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A REFLOW CASE STUDY

Vejle’s Road to Becoming a Circular Plasti-city

Implementing Circular Plastic Interventions in a Key Focal Area

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement number 820937.

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Implementing Circular Plastic Interventions in a Key Focal Area

Figure 1: Photo by Aleksandra Tsvigun on Unsplash

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Author(s)	Erika Hayashi (CBS); Dina Bekkevold Lingås (CBS)

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"Plastic products and packaging have an undeniably important role in our society. Plastic waste should not. Not only does plastic waste pollute our land and ocean – to the detriment of wildlife and humans – but the loss of plastic from the current plastic economy is an economic drain. Plastic waste is a problem we can solve, and we need to solve now."

Catherine Novelli, US Under Secretary of State for Economic Growth, Energy and the Environment

It was November 2019 and the Vejle team comprised of the Municipality of Vejle and the Danish Design Center (DDC), alongside their Steering Committee consisting of politicians, managers, and employees at the Municipality of Vejle, citizens from the local council, and a representative from DDC found themselves in a key moment of decision-making: *which focal area should they focus their circular plastic interventions in?* Clearly it needed to be one that would make the greatest impact towards transitioning the city's linear plastic stream to becoming circular and regenerative and to reach their long-term goal of reducing plastic use, increasing plastic reuse and improving recycling.

The city of Vejle became part of the REFLOW journey, a three-year European Horizon 2020 project running from 2019 to 2022 aiming to develop circular and regenerative cities[1] to address a complex array of global challenges realized through real and radical systemic change and which could keep the planet within safe planetary boundaries. The project utilized a pilot approach where six diverse European pilot cities would tackle a specific material stream in their urban areas by co-creating innovative circular solutions to be tested, implemented, and eventually scaled across other European cities and beyond. As a pilot city, Vejle sought to tackle their problematic plastic material streams in the city. Like many other European cities, the accumulation of non-recyclable plastic, plastic-based waste, and poor waste management was a significant problem faced by Vejle through which finding a more circular approach to plastic was key.

Leading up to the Vejle pilot team's moment of decision, they had undertaken extensive research to identify 4 possible focal areas for circular interventions that could address the plastic problem in Vejle. These were construction, healthcare, food retail, and households. Paired with each focal area, the team identified a micro-test site as a representation of the bigger picture and where the actual testing of circular plastic interventions would take place. Because plastics were an all-encompassing material – reaching across all sectors and aspects of society – the team decided that the best way to reach their long-term goal within a three-year timeframe would be to develop and test circular plastic interventions in one key focal area at a micro-scale test site. By using this approach, the team would have the ability to invest the necessary resources and to produce promising results.

[1] A circular economy is an economic system that is regenerative by design. Circular economy sees the elimination of waste and the recirculation of resources to tackle the challenges of global climate change, biodiversity loss, waste, and pollution. A circular and regenerative city in REFLOW represents an urban system with social and business practices which place equal attention to social, environmental, and economic impact; where technology is open and represents a central enabler of positive social and environmental change; where the urban system ensures and supports the resilience of social and ecological systems; where governance is collaborative and inclusive; where knowledge is shared, and stakeholders are active and involved.

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Simultaneously, while the Vejle team looked towards their long-term goal associated with their decision, they needed to achieve a short-term target of a 25% reduction in the quantity of plastic waste sent to incinerators within their chosen focal area's test site by May 2022. The team was up against a pressing three-year deadline from the REFLOW project and felt the urgent need to start the process of co-developing innovative circular plastic interventions. Thus, the team needed to have made their final decision of which focal area they would focus their circular interventions on fast. To ensure they were making the right decision, as part of their research carried out prior to this decision, the team sought to build up their knowledge of the plastic problem and the reality of plastic production, use, and waste in the city of Vejle. These results were circulated amongst the Vejle pilot team and Steering Committee to inform their final decision.

Understanding the Plastic Problem

The invention of plastics led to a revolutionary shift in the everyday lives of people across the globe. Proclaimed as "the material of a thousand uses[i]", plastics were seen as a multi-functional, adaptable, and inexpensive material derived from fossil fuels that could replace more expensive and scarce natural resources such as steel, bone, wood, and stone. Over the course of a century, plastic production had produced 8.3 billion tonnes worldwide as of 2020[ii]. Despite its celebrated innovation, plastics came with a long list of environmental and human health challenges.

As the world entered into the period known as the transition twenties, scientists persistently warned of the environmental and societal consequences that would occur if the planet hit a global warming above 1.5°C. The production of plastic had contributed significantly to increasing temperatures, mainly because plastic was made from petroleum, which when burned, released CO_2. To add further fuel to the fire, despite being a multi-functional and durable "material of a thousand uses", half of all plastics produced were ironically single-use, fundamentally designed to be used once and then thrown away[iii] with most of this waste being incinerated. Further, sites of plastic production and incineration were plagued with highly toxic compounds in the air people were breathing[iv] whilst plastic waste continued to pollute the world's oceans, fresh water supplies, and the soil, leading people and wildlife unwillingly consuming microplastic and plastic diets. This linear[2] model of plastic production, use, and disposal had therefore unmistakably worsened the impacts on the climate, environment, and society worldwide. To tackle this global challenge, plastics rapidly became a high priority on the global climate agenda.

From the European Union context, the plastic problem cutting across Denmark and the other EU Member States, stemmed greatly from plastic packaging and single-use plastics. In the EU, 60% of the region's 25 million tonnes of annual plastic waste was made up from packaging and single-use plastics[v]. To tackle this problem, the EU Single-Use Plastic Directive was put into force, which required the removal of 10 single-use plastics products from the EU market[3].

[2] Linear refers to an economic model following the principles of 'take-make-waste'. In this system, value is built up from producing and selling as many products as possible. Production of these products follow the linear steps of extracting often finite supplies of raw materials, transforming these into products, using these products, and then discarding these products as waste.

[3] Cotton bud sticks; cutlery, plates, straws, and stirrers; balloons and sticks for balloons; food containers; cups for beverages; beverage containers; cigarette butts; plastic bags; packets and wrappers; wet wipes and sanitary items.

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Compared to other European countries, Denmark topped in the ranking of municipal waste generation in Europe[vi], of which 350,000 tonnes or 12% was plastic[vii]. To make it worse, Denmark was at the bottom of the list when it came to recycling of municipal plastic waste, with only 17% being recycled[viii] out of which 13% was recycled in Denmark and 28% was exported to be recycled abroad. 2% of this plastic waste ended up in the landfill and a whopping 57% was incinerated[ix], with 34% of this stemming from households[x]. To address the Danish plastic problem, the Danish government released a National Plastic Action Plan in 2018 to reach the vision of circular plastic consumption in Denmark.

At the local-level, the Municipality of Vejle was home to a little over 110,00 inhabitants, making up just under 2% of Denmark's population in 2021. Despite its relatively small size, the city still played a role in the Danish and EU plastic problem. Over the course of one year[4], the city consumed 23,300 tonnes of plastic and generated 8,600 tonnes of plastic waste. Of this, 63% was incinerated, 29% was recycled, 4% was reused, 3% was used for substitute fuel production, and about 1% was sent to the landfill[xi]. The municipality was working on becoming a resilient and sustainable city, with waste management and recycling as a strategic goal. While this provided an overview of the plastic problem which Vejle was faced with, understanding the plastic problem on the ground offered key information for their decision.

Understanding the Plastic Types

Understanding that there was not just one type of plastic but in fact, many, provided the team with valuable information. The various types of plastic were associated with significant differences in characteristics, product types and sectors, as well as environmental impacts. To gather an initial baseline for understanding these differences, the team investigated the characteristics and usage of products across the 7 most common plastics types.

[4] Based on 2018 data.

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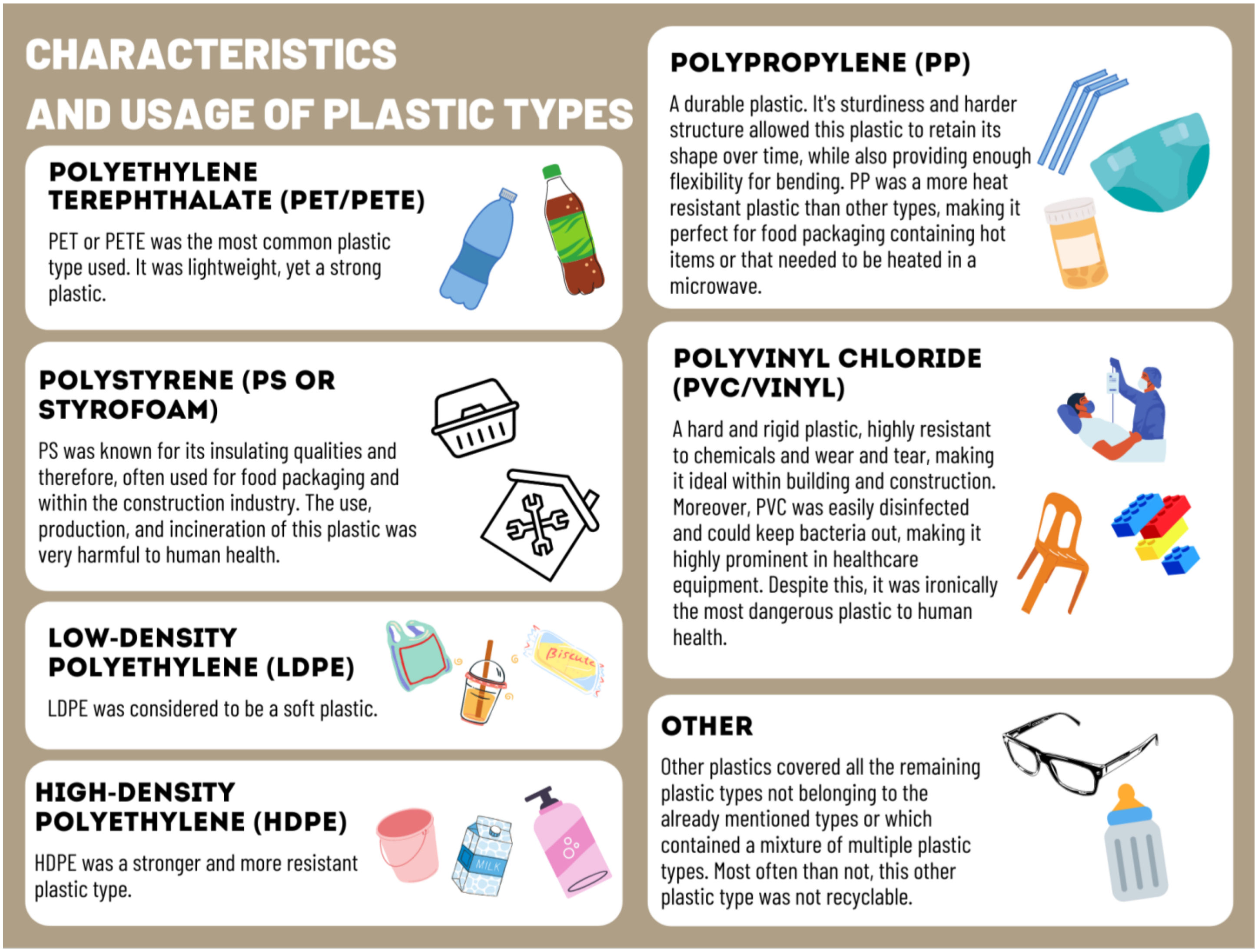

Figure 1: Characteristics of Plastic Types and Common Use in Products[xii]

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Plastic in Vejle

Based on this initial understanding of plastic types, the Vejle team then looked specifically at their own city. To gather a better understanding of the plastic problem particular to Vejle, the team needed to understand the different types of plastic that were in the city's material flow based on three factors: (1) quantities; (2) use; and (3) their environmental impact. This localized information was essential for the team in their decision-making process.

Quantity of Plastic Types in Vejle

To start, the team looked into the average amount of plastic consumption based on different plastic types in the city. Of the specified types of plastics being consumed by Vejle, polypropylene (PP), other[5], low-density polyethylene (LDPE), and high-density polyethylene (HDPE) accounted for the greatest plastic consumption types in Vejle.

Plastic Types Consumed into Vejle		
Plastic Type	**Amount in Tonnes**	**Percentage of Vejle's Total Plastic Consumption**
Not Specified	5,000 tonnes	21%
Polypropylene (PP)	4,500 tonnes	19%
Other	4,500 tonnes	19%
Low-Density Polyethylene (LDPE)	3,700 tonnes	16%
High-Density Polyethylene (HDPE)	3,000 tonnes	13%
Polystyrene (PS or Styrofoam)	1,300 tonnes	6%
Polyethylene Terephthalate (PET or PETE)	700 tonnes	3%
Polyvinyl Chloride (PVC or Vinyl)	580 tonnes	2%

Table 1: Plastic consumption in Vejle by plastic type[xiii].

Use of Plastic Types in Vejle

Turning their focus to the different usages of plastic types for products, the team found the following key information after conducting a thorough material plastic analysis[6].

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[6] See Appendix 1 for more details.

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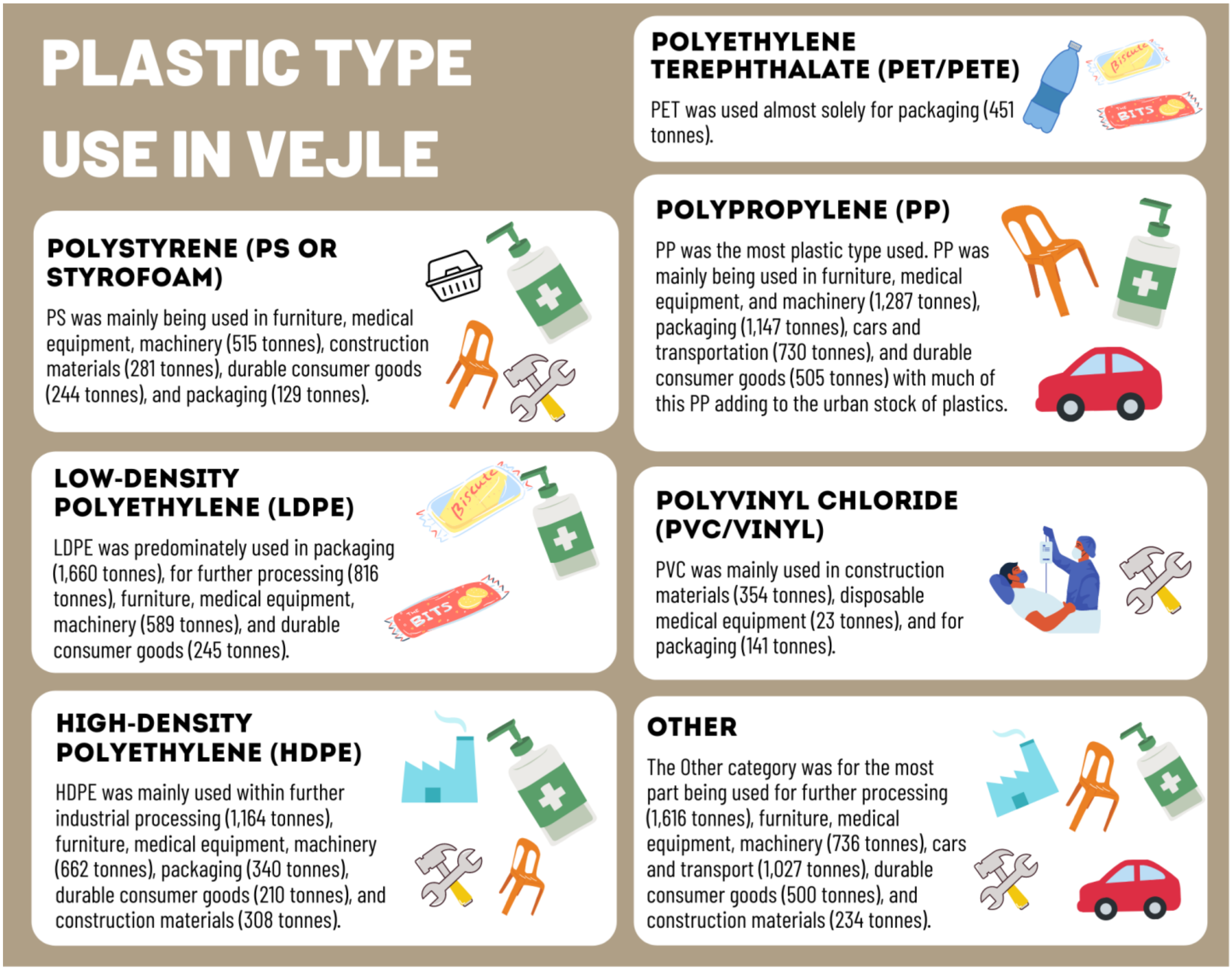

Figure 2: Overview of the use of different plastic types in Vejle.[xiv]

Environmental Impact of Plastic Types in Vejle

While these insights provided the team with an immense amount of data, they knew that the impact of plastic wasn't solely linked to quantity. Other factors such as the environmental and health impacts of plastic types during production and disposal also need to be considered in reaching the goal of producing the highest possible impact. To pinpoint these other conditions associated with generating the greatest impact, the team coordinator outlined the environmental and human health impacts linked to plastic types.

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Production of Plastic Types

The impacts of plastic production were often found outside of Vejle's boundaries, as the majority of plastics entering into the city came as finished plastic products. This meant that much of the impact surrounding global warming, human toxicity and air pollution were felt in the places where plastic production occurred. When looking at the CO_2 emissions associated with the production of plastic types, the total amount of specified plastic types found in Vejle contributed to 32,000 tonnes of CO_2 emissions[xv]. Emissions were driven mainly by the volume of the plastic type rather than by the type itself. On the other hand, human health impacts, indicated by human toxicity, told another story. Specific plastic types were, in fact, found to be responsible for high degrees of human toxicity. In this case, it was PET and PVC that were the most toxic for humans during its production. While the quantities of PVC coming into Vejle were relatively small, the associated effects on human health during its production were excessive.

Waste Management of Plastic Types

When it came to the waste management of plastic types – which was mainly incineration, this was found to release greenhouse gases and other air pollutants into the local environment. Crucially, PVC was indicated as an outlier of the environmental impact associated with its incineration, reaching a significantly higher human toxicity rate than the other plastic types, even though in terms of quantity was not particularly high in Vejle's plastic stream. Further, PP was also pinpointed as a plastic type which released a significantly higher amount of greenhouse gases during its incineration than the other plastic types.

To wrap up on the plastic facts and figures presented in the first half of the meeting, the pilot team coordinator turned to Vejle's Pilot Strategy and how they were going to use the information gathered to indicate the direction they could take.

The Vejle Pilot Strategy

Targeting one focal area within Vejle was just a fraction of the work that needed to be tackled if the city wanted to fully transition towards becoming circular and regenerative. The team believed if they could address a specific area through circular economy interventions, they could generate a vital impact not only within the chosen focal area, but which could also create momentum across other sectors. Further, they believed that the following four different focal areas could be represented by a micro-test site, through which circular interventions would take place. Through this micro-test site approach, the team felt that they could dig deeper into the associated plastic problems within the focal area from the bottom up. Thus, allowing them to truly understand the plastic challenges and behaviours on the ground. The four potential focal areas and their representative test sites were as follows:

Plastic in Vejle's Focal Areas and Test Sites[xvi]

Focal Area 1: Construction

Construction accounted for *19% of the total final and finished plastic good consumption* in the city. Plastic was mostly consumed as construction materials, generally made from PP, Other, LDPE, HDPE, PS, and PVC. The import of construction materials was the main source of PVC entering into Vejle's plastic stream. The focal area

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accounted on average for *18% of Vejle's total plastic waste, showing that most of what was consumed rapidly ended up as waste*.

The high degree of human toxicity associated with the production, use, and incineration of PVC was a key leverage point within the construction focal area. Since many construction materials being used by the construction industry were composed of PVC, targeting circular interventions within this focal area had great potential for generating great impact.

The Test Site: Trekant's Masonry Business

The construction focal area was represented by the small local business, Trekant's Masonry Business. The company employed two full-time masons who worked mainly on residential buildings and small renovation projects for private customers around Vejle and its environs. The company was well connected with other companies within the sector. Plastic consumption within Trekant's Masonry Business was mainly comprised of soft plastic packaging and hard plastics used in construction materials such as plastic concrete mixing tubs, which were reused 5 to 6 times before being disposed of.

Focal Area 2: Healthcare

The healthcare focal area was made up of hospitals and some public institutions such as elderly care homes. In Vejle, hospitals accounted for *2% of the total final and finished plastic good consumption*. Public institutions, by and large, accounted for *2% of the total final and finished plastic consumption* in the city. Hospital and public institutions' consumption of plastic mainly came from disposable medical equipment, plastic packaging, and durable consumer goods. Although only *less than 1% of final and finished plastic goods* imported in Vejle were derived from *disposable medical equipment*, largely produced using PVC and LDPE, the actors in the healthcare focal area were the only consumers of this plastic product. Plastic waste generated within this focal area accounted for *just over 3% of Vejle's total plastic waste*.

Like construction, PVC – particularly soft PVC – was a prominent plastic type being used in healthcare. With PVC being one of the most problematic plastics when it came to its high human toxicity rate, focusing in on healthcare could possibly generate the biggest and most long-lasting impact.

The Test Site: Sofiegården

The healthcare focal area was represented by the public elderly care home, Sofiegården. Sofiegården comprised of 50 apartments for the 50 elderly residents. In addition to the elderly residents, Sofiegården employed 100 homecare workers, administrators, and assistants. When it came to plastics in disposable medical equipment, the test site consumed and disposed of diapers, colostomy bag parts, pill boxes, medicine containers, and the associated packaging for these products While this disposable medical equipment was mainly being handled by the staff at Sofiegården, the elderly residents contributed to plastic consumption and waste, though, for example, food packaging. Residents were responsible for sorting their own plastic waste, made possible by mobile sorting stations located on each floor of the elderly care home.

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Focal Area 3: Food and Retail

The food industry accounted for approximately *24% of finished plastic goods* in Vejle, with the vast *majority consisting of packaging*. The local food industry in Vejle, was the second largest consumer of plastic packaging in the city. However, the majority of the finished goods encased in plastic packaging were exported out of the city. Retailers, including food retailers, were responsible for around *9% of final and finished plastic good consumption* in the city and mainly came from packaging and durable consumer goods. Much of the waste generated by these retailers was collected through privately owned waste management companies. In total, this focal area was responsible for generating *10% of Vejle's plastic waste*. Despite the amount of plastic being found in food packaging across retailers, much of the consumption and plastic waste generation was passed onto the citizens of Vejle through the purchasing of food items packaged in plastic.

Unrecyclable, contaminated, and problematic food packaging was a key issue in Vejle's plastic flows. Moreover, across Vejle's food retailers, products were sold packaged in materials that could not be recovered by the waste management system in the municipality. This included highly problematic, unrecyclable, and toxic plastics such as *black plastics, multi-layer packaging, EPS trays used for meat and cheese, and a small share of PVC packaging.*

The Test Site: Rema 1000

The food industry and retail focal area were represented by a local franchise of the international supermarket chain, REMA 1000. The supermarket was a no-frills discount chain with 868 stores – 616 in Norway and 270 in Denmark. The majority of plastics being consumed, disposed of and sold to customers consisted mainly of food packaging, plastic bottles, plastic crates, and plastic meat trays. The actual plastic packaging of food sold to customers was determined by the franchisor REMA 1000 Denmark for REMA 1000's own line of products. The remainder of the products found in the store were packaged from external suppliers. Other plastic at the test site, not sold to customers, involved the plastic crates received during deliveries of bread, meat, and milk. These crates were returned to the supplier after products were placed on shelves. Furthermore, the store was also an access point where citizens could return their plastic bottles under the Danish deposit bottle system which were then sent and handled as part of the Danish bottle return scheme. Much of the plastic waste at the actual site was found to be LDPE, which is found in plastic bags, food packaging, and trays.

Focal Area 4: Households

Households w accounted for *53% of the total final and finished plastic good consumption* in Vejle. Much of the plastic consumption within households was attributed to plastic packaging, primarily food packaging, culminating to1,880 tonnes. Plastic packaging was highly problematic, in the sense that much of this was unnecessary and short-lived. Furthermore, plastic packaging typically had low reprocessing and reuse rates after its disposal.

While households were large consumers of plastic, they were also largely responsible in sorting plastics correctly during their disposal. This entailed reducing the amount of recyclable plastic waste mixed into residual waste which was being sent directly to incinerators. If the Vejle team were to choose this focal area, they knew that they had a bigger chance of reaching their short-term target of reducing 25% of plastic being sent to incineration since the volume of plastic consumption, waste and incorrect sorting was so high. Despite this however, the team also wondered if this focal area would help to create the greatest impact in the long-term.

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The Test Site: Den Gamle Gård

Households were represented by the apartment complex, Den Gamle Gård. Den Gamle Gård was a 4-storey apartment building built during 1933 to 1937 and consisting of 289 social housing units. Much of the plastic consumed and disposed of at the test site was made up of plastic packaging and other single-use plastics. Waste at Den Gamle Gård was municipally managed. Residents had 24-hour access to 9 communal outdoor waste facilities, each in equal distance to residents in the apartment complex. Housed within the 9 outdoor waste facilities, were two bins for residual waste, 1 bin for organic, 1 bin for plastic/metal, and 1 for paper. Each bin within the waste facility was equipped with informative signs and pictures on the lids and above the specific containers. Issues of overflowing of waste containers was brought up at the test site. On average, the test site generated 56.2 kilograms of plastic waste *in residual waste* a week, with 4% of residual waste being made up of plastic. Much of this plastic waste found in residual waste consisted of shampoo bottles, empty plastic containers, and food packaging. Plastic food packaging was also found in organic waste, making up 6.5% of the volume.

Achieving Impactful Circular Interventions in Vejle: Decision Time

The Vejle team faced considerable challenges as they endeavoured to select a focal area which would lead them towards reaching their long-term goal of reducing plastic waste and increasing the reuse and recycling of plastics. They needed to ensure that the focal area they chose to implement their circular interventions in met the criteria associated with achieving the *greatest long-term impact*, namely:

- The scalability of the circular intervention (local, regional, national, international scale)
- The possible reduction in the quantity of plastic going to waste
- The relatively greater reduction of negative environmental and human health impacts based on plastic types
- The level of the intervention within the waste hierarchy, prioritizing the higher levels (prevention – preparing for re-use – recycling – recovery – disposal)[7]

Additionally, the team had to consider their short-term goal of decreasing the amount of incinerated plastics by 25% at the test site. Across the potential focal area test sites it was unclear to the Vejle team which would be the preferred site for their short-term goal.

What were the trade-offs within each focal area? Were there any synergies among them? Should they choose a focal area with the most environmental and human health impact, or should they focus on reducing the quantity of problem plastic types? Were some options better for certain impact generating conditions, if so, what? Was there a fundamental conflict between their short- and long-term goals? The team grappled with these questions as they searched for clarity in their dilemma to help guide them towards reaching their ambitious goals and target.

[7] Prevention: using less material in design and manufacture, keeping products for longer, re-use, using less hazardous materials; preparing for re-use: checking, cleaning, repairing, refurbishing whole items or spare parts; recycling: turning waste into a new substance or product; Recovery: incineration with energy recovery; disposal: landfill and incineration without energy recovery.

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Notes

[i] See reference in Crespy et al.'s 100 Years of Bakelite, the Material of a 1000 Uses.

[ii] From the UNEP's webpage on Beat Plastic Pollution.

[iii] From the UNEP's webpage on Beat Plastic Pollution.

[iv] See the IPCC report Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for further infomation.

[v] From the European Union's report on changing the way we use plastics.

[vi] From Eurostat's statistic on municipal waste.

[vii] From Statista's statistic on the share of plastic waste in municipal solid waste worldwide as of 2018, by region.

[viii] From DAKOFA's report on Plast.

[ix] Based on Eurostat's Municipal waste statistics.

[x] Read more in Aage Vestergaard Larsen's article contribution on State of Green, Changing plastic household waste to high quality recycled granulate.

[xi] From Corbin et al.'s report Urban Metabolism Analysis: Initial Assessment's chapter on Vejle's plastic material flow analysis.

[xii] From Bahraini's overview of 7 Types of Plastic that you need to know.

[xiii] From Corbin et al.'s report Urban Metabolism Analysis: Initial Assessment's chapter on Vejle's plastic material flow analysis.

[xiv] From Corbin et al.'s report Urban Metabolism Analysis: Initial Assessment's chapter on Vejle's plastic material flow analysis.

[xv] From Corbin et al.'s report Urban Metabolism Analysis: Initial Assessment's chapter on Vejle's plastic material flow analysis.

[xvi] See Corbin et al.'s report Urban Metabolism Analysis: Initial Assessment's chapter on Vejle's plastic material flow analysis for a full overview of plastic flows across the focal areas.

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