

Expanded polystyrene in a circular economy: barriers and pathways to recycling in Greater Manchester, UK

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Research Article

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Abstract

Background

Expanded polystyrene (EPS) is light, insulating, and protective, but these same traits make it costly to collect, hard to recycle, and slow to degrade, and it sheds buoyant microplastics into the environment. Although recycling technology exists, recycling rates remain low. This study asks what really holds EPS circularity back at a regional scale.

Methods

We paired a focused review of the academic and grey literature with semi-structured interviews of industry actors and local authority officials working on EPS use, collection, recycling, or waste policy across the Greater Manchester Combined Authority (GMCA) area. Interviews were recorded with consent, transcribed, and thematically analysed.

Results

Early circular practices are emerging, most visibly turning EPS packaging waste into insulation panels. However, participants repeatedly named the same barriers: low public awareness, bulky low-density waste that is expensive to move, contamination, underused processing technology, weak demand for recycled EPS, and vague regulation. The main constraint was governance and information, not technical feasibility.

Conclusions

EPS can enter a circular economy in Greater Manchester when policy, infrastructure, data, and public engagement are combined. The strongest levers are standardised waste characterisation, standing stakeholder platforms, investment in local processing, and coherent policies, including extended producer responsibility.

Plain language summary

Expanded polystyrene (EPS), a white foam used in packaging and building insulation, is difficult to deal with once thrown away. It is light and bulky, so it is expensive to collect and transport, it breaks into tiny pieces that pollute land and water, and most of it is buried or burned rather than recycled. This study examined how EPS waste is handled in Greater Manchester by talking to people who make, use, collect, and recycle it, and by reviewing published research. The main finding is that the technology to recycle EPS already exists; the real problems are poor information about how much EPS there is and where it goes, weak coordination between the organisations involved, gaps in local recycling facilities, low public

awareness, and unclear rules. The paper suggests practical steps, including better data, joint working, investment in local processing, public education, and firmer policy, to turn EPS from a troublesome waste into a resource that is kept in use.

1. Introduction

Plastic pollution is among the most pressing environmental problems of our time, and it deepens each year as global plastic production exceeds 300 million metric tons. (Trang et al., 2021) Plastics are cheap, versatile, and durable, which has made them fixtures of modern economies; these same properties allow them to persist in nature and turn their waste into a management burden. (Oluwatobi et al., 2024) Among plastics, expanded polystyrene (EPS) is a notable case because of its heavy use in packaging, insulation, and construction. It is light, insulates well, and protects fragile goods across packaging, construction, and civil engineering, making it difficult to replace. (British Plastics Federation, 2025) Yet those qualities also make it barely recyclable in practice, expensive to collect, and harmful over long timescales. (Ugwu & Obele, 2023)

Globally, only approximately 9% to 10% of plastics are recycled; the rest are landfilled, incinerated, or lost to land and water. (Venkatachalam et al., 2024) EPS is particularly problematic because of its low density and bulk, which make it costly to gather, haul, and treat; thus, it holds little appeal for many waste operations. The result is frequent escape into rivers, shorelines, and the ocean, where it fragments into microplastics that resist cleanup and pose ecological and human health risks. (Montalvo-Romero et al., 2022)

This study approaches EPS pollution through the lens of the circular economy, a framework that aims to decouple economic growth from resource depletion by fostering sustainable production and consumption. At its centre are the 3R principles of reduce, reuse, and recycle, whose purpose is to minimise waste and extract the most value from every resource. (Aranda et al., 2023) Focusing on the Greater Manchester Combined Authority (GMCA) area of the United Kingdom, the study examines local EPS waste practices, surrounding policy, and the obstacles industry meets. By combining the literature with new qualitative evidence from semi-structured interviews with industry experts and council officials, it identifies realistic ways to increase EPS recyclability and reduce its environmental toll. The central argument is that the main bottlenecks to EPS circularity in Greater Manchester lie in governance and information rather than technical feasibility, and that coordinated data systems, stakeholder platforms, and regionally tailored infrastructure are the levers most likely to unlock progress. (Ambrosious et al., 2025)

2. Plastic pollution and EPS: background

Plastic pollution refers to the accumulation and dispersion of plastic debris in natural settings, where durability and resistance to biodegradation keep it present for the long term. (Van Emmerik et al., 2023) Because plastics are water-repellent and often have low density, they travel readily across land and

water, and they now contaminate soils, rivers, lakes, and oceans, with fragments recorded from mountain heights to deep-sea trenches. A further concern is that plastic surfaces take up heavy metals, persistent organic pollutants, and disease-bearing microbes, moving and concentrating these agents through ecosystems and food webs. (Scopetani et al., 2023) Therefore, the risks run deeper than the visible objects.

Microplastics (below 5 mm) and nanoplastics (under 100 nm) have drawn growing scrutiny for being widespread and potentially harmful. They come from both larger debris fracturing and primary microplastics made for industry. Because they are so small, organisms across the food web, from plankton to fish, seabirds, and mammals, take them up, with recorded harm to growth, reproduction, and physiology. (Ziani et al., 2023) EPS is a notable source because it fragments rather than degrades, shedding many small, buoyant particles that wind and water easily disperse. (Jalaudin Basha et al., 2023)

The drivers of EPS pollution are systemic. Large-scale production, single-use habits, and weak waste infrastructure together tip high volumes into the environment each year. (Fayshal, 2024) EPS routinely appears in disposable packaging, from food containers to electronics wrap, and in insulation, where offcuts and construction debris are common. (Ansari, 2022) Material is also lost along the value chain when containment fails, while littering, illegal dumping, and weak collection let EPS reach drains, rivers, and the coast. (Mellink et al., 2021) Low awareness and weak incentives to separate waste raise leakage further, and gaps in collection, sorting, and specialist recycling leave councils poorly placed to manage EPS well. (Olusola Olaitan et al., 2021)

The environmental consequences are significant. An estimated 14 million tons of plastic waste reach the oceans each year, affecting more than 700 marine species through ingestion, entanglement, and habitat smothering. (Tekman et al., 2022) EPS adds to this through its persistence, buoyancy, and tendency to fragment; once ingested, particles can injure animals, reduce feeding, and carry absorbed pollutants. (Vagi et al., 2021) On land, and when burned under poor conditions, EPS can release toxic additives and residual monomers, and incinerating it alongside other plastics can emit dioxins and furans linked to respiratory illness and cancer. (Isaeva et al., 2023) Industry sources contest EPS's share of marine litter, estimating that foamed plastics make up a small fraction of ocean plastics and that under 1% of European beach litter is polystyrene, while noting that microplastic research is still developing. (British Plastics Federation, 2024) Regardless, these impacts point to the need for waste strategies built on prevention, reuse, and recycling.

3. Circular economy and the 3R principles for EPS

The circular economy recasts conventional patterns of production and consumption, foregrounding resource efficiency, waste reduction, and the continued use of materials. Against the linear “take, make, dispose” model, it closes material loops through redesign, repair, remanufacturing, and recycling, so that products are recovered at the end of life and fed back into production rather than discarded. (Solomon et

al., 2024) The 3R principles form its backbone: “reduce” engineers out unnecessary waste and consumption, “reuse” extends the working life of products and parts, and “recycle” reclaims materials from spent goods so they re-enter the economy. (Apriyani et al., 2021) A circular system depends on manufacturers, consumers, policymakers, and waste operators acting together, supported by rules and incentives that reward eco-design, extended producer responsibility (EPR), and high-grade recycling. (Darkoh, 2024; Knapčíková et al., 2025)

Applied to EPS, the three principles play distinct roles. **Reduce** means placing less EPS on the market, and therefore, less into the waste stream. Careful design can trim the thickness and bulk of EPS packaging without losing protection, while switching to biodegradable foams, fibre-based packaging, or recycled composites can cut impact where the application allows and lower transport emissions. (Rabelo et al., 2025) Policy adds pressure: bans or limits on particular single-use EPS items, taxes on EPS products, and robust EPR schemes each discourage overuse and steer producers toward greener design. (Wagner, 2020)

Reuse capitalises on the durability and insulating properties of EPS. In construction, EPS insulation panels can be recovered during refurbishment or demolition and reused with little loss of performance, retaining the embodied energy and reducing the demand for new EPS. (Sletnes et al., 2026) This matters because EPS insulation contributes materially to building energy efficiency, and the heating and cooling of buildings accounts for a large share of total energy use; therefore, keeping functioning insulation in service preserves both material and operational energy savings. (British Plastics Federation, 2008) Newer approaches convert EPS waste into building blocks, insulation aggregate, or filler for composite construction products, lengthening the material’s useful life and improving resource efficiency. (Rajeshwaran et al., 2025)

Recycling is technically achievable but is constrained by economics and logistics. Mechanical methods densify EPS through compaction or melting to make transport worthwhile, after which the stock can be reshaped into products such as picture frames, skirting boards, or insulation panels. Chemical recycling offers an alternative, breaking EPS into styrene monomers that can be purified and repolymerised into polystyrene equivalent to virgin resin. (Ugwu & Obele, 2023) Both routes can, in principle, run EPS through several cycles with little loss of quality; however, the economics remain limited by high transport and processing costs, contamination, and an erratic market for recycled EPS; therefore, scaling requires investment, supportive policy, and deliberate market building. (Xu et al., 2024)

These constraints recur as familiar barriers. Low density makes transport to central plants slow and costly, eroding recycling economics where landfill or incineration is cheap. Contamination with food residue or adhesives complicates sorting, lowering yield and value, and equipment such as densifiers and drop-off points is scarce in many areas. Awareness tends to be low; therefore, EPS is often sorted poorly or binned with general waste, cutting both the volume and quality available for recycling. (öpfer et al., 2025; Ugwu & Obele, 2023) Overcoming them requires policy, technology, capacity building, and stakeholder engagement. (Lageard et al., 2026)

4. Methodology

To examine EPS waste practices and circular economy prospects in Greater Manchester, this study used a qualitative approach. Semi-structured interviews were conducted with key stakeholders, including industry experts and council officials working within the GMCA area. Participants were selected for their direct involvement in plastic waste management, EPS use and recycling, or relevant policy and regulatory roles.

Semi-structured interviews were chosen for their capacity to yield rich, contextual insights while leaving room to pursue themes as they arose. An interview guide covered current practice for collecting, separating, and disposing of EPS; views on recyclability and existing recycling schemes; the economic, technological, and logistical barriers to recycling; policy drivers, gaps, and opportunities; and perspectives on circular economy strategies and future prospects.

With consent, the interviews were recorded, transcribed, and thematically analysed. This qualitative evidence was set alongside academic and grey literature to build a rounded view of EPS waste management in the region. Combining the two provided a firm basis for identifying systemic problems, highlighting practices that work, and framing recommendations suited to the local settings. Identifiable information was replaced with codes, and data were stored securely, with access limited to the research team, consistent with the terms of ethical approval.

5. Findings

This section draws on semi-structured interviews with participants who produce, use, collect, and treat EPS in Greater Manchester. The conversations examined how EPS waste is handled today, what obstructs better collection and recycling, and where participants saw opportunities for improvement. Table 1 summarises the main themes by stakeholder type, showing where views converge and diverge, and sets up the analysis that follows the table.

Table 1

Thematic summary of stakeholder-reported challenges and opportunities for EPS management in Greater Manchester

Participant	Key challenges reported	Opportunities identified
A (Industry)	Petroleum-based origin; legacy EPS containing banned HBCD flame retardant (only incineration feasible); high transport emissions for non-compacted EPS; scarce UK recycling facilities (export raises footprint); dirty and cross-contaminated inflows; costs passed to consumers; and difficulty in building infrastructure and logistics.	Engagement with influential bodies (e.g., Ellen MacArthur Foundation) to shape perceptions and policy; long-term council trials as learning models; collaborative networks; proven models as regional benchmarks; third-party segregation to improve efficiency.
B (Industry)	These difficulties include monitoring recycling effectiveness, contamination during retrieval, and the fact that much EPS is still landfilled or incinerated. Inaccurate public perception, competition from materials perceived as greener, and the non-recyclability of pre-2016 fire-retardant EPS not being recyclable under the new rules are also challenges.	Studies that improve the image of EPS can shift public perception and support council-supported household collection.
C (Industry)	Ensuring intake quality; higher transport and processing costs than incineration or landfill; inconsistent EPS inflow; household collection logistics; varied practice between councils; legacy view of EPS as insignificant for recycling.	Public education and awareness, collaboration on a circular EPS model, and effective household collection systems.
D (Council)	Collecting lightweight EPS from households; quality loss when mixed with other materials; separate high-cost vehicles required; added cost for collection authorities.	Multi-stakeholder communication and coordination; structured, contract-based collection of EPS waste.
E (Council)	Limited facilities for selective material recycling and a limited market for EPS waste and recycle.	Standardising recycling collection practices creates an avenue for EPS inclusion.

5.1 EPS recycling rates and practices

In Greater Manchester, EPS recycling remains comparatively new but is gaining pace. Industry figures suggest that national EPS recycling is more established than local practices imply: the British Plastics Federation reports that around 55 per cent of EPS packaging disposed of in the UK was recycled in 2020, rising to an estimated 66 per cent in 2023 on industry calculations, and that EPS is recycled in at least 38 countries, with rates above 70 per cent in Norway and above 50 per cent in several other European countries. (British Plastics Federation, 2024) These are industry estimates, and the gap between them and the nascent, uneven collection described by participants underlines that recyclability in principle does not guarantee recycling in practice. Interview data show that some local schemes and private operators are testing methods that convert EPS waste into higher-value goods rather than routing it to

landfills or incineration. A notable example is the conversion of EPS packaging waste into construction insulation panels, diverting material from disposal while generating durable, energy-efficient products. These nascent practices draw support from changing policy signals and mechanisms that reward sustainable waste handling and low-carbon technology. Participants noted rising interest among local authorities and firms in closed-loop systems for plastics as environmental rules and public expectations tighten. (Vdi, 2023)

A key technical strength underscored by the interviews is that EPS can be recycled repeatedly without much loss of its structural and insulating properties, which distinguishes it from plastics that downcycle heavily. (Ugwu & Obele, 2023) Given effective collection and processing, EPS can therefore pass through several product lives, easing the demand on virgin feedstock.

5.2 Challenges identified

Despite this movement, stakeholders have identified several barriers that limit the scale and effectiveness of EPS recycling.

Social and behavioural barriers. Public understanding of EPS recyclability was widely reported to be slight. Many residents and small businesses either do not know that EPS can be recycled or are unsure how and where, which yields low uptake of separate collection, high rates of EPS discarded with residual waste, and contamination of other recycling streams. Interviewees pressed for sustained education and plain communication, reinforcing the study's argument that information and engagement matter as much as any technical fix. (Lageard et al., 2026)

Logistical and infrastructural barriers must be addressed. The low bulk density of EPS makes transportation to central facilities costly, and collecting small amounts from scattered points is seldom cost-effective. Existing waste systems are often not configured to separate EPS at the source or at recovery facilities, and the lack of dedicated drop-off points, densifiers, and specialist processing within the region was seen as a major curb on scaling up. (Ugwu & Obele, 2023)

Technological constraints. Options for handling contaminated or mixed EPS are underdeveloped or underused. Interviewees noted the difficulty of cleaning, sorting, and processing mixed EPS efficiently, which lowers the yield and quality; although densification and mechanical recycling exist, deploying them at scale requires capital and favourable market conditions. (Ugwu & Obele, 2023)

Economic and regulatory barriers exist. Stakeholders described a difficult business case: cheap virgin EPS, unstable demand for recycled output, and thin financial rewards for recovery, all of which eroded profits. Regulations were considered too vague to enforce systematic collection and recycling. Without firmer policy signals, whether EPR schemes, minimum recycled-content rules, or targeted subsidies, businesses have little reason to invest in dedicated EPS recycling infrastructure. (Xu et al., 2024)

Together, these barriers explain why recycling EPS remains the exception rather than the norm and why clearing them requires coordinated work across awareness, technology, infrastructure, and policy.

5.3 Environmental and economic implications

For all these constraints, bringing EPS into a circular economy holds real promise for Greater Manchester. Keeping it out of landfill and incineration cuts leakage, microplastic formation, and the pollutants produced by burning, while recycling and reuse spare fossil resources by replacing virgin resin and trim energy use and emissions across the life cycle, in line with regional and national climate and resource targets. (Patel et al., 2021) It can also spur innovation and green jobs, from collection and densification to recycling technology and product design. As the biggest EPS users, construction and packaging stand to gain from cost savings and a steadier supply of local recycled material. (Berrio-Mesa et al., 2025) With the right policy and market support, participants felt that the region could become a hub for advanced plastic recycling and circular construction products, provided that today's barriers are cleared through investment, firmer regulation, and collaboration.

6. Discussion

The Greater Manchester evidence makes one thing clear: EPS pollution cannot be fixed at the end of the pipe alone. Action must be taken throughout the life of the material, from design and production to how people use it and how it is collected and treated. Applied at each of those stages, circular economy thinking and the 3R framework can cut environmental harm and make the local economy more resilient. (Hidalgo-Crespo et al., 2020) At the design stage, using less material and making products easier to take apart prevents waste; in use, shifting from single-use to reusable or service-based models lowers demand; and at the end of life, good collection and processing bring EPS back into production. (Belblidia et al., 2023)

The clearest message from participants was about information. When nobody has reliable local data on how much EPS there is, where it goes, and how dirty it arrives, evidence-based policy has nothing to stand on. Better data would allow councils to target the interventions that matter, see what is working, and justify the spending. This is where the Greater Manchester case adds to the wider literature: the real bottleneck is not the technology, which already exists, but the governance and information built around it.

Roles matter too, since councils, waste contractors, manufacturers, recyclers, and community groups all depend on one another. Standing platforms that bring them together can align goals and pool efforts rather than duplicate them. (Abatan et al., 2025) Technology still needs work, mainly adapting densification and mechanical recycling to local systems and making the economics stack up through regulation, market growth, and greener public procurement. (Bajaj et al., 2025; Collias et al., 2021) And none of it works without the public: without awareness and easy ways to take part, even a well-designed system will struggle to collect enough clean material. (Kripalani et al., 2025)

7. Recommendations

Drawing on the literature and what participants told us, five priorities stand out for moving EPS into a circular economy.

Get the data right. Map the EPS production of the GMCA area across homes, businesses, and industries, and follow it from collection through treatment to disposal, including contamination. Use consistent sampling across the region so that the numbers are comparable, and set indicators to track progress and adjust policy as lessons emerge.

Bring stakeholders together. Set up standing platforms for manufacturers, recyclers, local and regional authorities, NGOs, and consumer groups, and keep them running rather than convening once. Use them to agree shared goals, swap knowledge, jointly design initiatives, and determine who invests in what, with shared measures and open reporting.

Invest in technology and infrastructure. Back research on mechanical and chemical recycling that tackles contamination, densifies, and saves energy, answering industry concerns about contamination, transport costs, and patchy inflows (Table 1). Support pilot and demonstration plants locally, build EPS-specific infrastructure from segregated collection to regional processing to reduce costs, and pair universities with industry to accelerate progress.

Engage the public. Run steady campaigns so that residents and businesses know EPS can be recycled, how to sort it, and what goes wrong when it is not. Reach people through several channels and use clear labelling and signage at collection points to cut confusion.

Use policy and economic levers. Write rules that name EPS directly, including limits on single-use items where alternatives exist and standards for design and recycling. Introduce or strengthen EPR schemes so that producers and importers help fund collection and recycling, and weigh levies on virgin EPS, subsidies for recycled content, and green procurement. Keep local, regional, and national policies aligned so that the signals do not clash and the industry has the certainty to invest.

8. Conclusion

EPS sits awkwardly at the crossroads of environmental, economic, and governance problems. It is everywhere, weighs almost nothing, and is worth little once it is thrown away, which is exactly why it has been so difficult to manage well. Yet, it is durable and can be recycled repeatedly; thus, with the right systems in place, it is a strong fit for a circular economy. (Patel et al., 2021)

Across Greater Manchester, more people now accept that EPS must move off the old linear track. Participants showed both sides of the picture: the good practice starting to appear, such as turning EPS waste into insulation panels, and the stubborn barriers around awareness, infrastructure, technology, and policy. Clearing them will take data-led planning, closer collaboration, investment, and well-aimed policy. (Lageard et al., 2026) What happens regionally matters, because it feeds the wider effort to cut plastic pollution and support sustainable development. (Sgroi, 2022) More work is needed to map EPS flows,

compare the life-cycle impacts of different options, and sharpen the business and policy models that keep circularity going. With the public, private, and civil society sectors pulling together, EPS can shift from a troublesome waste to a resource kept in use.

Statements and Declarations

Ethics statement. Ethical approval for the semi-structured interviews with human participants was granted by the Faculty of Business and Law Research Ethics Committee, Manchester Metropolitan University, prior to data collection. All participants received a participant information sheet, were informed of their right to refuse or withdraw at any time, and provided informed consent. Identifiable information was anonymised, and data were stored securely with access limited to the research team.

Consent to participate. Informed consent was obtained from all participants included in the study.

Data availability statement. The qualitative interview data generated during this study are not publicly available because they contain information that could compromise the privacy and confidentiality of participants, consistent with the terms of ethical approval and participant consent. Anonymised excerpts may be available from the corresponding author upon reasonable request.

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Author contributions. M.N. conceived and designed the study, carried out the data collection and analysis, and wrote and revised the manuscript.

Declaration of generative AI use. During the preparation of this manuscript, the author used Paperpal and a large language model-based AI assistant to improve language, readability, and structure, and to check the manuscript against journal submission requirements. The author has reviewed and edited all the content and takes full responsibility for the final manuscript.

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