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Single Use Plastic Packaging Remoulded into Pallets

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EPA Research Report

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by

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This report is based on research carried out/data from Dec 2020 to May 2021. More recent data may have become available since the research was completed.

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Executive Summary

The European Commission has set ambitious targets for Member States to reuse and recycle 50% of all plastic packaging waste by 2025 and 55% by 2030. Ireland is performing strongly in the EU for plastic packaging recycling with recycling rates of 36% compared to the current European target of 22.5%. However, the recycling rate has largely stagnated with marginal increases over the last few years. Household and commercial films make up 57% of all plastic packaging waste in Ireland. Solutions up to now have largely included incineration and landfill. However, in line with the waste hierarchy concept in a circular economy, the focus is on waste prevention, repair and recycling over energy recovery and landfill. Soft plastics are used extensively for food packaging and are difficult to recycle because they are made up of many different plastic types and can be multi-layer with ink and adhesives present. As these are used as food packaging, they are also highly contaminated with food waste. In order to meet our EU recycling targets Ireland needs to develop recycling solutions for soft plastic waste.

This project was led by PALTECH in collaboration with Green Generation Ltd and Athlone Institute of Technology (AIT). PALTECH aims to develop and commercialise products manufactured from post-consumer plastics utilising its innovative and proprietary Enclosed Pressure Moulding (EPM) Process. Green Generation operates an anaerobic digestion plant in Kildare and accepts food waste with plastic packaging as a food stock for the digester. AIT involvement in the project added further expertise in the area of plastic processing and the facilities at the Institute were utilized for material characterisation. The overall aim of this project was to develop the EPM process to manufacture a recycled plastic pallet to contribute to the circular economy for plastics in Ireland.

Process development commenced to consider the size and complexity of moulding a pallet manufactured from mixed recycled plastic waste. A development mould was utilized to process material with a plastic wall thickness of 25mm. Project collaborators Green Generation prepared and supplied mixed plastic flake to the project. Their wash plant was upgraded to allow both soft and hard plastics to be recycled. Various mixes of materials were shredded, washed, dried and supplied to PALTECH for process trials and testing. At PALTECH process development was carried out using R&D equipment. Process parameters including, temperature, dwell time, pressure agent grade, pressure agent percentage, moisture content and process pressure were trialled and tested to develop the process to achieve an optimum moulded plastic product. A 400mm cubic mould was used for trials which has a 25mm wall thickness and is representative of the initial pallet concept features.

Test panels were manufactured for fire testing and sent to Impact Solutions in the UK. Test results for two test panels supplied show that the material meets the requirements of UL94 Horizontal Burn Test. Test laminates were manufactured for tensile, flexure and impact testing at AIT. A review of current plastic and wood pallets was carried out to establish key features required.

After a review the nine leg open base pallet was down selected as the demonstrator pallet and tooling was procured. The mould tooling was received and integrated into the manufacturing equipment. A range of test pallets were manufactured with varying thickness and process parameters.

The project demonstrated that mixed plastic packaging could be successfully moulded into new products. An example of a commercial application of the technology in a partnership between TESCO, Green Generation and PALTECH was discussed as one solution for single use plastic packaging.

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1. Introduction

1.1 Challenge

Increasing the level of recycling of plastic packaging waste is a key challenge facing the EU. Today, 95% of the value of plastic packaging material, i.e., between 70 and 105 billion euro annually worldwide, is lost to the economy after a very short first-use cycle (Ellen MacArthur Foundation). Every year around 319,000 tonnes of plastic packaging waste is generated in the Ireland with only approximately 28% of this waste recycled (EPA Waste packaging statistics for Ireland, 2019).

The European Commission has set ambitious targets for Member States to reuse and recycle 50% of all plastic packaging waste by 2025 and 55% by 2030. However, several barriers and technical challenges exist which are limiting the amount of recycling of plastic packaging waste within the EU. To date, the quality of the collected plastic packaging waste has limited its potential for recycling applications. 30% of the plastic packaging waste collected is mixed plastic packaging containing food traces which requires pre-treatment before recycling. Existing processes developed by the plastics industry for processing virgin plastics are not suitable for processing of mixed plastic waste due to the variation in density and melt flow index. The current process for sorting and cleaning waste plastic are labour intensive and expensive, failing to capture the economic benefit of this resource in a cost-effective manner.

1.2 Objectives

PALTECH aims to develop and commercialise products manufactured from post-consumer plastics utilising its innovative and proprietary Enclosed Pressure Moulding (EPM) Process. The overall aim of this project was to develop the EPM process to manufacture a recycled plastic pallet to contribute to the circular economy for plastics in Ireland. The specific project objectives are shown in Table 1.

Table 1.1 Project Objectives

Objective Description
Objective 1. Optimization of the EPM process. PALTECH to manufacture test laminates from recycled plastics received from Green Generation and AIT to carry out mechanical test programme to measure mechanical properties and variation.
Objective 2. Design a recycled plastic pallet to meet industrial requirements. To design a recycled plastic pallet to take advantage of the EPM process.
Objective 3. Full scale prototype pallet manufacture and testing. Manufacture pallet from mould tool and test to standards.

Objective 4. Communication of project results.

Communicate circular economy for plastics results throughout the project using social media, internet and attend trade shows and conferences.

2. Approach and Methodologies

2.1 Approach

This project was led by PALTECH in collaboration with Green Generation Ltd and Athlone Institute of Technology (AIT). This project directly addressed the fundamental issues which are limiting the amount of recycling of plastic waste by developing a novel manufacturing process utilizing mixed plastic packaging waste as a raw material (see Figure 2.1). Recycled plastic products manufactured using EPM technology developed by PALTECH eliminate the need for sorting of plastic.

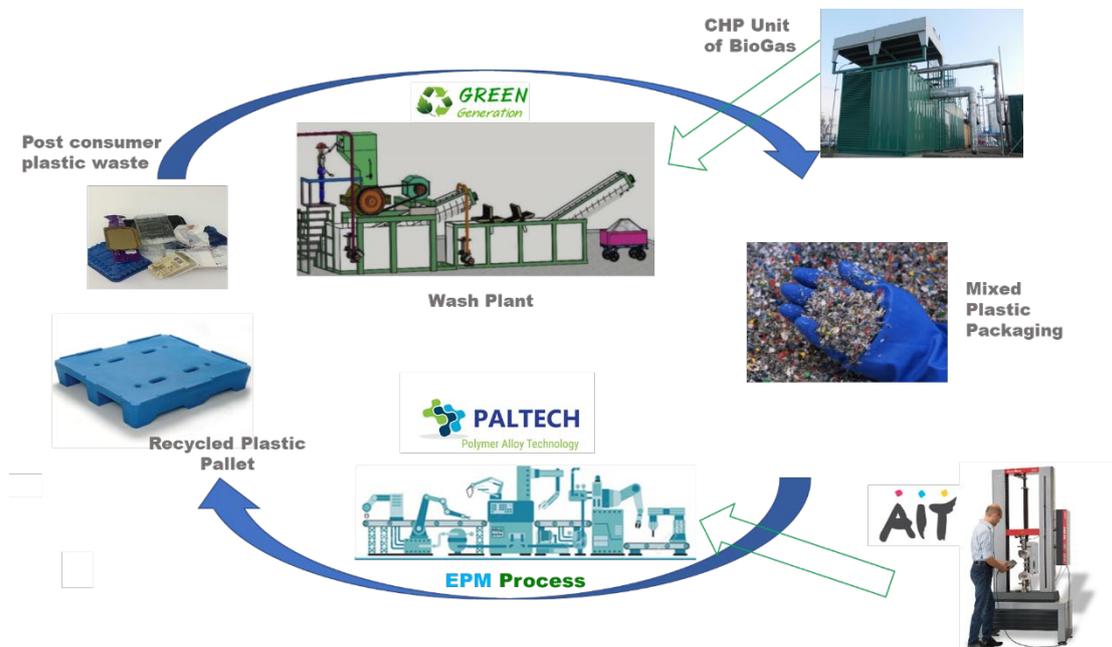


Figure 2.1 EPM Process Overview

The technology is used in combination with an innovative pre-treatment plant utilizing excess heat from an Anaerobic Digestion (AD) facility at Green Generation to provide a renewable energy source to hot wash and dry the plastic waste before processing.

The value chain for plastic waste for this project starts with the collection of the waste at Green Generation facility. Much of the food waste entering the facility contains plastic packaging. Green Generation has developed a system to use the excess renewable energy from the Combined Heat & Power (CHP) unit to wash the plastic packaging with hot water and the waste dirty water is then

feed into the AD on site as opposed to entry into the local waste water treatment system. The excess heat energy is also used to dry the plastic after washing. This environmentally friendly and energy efficient system is a more effective and lower cost solution to wash waste plastic compared to the existing systems used by the plastic recycling industry. Green Generation can supply clean mixed plastic in flake form to PALTECH at a low cost that would otherwise have been sent to landfill or incineration.

The recycled flake is then prepared by PALTECH for loading into the moulds along with pressure activators. The key novelty of the EPM process is the enclosed pressure moulding technology developed by PALTECH. This innovative technology eliminates the need for complex and expensive external mould equipment to produce plastic parts.

Testing and certification of the recycled plastic is essential for commercialisation of the technology. AIT involvement in the project added further expertise in the area of plastic processing and the facilities at the Institute were utilized for material characterisation.

2.2 Methodologies

The project activities were broken down into six work packages as listed in table 2.1 below.

Table 2.1 Work Packages

WP No.	WP Description
1	<i>Project Management</i>
2	EPM Process Development and Material Testing
3	Design and Analysis of Recycled Plastic Pallet
4	Manufacture of Prototype Pallet
5	Inspection and Testing of Prototype Pallet
6	Communication

Process development commenced to consider the size and complexity of moulding a pallet manufactured from mixed recycled plastic waste. A development mould was used to process material with a plastic wall thickness of 25mm. Project collaborators Green Generation prepared and supplied mixed plastic flake to the project. Their wash plant was upgraded to allow both soft and hard plastics to be recycled. Various mixes of materials were shredded, washed, dried and supplied to PALTECH for process trials and testing.

At PALTECH process development was carried out using R&D equipment. Process parameters including temperature, dwell time, pressure agent grade, pressure agent percentage, moisture content and process pressure were trialled and tested to develop the process to achieve optimum moulded plastic product. A 400mm cubic mould was used for trials which has a 25mm wall thickness and is representative of initial pallet concept features. Initially the organic contamination level in the plastic was too high and further work was required at Green Generation to upgrade the material preparation in terms of washing and drying.

Test panels were manufactured for UL 94 fire testing and sent to Impact Solutions in the UK. The test panels were manufactured using optimal materials and processing parameters but did not include any additional flame retardants. UL 94 Horizontal Burn Test is one of the most widely used flammability tests for determining relative flammability for plastic materials. It measures the ability of plastic part to extinguish the flame after ignition and its dripping behaviour in response to a small open flame or radiant heat source under controlled laboratory conditions. The test results for the two test panels supplied show that the material meets the requirements of UL94 Horizontal Burn Test.

Test laminates were manufactured for tensile, flexure and impact testing at AIT. The results are in line with test data for Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE) plastics.

Table 2.2 Tensile and Flexure Test Results

	Result
Tensile strength (MPa)	10.94
Tensile modulus (MPa)	1062.70
Elongation at break (%)	3.66
Flexural strength (MPa)	9.18
Flexural modulus (MPa)	309.48
Flexural strain (%)	6.70

A review of current plastic and wood pallets was carried out to establish key features required. A plastic pallet was also supplied by MSD in Carlow (figure 2.2) who were searching for a recycled plastic pallet. The pallet is used in a pharmaceutical application and required sterilisation after manufacturing.



Figure 2.2 Pallet supplied by MSD Carlow

Designs were produced by PALTECH for several pallet configurations. Designs considered were a one-shot moulding of pallets and a modular design where upper and lower pallet sections would be brought together in an assembly operation and joined using welding or fastening techniques.

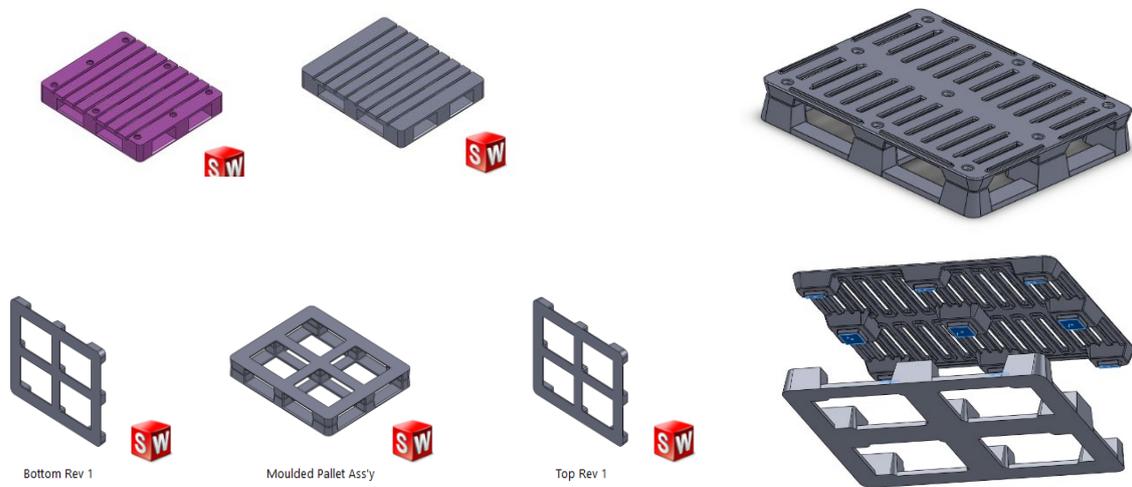


Figure 2.3 Pallet Designs

After a review the nine leg open base pallet was down selected as the demonstrator pallet and tooling design commenced. The nine leg open base design allowed for a simpler tooling configuration in line with the scope and timescale of the project.

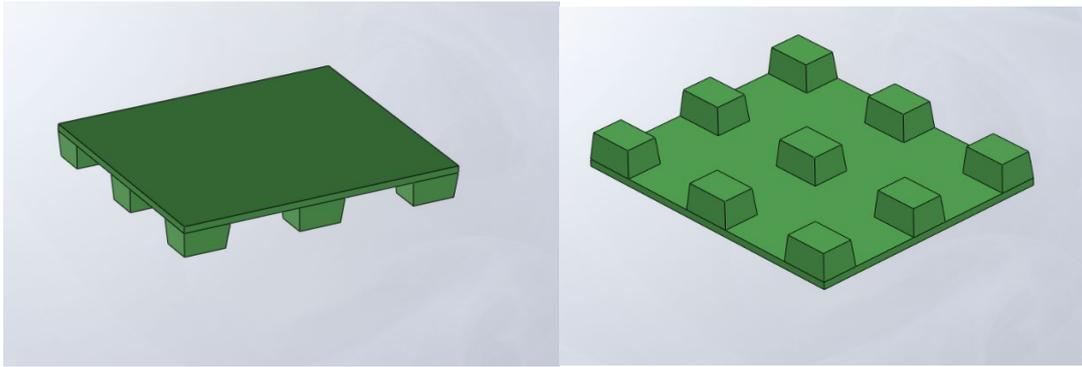


Figure 2.4: Down selected pallet design

The tooling design built on the process development knowledge gained over the first six months of the project. The mould tool was designed in house and consists of an upper and lower moulds surfaces with an interchangeable picture frame at the centre, this frame dictated the wall thickness of the pallet platform and having frames of various thicknesses allowed pallets of different weights to moulded in the same mould. After the mould profile was designed the individual mould details were designed to allow the profiles to be machined using a CNC laser jet cutter.

The mould was received and integrated into the manufacturing equipment. The first pallet trials used a 40mm thick picture frame. The first trials were moulded successfully using mixed plastic waste supplied by Green Generation. The pallets had good surface finish and filling of the mould. The density of the moulded polymer was higher than predicted and gave a pallet weight of 62kg. This is significantly higher than a standard plastic pallet so for the next moulding trials the 40mm picture frame was changed for 25mm frame.



Figure 2.5: 40mm pallet

Further trials produced pallets with the 25mm picture frame. Again, a high density was achieved and the overall pallet weight averaged 52kgs.



Figure 2.6: 25mm pallet

Plastic pallets on the market (1200mm x 1000m) weight 27-35kgs. The recycled pallet design was reviewed to access if the weight could be reduced. The weight of this pallet design is largely dependent on three factors.

- Moulding density
- Base weight
- Leg weight

An average moulding density of 770Kg/m³ was achieved with the EPM process. This higher than expected density offers greater structure properties.



Figure 2.7: Cross section of pallet at leg

Future activities to further develop the pallet **should include** methods to reduce the weight. The base thickness of 25mm could be reduced further to 20mm to reduce weight. Approximately 25kgs of the pallet weight currently comes from the nine legs. This could be dramatically reduced by hollowing out the design of the legs without significantly reducing the pallet strength. Since the end

of the EPA project PALTECH has continued to develop the pallet. The mould has been modified to reduce the weight of the pallet as this is one of the limiting factors for commercialisation.

3. Outcomes

This Green Enterprise project progressed the development of the EPM technology and delivered a demonstrator product in the form of a recycled plastic pallet. The process parameters for the EPM technology were enhanced by the development activities and a recycled plastic pallet was designed, manufactured and tested within the project through the collaboration with Green Generation and AIT.

The research added additional technical data for PALTECH in the form of test results from AIT and Impact Solutions for fire, flexure and impact properties. This data is essential for the further commercialisation steps of the technology.

The activities of the industrial partners in the area of the circular economy for plastics and the research supported by the EPA was communicated to wide audiences including webinars and national radio interviews. On 10th February Adrian Doyle from PALTECH was interviewed live by Vincent Wall from the Newstalk Breakfast Business show. The interview covered the recent partnership between PALTECH and TESCO to recycle customer plastic packaging in store. During the interview Adrian also referenced the EPA Green Enterprise funding projects.

During the project TESCO also announced partnerships with both PALTECH and Green Generation to recycle plastic packaging and convert waste food into renewable energy. The partners plan to recycle 500 tonnes of soft plastic packaging in year 1. This packaging was previously sent for incineration or landfill. PALTECH will be able to use the knowledge gained during the Green Enterprise project to develop products suitable for the TESCO plastic packaging. TESCO have also expressed an interest in the recycled plastic pallet concept and are interested in trialling the product once it is developed.

The collaboration between all the partners increased over the period of the project and included a second successful application for EPA Green Enterprise funding in 2020.

4. Policy and Legislation

This project addresses the EPA's Green Enterprise call "Innovation for a Circular Economy" under the thematic area of "Plastics". Ireland is performing strongly in the EU for plastic packaging recycling with recycling rates of 28% compared to the current European target of 22.5% however the recycling rate has largely stagnated with marginal increases over the last few years and higher targets of 50% by 2025 and 55% by 2030. The growth in plastic packaging, restrictions in the Chinese market for acceptance of waste plastic packaging for recovery, lack of a market demand for plastic recyclables in Europe, significant commodity price fluctuations for recycled plastics commodities along with infrastructure deficits across Europe have contributed to this stagnation. For a truly sustainable and circular economy solution we must think of developing the recycling system here in Ireland and remove the need to export our plastic waste for recycling. We must also tackle the more difficult to recycle plastics like the soft plastic food packaging. ~~This involves placing soft plastics back in the recycling bin.~~ The findings in this project demonstrate the potential to recycle these plastics into new products and offers an outlet for this mixed plastic packaging.

5. Recommendations Summary

The European Commission has set ambitious targets for Member States to reuse and recycle 50% of all plastic packaging waste by 2025 and 55% by 2030. Ireland needs to increase the rate of plastic recycling from the current level of 36% to meet these targets. Achieving these targets will require new technologies for plastic recycling. This project has demonstrated the potential of the EPM technology developed by PALTECH to increase the recycling rates in Ireland.

Household and commercial films make up 57% of all plastic waste packaging in Ireland. Soft plastics are used extensively for food packaging and are difficult to recycle because they are made up of many different plastic types and can be multi-layer with ink and adhesives present. As these are used as food packaging, they are also highly contaminated with food waste. These soft plastics are currently placed in the general waste bin. With the EPM technology these soft plastic can now be collected and recycled to increase our recycling rates.

References

Ellen MacArthur Foundation, The New Plastics Economy, 2016

EPA, Waste Packaging Statistics for Ireland, 2019

Acronyms and Annotations

EPM Enclosed pressure moulding

AIT Athlone Institute of Technology

CHP Combined Heat & Power

AD Anaerobic Digestion

LDPE Low Density Polyethylene

HDPE High Density Polyethylene

- **Identifying Pressures**

In November 2017 the Irish Government launched the “Clean Dry Loose” campaign for recycling and advised people not to place soft plastics in the recycling bin. This educational campaign was aimed at improving the quality of the materials going into the recycling bin. Since then, the recycling system is under pressure to find an outlet for these difficult to recycle soft plastics. Household and commercial films make up 57% of all plastic packaging waste in Ireland. Solutions up to now have largely included incineration and landfill. However, in line with the waste hierarchy concept in a circular economy, the focus is on waste prevention, repair and recycling over energy recovery and landfill. Soft plastics are used extensively for food packaging and are difficult to recycle because they are made up of many different plastic types and can be multi-layer with ink and adhesives present. As these are used as food packaging, they are also highly contaminated with food waste. The European Commission has set ambitious targets for Member States to reuse and recycle 50% of all plastic packaging waste by 2025 and 55% by 2030. To meet these targets Ireland needs recycling solutions for soft plastic waste.

- **Informing Policy**

In Ireland we are growing ever more conscious of negative effects of single use plastics for food packaging and the unsustainability of our current practices. At the time when this Green Enterprise funding was obtained there was a growing frustration with consumers about the amount of plastic packaging used **and the lack of recycling options**. Large supermarkets have reacted to public concern and are actively reducing plastic packaging and moving towards recyclable materials. Also, in recent months REPAK have announced that soft plastic packaging can now be placed in the recycling bin. This poses a challenge for the existing recycling system to deal with the mix of soft plastic and the high levels of contamination. This Green Enterprise project has demonstrated that the Enclosed Pressure Moulding EPM technology developed by PALTECH offers the potential to recycle mixed plastic packaging into new products and hence avoid landfill and incineration.

- **Developing Solutions**

Companies are engaging in sustainability strategies and circular economy solutions across their supply chain. Single use plastic is high on the agenda for food producers and supermarkets. In 2020 TESCO partnered with Green Generation and PALTECH to develop a sustainable solution for food waste and plastic packaging. TESCO’s remaining food surplus, which has not been donated to FoodCloud is sent to an anaerobic-digestion plant in Kildare operated by Green Generation and is used to generate biogas. This renewable gas is used to power six TESCO stores. The plastic

packaging which is separated from the food waste is recycled by PALTECH and converted into materials that can be used in TESCO stores. In February 2021 TESCO also announced that it was offering customers the opportunity to recycle soft plastics in store using recycling units manufactured by PALTECH using recycled plastic. This is an example of a proactive recycling solution developed outside the traditional waste collection and recycling system. The partners plan to recycle 500 tonnes of soft plastic in year 1 that up to now was sent for incineration or landfill. The recycled plastic pallet is one potential product for this project.