Interreg
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DigitalDeConstruction

WPT1 System development

Deliverable 4.4

Detailed pilot-level cost-benefit analyses linked to tools application and deconstruction at Stage 1 Pilots

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Interreg North-West Europe Digital Deconstruction

Contents

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Agreement form expectations

"Based on D.T1.4.3, detailed cost-benefit analyses will be carried out at the pilot level, covering the additional costs associated with deconstruction and the application of DDC tools, estimated total gains (including the estimated market value of materials) and risk factors."

Objectives of the cost-benefit analysis at pilot level

One of the objectives of the Digital Deconstruction programme is to test and verify the relevance of the tools developed. To this end, a cost-benefit analysis will be carried out during the deployment of the tools on each pilot project.

Although the first request was a purely financial analysis, it was decided to add an environmental part to the study. This analysis is then made not only to identify the financial savings or additional costs linked to the Digital Deconstruction approach but also to highlight the environmental benefits it brings. The main objective is to obtain the quantified results of the cost-benefit analysis of the pilot projects: in concrete terms, what were the overall costs of the different projects and what environmental benefits did they provide?

DT1.4.3: CBA methodology: data collection tool

The cost benefit analysis is based on the methodology developed in the DT1.4.3 "CBA methodology: data collection tool". The objective of this preliminary work was to provide a tool that will evaluate the financial and environmental impacts of the Digital Deconstruction approach during the deployment of pilot projects to highlight the main benefits that can be achieved thanks to the approach.

Two types of results were identified as expected from the cost-benefit analysis of the pilot projects and, more generally, from the Digital Deconstruction approach: financial impact and environmental impacts (carbon, material/waste, energy)

Scope of the cost-benefit analysis at pilot level

Explanation of the scenario used

To move from the financial and economic impacts of the pilot projects to a more general understanding of the costs and benefits of the Digital Deconstruction approach, the analysis will compare the real Digital Deconstruction scenario with a fictitious scenario of demolition of the pilot building without reuse. Indeed, even if some architectural projects exceptionally propose subjects of reuse during the demolition of the building, nowadays most of the projects in North West Europe proceed to a classic demolition with a landfill of the waste sorted according to the regulatory flows. The analysis will then compare the most common scenario to date (demolition without reuse) to the Digital Deconstruction pilot project's approach to identify the strengths and weaknesses of DDC approach.

Since the pilot projects did not fully utilize digital tools due to their incomplete development, the benefits that the tools should have brought were partial or did not occur and a lot of time was lost in helping for the development of the tools and in duplicating tasks. Therefore, we have decided that the Digital Deconstruction scenario will not consider the use of digital tools. They will still be analysed in parallel and can be added to the result as a filter (see Deliverable 1.4.5).

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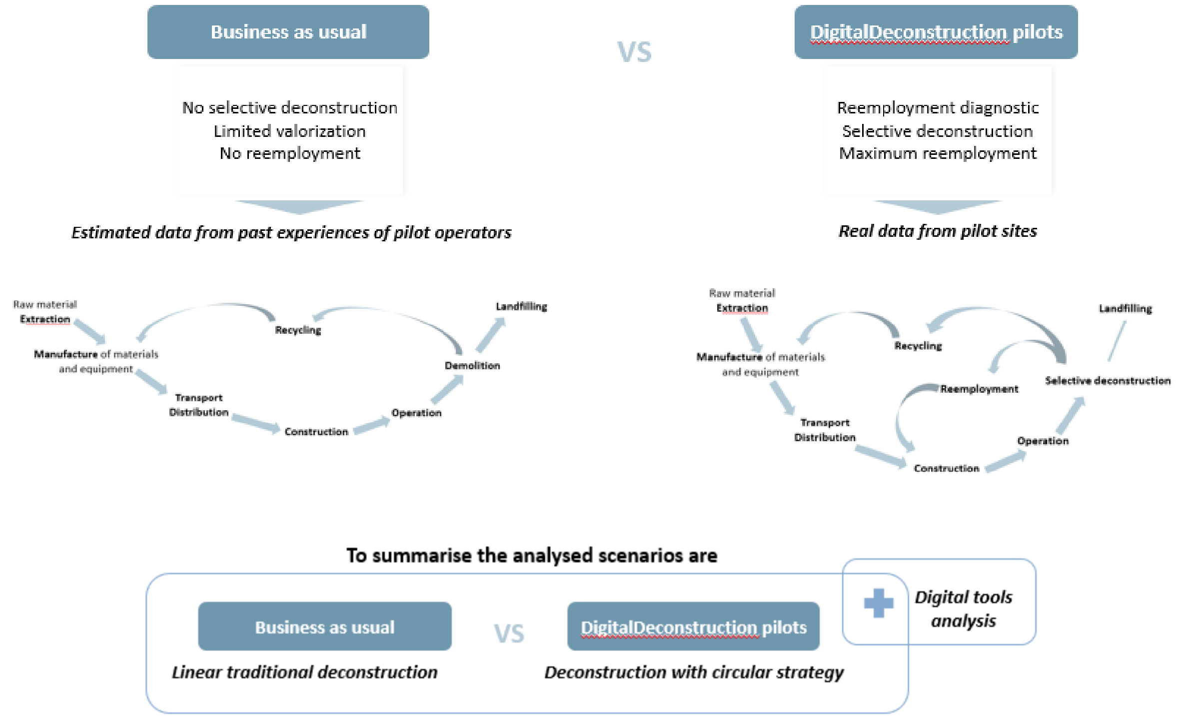

The classic demolition scenario forecasts the approximate costs for the project by imagining the scenario without a strategy of circular deconstruction. In this scenario we imagine that there are no more reemployments. For the recycled and energetically valued parts, we consider that it can either be the same as for the DDC scenario, but it can also be smaller (considering that the selective deconstruction has allowed to increase the part of valorised materials even apart from the reemployed part).

Pilots used for the analysis

The objective was to analyse the financial cost and environmental benefits of circular deconstruction in several contexts:

- Different type and size of buildings: train station, buildings…
- Different type of regulation context: two project pilots in France, one in Luxembourg, one in Belgium and one in the Netherlands

Here is a reminder of the pilot sites features.

Country	Pilot Name	Building type	Size	Construction year	DDC partner
FR	Gare du Nord	Haussmanian building	1190 m^3 1000 m^2	19th century	AREP
LUX	Ettelbruck	Train station	4500 m^3 3220 m^2	1873	Schroeder & associé

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FR	Lomme	Social houses	971 m^2	1978	Vilogia
BE	Hof Ter Laken	Farm	464 m^2	1865	Kempens Landschap
NL	Herleen	Museum			GTB Lab
FR	Villeneuve St George	Train station	870 m^2	1995	AREP
LUX	Euroffice		115 700 m^3 41 000 m^2		Schroeder & associé

Limitations related to data quality and hypothesis made.

Due to delays in some pilot projects, it was not always possible to carry out a cost-benefit analysis. As we can see in the table below, the data collection was finalized only for Gare du Nord, Ettelbruck and Lomme projects. It was therefore not possible to carry out an analysis on the other projects. It should also be noted that the only project for which the analysis was based on actual data rather than estimated data was Ettelbruck.

Pilot Name	Deconstruction progress	Data collection
Ettelbruck	Finalized	Finalized with real data
Gare du Nord	In progress	Finalized with predicted data
Lomme	Not started	Finalized with predicted data
Hof Ter Laken	Finalized	Not complete
Herleen	Not started	No started
Villeneuve St George	Not started	Not complete
2nd pilot in Luxembourg	In progress	Not started

Cross-cutting hypothesis

Two categories of data have been collected:

- Data linked to project costs identify the costs associated with the DDC project but not linked with the materials/equipment: working hours, human costs...
- Data linked to the materials inventory to identify all the elements/materials and the environmental and financial impacts and benefits associated with their deconstruction and recovery.

For each category, the data has been filled in two possible ways:

- When the pilot owner had all the data regarding the costs (how much they paid for people working on the project, time spent on each step...): for each category, the detailed costs has

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been collected, the € associated for each cost items, as some detailed information about hour spent for each work type and hourly rate.

- In a less specific case, the pilot owner had only the global costs (invoices, internal figures on the global human cost on the pilot...) without the associated details or the global environmental data (without the explanation)

Results of the cost-benefit analysis at pilot level

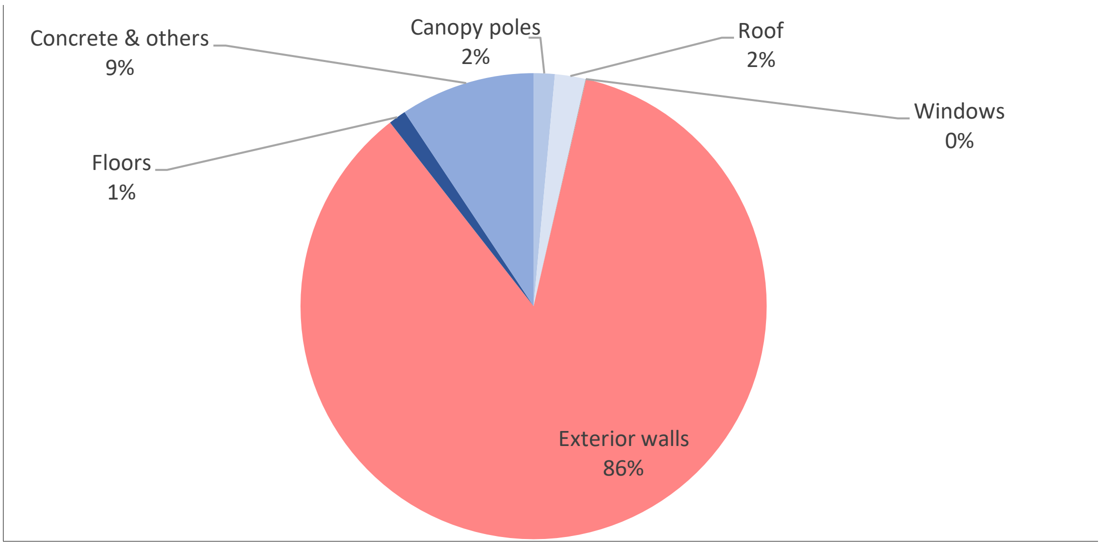
Ettelbruck train station

General results

Here are the different types of materials identified in the pilot project of Ettelbruck train station:

Type of materials	Categories
Metal	Part of canopy poles, windows
Wood	Part of canopy poles, floor, windows
Slate	Roof
Stones	Exterior walls
Glass	Windows
Concrete	Part of canopy poles, Exterior walls

Among the 2 447 tons of materials, the breakdown is as follows:



Mass distribution of materials (in tons)

The majority of the tonnage corresponds to exterior walls, including stones and concrete. Most of the exterior walls, except for the stones, has been recycled. The walls represent almost all the tonnage of recycled materials. Reuse is the second outlet, behind recycling, with 424 tons reused. 275 tons of materials ended as waste. The outlet the less common on this pilot project is the energy recovery, with

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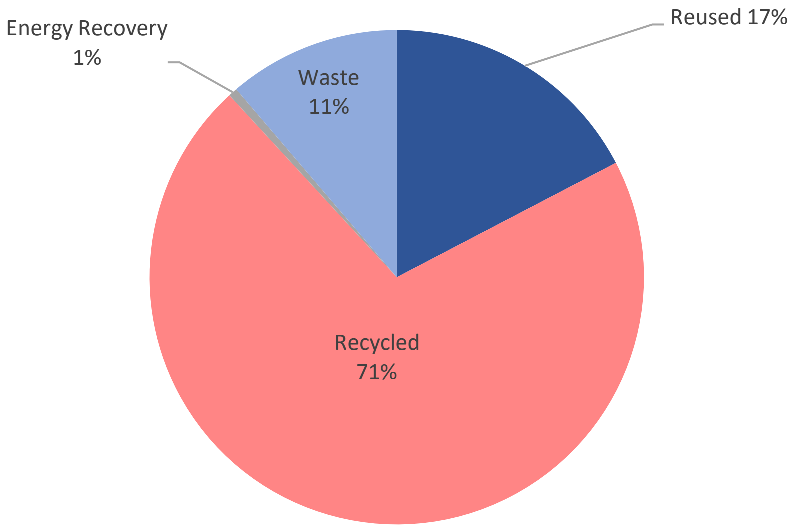
only 20 tons of materials. It was chosen for a part of canpoly poles, windows and floors, because those parts were in woods.



End of life of materials (in tons)

The results remain therefore satisfying with 17% of reused in the project.

Project Costs

The study of project costs is partly biased because of two major reasons:

- The cost of digital tools is not included, except for the time spent by the pilot project holders on these tools. The project ownership would have to pay for the use of the 3D Scan, Material inventory, etc in practice.
- Because of the experimental character of Digital Deconstruction, some methodologies were developed by the pilot project holders. That is why, the time spend on strategy and programming costs are likely to be overestimated.

The cost analysis of the project is calculated with the number of hours spent by Schröder and Associate teams for the 2 first steps: Inventory Cost and Strategy and Programming Costs, and by the time spent by the enterprise of construction or average time spent by enterprises of construction on each step of the construction. To that is associated hourly rates to estimate costs per step.

Phase	Cost per phase
Inventory Cost	1 810 €
Strategy and Programming Costs	18 671 €
Deconstruction Cost	661 561 €

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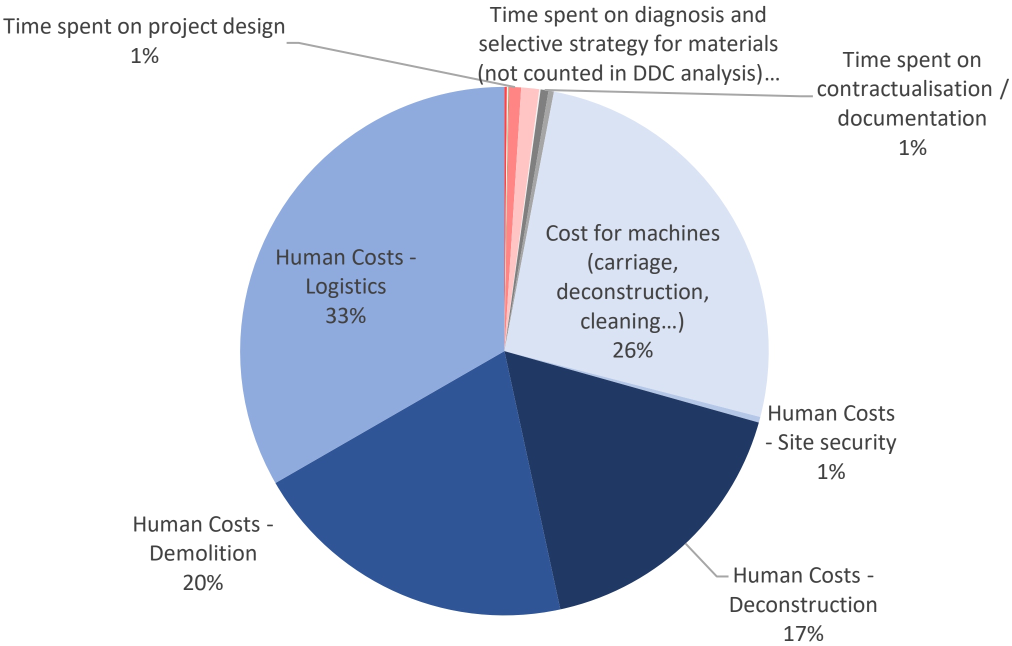
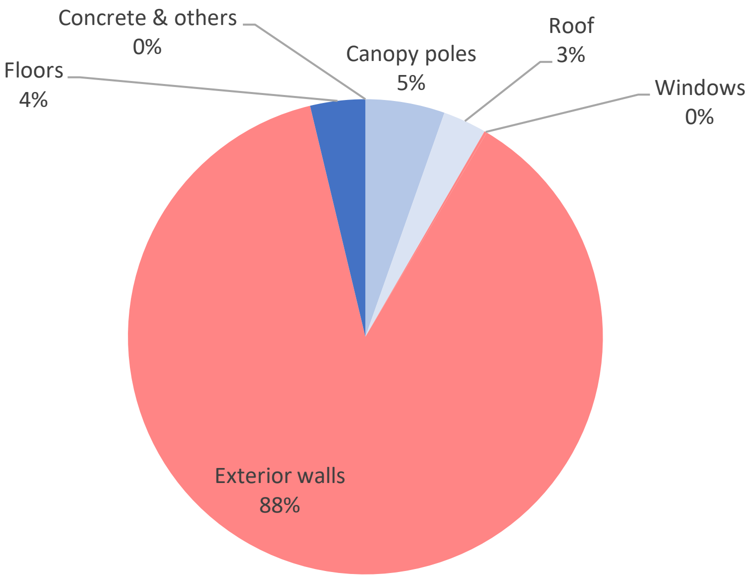


Breakdown of costs per stage of the pilot project

The deconstruction itself accounts for only 20% of the total cost and was estimated with time spent by the construction enterprise: 2 614 hours of work and hourly rate: 45€/hour. Some steps were longer than others such as the removal of awning post, that lasted 304 hours or parquet removal with 288 hours. These steps significantly increase the additional cost of this phase.

The Material Inventory phase is quite negligeable here with only 19 hours spent with modules carrier. The time spent on strategy and programming, is quite time consuming, although representing only 3% of the total costs and the most time-consuming phases were the project design, to collect plans and redraw them (around 11 days) and the contractualization and documentation, including on site visit.

Material inventory



Overall repartition of the materials reused by type (in tons)

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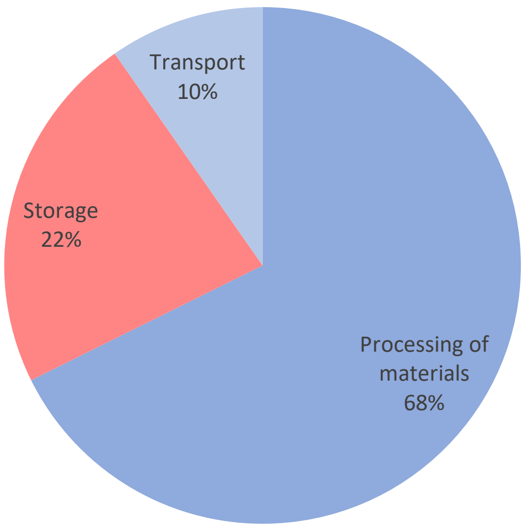
Among the 424 tons of materials reused, 372 tons were stones from walls, cornices, or windows trims, representing nevertheless only 18% of the total amount of walls. The materials that have been reused with the best rates are canopy poles, windows (windows stiles and not the glass) and floors, mostly because of their constitution: woods and metals.

Type of material	% of reused / product	% of recycling / product	% of energy recovery / product	% of waste / product
Canopy poles	64%	0%	15%	21%
Roof	24%	0%	0%	76%
Windows	71%	0%	29%	0%
Exterior walls	18%	82%	0%	0%
Floors	53%	0%	47%	0%
Concrete & others	0%	0%	0%	100%
TOTAL	**17%**	**71%**	**1%**	**11%**



Breakdown of costs per stage of the reuse process

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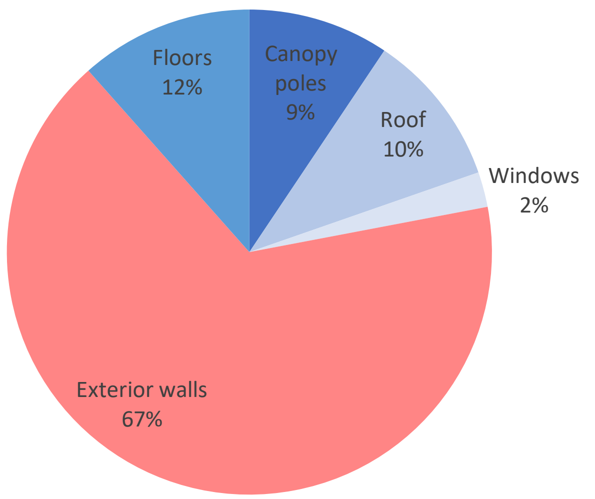
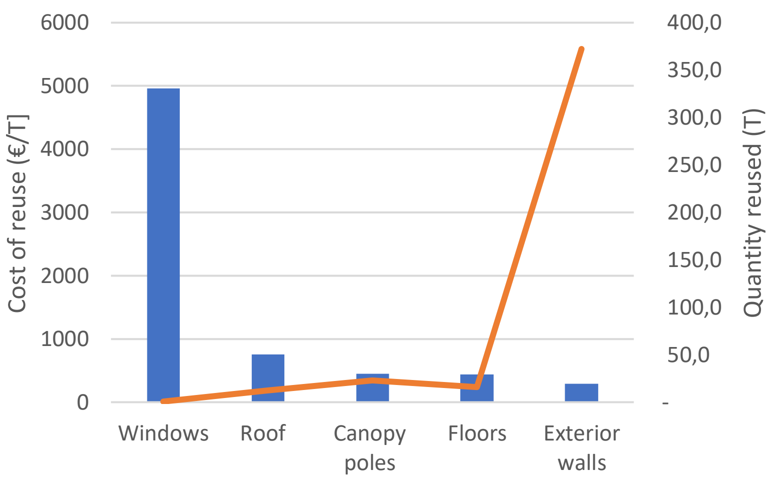
Most of the costs of reuse are due to the processing of materials, such as: reconditioning, removal, etc. Indeed, the costs for storage were low thanks to the localisation of the construction site: the deconstructed materials were stored within the train station and the land directly. For the transportation, the materials were transported to their new localisation, payable by beneficiaries.



Distribution of costs by type of material



Costs of reuse for a ton of material, based on the project.

With the second infographic, it is notable that the absolute cost of reused for exterior walls is the highest, but if we compare the price of reuse per ton of material, exterior walls are the most interesting, along with floors and canopy poles, partly because of the density of these materials. Nevertheless, this graphic can be biased because the functional units are not necessarily tons for each material, but rather the square meters for windows, roof, and floors, for example. However, it seems quite intuitive that windows have a higher cost of deconstruction, because of their fragility and links with other materials.

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Environmental analysis

As the Ettelbruck pilot project was one of the only to be entirely deconstructed and had the best data collected, we were able to study a bit further the environmental benefits linked to its work. In order to do so, we have analysed two main criteria:

- The environmental impact of the freight,
- The avoided emissions allowed by the reuse of materials,

The purpose of this exercise was to study a subject that is frequently addressed by the actors of reuse: **does reuse always present an environmental benefit, in comparison with regular scenarios, when considering the potential augmentation of distance travelled by the material after it has been deconstructed**?

Reuse represents benefits in terms of resources because it mostly prevents to extract and process new materials for new project of construction and renovation. However, it does not really change the end of life of the materials, the end of life will eventually take place but much later.

1. Freight generated by selective deconstruction.

To do so, the comparison of the freight in two scenarios was studied: Digital Deconstruction Scenario (DDC Scenario) and Business as Usual Scenario (BAU Scenario). For the DDC Scenario, the kilometres travelled by the materials for reuse were known (between 36 and 70 km). For the following waste outfalls, hypothesis of travelled kilometres was established: recycling, waste, energy recovery (in both scenarios).

The following hypothesis were used for the BAU Scenario :

km travelled for landfill*	30
km travelled for energy recovery*	50
km travelled for recycling*	50

*Estimation based on the number of landfill in France per km2 and number of recycling sites for construction waste

To estimate, the environmental footprint of freight, an emission factor, established by the French Agency for ecological transition (ADEME), was chosen:

Rigid truck, 7.5 to 12 T, road diesel, 7% biodiesel, mainland France: **0,24 kgCO_2e/t.km**

The equation to determine the extra cost associated to freight is the following:

Extra carbon cost for freight
=
Emissions linked to freight in DDC scenario – Emissions linked to freight in BAU scenario

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	Reused (T) (DDC Scenario)	Recycled (T) (DDC Scenario)	Recycled (T) (BAU Scenario)	Energy Recovery (T) (DDC)	Energy Recovery (T) (BAU)	Waste (DDC Scenario)	Waste (BAU Scenario)
Canopy poles	23,0	0	23,0	5,3	5,3	7,6	7,6
Roof	12,6	0	0	0	12,6	39,3	39,3
Windo ws	0,7	0	0,3	0,3	0,7	0	0
Exterior walls	372,3	1727,7	2100	0	0	0	0
Floors	15,9	0	0	14	29,9	0	0
Concret e & others	0	0	0	0	0	228,5	2285

End of life for each material in both scenarios (T)

For example, for canopy poles :
Emissions linked to freight in DDC scenario = 0,24 (EF) * (23 (reused tons) * 66 (km for reuse) + 5 (tons for energy recovery * 50 (estimated km for energy recovery) + 8 (tons of waste) * 30 (estimated km for landfill))
Emissions linked to freight in BAU scenario = 0,24 (EF) * (23 (recycled tons) * 50 (estimated km for recycling) + 5 (tons for energy recovery * 50 (estimated km for energy recovery) + 8 (tons of waste) * 30 (estimated km for landfill))
Extra carbon cost for freight = 693 – 392 = 300 kgCO_2e

With the collected data and the hypothesis above, the following results were obtained.

Type of material	Carbon extra cost for freight (in tCO_2e)
Canopy poles	0,3
Roof	0,1
Windows	0,0
Exterior walls	6,3
Floors	0,1
Concrete & others	0,0
Total	6,8

Carbon extra cost associated to freight between BAU Scenario and DDC Scenario (in tCO2e)

The carbon extra cost is here the emissions of greenhouse gases generated by freight of the reused material compared to the freight that would have been done in a classic scenario of deconstruction.

The final carbon extra cost associated to freight, in DDC Scenario, is only 6,8 tCO_2e. To compare, the carbon footprint of one element of the building: the canopy poles, is 47 tCO_2e. The extra cost linked to freight is less than 15% of the carbon footprint of a single element of the building, representing only 6% of the tonnage reused. Therefore, it appears that the extra cost linked to freight is not so significant in terms of general carbon footprint of the project. And for example, on average a Luxembourger emits 12 tCO_2e per year, a French 8,9 tCO_2e, a Dutch 7,5 tCO_2e and a Belgian emits around 10 tCO_2e per year.

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2. Avoided Emissions

To study the "avoided emissions", we used the carbon footprint of materials, considering that reuse was avoiding the production of material (Phase A1 to A3 in assessment life cycle). Therefor emissions generated by phases A1 to A3 (i.e., Raw material supply, Transport and Manufacturing) for each material reused will be referred as "avoided emissions" bellow.

The avoided emissions don't directly concern the pilot project that is deconstructed but the future project of construction that will reuse the deconstructed materials.

The database used for the carbon footprint of materials is the "Base Inies", the French national reference database for environmental and health data on construction products and equipment. We associated these carbon footprints to the tonnage of each material to obtain a result in carbon dioxide equivalent.

The estimated carbon gain of this pilot project is around **57 tCO_2e** and distributed as bellow:

Type of Materials	Carbon Gain (tCO2e)
Canopy poles	47
Roof	2
Windows	3
Exterior walls	4

3. Conclusion on the environmental analysis

With these results, we were able to estimate the distance the materials reused would have to travel for it not to be relevant, from a carbon accounting point of view, to be reused elsewhere:

Type of material	Distances from which reused is not a gain in terms of Carbon (in km)
Canopy poles	8583
Roof	598
Windows	18417
Exterior walls	48

With our hypothesis, it appears that materials that are responsible for a larger amount of energy consumption during their production, such as metals (canopy poles) and glass (windows) represent a bigger advantageous to be reused. If the supply is done respectively, from less than 8500 km and 18 400 km, it represents benefits on a carbon point of view to reuse these materials, so within Europe.

On the opposite, natural elements, that don't require lots of process, such as slate and natural stones have to be reused close from the construction site, otherwise there is no carbon gain due to their reused.

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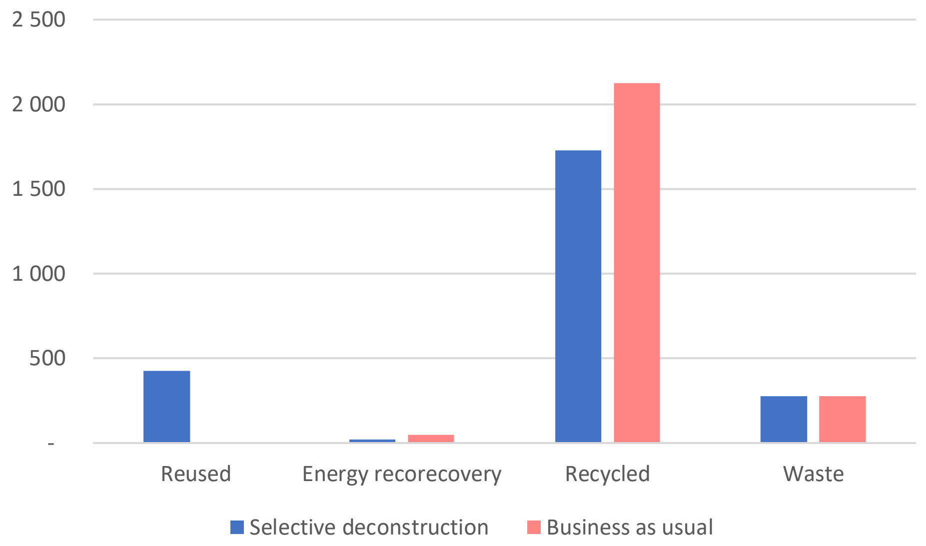
In this pilot project, the stones were reused 70km away from the construction site, therefore on a carbon point on view, it is not advantageous. Of course, the carbon is not the only indicators to take into consideration such as biodiversity or pollution.

Comparison of both scenarios



Comparison of end of life for the 2 scenarios

The major distinction in these two scenarios is the amount of material recycled. In this pilot project, the material reused were initially planned to be used in energy recovery or to be recycled. The amount of waste going to landfill, or incineration remains the same. The “BAU Scenario” was quite ambitious already, with only 11% of the materials ending as waste. It remains nevertheless interesting to implement a selective deconstruction because the recycling industry can be also responsible for pollution and greenhouse gas emissions, that is why it is interesting to valorise materials in other buildings, also for the avoided emissions, related to the production of new materials, studied above.

Business as usual	Selective Deconstruction	Relative evolution
512 540 €	661 560 €	+ 33 %
0 Tons reused	424 Tons reused	+17%

Steps	Comparison between costs	Detailed Comparison
Inventory Costs	- 1810 €	

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Strategy and Programmation Costs	- 7131 €	
Deconstruction Costs	- 160 561 €	
Cost for machines		40 830,00 €
Site preparation / security /etc.		16 224,00 €
Deconstruction		- 117 639,00 €
Demolition		- 65 736,00 €
Logistic		- 34 240,00 €
Site Management / Valorisation costs / others		
Total	- **169 502€**	

Comparison between a business-as-usual demolition scenario and a selective deconstruction scenario

The purpose of this study is also to analyse the differences between a deconstruction with DDC scenario and business-as-usual deconstruction scenario. Despite two cost-saving steps, cost for the machines and preparation of the construction site, the selective deconstruction implemented in the Digital Deconstruction pilot project presents an extra cost to Business-as-usual deconstruction of 169 502 € i.e., an extra cost of 33 %.

The extra costs are not only linked to the deconstruction itself, since 108 917 € are related to other steps. For example, the costs for demolition increased of 65k€, corresponding to roof removal, bathrooms and inside wall, because these sub steps were prerequisite to deconstruct cautiously the material of interest afterwards.

Because the regulations in Luxembourg are less binding than in other countries, such as France, Schroder and Associate was able to donate materials instead of putting them on the market, therefor it did not generate any revenue that could have partly compensate the other extra costs.

Lomme

General results

Here are the different types of materials identified in the pilot project in Lomme (Uranus residences):

Type of material	Category
Steel	Radiator, window frame and sink
Plastic, PVC	Finishing facades, floors and interior frames
Plaster	Wall panels
Wood	Door frame
Céramics	Wall tiles, sinks, toilet bowls and baths

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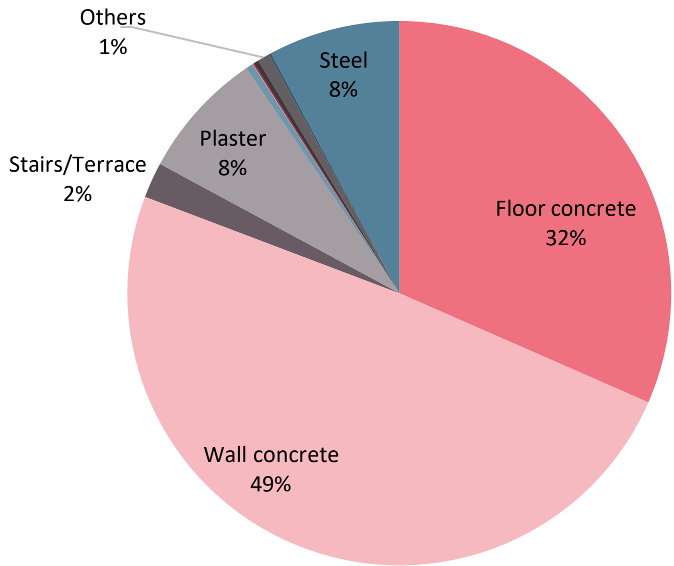
Concrete	Floors, walls and stairs

Among the 1017 tons of materials, the breakdown is as follows:



Mass distribution of materials

It can be observed that nearly half of the tonnage corresponds to concrete walls, and one-third to concrete floors. The steel railings and plaster wall panels each account for 8% of the total weight of the materials.

The potential end-of-life of the materials was estimated by the Neo-Eco reuse project management assistance. It can be observed that almost all the tonnage is destined for recycling (98%). A significant portion of this recycling quantity is attributed to the valorization of concrete from walls and floors.

The portion of energy recycling corresponds to PVC that could not be reused or recycled due to the presence of asbestos.

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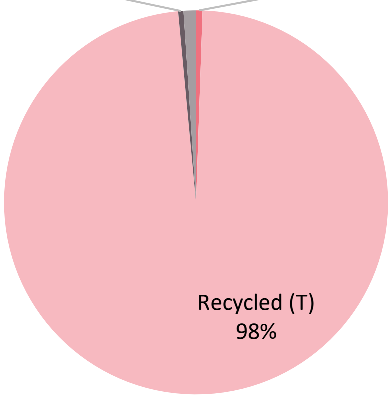

End of life of materials

Project costs

The cost analysis of the project is limited to the phases that could take place before the project's completion: the phase of using digital tools and the strategy and programming phase. These phases correspond to the costs associated with the number of hours spent by Vilogia teams on the project.

To complete the analysis, Vilogia estimated the costs that the deconstruction phase would have incurred based on the data from the deconstruction of buildings in a similar project.

Phase	Cost per phase
Inventory Cost	1 109 €
Strategy and Programmation Costs	35 812 €
Deconstruction Cost	Estimated at 309 000 €

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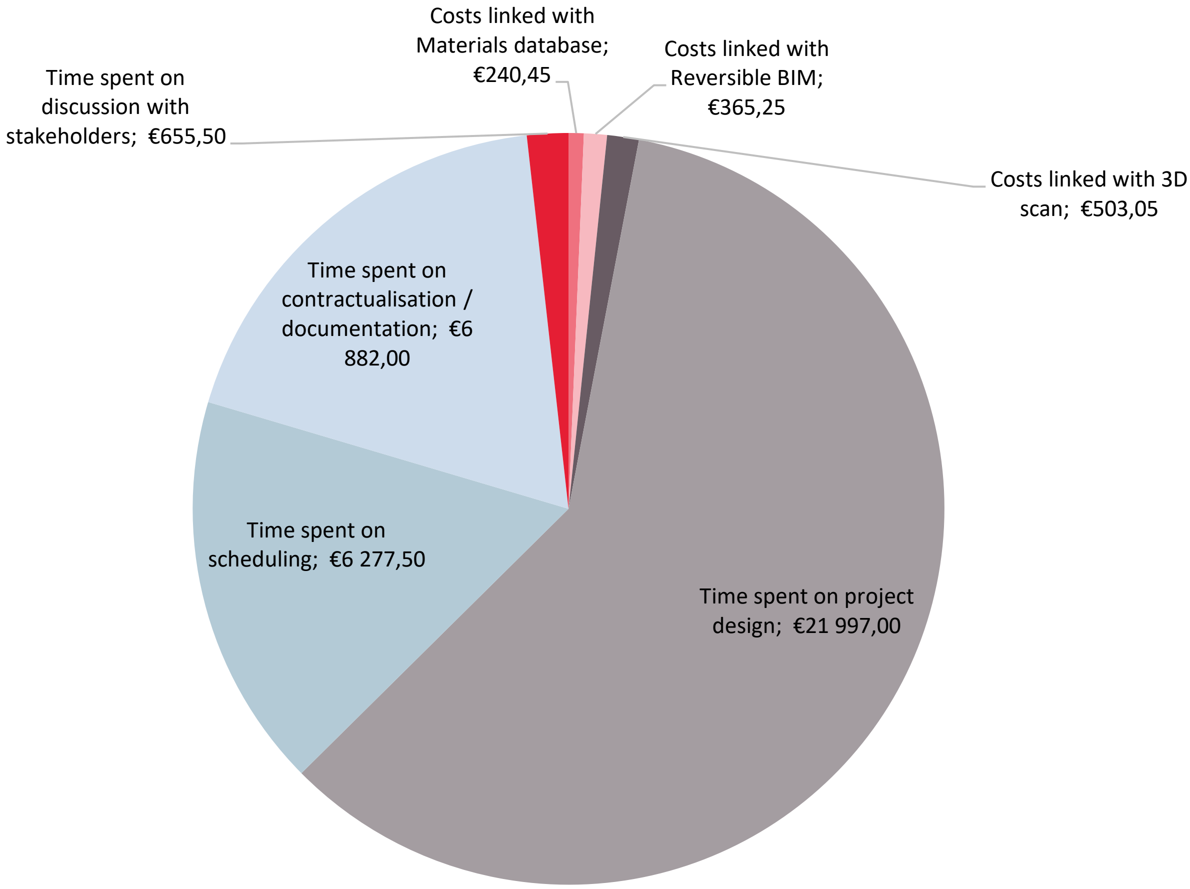

Breakdown of costs per stage of the pilot project (without deconstruction costs)

It can be observed that 60% of the costs in the inventory and programming phases are related to project design (i.e., costs associated with contracting with Neo Eco). Specifically, here are the details of the time related to this 'contractualization' part:

- The Material Inventory/Audit phase involves 0.5 days for preparation, 0.5 days for the audit, and 2 days for adaptation to the DDC format, resulting in a total of 3 days.
- The Resource Diagnosis phase requires 2 days for consolidating the audit and an additional 5 days for preparing the report/study of economics, etc., making it a total of 7 days.
- The Consultation Documents phase entails 10 days for drafting clauses, integrating paragraphs, conducting revisions, and other related tasks, summing up to 10 days.
- The Participation in the DDC phase involves 10 days for attending development meetings, tool presentations, workshops, and other relevant activities, resulting in a total of 10 days.
- The duration of the Construction Monitoring phase is yet to be determined and is estimated to be approximately 0.5 days per week throughout the entire duration of the construction project.

Considering the estimated deconstruction costs, the distribution would be as follows:

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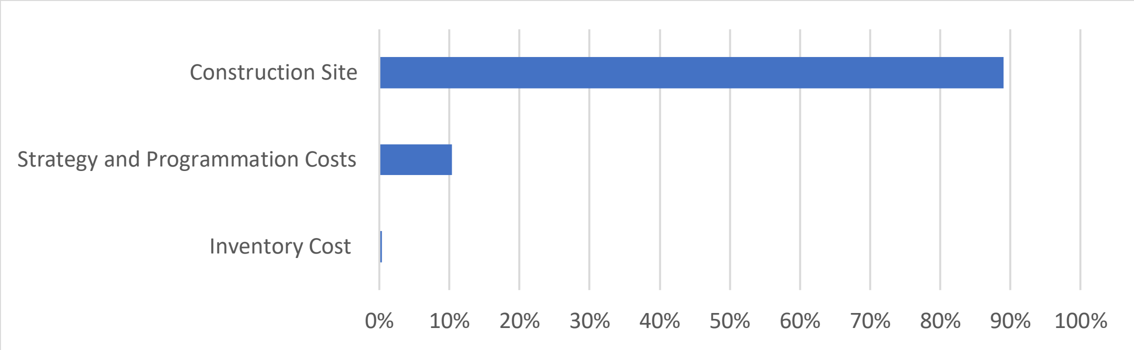
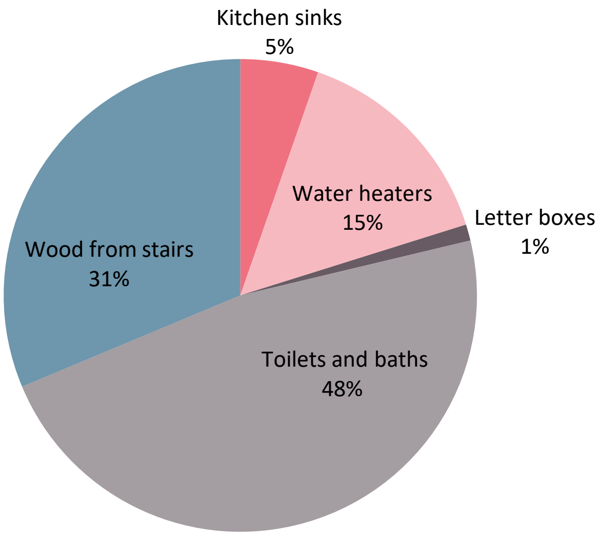


Breakdown of costs per stage of the pilot project, including estimation on deconstruction costs

It is observed that nearly 90% of the costs are associated with the construction phase, and the inventory costs related to the use of Digital Deconstruction digital tools are negligible compared to the rest of the costs.

Material inventory

An analysis of the environmental and financial impacts related to the material inventory was also conducted based on the data provided by Neo Eco. In 2021, Neo Eco identified the materials that could potentially be reused. It is noteworthy that only 5.4 tonnes of materials out of the total of over 1000 tonnes could be reused, which accounts for less than 1%. This is due to the presence of asbestos and lead. Only the wood of staircases, letterboxes, water heaters and sanitary equipment may be reused. Indeed, asbestos and lead are hazardous materials that require special handling and disposal procedures due to their potential health and environmental risks.



Overall repartition of the materials reused by type

In terms of units of reused materials, the 5.4 tonnes identified for reuse can be quantified as follows:

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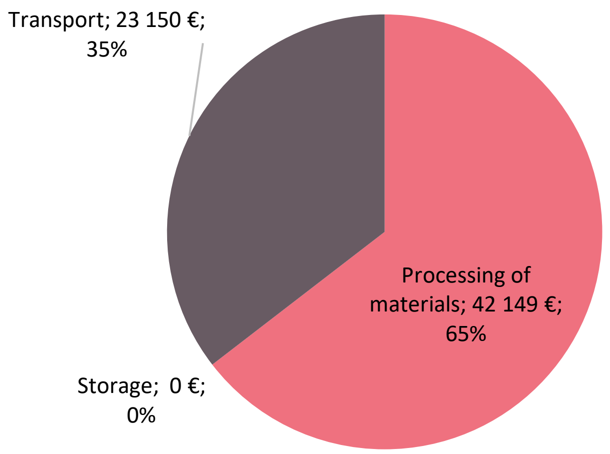
- 16 mailboxes
- 32 sanitary fixtures/bathtubs
- Stairs
- 16 water heaters
- Kitchen sinks

Indeed, it is noticeable that only easily detachable elements could potentially be reused. In the case of toilets and bathtubs it is easy to reuse them on site, for that, they only need to be cleaned.

The steel components from guardrails with lead-based paint, need to be scraped to remove the lead paint before being recycled. As for the windows, they cannot be reused so recycling them would be the appropriate course of action to valorise them.

So, while the digital inventory tools facilitated the identification and evaluation of materials, the actual quantity of materials suitable for reuse is limited. This suggests that the focus should be on other strategies such as recycling or proper waste management to reduce the environmental impact and maximize the financial benefits of the project.

The cost specific to the valorisation of materials (reuse, recycling, and/or energy recovery) reach **65 298 €**.



Breakdown of costs per stage of the reuse process

The analysis of these costs shows that, as seen in the graph above, 65% of the costs are associated with their treatment, while 35% are attributed to transportation. The treatment costs are primarily related to the selective removal of elements, except for the concrete floors, which incurred testing costs of 3000 €. The transportation costs are associated with transporting the concrete to treatment centres. It is worth noting that there are no storage costs as the materials are stored on-site.

It is also interesting to look at the breakdown of costs according to the different materials recovered and to look at the specific cost of reused materials.

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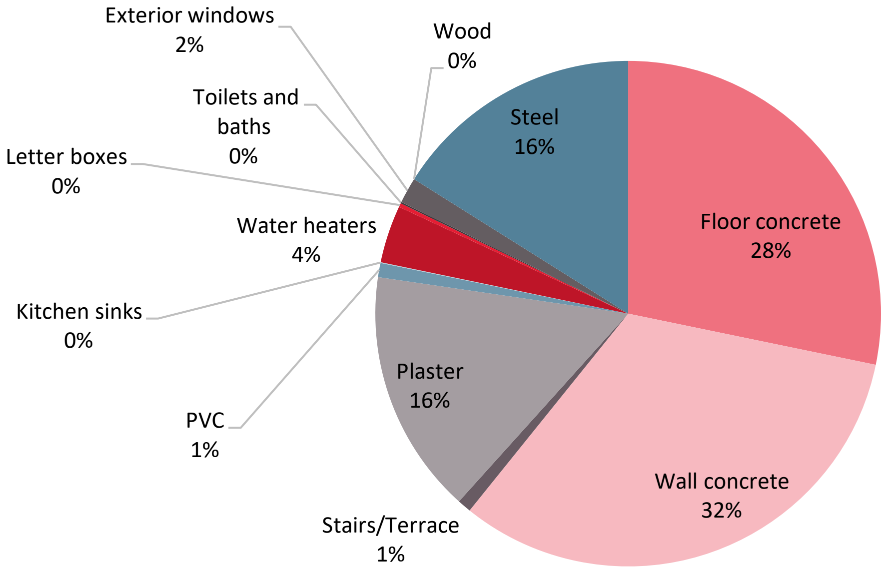
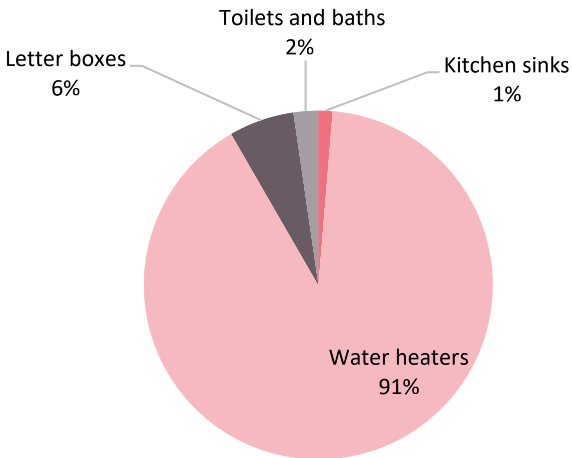


Distribution of costs by type of material



Distribution of costs by type of reused material

The high cost associated with concrete in the balance is due to both its significant tonnage and the substantial transportation costs, which amount to over 20,000 €. Unlike other materials that remain on-site, concrete requires transportation to treatment centres, resulting in additional expenses.

Regarding plaster, the presence of an adhesive coating makes its recycling challenging. The careful removal of plaster is time-consuming, leading to higher labour costs.

When focusing on the costs related to the reused materials, it's noted that 90% of the expenses are attributed to water heaters. However, for a meaningful analysis, it is crucial to relate these costs to the

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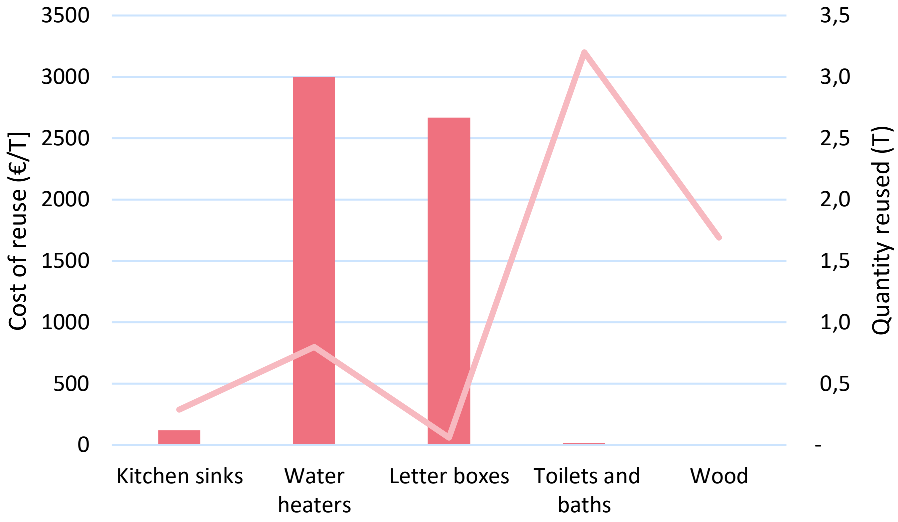
tons of materials reused and, consequently, the environmental benefits generated. It could also be interesting to relate theses costs to the number of unit of products reused.



Costs of reuse for a ton of material, based on the project

It may also be useful to include the resale of reused and recycled materials/equipment in the equation, by considering:

- For materials/equipment reused in situ, the avoided cost of purchasing new materials/equipment (in red in the table below) → indirect financial benefits.
- For materials/equipment reused ex-situ or recycled, the cost of resale → direct financial benefit.

These financial benefits have been evaluated by Neo Eco, please note that the figures have been calculated using 2021 pricing and represent the best-case scenario.

Considering all the financial benefits (direct and indirect), the total cost of materials fell from **€65,298** to **€45,680**, a reduction of **30%**. If only the direct benefits are considered, the total cost of materials falls from **€65,298** to **€49,760**, a reduction of **24%.**

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Here is the explanation of the benefits for reused materials (once again in the best-case scenario):

Type of material	TOTAL	Financial benefits
Floor concrete	18 445 €	1 059 €
Wall concrete	21 250 €	4 500 €
Stairs/Terrace	575 €	70 €
Plaster	10 212 €	5 138 €
PVC	590 €	0 €
Kitchen sinks	35 €	240 €
Water heaters	2 400 €	3 200 €
Letter boxes	160 €	160 €
Toilets and baths	60 €	480 €
Exterior windows	1 076 €	398,5
Wood	0 €	0 €
Steel	10 495 €	4 373 €
TOTAL	**65 298 €**	**19 619 €**

Material reused	Financial benefits
Kitchen sinks	15€/unit = 240€
Water heaters	200 per unit = 3200
Letter boxes	10€ per unit = 160
Toilets and baths	15€/unit = 480€

It is important to note that the financial benefits linked to not having to purchase new equipment for the new project (4 080 €) are more important than the cost of processing materials (2 655 €). This is mainly because it is in-situ reuse and so that there is no cost related to transport. In the case of this project, this does not represent a lot of money because very few materials are reused, but by imagining a project with more reuse, this could become a determining factor to be considered to achieve the economic equilibrium of the overall deconstruction / reconstruction project.

Comparison of both scenarios

As explained at the beginning of the document, in addition to analysing the costs and environmental impacts of the project itself, it is valuable to compare it to a business-as-usual deconstruction scenario. This comparison aims to highlight the environmental added value in relation to the associated additional costs.

Business as usual	Selective Deconstruction	Relative evolution

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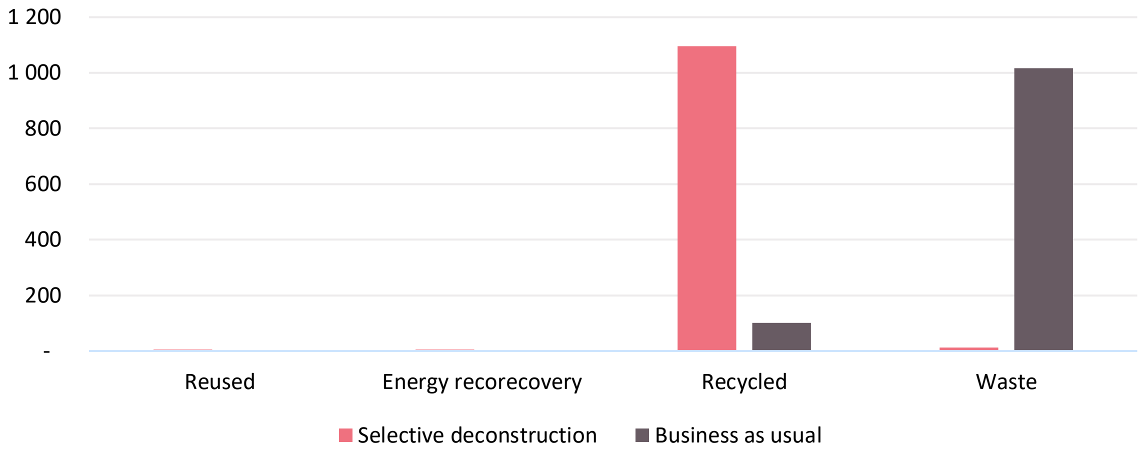
29 660 €	36 920 €	+24 %
0 Tons reused	12 Tons reused	+1%



Comparison of end of life for the 2 scenarios

We can see above that the selective deconstruction approach allows for the recycling of over 89% of the materials compared to the business-as-usual scenario. However, in terms of materials being reused, there is only a marginal increase of 1% in the selective deconstruction approach compared to the conventional scenario.

But it should be noted that selective deconstruction remains interesting from an environmental point of view as it enables the concrete to be crushed and recycled for roadworks. So, the significant difference in recycling rates highlights the effectiveness of the selective deconstruction process in diverting materials from landfills and promoting their reintegration into the production cycle. Moreover, if the operation had been larger, it might have been economically profitable to drill core holes to recycle the concrete into structural concrete.

In terms of cost, here is the difference between both scenarios. Unfortunately, the calculations can only be made for the inventory and strategy/programming phases, as the deconstruction has not yet taken place, and the costs for this deconstruction have already been estimated. It is too challenging to estimate the costs of this deconstruction without a circular strategy.

Steps	**Extra Costs**
Inventory costs	-1 109 €
Strategy and Programmation costs	- 6 153 €
Selective deconstruction costs	N.A.

Comparison between a business-as-usual demolition scenario and a selective deconstruction scenario

Despite some cost-saving steps, the selective deconstruction implemented in the Digital Deconstruction pilot project presents an extra cost to Business-as-usual deconstruction of 7 2612 € i.e., an extra cost of 24 %.

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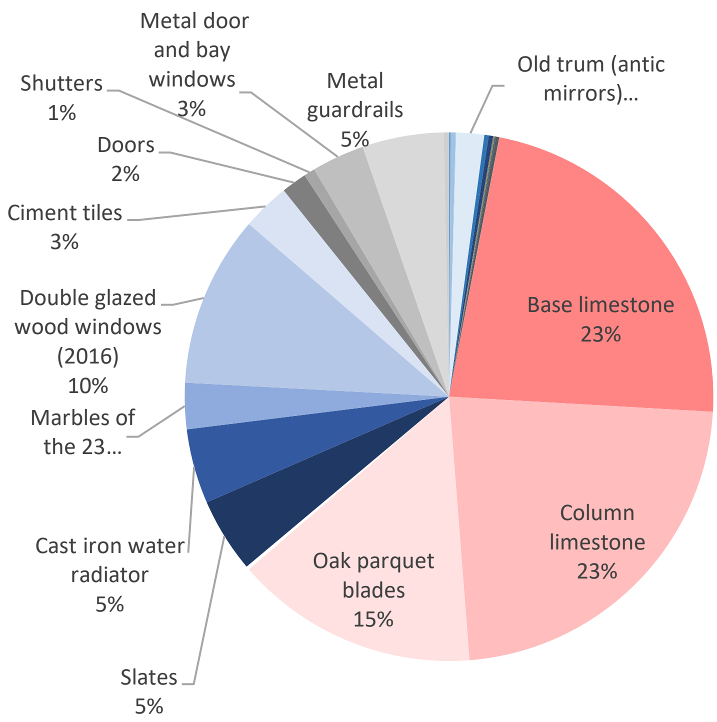
To conclude on the analysis of Lomme pilot project, this forecasted costs and benefits analysis provides valuable insights into the future positive ecological impact of the project and showcases the sustainability gains achieved by opting for innovative and environmentally conscious methods even if the project is not suitable for reuse (due to its small size and the presence of asbestos). A larger building with more materials and without asbestos would have presented better environmental results compared to the additional costs.

Gare du Nord

General results



Mass distribution of materials

Only materials that have been selectively deconstructed are shown here. Together, these materials represent 74t of the total 1030t of waste.

The repartitions of the 1030t is as bellow:

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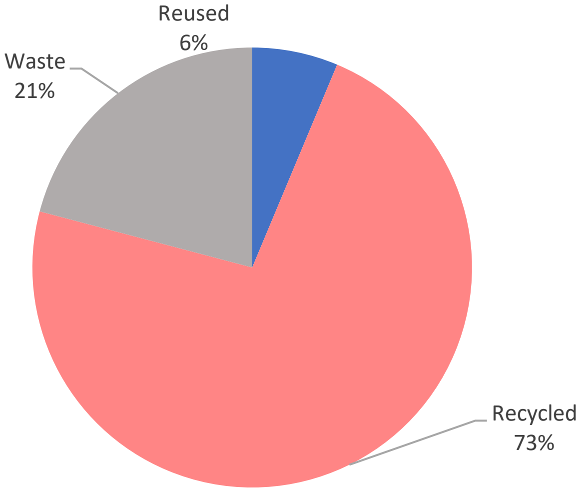

End of life of materials

A large proportion of the recycled materials does not appear in the study, as they were not selectively deconstructed and would have been recycled in a conventional scenario.

Project costs

The project of Gare du Nord is not entirely finished yet, however a first estimation was used to study the general costs of the project. Most of the costs are real, the only ones partly estimated are the costs associated to the deconstruction of material to be reused IN-SITU and EX-SITU, costs of tests of characterisation and the benefits linked to sales of reused materials.

Phase	Cost per phase
Inventory Cost	- €
Strategy and Programming Costs	123 319 €
Deconstruction Costs	759 649 €
Valorisation Costs	- 427 €

The inventory costs here are not presented because there was no tracking of the time spent with each digital tools. It appears that these costs would be not significant with the results of the other pilot projects.

Strategy and programming costs accounted for 14% of total costs. This phase was costly due to the research nature of the project. AREP had to create and try out different methodologies in order to implement selective deconstruction. This phase, outside of a research programme and if selective deconstruction were commonly used, would be less costly.

The valorisation costs are negative because all the requalification and tests operated to the reused materials are less expensive than the benefits generated by the sales of those materials.

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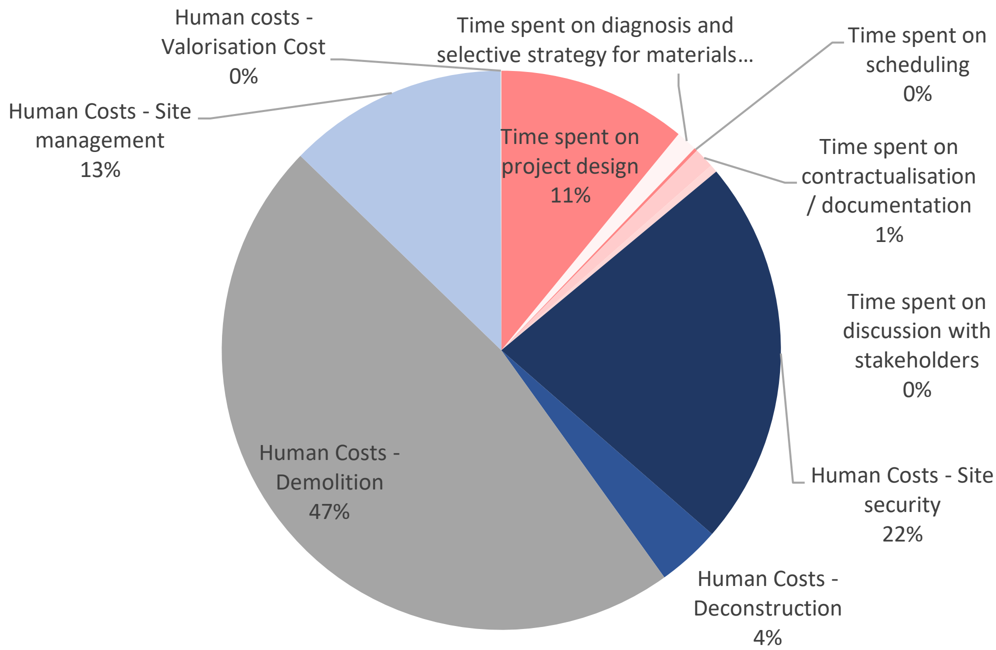
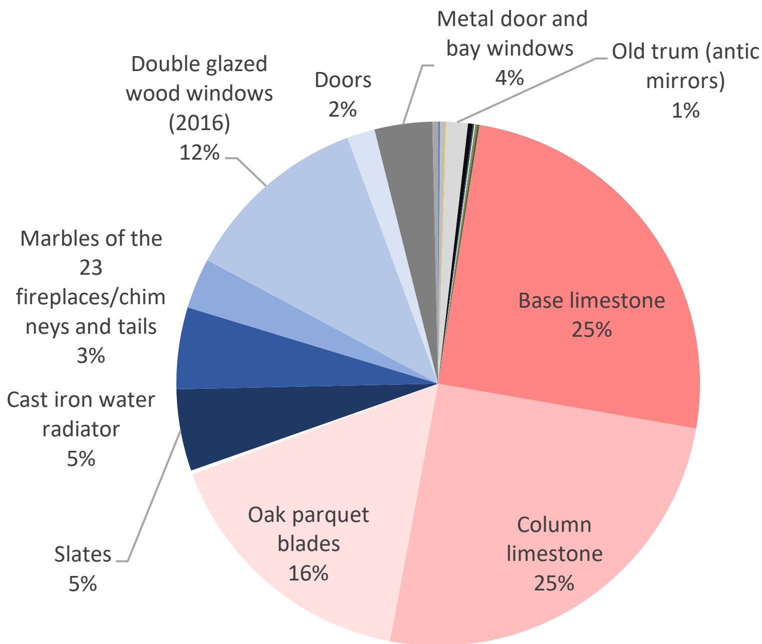


Breakdown of costs per stage of the pilot project

Costs for machines are included in the "Human Costs" because they were integrated in the general costs of the construction enterprise.

Material Inventory



Overall repartition of the materials reused by type (in tons)

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Type of material	% of reused / product	% of recycling / product
Old ceramic handle	100%	0%
Old brass handle	100%	0%
Electric radiators	100%	0%
Electric dry towel	100%	0%
Old trum (antic mirrors)	71%	29%
Whole fireplace	100%	0%
Bathromm sinks including mixers	30%	70%
Kitchen sinks aluminium including mixers	100%	0%
Bathroom mirrors	100%	0%
Large agglomerated wooden dorr	100%	0%
Furniture/shelves	100%	0%
Light including LED spots	58%	42%
LED light source	100%	0%
Base limestone	100%	0%
Column limestone	100%	0%
Oak parquet blades	100%	0%
Lambourdes wood	100%	0%
Slates	100%	0%
Cast iron water radiator	100%	0%
Marbles of the 23 fireplaces/chimneys and tails	100%	0%
Double glazed wood windows (2016)	100%	0%
Ciment tiles	0%	100%
Doors	100%	0%
Shutters	0%	100%
Metal door and bay windows	100%	0%
Metal guardrails	0%	100%
Electric radiators and dry towels	100%	0%

Only a few materials, such as light, antic mirrors and bathroom sinks were both reused and recycled according to the quality after the selective deconstruction. For the rest of the materials, they were either fully reused or fully recycled.

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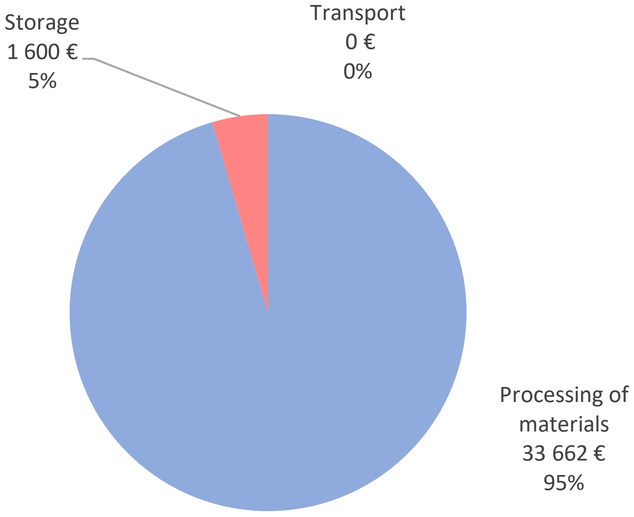
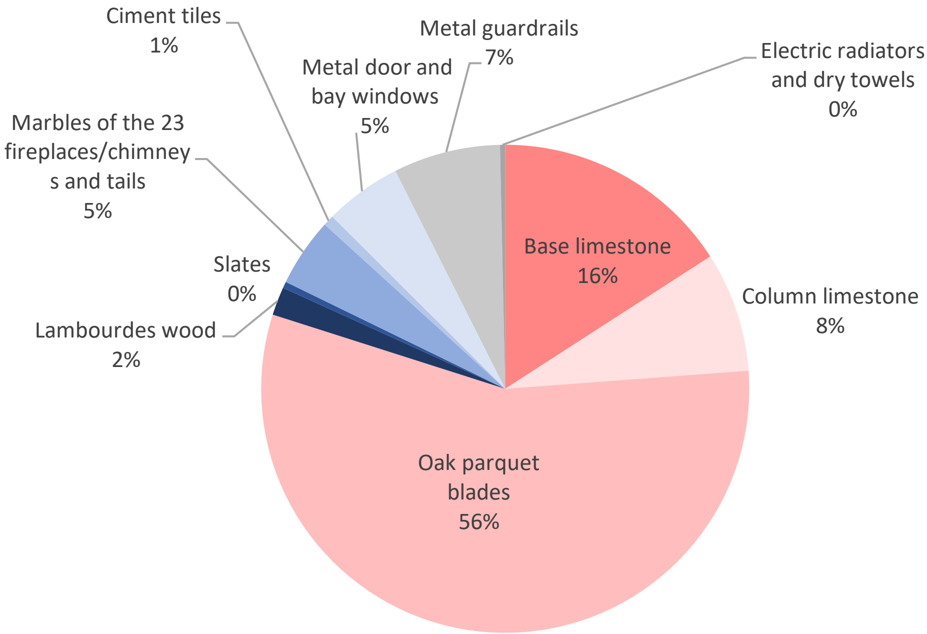


Breakdown of costs per stage of the reuse process



Distribution of costs by type of material

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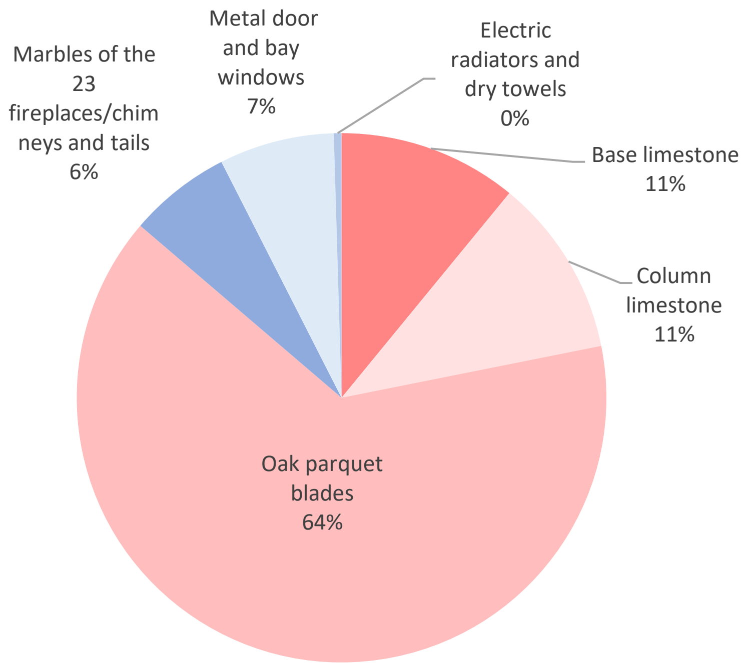
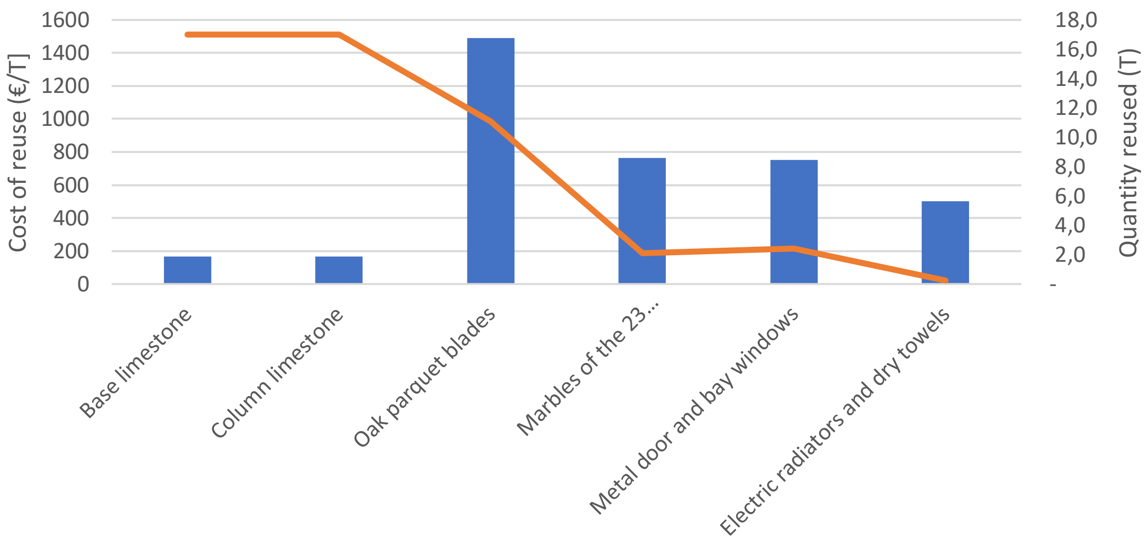


Distribution of costs for reuse only by type of material

The oak parquet blades account for the highest reuse costs. This can be explained by the quantity of parquet reused: over 16 tonnes, making it the most reused material. Below, we put the reuse cost per tonne and the tonnage per material into perspective. Parquet is the third most expensive material in terms of cost per tonne, behind basic limestone and columnar limestone. This must be qualified by the density of the materials. For example, for the same volume in m3, the weight associated with marble or metal doors is much greater than for wood.

Furthermore, parquet is one of the materials that has been the most revalued, being sold for 16,200€ out of total sales profits of 22,140€.



Costs of reuse for a ton of material, based on the project

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Comparison of both scenarios

Business as usual	Selective Deconstruction	Relative evolution
810 956 €	882 540 €	+ 9 %
0 Tons reused	67 Tons reused	+23%

The additional cost linked to the selective deconstruction is “only” 9% for a reused of 23% of the materials. This project shows that the sale of materials can partially offset the extra cost of certain phases. In this case, the qualification tests are cheaper than the resale of materials and equipment.

Furthermore, a collaborative day was organised during which time 2,5 tons of materials and equipment were given without generating any benefits, and these potential benefits could have reduced a bit more the additional costs.

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