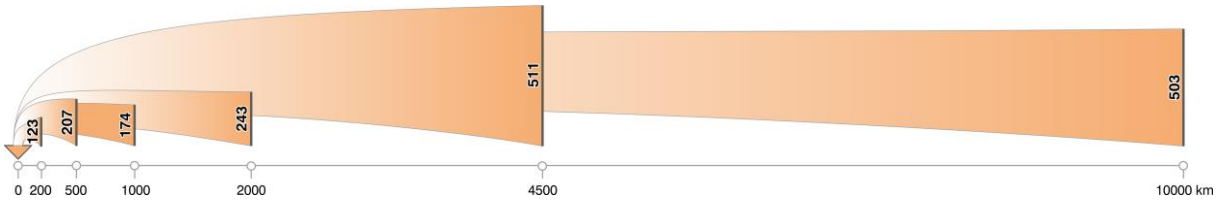

Figure 4: Emission of greenhouse gases for «1 ton x number of kilometers covered", calculated on the basis of the average of the scenarios for each geographic area - [kg CO_2]

In fact, when the distance increases, the mode of transport changes from the truck to the freight train, inland waterways or to sea waterways. The consequence of this change is a significant reduction of the environmental impact.

2. *Influence of the mode of transportation on the environmental impact*

This contribution highlights that the mode of transport strongly influences the energy requirement and the environmental impact, especially over short distances where road transport (especially vans) is predominant [6], [7].

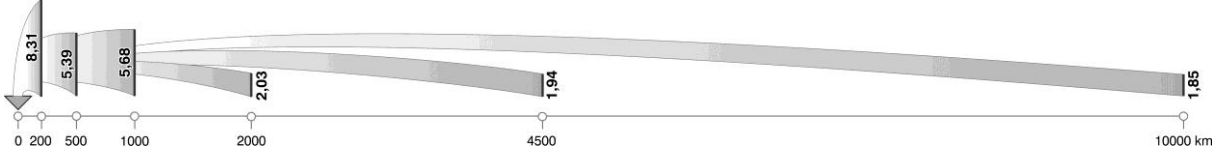

Figure 5: Grey energy consumption for "one ton travelled one kilometer" - [MJ]

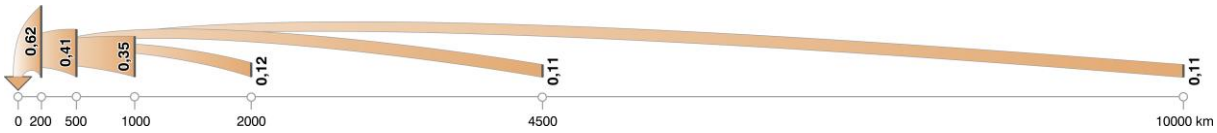

Figure 6: Emission of greenhouse gases for "one ton travelled one kilometer" - [kg CO_2]

This contribution also demonstrates that the combination of several alternative modes of transport with road transport could significantly reduce energy requirement and environmental impact of transport in general, over short and long distances.

So, with the objectives of reducing the environmental impacts related to transportation and encouraging the use of local, regional and / or European materials, it is therefore essential to consider not only the distance, but even more, the modes of transport used to carry the raw materials and buildings products. Some Belgian manufacturers, aware of the challenges of sustainable construction, have chosen to follow this goal and thus have chosen alternative modes of transport (train or inland waterways) to carry their raw materials and products.

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