



THE CHALLENGE OF CIRCULARITY FOR SMALL AND MEDIUM SIZED ENTERPRISES, IN THE UK PVC, WINDOW PROFILE EXTRUSION INDUSTRY

MSc International Innovation Management

Williams, Nathan
2126256@student.uwtsd.ac.uk

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Introduction

Polyvinyl chloride (PVC) is one of the world's most commonly produced plastics. Although the thermoplastic is manufactured from 57% salt and typically 43% hydrocarbon oil, PVC is considered resource efficient, requiring less non-renewable fossil fuel to produce than other commodity plastics that are entirely derived from oil (British plastics federation, (No date)).

In the production of virgin material, electrolysis is used to form chlorine from the salt (NaCl), which is reacted with ethylene in the presence of a catalyst, to form Ethylene Dichloride (EDC). EDC is converted to Vinyl Chloride Monomer (VCM) which is the initial building block of PVC. VCM is then added to water, agitated, pressurised and heated in a process known as polymerization to form PVC resin. Complex additive packs are mixed with PVC resin, to manipulate its characteristics, forming compounds known as 'dry blends'. Additives enhance the versatility of the compound and can be formulated to meet unique technical specifications, which are used in industries throughout the world, from building and construction to medical and fashion.

Since the industrialisation of the polymer, PVC has become the world's third most used plastic and since the 1930's, global demand has soared with nearly 21 million tons of PVC produced annually. In 2021 the industry generated a revenue worth around US\$78.90 billion, with approximately US\$101.45 billion projected by 2028 (Zion market research, 2022). Despite its rise in popularity, PVC has not developed without its fair share of controversy and as demand for the polymer increased, so did concerns regarding the sustainability of the material. In 1998, PVC production in Western Europe reached 5.5 million tonnes per year, contributing to 26% of global production (communities, 2000). A lack of infrastructure and legislation to manage post-consumer waste, resulted in an estimated 2.6 to 2.9 million tonnes of PVC waste disposed in landfill (communities, 2000). In addition to the environmental impact posed by PVC, health concerns surrounding the toxicity of its additives, further tarnished the reputation of the product. Communities and governments called for change (Williams, 2022).

In 2000, the European PVC industry united, launching Vinyl 2010. The voluntary initiative spanned across all sectors of the industry, from material suppliers to recyclers, with the aim of cleaning up the image of the polymer (Williams, 2022). Research conducted by the organisation, set ambitious sustainability targets and outlined a strategic, collaborative plan (Williams, 2022) which helped initiate the shift away from linear business models to circular, closed loop concepts.

The scale of the issue is highlighted in research published by The Organisation for Economic Co-operation and Development (OECD) who estimated that global plastics production doubled from 2000 to 2019 to reach 507 million tons, with only 9% being recycled. An alarming 50% ended up in land fill with 22% being dumped illegally (OECD, 2022). Data modelling was used to predict that plastic use and plastic waste could almost treble by 2060, with less than a fifth being recycled. The report also stated that although secondary plastics could experience quicker growth, it would still only make up 12% of the of all plastics in 2060 (OECD, 2022). Within the PVC industry, the OECD reported that global use reached over 50 million Tons in 2021 and by 2030 is projected to reach over 64 million Tons (OECD, 2022). The building and construction sector has special requirements (including for durability and strength) for the plastics it uses. The most

commonly used plastic is polyvinyl chloride (PVC), accounting for 43 % of plastic used in the sector. In fact, 69 % of all PVC produced is used in building and construction (Häkkinen, 2021)

Despite advances in innovation, considerable investment in infrastructure and greater market pull for recycled PVC, it remains evident that sustainability in the plastic industry as a whole is struggling to keep pace with consumer demand. This research proposal examines sustainability within the PVC window profile industry and explores challenges faced by smaller profile manufacturers, competing with larger organisations for waste material. It investigates internal and external processes and attempts to understand if small profile businesses can effectively contribute to sustainability within the PVC industry.

Overview of the mechanical recycling process for PVC window frames.

Material used in the recycling process is fed from two waste streams, post-industrial and post-consumer waste. Post industrial waste is generated from PVC extrusion and fabrication processes. Extrusion head waste, start-up scrap, swarf and offcuts are all unavoidable by products of the converting and fabricating profile. Mechanical recycling post-industrial waste can be carried out at source or transported to a recycling facility. First, waste is manually sorted, segregating by colour and then granulated into small chips. The chipped material is then passed through an optical colour sorter which removes rubber. Clean chipped material can be fed directly into extruders, however, for more efficient processing, material is typically pulverised into a micronised powder.

Mechanical post-consumer waste recycling requires a more complex recovery process. Frames collected from site are broken up using hammer mills to detach mixed materials such as reinforcing bars, fixing and furniture. The hammer mill also creates a denser, more manageable material for transport. Waste is delivered to a recycling facility and manually sorted. The waste is fed through shredders where magnets are used to remove metals. Shredded material is then washed and granulated. As with post-industrial waste chips, optical colour sorters remove rubber, non-metal fragments and separate colours. Granules are then micronised into powder form. To further purify the material, an additional level of screening is needed. The pulverised powder is extruded and any remaining contaminants are removed using a process known as melt filtration. Following the filtration process, extruded strands are cut into pellets, ready to be used in the manufacture of new window profiles.

Challenges faced by SMEs

Material availability

For smaller organisations, the availability of internal post-industrial waste is considerably limited. As businesses improve machine and processing efficiencies, scrap volumes reduce, forcing them to look externally to fabricators and recycling businesses for clean waste. This presents further challenges. In an interview conducted with Barry McCarthy, uPVC recycling consultant and former Operations Support and Projects Director at Duraflex, he states “what extrusion businesses struggle with, is that customers are

not obligated to return their offcuts” (McCarthy, 2022). As window fabricators typically use multiple profile suppliers, offcuts are often returned to the largest supplier to negotiate more favourable profile or offcut prices, “we are in an industry where cost almost overrides everything else. Most of our external offcuts waste streams are purely based on our long-standing relationships with our customers and generating new, large volume waste streams is near impossible, as we simply cannot compete on price, with the large profile manufacturers” (McCarthy, 2022).

Post-consumer waste supplies the industry with significantly greater volumes of material for reuse, providing smaller businesses with the opportunity to establish external waste streams. Regarded as a dirty material, waste is collected from used profiles from homes and construction sites and contains mixed materials, such as rubber seals, metal fixings, silicone and mortar. Despite the vast quantities of waste available, removing contamination from the material so it is clean enough to process, presents even bigger challenges to smaller business. Unlike post-industrial recycling, considerably greater capital investment in infrastructure is required for businesses to internally manage post-consumer waste on a scale that would be feasible to smaller organisations. With a network of around 150 PVC recyclers throughout the whole of Europe (VinylPlus, 2021), businesses planning to use external recyclers, undergo the challenge of finding one capable and with the knowledge, equipment and capacity, to recover profiles to the specifications and volumes required to remain cost effective. Material availability is further compounded by the excellent properties of PVC, which unlike other plastics PVC is extremely durable and weatherable with a 30-40 year lifespan.

Infrastructure

Compared to mechanical post-consumer recycling, the infrastructure required to internally recycle post-industrial waste may be a more manageable prospect. Although businesses are still faced with an investment requirement, a growing second-hand market for refurbished machinery creates a more affordable opportunity for smaller businesses, nevertheless even a small-scale operation presents significant challenges. Businesses would need the footprint to expand their facilities and modify existing processes to incorporate new machinery, as offsite facilities would result in additional transportation costs. A rudimentary facility required to manage offcuts and clean scrap profile would consist of a granulator, pulveriser, and conveying equipment. Dedicated operators would also be required to manage the process. Sorting internal scrap produced with rubber seals or foils, does present a bigger challenge. To manage this process internally, SMEs should expect significantly increased cost, as optical colour sorting equipment is required. Without



Fig 1. photo take on site visit - Shredding and granulating line at RPCS

this resource, mixed post-Industrial waste would either require external sorting or would be sold to recycling firms.

Internal post-consumer waste recycling poses enormous challenges for smaller businesses and unlike recycling post-industrial waste, which could be undertaken as a large project, internal post-consumer waste management requires radical changes to business models. Organising waste collection that guarantees raw material availability and quality is a strategic task (Lewandowski, 2022). Vast logistical networks would need to be established to collect, sort and transport waste to recycling facilities, requiring large fleets of vehicles, satellite facilities and operators. Large



Fig 2. Massive volume of post-consumer waste at Veka recycling facility (VEKA, 2021)

purpose-built recycling centres would be essential to handle large volume of waste flows. Machinery costs would also be a factor that some SMEs may consider unfeasible. Unlike post-industrial recycling, where an operation may consist of one or two systems, large scale post-consumer recycling requires multiple, complex systems carrying out sorting, shredding, grinding and pellet extrusion. An example of the scale of this type of facility is Veka recycling, who, in 2018, invested 15 million in a 6-acre purpose-built recycling centre in Northamptonshire and claim to have capacity to recycle 35000 Tons of PVC windows annually (Veka, 2022)

Waste preparation

Segregation of waste is a critical factor in the recycling process and, if mismanaged, can result in businesses seeing less return for scrap or unable to use the material in their process. Efficient collection and separation processes are prerequisites for enabling high yields in recovery and recycling. Organisations with large recycling facilities employ dedicated sorters who manually sort waste, this is followed by secondary mechanical separation and is carried out on both post-industrial and post-consumer waste. In SMEs, post-industrial waste sorting is carried out by machine operators, with offcuts and scrap profile segregated by colour in designated areas. Lack of worker education and weak processes within smaller businesses, results in mixed colour waste, that when granulated, produces non-white chips known as Jazz. This material is less desirable for use in the manufacture of new window profiles and due to the significantly off-white colour is sold for a lower value per Ton compared to segregated waste. SME's purchasing clean sorted waste from external recyclers, are also face the challenge of competing with the huge demand from markets that don't require white PVC. McCarthy (2022) questioned "Why would recyclers invest in colour sorting equipment and commit extra resource to provide clean waste to extruding SMEs, when they can just re-grind mixed colours and sell to mass market such as the pipe industry, for a slight reduction in price, this significantly reduces material availability for small extrusion businesses".

Transportation costs

Collection and distribution of waste is also a difficult factor for SMEs. Vehicles, drivers and fuel costs all increase the price of waste. Larger organisations span large networks using strategically located regional recyclers as satellite hubs, who collect and condense the material for more efficient lorry loading. Condensed material is then collected and delivered to the main recycling facility for rework. For smaller organisations, to make waste collection feasible, transport cost must be kept to a minimum. The return journey from customer deliveries, presents an opportunity to collect offcuts from window fabricators, as lorries are unladen. This process can still be problematic due to the limited space on each lorry. Smaller businesses need to be selective in their approach, as customers offering small volumes of offcuts could be rejected to leave space for those with larger offerings. This challenge was highlighted by McCarthy (2022) “if we had a customer that could supply us with 5 Tons of offcuts a week and four customers with 1 Ton a week, we would have to turn the 4 customers down, saving space for the larger offering. To make collections work, there cannot be any additional cost involved” (McCarthy, 2022). This issue means that easily recyclable post-industrial waste, available to SMEs is being rejected as it is deemed not cost effective to recycle.

Processing

Extruding PVC recyclate requires specialist co-extrusion technology, that is a necessity in producing new windows profile, using recycled material. During process of co-extrusion, Virgin material and recycled PVC is extruded through a single specially arranged die. One extruder pushes recycled material through the core of the profile, while another extrudes a skin of virgin material encasing it. The virgin layer provides specific functional and visual properties, as well as reinforcing the recyclate layers with lower mechanical properties (Lewandowski, 2022). Co-extrusion technology requires significant investment, with the introduction of specialist dies, secondary extruders and modifications to material conveying systems. This is an inhibiting factor for SMEs as the cost of new machinery is balanced against material availability, McCarty (2022) stated “ It is all very well, purchasing and installing new core technology, but if you cannot secure reliable, high quality waste streams, then you will have no choice other than to run these machines on virgin material which is counterproductive and not cost effective”

Literature Review

The aim of this literature review is to draw upon existing research, to explore the current recycling challenges and to identify similarities with those faced by UK SMEs.

Many reports published in European member states highlight challenges with PVC recycling. In 2020 the Circular Plastic Alliance (CPA) issued a report titled the ‘State of play for collected and sorted plastic waste from construction.’ The CPA found that in most EU 27 countries, construction or post-consumer waste is first sorted on site, then collected by waste management specialists and delivered to a recycling facility, where manual sorting and mechanical sorting takes place. The report also recognised the high quality and value attributed to used window frames stating ‘PVC window waste can be easily identified and picked

out from the waste stream in the sorting process, without the need for sophisticated sorting technology. It is straightforward to identify PVC windows by sight and therefore contamination from other plastics is minimal.' As with business models in the UK, the report's findings acknowledge the need for the organised logistical networks that could be deemed not feasible for UK SMEs

The CPA highlighting the general ease in sorting and recycling compared to other plastic combined with its ability to be recycled back into new profiles, leads to very high demand for material from recyclers who are willing to pay for frames. Included in the reports 'key challenges' were separate collection and sorting, mixed waste and material availability compared due to the longevity of PVC.

In another report carried out by Reichel et al. (2019) on behalf of the European Environment Agency pointed out one constraint to creating circular environments within plastics as 'complexity of collecting and sorting', adding that within Europe 'there is also a growing amount of investment going into improving waste management infrastructures.' The paper also commented on the importance of circular business models also highlighting that 'Current business models in the plastics industry are dominated by traditional and very linear business models enabling the extraction, production, consumption and waste management of plastics, with little or no focus on circularity.'

Most interestingly, research conducted by Schuyler et al. (2022) into PVC recycling in Australia, identifies many challenges that could be easily compared with those faced by UK SMEs. The first was insufficient supply and lack of recyclers to produce a supply of secondary input material. The report states 'the development of new re-processors is certainly limited by small volumes. The lack of adequate supply has almost certainly led to the cessation of schemes to recycle the small volumes of flexible plastic PVC recycling from municipal sources' As with UK infrastructure, a lack of internal and external re-processing facilities decreases the availability of feedstock supply for SMEs within the fenestration industry.

Another challenge faced by both Australian and UK SMEs is difficulties in collecting post-consumer waste, with the paper suggesting that 'Collecting post-consumer PVC separated at source requires specific collection processes and consumer behaviours to ensure an effective and contaminant-free supply.' The report noted that 'as result of the difficulties associated with collection and sourcing a clean supply of secondary PVC, compounders often establish closed loop collection arrangements, with PVC manufacturers who send them the 'offcuts' from their manufacturing processes.' As with UK fenestration, SMEs struggling to manage secondary waste streams turn their attention to forming post-industrial waste networks with existing suppliers, resulting in zero contribution to the reduction on waste to landfill.

Although waste transportation challenges are amplified due to the sparsely populated demographic of the country, the research also pointed out the logistics and density inefficiencies of collecting waste, as a factor that adds additional costs to the process, often rendering the collection not feasible.

The report also highlights constraints with processing recycled PVC, suggesting material use would be limited to certain product types due to design and specification of goods. It also detailed the technical challenges of operating co-extruders and the finance and space to purchase and house them, all issues shared by UK SMEs.

Lewandowski and Skórczewska (2022) in their review of PVC recycling, highlighted the contrast in complexity between post-industrial and post-consumer waste, noting 'Mechanical recycling of manufacturing waste seems particularly well-grounded. It is definitely the easiest, since it concerns a material of a defined composition and properties, and an appropriate manufacturing organisation at a company enables, in many cases, uses already-owned equipment extruders, mills, agitators.' The review detailed the challenges when in developing adequate technologies capable of segregating post-consumer waste, suggesting that the versatility of PVC and its ability to be simply modified actually 'constituted as a significant hindrance' to the recycling process. This issue was also suggested by Ciacchi, Passarini and Vassuraa (2016) who stated 'Collection and separation is a prerequisite for enabling recovery and recycling. Contamination is a great barrier for plastic recycling and the presence of different polymers in the flow to be recycled may limit recovery process efficiency.'

Collection and material availability of post-consumer waste was also identified by Lewandowski and Skórczewska as a challenge for firms. Their report described the how 'organising waste collection that guarantees raw material availability and quality is a strategic task', highlighting the requirement for changes in business models and investment that larger UK firms seem to have successfully conducted.

The report also commented that the excellent properties of PVC such as weatherability and durability, limits the availability of post-consumer material, due to the long lifespan of the polymer compared to other plastics.

A visit to RPCS a small plastic recycling management company, provided example of the scale of infrastructure required to manage post-industrial waste alone. A sizable facility operating, three granulating lines, three pulverising lines and one shredder give me an indication of the sheer size of an operation requires to recycle thousands of tonnes of post-consumer waste.

Observations from Literature review

While there appears to be a considerable amount of literature focusing on sustainability and circularity within the plastics industry over the last two decades, there is significantly less specifically concentrated within the PVC window manufacturing sector, especially focussing on the challenges and barriers faced by SMEs and how they compete with larger organisations for waste material and effectively contribute to sustainability. Although there is significant and obvious coverage regarding plastics impact on the environment from media and governments, much of the literature covered by organisations, such as VinylPlus and British Plastics Federation (BPF) appear to highlight and promote the successes and progress of the sector in more detail than the challenges currently faced. There is a gap in information available, concentrated on UK SME's, regarding PVC window circularity.

Research methodology

The literature reviewed as part of this proposal identifies considerable research gaps regarding the challenges and barriers for SMEs in the PVC window extrusion industry, attempting to create circular business models. This research aims to collect data and focussed feedback, directly from businesses within

the UK industry, which once analysed could be used to generate improvement ideas or as a source of information for SMEs new to PVC recycling.

Data collection

To evaluate these challenges, 3 methods are proposed.

1. In the first method a targeted questionnaire will produce qualitative data.
2. The second method will invite the reader to provide written recommendations, thoughts and feedback. This will produce qualitative data source.
3. The third Method will comprise of interviews, this will also provide qualitative data.

The combination of qualitative data collected from inside and outside the extrusion industry, will help address the gaps found in the current literature available and could be used referenced as holistic viewpoints directly from UK PVC extrusion businesses and key stakeholders.

Using the BPF directory to access company details, twenty UK PVC extrusion firms will be selected. The companies will represent small, medium and large enterprises. The recipients of the questionnaire will hold company positions of operations manager and above. The questionnaire will be presented with a column stating factors that contribute to circularity. The second column titled 'inhibiting factor' invites the reader to assess a series of statements that negatively impact or inhibit circularity within the industry. Finally, the third column asks the reader to rate the statement to the extent to which they feel it impacts circularity within the industry. Impact ratings will be scored 1 – 5, with one representing 'no impact' and 5 representing 'severe impact'.

The questionnaire will be sent via email. Also included in the email, a short question will ask the reader to participate in providing personal feedback. The question, 'What changes do you think would accelerate circularity in SMEs within the PVC window manufacturing industry?'.

Interviews will be arranged with three UK PVC window fabricators and three UK PVC waste management firms. The original questionnaire will be adapted to provide interview style data collection. This will aim to get the perspective of individuals outside of extrusion businesses.

Data Analysis

It is important that all data gathered using the questionnaire, open question and interview method is categorised then analysed to compare and correlate findings.

1. Questionnaire Data

Businesses that complete the survey will be placed in order of businesses sizes using definitions of large, small and medium enterprises issued by the UK Department for Business, Energy and Industrial strategy shown in Fig 3

Fig 3. Definition of businesses (Gov.uk, 2021)

Term	Definition
Large business	a business with 250 or more employees
Medium-sized business	a business with 50 to 249 employees
Small business	a business with 0 to 49 employees

Ratings submitted from each business for each impact statement will be added together to give the total score for each statement. Once this has been completed for each impact statement, statements will be placed in order of most severe to least.

Businesses will also be grouped in terms of large, small and medium enterprises. As with the first task, impact ratings selected for each statement, from all businesses in the group size, will be totalled. Statements will be placed in order of those deemed most severe to least, for each group. This will help compare similarities and form correlations.

Totals can also be added up for each contributing factor. This can also be analysed, for individual companies and also business size groups to show which contributor is deemed the biggest impact.

2. Open Question Feedback

To best highlight the opinions of the participants, suggestions and opinions from the open question will be reviewed and an additional analysis report will be written, drawing upon and summarising the feedback. To add a visual element to the analysis, prominent statements from each question will be added to a word cloud. The names of businesses and participants will be left anonymous in the report, to encourage participation.

3. Interview notes

As with the open question feedback, interview notes from waste management firms and fabricators will also form part of the additional report, helping add an additional layer paper.

Fig4. Questionnaire

Contributor to circularity	Inhibiting factors	Comments	<i>Contributor to circularity'</i>- Factors that contribute to circularity. <i>'Inhibiting factor'</i>- Statements that negatively impact or inhibit circularity within the industry. <i>'Impact rating'</i>- 'Rate impact to circularity within the industry' Rate 1-5 0 representing- No impact 1 representing- Very low 2 representing- Low 3 representing- Medium 4 representing- High 5 representing- Very high
Correct segregation of post-industrial waste (on-site)	Behaviours and attitude of workers		
	Education and awareness of importance of segregation		
	Inadequate collection facilities (e.g. bins, containers)		
	Labour resource available to segregate		
Recovery of post-industrial waste (on-site)	Inadequate machinery to recover material (e.g. regrind, pulverise, convey)		
	Inadequate footprint to house recycling machinery (e.g. granulators, Pulverisers, shredders)		
	Insufficient post-industrial waste for feasible investment in machinery		
	Insufficient labour resource for post-industrial waste recovery		
	Insufficient collection capability (frames from site)		
	Insufficient sorting capability		
Recovery of post-consumer waste (on-site)	Insufficient knowledge/expertise		
	Inadequate machinery to recover post-consumer (e.g. sort, shred, regrind, pulverise, filter)		
	Inadequate footprint to house recycling machinery (e.g. granulators, Pulverisers, shredders, colour sorters)		
	Insufficient post-consumer waste for feasible investment in machinery		
	Insufficient labour resource for post-consumer waste recovery		
External post-industrial material availability (Off cuts from customers, Regrind or micronised from recyclers)	Insufficient knowledge/expertise		
	Insufficient material availability from recyclers		
	Insufficient material availability from customers		
	Cost of material availability from recyclers		
External post-consumer material availability (Micronised or pellet)	Insufficient collection capability		
	Insufficient material availability from recyclers		
	Limited recycling/waste management companies		
	Cost of material availability from recyclers		
Processing of recycled waste	Poor quality poor material supply		
	Insufficient technology to process material (e.g. Co-extrusion, conveying)		
	Poor market pull for recycled goods		

Fig 5. Interview questions

Contributor to circularity	To what impact do the following statement effects circularity in SMEs in UK PVC window profile manufacturing?	Comments	<i>Contributor to circularity'-</i> Factors that contribute to circularity. <i>'Inhibiting factor'-</i> Statements that negatively impact or inhibit circularity within the industry.
Correct segregation of post-industrial waste (on-site)	Behaviours and attitude of workers		
	Education and awareness of importance of segregation		
	Inadequate collection facilities (e.g. bins, containers)		
	Labour resource available to segregate		
Recovery of post-industrial waste (on-site)	Inadequate machinery to recover material (e.g. regrind, pulverise, convey)		
	Inadequate footprint to house recycling machinery (e.g. granulators, Pulverisers, shredders)		
	Insufficient post-industrial waste for feasible investment in machinery		
	Insufficient labour resource for post-industrial waste recovery		
	Insufficient collection capability (frames from site)		
	Insufficient sorting capability		
Recovery of post-consumer waste (on-site)	Insufficient knowledge/expertise		
	Inadequate machinery to recover post-consumer (e.g. sort, shred, regrind, pulverise, filter)		
	Inadequate footprint to house recycling machinery (e.g. granulators, Pulverisers, shredders, colour sorters)		
	Insufficient post-consumer waste for feasible investment in machinery		
	Insufficient labour resource for post-consumer waste recovery		
	Insufficient knowledge/expertise		
External post-industrial material availability (Off cuts from customers, Regrind or micronised from recyclers)	Insufficient material availability from recyclers		
	Insufficient material availability from customers		
	Cost of material availability from recyclers		
	Insufficient collection capability		
External post-consumer material availability (Micronised or pellet)	Insufficient material availability from recyclers		
	Limited recycling/waste management companies		
	Cost of material availability from recyclers		
	Poor quality poor material supply		
Processing of recycled waste	Insufficient technology to process material (e.g. Co-extrusion, conveying)		
	Poor market pull for recycled goods		

Results

As part of this research proposal, the following research methods have been carried out.

- Site visit to a small recycling plant
- Interviews an industry expert
- Literature review
- Drawing on my own experiences within the industry

Combining the information I have gathered, I expect the results to show all inhibiting factors posing a very high impact to small firms with recovery of post-consumer waste contributors scoring the highest.

In medium sized businesses, I expect recycling of post-industrial waste and processing recycled waste, to pose less impact, as some basic infrastructure may already have been established. Medium sized firms could also rate segregation as medium impact, as they have resource to segregate, however awareness of the importance of sorting may be lacking. I also expect material availability of post-consumer waste to be a major impact to medium businesses due to considerable competition and limited infrastructure within the UK to enable it.

In larger businesses I expect none of the inhibiting factors to pose any major impact to circularity. Segregation could however still factor as a low-medium impact, due to the complex nature of the task and the process investment required for training, resource and machinery.

From the interviews conducted with fabrication and recycling firms, I anticipate segregation, collection and transportation be the biggest topic for discussion. As these are the factors I believe could most improve waste streams in and out of their business.

Evaluation

To conclude, research for this proposal has highlighted the lack of specific literature, specifically focusing on the challenges faced by SMEs in the UK PVC extrusion industry, attempting to create circular models within their businesses. A successful outcome for the research is that it may address some of the gaps identified in current literature and maybe as a reference of reliable feedback direct from the industry. The quality of the data maybe impacted by the return rate of questionnaires, reluctance to reveal company information and the availability of participants who hold senior position within businesses.

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