# Appendixes

***Appendix C**: Comparative Cost-Benefit Analysis*

## Executive Summary

Amcor, a prominent packaging company, is committed to making all of its packaging recyclable, reusable, or compostable by 2025. However, a significant challenge arises from the fact that much of their flexible packaging is not currently recyclable at scale due to a lack of consistent materials recovery facilities (MRFs) in the United States. In Ann Arbor, Recycle Ann Arbor has reported receiving large quantities of flexible packaging that cannot be processed with their existing infrastructure. This appendix aims to conduct a comparative cost-benefit analysis between store drop-off and curbside pickup methods, recommending the most financially viable approach for flexible packaging recycling in the area.

The research methodology involved conducting stakeholder interviews, market research analysis, and benchmarking collection options. This analysis focuses on identifying the strengths and weaknesses of each method, evaluating their financial implications, and determining the best strategy to enhance recycling efforts. By assessing various factors such as initial investment costs, operational expenses, collection rates, and potential revenue from recycled materials, this report seeks to provide a comprehensive understanding of the options available for improving flexible packaging recycling in Ann Arbor. Ultimately, this analysis will inform decision-makers about the most effective approach to implement, ensuring that the chosen method aligns with both financial viability and community sustainability goals. The final recommendations include a two-way strategy: expanding store drop-off programs as a short-term solution and exploring the potential upgrade of the Ann Arbor MRF as a long-term solution.

To enhance the financial viability of the curbside program, several key areas for improvement were identified. Investing in advanced sorting technology could significantly boost collection rates and reduce contamination. Implementing better collection strategies and expanding end markets for recycled flexibles are also crucial for long-term sustainability. Before considering an upgrade to the MRF, it is essential to evaluate whether the current facility has the capacity for expansion and if such upgrades would lead to improved recovery rates. Ultimately, the goal is to create a hybrid system that allows for both store drop-offs and curbside recycling in the future, enabling Recycle Ann Arbor and the City of Ann Arbor to manage all sorting and processing needs effectively.

*Comparative Cost-Benefit Analysis*

The following analysis provides high-level estimates of all costs and assumptions associated with both short-term and long-term solutions for flexible packaging recycling.[1] As solutions are implemented, the team recommends a more in-depth study of the specific costs and detailed quotations as necessary to ensure accuracy and feasibility. There is a lack of data on the generation and recovery of film and flexible packaging in the United States and flexible packaging in the U.S., and the basic data available do not exist for film and flexible film and flexible packaging.[2] This deeper analysis will involve collaborating with key stakeholders, obtaining updated market prices, and conducting thorough financial modeling to refine our cost projections and validate assumptions included below.

The model considers several assumptions due to limited available data and project scope:

1. Processing contaminated flexibles: The project scope does not include the entire recycling process for flexibles, focusing only on the selected approach and end market. The chemical treatment step for cleaning contaminated flexibles is not within the project scope. Consequently, companies like Alterra that chemically treat contaminated flexibles are not considered.
2. MRF film processing: When the MRF receives films from curbside collection, they need to be separated, sorted, and baled. This project's projected value for MRF upgrades does not extensively explore the capacity to clean contaminated flexibles or the associated price values. Further analysis is necessary to design a specific project for Ann Arbor to obtain more accurate results.
3. Recycled flexibles pricing: The closest available price value used was a proxy for rLDPE colored price commercialized in Europe. Actual price values were not publicly available, and stakeholders could not share this information. The real price is likely lower than the value considered. According to Closed Loop Partners (2023), MRF film typically has a value of $40 per ton[3]. Additional studies comparing different sorting technologies with reclamation technology are necessary to accurately estimate MRF costs and obtain specific quotations.
4. Collection rates: This study used a curbside collection rate of 1.6 lbs/household, as reported by The Recycling Partnership's Film and Flexibles Coalition (2021)[4]. Despite limited information on recovery rates, film recycling lags behind other packaging materials. Closed Loop Partners estimates a 4% recovery rate for residential polyethylene film, in which only 3% can be marketed. The American Chemistry Council reports 187 million pounds of residential film recovered in 2018, translating to roughly 1.6 pounds per household per year for return-to-retail programs which was the closest information available.
5. Store drop-off vs. curbside collection: Store drop-off programs only accept clean, dry polyethylene films, bags, and wraps, resulting in higher collection rates compared to curbside collection. According to Moore Recycling Associates, of the approximately 300 million pounds of residential film MRFs receive annually, only 10 million pounds

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[1] SHUHAN HUANG ET AL., REVIEW OF LIFE CYCLE COST ANALYSIS FOR REUSABLE PACKAGING FOR THE RETAIL INDUSTRIAL, 10.

[2] Marissa Heffernan, *US Plastics Pact estimates 13.3% packaging recycling rate*, Resource Recycling (Mar. 1, 2023), https://resource-recycling.com/recycling/2023/02/27/u-s-plastics-pact-estimates-13-3-packaging-recycling-rate/.

[3] Closed Loop Partners. (2023, October 15). Investment opportunities in film plastic recycling. https://www.closedlooppartners.com/foundation-articles/investment-opportunities-in-film-plastic-recycling/. Page 25.

[4] Recycling Partnership. (2021). Collection rate per household: 1.6 lb. Retrieved from https://recyclingpartnership.org/wp-content/uploads/dlm_uploads/2021/04/FF_Whitepaper_final.pdf. Page 6.

are marketable due to limited recycling markets for MRF film. In 2014, only 9.7 million pounds (approximately 3%) of film entering MRFs was recycled[5].

6. Transportation costs: This model does not include transportation costs to the final end market. Due to the difficulty in obtaining reliable data to estimate transportation costs for curbside collection of flexibles, this variable was not included in the analysis for both approaches. Additional studies are required to incorporate these costs for a more comprehensive evaluation.

Table 2 - Cost-benefit analysis for short-term approach - Expand drop-off locations

Table 2 presents a cost-benefit analysis for expanding drop-off locations as a short-term solution for flexible plastic recycling in Ann Arbor, Michigan.

| | | | |
|---|---|---|---|
| **Initial Costs** | Population in Ann Arbor | | 119,381 |
| | Person per household | | 2.19 |
| | Education campaign cost per household ($) | | $ 1.39 |
| | Consumer Education Campain ($) | | $ 75,935.04 |
| | Collection cost | Retail business in Ann Arbor | 2,123 |
| | | Stores | 106.15 |
| | | Bin/box Cost ($) | $ 61.00 |
| | | Bin/box per store | 2 |
| | | Total collection cost ($) | $ 12,950.30 |
| | Additional labor | Monthly Hours of work | 2 |
| | | Base Salary - Minimum wage ($) | $ 12.48 |
| | | Annual labor cost ($) | $ 31,794.05 |
| | Ongoing Education | Annual reinforcement educational campaign ($ | 51,241 |
| | **Estimated upfront cost** | | $ 171,920.55 |
| | **Estimated Annual cost subsequent years** | | $ 83,035.21 |
| **Benefits** | Annual Material Collection (tons) | Monthly collection rate per store (lb) | 1953.125 |
| | | Annual material collection (ton) | 103.6621094 |
| | Revenue from recycled materials | Sale price ($) | 694.6 |
| | | Potential revenue ($) | $ 72,003.70 |
| | Landfill Savings | Landfill savings per ton ($) | $ 7.36 |
| | | Annual savings cost ($) | $ 762.95 |
| | **Total benefits ($)** | | $ 72,766.65 |
| **Net Cost - Benefit after the first year ($)** | | | **$ -10,268.55** |
| **ROI** | | | **87.63%** |

[5] Closed Loop Partners. (2023, October 15). Investment opportunities in film plastic recycling. https://www.closedlooppartners.com/foundation-articles/investment-opportunities-in-film-plastic-recycling/. Page 1.

The analysis considers initial costs, annual operational costs, and potential benefits. The initial costs include a consumer education campaign ($75,935.04)[6] and collection bin setup ($12,950.30)[7] for approximately 106 stores (5% of all retail stores)[8].
Annual operational costs comprise additional labor ($31,794.05),[9] and ongoing education ($51,241).[10] The total estimated upfront cost is $171,920.55,[11] with subsequent annual costs of $83,035.21.[12] Benefits are calculated based on an estimated annual material collection of 103 tons. This assumes a monthly collection rate of 1,953.125 lb per store.[13] The potential revenue from recycled materials is significant at $72,003.70, based on a sale price of $694.60 per ton.[14] Additional benefits include landfill savings of $762.95. The net cost-benefit after the first year is negative at $10,268.55, with an ROI of 87.63%. These figures suggest that the program could be profitable in the long term, though they rely on several assumptions:

1. The population and household data for Ann Arbor are accurate and current.
2. The education campaign costs and effectiveness are as estimated.
3. The number of retail businesses and participating stores is accurate.
4. Transportation costs and collection frequencies are as projected.
5. The material collection rates and sale prices for recycled materials are achievable.
6. Labor costs are based on minimum wage and estimated work hours.

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[6] Total cost of a consumer education program calculated by taking total Ann Arbor Population (119,381) divided by the person per household size (2.19) then multiplying that number by $1.39. *QuickFacts*, UNITED STATES CENSUS BUREAU, https://www.census.gov/quickfacts/annarborcitymichigan (last visited Nov. 21, 2024); *see* Robert Priester, *How Much Does a Direct Mail Marketing Campaign Cost?*, STORAGEPUG (May 28, 2024), https://www.storagepug.com/blog/direct-mail-marketing#:~:text=The%20cost%20of%20a%20direct,lot%20of%20variables%20to%20consider.&text=To%20start%2C%20here%20are%20some,you'll%20need%20to%20consider.

[7] Total collection bin set up calculated by taking the total number of stores(~106) participating in the program multiplied by having at least two collection bins at $61.00. *See Regional Demographics*, Ann Arbor SPARK, https://annarborusa.org/spark-services/business-expansion/regional-demographics/ (last visited Nov. 21, 2024); *Recycling*, A2Gov, https://www.a2gov.org/departments/trash-recycling/pages/recycling.aspx (last visited Nov. 21, 2024).

[8] Ann Arbor SPARK. (n.d.). Regional demographics. https://annarborusa.org/spark-services/business-expansion/regional-demographics/ (last visited Oct. 1, 2024),

[9] Total labor cost increases calculated using the following: 2 hours * $12.48 * 12 months * 106.15 stores = $31,794.05. The assumption is that this program will only increase work hours by two hours a month. *Michigan Minimum Wage Rate 2025 Increase Schedule*, Michigan Department of Labor and Economic Opportunity (Oct. 1, 2024), https://www.michigan.gov/leo/news/2024/10/01/michigan-minimum-wage-rate-2025-increase-schedule; Ann Arbor SPARK, *supra* note 81 (citing to store numbers).

[10] Total cost for continuing education decreased due to direct mailing only, no production of new materials. Priester, *supra* note 80.

[11] Calculation: Consumer Education Campaign + Total collection cost + Annual labor cost + Annual reinforcement educational campaign = 75,935.04 + $12,950.30 + $31,794.05+ $15,897.02 + $51,241 = $171,920.55. *Supra* notes 80-84.

[12] Calculation: Annual labor cost + Annual reinforcement educational campaign = $31,794.05 + $51,241 = $83,035.21. *Supra* notes 80-84.

[13] Assumptions used in the calculation include, monthly collection rate per store of nearly 1953.125 pounds based on Meijer Store reporting. *See Meijer Joins Consortium to Reinvent the Retail Bag*, Meijer (Dec. 17, 2020), https://newsroom.meijer.com/2020-12-17-Meijer-Joins-Consortium-to-Reinvent-the-Retail-Bag (last visited Nov. 21, 2024) (estimating six million pounds of plastic bags collected in 2020). Annual material calculation was determined by taking the estimated monthly collection rate divided by 2000 pounds per ton (1 ton equals 2000 pounds) and multiplied by number of stores again multiplied by number of months Ann Arbor SPARK, *supra* note 81 (citing to store numbers).

[14] *See* POLYMERS, PLASTICS INFORMATION EUROPE (PIE), https://pieweb.plasteurope.com/ (last visited November 22, 2024) (relying on going rate of rLDPE in Europe).

It's important to note that these are high-level estimates and actual results may vary based on real-world implementation factors.

Revenue from recycled materials:

- Sale price: 694.6 $/ton
  Assumption: rLDPE colored price value of 755 Euros per ton at 0.92 dollar/euro Nov-2024 [15]
- Potential revenue: $72,766.65
  Calculation: 103.6621 ton * $694.6/ton = $72,003.70

Landfill Savings:

- Landfill savings per ton: $7.36
- Assumption: Price per landfill bulk $7.36[16]
- Annual savings cost: $762.95
- Calculation: 103.6621 ton * $7.36/ton = $762.95

Total benefits: $72,766.65
Calculation: Potential revenue + Annual savings cost = $72,003.70+ $762.95= $72,766.65
Net Cost - Benefit after the first year: $14,079,611.90
Calculation: Total benefits - Estimated Annual cost = $72,766.65-$83,035.21 = -$10,268.55
ROI [17]: 87.63%
Calculation: (Net Benefit / Total Cost) * 100 = ($72,766.65/ $83,035.21) * 100 = 87.63%

[15] PIE Web. (2024). Sale price: 694.6 $/ton; Assumption: rLDPE colored price value of 755 Euros per ton at 0.92 dollar/euro Aug-2024. Retrieved October 21, 2024, from https://pieweb.plasteurope.com/
[16] University of Michigan. (n.d.). Waste management services and rates. Retrieved October 21, 2024, from https://ltp.umich.edu/waste-management/waste-management-services-and-rates/
[17] Applied Geographics, Inc. (2009). Economic justification: Measuring return on investment (ROI) and cost benefit analysis (CBA). National Spatial Data Infrastructure. Retrieved October 21, 2024, from https://www.fgdc.gov/initiatives/50states/newspbp/EconomicJustification_ROI-CBA-Tutorial_v2_052809_FinalVersa.pdf. Page1.

Table 3 - Cost-benefit analysis for long-term approach - MRF upgrade

| | | | |
|---|---|---|---|
| **Initial costs** | Population in Ann Arbor | | 119,381 |
| | Person per household | | 2.19 |
| | MRF upgrades | | $ 7,500,000.00 |
| | Collection Modifications | Trucks | 1 |
| | | Truck cost - truck and adaptation ($) | $ 180,000.00 |
| | **Estimated initial costs ($)** | | **$ 7,680,000.00** |
| **Annual Operational Costs** | Additonal labor | Additional Full-time employees | 5 |
| | | Base Salary - Minimum wage yearly ( | $ 43,888.00 |
| | | Total Labor cost ($) | $ 219,440.00 |
| | City-wide Education campaign ($) | | $ 272,559.36 |
| | Ongoing Education - Annual reinforcement educational campaign | | $ 51,241.16 |
| | **Estimated upfront costs ($)** | | **$ 8,171,999.36** |
| | **Estimated annual operational cost ($)** | | **$ 270,681.16** |
| **Benefits** | **Annual Material Collection (tons)** | Collection rate per household (lb) | 1.6 |
| | | Annually material collection (ton) | 43.60949772 |
| | | Current collection rate In Ann Arbor | 0% |
| | **Revenue from recycled materials** | Annually material collection (ton) | 43.609 |
| | | Sale price ($) | $ 694.60 |
| | | Potential revenue ($) | $ 30,291.16 |
| | **Landfill Savings** | Landfill savings per ton | $ 7.36 |
| | | Annual savings cost ($) | $ 320.97 |
| | **Total benefits ($)** | | **$ 30,612.12** |
| **Net Cost - Benefit after the first year ($)** | | | **$ -240,069.04** |
| **ROI** | | | **11.31%** |

Table 3 presents a cost-benefit analysis for upgrading a Materials Recovery Facility (MRF) in Ann Arbor, Michigan, as a long-term solution for improving recycling capabilities.

The analysis is based on the city's population of 119,381 and an average of 2.19 persons per household.[18] The initial costs include a significant estimated $7,500,000 investment for MRF upgrades[19] and $180,000 for one additional collection truck,[20] totaling $7,680,000[21] in upfront costs. Annual operational costs are estimated at $270,681.16[22], which includes labor costs for five additional full-time employees at minimum wage ($43,888 per year each)[23] and annual reinforcement educational campaign $51,241.16[24]. The total estimated upfront cost is

[18] *Supra* note 80.

[19] Video Conference Interview with Mark Fisher, CEO, Circular Great Lakes (Jul. 12, 2024) (estimating MRF upgrades to be between $5-10 million). For this analysis it was considered the average cost.

[20] Currently Recycle Ann Arbor fields seven recycling trucks, if the recycling rate increases another truck would be necessary to support operations. Tour of Ann Arbor MRF with Bryan Ukena, CEO, Recycle Ann Arbor (Sep. 29, 2024) (stating the MRF currently uses seven vehicles for collecting recycling).

[21] Calculation: Estimated initial cost = MRF upgrades cost and Truck cost = 7,5000,000 + 180,000 = 7,680,000.

[22] Calculation: Estimated operational cost = Total labor cost + Annual reinforcement educational campaign = $219,440 + $51,241.16 = $270,681.16

[23] This is an assumption based labor calculations from Table 2 and requiring full-time employees rather than part-time. *Supra* note 83.

[24] Total cost for continuing education decreased due to direct mailing only, no production of new materials. Priester, *supra* note 80.

$8,171,999.36[25], which includes total estimated initial cost $7,680,000, total labor cost $219,440 and City-wide education campaign $272,559.36[26]. The increase in transportation fuel and maintenance costs wasn't possible to estimate and it is not being considered in this model.

The analysis assumes a collection rate of 1.6 tons[27] per household annually, resulting in a potential material collection of 43.6094[28] tons. The revenue from recycled materials is calculated based on a sale price of $694.60 per ton, yielding a potential annual revenue of $30,291.16[29]. Additional benefits include landfill savings of $7.36 per ton, totaling $320.97 annually.

The net cost-benefit after the first year is estimated at -$240,069.04 indicating that the project would not break even in its first year of operation. However, the Return on Investment (ROI) is calculated at 11.31%, suggesting potential long-term financial viability. It's important to note that this analysis makes several assumptions:

1. The population and household data for Ann Arbor are accurate and current.
2. The education campaign costs and effectiveness are as estimated.
3. Transportation costs and collection frequencies are as projected.
4. The material collection rates and sale prices for recycled materials are achievable.
5. Labor costs are based on minimum wage and estimated work hours.
6. The effectiveness of the MRF upgrades and its ability to separate flexibles from other recycles.
7. Consistent collection rates

The actual outcomes may vary based on changes in these factors and other unforeseen circumstances.

Revenue from recycled materials:
Sale price: $694.60 per ton
Assumption: rLDPE colored price value Aug-2024 755 Euros at 0.92 dollar/euro [30]
Potential revenue: $30,291.16
Calculation: 43.60949 ton * $694.60/ton = $30,291.16

Landfill Savings:
Landfill savings per ton: $7.36[31]
Assumption: Price per landfill bulk per ton is $7.36
Annual savings cost: $320.97
Calculation: 43.60949 ton * $7.36/ton = $320.97

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[25] Calculation: Estimated upfront cost = Estimated initial cost + Total labor cost + City-wide education campaign = $7,680,000 + $219,440 + $272,559.36 = $8,171,999.36.
[26] City-wide/door to door campaign in US costs at least $5 per household. This information was a proxy analysis with Delterra extrapolating from the implementation cost in Argentina. Calculation: (122,216 population / 2.19 persons per household) * $5 = $272,559.36. Video Conference Interview with Shannon Bouton, CEO, Delterra (Oct. 15, 2024).
[27] Recycling Partnership. (2021). Collection rate per household: 1.6 lb. Retrieved from https://recyclingpartnership.org/wp-content/uploads/dlm_uploads/2021/04/FF_Whitepaper_final.pdf. Page 6.
[28] Potential annually material collection (ton) was determined by taking the estimated monthly collection rate per household divided by 2000 pounds per ton (1 ton equals 2000 pounds) then multiplying that number by taking total Ann Arbor Population (119,381) divided by the person per household size (2.19).
[29] Calculation: potential material collection *
[30] Plasteurope. (2024). Revenue from recycled materials: Sale price and assumptions. Retrieved August, 2024, from https://pieweb.plasteurope.com/
[31] University of Michigan. (n.d.). Waste management services and rates. Retrieved October 21, 2024, from https://ltp.umich.edu/waste-management/waste-management-services-and-rates/

Total benefits: $30,612.12

Calculation: Potential revenue + Annual savings cost = $30,291.16+ $320.97 = $30,612.12

Net Cost - Benefit after the first year: $-240,069.04

Calculation: Total benefits - Estimated operational cost = $30,612.12- $270,681.16 = $-240,069.04

ROI [32]: 11.31%

Calculation: (Net Benefit / Total Cost) * 100 = ($30,612.12/ $270,681.16) * 100 = 11.31%

Table 4 - Comparison between short and long term approach

| | |
|---|---|
| **Projection annual increase community participation** | 10% |
| **Years in consideration** | 5 |
| **MRF upgrades** | $ 7,500,000.00 |

**Five-Year Projection**

| **Short-term** | | | | | | |
|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total |
| Upfront costs | $ 171,920.55 | $ - | $ - | $ - | $ - | $ 171,920.55 |
| Cumulative Costs | $ 83,035.21 | $ 83,035.21 | $ 83,035.21 | $ 83,035.21 | $ 83,035.21 | $ 415,176.04 |
| Cumulative Benefits | $ 72,766.65 | $ 80,043.32 | $ 88,047.65 | $ 96,852.42 | $ 106,537.66 | $ 444,247.70 |
| Net Cost-Benefit | $ -182,189.10 | $ -2,991.89 | $ 5,012.44 | $ 13,817.21 | $ 23,502.45 | **$ -142,848.88** |

| **Long-term** | | | | | | |
|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total |
| Upfront costs | $ 8,171,999.36 | $ - | $ - | $ - | $ - | $ 8,171,999.36 |
| Cumulative Costs | $ 270,681.16 | $ 270,681.16 | $ 270,681.16 | $ 270,681.16 | $ 270,681.16 | $ 1,353,405.80 |
| Cumulative Benefits | $ 30,612.12 | $ 33,673.34 | $ 37,040.67 | $ 40,744.74 | $ 44,819.21 | $ 186,890.07 |
| Net Cost-Benefit | $ -8,412,068.40 | $ -237,007.82 | $ -233,640.49 | $ -229,936.42 | $ -225,861.95 | **$ -9,338,515.09** |

**Break-even Analysis**

| Short/Long term | Short-term | Long-term |
|---|---|---|
| Net Benefit after 5 years | $ 29,071.66 | $ -1,166,515.73 |
| Number of years to breakeven | 5.913681349 | -7.005477228 |

Table 4 presents a comparative analysis of short-term and long-term strategies for enhancing recycling infrastructure, over a five-year period. The analysis is based on several key assumptions, including a 10% annual increase in community participation and a total population consideration.

In the short-term strategy, the upfront costs are estimated at $171,920.55 in the first year, with no additional upfront costs in subsequent years. The annual costs remain constant at $83,035.21, while the benefits increase annually, starting at $72,766.65 in Year 1 and reaching $106,537.66 by Year 5. This results in a negative net cost-benefit from the outset, totaling $142,848.88 over the five years. In contrast, the long-term strategy involves significantly higher upfront costs of $8,171,999.36 in the first year. The annual costs are higher at $270,681.16, and the benefits are substantially lower, starting at $30,612.12 in Year 1 and reaching $186,890.07 by Year 5. This strategy shows a negative net cost-benefit throughout the five-year period, totaling -$9,338,515.09.

[32] Federal Geographic Data Committee. (2009). Economic justification: Measuring return on investment (ROI) and cost benefit analysis (CBA). Retrieved October 21, 2024, from https://www.fgdc.gov/initiatives/50states/newspbp/EconomicJustification_ROI-CBA-Tutorial_v2_052809_FinalVersa.pdf

The break-even analysis reveals that the short-term strategy breaks even in just 5.91 years (approximately 6 years), indicating a potential financial viability. However, the long-term strategy does not break even within the analyzed five-year period. In addition to financial metrics, there are some non-financial benefits, including environmental impact (reduced carbon emissions), community engagement (job creation), and long-term sustainability (community and environmental awareness) that can be calculated in future studies. These benefits, though not quantified, are important considerations that could offset some of the financial disadvantages of the long-term approach. Overall, the analysis suggests that the short-term strategy is more financially viable in the short term, while the long-term strategy, despite its higher initial investment, may offer significant non-financial benefits that could justify its implementation.

In conclusion, the store drop-off program has a much lower initial investment and potentially becomes self-sustaining after the first 6 years. Its collection rates are higher, and it relies heavily on consumer participation. The curbside pickup program requires a significant upfront investment and ongoing operational costs. While it potentially collects more material with the right separation and collection, it would take many years to recover the initial investment through material sales and landfill diversion savings alone. However, the curbside program offers broader societal benefits, such as: increased convenience for residents, potentially leading to higher participation rates over time, fewer individual trips to drop-off locations and others[33].

To make the curbside program more financially viable, additional funding sources or incentives may be necessary, such as government grants, extended producer responsibility programs, or increased fees for non-recyclable waste disposal. The choice between these short-term and long-term strategies will depend on several factors:

- Available capital: This could come from municipal governments, private waste management companies, or public-private partnerships[34].
- Long-term environmental goals: These are typically set by local or state governments, but may also be influenced by environmental agencies, community organizations, and corporate sustainability initiatives[35].
- Potential for technological advancements: This involves collaboration between waste management companies, recycling technology developers, and research institutions to reduce operational costs of the curbside program over time[36].
- Potential for better collection methods: This includes investments in R&D to develop improved technology that can enable contaminated flexibles to be recycled without losing value. It also involves exploring more efficient ways to collect clean materials from households and avoid contamination within the process, as seen in other parts of the country. For example, San Antonio and

[33] DiGiacomo, A., Wu, D. W.-L., Lenkic, P., Fraser, B., Zhao, J., & Kingstone, A. (2018). Convenience improves composting and recycling rates in high-density residential buildings. Journal of Environmental Planning and Management, 61(2), page 311. https://zhaolab.psych.ubc.ca/pdfs/Convenience_JEPM_2018.pdf

[34] Northeast Michigan Council of Governments. (2016). Successful recycling programs, best practices, and diversion potential final report. Michigan Department of Environmental Quality. https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/MMD/Recycling/2016-NEMCOG-Recycling-Report.pdf, page 8.

[35] U.S. Environmental Protection Agency. (2023). Recycling education and outreach grant reporting quick reference guide. https://www.epa.gov/system/files/documents/2023-01/Final%20REO%20Grant%20Reporting%20Quick%20Reference%20Guide_508.pdf. Page 1.

[36] Brown, M. S., Yoder, J., & Chouinard, H. (2016). Revenue sources for recycling, reuse, and waste reduction programs. Washington State Department of Ecology. https://apps.ecology.wa.gov/publications/documents/1607015.pdf. Page 56-57.

Vancouver, Washington use separate plastic bags for collection or promote the return of bags and wraps to retail locations.[37]

- Expanding the available end markets that accept recycled flexibles: Currently, there are limited end markets available that accept recycled flexibles, and the sale price is often much lower than that of virgin resin[38]. This disparity frequently makes it challenging to recoup investments. Therefore, with more investments and market expansion, recycled flexibles can be more widely used and economically viable.

The decision-making process for implementing these strategies often involves multiple stakeholders, including city councils, waste management authorities, environmental departments, and sometimes public referendums. It requires careful consideration of local economic conditions, environmental priorities, and community support for recycling initiatives.

[37] Closed Loop Partners. (2023, October 15). Investment opportunities in film plastic recycling. https://www.closedlooppartners.com/foundation-articles/investment-opportunities-in-film-plastic-recycling/. Page 22 and page 69.

[38] Closed Loop Partners. (2023, October 15). Investment opportunities in film plastic recycling. https://www.closedlooppartners.com/foundation-articles/investment-opportunities-in-film-plastic-recycling/. Page 29 and page 31.

## Recommendations

Based on the analysis, a two-way approach is recommended to address flexible packaging recycling in Ann Arbor. In the short term, expanding and increasing the use of store drop-off programs due to their lower initial investment and potential for self-sustainability within the first 6 years. This approach shows a positive ROI of 87.63%. The store drop-off program relies heavily on consumer participation but demonstrates higher collection rates, making it a financially viable solution that could be implemented quickly.

For the long-term strategy, upgrading the Materials Recovery Facility (MRF) in Ann Arbor is recommended, despite the significant upfront investment of $8,171,999.36. Before considering an upgrade to the Materials Recovery Facility (MRF) in Ann Arbor, it's essential to evaluate if the current facility has the physical space and infrastructure to accommodate new equipment. If expansion is possible, a detailed assessment of potential upgrades, their costs, and expected improvements in recovery rates should be conducted to determine the feasibility and potential return on investment. While this approach shows a negative net cost-benefit of $-240,069.04 in the first year, it offers broader societal benefits such as increased convenience for residents and potentially higher participation rates over long time.

To enhance the financial viability of the curbside program, several key areas can be explored for improvement. Investing in advanced sorting technology could significantly boost collection rates and reduce contamination. For instance, optical sorters and artificial intelligence-driven systems can more accurately identify and separate different types of flexible plastics, improving the quality of recovered materials[39]. Additionally, implementing better collection strategies, such as using separate bags for flexibles or returning to the retail or providing clear guidelines to residents, could minimize contamination at the source. This approach has proven successful in San Antonio and Vancouver Washington, where this different collection method has improved the quality of recovered materials [40].

Expanding end markets for recycled flexibles is crucial for long-term sustainability. Currently, limited end markets and low sale prices for recycled flexibles compared to virgin resin make it challenging to recoup investments[41]. However, with increased investment in research and development, new applications for recycled flexibles could be developed, potentially increasing demand and value. Collaborations between waste management companies, recycling technology developers, and research institutions could lead to innovations that make recycled flexibles more competitive in the market.

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[39] Closed Loop Partners. (2023, October 15). Investment opportunities in film plastic recycling. https://www.closedlooppartners.com/foundation-articles/investment-opportunities-in-film-plastic-recycling/. Page 55-58.

[40] Closed Loop Partners. (2023, October 15). Investment opportunities in film plastic recycling. https://www.closedlooppartners.com/foundation-articles/investment-opportunities-in-film-plastic-recycling/. Page 22 and page 69.

[41] Closed Loop Partners. (2023, October 15). Investment opportunities in film plastic recycling. https://www.closedlooppartners.com/foundation-articles/investment-opportunities-in-film-plastic-recycling/. Page 29 and page 31.

## rLDPE colored price value of 755 Euros[42]


### Polymers

**Polymer prices in EUR/t**

| | August 2024 | | | | September 2024 | |
|---|---|---|---|---|---|---|
| Type | Price | Change | Range | Market | Price trend | Market |
| rLDPE film natural | 1,330.00 | +10.00 | 1,300.00 - 1,360.00 | balanced (short) | little change | balanced |
| rLDPE film translucent | 1,135.00 | +10.00 | 1,100.00 - 1,170.00 | balanced | little change | balanced |
| rLDPE film coloured | 755.00 | 0 | 730.00 - 780.00 | balanced | little change | balanced |
| rLDPE film dark | 755.00 | 0 | 720.00 - 790.00 | balanced | little change | balanced |
| rLDPE extrusion black | 650.00 | 0 | 630.00 - 670.00 | balanced | little change | balanced |
| rLDPE inj. moulding grade black | 640.00 | 0 | 610.00 - 670.00 | balanced | little change | balanced |
| rHDPE Pipe above 930 black | 955.00 | 0 | 930.00 - 980.00 | balanced | increasing | balanced |
| rHDPE blow moulding coloured | 905.00 | 0 | 880.00 - 930.00 | balanced | little change | balanced |
| rHDPE inj. moulding grade black | 950.00 | +10.00 | 920.00 - 1,000.00 | balanced | increasing | balanced |
| rPP homopolymer black | 970.00 | 0 | 930.00 - 1,010.00 | balanced | increasing | balanced |
| rPP copolymer black | 1,110.00 | 0 | 1,070.00 - 1,150.00 | balanced | little change | balanced |
| rHIPS black | 1,120.00 | 0 | 1,060.00 - 1,180.00 | balanced | little change | balanced |
| rPET clear | 1,565.00 | +10.00 | 1,520.00 - 1,610.00 | balanced | little change | balanced (long) |
| rPET flakes clear | 1,260.00 | +15.00 | 1,220.00 - | balanced | little change | balanced |

[42] *Supra* note 88.