2020 KEY LEARNINGS REPORT:
RFLEX BALE PRODUCTION AT PILOT FACILITY

HIGHLIGHTS

- **rFlex** is a new post-consumer material stream made up of flexible plastic packaging, currently recovered through a pilot program to collect and sort this material from curbside single-stream recycling.
- The **rFlex bale** primarily consists of polyolefin materials such as retail carry bags, storage bags, shrink bundling, and wrap, along with multilayered packaging and fiber materials.
- The pilot facility is expected to have the capacity to produce **6,000,000 pounds** of rFlex annually at full implementation. Recovery of rFlex from other recycling facilities could significantly increase capacity.
- **Materials Recovery for the Future (MRFF)**, a program of the Foundation for Chemistry Research & Initiatives and the sponsor of this pilot, is a collaboration between leading members of the packaging value chain. MRFF supports research to recycle flexible plastic packaging curbside and allow the recovery community to capture value from it.

The ongoing evolution of packaging types and formats is clearly visible to anyone browsing supermarket shelves today. Flexible plastic packaging (FPP) is one of the fastest growing consumer packaging formats, displacing a variety of heavier, rigid materials. Its sustainability benefits include lighter weight, diminished amount of material required for packaging, and reduced food waste. But what happens to post-consumer FPP once its job protecting and storing products is done?

The Materials Recovery for the Future (MRFF) program, a collaboration among leading members of the packaging value chain, was created to research and develop solutions to recover the value from, rather than landfill, this evolving type of packaging. Through this research program, the MRFF members aim to solve bale quality issues at recycling facilities and produce valuable recovered materials that could be used in a wide variety of new products.

rFlex is a new bale of post-consumer materials consisting primarily of film plastic and FPP produced through MRFF's 2019 research pilot at Total Recycle, a single stream recycling facility located in Berks County, Pennsylvania. This report summarizes initial learnings from the pilot facility's research into rFlex production, the qualities of the bale, and the opportunities presented to use this new material in production processes. A full report will follow in Spring 2020 that presents the impact on facility operations and other commodities, end market test results, and the details of community curbside collection for other facilities managing this packaging type.

MRFF came together to achieve a shared vision: that FPP is recycled curbside, and that the recovery community captures value from it. Over the past four years, MRFF sponsors have funded MRF and end market testing to evaluate scalable pathways for flexible packaging recovery.

Pilot Facility rFlex Production

Since September 2019, the MRFF pilot facility has been producing rFlex from single-stream recycling feedstock collected from residential customers. Residents in pilot communities have been instructed to include a variety of loose, unbagged plastic pouches, film, and bags in their recycling carts, as shown to the right. At the pilot facility, optical sorters are used to eject these materials from the two-dimensional fiber stream. This material is further cleaned to remove as much fiber as possible and produce a relatively pure stream of FPP.

FIGURE 1: INSTRUCTIONS TO RESIDENTS

The rFlex bales produced at the pilot facility currently consist of an average of 80 percent or greater FPP with a goal to consistently reach 85 percent or greater FPP. The FPP itself is primarily polyolefin (60% of the total bale) such as retail carry bags, storage bags, shrink bundling, and wrap. This 60% polyolefin component is estimated to consist of 54% polyethylene and 6% polypropylene. Multilayer FPP such as standup pouches and chip bags make up 10% of the bale and unidentified FPP makes up another 10%. The 10% unidentified FPP consists primarily of pieces of packaging that are too small to identify by sight. The remaining 20% of the bale consists of fiber (11%), flattened containers including PET bottles, steel or aluminum cans (4%), and other contaminants such as organics or heavily contaminated packaging (5%). On average, the pilot facility is producing between 90-100 rFlex bales per month, equating to 90-100 tons of rFlex produced per month based on an estimated rFlex bale weight of 2000 lbs. As community collection continues to expand, rFlex production capacity at the pilot facility is expected to increase.

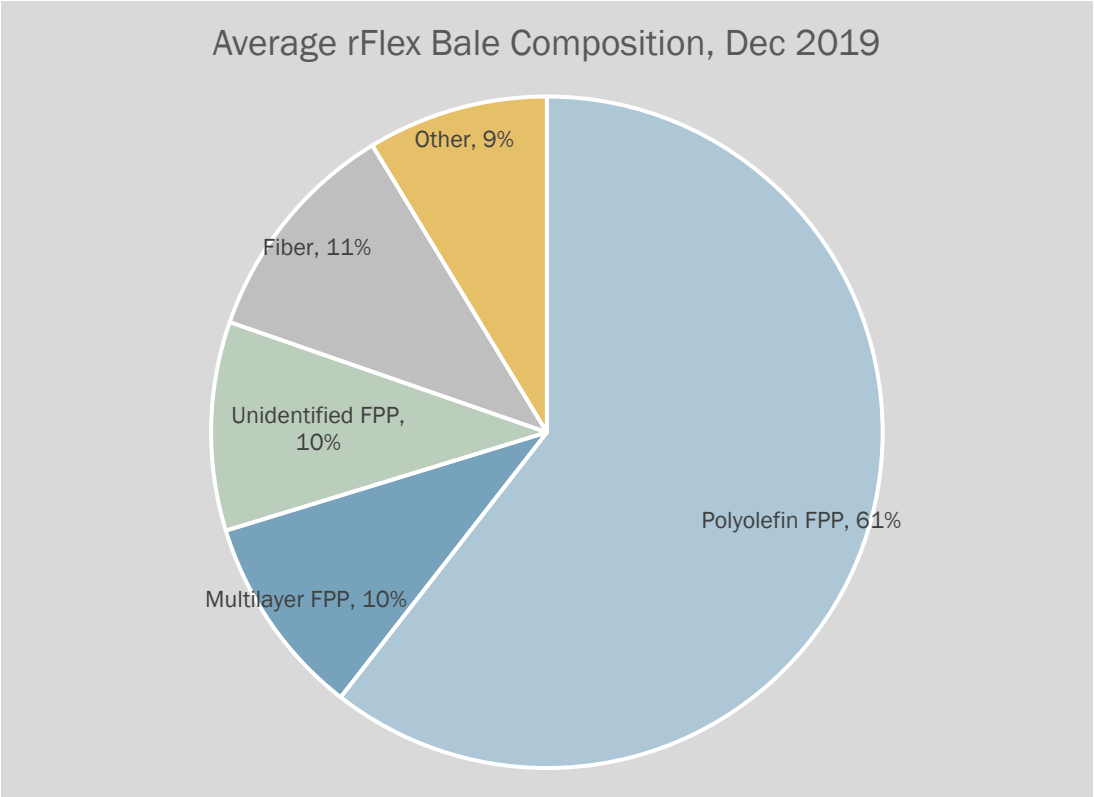

FIGURE 2: AVERAGE RFLEX BALE COMPOSITION DECEMBER 2019

The current production and quality of rFlex represents the results of 9 months of tuning and continual improvement since the rFlex collection system was installed. The pilot equipment and bale quality has been evaluated over the pilot period in several ways.

The composition of the rFlex bale described above has been tracked using weekly **bale breaks**. The bale break procedure relies on manual sortation to measure the composition of material sorted to the FPP bunker into specific categories. The samples are sorted into the target material (e.g. FPP) and different categories of contaminants (e.g. fiber, containers, and trash). Detailed bale audits of the FPP product have provided data on the types of materials and packages found in the incoming stream.

Radio-frequency identification (RFID) testing has been used to track the flow of FPP through the entire MRF. In this testing method, RFID tags are attached to individual packages which are then seeded into inbound material. RFID readers set up at various points through the MRF line detect the RFID tags, read their information and relay that information back to networked computers for display and storage. By placing RFID readers at strategic locations and comparing tag reads from one reader to another it is possible to determine how each tagged package flowed in the MRF.

Other measurement and assessment methods, ranging from simple observation to lab testing to enhance programming of the optical sortation equipment, have been used from time to time to assess progress towards goals and identify areas needing improvements. While these techniques do not provide trackable metrics, the information gathered through close monitoring of the system has influenced the use of equipment and the design of quantitative testing.

The results of the bale measurement and improvement process are shown below. The current bale purity has been enhanced greatly over the course of the pilot.

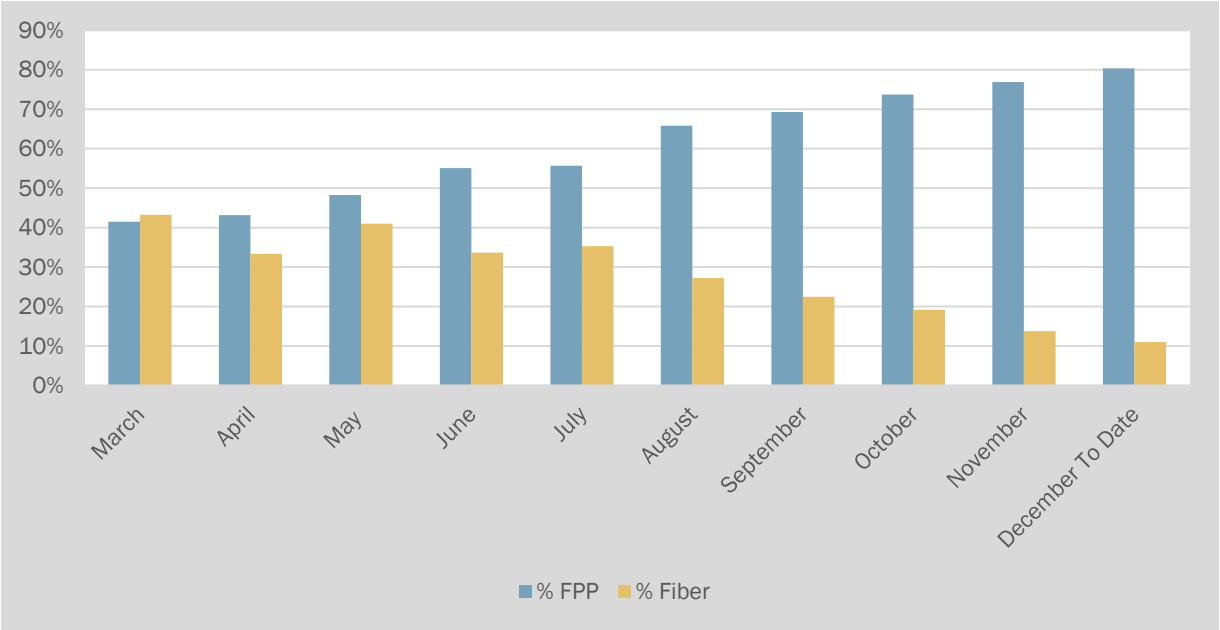

FIGURE 3: MONTHLY BALE PROGRESSION FROM EQUIPMENT TURN ON. PERCENTAGE FPP AND FIBER BASED ON WEEKLY BALE BREAK DATA

Developing the Bale – R&D Background

The MRFF research program was launched as a result of economic modelling conducted in 2014 demonstrating the theoretical feasibility of collecting and sorting FPP through residential single stream recycling. This investigation led to the program's foundational research in 2015-16 showing the potential for existing MRF equipment, specifically optical sorters, to remove flexibles from fiber lines at efficiencies of 70% or greater. The full results of the foundational research are available for download at www.materialsrecoveryforthefuture.com.

As the foundational research pointed the way to establishing a pilot facility to sort FPP, the MRFF program produced an estimate of the composition of a theoretical bale of rFlex. Data from the Flexible Packaging Association (FPA) showed the production of various packages and resin types put into the US marketplace annually. After applying an estimated real world recovery rate to the material produced, as well as anticipated fiber residual as seen in performance testing, the bale was expected to consist of a mix of polyolefins, including single-resin polyethylene and polypropylene; multi-material laminates; and fiber. The specific theoretical bale specification was established at:

- At least 60% single-resin polyethylene films and laminates, including grocery bags, product overwraps, and similar materials;
- Up to 18% multi-material films, bags, pouches and other laminates with the predominant material consisting of polyethylene and limited contaminants not to exceed the following levels: PET 2%, PVC 1%, metal foil 1%, nylon 1%;
- Up to 7% single-resin polypropylene films and laminates;
- Up to 15% paper contamination.

The development of the MRFF Pilot has proceeded along with the development of the rFlex bale specification. In March 2017, MRFF issued a public announcement seeking to identify a domestic MRF interested in partnering to conduct a flexible packaging recycling pilot. An important eligibility factor was that the candidate be a large (>20 ton/hr) facility suitable for testing a scalable automated sorting solution. Over 50 facilities in multiple regions where the regulatory/economic environment supported increased diversion and large flexible packaging streams were identified as potentially eligible candidates.

MRFF organized management consultations and facility visits to screen potential facilities and identify the eventual pilot facility. This facility utilizes a 40-Ton per hour Bollegraaf system featuring anti-wrap screens, considered to be industrial-grade. The system installed to sort rFlex at the pilot facility consists of three Tomra Autosort 4 optical sorters that eject FPP from the fiber lines, followed by a fourth Autosort 4 that ejects fiber from the resulting FPP stream. The final component of the system is a Lubo PaperMagnet used to remove 3-D materials from the cleaned FPP stream. The resulting materials are conveyed via a suction system to a dedicated rFlex bunker.

Future Sortation System Improvements

Improvements to the pilot facility's FPP sortation system are planned to remove containers and help ensure continued output of high quality rFlex bales, working to exceed the theoretical bale specification. The planned improvements are shown below.

Planned Improvement	Schedule
Addition of collection hood over paper QC station. Creates direct line for FPP removed by QC staff from paper QC to rFlex bunker	2nd quarter 2020
Addition of QC station following paper magnet. Will allow for removal of fiber and other contamination following the final piece of equipment. Bale contents can be tuned based on end market-specific needs.	2nd quarter 2020
Addition of air assistance on the belt leading to the fourth optical sorter. Will improve sorting of FPP from fiber at final optical sorter.	2nd quarter 2020

With the planned improvements to the FPP sortation system and the continued expansion of FPP curbside collection, production capacity of rFlex from TotalRecycle is expected to increase.

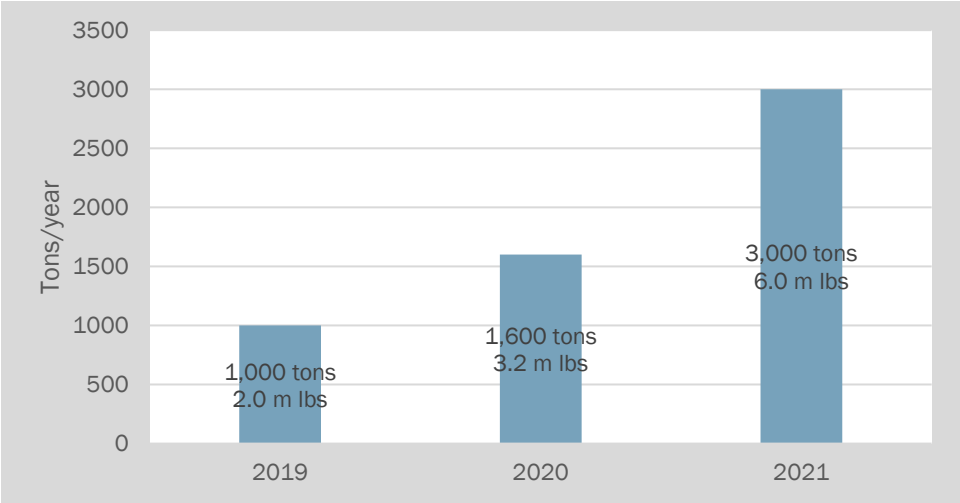

FIGURE 4:POTENTIAL ANNUAL RFLEX PRODUCTION AT TOTALRECYCLE

The pilot facility is estimated to have the capacity to produce 6,000,000 pounds of rFlex annually at full implementation.

The chart below shows the potential for rFlex production if the system implemented at the pilot facility were to be adopted by the largest single stream US MRFs[1]. The program growth illustrated in the chart represents the capture of FPP growing over a five-year period to match the capture rate of other plastic packaging formats with a longer history of inclusion in the recycling system.

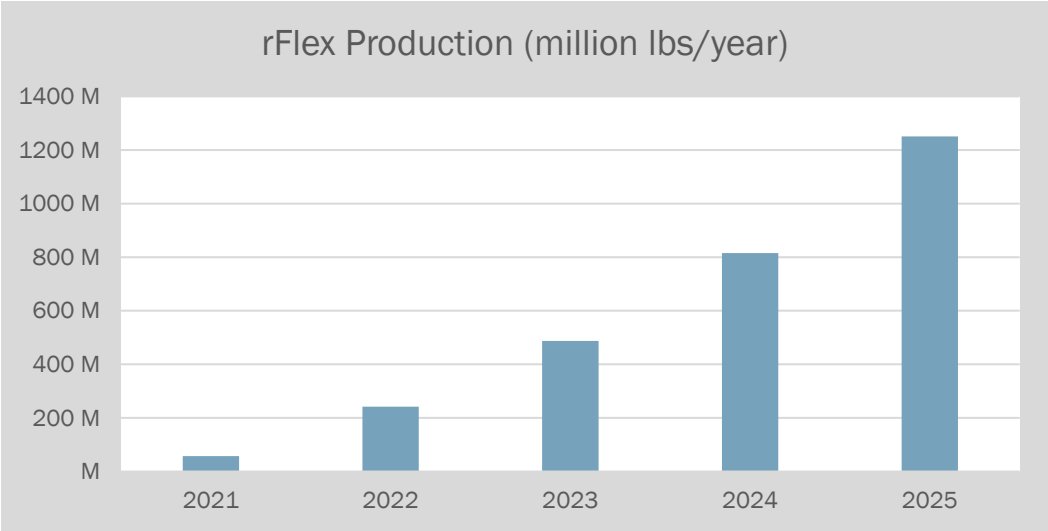

FIGURE 5: ANNUAL POTENTIAL RFLEX PRODUCTION

The MRFF program has integrated the development of end markets for the existing and potential future supply of rFlex concurrent with the MRF facility upgrade. As potential end users of the rFlex material are identified, the MRFF program works with them to support testing and eventual utilization of the rFlex material.

Conclusion

The MRFF pilot has demonstrated the ability to produce a consistent bale of rFlex material from single stream residential recycling. While the pilot research was expected to take 6-12 months to tune and optimize the equipment, the purity of the rFlex produced now stands around 80% with additional enhancements planned over the next six months. This bale is primarily polyolefin films, including polyethylene and polypropylene; multi-layer materials; and fiber. Testing of the physical properties of the bale and intermediate products, such as pellets, is currently underway. The learnings from the MRFF pilot could be used to rapidly implement similar systems at large MRFs around the country. The sponsors of the MRFF program are committed to capturing the value from packaging materials through successful recycling programs. Manufacturers interested in incorporating rFlex into their processes can learn more at the www.materialsrecoveryforthefuture.com website or contact the Research Team members listed below.

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[1] Largest MRFs as listed in:
DeAnne Toto, 'The Largest 75 MRFs in North America', *Recycling Today*, 2019 <https://www.wastetodaymagazine.com/article/largest-north-american-material-recovery-facilities/> [accessed 31 January 2020].