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(Review Article)

Barriers and Policy Gaps in U.S. Film Plastics Recycling: A Scoping Review Toward Reform

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Abstract

Film plastics are recycled at approximately 2% in the United States despite a federal goal of 50% by 2050. Previous studies have examined the technical, economic, infrastructure, and policy factors associated with this low recycling rate. However, there remains limited evidence on the barriers and policy gaps affecting film plastics recycling in the United States. This study systematically mapped and synthesized the literature on these barriers and policy gaps. This scoping review, conducted in line with PRISMA-ScR guidelines, identified 30 peer-reviewed and grey literature sources published from 2015 to 2026. Data were extracted and analyzed using thematic analysis. Across the literature, technical barriers were the most consistently documented, while policy studies were relatively few. Recycling was constrained by sorting limitations, contamination, processing capacity, and multilayer film design. Economic studies showed that recycling performance depended heavily on market conditions and end-market demand. The review also found no coordinated federal producer responsibility framework and continued uncertainty over the regulation of chemical recycling. The findings suggest that improving film plastics recycling will require policy reforms alongside technological advances, particularly clearer federal policy to support collection systems, infrastructure investment, and market development.

Keywords: Barriers; Policy Gaps; U.S. Film Plastics Recycling; Review; United States

1. Introduction

Film plastics, including polyethylene (PE) film, polypropylene (PP) film, flexible packaging, and multilayer film materials, make up an increasing share of plastic waste in the United States (Milbrandt et al., 2022). Approximately 44 million tonnes of plastic waste were generated in the United States that year, with about 86% landfilled, 9% combusted, and only 5% recycled (Milbrandt et al., 2022). Within that already low-performing system, the recycling rate for flexible plastic packaging was estimated at approximately 2%, far below the federal target of a 50% plastic recycling rate by 2050 (Severson et al., 2025).

Several factors contribute to these low recycling rates. Material flow analysis for 2015 showed that the overall recycling rate for plastics in the United States was only 6.2% (Di et al., 2021). For many years, the United States relied partly on exporting plastic waste to China for processing (Erickson, 2024). This changed after China introduced the National Sword policy in 2018, which restricted plastic waste imports and exposed weaknesses in U.S. recycling infrastructure (Erickson, 2024). Circular economy strategies are increasingly recognized as essential for improving sustainable municipal solid waste management (Kodua et al., 2025).

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Many curbside recycling programs in the United States do not accept flexible plastic packaging (Severson et al., 2025). This makes film plastics even more difficult to recycle than rigid plastic materials. In addition, the lightweight and multi-layer nature of film plastics makes them difficult to process through conventional recycling systems. Previous studies have linked low recycling rates for flexible packaging to problems such as poor sorting technology and contamination during consumer use (Horodytska et al., 2018). Economic factors also contribute to the problem, including competition from cheaper virgin plastic materials and limited markets for recycled film plastics, which reduce investment in recycling systems (Heller et al., 2020). Circular economy strategies are increasingly recognized as essential for improving sustainable municipal solid waste management (Kodua et al., 2025). Improved product design and sustainable manufacturing processes are increasingly being promoted to reduce the environmental impact of modern production systems (Annankra & Sefa-Boateng, 2025).

Film plastics have a recycling rate of approximately 2% in the United States, with most material ending up in landfill or incineration (Severson et al., 2025). Landfilling plastic waste causes pollution and disrupts biodiversity, while incineration releases volatile organic compounds, which have implications for public health (Capello et al., 2025). Existing studies have examined the technical, economic, infrastructure, and policy factors associated with this low recycling rate separately and across different geographic contexts. The most comprehensive review of plastic flexible film waste management predates the significant U.S. policy changes, such as state EPR laws and the Infrastructure Investment and Jobs Act, that followed China's National Sword import ban in 2018 (Horodytska et al., 2018). More recently, Bening et al. (2021) examined challenges within the flexible packaging value chain, but primarily within European recycling systems rather than the U.S. policy context. Consequently, there is limited synthesis of the post-2018 evidence on barriers to film plastics recycling in the United States.

To address that gap, this scoping review aims to systematically map and synthesize the scope and range of peer-reviewed and grey literature addressing barriers and policy gaps in U.S. film plastics recycling, to identify understudied areas and inconsistencies across the literature. The primary question guiding this scoping review is: *What does the existing literature reveal about the barriers and policy gaps hindering film plastics recycling in the United States?* Geographically, this review focuses on the United States, including both federal and state-level policy approaches to film plastics recycling. Conceptually, the review focuses on film plastics as a separate category of plastic waste, specifically polyethylene (PE) film, polypropylene (PP) film, flexible packaging, and multilayer film materials.

2. Methods

2.1. Research Design

This study used a scoping review design. A scoping review is appropriate when the goal is to map the range of existing evidence on a topic rather than synthesize findings to answer a specific evaluative question (Arksey & O'Malley, 2005). The reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR).

2.2. Eligibility Criteria

The Population, Concept, and Context (PCC) framework structured the criteria. The population comprised stakeholders across the U.S. film plastics recycling system, including municipalities, material recovery facilities (MRFs), producers, recyclers, and policymakers. The concept addressed systemic barriers and policy gaps inhibiting film plastics collection, sortation, processing, and end-market development. The context was the U.S. waste management and recycling policy landscape.

Table 1 Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Publication date	2015 to 2026	Before 2015
Geographic scope	United States (national, federal, or state-level focus); international sources retained where findings have direct transferable relevance to U.S. policy	Studies focused exclusively outside the United States with no transferable U.S. policy relevance

Source type	Peer-reviewed journal articles, technical reports, and book chapters from academic volumes	Opinion pieces, editorials, and commentary without methodological transparency
Language	English only	Non-English publications
Waste stream	Film plastics, specifically PE film, PP film, flexible packaging, and multilayer film, where recycling barriers or policy is the primary focus	Rigid plastics, microplastics, marine plastics, and agricultural film, regardless of recycling context; film plastics in manufacturing or production contexts, with no end-of-life focus

2.3. Search Strategy

Searches were conducted across the following databases: Scopus, Web of Science, and Environment Complete. This was supplemented by hand-searching via Google Scholar for grey literature. Search strings combined terms for film plastics, recycling, barriers, and policy using Boolean operators AND and OR as illustrated:

("film plastic" OR "plastic film*" OR "flexible plastic" OR "flexible packaging" OR "polyethylene film" OR "polypropylene film" OR "multilayer film") AND (recycling OR "plastic waste management" OR "materials recovery facility" OR "mechanical recycling" OR "circular economy") AND (barrier OR challenge OR contamination OR sortation OR collection OR infrastructure OR processing OR "end market") AND ("policy gap*" OR policy OR regulation OR governance OR legislation OR "extended producer responsibility" OR EPR OR stewardship OR reform) AND ("United States" OR U.S. OR USA). All strings were filtered to the United States, and searches were limited to the period 2015 to 2026.

2.4. Study Selection

Searches across databases and supplementary sources identified 430 records, of which 30 sources met the final eligibility criteria and were included in the review. The study selection process is summarized in the PRISMA-ScR flow diagram presented below.

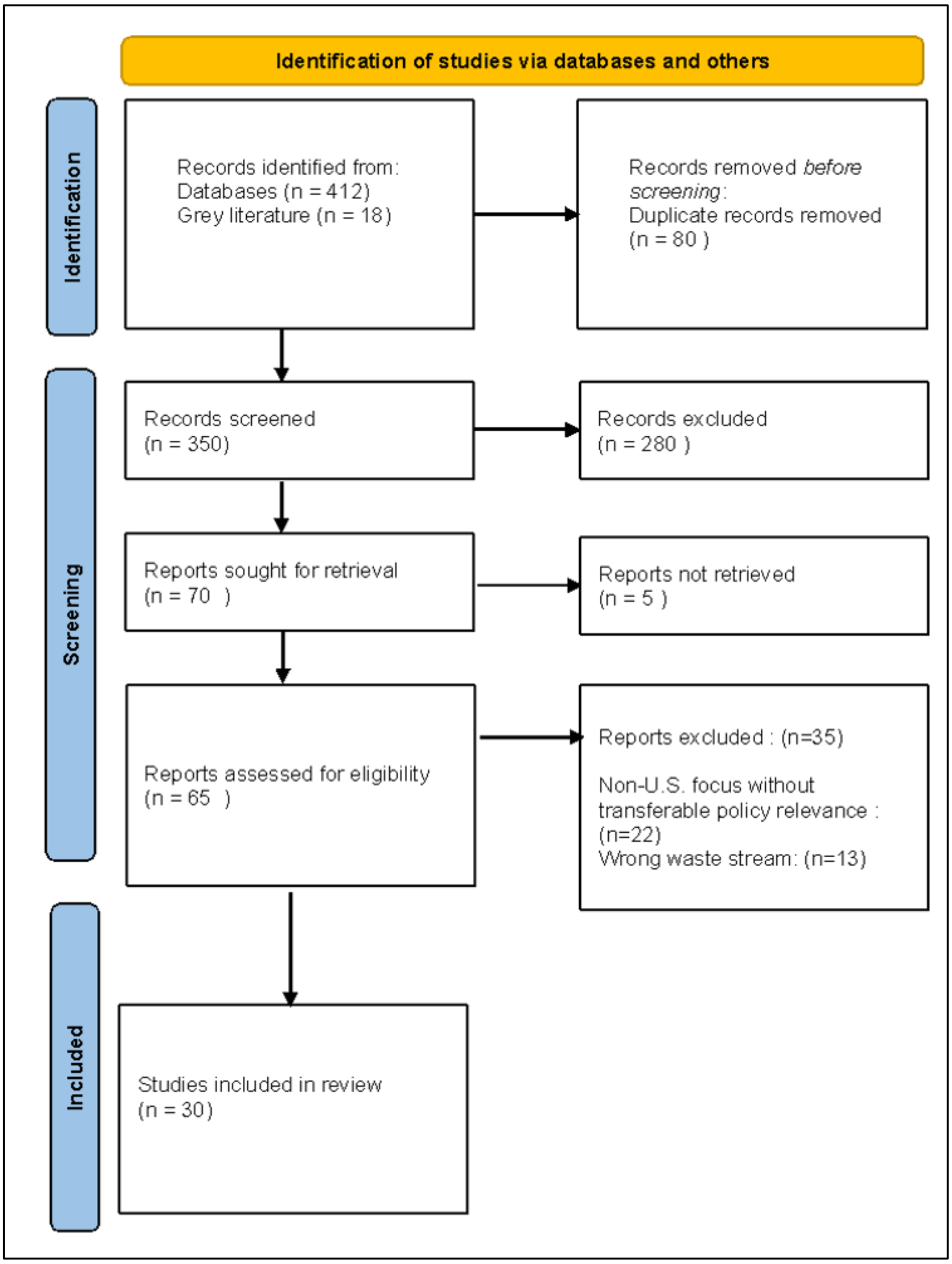

Figure 1 PRISMA-ScR Flow Diagram

2.5. Data Extraction

Data extraction followed the scoping review convention of charting. For each included source, the following were recorded: author(s), year, study setting, study type, waste stream focus, data source, thematic focus, and analysis method. Charted data were analyzed using inductive thematic analysis (Braun & Clarke, 2006). Themes were generated from the data with the aim of mapping and describing what the literature addressed and how.

3. Results

3.1. Characteristics of Included Studies

The full characteristics of all included sources are presented in Table 2 below in alphabetical order of main authors.

Table 2 Characteristics of Included Studies

Author(s), Year	Setting	Study Type	Waste Stream Focus	Data Source	Thematic Focus	Analysis Method
Afzal et al. (2023)	US	TEA/LCA	Mixed plastic waste	Process modeling	Chemical recycling — gasification	TEA, LCA
Bashirgonbadi et al. (2022)	Europe (Belgium)	Empirical	Post-consumer flexible plastics	Process/experimental data	Mechanical recycling quality and economics	Quality evaluation, economic assessment
Bening et al. (2021)	Europe (Switzerland/EU)	Qualitative	Flexible packaging	Expert interviews, regulatory documents	Interacting barriers — regulatory, economic, technical	Value chain analysis, qualitative coding
Cappello et al. (2025)	International/Europe	Review	Multilayer flexible packaging	Published literature	Delamination technologies for recycling	Narrative review
Cecon et al. (2023)	US	Empirical	Mixed #3–7 plastics from MRFs	MRF bale samples	Sortation, contamination, and recyclability	Material characterization
Cecon et al. (2021)	US	Review	Post-consumer polyolefins	Published literature	Technical barriers, food contact regulations	Narrative review
Di et al. (2021)	US	Material flow analysis	Seven major plastic resins	EPA data, industry reports	Material flows, recycling rates	MFA
Diggle & Walker (2020)	Canada	Policy analysis	Single-use plastic packaging	Policy documents	EPR policy design	Policy review
Diggle et al. (2023)	Canada (Nova Scotia)	Empirical/ policy	Printed paper and packaging	Industry data, policy documents	EPR business and policy impacts	Economic and policy analysis
Erickson (2024)	US	Policy review	Mixed plastics/plastic waste	Policy documents, published literature	Federal chemical recycling strategy, policy gaps	Policy analysis

Gracida-Alvarez et al. (2023)	US	LCA	Post-use plastics	Process modeling	Pyrolysis life cycle impacts	LCA
Heller et al. (2020)	US	Material flow analysis	All plastics	Industry reports, EPA data	Material flows, packaging recycling barriers	MFA
Horodytska et al. (2019)	International	Book chapter/review	Plastic waste broadly	Published literature	Waste management status and weaknesses	Narrative review
Horodytska et al. (2018)	International/Europe	Review	Plastic flexible films	Published literature	Technical barriers, recycling methods, LCA	Narrative review
Kaiser et al. (2018)	International/Europe	Review	Multilayer polymer packaging	Published literature	Technical barriers, multilayer recycling	Narrative review
Lase et al. (2022)	Europe (Belgium)	Empirical/ MFA	Post-consumer flexible plastics	Process/pilot data	Mechanical recycling performance	MFA, mass balance
Li et al. (2022)	International/US	Tutorial review	All plastics	Published literature	Chemical recycling technologies	Technical/narrative review
Lin et al. (2023)	US	TEA/LCA	Flexible plastic packaging	MRF pilot facility data	Economic and environmental feasibility	TEA, LCA
Makarova et al. (2025)	US	Material flow analysis	Post-consumer flexible plastic packaging	Industry/EPA data	Material flows, recyclable fractions	MFA
Meert et al. (2021)	US (New York)	Empirical	PE film — retail return stream	MRF/retail return program data	Contamination and bag ban impacts on collection	Statistical analysis, material speciation
Meys et al. (2020)	Europe/International	LCA	Plastic packaging waste	Process modeling	Chemical recycling environmental potential	LCA

Milbrandt et al. (2022)	US	Empirical/ geospatial	All plastics including film	EPA data, waste composition studies	Plastic waste quantification and landfill losses	Statistical and geospatial analysis
Olafasakin et al. (2023)	US	TEA/LCA	Mixed recyclables — MRF	MRF operational data	MRF economics and environmental impacts	TEA, LCA
Sánchez-Rivera et al. (2023)	US	Empirical	Printed multilayer plastic film	Laboratory/experimental data	Chemical recycling — STRAP process	Technical characterization
Severson et al. (2025)	US	System dynamics modeling	Flexible plastic packaging	MRF pilot data, market data	Scale-up, end-market development, policy implications	System dynamics model, LCA
Stathatou et al. (2025)	US	Perspective / analytical	Mixed plastics	Published literature, process data	Pyrolysis decision-making, environmental trade-offs	Multi-perspective analysis, LCA
Ügdüler et al. (2021)	Europe (Belgium/Germany)	Empirical	Multilayer flexible packaging	Laboratory data	Delamination mechanism — carboxylic acids	Chemical and kinetic analysis
Uekert et al. (2023)	US	Comparative TEA/LCA	Common plastics	Process modeling	Closed-loop recycling technology comparison	TEA, LCA
Vogt et al. (2021)	International/US	Review	Postconsumer plastics	Published literature	Technical and economic recycling barriers; mechanical and chemical recycling strategies.	Narrative review

Yadav et al. (2023)	US	TEA/LCA	Mixed plastic waste	Process modeling	Catalytic fast pyrolysis	TEA, LCA

3.2. Thematic Mapping of Findings

3.2.1. Technical Barriers

Sortation Incompatibility

The physical properties of film plastics are fundamentally incompatible with standard MRF infrastructure. Films tangle around rotating disc screens, forcing complete line shutdowns and manual removal; an estimated 90% of single-stream MRFs in the United States operate equipment susceptible to this type of fouling (Meert et al., 2021). The recycling volume consequence is stark: in 2017, MRFs accounted for only 2% of all film plastics recycled, compared to 22% from retail return programs and 76% from commercial, industrial, and agricultural channels (Meert et al., 2021). Near-infrared (NIR) detection, the most widely deployed automated sorting method, faces specific limitations with films: compressed air ejection systems paired with NIR lines are less effective for lightweight materials (Bashirgonbadi et al., 2022), and NIR cannot identify thin coating layers or black-colored film (Horodytska et al., 2018). At the resin level, polyethylene and polypropylene are close enough in density and melting point that current sorting equipment cannot reliably separate them (Makarova et al., 2025).

A material flow analysis of U.S. FPP flows for 2021 found that EU-based MRFs processing dedicated lightweight packaging streams recover film at over 50% efficiency, while U.S. single-stream MRFs recover the same material at substantially lower rates(Makarova et al., 2025). Out of 48 kt of collected household and depot film in 2019, only 14 kt were sorted and 8.7 kt ultimately recycled (Makarova et al., 2025). Bale composition analysis of three U.S. MRFs in Iowa and Wisconsin found considerable differences in output quality tied directly to sorting technology, with the facility relying exclusively on manual sorting showing markedly higher rates of misidentified and misclassified material (Cecon et al., 2023).

Contamination

Films carry a high surface-to-weight ratio, meaning food residues accumulate at disproportionately high levels relative to the material being processed (Bashirgonbadi et al., 2022). Washing procedures are also less effective for flexible than rigid plastics because films deform during the wash cycle and cannot maintain stable surface contact with the washing medium; current washing lines additionally fail to remove inks, adhesive residues, and non-polymer components such as aluminum and paper (Bashirgonbadi et al., 2022). Consumer behavior at the collection point compounds the problem. A study of retail return PE film programs in Western New York before and after the New York State Plastic Bag Reduction Law found that removing grocery bags from circulation increased contamination from 10.0% to 28.3% at one store and from 21.6% to 30.2% at another, with incorrect plastic films comprising 37.7 to 74.3% of total contamination by weight (Meert et al., 2021). For recycled polyolefins entering food contact applications, contamination creates an additional regulatory constraint: residual chemicals and additives present in post-consumer material risk migrating into food at levels that current mechanical recycling cannot consistently control (Cecon et al., 2021).

Processing Constraints

Conventional extrusion equipment lacks sufficient filtering and degassing capacity for contaminated film fractions, producing low-quality regranulate suitable only for downcycled applications (Bashirgonbadi et al., 2022). Each mechanical recycling cycle degrades polymer properties through heat and mechanical stress, with an estimated 10% degradation occurring per cycle (Erickson, 2024). A classification of U.S. FPP flows found that only a minority of post-consumer FPP qualifies as mechanically recyclable under current system conditions; the majority was categorized as either challenging for recycling or non-recoverable, primarily because mixed-resin fractions produce recyclate with inconsistent properties and limited applications (Makarova et al., 2025).

Multilayer Film Complexity

Multilayer or mixed material films represent the most technically constrained segment of the film plastics waste stream. Since their layered construction bonds polymers combined with adhesives, aluminum, or paper, conventional mechanical recycling cannot separate the components, and most multilayer packaging currently ends in incineration or landfill (Kaiser et al., 2018). Laboratory research has established that delamination using carboxylic acids is technically feasible and can be modeled kinetically, but precise control of temperature, acid concentration, and solid-to-liquid ratio is required, and the process has not been translated to an industrial scale (Ügdüler et al., 2021). Material flow analysis of post-consumer flexible plastics in Belgium found that even under an improved sorting process, multilayer fractions persisted in the output and could not be fully characterized by standard analytical tools, including FTIR, which penetrates only 5 μm of surface depth (Lase et al., 2022). Household flexible packaging, which was the category with the highest proportion of multilayer structures, consistently records the lowest recycling rates across film types, in part because delamination and compatibilization methods remain underdeveloped for post-consumer applications (Horodytska et al., 2018).

3.2.2. Economic Barriers

Commodity Price Competition and Recyclate Value

A fundamental economic constraint identified across the literature is the price gap between virgin and recycled film plastics. Low recycling rates for plastic packaging have been traced to market conditions in which inexpensive virgin feedstocks consistently undercut the economic case for recyclate (Heller et al., 2020). Qualitative value chain research drawing on 25 semi-structured interviews with industry representatives across the flexible plastic packaging supply chain in Europe found that recycling is not commercially viable for most flexible packaging waste streams under current market conditions, with economic barriers interacting with and reinforcing both technical and regulatory constraints (Bening et al., 2021). A system dynamics model of U.S. FPP recycling to 2050 found that the inferior quality of recycled flexible plastic packaging relative to conventional feedstocks creates a ceiling on buyer willingness to pay, which in turn constrains the investment case for scaling collection and processing capacity (Severson et al., 2025).

Cost of Collection and Processing

The economics of film recycling plastics are shaped by high processing costs relative to low material value. A techno-economic analysis of a standalone single-stream MRF processing 120,000 tonnes per year in the United States found a total fixed capital cost of $23 million and an operating cost of $45.48 per tonne; net present value ranged from $3.57 million to $60 million across scenarios, with that range driven substantially by waste stream composition and market price volatility for recovered materials (Olafasakin et al., 2023). Processing flexible plastic packaging within a single-stream system adds specific cost pressure because FPP is lightweight but voluminous, increasing energy consumption and reducing sorting productivity per tonne of material handled (Lin et al., 2023). A pilot study evaluating FPP recycling from single-stream curbside collection in the United States found that the cleaning and pelletizing stage at reclaimers was the single largest contributor to total greenhouse gas emissions across the recycling chain, and noted that published U.S. techno-economic analyses for mechanical recycling of film plastics remain scarce, largely because of industry confidentiality constraints (Lin et al., 2023).

End-Market Thinness and Recyclate Demand Gaps

Even where film plastics are collected and processed, end-market demand for recycled polyethylene and polypropylene remains thin. Low-quality regranulate from contaminated film fractions is restricted to downcycled applications, narrowing the pool of viable buyers and suppressing material prices (Bashirgonbadi et al., 2022). A geospatial quantification of U.S. landfilled plastic waste estimated that approximately $7.2 billion in market value and 3.4 EJ of embodied energy were lost to landfilling in 2019, with LDPE/LLDPE, the dominant resin in film, wrap, and bags, among the highest-volume landfilled fractions (Milbrandt et al., 2022). A modeling study projecting U.S. FPP recycling to 2050 found that market r esitance for products containing recycled FPP constrains substitution before 2035, and that achieving a recycling rate of 22 to 61% by 2050 requires optimistic assumptions about both end-market substitution and collection scale-up (Severson et al., 2025).

3.2.3. Infrastructural Barriers

Collection System Gaps

The most immediate infrastructural constraint is the absence of a functioning collection pathway for FPP in most U.S. communities. Most curbside collection programs do not target flexible plastic packaging, and in-store drop-off programs for mono-material FPP achieve a collection rate of only 2% (Severson et al., 2025). A material flow analysis of U.S. FPP for 2021 found that U.S. single-stream MRFs treat FPP as a contaminant, estimating film recovery efficiency at approximately 1%, which is far below the 50% or greater recovery rates achieved by EU-based MRFs processing dedicated lightweight packaging streams (Makarova et al., 2025). Under a business-as-usual scenario projecting to 2050, the existing U.S. collection system is estimated to be capable of capturing at most 32% of end-of-life FPP from municipal solid waste (Severson et al., 2025). Three distinct collection pathways for FPP have been identified in the U.S. literature: direct bulk collection from industrial, commercial, and institutional generators; aggregated drop-off collection through retail locations; and curbside mixed recyclables. The decentralized and fragmented nature of these pathways makes system-level planning difficult to model or implement (Makarova et al., 2025).

MRF Infrastructure Limitations and Geographic Fragmentation

U.S. mechanical recycling systems face poor standardization of local infrastructure, with variation in equipment, accepted materials, and processing capacity across states and municipalities (Erickson, 2024). Analysis of bale compositions from MRFs in Seattle, Oregon, and Pennsylvania found near-zero quantities of plastic films in the waste streams characterized at recovery facility gates, attributed to the fact that most recovery facilities do not accept plastic films in single-stream waste (Olafasakin et al., 2023). Waste stream composition varies from state to state and municipality to municipality, driven by differences in waste management regulation, community type, and level of industrialization (Olafasakin et al., 2023). In 2015, most U.S. local s employed single-stream curbside recycling, with only a small number operating dual-stream systems better suited to separating flexible materials from the broader waste stream (Di et al., 2021). A pilot project in Berks County, Pennsylvania, which retrofitted an existing MRF to sort FPP from incoming recyclable streams, produced a finished product comprising 85% FPP and 15% fiber, demonstrating that dedicated sorting infrastructure can generate a marketable FPP fraction from single-stream inputs (Severson et al., 2025).

Design for Recyclability

A cross-cutting constraint identified in the literature is the absence of upstream design-for-recyclability requirements. Film plastics are rarely designed with recycling in mind, as manufacturers prioritize strength, durability, safety, cost, and appearance; relatively few plastic types are currently accepted by U.S. mechanical recycling systems as a result (Erickson, 2024). Low packaging recycling rates have been traced in part to material quality constraints inherent in the current system, arising from product design choices including material selection, additive use, and multilayer construction (Heller et al., 2020). The literature identifies the absence of coordination between upstream product design and downstream end-of-life management as a persistent structural gap for film plastics specifically (Heller et al., 2020).

3.2.4. Policy Gaps

Absence of a Coordinated Federal Framework

No federal policy framework specifically governs film plastics collection or recycling in the United States. The most comprehensive federal proposal to emerge in recent years, the Break Free From Plastic Pollution Act (BFFPPA) introduced in 2021, included a national EPR scheme, container deposit programs, post-consumer recycled content mandates, and bans on common single-use plastics; the act was introduced amid what the literature characterizes as a period of no direct federal legislative progress on plastics and recycling (Erickson, 2024). The Canadian experience provides a comparative reference point: Canada has operated a national EPR strategy since 2009, implemented in five provinces, with industry stewards contributing $485.2 million in EPR funds to provincial programs by 2020 (Diggle et al., 2023). A case analysis of EPR implementation potential in Nova Scotia found that a provincial EPR program was projected to generate $14 to $17 million CAD in municipal waste management savings (Diggle & Walker, 2020). Collection and processing costs typically account for between 77% and 95% of total costs within recycling programs, a proportion that increases further for difficult-to-recycle materials such as film plastics, reinforcing the structural case for producer-funded frameworks (Diggle et al., 2023).

Inconsistent and Fragmented State-Level Policy

State-level plastic policy in the United States is inconsistent and in some cases contradictory. As of April 2023, 24 states had enacted laws to support advanced recycling, many using American Chemistry Council (ACC)-backed definitions that classify chemical recycling facilities as manufacturing operations rather than waste management facilities, reducing the environmental permitting requirements applied to those facilities (Erickson, 2024). Separately, 18 states have enacted preemption laws preventing local governments from restricting plastic products; 12 of those same states have enacted both preemption bans and ACC-backed advanced recycling legislation (Erickson, 2024). Prior to China's National Sword import policy in 2018, plastic waste exported to China was counted as recycled in U.S. national statistics, meaning reported recycling rates overstated actual domestic recycling performance (Erickson, 2024).

Regulatory Gaps for Chemical Recycling

No settled federal regulatory classification exists for chemical recycling technologies. In 2020, the EPA proposed removing pyrolysis and gasification from the Other Solid Waste Incineration regulatory category under the Clean Air Act, a change that would have opened a regulatory gap for those technologies; the proposal was withdrawn in June 2023, but final rulemaking remained ongoing at the time of publication (Erickson, 2024). Without a resolved federal definition, individual states retain discretion to classify chemical recycling as a manufacturing process subject to less stringent environmental oversight (Erickson, 2024). As of 2022, the United States had only eight chemical recycling facilities in operation, most producing fuel rather than plastic, and no plastic-to-plastic facility had demonstrated commercial viability (Erickson, 2024).

Contested Policy Solutions Across the Value Chain

Qualitative research along the flexible plastic packaging value chain in Europe found that while stakeholders agreed that regulatory intervention is necessary to move the industry toward circularity, there was no consensus on the form that intervention should take (Bening et al., 2021). Value chain players held sharply divergent views on whether demand-pull instruments, such as recycled content mandates, or technology-push instruments, such as R&D grants, were the more appropriate policy levers (Bening et al., 2021). Insufficient product labeling and the absence of clear recyclability standards were identified as cross-cutting regulatory gaps affecting sorting, collection, and end-market development (Bening et al., 2021).

3.2.5. Directions for Reform and Advanced Recycling Technologies

Policy and System Reform

The policy-oriented literature identifies several reform directions. A federal coordinating strategy for chemical recycling in the United States is proposed, covering technology definition standards, environmental impact requirements, knowledge gap reduction, and a complementary policy suite rather than single-instrument approaches (Erickson, 2024). Harmonized mandatory EPR for packaging is identified as a mechanism to increase producer financing of collection and processing infrastructure, drawing on Canadian provincial program evidence (Diggle & Walker, 2020). Empirical assessment of EPR implementation in Nova Scotia found that without regional harmonization, jurisdictions bear program costs without receiving corresponding infrastructure benefits (Diggle et al., 2023). Institutional intervention is identified as a necessary condition for circular transition in flexible packaging, with debate documented across value chain actors between demand-pull and technology-push policy instruments (Bening et al., 2021). System dynamics modeling identified collection capacity limits and end-product price ceilings as the binding constraints on reaching US FPP recycling targets (Severson et al., 2025).

Improved Mechanical Recycling

Improved mechanical recycling process designs incorporating additional sorting, hot washing, and enhanced extrusion have been assessed. Regranulate quality from these improved processes was found to meet the requirements of more demanding flexible film applications (Bashirgonbadi et al., 2022). Multilayer or mixed material fractions were identified as a persistent challenge that remained even after sorting and processing improvements (Lase et al., 2022).

Chemical and Advanced Recycling Technologies

The largest cluster of sources examines chemical and advanced recycling as potential complements to mechanical systems. A tutorial review mapped chemical recycling technologies across the plastics lifecycle, identifying barriers to industrial-scale deployment and areas where further research is needed to expand recycling beyond current capacity (Li et al., 2022). LCA modelling found that the environmental potential of chemical recycling for plastic packaging varies substantially by technology type, with some processes yielding no environmental benefit even under ideal performance assumptions (Meys et al., 2020). Pyrolysis has attracted the most research attention: LCA of pyrolysis-derived polyethylene found GHG outcomes vary with plant maturity, feedstock substitution rate, and grid carbon intensity (Gracida-Alvarez et al., 2023), while a perspective analysis of the pyrolysis LCA literature documented net GHG emissions ranging from 220% lower to 60% higher than current US plastic waste management practices depending on system conditions (Stathatou et al., 2025). Catalytic fast pyrolysis of mixed plastic waste was evaluated across multiple product pathways, with economic and environmental outcomes varying by process configuration (Yadav et al., 2023). Gasification was assessed for methanol and hydrogen production, with a feedstock price below $0.02 per kg identified as necessary for cost parity with fossil-derived alternatives (Afzal et al., 2023). Comparative analysis of closed-loop recycling technologies found mechanical recycling and PET glycolysis performed best on combined economic and environmental metrics, while solvent-based dissolution produced higher recyclate quality (Uekert et al., 2023).

Delamination and Solvent-Based Separation

For multilayer film, a review catalogued delamination technologies including acidic and alkaline treatments, deep eutectic solvents, and mechanical methods, noting industrial scaling potential alongside identified process limitations (Cappello et al., 2025). Kinetic modeling of delamination by carboxylic acids characterized the adhesive dissolution mechanism and parameters relevant to scale-up (Ügdüler et al., 2021). The STRAP solvent-targeted recovery process demonstrated above 99% polymer recovery by weight from post-industrial multilayer film, with economic and environmental viability dependent on the number of recovery steps included (Sánchez-Rivera et al., 2023).

4. Discussion

This scoping review mapped 30 sources published between 2015 and 2026 on barriers and policy gaps in U.S. film plastics recycling. Seventeen sources were U.S.-based; the remainder drew on European or Canadian evidence with direct relevance to U.S. conditions. Study types varied, including techno-economic analyses, life cycle assessments, material flow analyses, empirical studies, policy analyses, and reviews. Most studies were regional or facility-level rather than national in scope. Nine sources were techno-economic analyses or life cycle assessments, and seven were narrative or technical reviews; only three were dedicated policy analyses. This distribution reflects the structure of the field: technical and economic scholarship on film plastics is more developed than its policy counterpart, and the two bodies of work rarely intersect across the included literature.

Technical barrier findings were highly convergent across independent studies. Sortation incompatibility, contamination, mechanical recycling output limitations, and multilayer film complexity were consistently identified regardless of national setting, methodology, or study design. The most relevant prior review of plastic flexible films waste management identified the same fundamental set of constraints (Horodytska et al., 2018). Sources published after 2020 contributed greater empirical specificity, including recovery rate comparisons between U.S. and EU infrastructure, bale composition data from U.S. MRFs, and kinetic models of multilayer film delamination, but did not alter the fundamental technical barrier picture established in earlier work. That consistency across studies with different designs, data sources, and national contexts strengthens confidence in the robustness of the technical findings.

Techno-economic analyses consistently found that the viability of FPP recycling is highly sensitive to scenario assumptions, including end-market price levels, substitution rates, and collection volumes (Lin et al., 2023). A system dynamics model projecting U.S. FPP recycling to 2050 estimated recycling rates ranging from 22% to 61%, depending on price cap and substitution assumptions, a range wide enough to reflect genuine market uncertainty rather than a settled economic verdict (Severson et al., 2025). Published U.S. techno-economic analyses for film plastics are scarce, attributed in the literature to industry confidentiality constraints, which limits the precision of domestic economic assessments and represents a meaningful evidence gap (Lin et al., 2023).

The policy literature documented a divided regulatory environment with no coordinated federal framework governing film plastics collection or recycling. State policies have developed unevenly, with advanced recycling legislation, preemption bans, and recyclability labeling standards varying in ways that create jurisdictional inconsistency rather than a national system (Erickson, 2024). The unresolved federal regulatory classification of chemical recycling technologies adds further uncertainty to long-term investment planning (Erickson, 2024). Canadian EPR program evidence offers the closest available body of experience with producer responsibility frameworks at a meaningful scale; industry steward contributions to Canadian provincial EPR programs reached $485.2 million annually by 2020 (Diggle et al., 2023). Direct transfer of the Canadian model to the U.S. federal-state governance structure is not straightforward, but the evidence demonstrates that producer-funded collection infrastructure is achievable where a legislative mandate is in place.

Across all four thematic areas, the evidence points to barriers that interact and compound one another rather than operating independently. Qualitative research on the flexible plastic packaging value chain found that regulatory, economic, and technical barriers reinforce each other, and that proposed solutions were fiercely contested across value chain players, reflecting divergent interests rather than information gaps alone (Bening et al., 2021). Patterns documented in this review are consistent with that framing. Low recyclate quality limits end-market demand. Thin end markets reduce the investment case for processing infrastructure. Weak collection infrastructure limits feedstock supply. The absence of regulatory mandates removes the structural pressure to change any part of this cycle.

A federal producer responsibility framework for packaging, not yet enacted in the United States, would establish the financial mechanism that the Canadian experience indicates is necessary to fund collection infrastructure at scale (Diggle et al., 2023). Resolution of chemical recycling's federal regulatory classification would provide the definitional clarity that investors and municipalities need for long-term infrastructure planning (Erickson, 2024). Upstream product design interventions, such as reducing multilayer film constructions and incompatible additive combinations, address constraints that downstream recycling infrastructure alone cannot resolve. Standardized national reporting on film plastics recycling rates, disaggregated from broader plastic recycling statistics, would strengthen the evidence base and improve accountability for any future policy framework.

Limitations of the Study

Several limitations apply.

- The search was restricted to English-language publications, which may have excluded relevant technical literature published in other languages.
- Scoping review methodology does not include formal quality appraisal; the range of evidence is mapped, but the methodological strength of individual sources is not assessed.
- Several techno-economic analyses relied on modeled rather than operational data, and findings are contingent on scenario assumptions that may not reflect real-world conditions.
- The definition of film plastics varied across included sources, with some focusing narrowly on mono-material PE film and others addressing flexible packaging more broadly, introducing heterogeneity that limits direct comparison of findings across the evidence base.

5. Conclusion

Film plastics recycling in the United States is not only constrained by technical limitations, but by the absence of a coherent policy framework capable of making existing solutions economically and operationally viable at scale. This review demonstrates that while technical barriers are well documented, the policy and governance mechanisms needed to support infrastructure, collection systems, and market development remain insufficient. Significant evidence gaps also persist, particularly in published techno-economic analyses and disaggregated national material flow data for film plastics, largely due to industry confidentiality and limited reporting. Future research should therefore prioritize integrated studies that bridge economic and policy dimensions, as this remains the most underdeveloped area within the current evidence base. Ultimately, advancing film plastics recycling in the United States will depend on creating the institutional and policy conditions necessary to scale already existing technical solutions. The evidence presented in this review provides a foundation upon which more policy-responsive recycling systems can be developed.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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