Stretch Wrap Alternative Project

White Paper

Learnings from eleven organizations about circular alternatives to linear stretch wrap

Plastic packaging—from bottles to takeout containers to shopping bags—is often used once and then discarded to landfills, incinerators, or directly into the environment, contributing to a growing plastic waste problem that is polluting waterways and oceans, threatening marine life, and contaminating soil and groundwater around landfills. Although the most visible sources of plastic packaging are those distributed to consumers, business-to-business use is a significant part of the problem. In particular, stretch wrap is highly prevalent. **Stretch wrap is used to secure loads to pallets so that products can be transported safely. It performs well and is cost effective, but it is also generally discarded after use, with only 21 percent recycled in the US[1] and 30 percent in Europe[2].** Businesses must work across the value chain to drastically reduce reliance on this linear plastic packaging model and transition to circular packaging models to reduce the environmental impact from the use of plastic.

In August 2020, Microsoft committed to becoming zero waste across our direct operations, products, and packaging by 2030, and as part of that commitment, we will eliminate single-use plastic from our packaging by 2025. This commitment includes the stretch wrap used in the delivery of the IT hardware for our datacenters from our cloud suppliers. However, because stretch wrap is commonly used across industries as a standard, it is not an easy issue for a single company (even one the size of Microsoft) to tackle in isolation. We recognize that collaboration is key.

In January 2021, we initiated a project —the **Stretch Wrap Alternative Project (SWAP)**— including ten companies from the Ellen MacArthur Foundation network.

Our collective goal: to reimagine pallet wrap by starting with design, inspired by the Foundation's Upstream Innovation guide

SEE GUIDE

1. RSE USA. (n.d.). The Closed Loop Foundation. Film Recycling Investment Report.
2. Eunomia And Plastics Recyclers Europe. (n.d.). *Flexible Films Market in Europe. State of Play. Production, collection and recycling data.* LINK

We tested three alternatives to linear stretch wrap, focusing on reuse, recycling, and composting options. **Our aim was to assess whether they could be technically feasible, scalable, and commercially viable while reducing the environmental impact when compared with the current stretch wrap option.** We found that all three alternatives have potential, though no single option is right in every case—the best solution depends on the specific product, situation, and geography and requires full life cycle thinking to identify and implement.

With this project, we hope to spotlight viable circular alternatives to linear stretch wrap for transport packaging, providing the evidence and key considerations to drive adoption across industries globally. Ultimately, we want uptake of circular models to occur at a scale that will significantly reduce the amount of plastic packaging that ends up in landfills, incinerators, and the environment.

Alessandra Pistoia
Zero Waste and Circularity Program Manager
Microsoft Corporation

Contents

Executive Summary

The world is in a plastic crisis

78 million metric ton

of plastic packaging[3] are generated per year, with the vast majority following a linear route of disposal to landfill, incineration, or worse, leakage into natural environments.

Commercial film alone contributes around

3 million metric ton

annually in Europe and the US to this growing problem[4].

Following the increased focus on tackling this issue, a network of eleven key organizations have formed the **"Stretch Wrap Alternative Project"** (SWAP) to explore circular alternatives.

3. Ellen MacArthur Foundation. (2016). *The New Plastics Economy. Rethinking the future of plastics.* LINK

4. (Callari, 2020), Eunomia And Plastics Recyclers Europe. (n.d.). Flexible Films Market in Europe. State of Play. Production, collection and recycling data. LINK

Three working groups were formed, each group piloted a circular solution pathway inspired by the Ellen MacArthur Foundation's UPSTREAM INNOVATION GUIDE. **The guide outlines its vision of the circular economy for plastic packaging, creating a hierarchy of preferred solutions that aims to prevent waste generation.** It prioritizes upstream innovations, like reducing plastics and implementing reusable solutions, then considers downstream innovations to increase recycling and composting. We tested one upstream intervention and two downstream pathways in this study.

Reuse
Assessed reusable options and tested a reusable pallet hood

Recycling
Explored the potential for pallet stretch wrap to be recycled back into pallet stretch wrap

Composting
Tested the use and end-of-life disposal of an industrially compostable pallet stretch wrap

The three solutions and a linear low-density polyethylene (LLDPE) plastic baseline were each tested once throughout 2021, including standardized transit tests and Life Cycle Analysis (LCA). **Four criteria were used to qualify success: technical feasibility, scalability, environmental impact, and commercial considerations.**

Our findings showed that there is no "one size fits all" circular solution that can replace linear stretch wrap, due to the unique requirements of products, supply chain, geography, and use case. While upstream interventions, like reduction and reuse, should be prioritized, each of the alternatives piloted have their place, and should be implemented based on the specific use and geography. While circular alternatives should be prioritized, linear stretch wrap may remain the only viable option in certain circumstances where upstream changes are not viable to implement, or recycling and composting infrastructure does not exist in a specific geography.

While this study tests three solutions, there are many other solutions available on the market. **We recommend a full life cycle thinking when identifying and testing circular alternatives, including ensuring required infrastructure and training is put in place.**

Collaboration across industry and stakeholders is crucial to ensure that stakeholders throughout the value chain benefit and solutions have an environmental benefit.

High–level pilot results

Key lessons learned during each of the pilots across our four criteria

Table 1

	Reuse	Recycling	Composting
Technical feasibility	Successful when suitable management and return systems are in place to prevent damage and maximize repeated use.	Performance issues caused by contamination limit the level of post-consumer recycled (PCR) content and make it more suitable for hand application.	The compostable wrap tested encountered some issues during mechanical application, but successfully passed the transit test. Composting test was successful.
Scalability	Challenging to develop return systems for reusable options within more complex supply chains and on products destined for export.	Increasing the quality and quantity of film captured for recycling, including addressing washing capabilities for reprocessing.	Limited access to global industrial composting facilities. Limited acceptance of compostable film, except for food packaging.

	Reuse	Recycling	Composting
Environmental impact	When used enough[5] times, this option was the most favorable from an environmental perspective, emphasizing the importance of maximum uses.	The compostable and recycled content wrap had higher environmental impacts than the baseline linear stretch wrap, due to the machine-applied baseline requiring less weight than films for hand application which requires twice the amount of material, outweighing the benefits of improved end-of-life treatment options.	
Commercial considerations	Commercial implications are extremely variable, depending on market and operational factors including material prices and infrastructure. Collection, preparation, and treatment costs are large influences on the cost of compostable and recycled content options. Initial purchase cost, reverse logistics and number of uses obtained are the main factors contributing to the overall cost of the reusable option.		

The findings of this project provide evidence of circular solutions for pallet wrap, and the need for cross-industry collaboration to transition. Next steps include prioritizing reduction and reuse where possible, further testing and live testing applications for circular solutions, establishing more recycling systems for stretch wrap used today, developing a standardized chemical formulation for stretch wrap, and increasing investment into the development of global recycling and composting infrastructure.

An increase in demand in piloted applications is likely to increase both best practice examples and investment into new infrastructure, reinforcing the transition towards a circular economy for pallet stretch wrap. **The SWAP group is intending to present learnings at conferences relevant to the industry, share best practices throughout the value chain, and support other businesses in their transition towards circular pallet wrap.**

5. Based on the result of the LCA study undertaken of this project and its specific use case, the environmental breakeven point was a use number of 50.

Introduction

Against a backdrop of high consumer awareness, action by policy makers, and circular packaging commitments by corporations[7] there are increased global efforts to tackle plastic waste via changes to packaging design and investment in infrastructure and education. **Efforts tend to focus on consumer packaging, though business-to-business packaging is also a significant contributor to plastic waste volumes.**

Most plastic packaging follows a linear route of disposal with only

14%

of packaging collected for recycling globally[6].

In Europe[8] and the USA[9] alone almost

3 million metric ton

of commercial film, including the stretch wrap used to stabilize pallet loads in transportation, are being used every year.

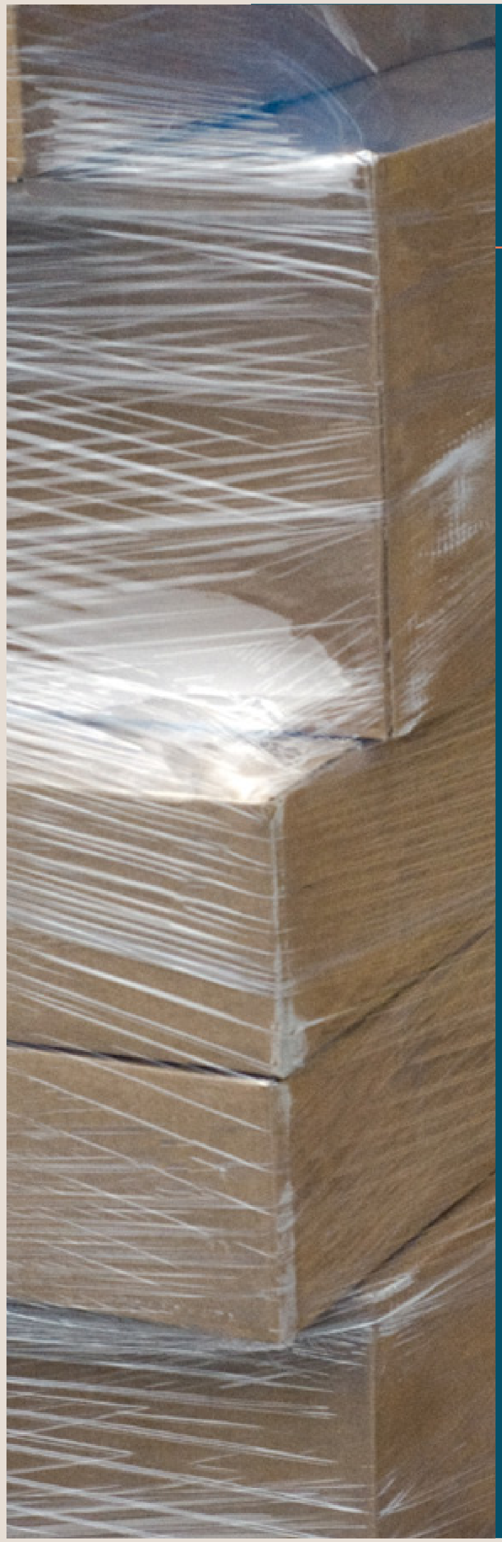
Stretch wrap is the industry standard for securing pallet loads because of its performance, flexibility, and favorable economics. It can be applied to nearly any load shape, colored to hide products, is inexpensive, and allows easy handling. It's a challenge to find comparable alternatives.

Although it is technically possible to recycle stretch wrap, recycling rates are estimated to be just 21% in the US[10] and 30% in Europe[11]. Furthermore, the material is often recycled in open loop systems, which uses the recycled material to create other products such as trash bags or commercial film with thicker gauge. Only a minority of material used is recycled back into stretch wrap in a closed loop system (mainly into hand-applied film), due to contamination challenges.

6. Ellen MacArthur Foundation. (2016). *The New Plastics Economy. Rethinking the future of plastics.* LINK
7. As seen through the increase of signatories to the NEW PLASTICS ECONOMY GLOBAL COMMITMENT by the Ellen MacArthur Foundation.
8. Eunomia And Plastics Recyclers Europe. (n.d.). *Flexible Films Market in Europe. State of Play. Production, collection and recycling data.* LINK
9. Callari, J. (2020, June 24). Plastic Technology Online. Retrieved February 07, 2022, from PE Film Market 2020 Snapshot: Stretch Film. LINK
10. RSE USA. (n.d.). The Closed Loop Foundation. Film Recycling Investment Report.
11. Eunomia And Plastics Recyclers Europe. (n.d.). *Flexible Films Market in Europe. State of Play. Production, collection and recycling data.* LINK

Acknowledging the industry-wide use of the material, as well as the difficulty of large-scale stretch wrap recycling, a group of eleven key industry organizations has come together through the ELLEN MACARTHUR FOUNDATION NETWORK, to explore circular solutions and ideas that could reduce environmental impact.

Closed loop	This term refers to a closed loop recycling process, where **the material is recycled back into the same application**, e.g., stretch wrap back into stretch wrap. A closed loop supply chain is typically limited to one part of the supply chain and entails a repetitive back and forth use of reusable packaging on shipments.
Open loop	**An open loop recycling process does not prepare the material for the same use and application, but often for lower value applications.** E.g., stretch wrap recycling into bin bags. Open loop supply chains are based on cross-industry operations which run through multiple parts of the supply chain. In this case multiple stakeholders are involved, and the packaging may move across various operations and regions.



A technical note on stretch wrap

Stretch film is a multilayer material mainly comprised of linear low-density polyethylene (LLDPE) or low-density polyethylene (LDPE).

The application of stretch wrap can be either manual or mechanical. For either application, the standard film width is 500 mm and ranges from 9-30 microns in thickness. The film can be classified as either standard stretch or pre-stretch where the film is stretched between two rollers with the secondary roller being larger to mechanically increase the stretch. This produces a film of a smaller width around 430 mm and 8-12 microns in thickness. The choice of film application will depend on the product, location, and mode of transportation.

To avoid any confusion, while pallet protection can be either stretch or shrink wrap, this paper focuses on pallet stretch wrap.

The SWAP Network and pilots

This white paper details the pilots and findings of this collaboration, the "Stretch Wrap Alternative Project" (SWAP). Three working groups were formed to identify circular solutions for linear stretch wrap, each piloting a solution pathway inspired by the Ellen MacArthur Foundation's UPSTREAM INNOVATION GUIDE [12]

Reuse

Assessed reusable options and tested a reusable pallet hood. This pathway is prioritized within the Foundation's Upstream Innovation Guide after eliminating any unnecessary or problematic plastic packaging.

Recycling

Explored the potential for pallet stretch wrap to be recycled back into pallet stretch wrap. This pathway explores a closed loop recycling model for stretch wrap to optimize the material use at end-of-life.

Composting

Tested the use and end-of-life disposal of an industrially compostable pallet stretch wrap. This pathway tests the circularity of stretch wrap through a biological cycle.

12. Ellen MacArthur Foundation. (2020). Upstream Innovation. A guide to packaging solutions. Isle of Wight. LINK

The organizations involved in this project cover the majority of the full "life cycle" of packaging, inclusive of material producers, packaging designers & manufacturers, Fast Moving Consumer Goods (FMCG) companies applying the material to their products and finally, recyclers, representing each step along the supply chain.

The goal of each pilot was to identify the benefits and challenges of each option and gain a better understanding of what needs to be done to improve its circularity.

Success criteria selected to assess the pilots

1 Overall technical feasibility

Including performance, safety, and convenience

2 Scalability

Potential for implementation on a wider scale

3 Environmental impacts

Including greenhouse gas emissions, water use, material circularity and ecotoxicity

4 Commercial considerations

Key influences on financial aspects

The three solutions and a baseline, represented by conventional and linear LLDPE wrap, were tested throughout 2021 using standardized transit tests (International Safe Transit Association (ISTA) 3E transit tests[13]) in a laboratory environment under equal conditions. Laboratory tests, compared to live distribution tests, provide a fully monitored environment, while imitating real life forces to pallet and load. Results should be indicative of how the load will perform in real life, but it is recommended to also do a live distribution test to confirm its true performance.

13. The ISTA 3E test is a "general simulating test for unitized loads of similar retail or institutional packaged-products shipped from a manufacturing location to a distribution center" (LINK) The testing procedure of 3E covers 7 testing criteria, covering a variety of different test types. The main criteria which were assessed during this pilot was shock, both incline impact and rotation edge drop, compression, and vibration.

The ISTA 3E transit test

The ISTA 3E transit test provides a laboratory simulation of damage-producing motions, forces, conditions, and sequences of transport environments. The test includes:

- **Shocking the pallet through an incline impact** to simulate the load hitting the inside of a truck
- **Compressing the pallet** with a machine to simulate double/triple stacking in a warehouse
- **Simulating truck vibration** that occurs in transportation
- **Shocking the pallet by rotational edge** drops to simulate warehouse handling with a pallet jack or forklift

To assess the reusable, recycled content, and compostable pallet wrap options discussed in this report, ISTA 3Etransit tests were conducted. The tests aimed to assess whether the material was able to perform equally or better than the control (100% virgin LLDPE pallet stretch film) in terms of:

01 **Application of wrap to the load**

02 **Securing of the load**

03 **Holding the load through ISTA 3E protocol**

Further details are provided in Appendix 1.

A high-level LCA study for the three different solutions and the baseline was conducted to assess the environmental impacts. Further details of the LCA approach are provided in Appendix 3.

Geographically, the pilots focused on Europe and the US, due to SWAP members' location and a greater level of available stretch wrap data for these regions.

It should be noted that the solutions piloted are examples and proof of concepts and further real-world testing is recommended to inform adoption. This could include pilots and tests for specific products within individual operations, or between two companies in existing logistic chains. There are many other alternatives to stretch wrap not covered in this report.

Reuse Workstream

Background

Reusable pallet protection can replace single-use and linear stretch wrap, reducing environmental impacts from manufacturing, demand for material, and end-of-life waste, along with offering a durable solution that can be managed through different parts of a logistics operation. **Reusable packaging is the preferred option after reducing problematic or unnecessary plastic.**

Reusable packaging can reduce the need for single-use packaging on the path towards transitioning to a circular solution.

It is estimated that at least **20%** of total plastic packaging could be replaced by reusable systems[14].

The more often reusable options are used, the greater the environmental benefit and return on investment can be.

According to the GLOBAL COMMITMENT REPORT[15], the number of companies planning to establish reuse pilots is growing, increasing knowledge of options available and their viability. Reuse options are being explored for both intra-company transport as well as industry-wide transportation systems. There are multiple successful pilots and scaled implementation of business-to-business reusable pallet wraps, including examples in the Foundation's UPSTREAM INNOVATION GUIDE and a use case detailed by Cisco below, providing the use case for this circular packaging solution.

Reusable options can require an initial high financial investment and inventory (and return) management, so it's important to consider the type of transport system the packaging will be used in.

The operational and commercial implications of reusable packaging vary among different types of transport systems. For the purposes of the pilot, we focused on closed loop systems because they offered greater opportunities for the organizations represented in the working group, and ease of testing. Ahead of deciding which solution to pilot in more detail, we considered both flexible and rigid reusable pallet protection solutions, including mesh hoods, rigid boxes, nets, strings, and strapping.

14. Ellen MacArthur Foundation. (2017). The New Plastics Economy. Catalysing Action. Isle of Wight. LINK
15. Ellen MacArthur Foundation. (2020). The Global Commitment 2020. Progress Report. LINK

case study

CISCO

Cisco was looking for ways to reduce reliance on single-use plastic, including use of stretch wrap to transport freight. A global logistics partner proposed a reusable pallet cover provided by a US-based company that provides structural integrity and high durability. The pallet covers are made of heavy duty ventilated and breathable mesh or opaque vinyl and are designed to be reused up to 2,500 times (i.e., for approximately three to four years). The initial stock of pallet covers purchased by Cisco's logistics partner have proven to be very durable, and remain in rotation five years after introduction.

The pallet covers are easiest to use in recurring pallet loads that are full sized, and perform best when the pallet is a standard build and squared off at the top with cartons of the same size, for example with configured cartons. However, they can also be used for cartons that don't fit the configuration requirements.

The pallet covers are applied at several manufacturing warehouse shipping sites across the globe by Cisco's logistics partner. Training for the staff to use the covers is not complex and does not require significant time or resource investment. Steps must be taken to ensure appropriate management of the covers, including establishing a rotation process to ensure that they are returned to the manufacturing floor if transportation is one way.

It is preferable to use the covers in a closed loop system unless there's a sharing/tracking system with other entities in the supply chain that are using the covers. The covers can be folded and stored in moveable carts when not in use.

Some of the main barriers to scaling the use of the pallet covers across Cisco products and other transportation partners are the cost of initial purchase, administrative cost of handling the covers, the need to limit the use of the covers to large volumes of shipment across short distances, and the inability to use them for air freight due to the likelihood that they may not be returned.

Despite these barriers, these pallet covers have been an effective solution in Cisco's journey to reduce the use of plastic in a sustainable and cost-efficient manner.

Comparative cost savings depend on the cost of plastic stretch wrap in the market and on the investment needed to effectively adopt the use of the covers. Each unit costs approximately USD $150 for a standard pallet, with savings distributed across the supply chain depending on which entity is paying for them. **Overall savings and reduction in carbon (CO_2e) emissions can be achieved from reuse of the covers over a multi-year period.** The pallet covers have proven to be straightforward to adopt, durable, reusable under the right conditions as described above, and have contributed to reductions in cost and CO_2e emissions.

Case study

CHEP

Total load delivery systems provide a reusable solution to replace both stretch wrap and cardboard shipping containers with a reusable alternative. The resulting solutions can reduce cost and environmental impacts of material use as well as offering higher load stability and better load securing. They can also offer higher protection for high value products and the ability to double-stack loads in vehicles, opitmizing transport efficiency, and reducing associated CO_2.

CHEP is a supplier that has a number of resuable transport packaging solutions. This includes stackable boxes, which come with a load lid, and collapsible bulk containers with integrated pallet.

01 **The IcoQube comes in multiple foldable sizes.** It has a four-way access system for forklift trucks, two folding lids for simple filling and emptying and is RFID compatible. It can be double or triple stacked within specification limits.

02 **The CHEP range of stackable crates (R-KLTs) provide durable containers that optimize space and reduce waste and contamination.** The crates are engineered to fit and stack on the CHEP pallets with lids in place. They can be double, or triple stacked within specification limits.

Pilot

Aim

The reuse working group chose to pilot a mesh hood secured around the pallet and its load. **The objective was to assess how the reusable pallet wrap performed in comparison to linear stretch wrap.**

Figure 1: Reusable pallet wrap during transit test

Approach

A laboratory-based transit test (in line with the ISTA 3E standard) was conducted **to assess the performance of the selected reusable pallet protection option in comparison to a linear stretch wrap** made from 100% virgin material, as detailed before.

Results

Key finding

The reusable hood passed transit tests and was successful in protecting the pallet load against damage. After 50 uses, this solution becomes more environmentally beneficial than linear stretch wrap. Upfront investment and more complex supply chains can be a limiting factor for a reusable solution.

For detailed results of the outcomes of the transit test and LCA, please see the Appendix 1 and Appendix 3.

Technical feasibility

Application of this solution took a similar amount of time as the hand-applied control and was successful in passing the ISTA 3E transit test.

Scalability

The group believes that reusable solutions can be scaled most easily when used in a closed loop supply chain and logistics system and/or there are methods to track the movement of the wraps to ensure that they are reused in open loop systems.

Environmental impact

As identified with the LCA, 50 use cycles would be needed to achieve an environmental breakeven (though this pilot did not test this number of reuse cycles). Use cycles beyond the breakeven point reduce the environmental impact of the reusable hood further, emphasizing the importance of logistic loops viable for reusable solutions. The manufacturer states that the mesh hoods can be used up to 2,500 times, which would lead to transportation emissions being responsible for nearly all environmental impacts.

Commercial considerations

The financial impacts of reusable pallet protection solutions largely depend on the initial outlay and the asset management of the reusable solution to ensure use through multiple cycles. Due to the high number of variables, we did not calculate specific cost impacts.

Key considerations

Key considerations throughout the full life cycle of reusable pallet wrap for organizations to improve circularity:

Design

- Design for **repair and recycling at end-of -life** to make it fully circular.
- Design the **reusable pallet protection** to last for many applications.
- **Manufacture with recycled materials** where possible.

Use

- **Establish the typical load weight, shape, and dimension to find the most suitable reusable packaging solution.** Application of reusable packaging on uniform load is easier than on non-uniform load shapes.
- **Evaluate the transport distances, shipping types, necessary training, and supervision of handlers** at different sites and how these can accommodate the protection, maintenance, and return of reusable packaging.
- **Determine who will pay for and maintain ownership of the packaging,** especially when it will be used by two or more companies. This will help identify where cost savings will be realized and help ensure the packaging is used correctly at each stage of the logistic chain.
- **Identify the anticipated use life of the reusable packaging.** The number of reuse cycles will impact the return on investment and the overall environmental benefit.
- **Identify logistic routes** where implementation of reuse option is feasible, both environmentally as well as economically to receive benefits on both.
- **Factor in a training period when changing from linear stretch wrap to a reusable solution** to ensure safe application.
- **Implement tracking solution** to help ensure a long-lasting use period.

End-of-life

- **Ensure that you have closed loop transport systems** if you wish to implement a company owned and operated return system.
- **Assess your logistic system** for routes suitable for a share and reuse model with pooled pallet wraps.

Recycling Workstream

Background

While commercial stretch wrap is one of the more recycled plastic films today, with

21% in the US[16] & **30%** in Europe[17],

there are limitations which impact recovery rates and quality of post-consumer recycled (PCR) content film.

Contamination in the collected film bales (including paper labels, adhesives, metal, wood, organics, and other non-polyethylene (PE) plastics) can be difficult to remove in the recycling process and lead to defects in recycled film. Therefore, film is mainly recycled in an open loop system, into more defect-tolerant applications such as PE bags, sheeting, industrial (non-food) packaging, agricultural films and packaging, rigid totes/pails/bins, and composite decking and furniture.

3 types of stretch wrap, each with different suitability for incorporating PCR content

- **Hand-applied stretch film**
- **Pre-stretched hand-applied film**
- **Machine-applied films**

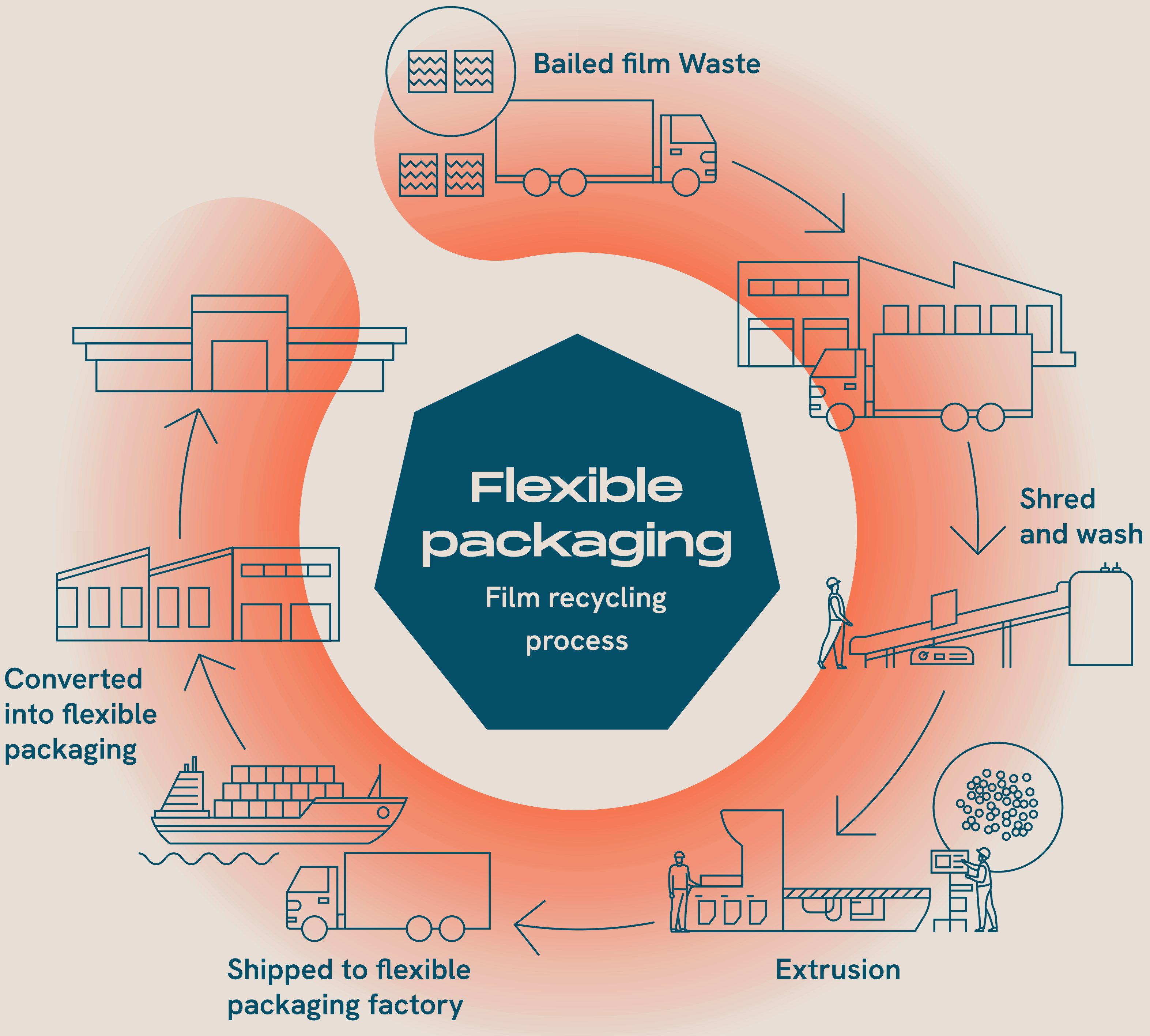
16. RSE USA. (n.d.). The Closed Loop Foundation. Film Recycling Investment Report.
17. Eunomia And Plastics Recyclers Europe. (n.d.). *Flexible Films Market in Europe. State of Play. Production, collection and recycling data.* LINK

Hand-applied films (with a 45% market share[18]) are mostly used for smaller operations, mixed pallets, and non-uniform pallets. These films are stretched ~30% in use and are typically the thickest of the three. They are much less vulnerable to the stress applied by mechanical stretching, and films of this type incorporating PCR are already commercially available.

Machine-applied films (with a 55% market share) are used on high-volume operations and uniform pallets. They offer high efficiency but also involve higher costs.

Defects or contamination in pre-stretched hand-applied or machine-applied films will result in breakage or failure, and thus PCR content has yet to be proven feasible for these higher-performance films.

The recycling working group aimed to identify the contaminants in used stretch film and the challenges with removing those contaminants, and to pilot recycling of stretch wrap back into stretch wrap to drive towards a closed loop system.



18. AMI Conference. (2021). Stretch & Shrink Film. New Orleans, USA

Pilot

Aim

The recycling working group designed a pilot to test if post-consumer stretch film could be cleaned to a level that would allow it to be recycled back into stretch film (or other high-value applications), enabling a closed loop model.

The group initially intended to collect material from a single provider to allow tracking of behavior, materials, and interventions to reduce contamination. However, sufficient volumes of material could not be identified so material was instead sourced from the open market. The material was much cleaner than average bales but included common contaminants such as paper labels and particulates from storage and transportation.

Through the pilot, the group wished to identify:

- **The most prevalent contaminants** and those that are most difficult to remove.
- **How material could be cleaned to a level that would allow it to be used as stretch wrap** in both mechanical and hand applications.
- **The processes that could be used to improve the quality of recycled stretch wrap.**

Approach

Part 1: Polymer identification

To understand the types of pallet wrap on the market, material from different sources was collected (including from electronic product warehouses and distribution centers as well as retail warehouses), and assessed in a laboratory to identify polymer types used. It was important to identify the polymer types as this can impact the recycling process and scalability of recycling solutions.

Part 2: Recycling tests

The collected open-market material was recycled at two sites, which operate different cleaning technologies and processes. These are not specifically optimized for this type of stretch wrap material and recycling, but can be seen as an example of processes used for broader film recycling in the industry.

Laboratory test: Material testing

The output product from both processes was tested for performance against the benchmark virgin stretch wrap.

The testing included:

- Pellet analysis and test on recyclates through melt flow rate test, density test, and differential scanning calorimetry test
- Extrusion trials of recyclates, reference material and blends of both (50%/ 50%)
- Small scale extrusion and gel count
- Filter test, small scale extrusion and measure pressure build up with 120mesh filters

For more information on the laboratory test, please see Appendix 2.

After arriving at the sites, the bales of film were pre-sorted for any visible contaminants, such as colored material and non-LDPE/LLDPE plastic materials. Following the first sorting process, the material was shredded into small flakes ready to be washed. This is where the two processes start to differ.

One site used a **hot chemical washing process**, which is designed to remove paper contaminants stuck to the polymers, as well as ink printed on the material.

The other site used a **cold washing process**, which removed any non-PE contaminants (e.g. paper fiber, metal, wood, stone, and soil) through mechanical washing and density separation.

Once the flakes were washed, they were rinsed and dried before being sent for extrusion. Through laser filtering during the extrusion process, additional impurities were removed, and the melted material was pelletized to be ready for reprocessing into new products.

Part 3: Transit tests

A laboratory-based transit test (in line with the ISTA 3E standard) was conducted to assess the performance of a hand-applied stretch wrap with a 25% PCR/25% post-industrial recycled (PIR) content blend in comparison to a linear stretch wrap made from 100% virgin material, both hand-applied and machine-applied.

Results

Key finding

Stretch film can be recycled back into stretch film for hand application but quality limitations mean it is not yet suitable for mechanical application. Nonetheless, opportunities to increase recycling, whether with open or closed loop models should be targeted to improve processing technology and increase the demand for infrastructure.

Technical feasibility

The recycling pilot indicates that, while the hot wash process was able to remove a higher level of contamination than the cold wash, gels were evident in all samples produced with PCR content, primarily from paper labels and polyethylene terephthalate (PET) contamination. The cellulose fibers were the main contaminations remaining after the cold-wash, while the hot-washed material showed mainly transparent PET. Because cellulose fiber has a higher impact on the film quality, this was a useful observation of the wash processes.

The transit test indicated the wrap with 25% PCR and 25% PIR content had a comparable performance to the wrap made entirely of virgin material. This suggests film with some level of recycled content is suitable for use as pallet wrap.

However, the observed quality of material during the lab test indicates that 100% PCR recycled content is unlikely to be realistic for stretch applications under current technologies. However, there is strong potential to use a lower PCR content from either wash-process in less demanding applications like hand stretch film, and other flexible and rigid PE.

Scalability

To allow closed loop stretch wrap recycling to become a fully scaled solution, development and improvement in the material wash process, as well as a more standardized composition of the material is needed. **The limited collection, consolidation, and reprocessing infrastructure for film in different parts of the globe offers another challenge,** which could be eased through increased demand and investment.

Environmental impact

The hand-applied stretch wrap with recycled content (25% PCR and 25% PIR) performs better across multiple environmental factors than a comparable wrap made fully with virgin LLDPE material.

Compared against machine-applied virgin material, the recycled material performs less well, as the benefit of lower material use through machine application outweighs the benefits of the recycled material. This emphasizes the environmental opportunity which would arise once recycled content could be used in machine-applied stretch wrap.

The material required for securing the load during the ISTA test was of similar weight as the hand-applied baseline, indicating a similar material intensity required.

For detailed results of the outcomes of the transit test and LCA, please see the Appendix 1 and Appendix 3.

Commercial considerations

The economics of stretch film recycling, and the use of recycled content stretch film is highly dependent on the process involved, including transport from the point of origin to the recycling facility, the cost of cleaning and sorting, and the transport costs to the manufacturing site. This overall cost needs to be compared to the price of virgin material, which is highly dependent on the raw material price for virgin polymers.

Furthermore, the price of PCR material can vary greatly between different PCR polymer types based on demand and supply. LLDPE PCR has developed a stable supply with a wide application range, leading to a stable pricing situation for this PCR polymer. In the US, for example, this material can be sold for higher prices than virgin material today, but there have also been points in time where the price for PCR material was similar, or lower than virgin material. **With anticipated increased demand for PCR material in the coming years, there is a good opportunity to increase the supply of recycled content material through increased recycling efforts.**

Key considerations

For recycling of stretch wrap to be more successful, different parts of the value chain need to be proactively engaged to improve recycling outcomes and the application of high-value PCR content use. Education should be seen as a shared responsibility across the full life cycle to ensure the material remains in its highest quality for closed loop recycling.

Design

- **Design stretch wrap to a standardized chemical blend** to improve the overall consistency of the PCR and possibility of re-blending collected material
- **Avoid additives where possible**, increase transparency to distinguish between different film products and polymer types, to enable recycling of mixed collected material.

Use

- **Separate materials into discrete streams at source and avoid contamination at the point of collection,** with paper labels and PET being identified as the main source of contamination.
- **Change to the use of recycling friendly labels,** e.g. with water-soluble adhesives for easy removal.
- **Establish efficient ways to collect, accumulate, and transport the material to a recycler for logistical efficiency**, while keeping the material clean.
- **Increase recycling within your operations, a**s well as the procurement of material containing PCR content where possible.

End-of-life

- **Optimize the wash and processing technology for stretch film recycling,** and its typical contamination of paper label and PET.
- **Assess the impacts of an improved sorting and wash processes on both operational and capital expenditure,** as well as the increased energy consumptions, and identify supply chains where the additional impact does not outweigh the benefits of material recycling.

Composting Workstream

Background

To reduce the impact of end-of-life plastic packaging to landfills or incinerators, some organizations are exploring compostable materials. Within specific environments, these materials biodegrade at the end of their life into carbon dioxide, water, and inorganic compounds while leaving no visually distinguishable remnants or unacceptable levels of toxic residues[19]. **Compostable packaging, though single-use, is circular because its materials are circulated back into biological cycles.** Composting facilities see primary value in compostable food packaging, as it diverts food waste from landfill, capturing it to facilitate degradation and add nutrients to the soil. The properties of compostable materials can have similar technical properties as existing non-compostable materials so they could, in theory, be used in non-food applications. **The composting working group aimed to identify whether compostable plastic is viable for use as pallet stretch wrap.**

When evaluating the use of compostable material, there are a number of factors that need to be considered including:

- **Responsible sourcing and manufacturing**
- **Performance during handling, application, and load protection**
- **Collection, transport, and composting arrangements**
- **Certified compostability (confirming the ability of the material to break down within specific time/temperature parameters)**

Within this project, the group focused on exploring material performance through application, distribution, and live compost tests.

19. Sustainable Packaging Coalition. (2021). *Understanding the role of compostable packaging in North America.* LINK

Pilot

Aim

It's important to ensure compostable material meets established industry standards (such as EN13432 and ASTM D6400). Typically, these standards require lab-based testing. However, in some instances the tests don't completely replicate 'in-practice' composting settings, meaning there are performance differences between the two environments. **The Composting working group wanted to explore this by testing a commercially available, lab-certified home and industrial compostable, polybutylene adipate terephthalate (PBAT) stretch film in a live, 'field' disintegration test.**

In addition to the composting test, the compostable material was also tested with the ISTA 3E test, to assess the performance of the compostable wrap as pallet stretch wrap.

Approach

Part 1: Composting trial

Samples of material were prepared (both in single sheet and bundled form) **and submitted for testing to an industrial composting testing facility** which uses gore-covered, in-vessel composting[20] technology. After 49 days of active composting, samples were removed and evaluated.

Part 2: Transit Test

A **laboratory-based transit test** (in line with the ISTA 3E standard) **was conducted to assess the performance of the compostable stretch wrap in comparison to a linear stretch wrap made from 100% virgin LLDPE material.**

20. In-vessel composting is designed to treat organic waste in a highly controlled covered system (drum, silo, or similar equipment) that automatically oxygenates the pile when needed.

Results

Key finding

The film successfully composted in an industrial in-vessel composter and successfully passed the ISTA 3E testing but had some difficulties during application. Application with pallet wrapping equipment failed and during hand application some stickiness and tearing were documented. To make this a more favorable option, select materials that are compatible with your machine wrapping application.

Technical feasibility

The tested PBAT film passed the field disintegration test at an industrial in-vessel composter with <10% material recovered at the end of 49 days.

Application tests suggest PBAT film should be suitable for hand wrap application but may be difficult to use in high-speed pallet wrapping equipment; during tests, the material was unable to pass through automatic pallet wrapping equipment and ripped during attempted application. During hand application, some stickiness and tearing were documented, which lead to longer application times.

Scalability

To scale this solution, **access to industrial composters with operators willing to accept the material need to be identified.** Material would be needed in sufficient volumes to ensure efficient transport.

The material would need to be kept free of contamination during use and collection, for example with avoidance of non-compostable labels and mixing with non-compostable films.

Environmental impact

The hand applied PBAT film shows higher environmental impacts on most parameters assessed compared to the LLDPE stretch wrap, except from the freshwater ecotoxicity. **In the tested scenario, the benefits of composting at the end-of-life don't outweigh the higher material impact of the PBAT.**

The assumption used regarding composting infrastructure was 11% access in the US[21]. The composted material is single-use and is not available for further uses within a similar form.

The material required for securing the load during the ISTA test was of similar weight as the hand-applied baseline, indicating a similar material intensity for the compostable materials as for virgin LLDPE stretch film.

For detailed results of the outcomes of the transit test and LCA, please see the Appendix 1 and Appendix 3.

Commercial considerations

Compostable materials today generally have a higher material cost (currently 100% more on a per kilo price than virgin LLDPE, which can be expected to decrease with increased scale) **than conventional LLDPE stretch films,** and collection and reprocessing costs may be higher than for plastic film. A cost-benefit analysis is suggested to understand the profitability of the additional handling and end-of-life disposal requirements of this film.

Before:

After:

Figure 2: Plastic stretch film sheet, before composting trial (up) and after composting trial (down)

21. Sustainable Packaging Coalition. (2021). *Understanding the role of compostable packaging in North America.* LINK

Key considerations

For compostable stretch wrap to be successful, different parts of the value chain need to be proactively engaged to improve composting outcomes. Key considerations across the full life cycle of compostable pallet wrap include:

Design

- **Consider tinting film with color to indicate different handling and enable separation from linear and non-compostable stretch wrap.**
- **Optimize the material to allow it to work with high-speed automatic pallet wrappers** (allow it to be used for both types of application).
- **Ensure material has adequate shelf life and ability to withstand environmental conditions** (moisture, temperature changes, ultraviolet radiation).

Use

- **Identify materials that are certified as industrially compostable,** and test application performance of the film in both lab and live settings.
- **Ensure material is kept free of contaminants** (e.g., plastic labels, tape etc) at each stage of handling, collection, and transport.
- **Engage local industrial composting sites early to understand interest, capacity, and capability in accepting material in the proposed volume, form, and shape at delivery.** Conduct a small pilot with the composting facility to better understand the viability of scaling and assess environmental and financial impact of transportation to the destination.
- **Optimize your pallet application technology to the new material**, to allow for optimum use and to assess whole system costs.

End-of-life

- **Consolidate transportation routes** for acceptable environmental and financial impacts.
- **Explore the ability for a business to pre-treat material prior to collection and composting.**
- **Invest and support the development of composting infrastructure** to process compostable packaging material.

Lessons learned and next steps

TOP 5 LEARNINGS

Together we have learned lessons that will help us shape how we transition to circular packaging

1

There is no "one size fits all" circular solution to replace linear stretch wrap. Each of the alternatives piloted have their place within the supply chain and should be selected based on the specific use case. A full life cycle thinking is key to identifying successful alternatives while continuing to prioritize upstream interventions, like reduction and reuse, first.

2

Define performance requirements for the pallet wrap based on sourcing, handling, manufacturing, and regional availability. This information will help determine which solution is best suited for a specific product.

3

The availability of local infrastructure should also be identified early in the decision-making process as it can limit possible solutions. Recycling and composting infrastructure is crucial to a successful implementation of any circular solution, especially downstream interventions.

4

Collaboration across industries is crucial to implement a circular solution that benefits the entire value chain. The diverse stakeholder group of this project played an important role in the project's success towards advancing circular packaging solutions.

5

Though the overall aim should be to reduce linear stretch wrap, its performance and ability to deliver a safe transport to a variety of products must be acknowledged, as well as lower material use for high-performing, machine-applied stretch wrap compared to many alternatives (in this scenario the baseline LLDPE wrap used the least amount of raw material).

Next steps

The results and learnings from the three pilots can be taken as a starting point for others across the industry to further test and implement circular pallet wrap solutions that optimize environmental outcomes. We recommend the next steps for the following accountable stakeholders across the value chain to be tackled in collaboration

Designers & Manufacturers

- **Continue to refine and develop reusable materials** that are lightweight, sustainably sourced, and high performing.
- **Increase the acceptance of visible impurities in recycled material.**
- **Continue to develop strategies for improved recyclability and recovery** that enables higher value PCR content products.
- **Create an industry standard for business-to-business stretch film composition** that allows for more high-quality recycling.
- **Engage with stakeholder outside of the direct stretch film value chain** such as label manufacturers to ensure compatibility of materials for recycling process.

Businesses

- **Test circular stretch wrap solutions** in locations with suitable infrastructure and systems in place, ahead of attempting to scale across operations and industry to test their feasibility.

- **Explore how material streams can be kept free of contamination and separated for collection,** like employee training and distinct collection containers

- **Require post-consumer recycled content in circular packaging.**

- **Create regional collaboration to facilitate pilots** and develop best practice examples and economies of scale.

- **Assess the whole systems costs when identifying a new solution,** including material procurement, material use per application and end-of-life disposal costs.

- **Map downstream recycling and composting capabilities** in relation to the business operations or points of generation of stretch film.

End-of-life facilities

- **Connect with local industries and communities** to identify if others in the region are generating significant volumes of stretch wrap and ideate on how to develop a circular model together

- **Leverage reverse logistics routes and points of consolidation** to advance reuse pallet wrap options

- **Re-evaluate current LCA models that assign diesel transportation emissions factors for reuse models** and recalculate to assess emissions factors associated with fleet electrification

- **Further investment in end-of-life facilities and development of material processing technologies** are necessary to move towards a more circular economy.

Appendix 1:
Transit tests approach and outcomes

Test materials:

The following materials and solutions were piloted during the project:

Samples	Application method	Material	Test location & company
Control	Machine	100% Virgin LLDPE	Transit test: CHEP, Innovation Lab, Florida USA
Control	Hand	100% Virgin LLDPE	Laboratory test: SCG, Norway Transit test: CHEP, Innovation Lab, Florida USA

Samples	Application method	Material	Test location & company
Recycled	Hand	PCR 25%, PIR 25% LLDPE	Recycling process: Mainetti, UK (Hot-wash process) Berry Global, UK (Cold-wash process) Laboratory test: SCG, Norway Transit test: CHEP, Innovation Lab, Florida USA

Samples	Application method	Material	Test location & company
Compostable	Hand & Machine	PBAT	Composting test: USA Transit test: CHEP, Innovation lab, Florida USA
Reusable	Hand	Reusable pallet hood	Transit test: CHEP, Innovation lab, Florida USA

Background

Pallet wrap needs to be able to adequately wrap, secure, and protect a unit load through warehouse handling and distribution. When considering alternative materials, it is important to evaluate its performance (ideally both in a lab and live setting) to understand likelihood of a successful implementation. We used the International Safe Transit Association (ISTA)[22] 3E test to examine the performance of pallet stretch alternatives within a controlled lab environment, by shock test (include and rotation), compression and vibration tests.

Success criteria

We evaluated whether the material was able to perform equal to or better than control pallet stretch film (100%) virgin LLDPE in its ability to:

01) Apply stretch wrap according to wrap pattern instructions to two-unit loads

02) Time application and document

03) For unit load 1:
- **a_** Measure stretch wrap tension at three points: top, middle, bottom
- **b_**Remove wrap and weigh material

04) For unit load 2:
- **a_**Test unit load using ISTA 3E protocol, recording any issues with the stretch wrap, unit load security
- **b_**Measure stretch wrap tension after transit test is complete, measuring at the same three points
- **c_**Remove wrap and weigh

22. International Safe Transit Association. (2022, February 04). Ista.org. Retrieved from Test Procedures. LINK

ISTA 3E TESTING RESULTS

Table 2

Results: Metric	Methodology	Comment
Application: Time	Time it takes to wrap a pallet according to standard wrap pattern	Compostable film had the longest application time at 2 minutes and 54 seconds, significantly longer than other hand-applied variables. (See Table 4 for further details)
Application: Containment force[23]	The hugging pressure that holds the load together in order to reduce damage and ensure safe to ship loads	Machine-applied control had the lowest containment force numbers, in contrast the hand-applied control had the highest numbers. Force numbers slightly decreased at the top and middle points over time; bottom reading slightly increased overtime. (See Table 3 for further details)
Application: Material used	The weight of the pallet wrap material used to secure one unit load	All hand-applied variables' weights were similar, but double that of the machine control as seen in Figure 3 (See Table 3 and 4 for further details).
Application: Observations	Observations made during application process to understand how easy it is to wrap a unit load	The compostable material was unable to successfully work in a pallet wrapping equipment. During hand application, stickiness and tearing were documented.
Transit test	Transportation simulation test to ensure unit load is secure through handling and trucking forces	All variables passed the ISTA 3E protocol, equal or better than control with minimal to no damage.

23. (Lantech, 2022)

Figure 3: Machine-applied shrink film uses half of the material than a hand-applied alternative (from left to right: Control machine-applied, control hand-applied, PCR, compostable)

TRANSIT TEST RESULTS (CONTAINMENT FORCE)

Table 3

Containment force (pounds of force, lbf)						
Sample	**Measurement location**					
	Top	**Middle**	**Bottom**	**Top**	**Middle**	**Bottom**
Control machine	7.90	8.40	10.50	10.50	8.30	7.90
Control hand	10.85	10.35	12.00	10.50	12.90	15.80
PCR	9.50	9.85	8.75	12.60	8.15	10.25
Compostable	8.30	9.40	9.25	7.10	6.65	10.05
Reusable	NA	NA	NA	NA	NA	NA

TRANSIT TEST RESULTS (TIME AND MATERIAL USE)

Table 4

Sample	Application time for 1 unit load	Material used for 1 unit load
	Minutes	Average weight (lbs)
Control machine	2.20	0.50
Control hand	1.42	0.99
PCR	1.41	1.00
Compostable	2.54	1.34
Reusable	1.38	1.38

TESTED SOLUTIONS DURING ISTA 3E TEST

Table 5

Compostable: Post Test

Recycled Content: Post Test

Reuse: Post Test

Appendix 2: Recycled material tests approach and outcomes

Introduction

This appendix outlines the outcomes of the testing by Norner on behalf of the recycling working group.

Part 1: Polymer identification

To gain a good understanding of the types of pallet wrap on the market, material from different sources was collected (from warehouses and distribution centers for electronic products and from retail warehouses) and assessed in a laboratory to identify polymer types used. It was important to identify the polymer types, as this can impact the recycling process and how easy recycling solutions are to scale.

The main polymer types identified were LDPE / LLDPE, with a variety of additives such as PP, plastomer, ethylene-vinyl acetate (EVA) and C4-LLDPE. The melt flow rate (MFR)/viscosity values of the recycled batches are between blown and cast film resin types. The variety of different polymers and additives highlights the challenge of recycling stretch wrap collected in aggregated format, as stretch wrap is not necessarily homogenous in terms of polymer and presentation, making high-quality recycling of the material more challenging.

Part 2: Recycling test tests

Both recycled samples have a high contamination level due to the current capabilities of the washing / decontamination systems. The melt pressure build-up in extrusion with the cold-washed material is about 10x higher than virgin material, and the hot-washed material is about 6x higher. This confirms that cold-washed material has a higher level of contaminates than the hot-washed material and that both are much higher in contamination than virgin material.

On the examined factors, including gel count, pressure testing and puncture energy, the PCR content material performed lower than the virgin material, with better performances in 50/50 blends of virgin and recycled content compared to 100% recycled content. Compared to the virgin LLDPE material, the puncture energy, dart drop impact, tear resistance as well as tensile strength is about 50% lower for the films made with pure recycled material. Films made from a 50/50 blend of virgin/recycled show only a moderate improvement in the same properties, while lower blend ratios show improved performance.

Conclusions

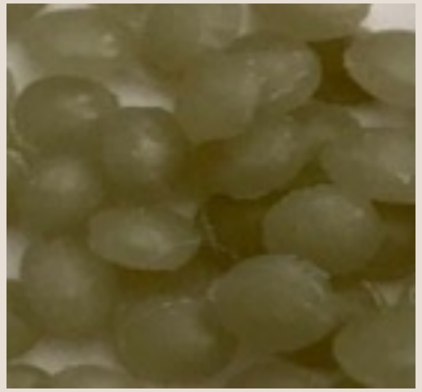
The initial assessment of polymer types from different sources showed a mixture of blown (hand stretch) and cast film (machine stretch), including different polymer types such as LDPE / LLDPE and various additives, giving a first indication on the challenges of mixed collected film materials.

Both recycled samples showed high levels of gel count, i.e. inhomogeneity and inclusions, with higher levels in the cold-washed material compared to the hot-washed material. A difference was seen in the type of contamination remaining in the recycled material. While the contamination in the cold-washed material was mainly cellulose fibers and a small amount of PET, the hot-washed material showed mainly transparent PET, and with some being cross-linked PE materials. With cellulose fibers having higher impact on the film quality, this was a useful observation and comparison of the wash processes used during the pilot.

Following the different examination factors, the observed quality makes 100% PCR recycled content not realistic for stretch applications with current technologies.

Overall, the hot-wash gave better results than the cold-wash and was able to remove a higher level of contamination. However, the achieved quality of material can realistically only be used in thicker film applications and/or where the quality issues are less critical.

PCR resin produced from cold wash



PCR resin produced from hot wash

100% PCR film @24mu

Data tables

RESULTS FROM PELLET ANALYSIS

Table 6

	Unit	Berry rPE	Mainetti rPE	Ineos LL6208LJ	50/50% Berry+Ineos	50/50% Mainetti+Ineos
MFR (190/2,16)	g/10min	2,2	1,9	0,9		
Density	Kg/m3	922	927	920		
DSC, Tm	°C	107,5 / 120,5	108,1 / 121,1	122		
Filter test	Δbar/kg	149	89	15	93	47
	Unit			**Ineos LL6208LJ**	**10/90% Berry+Ineos**	**10/90% Mainetti+Ineos**
Gels <200µ	Count/kg			7600	440000*	196000
Gels >200µ	Count/kg			220	135000	38000

*The gels level was very high for both recycled samples. For the gel counter to manage the counting, we reduced the blend to a 90/10% content of Ineos/recycled respectively.

RESULTS OF MECHANICAL TESTING OF BLOWN FILMS

Table 7

	Unit	Berry	Mainetti	Ineos LL6208LJ	50/50% Berry+Ineos	50/50% Mainetti+Ineos
Puncture energy	J	2,8	2,8	4,3	2,5	3,0
Tear resistance MD	N	6,3	3,7	8,6	6,6	5,9
Tear resistance TD	N	5,2	5,0	10,3	7,0	8,0
Dart drop Impact	g/50	140	165	460	175	200
Tensile strength MD	MPa	13,7	23,8	33,1	21,2	32,9
Tensile strength TD	MPa	13,3	24,2	30,9	18,7	30,7
Elongation at break MD	%	590	580	610	610	630
Elongation at break TD	%	590	660	630	590	690
Haze		25	20	24	25	23
Gloss 60°		61	71	68	63	66

*MD = machine direction, TD= Transverse direction

Appendix 3: LCA modeling approach and outcomes

Introduction

The environmental impact of the baseline virgin material stretch film and the alternatives was modeled in Trayak's EcoImpact-COMPASS screening LCA platform. This section describes the approach and outcomes of the LCA modelling. The geographical region used for the LCA inputs was the US.

Baseline virgin film: Core assumptions

Conventional LLDPE stretch film was modeled to provide a baseline or a reference for the alternatives within this LCA. It is assumed that this film is only able to be used once.

Material

The material of the baseline stretch film is linear low-density polyethylene with a corrugated fiber core. The film can be machine-applied or hand-applied.

Hand-applied film

With hand application, the mass of the 80-gauge (0.8 mil or 20µm) LLDPE film is 300 grams per 48″ x 40″ x 50″ pallet.

The fiber core of the stretch film in both the hand and machine application has a diameter of 3″ with an 18″ width film and weighs 0.95 lbs. or 430.93 grams. The mass of the fiber core is considered as the fraction of mass attributed to one application of the film per pallet. Each roll of hand-applied film can wrap 12.93 pallets, so the fraction of the fiber core mass is 430.93 grams/12.93 pallets = 33.33 grams.

Machine-applied film

With the machine application, the mass of the 80-gauge LLDPE film is 160 grams per 48″ x 40″ x 50″ pallet.

The fiber core of the stretch film in both the hand and machine application has a diameter of 3″ with a 18″ width film and weighs 0.95 lbs. or 430.93 grams.

The mass of the fiber core is considered as the fraction of mass attributed to one application of the film per pallet. Each roll of machine-applied film can wrap 24.37 pallets, so the fraction of the fiber core mass is 430.93 grams/24.37 pallets = 17.68 grams.

Manufacturing

The mode of application of the film also affects the manufacturing process of the film. For this comparison, the assumption is that the hand-applied film is converted with a blown film process and the machine-applied film is converted with a cast film process. The manufacturing process for the fiber core is modeled as production of corrugated containers.

Transportation

Each stretch film is assumed to be transported 500 km outbound by an average size truck.

End-of-life

For this comparison, the end-of-life values are all taken from the Environmental Protection Agency's Advancing Sustainable Materials Management: 2018 Tables and Figures report published in December 2020. The film is denoted with the packaging type of Bags, Sacks & Wraps. According to the EPA report, the packaging type of Bags, Sacks & Wraps has a breakdown of 13% recycling, 17% waste to energy, 70% landfill, and 0% composting. The fiber core is modeled as Other Paperboard Packaging which has a breakdown of 21% recycling, 15% waste to energy, 64% landfill, and 0% composting.

Reuse option: Core assumptions

The reusable stretch film alternative is similar to a tarp / hood style and is modeled to consider a more durable format that can be reused. Multiple scenarios for the reusable pallet wrap are evaluated representing the manufacturers claim and the breakeven point for the reusable alternative compared to the baseline hand-applied single use stretch film.

Material

The reusable pallet wrap is made of a combination of polyester, nylon, and poly vinyl chloride. The actual weight breakdown is not provided in this report. The mass of a reusable pallet wrap for a pallet sized 48″ x 40″ x 50″ weighs 10.77 lbs. or 4,885 grams.

Manufacturing

Each component of the reusable pallet wrap has a different manufacturing process. The manufacturing region of the components is assumed to be the United States.

Transportation

The outbound transportation of the pallet wraps is the same as the other stretch films at 500 km by average size truck. With the reusable pallet wrap, reverse logistics are required to recollect these wraps to be used again. It is assumed the average return distance is 500 km by average size truck. This return distance is considered within the LCA.

Reuse

In order to make this a realistic comparison, an average return rate for the pallet wraps needs to be considered. It is assumed that the average return rate for the pallet wraps is 95%, so 5% of the pallet wraps are lost and not returned. This loss is factored into the comparison and used to calculate an effective use rate to be considered when establishing the environmental breakeven point of the LCA.

End-of-life

The packaging type considered for the pallet wrap is Other Plastic Packaging which has an end-of-life breakdown of 3% recycling, 19% waste to energy, 78% landfill, and 0% composting. This end-of-life phase is considered after the useful life of the pallet wrap.

Recycled content film: Core assumptions

The recycled content LLDPE stretch film alternative is modeled to consider displacing virgin plastic with recycled content. It is assumed that this film is only able to be used once. The recycled content film considered in this analysis is only able to be applied by hand, not machine.

Material

The material of the recycled stretch film is linear low-density polyethylene with a fiber core.

Hand-Applied Film

The recycled content film that is hand-applied includes 50% recycled content, 25% post-consumer recycled (PCR) content and 25% post-industrial recycled (PIR) content. It is assumed that incorporating recycled content into the LLDPE film would not require a higher gauge material. The mass of the LLDPE 50% recycled content hand-applied film per 48″ x 40″ x 50″ pallet is 300 grams.

Similarly, to the baseline stretch film, the fraction of the fiber core mass per 1 application of film on the pallet is considered for this comparison. With the recycled content hand-applied film, one roll of film can wrap 12.93 pallets, so the fraction of the fiber core mass is 430.93 grams/12.93 pallets = 33.33 grams. The material of the fiber core is assumed to be corrugated.

Manufacturing

The hand-applied film is converted with a blown film process. The manufacturing process for the fiber core is modeled as production of corrugated containers.

Transportation

Similarly, to the baselines, the recycled content stretch film is also assumed to be transported 500 km outbound by an average size truck.

End-of-life

For this comparison, the end-of-life values are all taken from the EPA report. Similarly, to the baseline, the recycled content film is denoted with the packaging type of bags, sacks & wraps. The fiber core is modeled as other paperboard packaging.

Composting option: Core assumptions

The compostable Polybutylene adipate terephthalate (PBAT) stretch film alternative is modeled to consider end-of-life scenarios where the film can break down and not end up as waste in a landfill. It is assumed that this film is only able to be used once.

Material

The material of the compostable stretch film is polybutylene adipate terephthalate (PBAT) with a fiber core, similar to the baseline. PBAT is biodegradable, which means that it can be broken down by microorganisms into carbon dioxide, water, and biomass. This material data does not come directly from ecoinvent and was created based on research and existing LCAs[24].

Hand-applied film

With hand application, the mass of PBAT compostable film is assumed to be 300 grams per 48″ x 40″ x 50″ pallet, the same as the baseline.

The fiber core of the hand-applied compostable film has a diameter of 3″ with an 18″ width film and weighs 0.95 lbs. or 430.93 grams. The mass of the fiber core is considered as the fraction of mass attributed to one application of the film per pallet. Each roll of compostable hand-applied film can wrap 12.93 pallets, so the fraction of the fiber core mass is 430.93 grams/12.93 pallets = 33.33 grams. The material of the fiber core is assumed to be corrugated.

Manufacturing

The hand-applied film is converted with a blown film process. The manufacturing process for the fiber core is modeled as production of corrugated containers.

24. Choi B, Yoo S, Park S-i. Carbon Footprint of Packaging Films Made from LDPE, PLA, and PLA/PBAT Blends in South Korea. *Sustainability.* 2018; 10(7):2369 LINK

Transportation

Similarly, to the baselines, the compostable stretch film is also assumed to be transported 500 km outbound by an average size truck.

End-of-life

The compostable films will have a different end-of-life than the standard, baseline films. The benefit is that these films can be diverted to composting facilities rather than being sent to a landfill or burned in incineration. Composting infrastructure is limited, but growing in the United States. For this comparison, the end-of-life scenario uses data from the Environmental Protection Agency's report as well as research from the Sustainable Packaging Coalition to determine the breakdown of composting, landfill, and incineration of the compostable film.

According to the EPA report, the packaging type of Bags, Sacks & Wraps has a breakdown of 13% recycling, 17% waste to energy, 70% landfill, and 0% composting. Based on research conducted by the Sustainable Packaging Coalition and detailed in their report[25] *Understanding the Role of Compostable Packaging in North America* published in January 2021, 19% of the largest cities in the United States have some kind of composting program that accepts some form of compostable packaging. These cities represent 11% of the total US population.

For this LCA, this 11% composting value is going to be considered as the percentage of the compostable film that is sent to composting. It is assumed that the compostable film cannot be recycled.

To focus on the switch to composting, the ratio of landfill and waste to energy will be kept the same. The new end-of-life breakdown will be 0% recycling, 17% waste to energy, 72% landfill, and 11% composting.

Life Cycle Impact Assessment outcomes

The COMPASS method is a compilation of indicators that were selected for their relevance to packaging as well as those that are well accepted by the LCA community. This method consists of 8 indicators to provide a full picture view of the impact across different categories and considerations.

Overall Life Cycle Assessment

Table 8 shows the breakdown of the functional unit comparison of the stretch films and the alternatives. To determine the breakeven environmental point for the reusable pallet wrap, the greenhouse gas (GHG) emissions indicator was used as the decision maker because it is top of mind in many companies packaging goals and sustainability initiatives.

25. Sustainable Packaging Coalition. (2021, January). Understanding the Role of Compostable Packaging in North America [PDF]. Retrieved from https://sustainablepackaging.org/resources/.

The breakeven environmental point was determined through simulating different use rates until the reusable pallet wrap had a lower GHG impact than the baseline hand-applied LLDPE film. It was determined this breakeven point was around 50 uses with a return rate of 95%.

FUNCTIONAL UNIT COMPARISON OF STRETCH FILMS AND ALTERNATIVES

Table 8

Stretch Film Name	Number of Applications of Film
Hand-Applied LLDPE Film	2500 films
Machine-Applied LLDPE Film	2500 films
Hand-Applied LLDPE 50% Recycled Content Film	2500 films
Reusable Pallet Wrap 50 Uses - Breakeven	50 wraps each used 50 times
Reusable Pallet Wrap 2500 Uses Manufacturer Claim	1 wrap used 2500 times
Hand-Applied PBAT Compostable Film	2500 films

Figure 3 shows an overview of the LCA comparison with the 8 COMPASS indicators. Each stretch film is denoted in a different colored area in the spider web chart. For each indicator, the points closer to the center of the graph represent the better or lower environmental impact. For example, looking at water use, the lowest impact comes from the reusable pallet wrap manufacturer claim and the highest impact comes from the hand-applied PBAT compostable film.

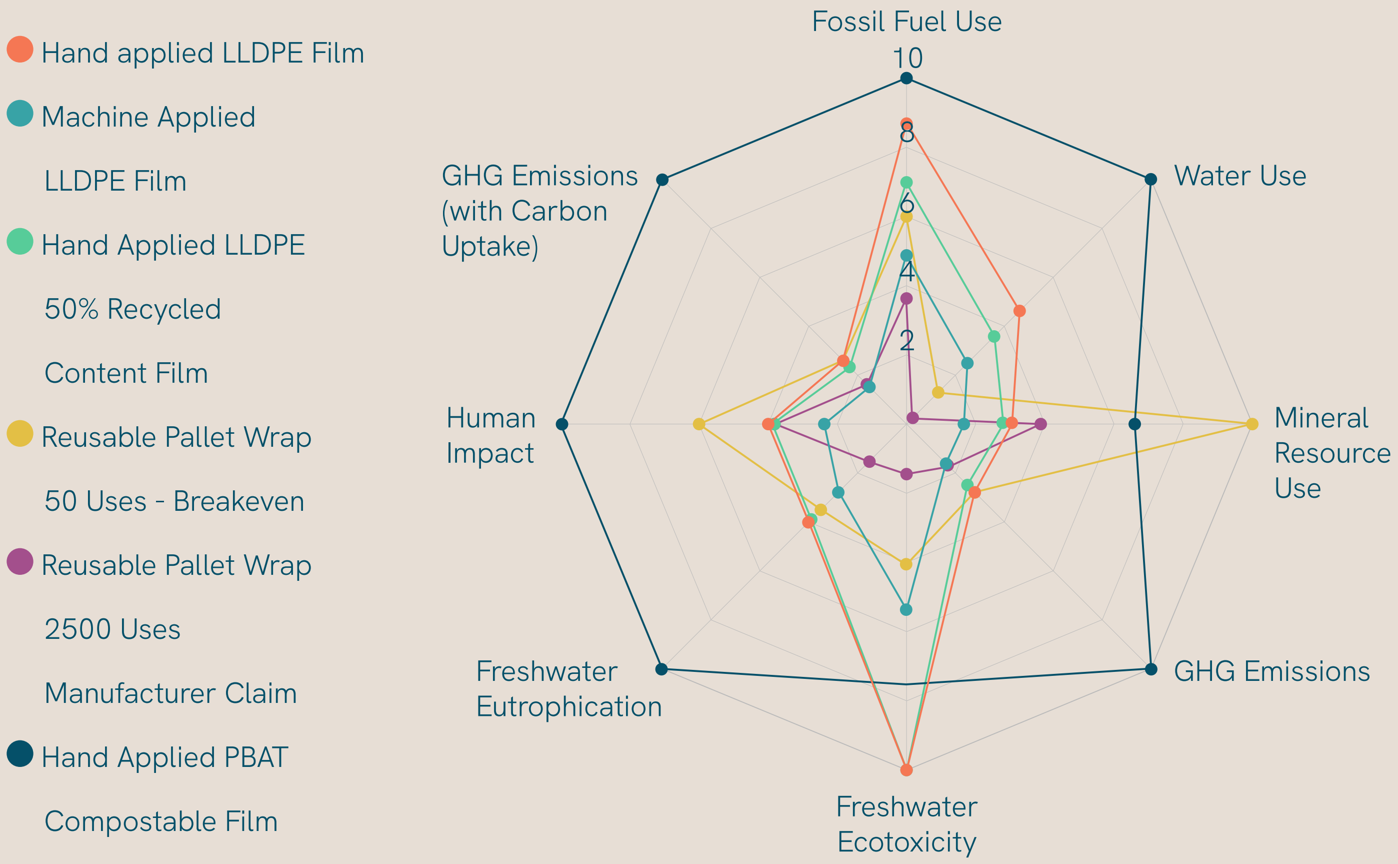


Figure 3: Spider Web Chart Overview of LCA Impacts for Stretch Films and Alternatives

When comparing all the films and alternatives, the reusable pallet wrap with the manufacturer claim of 2500 uses has the lowest environmental impact in nearly all of the eight tested indicators. The machine-applied film has the lowest greenhouse gas emissions and mineral resource use when compared to all other films and alternatives.

The absolute values of the comparison are shown below in Table 9 with the higher impacts highlighted in orange and the lower impacts highlighted in blue. The impacts are shown for 2500 applications of the film.

FUNCTIONAL UNIT COMPARISON OF STRETCH FILMS AND ALTERNATIVES

Table 9

- +

Lowest | Impact for Each LCA Indicator | Highest

Stretch Film Name	Fossil Fuel Use (GJ deprived)	Greenhouse Gas Emissions w/o Carbon Uptake (metric tons CO_2 eq)	Water Use (m^3)	Freshwater Eutrophication (kg PO_4 eq)	Mineral Resource Use (kg deprived)	Human Impact (DALY)	Greenhouse Gas Emissions w/ Carbon Uptake (metric tons CO_2 eq)	Freshwater Ecotoxicity (CTUe)
Hand-Applied LLDPE Film	61.52	2.63	1858.16	1.71	22.12	0.0012	2.6	72701.7
Machine-Applied LLDPE Film	34.18	1.51	1010.93	1.18	12.07	0.00077	1.49	39792.1
Hand-Applied LLDPE 50% Recycled Content Film	49.37	2.35	1438.32	1.66	20.56	0.0012	2.34	74715.7

Stretch Film Name	**Fossil Fuel Use** (GJ deprived)	**Greenhouse Gas Emissions w/o Carbon Uptake** (metric tons CO_2 eq)	**Water Use** (m^3)	**Freshwater Eutrophication** (kg PO_4 eq)	**Mineral Resource Use** (kg deprived)	**Human Impact** (DALY)	**Greenhouse Gas Emissions w/ Carbon Uptake** (metric tons CO_2 eq)	**Freshwater Ecotoxicity** (CTUe)
Reusable Pallet Wrap 50 Uses - Breakeven	42.49	2.6	523.77	1.5	72.99	0.0019	2.59	30574.9
Reusable Pallet Wrap 2500 Uses Manufacturer Claim	25.64	1.64	96.11	0.657	28	0.0012	1.64	10851
Hand-Applied PBAT Compostable Film	70.61	9.44	4041.76	4.27	47.88	0.0032	10.02	56131.6

The packaging type with the highest environmental impact across many of the indicators is the hand-applied PBAT compostable film. PBAT has a higher environmental impact than the linear low-density polyethylene and the benefit of the composting at the end-of -life is not enough to outweigh the higher material impact of the PBAT.

When comparing just the hand-applied baseline film and the alternatives, the least impactful stretch film is the recycled content film. This film has 25% post-consumer recycled (PCR) content and 25% post-industrial recycled content. The LCA impact is only considering the PCR content because the PIR content is considered as coming from a different manufacturer, so therefore is a virgin material in the scope and boundary conditions of this project.

Life Cycle Phase Breakdowns

The LCA indicators can be broken down into the phases of the life cycle which are shown in the following figures.

These graphs also show the percent change of the impact calculated from the baseline hand-applied stretch film.

A general trend seen in the results when looking at the reusable pallet wraps is that with increased number of uses, the material and manufacturing phase impact decreases and the transportation impact increases. This is because increasing the useful life of the wrap from 50 to 2500 means that only 1 wrap is needed rather than 50 wraps. However, with the increase of the useful life of the wrap, more transportation is required to keep the wrap in the loop through reverse logistics and return distances. From the bar graph, the transportation impact is nearly all the impact attributed to the reusable pallet wrap 2500 uses.

Fossil fuel use

For fossil fuel use, the least impactful stretch film or alternative is the 2500 uses reusable pallet wrap with a 58% reduction in impact compared to the baseline. The most impactful stretch film for fossil fuel use is the compostable PBAT material with most of the impact attributed to the material phase shown in red in the bar graph in Figure 4.

Looking at just the hand-applied film alternatives, the recycled content film uses the least fossil fuel. The compostable film shows the highest fossil fuel use of the hand-applied films.

BREAKDOWN OF FOSSIL FUEL USE (GJ DEPRIVED) INTO VARIOUS COMPONENTS

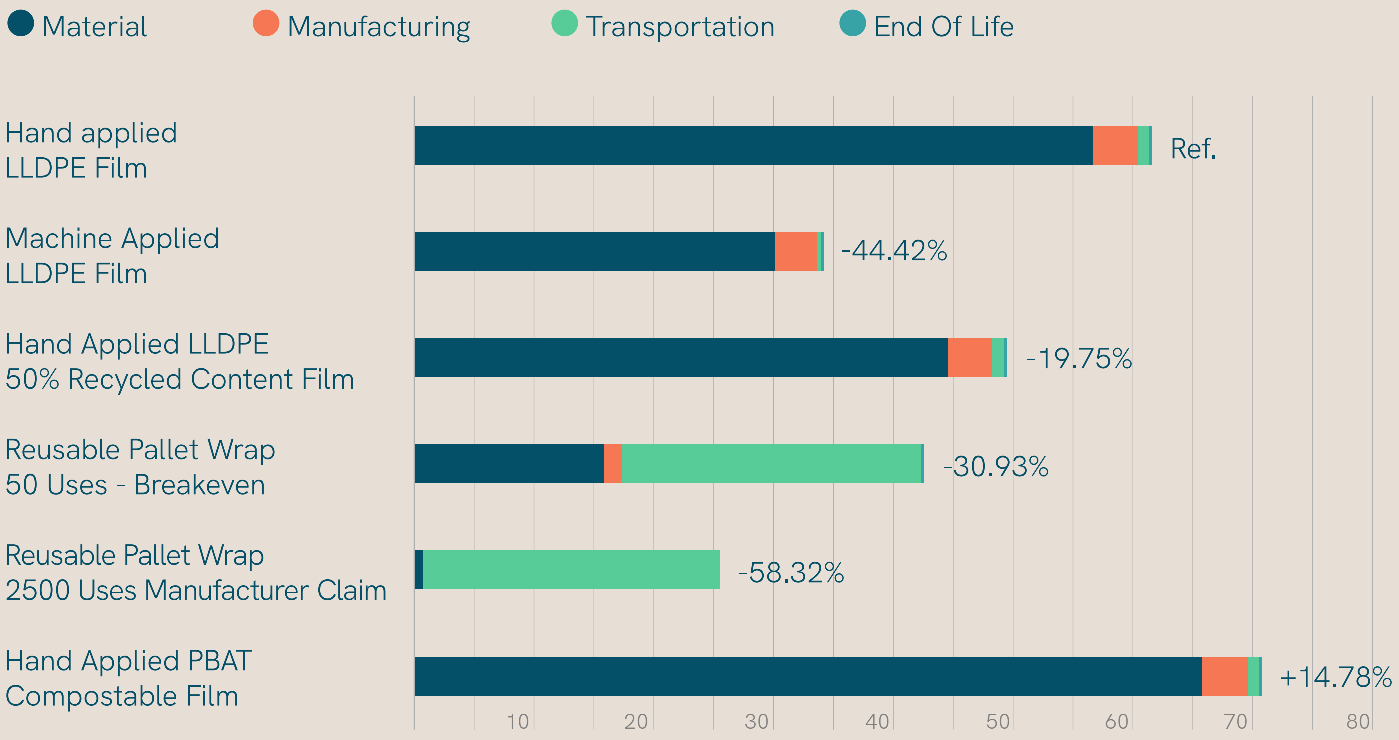


Figure 4: Fossil Fuel Use LCA Phase Breakdown

Greenhouse gas emissions

Greenhouse gas (GHG) emissions impacts have a similar trend to the fossil fuel impacts with a key difference: the 50 uses reusable pallet wrap is now higher impact than the recycled content film. Again, the least impactful stretch film is the 2500 uses pallet wrap and the most impactful stretch film is the compostable film.

BREAKDOWN OF GHG EMISSIONS (TON CO_2 eq.) INTO VARIOUS COMPONENTS

● Material ● Manufacturing ● Transportation ● End Of Life

Hand applied LLDPE Film

Machine Applied LLDPE Film

Hand Applied LLDPE 50% Recycled Content Film

Reusable Pallet Wrap 50 Uses - Breakeven

Reusable Pallet Wrap 2500 Uses Manufacturer Claim

Hand Applied PBAT Compostable Film

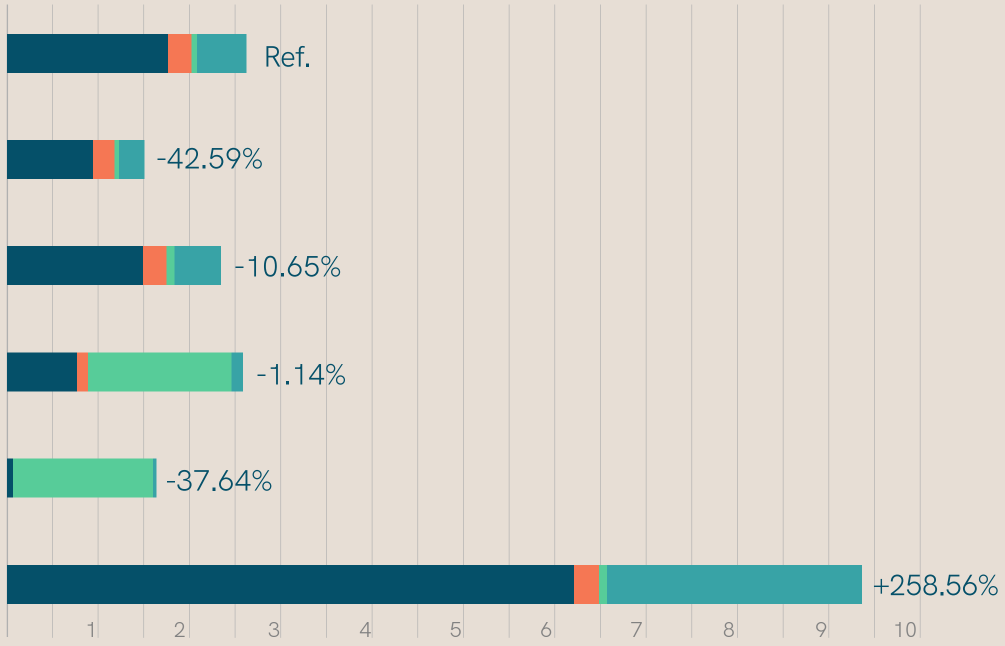


Figure 5: Greenhouse Gas Emissions LCA Phase Breakdown

Water use

Water use follows the same trends as fossil fuel use with the least water intensive stretch film or alternative as the 2500 use reusable pallet wrap and the most water intensive stretch film as the compostable film.

With the water use, the reusable wraps have a higher reduction because transportation doesn't have a large water footprint unlike with fossil fuel use and GHG emissions.

BREAKDOWN OF WATER USE (m^3) INTO VARIOUS COMPONENTS

● Material ● Manufacturing ● Transportation ● End Of Life

Hand applied LLDPE Film

Machine Applied LLDPE Film

Hand Applied LLDPE 50% Recycled Content Film

Reusable Pallet Wrap 50 Uses - Breakeven

Reusable Pallet Wrap 2500 Uses Manufacturer Claim

Hand Applied PBAT Compostable Film

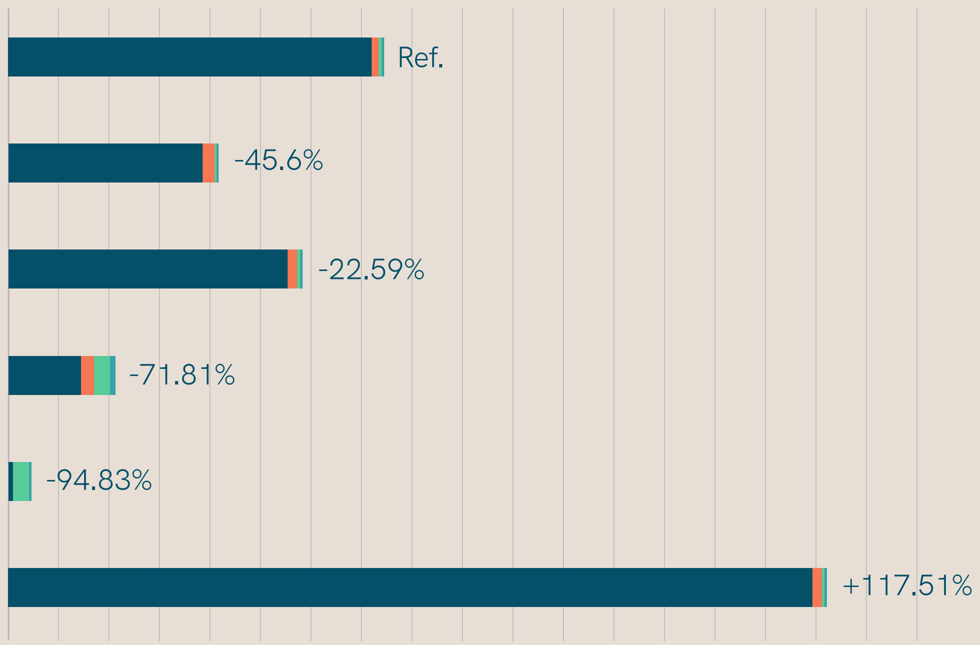


Figure 6: Water Use LCA Phase Breakdown

Additional sustainability attributes

Alongside the LCA attributes, other sustainability attributes can be tracked and evaluated for the stretch film and its alternatives to help illuminate any trade-offs. The additional attributes of interest include post-consumer recycled content, post-industrial recycled content, package to product weight and material circularity index.

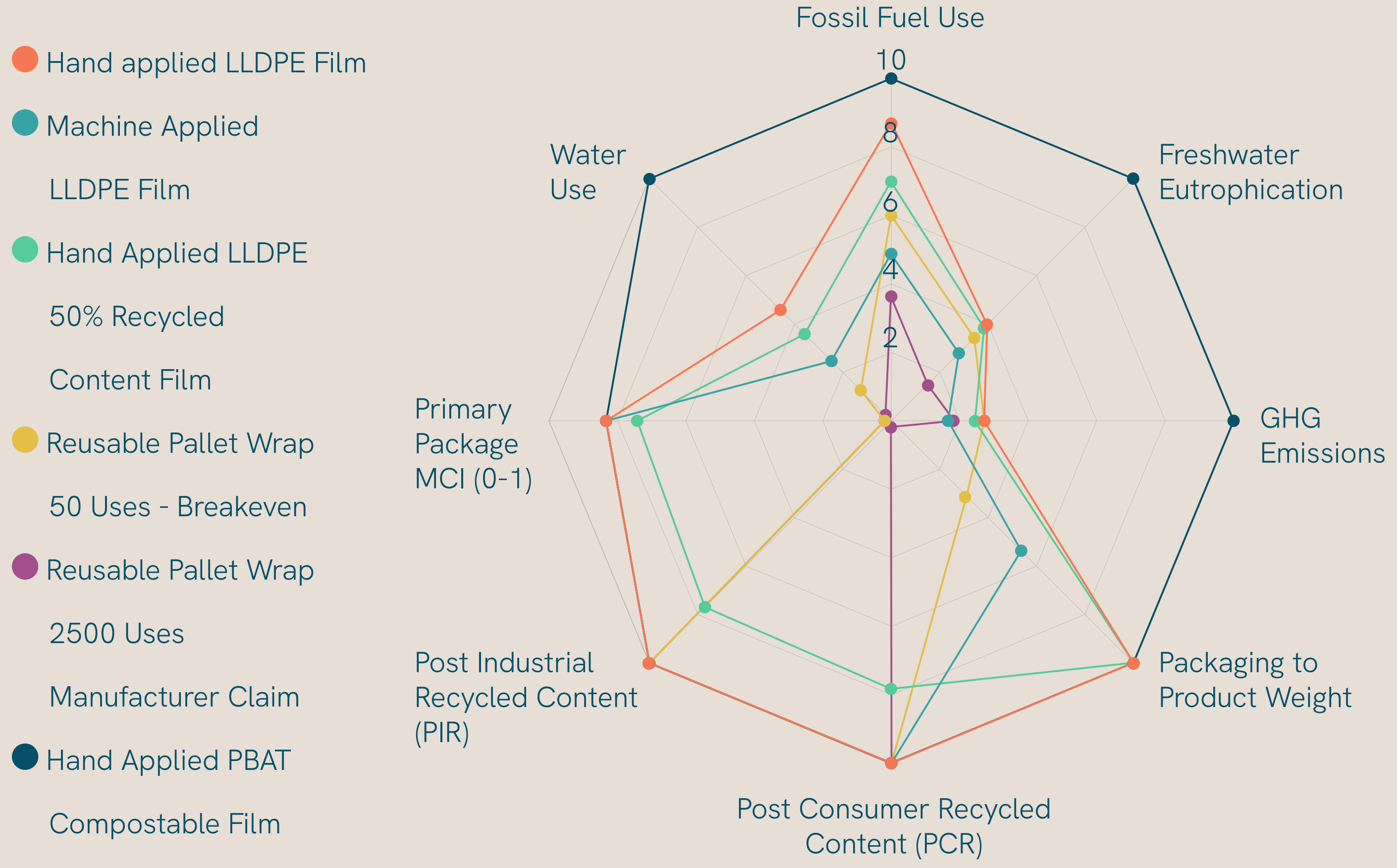


Figure 7: Spider Web Chart of Additional Sustainability Attributes

In Figure 7, the LCA attributes of fossil fuel use, GHG emissions, water use, and freshwater eutrophication are mapped alongside the sustainability attributes of PCR content, PIR content, packaging to product weight, and primary package circularity index (MCI). Similar to the overview chart, the values closest to the center for each indicator represent the lowest impact and the values plotted on the outside of the chart represent the highest impact for that indicator.

The best stretch film for the recycled content attribute is, of course, the recycled content film because the other films and alternatives have no recycled content. The best stretch film for the PIR content is also the recycled content film because it has 25% PIR while the other films have 0% PIR. For the packaging to product weight attribute, it is a calculation of the mass of packaging that is required to deliver the functional unit which in this analysis is one application of film. The reusable pallet wraps have the best score for packaging to product weight because of the longer useful life and overall, less material used.

Within EcoImpact-COMPASS, the material circularity index (MCI) can be calculated. The calculations are based on the Ellen MacArthur Foundation's circularity methodology and are calculated as a range from 0 to 1, with 1 representing an entirely circular package. This metric is affected by three attributes: recycled/reused content in the packaging components, reuse or recycling at the end-of-life, and utility or useful life of the package. Increasing the useful life has the most significant impact on improving the circularity score which is seen in the results of the comparison. The circularity index results are plotted within Figure 5 as a SCORE attribute.

Appendix 4: Company overview

The SWAP Network is made up of the ten organizations:

Anthesis

Anthesis is the Sustainability Activator. We are the largest group of dedicated sustainability experts in the world: a team of 800 people, operating in 40 countries, to serve more than 2,000 clients.

Proud to be a B Corp, we exist to shape a more productive and resilient world by helping organisations transition to new models of sustainable performance. Our team combines broad and deep sustainability expertise with the commercial and operational capabilities it takes to conceive and deliver real change.

We have set ourselves the goal to support our clients to avoid, reduce and remove at least 3GT of carbon dioxide emissions by 2030. Anthesis works with companies along the entire plastic value chain to help transition towards a more circular economy and meet the ever increasing demand for recycled materials. This includes supporting businesses with the development of sustainable packaging strategies and advanced recycling technologies as well as working with investors to increase the recycling capacity globally.

BASF

We create chemistry

At BASF our corporate purpose is 'We create chemistry for a sustainable future'. In order to create this sustainable future, we need optimise the use of our resources and that includes the creation of circular systems that reduce the need to use virgin feedstocks. Pallet wrap plays an important function in getting industrial products from manufacture to destination. But at present, the end-of-life scenarios for pallet wrap are not ideal. The importance of this project, in looking at circular economy models for pallet wrap, is that it will reduce the need for landfill or incineration and so will reduce our reliance upon virgin fossil fuel-based feedstocks.

With more than 110000 employees across nearly 400 sites in >90 countries, BASF is the world's largest chemical company. We create the chemical building blocks that make products that are supplied into a wide variety of markets and end applications. **Sustainable packaging is an area of focus for the company and we supply a number of solutions across several business units. We also have a strategic focus on circular economy models – closing resource loops, reducing resource waste and extending product durability.** As such, we have a part to play in all of the workstreams within this project in terms of both product offering and access to expertise.

At Berry Global, we create innovative packaging and engineered products that we believe make life better for the people and the planet. We do this every day by leveraging our unmatched global capabilities; sustainability leadership; and deep innovation expertise to serve customers of all sizes around the world. As a leading manufacturer of stretch film, we recognize the responsibility to shift pallet wrap to a circular economy. Stretch film is highly efficient today, requiring very little material to stabilize and protect the goods that we all ship across the world. **We are making progress to further its efficiency, including designing for material reduction and recycled content, as well as expanding the capabilities of our recycling operations, all of which reduce the reliance on fossil fuel based plastics. It is through collaborations like this SWAP project, engaging with a broad coalition of stakeholders, that we can further that progress.** Back of store PE film (stretch and shrink film) is the lifeblood of PE recycling today. We see a great opportunity to expand the collection and recycling of those materials, and further improve the quality and value of the resulting PCR.

Single use plastic stretch is used to secure pallets during transport and storage. Pallets are in average manipulated by 8 to 12 entities before arriving to the point of sale and very often removed from stretch and re-stretched. This plus the fact that stretch is seen as little wasteful, triggers a behaviour of using stretch in abundancy especially when the risk of losing a high value load could be involved. The consumption of single used stretch film in Europe could wrap the earth entirely each 4 years or each year depending on practices, largely contributing to the linearity of the Supply Chains. Considering it is extremely difficult to recycle, in practice, it is very little recycled. Supply chain activities are also generating packaging waste, consuming fossil resources. This needs to change

At CHEP and Brambles, while we thrive to increase the positive impacts of our circular business model by DNA, we have committed to pioneering regenerative supply chains, and this starts by addressing how tertiary packaging is used and which additional packaging accompanies them. Tackling this high impact universal practice to find jointly a circular solution is part of our Zero Waste World Program mission.

With 70 years of experience in operating a share and reuse model across supply chains, we are bringing our knowledge and expertise of supply chains, international standards and our innovation center capabilities to assess the new alternatives prior to them being tested live.

With regenerative supply chains as the core of our new strategy, we see it as our task to at best support, alternatively advise our clients and prospects on the current best use practices on load securing. Being part of the latest evolution and remaining at the front end; building capability and supporting the developments with key stakeholders is seen as the only way forward for us.

Cisco is the worldwide leader in technology that powers the Internet. It has a diverse portfolio of products and solutions, including networking, collaboration solutions, security solutions, wireless and mobility, data center, IoT, video, analytics, and software solutions. Cisco has an enterprise-wide circular economy program that focuses on designing out waste, extending the life of products and materials, and regenerating natural systems. **As part of the company's focus on reducing product and packaging waste, as well as materials used in transporting products, Cisco is committed to reducing the amount of single-use plastic used and has been taking steps where feasible to replace the use of single-use stretch wraps for pallets.**

In fiscal 2019, Cisco piloted reusable pallet wraps with one of its many global logistics partners in its operations in APJC and North America, and continued to use reusable wraps through 2021. With this effort, Cisco avoided the use of 174,490 pounds of plastic wrap over three years, which is equivalent to 14 million high-density plastic shopping bags.

Cisco has shared learnings from the use of reusable pallet wraps with this industry collaboration and in turn, has also gained insights from others. As a part of the company's efforts to reduce plastic, it is working with its logistics partner to determine which other transportation lanes reusable pallet covers can be used in and is ensuring that the environmental and cost benefits from switching to reusable pallet covers are consistently quantified and tracked.

flex

Flex is the manufacturing partner of choice that helps a diverse customer base design and build products that improve the world. Through the collective strength of a global workforce across 30 countries and responsible, sustainable operations, Flex delivers technology innovation, supply chain, and manufacturing solutions and services to diverse industries and end markets. Through its GLOBAL SERVICES AND SOLUTIONS, the company provides a unique level of regionalized solutions across a global footprint, delivering strategic insights around circular economy capabilities, value-added fulfilment, logistics, repair, refurbishment, and recycling services independently and in partnership with manufacturing services.

As a result of growing awareness of the global need for greener manufacturing, supply chain and after-sales services, companies are rethinking how sustainability can be further embedded in the product lifecycle. **Flex has developed proprietary CO_2 measurement, life cycle assessment and analytical tools, focused on repair and refurbishment activities, helping customers tap into invaluable data for informed, strategic decisions to reduce their environmental impact.** Through Flex ECO2TM, the company's cloud-based indicator tool, Flex can model the potential environmental savings equivalents possible with its circular economy solutions as compared to a product's baseline.

Metrics include carbon emissions, energy, water, waste, and resource and material use. Through a streamlined assessment and data visualization, the tool yields understandable, actionable findings for brands to pinpoint the optimal circularity interventions for their sustainability goals.

Flex helps customers drive sustainability throughout the product lifecycle and realize new financial value. This effort has assisted in deepening customer partnerships beyond traditional EMS, opening new revenue streams for customers and advancing a regenerative, closed-loop future.

MAINETTI

For sixty years, Mainetti has been a trusted partner to the world's most respected and well-known retail and apparel brands. Our 6,000 employees in 90 locations on 6 continents come to work every day with a mission to deliver innovative and sustainable solutions for our customers.

As the largest hanger company in the world, the name Mainetti is synonymous with superior quality and exceptional service. Mainetti pioneered garment hanger reuse and recycling with Hangerloop, introducing circular practices that continue to lead the industry. Mainetti's diversified portfolio includes Packaging, Branding, Supply Chain, Intelligent (RFID), and Health and Safety Solutions.

In 2021, Mainetti started working with a number of retailers to provide a world first closed loop recycling initiative. **The Mainetti Polyloop system has enabled us to clean and recycle post-consumer polyethylene materials to an exceptionally high quality. This has opened new possibilities for the use of recycled materials, while preventing them from being downcycled.**

Mainetti is excited to be collaborating across industries with leaders in the circular economy. We are optimistic that our combined efforts and the application of technology will lead to a reduction of the amount of virgin plastic materials required for pallet wraps.

Microsoft

Microsoft is accelerating progress toward a more sustainable future by reducing our environmental footprint, accelerating research, helping our customers build sustainable solutions and advocating for policies that benefit the environment. **We focus on four areas—carbon, water, waste, and ecosystems—where we can scale by minimizing the negative impacts of our operations and maximizing the positive impacts of our technology. While we start with our operations, our strategy expands beyond our four walls by ensuring those changes also benefit the communities in which we operate and flow into our product strategy.** Through technology adoption by customers and partners, we can drive positive impact across the globe, accelerated by our investments, engagement in policy, and commitment to innovation.

As part of our zero waste agenda, we are committed to eliminating single-use plastics from primary product packaging and our IT asset packaging by 2025.

SCG

Pallet wrapping qualities to protect and stabilize goods during transport is important for the global economy and it is therefore essential that we find a circular solution that can maintain the high quality properties while making sure we reuse the resources. Circular pallet wrapping will not only reduce plastic waste but also have an important impact to reduce our climate emissions. **For SCG, we are both a consumer and raw material producer of pallet wrap. SCG are working to find circular solutions throughout our product portfolio and pallet wrap is therefor an essential part of this.**

SCG Chemicals is one of the largest integrated petrochemical companies in Thailand and a key industry leader in Asia offers a full range of petrochemical products ranging from upstream production of olefins to downstream production of 3 main plastics resins; polyethylene, polypropylene and polyvinyl chloride. We have a mission to be a regional industry leader with focus on sustainability and innovation and we have a strong focus on conducting our business in line with Environmental, Social and Governance standards to achieve the Sustainable Development Goals. To be in the forefront in circular economy, SCG collaborate with key technology providers and brand owners world-wide. We accelerate this through our newly launched portfolio of SCG GREEN POLYMERs building on the four principles of reuse, recyclable, recycled and renewable. SCG have set targeting sales of at least 200,000 tons of SCG Green Polymers by 2025.

ESTĒE LAUDER COMPANIES

At the Estée Lauder Companies (ELC) we are committed to environmental responsibility by applying ingenuity and innovation to create more sustainable prestige beauty products, while helping to contribute to a stable climate and healthy, beautiful planet. Stretch wrap is used throughout our global operations to prepare and stabilize boxes during transport. In fiscal 2020, ELC began working on stretch wrap reduction and sustainable management solutions. **When we approached Ellen MacArthur Foundation Network and learned about the SWAP project, we were very interested in the collaborative work to develop and pilot circular B2B solutions to eliminate single-use plastic wrap. While a large percentage of our stretch waste is segregated and recycled, we continually look for ways to drive towards more responsible packaging solutions.** We will continue to explore our operations and where we can apply learnings from the pilots to either move management practices up the waste hierarchy or towards a more circular economy.

WSP USA is the U.S. operating company of WSP, one of the world's leading engineering and professional services firms. WSP USA designs lasting solutions in the buildings, transportation, energy, water and environment markets. With more than 10,000 employees in 170 offices across the U.S., we partner with our clients to help communities and businesses prosper.

WSP USA works with organizations and communities to help them become Future Ready. **We develop strategies to mitigate emissions and enhance sustainability, identify potential risks and opportunities to become more resilient, and implement equitable adaptation solutions that prioritize community and stakeholder engagement and environmental justice.**

Our Sustainability, Energy, and Climate Change team helps clients navigate a complex sustainability and energy landscape and unlock opportunities to reduce cost, create brand value and mitigate risk across the value chain, ultimately building more resilient organizations that can thrive in a changing global market. We draw on the skills and experience of our team to collaborate with clients in developing a systematic approach to identify and implement viable solutions. Our technical knowledge, engineering heritage and multidisciplinary experience position us to partner with clients, from strategy through to solutions design and implementation. We serve as trusted advisors to unite our client's internal efforts and business strategies and align it with sustainability goals and priorities.