HEC LIÈGE Management School - Liège Université | ENTREPRENEURS

UNIVERSITY OF LIÈGE

IMPACT STRATEGY

MISSION 1

Management of industrial waste from building and demolition site

Authors:
Pierre-Yves Bastin
Antoine Rousseau
Julien Hindrickx

PROMOTION Cybèle

Supervisors: Bernard Surlemont
Caroline Gerkens
Sybille Mertens
Frédéric Ooms

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Abstract

In terms of construction wastes recycling, Europe and Belgium are rather in advance compared to the rest of the world. For a few years, landfills have been disappearing in the country, leading to an increasing number of wastes to recycle (concrete, metals, plastic wastes, etc). However, polystyrene used in building and retrieved from demolition sites has still no proper recycling ways in Belgium. In addition, its small mass but great volume is an issue for transportation. Most of the times, it is used as fuel for electricity production. Yet, solutions exist to compact and recycle polystyrene in the world. They reduce the amount of oil needed to transport it and to produce it. This problem is not solved in Belgium for two reasons: First, small companies do not invest in compacting engines as their polystyrene wastes are not worth the investment. Second, most of the buildings insulated with polystyrene are not demolished yet, as they are still recent. This means that the biggest amount of polystyrene wastes to manage is still to come, while there is no solution in our region to do so. Ideal solution to this social issue is proposed in this work. This solution is based on the needs of stakeholders that we were able to identify. It makes use of technologies such as compression and dissolution in order to reduce the volume of expanded polystyrene.

Contents

1 Introduction

In this section, we start by introducing the issue tackled by our team. We also present the methodology used to completely understand the ins and outs of this problematic.

1.1 Problematic definition

Since a few years, Wallonia adopted "End of waste" decrees to enhance recycling process in industries (Portail-Wallonie, 2019). This means that products resulting from recycling or valorisation lose their "waste" status to become by-product. This administrative process is particularly useful to provide guarantees on the product quality and help introducing it on the market. In this context, the construction sector has experienced many changes in its habits. Indeed, the different types of waste produced from the building and demolition sites became largely recycled, especially inert wastes (i.e. concrete, bricks, ceramics) or valuable products as window frames or metals.

Through this mission, we identified one type of materials from the construction sector that caused some of the biggest problems : the polystyrene. Indeed, expanded polystyrene is used for concrete part formwork and extruded polystyrene represents the biggest part of the modern isolation. As this material has a large volume for a small mass, it is a true concern for construction actors to transport it to collect zones. Furthermore, polystyrene from this sector (as well as households) is nowadays mostly used as fuel for electric production, rather than recycled into useful by-products (Essenscia & Agoria, 2019).

By tackling the polystyrene issues, we help decreasing the amount of oil resources used to create and transport it, which aligns with the United Nations sustainable development goals 9, 11, 12 and 13 as given in **Figure 1** (United-Nations, 2020).

Figure 1: UN's sustainable development goals tackled by our mission.

1.2 Mission methodology

The original topic provided to our team was "Management of industrial wastes". In order to find the particular sector in which we wanted to act, we needed to refine the global subject more and more. This has been achieved thanks to the following methodology:

1. Choice of the industrial sector; based on our own skills and affinities. At first, we selected three industrial sectors. Then, we chose one in particular thanks to coaches help and advice.
2. Research phase; establishment of the sector cartography, understanding of the ecosystem, sorting of the actors in each part of the ecosystem.
3. Benchmarking; contact actors from each part of the ecosystem, discuss about their waste and daily concerns, make formal interviews, understand what works nicely and what issues remain in this sector, identify our angle of attack.
4. Impact Gap Canvas; make sure that the identified issue is a true issue of this sector, obtain quantitative data, look at the existing solutions and see why they are not sufficient.
5. Ideal solution proposition; definition of our value proposition statement, identification of our first pretotype and the points that our ideal solution would solve.

2 Ecosystem

The industrial sector we decided to focus on is the building sector. This choice was motivated by the facts that the building sector is responsible for the consumption of 40-45% of natural resources, consumes 40% of the energy produced worldwide and accounts for 50% of total wastes (Léonard et al., 2017).

The construction sector is a complex ecosystem in which a great number of key players interact with each other. For the purpose of this research, we divided the main players in several categories:

- General contractors; these companies are responsible for the on site building of a project. Because the type of waste produced varies greatly from project to project, we subdivided this category even more to differentiate between:
  - building and demolition work, characterized by both inert (i.e. concrete, bricks, ceramics) and non-inert wastes (i.e. wood, plastic, metals)
  - roads and infrastructures work, characterized almost exclusively by inert wastes (i.e. earth, concrete, asphalt)
- Towns and local communities; these organisations are responsible for mandating public works.
- Suppliers of building materials; these companies interact constantly with the general contractor to provide the materials needed on-site. Their actions and products are a major source of waste on the building site.
- Collectors and waste carriers; they set the price of waste containers and impose a sorting routine of on-site wastes.
- Recycling company; they are active in the valorisation process of wastes (concrete, asphalt, metals). They transform the waste in a secondary material/product or use it to produce energy.
- External entities; through their academic researches, Universities and higher education institutions have developed an intricate knowledge of materials and waste issues.
- Technical engineering and architectural firms; they design projects and later accompany the general contractor in the process of building.

All these key players are represented on the sector's environment map in **Figure 2**. It appeared essential to us to explore every part of this map and interview individuals working for each category of this environment.

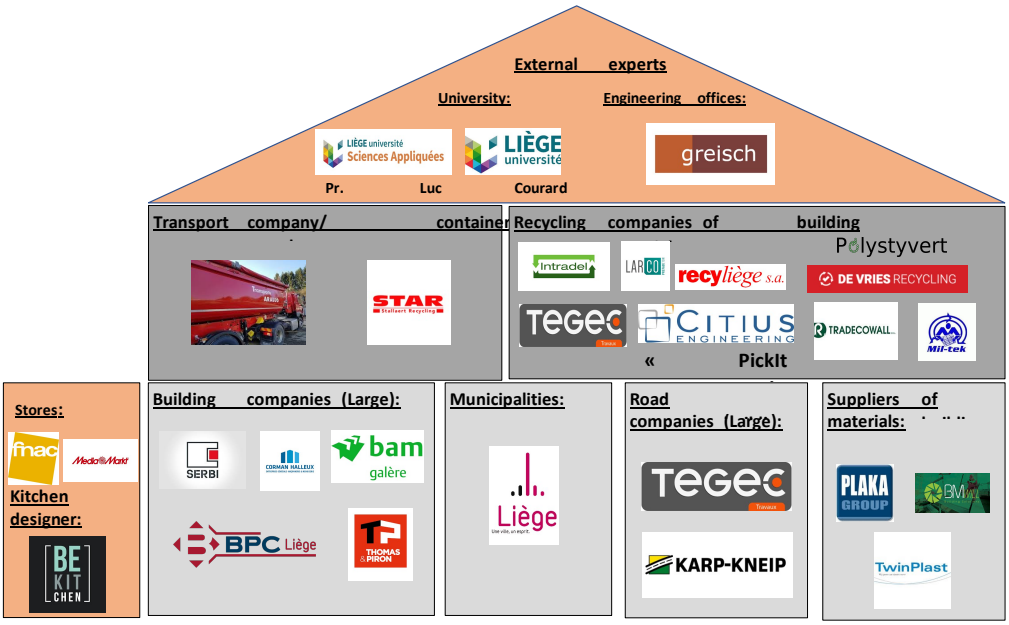

Figure 2: Ecosystem of waste generation and treatment in the construction sector.

3 Benchmarking

Once we understood how the ecosystem of the construction sector works, we managed to contact several players of each category to have their feeling and experience about the waste management. In this section, we describe the different types of interviews we had and the main information they provided.

3.1 General considerations for the building sector

Luc Courard, professor at the University of Liège, taught us that, from a general standpoint, Europe and Belgium are rather in advance compared to the rest of the world for waste recycling in the building industry. A European Union Directive for 2020 requires that 70% of waste from the construction industry are recycled or valorised in some way. According to him, we can safely say that the building sector is moving in the right direction. However, 4 elements characterizing the construction industry in Belgium prevent it from moving faster:

1. The building sector is very conservative. There exists a great resistance to change. It is hard for new methods to be integrated by building companies.
2. The construction industry is subject to an enormous amount of regulations (building norms, standards, specifications). Introducing a new product on the market requires lengthy studies and normalisation which increases costs. As a result, few take the risk.
3. The building sector is made up of countless SMEs. These scattered companies can be very small and cannot afford to conduct researches. Overall, this leads to less innovation in the sector.
4. Not too long ago, there existed no branch dedicated to recycling. In Wallonia, recycling was only considered seriously once waste from the sector were banned from landfills. Opportunities from recycling are emerging now and do not exist for every material yet.

While they are important players in the construction industry, it became rapidly clear that technical engineering firm such as Greish are not involved directly in the generation of waste on site since they focus on the design only. Similarly, waste collector and transport companies ship waste from one location to another but are not involved in the generation of waste. As these companies do not play a key role in waste generation, we focused our research on other players.

3.2 Inert wastes recycling

Most of the interviews tackled the concern of inert wastes recycling, and especially concrete recycling. Indeed, concrete is the most recurring material in modern building and it turns out that it is the one of the most recycled nowadays. Here is a list of the players we interviewed and their main instruction :

- Luc Courard; in the years to come, the amount of recycled materials is likely to grow. Indeed, many structures built during the post-world war boom now arrive at the end of their life-cycle and must be demolished. Concrete waste can be recycled. The recycling process includes crushing, grinding, deferrisation, sorting and sieving. At the end of this process, a sand or gravel material is obtained (depending on the diameter) which can be used again in a new concrete mix. While concrete waste make up for a large percentage of total waste, they are not the most problematic. Plaster, synthetic joints and polystyrene are harder to recycle than wood, concrete and metals.
- Michel Leroy, manager of RecyLiège, a recycling center located at Thimister-Clermont; in Belgium, wastes are classified in three classes, with respect to their type and their dangerousness. Most of the construction wastes are from class 2. Some landfills exist in Belgium to gather wastes from class 2, but they disappear year after year due to the recycling dynamic.

Indeed, recycling sites appear more and more in our country in order to process wastes that can not go to landfills anymore (as plastic, wood, tires,...) due to the lack of space. This is a way politicians have to promote recycling of construction wastes in Belgium.
At RecyLiège, entrepreneurs who bring trailers full of concrete can get rid of it for free, while they have to pay if it is a mix of different materials. This motivates them to demolish buildings step by step. In the province of Liège, competition is tough between recycling players, which makes that selling prices of recycled materials is lower than in other provinces of the country, while they should already be lower than prices of natural resources from quarry. Also, the fact is that entrepreneurs have to reduce transportation as much as possible because it represents a large part of their costs. Therefore, it is necessary for them to have recycling centers close to their building site, which favors also an increasing number of centers in the country.
Entrepreneurs are willing to use recycled materials, as long as their client agree. However, the main issue for RecyLiège nowadays is the mix of concrete and masonry which is a material they get in large quantities and most entrepreneurs are unwilling to buy it.

- Jean-Louis Gerardy, manager of Larco, concrete company located at Welkenraedt; since 2020, Georgy Collard, CEO of Larco, has a project for recycling excess material obtained from concrete production. His goal is to crush the excess concrete into small aggregates in order to obtain a usable by-product to sell. At that point, the company will work in close loop. There are two main motivations :

  1. Reducing the amount of wastes of his company;
  2. Reducing the amount of resources to buy from the quarry.

  On top of that, recycling concrete and producing it at the same place decreases significantly transportation costs for the company. Georgy Collard plans to achieve this project within two years (Bastin, 2020).

- Interviews with road contractors; Tom Genicot, an engineer from TEGEC, explains in his interview that current technology in the road sector makes it possible to separate the different layers that make up the road system. Some of these layers are directly crushed on site for reuse in the foundations of new roads, while other layers are transported to a sorting centre. As the volumes of material are large, transportation costs are a very important cost in this sector. In order to reduce these costs, some companies such as TEGEC have decided to open their own sorting centre. This interview as well as the interview with Louis Martin, engineer for the Luxembourg group "Karp-Kneip", which is also active in this sector, highlighted the fact that many recycling solutions are already available in this sector.

We also had the opportunity to visit the site of RecyLiège. Pictures of this recycling site are given in **Figure 3**. It was impressive to see the way everything was arranged. Trucks were coming to the site at regular intervals, with inert wastes to junk, and took the opportunity to fill their trailer with sand or recycled materials at the same time. Indeed, it is not interesting for such truck to drive with an empty trailer. This makes that the site runs with two kinds of revenues:

1. Firstly when incomers pay to get rid of their wastes;
2. Secondly when they buy recycled materials to fill their empty trailer on the way out.

Moreover, the site is located next to a concrete factory. This is very convenient, as it provides a constant amount of concrete wastes to the site. Finally, the site is part of a new activity zone of industries. As lots of building appear in the surroundings, they get wastes from all those building sites and sell their products at the same time.

This meeting was meaningful for our team. It showed us how a recycling center needs to be thought and designed.

Figure 3: Recycling site of RecyLiège. Left: home office and wasteland for resources storage. Right: crushing engine.

3.3 Metallic wastes sorting

Through our research in industrial waste management, we found out the project PickIt, an automatic metallic waste sorting using artificial intelligence. Founded in collaboration with Citius Engineering, the University of Liège and Comet Traitements, this innovative process really inspired us about how modern technology could enhance waste management. Figure 4 displays the project installation.

Figure 4: PickIt recycling project. From left to right : the project container, a typical mix of metals, robotic waste sorter

During a meeting with the team of PickIt, we had the opportunity to ask them several questions about their technology and its application in the construction sector. Therefore, we learned that this project would be really suited for this sector, as the sensors used to sort the metallic wastes could work nicely with any types of materials. Also, the fact that the engine is located inside of a container makes it easy to transport to a demolition site for instance. It is cost effective for them as the price for a ton of sorted metals is much greater than the one of mixed metallic waste. However, an application of this technology for inert wastes sorting would not as profitable, which is a big obstacle for practical application.

3.4 Polystyrene issue

While most of our interviews highlighted effective ways to recycle construction wastes, it finally appeared to us that polystyrene was still not properly recycled in Wallonia. Through a conversation with the François Pahaut and Olivier Knubben, Tilff Bridge site managers from Galère, we learned that some of the concrete pieces were poured using polystyrene formworks. While this is a practical way to obtain curved shape for concrete, the manager told us that, unfortunately, they did not find solution to get rid of this polystyrene, as it was particularly soiled. As depicted in **Figure 5**, the issue was that they had a really large volume

(around 130 cubic meter of this expanded polystyrene). Eventually, the only solution they found was to give it to a carnival of the region, for tank conceptions. As polystyrene has a large volume for a small mass, transporting it is very expensive.

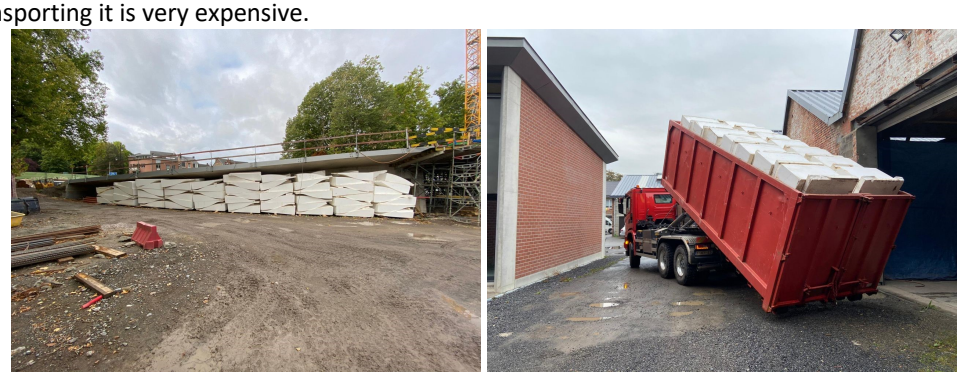

Figure 5: Building site of BAM Galère (BAM-Galère, 2020). Left: 130m^3 of expanded polystyrene. Right: full transportation trailer.

Discussing about this material with Luc Courard taught us that polystyrene products do not pollute the ground and do not release dangerous compounds when washed over by water. However, polystyrene does not degrade naturally and will remain in the environment for more than 100 years. Burning polystyrene and polyurethane (another product used for insulation of buildings) releases toxic fumes that must be treated. In the building sector, a large majority of polystyrene comes from demolition waste of insulation (Léonard et al., 2017). A small percentage of polystyrene is also used for concrete forms with a very specific shape. At the moment, buildings that are being demolished were built before the oil crisis of 1970. At that time, buildings were rarely insulated as heating costs were very low. As a result, the amount of polystyrene being collected today is manageable. Nevertheless, it might be problematic in the future as we demolish more and more insulated buildings. Polystyrene is most often incinerated to produce energy.

When this issue was identified, we interviewed other players of the sector to see if the polystyrene problem was recurrent. Thus, a site manager from Serbi, Robin Smets, told us that their formworks were also made in polystyrene. Their solution was to junk them in container of class 2, which cost them large amount of money (650~~€~~per container + the transportation cost). Furthermore, the polystyrene is problematic as it fills quickly the container. Also, a site manager from Corman Halleux, Etienne Henssen, confided us that polystyrene was increasingly used in their building site.

Of course, polystyrene is not only used in the construction sector. Therefore, we wanted to see if other types of industries experimented the same kind of issues. We interviewed manager from Mediamarkt and La Fnac, but they told us that packaging polystyrene was mainly taken away by the customers. Thus, it ends in collection centers like other household wastes. Also, a kitchen installer from Be Kitchen told us that lots of polystyrene was stacked at the end of each installation. It remains a big constraint for them as they need to drive it to a collection center. In both cases, it is Intradel that manages the waste end of life. About polystyrene, it finishes as fuel for electrical valorisation, rather than recycled into useful by-products.

Solutions exist for the problem we identified, however they are not applied practically by the companies in Wallonia. To solve the transportation issue, there exists compactors, from Mil-Tek for example, that help reduce the volume of polystyrene by 97.5%. From the sustainable point of view, there exists companies that recycle polystyrene. For example, De Vries Recycling B.V. is a company that combines standard polystyrene and recycled polystyrene for their isolating material. Recently, Polystyvert, a Canadian company, innovated in the polystyrene recycling, by using essential oil for dissolution of this material (Savoir-média, 2016). The phenomenon is similar as the dissolution of sugar in water. This is meaningful, as it reduces the volume of the polystyrene to facilitate its transportation. Indeed, the volume of the polystyrene is reduced by 94%. Moreover, this dissolved polystyrene can be sold afterwards as a new primary resource. Such applications transform the life cycle of polystyrene into a closed loop. The fact such companies exist is essential for us, as it shows that there is a market for businesses in this sector.

4 Impact Gap Canvas

In this section, we investigate the identified problem through the Impact Gap Canvas strategy. Therefore, we start by defining the challenge. Then, we highlight the landscape gaps in this sector. Finally, we provide existing solutions that could solve this problem.

4.1 Challenge Mapping

The numerous interviews conducted prior to this report with experts and stakeholders made it possible for us to first map the construction sector in terms of waste management. In a second step, the diversity of the interviews made it possible to analyse several construction materials and construction/renovation waste. Finally, in a third step these interviews enabled us to highlight the issue of the transportation, the volume and the recycling of polystyrene in the construction sector.

The increasing use of polystyrene in the construction sector (formwork, insulation....) leads today to an increase in polystyrene waste on building sites, according to the interviewees. According to Luc Courard, this trend is likely to increase in the coming years, on the one hand through the increasingly widespread use of polystyrene in the construction sector, and, on the other hand, through the demolition of old buildings insulated with polystyrene. Being composed by 98 percents of air, the use of polystyrene leads to a large volume of waste, resulting in high transportation costs for construction companies, which generally have to transport this waste to the recycling centre by their own means.

A few recycling companies in Flanders and the Netherlands offer solution for the recycling of unsoiled polystyrene. However, this the cost of transport is too high to ship wastes over long distances. Based on our interviews in the field, recycling centres currently represent the only recycling solution for building companies in Wallonia. It is estimated that expanded polystyrene wastes account for <1% of total mass of wastes in landfills. However, the space that these waste take in landfills is much higher (Rubio, 2014).

The challenge of this impact strategy mission, which aims to provide a response to the UN's sustainable development goals is therefore to find an entrepreneurial response to the issue of polystyrene waste on building sites. In the first instance, by the reduction of the volume of the polystyrene directly on sites, in order to reduce transportation costs. In the second instance, the challenge is to find better recycling solutions for soiled and clean polystyrene.

4.2 Landscape gaps

As Luc Courard reminds us in his interview, there are four obstacles to the recycling of building materials in the construction sector:

- Firstly, the construction sector is a very traditional sector in its way of operating ("we do as we have always done"). This state of mind does not facilitate the integration of new recycling cycles and the use of new building materials.
- Secondly, the construction sector is a highly codified sector. The approval process for new materials as well as new techniques can take up to 10 years, which considerably slows down the implementation of new construction techniques. As research and development involves large investments, the risk of non-approval leads to reluctance in the sector.
- Thirdly, the construction sector is made up of many construction companies generally operating in a small geographical area. As transport costs are important in this sector, local solutions must exist to resonate with contractors. The owner of small construction companies is often himself a worker in his company and therefore has very little time to find innovative solutions.
- Finally, the recycling and treatment of waste is a fairly recent concept in Wallonia. In the past, all types of construction waste were dumped in landfills. For some years now, inert waste can no longer be landfilled and must be recovered in earthworks for example. Research is also being carried out on other construction materials.

Some solutions currently exist to reduce the volume of polystyrene in companies or directly on the building sites (e.g. Mil-tek), however none of the companies surveyed currently use this method. The cost of these compactors is undoubtedly a hindrance to this type of investment. Companies who do not see the financial interest in investing in a compactor today, as the current volumes of polystyrene are not yet large enough, must nevertheless anticipate the increase in its use.

Furthermore, the companies that recycle are mainly based in Flanders and the Netherlands, the transportation costs are too high for companies in Liège. It should also be noted that all these recycling solutions only recycle unsoiled polystyrene. Most of the polystyrene therefore ends up in recycling centres to be burnt. The fact that the volume is not reduced directly on the construction site and that the soiled polystyrene is actually not recycled are therefore a hindrance to the actual solution.

Moreover, during our research, we discovered an innovative solution, based on essential oils, proposed by the company "Polystyvert". It also enables soiled polystyrene to be recycled for the first time. It seems to be an ideal solution for reducing the volume of polystyrene and recycling it. However, this technology is protected by a patent and does not exist in Europe.

4.3 Solution mapping

A number of solutions exist for the collection and treatment of polystyrene waste. On large sites, class two containers are used to sort this waste. The polystyrene is then transported to the recycling centre. On smaller sites, the transportation of this waste is carried directly by the workers. As the polystyrene is quite bulky, its transportation involves many trips for the company to the recycling centres. This increases considerably the workload of these companies, especially at the end of the construction site.

An internet search highlights the existence of compactors that can be used to reduce the volume of polystyrene. For example, the Brussels company Mil-tek offers various models of polystyrene compactors for different sectors. The use of these compactors makes it possible to reduce the volume of polystyrene by up to 40 times.

Further research also highlights some solutions for the recycling of pure, white, unsoiled polystyrene. One example is the company De Vries Recycling B.V. in the Netherlands, which processes and recycles this polystyrene in order to re-inject it into home insulation. Other projects also make it possible to re-inject up to 30 percents of used polystyrene into new polystyrene sheets.

The Quebec company "Polystyvert" is going one step further. The installation of compactors containing a revolutionary process based on essential oils makes it possible to reduce the volume of polystyrene present in companies in the blink of an eye. This patented process then makes it possible to recover the polystyrene residues and recycle them afterwards. This process also makes it possible to recycle polystyrene soiled by food, dirt... which was not possible until now.

5. Main learnings synthesis

5 Main learnings synthesis

The aim of this section is to synthesize learnings obtained from the research phase and from the conducted interviews.

Through our field research, visits as well as interviews with actors in the construction sector, our study highlights a number of global findings:

- First, the construction sector as well as the demolition sector produces a considerable amount of various types of waste. Some materials such as concrete, wood, steel or metals are now entering a recycling cycle. Thanks to the know-how of numerous university studies, centres of excellence as well as many companies active in recycling being dedicated to these materials, the majority of them are recycled. The recycling of other materials such as polystyrene, plaster, glass wool, tar... is more restrictive.

- Second, the sorting of building materials takes place mainly directly on the construction or demolition site. Four types of containers are separated according to the class of waste present. Each type of container is then transported to a sorting, burying or recycling centre...
  either via external transportation companies or directly by the contractor and his teams.

- Third, as the cost of transporting this waste represents a considerable cost for construction companies, local or nearby solutions are preferred. The fragmented nature of the construction sector, whose radius of action is often spread over a few square kilometres, means that these solutions must be duplicated throughout the territory and be local.

Following the identification of global lessons on the construction sector, our field analysis on the management of polystyrene waste revealed other lessons specific to this construction material:

- Polystyrene is found in many applications in the construction sector. In particular, polystyrene can be used in the formwork of parts of artistic buildings (e.g. on the Tilff Bridge), but it is also used in the pile formwork of various building constructions. The pressure resistance and watertightness of polystyrene give it additional interesting properties, both in terms of protecting consumer goods (TV, fridge, etc.) and certain building materials against breakage. In addition, polystyrene can also be used as thermal insulation in buildings.

- The different uses of polystyrene in the construction and demolition of buildings therefore result in the generation of important waste volumes. The presence of polystyrene in class two containers leads to a more regular emptying process. The treatment and transportation of this waste therefore involves the implementation of logistics and significant transportation costs for construction companies.

- Few solutions exist today in Wallonia concerning the recycling of polystyrene, the majority of this polystyrene therefore ends up mainly in sorting centres. Clean polystyrene can be recycled and re-injected, up to 30 percents, into new polystyrene. Recycling soiled polystyrene is more problematic, so it is not recycled at present.

Polystyrene is a material that is already very present in the current construction sector. Our interviews and field research nevertheless allow us to predict an increase in the use of this material in the future on construction sites. The demolition of recent buildings will also generate significant waste of this kind. This increase in polystyrene consumption will have the effect of increasing the volume of polystyrene waste on building sites.

6 Ideal solution to the identified problem

At the end of this field investigation, we have acquired valuable knowledge and understanding of the problem. This section introduces an idea that we could scale up to solve the problem we identified. The presentation of our solution first states clearly the work to be done and the elements of value looked for by our potential customers. To end with, the section presents our value proposition statement and an explanation of our proposed solution.

6.1 Work to be done

Polystyrene waste management was identified as a problem. Nowadays, businesses get rid of their polystyrene wastes in a way that is very costly in terms of time and money. The applications making use of recycled polystyrene are rare. This leads to a large portion of polystyrene waste being burnt to produce energy.

Work to be done: Find a solution to the problems related to polystyrene on building/demolition site both in terms of transportation and recycling.

Let's note that while our initial search focused on industrial wastes from the building sector exclusively, a solution that meets this work to be done would undeniably please to other polystyrene users.

6.2 Bain's elements of value (B2B)

The elements of value that polystyrene users seek are mainly:

Ease of doing business	Productivity:	Operational:
	Saving time - disposing of polystyrene takes time that could otherwise be invested in doing business	Simplification - polystyrene is a waste that needs to be sorted and disposed of separately. Companies would appreciate a simpler way to get rid of polystyrene
Functional value	Economical:	Performance:
	Cost reduction - the cost of transportation and treatment of container full of waste is important.	Innovation - once collected, polystyrene can be recycled. New applications using recycled polystyrene must therefore be developed.

These 4 elements are located in the B2B bain's elements of value in **Figure 6**. To comply with our field observation, our value proposition must therefore satisfy those 4 needs.

6.3 Value proposition statement

We help polystyrene users **who want to** transport polystyrene waste in a cost and time effective manner and reduce their waste production
by delivering more efficient ways to transport polystyrene and to recycle it **and** prevent waste of resources and pollution.

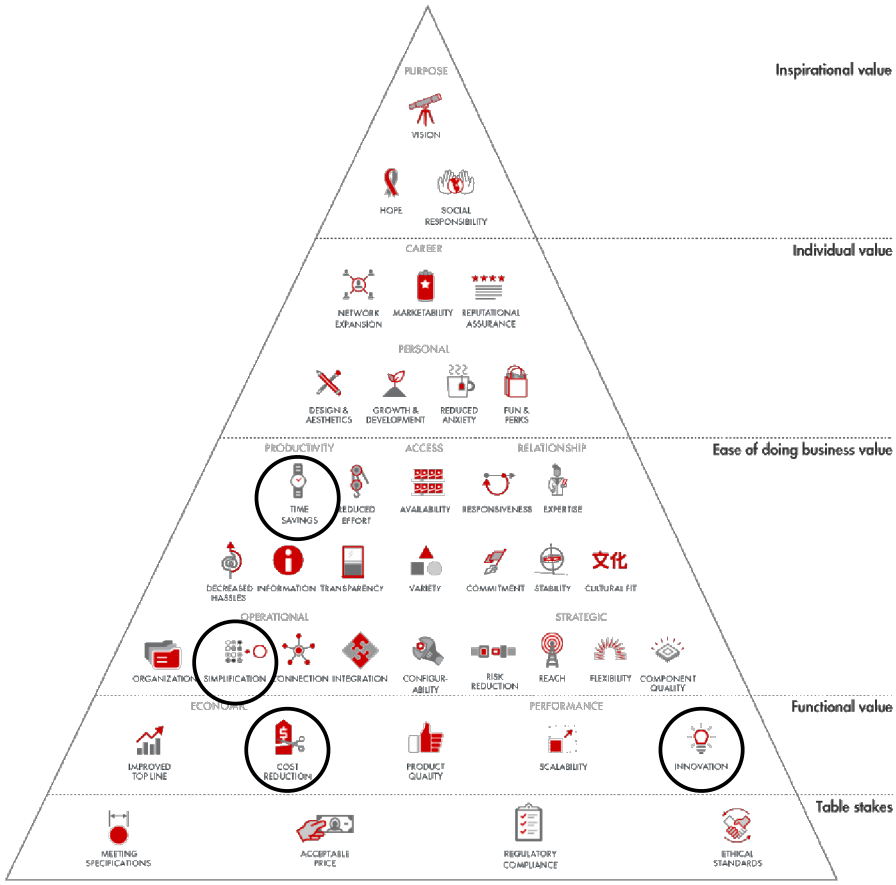

Figure 6: B2B Bain's elements of value.

6.4 Proposed solution

Because the cornerstone of the problem is the volume of polystyrene, our solution must be able to reduce the volume of expanded polystyrene before its transportation. By doing so, the number of truck rides needed to transport the waste to a collect centre will be significantly reduced.

As depicted on **Figure 7**, a dump truck equipped with a compactor on board and a large storage area would go from site to site upon demand of businesses. Because a compactor can reduce the volume of polystyrene up to a factor of $1:40$, it means that one full loaded truck can carry as much as 40 conventional trucks. Such a decrease in number of truck rides would substantially reduced the cost of disposing polystyrene.

Our field researches also pointed that polystyrene users want a simple way to dispose of their waste. Dumping polystyrene at a collect centre takes time that businesses would like to save. As a result, we want our truck to go directly to where the waste is. Businesses do not have to transport their waste, thus they are able to save a considerable amount of time. On top of that, it is hard to imagine anything simpler than a dump truck coming to the site on demand. This would meet the operational criteria of simplifying the disposal of polystyrene.

Once fully loaded with compacted polystyrene, the truck comes back to the collect centre. Collecting wastes generates stocks for which we must find a use. Other than energy production, polystyrene recycling rate is very low. Our solution to this problem is to use a solvent to dissolve polystyrene. Acetone is one out of several solvent that is able to entirely dissolve polystyrene. This process removes all the air trapped into the polystyrene waste. Because the air escapes, the only product remaining is raw

polystyrene. Following a cleaning and purification process if needed, this substance can be then be sold for the making of any polystyrene product.

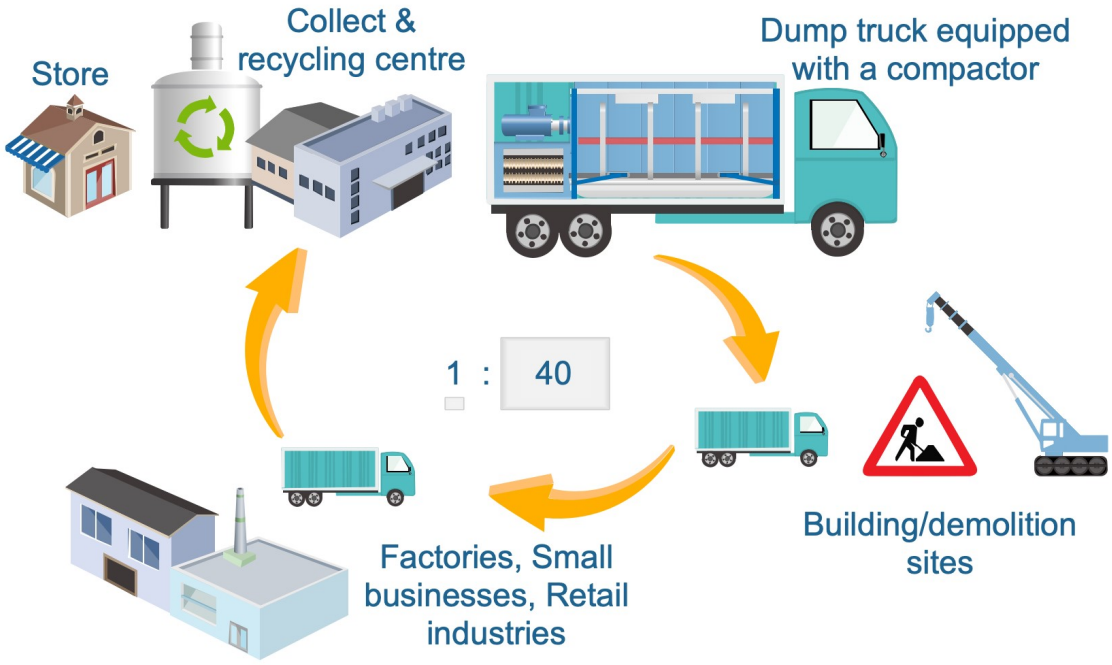

Figure 7: Schematic drawing of the solution.

Pretotyping our solution requires that we verify that polystyrene users are willing to give their polystyrene away directly from their activity site. If this assumption is met, our idea can be developed. In this case, we would have to discuss with polystyrene users the modalities of our service (such as the frequency of our collection, the time of our coming, whether we should come on demand or on a regular basis, etc).

7 Conclusion

Throughout this mission, we have experimented with a systematic methodology that can be used to identify problem and opportunities in line with UN's sustainable development goals. To begin with, we determined a set of sustainable development goals that we wanted to tackle. Based on that, we identified the most relevant sector of activity to work on.

Before acting and trying to find solutions, we focused on:

1. Accurately scaling the dimensions of the problems;
2. Understanding the causes;
3. Finding a line of attack (work to be done).

For this reason, we visited local players and interviewed companies and individuals who deal with this problem daily. They provided us with valuable information on the effects of the problem on their activity and the cost of not doing anything. During the benchmarking, we got insights on the current situation, on the solutions that exist and the reasons why the problem still exists.

Step after step, this strategy led us to define a real problem that we could work on. Lastly, relying on our backgrounds, our acquired knowledge in the field and our creativity, we put forward an idea that would solve the problem.

The writing of this report ends on October 26. List of contributors to this mission is provided in Appendix 1 in **Figure 8**.

1 Appendix - List of contributors

Name	Company	Job	Successful discussion
Luc Courard	Uliège	Professor and researcher	Yes
Olivier Knubben	BAM Galère	Building site manager	Yes
François Pahaut	BAM Galère	Building site manager	Yes
Louis Martin	Karp Kneip	Building site manager	Yes
Marine Meys	BPC Liège	Project engineer	Yes
Charle-Eric Bourge	BPC Wallonie	Quality, Safety and Env. manager	Yes
Anatoli Boxus	Be Kitchen	Junior kitchen installer	Yes
Bérengère Franck	Greish	Civil engineer	Yes
Michel Leroy	RecyLiège	Manager	Yes
Jean-Louis Gerardy	Larco	Manager	Yes
Robert Baudinet	ULiège, Citius Engineering	Engineer	Yes
Tom Genicot	TEGEC	Engineer	Yes
/	Fnac	Manager Fnac Liège	Yes
/	Médiamarkt	Manager Mediamarkt Liège	Yes
Robin Smets	Serbi	Site Manager	Yes
Etienne Henssen	Corman Halleux	Site Manager	Yes
Ricardo Dibarbora	City of Liège	/	No
Mister Visyni	Thomas & Piron	Employee at Thomas et Piron	No
Catherine Coppens	L'A.R.I Uliege	Director	No
Total : 19 Stakeholders contacted			

Figure 8: List of contributors

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