

Redesigning Secondary Packaging and Integrating Automated Machinery for Improved Packaging Efficiency

[Balazs Barcza]

[TU Dublin Ireland]

[Diploma In Packaging Technology]

[06/04/2024]

1. Introduction:

My project centers on exploring the installation of a new Automated Packaging Machinery and its significance. Before delving into the project's specifics, I'll provide an overview of the current state of the Irish employment labor market and highlight the importance of modernizing companies through robotic and automation implementation.

The unemployment rate in Ireland is currently 4.2% (Statista, n.d.), which is low compared to other European countries. However, this low figure presents a challenge for Irish companies, particularly factories, in finding skilled workers. Several factors contribute to this difficulty, the primary being a skills shortage. The Irish education system produces well-educated graduates and skilled employees. However, many Irish students leave the country after college to find better opportunities outside Ireland. Another challenging issue is demographics; the Irish population is aging, resulting in a smaller pool of young people entering the workforce.

Manufacturing jobs also fail to attract young people into the sector. This is because other European countries have lower unemployment rates, allowing young, talented, skilled workers to find employment in their home countries, reducing their incentive to relocate to Ireland.

Another major factor is the ongoing housing shortage in Ireland. The high rent prices and shortage of affordable housing make it difficult for people, especially younger individuals, to establish themselves in the country, further complicating the recruitment process for factories. In order to compete in the labor market and attract new employees, companies have few options. The company can increase salaries to attract more workers, but this will increase production costs. Alternatively, the company can partner with educational institutions to develop vocational training programs that provide students with the skills they need to work in manufacturing. The company can also invest in employee training to provide opportunities for employees to learn new skills and upgrade their knowledge. Additionally, the company can adopt automation and robotics, which can handle repetitive tasks and improve efficiency in the manufacturing process, freeing up employees to focus on more complex and value-added activities.

For my project, I will focus on automated case erector machines. A case erector is an automated machine designed to assemble and erect flat-packed cardboard boxes. The equipment picks up the flat box, shapes it into its proper form, folds the bottom flaps, and then seals them with tape or glue, preparing the box for product insertion. This process not only speeds up the packaging operations but also ensures consistency and reliability in box assembly. While it may seem simple for a human to assemble a flat box, this repetitive task can lead to workers losing focus and slowing down their work. This job is not challenging, so it is difficult to retain workers for long periods. This is why there is a high level of turnover in this position. Our goal is to demonstrate why a modern food company should invest in automated packaging machines for the future. If the current trend of labor shortages continues in the Irish employment market, it will become increasingly difficult to find new employees. Moreover, if the company is able to find employees, their salaries will likely rise, making automation a more cost-effective option in the long run. Implementing automated packaging machinery in a food company can bring about various benefits, including increased efficiency, improved product quality, and enhanced operational effectiveness. If a company decides to purchase a new machine, it needs to carefully consider various factors to make an informed decision. In this project, I will identify and emphasize the compelling reasons why opting for an automated machine is a sound investment. I will also highlight the positive improvements and cost-saving benefits that automation can bring to a company's operations. In my literature review, I discussed the importance of ready meal

packaging and how it has become increasingly popular in shops due to our fast-paced world demanding quick and convenient food.

Company Background:

Freshways, Ireland's leading sandwich maker founded in 1990, commands one-third of the Irish sandwich market. It has undergone a management buyout by Diarmuid Shanahan and Garrett Fitzgerald. The undisclosed deal ensures the continuity of the business, employing over 170 staff at its 60,000 sq. ft. facility in Finglas. With an annual turnover of approximately €25 million, Freshways produces 300,000 handmade sandwiches weekly for customers in Ireland. The company, known for its commitment to quality and freshness, plans strategic investments for growth. Freshways serves as a significant provider of sandwiches to the food services and diverse catering sector, like workplaces, schools, colleges, and hospitals. Additionally, the company caters to large-scale events such as race meetings, as well as music and sporting events. (Freshways, n.d.)

The sandwich market has grown significantly in recent years. Many busy people are opting for this type of fast food because it's quick and easy to grab from a shop and a nutritious snack. Sandwiches are popular meals made by combining various ingredients and placing them between two slices of bread. Market research indicates that the sandwich industry is expected to expand steadily at a rate of 10% in the coming years. This growth is attributed to the increased demand for healthier and more customized sandwiches. Consumers are increasingly seeking fresh, nutritious, and sustainable ingredients for their sandwiches. (Halo Research, December 18, 2023) In recent years, inflation has started to rise in Europe. This has caused the prices of goods (ingredients) to increase, and it has also led to higher production costs. In this competitive market, it is essential to find ways to reduce production costs and maintain a competitive edge.

2. Current Packaging Machinery and Issues:

Freshways is a sandwich-making company known for its flagship product, the Fresh Sandwich. In recent years, the company has garnered several accolades and witnessed a surge in demand for its products. However, this increased demand has put pressure on their production line. Despite attempts to hire more personnel to keep up with packaging needs, Freshways has faced challenges in retaining employees and making the job attractive.

One of the primary issues has been the lack of automation and modernization in their packaging process. As a result, the case-making section has struggled to maintain pace with the production line, leading to inefficiencies and increased labor costs. To address these challenges, Freshways has had to consider either raising product prices or finding innovative ways to streamline operations and reduce costs.

Recognizing the need for an automated solution, Freshways sought to implement a system that would fit within their limited space, adhere to ergonomic standards for employee safety, and meet the desired output levels. This strategic approach aims to optimize productivity while ensuring a sustainable and competitive position in the market.

3. Automated Packaging Machinery Upgrade:

Freshways faces critical decisions regarding their production optimization and addressing challenges. They must carefully consider their objectives and strategies for resolving production issues, particularly regarding case erecting and sealing processes. Should they persist with manual methods or transition to full automation?

In the realm of case packing and end-of-line packaging, the spectrum spans from manual to fully automated processes. To make informed decisions, it's imperative for Freshways to explore and understand all available options.

1. Enhanced Productivity: While manual box erection averages three per minute, a basic case erector can produce up to 10 per minute, boosting productivity by 233%. Machines with higher speeds offer even greater gains. For instance, erecting 2,500 cases manually takes almost 14 hours, whereas a case erector reduces it to four hours.
2. Operational Cost Reduction: Adding more workers to meet production demands can be costly. Efficient box-making machinery enhances overall operational efficiency, potentially reducing overtime expenses or reallocating labor resources.
3. Mitigation of Repetitive Strain and Injury Risks: Manual tasks expose workers to repetitive strain injuries and the risk of cuts and lacerations. Adopting a case erector significantly reduces these risks.
4. Inventory Optimization: Stockpiling boxes ahead of large shipments leads to storage challenges and wasted space. Storing pre-erected boxes consumes valuable floor space, akin to stocking pre-ordered raw materials or pre-assembled finished products.
5. Reduces Shipping Damages: Hand-erected cases are prone to unevenness, increasing the risk of shipping damage. Case erectors ensure well-formed, sturdy boxes, minimizing the risk of damage during shipping for Freshways' products.

In my literature review, I have discussed Automation and Sustainability. "Automation plays a pivotal role in streamlining packaging processes and reducing labor expenses. Automated machinery can handle repetitive tasks such as labeling, filling, and sealing, freeing up human workers for more strategic roles and reducing the risk of errors."

Freshways is seeking ways to improve their packaging processes. After conducting thorough research, they discovered NPP, a company that specializes in packaging solutions. NPP offers a comprehensive packaging solution that combines best-in-class packaging materials, high-performance machinery, and innovative automation systems. NPP provides a wide range of case erector machines, tailored to the specific needs of your business, ensuring increased productivity and palletizing efficiency. NPP is supplying Lantech-branded case erectors. We listened to the customer's needs and offered our Lantech C-1000 Case Erector. This machine is an excellent choice for medium-sized businesses. It can erect 10-30 cases per minute and can be equipped with either tape or hotmelt application. This automatic case erector features ergonomic blank loading, precise case forming, and automatic case adjusting.



Lantech C-1000 Case Erector.

The Lantech C-1000 Case Erector is a functional and efficient machine suitable for a wide range of operations. Those are the few important spec about the machine:

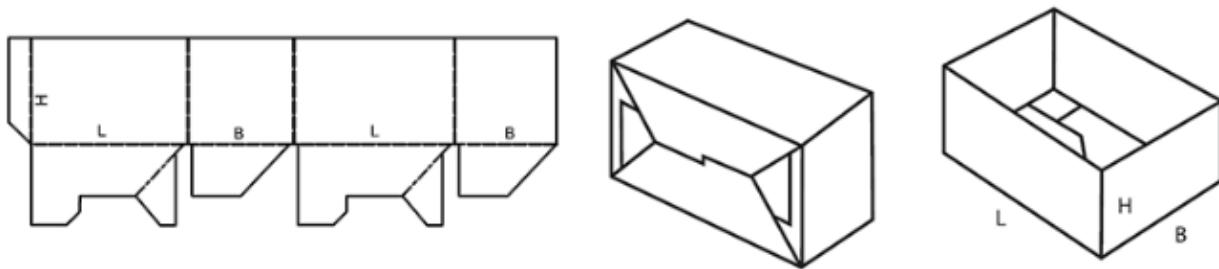
CRITERIA	CI-1000 TAPE	CI-1000 HOTMELT
Speed	10-25 cases per minute Options and application can change the speed	10-25 cases per minute Options and application can change the speed
Minimum Case Outer Dimensions	200 mm L x 150 mm W x 150 mm C (7 7/8" L x 5 7/8" W x 5 7/8" C)	200 mm L x 150 mm W x 150 mm C (7 7/8" L x 5 7/8" W x 5 7/8" C)
Maximum Case Outer Dimensions	500 mm L x 325 mm W x 520 mm C (19 5/8" L x 12 3/4" W x 20 1/2" C)	500 mm L x 325 mm W x 520 mm C (19 5/8" L x 12 3/4" W x 20 1/2" C)
Case Type	RSC, HSC, FEFCO 0200/0201	RSC, HSC, FEFCO 0200/0201
Flute Type	B, C, E	B, C, E
Wall Type	Single Wall, Double Wall	Single Wall, Double Wall
Standard Sealing Device	Lantech® TH-Series Tape Head	Robatech/Nordson
Dimensions - Machine	3400 mm L x 1325 mm W x 2400 mm H (133 7/8" L x 52 1/6" W x 94 1/2" H)	3400 mm L x 1325 mm W x 2500 mm H (133 7/8" L x 52 1/6" W x 98 2/5" H)
Weight - Machine	±725 kg (±1600lb)	±825 kg (±1800lb)
Electrical Service Choices	3L-PE-400V-50Hz-Neutral 230V, 3-ph, 60Hz, Wye w/ Ground	3L-PE-400V-50Hz-Neutral 230V, 3-ph, 60Hz, Wye w/ Ground
Pneumatics	6 Bar (80 PSI)	6 Bar (80 PSI)

Lantech C-1000 Case Erector Specs. (Lantech Case Erectors, n.d.)

4. Redesigning Secondary Packaging:

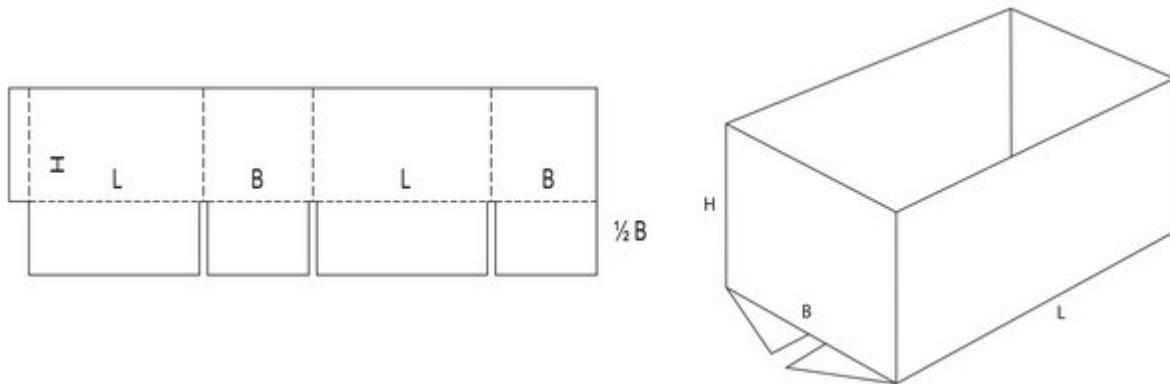
Freshways is currently utilizing the FEFCO 0700 packaging design. This design features ready-glued cases that are shipped flat and can be easily assembled. The boxes can be made with either a bottom or diagonal folding pattern. The boxes arrive fully glued, and the end user, a

Freshways employee, must manually open them. This design is well-suited for either manual assembly or the use of a specialized machine that can open the boxes and prepare them for filling. Tray-type boxes have a single-piece design with an open top and sides, allowing for easy access to the contents. They are commonly used for storing or displaying products. Freshways does not have this specialized case erector machine, so this process requires the employee to manually open the boxes, which can be time-consuming. This employee could be more productively utilized elsewhere in the production process.



FEFCO O700. (Anon, 2019)

NPP sells Lantech automatic case erector machines, but these machines can only take FEFCO 0200 and O201 boxes. My research led me to find that the FEFCO 0700 design is not popular for automatic case erectors. Not many companies sell this type of machine. The most popular design to automate the process is FEFCO 0200 and O201.



FEFCO O200.(Anon, 2019)

FEFCO 0200 is a slot-style box with four flaps at the bottom and an open top. The flaps can be glued or taped, and they can be made manually or automatically. This design is very popular with packaging products because it is easy to manufacture by packaging converters (NPP has a rotary case maker machine that is a fast production machine). The basic O200 or O201 box can be produced using a rotary casemaker machine. This is because these types of machines have both stilt and slotting blades. However, as we'll see later in my project, the redesigned box will not be a standard FEFO style. Therefore, a rotary die tool will be necessary for its production. The O200 and O201 provide good protection for fragile products. FEFCO O200 boxes are well-suited for automated packaging systems. They can be opened, glued, or taped up by machine.

Feature	FEFCO 0700	FEFCO 0200
Construction	Ready-glued	Slot-style
Opening	Manual or automated	Automated
Suitability	Products that are not fragile	Products that are fragile or need to be protected from damage
Applications	Storage, display, and shipping	Packaging, display, shipping, and distribution

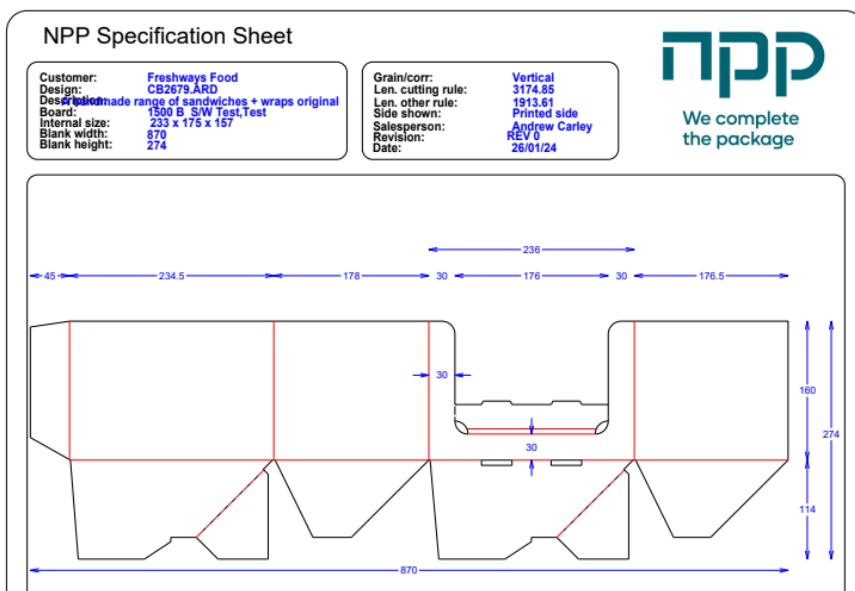
Key different FEFCO O700 vs O200.

I would like to suggest to the customer to change the design to FEFCO 0200. If Freshways is concerned about labor costs and efficiency, then they should consider switching to FEFCO 0200 packaging. The automated opening and closing of FEFCO 0200 boxes can significantly reduce labor costs and improve efficiency.

I have redesigned the packaging using CAD program ArtiosCAD (www.esko.com, n.d.). ArtiosCAD is a powerful software program designed to create intricate folded packaging, particularly corrugated boxes and folding cartons. It is widely used by packaging experts, including box designers, sample makers, and die makers. Developed in Ludlow, Massachusetts, ArtiosCAD is a subsidiary of Esko, a global visual communications company headquartered in Gent, Belgium.

In my literature review, I explored the factors to consider when redesigning packaging and I discussed the complexity of the packaging decision process and the various stakeholders involved when a design change is implemented.

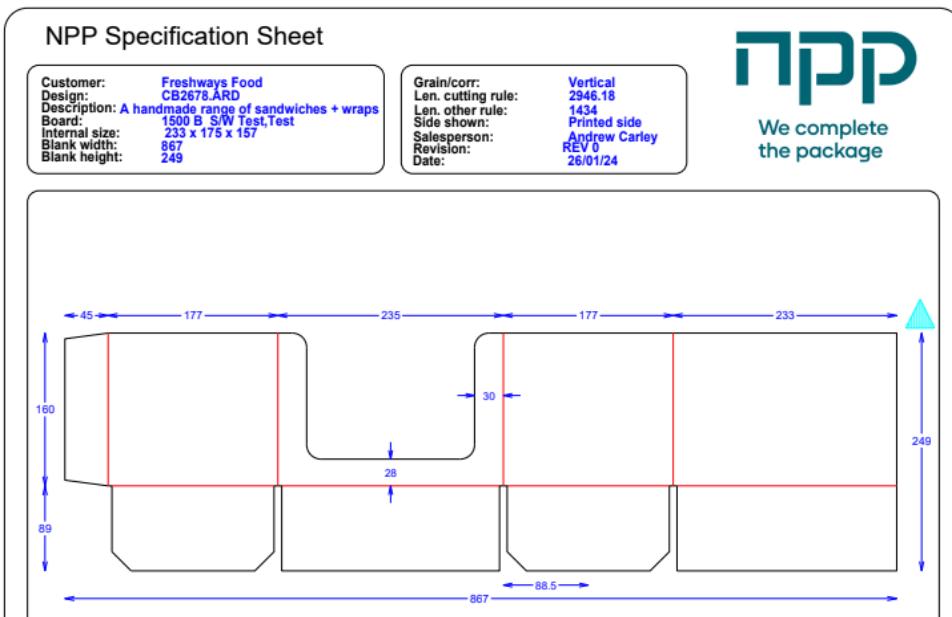
I will continue the discussion about the new design and how it can be used with the new case erector that we can offer to Freshways. I will describe the following benefits of the design change and why it is beneficial to the customer.



Freshways design FEFCO 0700.

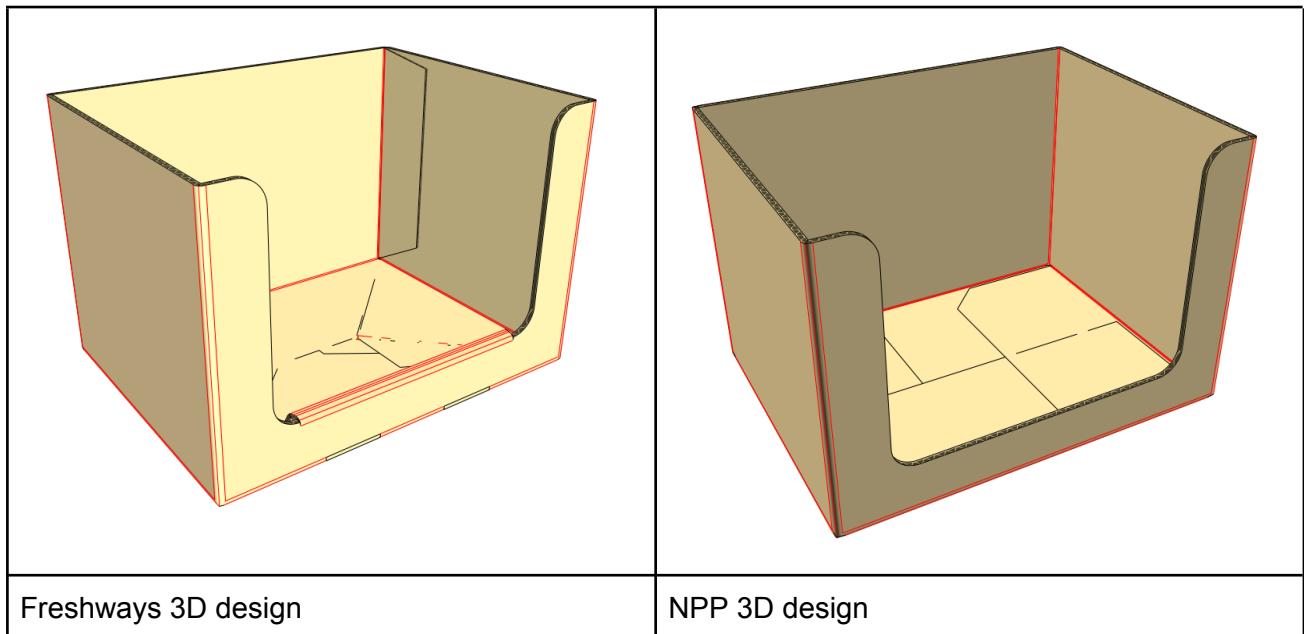
In the original design, the front panel has a display edge that is designed to fold inward after the box is opened. This creates a display cutout that allows customers to see the actual product.

This design also provides easy access for customers to remove the product from the secondary box. The display cutout helps customers identify the product and understand what they are purchasing. I have observed that the original design includes a display cutout, which necessitates the use of a specialized die-cutting tool. Therefore, when redesigning the packaging, I must consider this factor in the final cost estimation.



NPP design FEFCO O200.

I have redesigned the box by adding a front cutout. I have also simplified the design to eliminate the need to fold down the front lip. This will make the box suitable for use with an automatic erector machine.



I have continued to compare the two packaging designs using ArtiosCAD software. This has allowed me to gather additional data about the two designs. The table compares the amount of material required for each design. If we order a new rotary die tool for the new design, it will only

require 4.3 meters of cutting and creasing rules. The old design requires 5 meters of cutting, creasing and special rules. Therefore, the new die tool will be more cost-effective than the old die tool (If Freshways must reorder it in the future. Over time, the die-cutting tool can wear down due to repeated use. The sharp edges may become dull, leading to less precise cuts or tearing of the material. It can be damaged).

Freshways O700 keyline rule length	O200 keyline rule length

In my project, I chose to use a rotary die tool because it is the most cost-effective method for producing FEFCO O200 or O201 designs. NPP recently acquired a brand-new rotary die cutter, Macarbox. While flatbed die cutters can also produce these designs, their production speed cannot match that of rotary die cutters.

NPP has two corrugated case makers: a flatbed and a Macarbox Rotary Die Cutter. The rotary die cutter has many benefits for producing the FEFCO O200 and O201 boxes because it's a high-performance flexographic printer that integrates printing, die-cutting, and stacking into the production process.



Macarbox Rotary Die Cutter. (www.macarbox.com, n.d.)

RDC Features:

- High performance production orientated to die-cut boxes.
- Quick die-change system.
- Automatic Anvil grinding system.
- High quality flexographic printing at high working speed.
- Production speed up to 25000 box/hour.
- Up to 4 outs/piles.
- Stripping station.
- Innovative doctor blade chamber: automatic inking and wash-up, without side seals, low maintenance, etc.
- Possibility to print both inner and outer faces of the sheets.
- Vacuum sheet transfer along the machine.
- Available with Direct Drive or Gear transmission.

The Macarbox Rotary Die Cutter (RDC) can achieve production speeds of up to 25,000 boxes per hour, significantly surpassing the speed of a standard flatbed die-cutter, which typically operates at around 9,500 sheets per hour. (MASTERCUT 145 PER - Autoplaten® die-cutter) (www.bobst.com, n.d.)



Rotary cutting tool (STEREOPHONIX, n.d.).

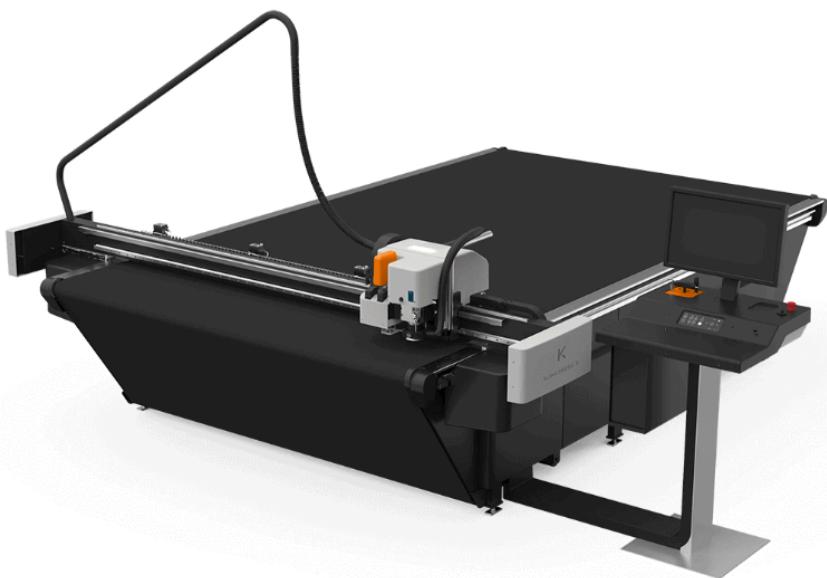
I have requested a quotation from the NPP die tool supplier, and the tool costs around 1000 euros. I will include this price in my Budget Resources Pricing section.

Sustainability:

In this section, I will further delve into the comparison of the two packaging designs by analyzing their sustainability characteristics. This is a crucial aspect of packaging development, as sustainability plays a vital role in various facets of human life, industry, and the environment. Sustainability is essential for maintaining a healthy planet, supporting economic stability, promoting social responsibility, and ensuring the well-being of current and future generations. It is an integral part of addressing global challenges and building a more resilient and equitable world. I will highlight why the new packaging design offers greater sustainability advantages compared to the older design.

<p>Blank Size</p> <p>Blank size in X: <input type="text" value="870.00"/></p> <p>Blank size in Y: <input type="text" value="274.00"/></p> <p>Blank area: <input type="text" value="2383.800"/> sq. cm</p>	<p>Blank Size</p> <p>Blank size in X: <input type="text" value="867.00"/></p> <p>Blank size in Y: <input type="text" value="249.00"/></p> <p>Blank area: <input type="text" value="2158.831"/> sq. cm</p>
<p>Area</p> <p>Area: <input type="text" value="1892.80"/> Waste: <input type="text" value="20.60 %"/></p> <p>Area minus holes: <input type="text" value="1886.03"/> Waste: <input type="text" value="20.88 %"/></p> <p>Area of holes: <input type="text" value="6.76868"/> sq. cm</p>	<p>Area</p> <p>Area: <input type="text" value="1852.16"/> Waste: <input type="text" value="14.21 %"/></p> <p>Area minus holes: <input type="text" value="1852.16"/> Waste: <input type="text" value="14.21 %"/></p> <p>Area of holes: <input type="text" value="0.000000"/> sq. cm</p>
<p>Freshways O700 keyline area</p>	<p>NPP O200 keyline area</p>

The above table allows me to compare the two types of designs in terms of blank size. I found out that the O700 design is larger than the O200 design. The O700 design has a blank size of 2383 square centimeters, while the O200 design has a blank size of 2158 square centimeters. Additionally, the waste size for the O700 design is 20%, while the waste size for the O200 design is 14%. Therefore, I can conclude that the old design uses more board than the new design. This means that the O700 design has a greater environmental impact. If Freshways wants to become more sustainable, they should consider choosing the new design. After the die cutting process, the new design creates less waste and has a lower environmental impact. I have cut out the two design samples on my digital sample maker table and measured their weight.



KONGSBERG X24 sample maker table (www.kongsbergsystems.com, n.d.).

I used the same type of board for both samples to ensure a fair comparison. After removing all of the excess material and weighing each sample, I obtained the following results: The O700 design weighs 0.065 kg, while the new O200 design weighs 0.063 kg. This difference of 0.002 kg may seem insignificant for a single box, but when multiplied by a production run of approximately 10,000 boxes, it amounts to an additional 20 kg of weight. This extra weight

increases transportation costs and requires more fuel to transport, resulting in a greater environmental impact.

Palletization:

Palletization is important for several reasons in my project, presenting some unique challenges. Optimizing warehouse space and efficient transportation are key considerations. Anyone who has worked on a production floor understands the limitations of space, and maximizing production is crucial. I need to find the most effective way to store the finished product (flat die-cut boxes). Choosing the correct pallet size and effectively packing the boxes can significantly reduce our limited storage space. By stacking the pallets efficiently, we can utilize the space effectively.

Transportation is another important aspect. I know that optimizing the pallets will enable more efficient transportation from the NPP warehouse to the Freshways location. Forklifts can easily move large quantities of boxes securely, reducing manual handling and minimizing damage risks. Choosing the right pallet size that accommodates both box sizes can further optimize truck/trailer loading and transportation costs. Comparing the two designs, I found that the new design, O200, has a smaller flat size than the old design, O700.

After folding, gluing, = pallet load size:

O200 (CB2678) is 410mm x 247mm flat size.

O700 (CB2679) is 410mm x 273mm blank size.



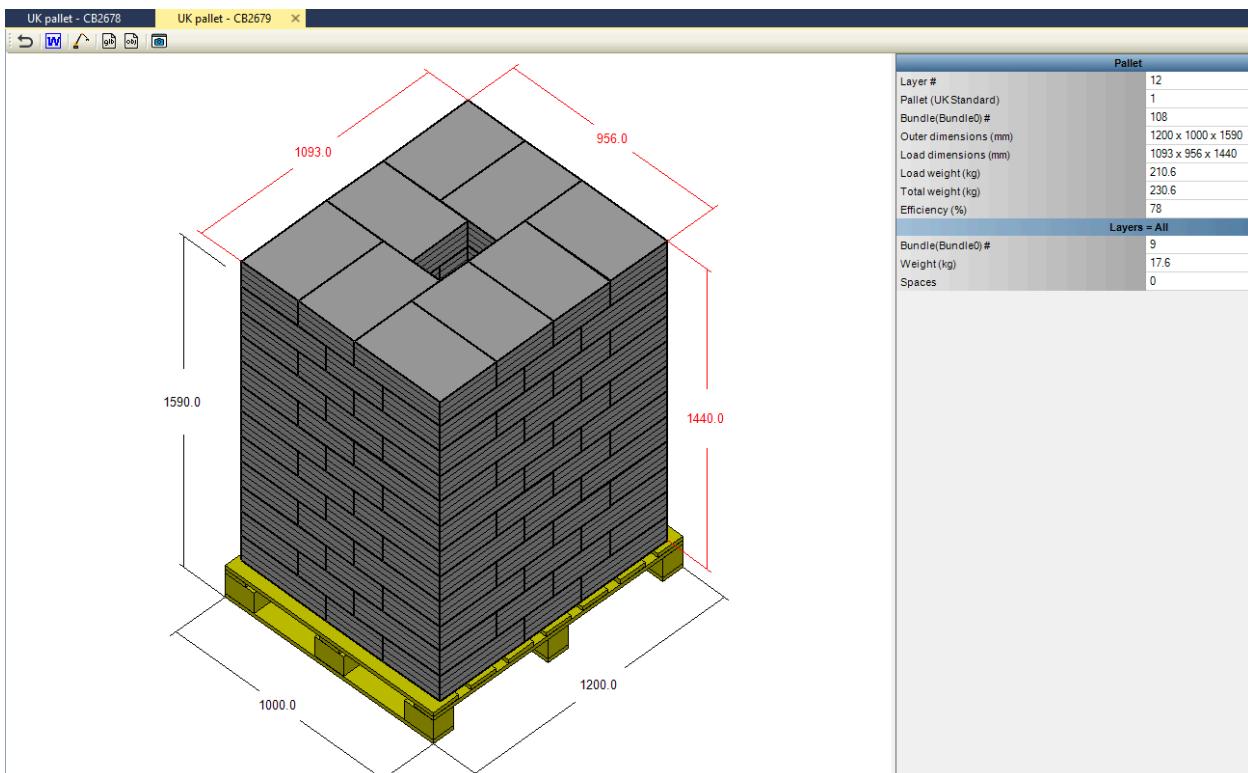
Box is after glued and fold. (s.r.o, n.d.)

As I mentioned previously, the smaller blank size is beneficial for sustainability. However, I also discovered an additional advantage when it comes to palletizing the die-cut boxes (O200). The smaller boxes allow for more product to fit onto each pallet, further improving space utilization and resource efficiency. At NPP, we utilize two pallet sizes: the standard European size of 800x1200mm and the standard pallet size (UK) of 1200x1000mm. While the latter enjoys more widespread use across Europe and Asia, a EURO pallet, also known as a EUR pallet, EUR1, or EPAL pallet, adheres to the 800x1200mm standard.

Pallet size 800x1200x144mm

(UK) Standard pallet size: 1200x1000mm

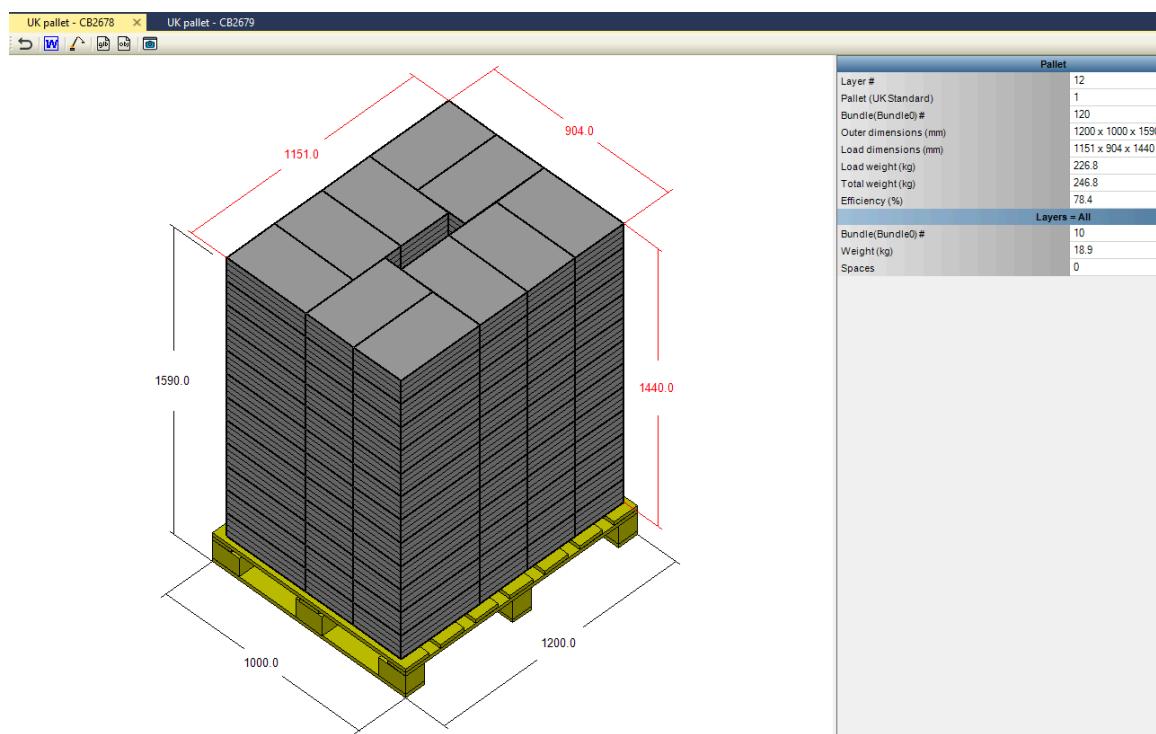
Using the stackbuilder program, I tested both pallet sizes with the new design O200 and found that the 1200x1000mm standard pallet provides the best fit. Additionally, Freshways typically receives products from other suppliers using this standard pallet size. This compatibility allows for an easier comparison between the two designs. To create the pallet design, I used the same type of board: R-flute. The thickness of the R-flute board is 2-3mm. At NPP, we typically bundle 30 boxes together and then palletize them with 10-12 height.



O700 CB2679 pallet design.

In the attached picture, you can see the palletization plan for the old design. It's arranged in 12 layers, with each layer containing 9 bundles. This adds up to a total of 108 bundles on a standard UK pallet. This plan maximizes available space due to the full utilization of the pallet area. Additionally, divider sheets are used every second layer for stability, preventing the pallet from collapsing. Shrink wrap is applied after palletization for further security.

The next picture showcases the palletization plan for my recommended design. As you can see, it offers greater efficiency compared to the first plan. This is because the bundles have a smaller footprint size, measuring 410 x 247 mm, compared to the older FEFCO O700 design's 410 x 273 mm. Although I use the same pallet size of 1200 x 1000 mm, the combination of 10 bundles per layer and 12 layers enables me to fit a total of 120 bundles on the pallet.



O200 CB2678 pallet design.

Comparing the two different palletization plans, we can clearly see that the new design is significantly better than the old one. My 3D stackbuilder design shows this by utilizing less empty space on the pallet. For easier comparison, I created a spreadsheet that calculates the differences between the plans. Notably, the new design accommodates 12 additional units, resulting in improved volume efficiency.

Category	Feature	FEFCO O700	FEFCO O200
Packaging Unit	Dimensions (mm)	410 x 273	410 x 247
	Number of flats	30	30
	Unit thickness (mm)	4	4
	Unit weight (kg)	0.065	0.063
Palletization	Bundle(Bundle0)	108	120
	Layers x Cases	9 x 12	10 x 12
	Load weight (kg)	210.6	226.8
	Dimensions (mm)	1093 x 956 x 1440	1151 x 904 x 1440
	Weight (kg)	230.6	246.8
	Dimensions hors tout (mm)	1200 x 1000 x 1590	1200 x 1000 x 1590
	Volume efficiency	78	78.4

To create the palletization plan, I used the StackBuilder (www.treedim.com, n.d.) program. StackBuilder is a software tool designed to optimize the packing of articles into cases, palletizing of boxes onto pallets, and shipping of pallets onto trucks. I have created a report about the two palletization specifications and added the associated documentation files to my project library.

Marketing & Print:

In this topic, I'll explore the synergy between marketing and print in the context of secondary packaging redesign. My redesign of the secondary box presents a valuable opportunity to refresh the print design as well. Let's delve into the compelling reasons why you should consider revamping the print and potentially adding a splash of color to make the product truly stand out on the shelf. A well-designed secondary box strengthens brand identity and boosts visibility on retail shelves. Eye-catching packaging can lead to increased sales, contribute to building a strong, recognizable brand, and instill trust in consumers. It also provides valuable space to highlight product features, such as being vegan or containing special spices or ingredients. Additionally, it effectively communicates product benefits, further influencing purchasing decisions. In my literature review, I discussed secondary packaging and its importance. I explored how it influences changing shopping habits and how it can be used for marketing purposes.



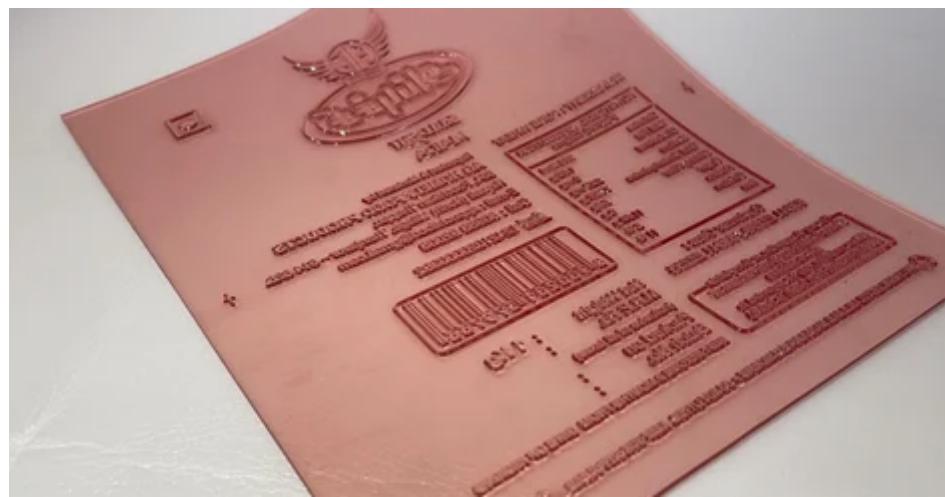
Freshways printed box.

The current print design for the packaging, using only two colors with a brown image/logo and white letters, doesn't stand out effectively on the shelf in my opinion. While it conveys the necessary product information, it appears too simple and can easily be overlooked by potential buyers. The secondary box uses a plain kraft color with brown overprinting, resulting in a design that lacks visual appeal. Having access to our 4-color printer at NPP provides an opportunity to make the box more visually appealing. However, it's important to consider the cost implications before proceeding. Each additional color used requires a separate printing plate, which incurs additional expense for the customer.



Freshways printed box in full open.

A stereo printing plate typically refers to a printing plate used in flexographic printing, where the image or text is raised on the plate rather than recessed. These plates are usually made from flexible materials like rubber or photopolymer. (Wikipedia, 2023)



Stereo / printed plate (Imimg.com, 2024).

In flexography, stereo plates are mounted onto printing cylinders or sleeves. They transfer ink onto the printing substrate, typically a variety of materials such as paper, cardboard, plastic, or metallic film. This method is commonly used in the production of labels, packaging materials, newspapers, and other products requiring high-speed, high-volume printing.

I think it could be a good choice to change the corrugated board from brown to white. It could improve the shelf visibility and provide nice marketing for Freshways. I will discuss the next topic, the board change, here only. I would like to focus on the print quality.



White outer liner printed secondary packaging (Food and Drink Technology, 23 August 2016).



Brown outer liner printed secondary packaging (Elopak, n.d.).

The primary difference between white and brown corrugated boxes lies in the color of the outer liner paper. The inner liner paper and the fluting (the wavy layer between the liners) may still be brown. Only the outer liner can change from brown to white. How does it help the appearance? White boxes often provide a cleaner, more aesthetically pleasing look. They are frequently chosen for retail packaging where presentation is crucial or when printing high-quality graphics or labels on the box. Brown boxes have a more natural, traditional appearance. They are mostly used for shipping purposes. The main difference is in the printing quality. The white surface provides a better base for printing high-quality graphics, text, or branding. Colors tend to appear more vibrant and stand out better on a white background. You can print on the brown liner, but you have to choose colors carefully to achieve the same vibrancy and visibility. The cost of white board is slightly more expensive than brown. Both have the same strength and durability. The choice between white and brown corrugated boxes depends on factors such as the intended use, branding preferences, printing requirements, and budget considerations.

YRG Group, one of the UK and Europe's leading packaging design and reprographics companies, offers a wide range of packaging-related services, including artwork services and color management, as well as print services such as digital proofing, flexo proofing, HD plate making, and digital flexo services. NPP works closely with YRG Group; they provide us with the printed plates after I have requested a quotation for a 2-color printing plate. They charge 250 euros per color for stereo plates. I suggest opting for a minimum of two-color printed artwork because it can make the secondary packaging stand out on the shelf and attract attention. Therefore, the estimated cost is 500 euros, which I will use in my final costing section.

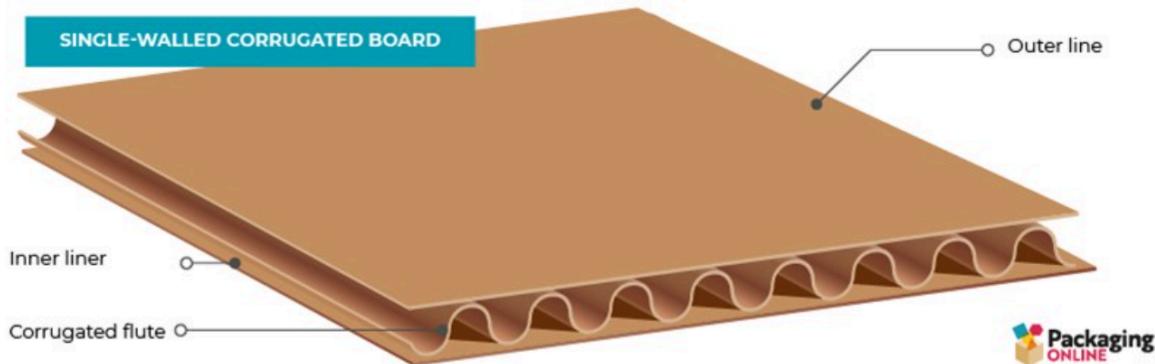
Board:

If I want to redesign the packaging, I must know a few important pieces of information about the previous box. I need to understand what product Freshways will place in the secondary box, where they will store the box (in freight or on the shelf), what temperature the box will be exposed to, and what weight will be placed into the secondary box. This information is necessary to improve and implement new packaging. If I do not consider this information and do

not choose the correct corrugated board, the redesigned packaging could fail, and the customer could face significant problems. They would have to recall the product, incurring extra costs and potentially damaging the brand.

Corrugated cardboard, often simply called corrugated, is a common material in the packaging and shipping industries. It comprises three layers: two flat outer layers with a fluted (wavy) inner layer sandwiched between them.

CORRUGATED BOARD GRADES GUIDE



Corrugated board (single wall) (Qualitytrade.com, 2024).

I received a few samples from Freshways, which helped me identify the type of board it is. I can identify the type of corrugated board by examining the sample characteristics, including the flute profile, thickness, and appearance of the outer liners. I can measure the thickness of the corrugated board using a caliper, which helps me determine the type of flute profile. Additionally, I can inspect the outer liners to identify the surface smoothness and check the color and print quality of the board. In NPP, it's important to determine the weight (grammage) of the board so I can choose a similar characteristic board for the customer. NPP has a few suppliers (Smurfit, Board24, CGW, Saica), so we can easily find a similar board for the customer. After testing and identifying the board, I found out the sample is a B-flute test-test board.

- Kraft Board:

Composition: Made from virgin wood pulp, primarily long fibers from softwood trees.

Strength: Strong and tear-resistant due to its long fibers.

Appearance: Brown color, natural and unbleached.

Use: Often used for outer liners of corrugated boxes requiring high strength and durability, e.g., shipping boxes, industrial packaging.

- Test Board:

Composition: Made from recycled paper fibers of varying quality and consistency.

Strength: Less strong and tear-resistant than Kraft board due to shorter fibers.

Appearance: Brown color, may vary in shade due to recycled content.

Use: Often used for inner liners of corrugated boxes where cost is a significant consideration, e.g., retail packaging, lighter-weight items.

Feature	Kraft Board	Test Board
Composition	Virgin wood pulp	Recycled paper fibers
Strength	High	Moderate
Appearance	Consistent brown	Varies in shade
Cost	More expensive	Less expensive
Use	Outer liners, demanding applications	Inner liners, cost-sensitive packaging

Key difference between the kraft board and test board.

In my project, I'm unable to use the confidential data list containing NPP board supplier pricing and grades. Therefore, I've researched the internet and found a different corrugated supplier's performance grades list. I'll use this list to select a suitable board for Freshways.



Different type of Corrugated board (Qualitytrade.com, 2024).

Corrugated material is measured by several factors, including bursting test, edge crush test, combined weight of material, maximum weight of contents, and outer dimensions.

GRADE	FLUTE	ECT	NEW CODING	GRADE	FLUTE	ECT	NEW CODING
125T125T	B	3.08	BBBTT100	125T125T	R	3.11	RBBTT100
125L125T	B	3.41	BBBTT111	125L125T	R	3.41	RBBTT112
150T150T	B	3.74	BBBTT121	150L150T	R	3.99	RBBTT130
150L150T	B	3.99	BBBTT134	200L200T	R	4.23	RBBTT138
200T200T	B	4.23	BBBTT137	125K125T	R	3.39	RBBKT100
200L200T	B	4.23	BBBTT145	150K150T	R	3.9	RBBKT116
125K125T	B	3.39	BBBKTT100	200K200T	R	4.38	RBBKT151
150K150T	B	3.9	BBBKTT110	125D125T	E	2.72	EWBTT100
200K200T	B	4.38	BBBKTT133	150D150T	E	3.11	EWBTT114
300K300T	B	5.26	BBBKTT159	125W125T	E	2.78	EWBKT100
125K125K	B	3.71	BBBKK100	150W150T	E	3.29	EWBKT125
150K150K	B	4.04	BBBKK109	180W200T	E	3.73	EWBKT140
200K200K	B	4.53	BBBKK122	125W125W	E	3.16	EWKK100
125D125T	B	3.39	BWBTT100	150W150W	E	3.52	EWKK112
150D150T	B	3.78	BWBTT113	180W180W	E	3.89	EWKK123
125W125T	B	3.46	BWBKT100				
150W150T	B	3.97	BWBKT110				
180W180T	B	4.4	BWBKT125				

Ds smith Performance Grades List (www.dssmith.com, n.d.).

I received a sample from Freshways and used the corrugated board list from DS Smith to find a matching board. The board resembles the BBBTT121 board from the table, specifically a 150T150T test-test board with an ECT (edge crush test) of 3.74. It is a cheap economical board.

I would like to recommend the customer to switch to a more sustainable packaging board. It is an R-flute. The R-flute has a lot of benefits. The R-flute is a type of corrugated fluting that will help reduce costs throughout the supply chain. Compared to the widely used B-Flute, R-Flute delivers an improved printing substrate, machine line efficiencies and dramatic savings in logistics, whilst continuing to offer comparable performance characteristics.

After cross-referencing with the R-flute list, I found a similar board with a comparable ECT value. I suggest switching to R-flute because it offers a better surface for printing and higher quality. I selected the RBBKT116 R-flute board, which surpasses the B-flute in ECT with a result of 3.9. It is a 150K (Kraft outer layer) - 150T (Test inner layer) kraft-test board.

I've switched the board from two recycled board layers to Kraft-test layers. While I understand the virgin Kraft layer isn't recycled, it offers a superior surface for flexographic printing.

Switching to R Flute offers numerous benefits, including cost savings, enhanced performance, and improved environmental credentials:

- R-Flute utilizes 30 percent more flute tips per centimeter or inch, resulting in products containing this board exhibiting greater resistance to pressure from items such as cans and bottles.
- The board boasts an improved print surface, ideal for small businesses and online traders keen on maintaining quality control.
- By transitioning to R-Flute, you can receive at least 20 percent more packaging delivered per pallet. This leads to reduced inbound handling and fewer packaging deliveries, resulting in decreased traffic, less administrative work, and ultimately saving you money.
- Additionally, R-Flute employs an improved geometry for optimum performance, resulting in crisper creasing.

I couldn't find the exact grammage of the board online, but since they have similar ECT values, I assume their grammage is similar. For my project, I'll use ECT as the primary factor to match the boards.

I can replace a B-flute board with a similar R-flute board because they have similar ECT (edge crush test) values, grammage, and provide a smoother surface for printing compared to B-flute boards. If the R-flute board has a similar ECT value and grammage, it indicates similar strength and durability. R-flute can provide similar protection to the product during shipping and handling as a B-flute board. Other positive benefits include its thinner profile, which saves space, benefiting transportation and storage, especially for large quantities of packaging. R-flute is also eco-friendly, requiring less material to achieve the same strength as thicker flute profiles like B-flute. This alignment with sustainability goals can help reduce environmental impact.

Feature	B-flute	R-flute
Thickness	0.16 in (4 mm)	0.09 in (2.3 mm)
Strength	More rigid, stronger	More flexible, moderate strength
Cost	More expensive	Less expensive
Printability	Good	Excellent
Applications	Shipping, industrial	Retail, food, cosmetics, e-commerce

If I would like to price the board, there is some important information to consider. We need to know the board supplier (sheet feeder/plan) and their selling price per square meter (m^2). When ordering boards to produce boxes, it's essential to determine the total square meters of board needed. Corrugated converters can often negotiate better deals when ordering larger quantities of board. Typically, price breaks occur at 200 m^2 (the minimum order), followed by 500 m^2 , with the best prices available for orders exceeding 1000 m^2 .

Board Order Calculation:

O200 (CB2678) is 410mm x 247mm flat size

$$0.41m \times 0.247m = 0.10 \text{ m}^2 \text{ (square meter)}$$

weekly order: 10,000 boxes

blank size x weekly order = total board order

$$0.10 \text{ m}^2 \times 10 \text{ 000 boxes} = 1 \text{ 012 m}^2$$

Board cost price is around 374 euro per 1000 m^2 (estimated cost)

The cost of the board is

weekly order board m^2 x board price = total cost of the order

$$1012 \text{ m}^2 \times 0.374 \text{ euro} = 378 \text{ euro}$$

If NPP were to order the board, it would cost 378 euros per order. I won't delve deeper into pricing the job because I need to account for additional costs such as production, machine setup time, labor costs, margins for NPP, delivery, ink, etc.

Box price:

To price a box, you need to factor in several conversion costs, which can vary depending on the complexity of the project.

- Conversion Costs: This includes any additional actions required to transform the raw material into the finished box. Examples include die-cutting, folding, and gluing.
- Printing Costs: If the box requires printing, you'll need to consider:
- Printing Plate Costs: The cost of creating the physical plates used to transfer the design onto the box.
- Ink Costs: The cost of the ink used for printing.
- Design Fees: The cost of a designer creating the artwork for the box. This can be done by the customer, or the company (NPP) can hire a designer for an additional fee.
- Shipping and Delivery Costs: The cost of transporting the boxes to your location.

- Profit Margin: The percentage markup you add to your costs to determine the final selling price.

This was a basic pricing exercise to understand how the board ordering cost calculation works. I won't include these costs in my final price because they are part of the monthly order of the box.

5. Benefits of Redesign:

The current packaging design, FEFCO 0700, uses ready-glued cases that require manual opening by an employee. This is time-consuming and could be automated. The proposed redesign, FEFCO 0200, uses slot-style boxes that can be automatically opened and closed by a machine, improving efficiency, and reducing labor costs.

- Reduced labor costs: Automatic opening and closing of boxes eliminates the need for manual labor.
- Improved efficiency: Faster packaging process due to automation.
- Better protection for fragile products: FEFCO 0200 is better suited for protecting fragile products.
- Sustainability: The new design uses less material and creates less waste, making it more environmentally friendly.
- Marketing and branding: The new design allows for more visually appealing printing with the use of a white outer liner and up to 4 colors.
- Palletization: The new design allows for more efficient palletization, utilizing less space and potentially reducing transportation costs because the The new design is R-flute
- Cost-Effectiveness: Rotary die tool for FEFCO 0200 design is more economical than for FEFCO 0700, reducing production costs over time.
- Packaging Material Selection: Transition from B-flute to R-flute board offers similar strength, better printability, and eco-friendliness.
- Pricing board: Estimating board costs involves understanding supplier prices and calculating total board needed for production.

Transitioning to the FEFCO 0200 design offers multifaceted benefits, ranging from cost savings and operational efficiencies to improved sustainability and brand appeal. By embracing automation and optimizing packaging materials, Freshways can enhance its competitiveness and environmental responsibility while improving product presentation and protection.

6. Implementation Plan:

This Implementation Plan outlines the steps required for Freshways to successfully implement the new Automated Packaging Machinery (Lantech C-1000 Case Erector) and redesign its secondary packaging to a FEFCO 0200 design.

1. Project Kick-Off (Week 1)
 - Establish a project team with representatives from engineering, packaging, procurement, and operations.
 - Define project timelines, milestones, and deliverables.

- Secure project budget and identify funding sources.
 - Develop a communication plan to keep stakeholders informed throughout the project lifecycle.
2. Machinery Acquisition (Weeks 2-4)
 - Finalize the Lantech C-1000 Case Erector specifications.
 - Obtain quotes from vendors and negotiate pricing.
 - Secure purchase order and finalize delivery schedule with the chosen vendor.
 - Arrange for installation and training on the new machinery by the vendor.
 3. Packaging Redesign (Weeks 3-6)
 - Finalize the FEFCO 0200 secondary packaging design for compatibility with the Lantech C-1000.
 - Conduct structural analysis and testing of the new packaging design to ensure product protection during transport.
 - Source and secure a reliable supplier for the new packaging materials.
 4. Integration and Testing (Weeks 7-8)
 - Prepare the existing packaging line for the integration of the new machinery.
 - Install the Lantech C-1000 Case Erector according to the manufacturer's instructions.
 - Conduct test runs with the new packaging design and machinery to identify and resolve any issues.
 - Refine and finalize the packaging line setup for optimal efficiency.
 5. Training Management (Week 9)
 - Develop training materials and conduct training sessions for packaging line operators on the new machinery and procedures.
 - Address employee concerns and answer questions regarding the changes.
 - Implement a communication plan to keep employees informed throughout the transition.
 6. Go-Live and Monitoring (Week 10)
 - Initiate full production with the new automated packaging line and redesigned secondary packaging.
 - Monitor performance metrics such as production speed, packaging quality, and material usage.
 - Identify any areas for improvement and adjustments as needed.
 7. Post-Implementation Review (Week 11)
 - Conduct a post-implementation review to assess the project's success in meeting its objectives.
 - Analyze data and metrics to quantify the improvements in efficiency, cost savings, and sustainability.
 - Document lessons learned and best practices for future projects.
 8. Contingency Plans
 - Develop a contingency plan to address potential delays in equipment delivery.
 - Have backup plans for sourcing materials in case of supply chain disruptions.
 - Allocate additional budget for unforeseen circumstances during implementation.

7. Budget, Resources Pricing:

In this paragraph, I write about providing an estimate of the budget required for the project. I identify the necessary resources and their costs, including the machine and any additional costs.

Rotary die tool cost: 1000 euro

Stereo cost (2 color print plate): 500 euro

Machine total cost: 48,850 euro

Break down the machine cost:

- CL 1000 case erector: c€40,000 - €55,000
- PDI (pre delivery inspection): €400 - €500
- Delivery: c€300 - €500
- Installation: c€500

These costs are only rough estimates, so I wouldn't like to use the real costs because they are confidential. I will use an average price instead.

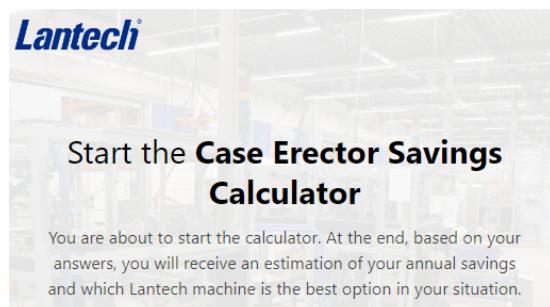
When ordering a machine, the total cost goes beyond just the machine itself. There are additional costs to consider, such as pre-delivery inspection, delivery, and installation.

"PDI stands for Pre-delivery inspection. Before you take delivery of your new machine, the seller will carry out a PDI to ensure the machine is in full working order and is safe to use."

The total cost to switch from the old packing process to the new automatic case erecting system would be €50,350. This includes the cost of the machine, the rotary die cutting tool, and the new printed plates (stereo).

To compare this cost, I can calculate the potential annual savings achieved by switching from hand-erecting cases to automatic case erecting. I used the Lantech website tool to estimate the annual savings. (Lantech, n.d.)

Calculate the annual savings version 1:



To calculate the annual savings, I need to know the average number of cases Freshways uses per day. In my project, I'm focusing on switching to the O200 design for one specific box size. While Freshways uses various box sizes and produces different types of sandwiches, I'll only consider the project box for this simplified calculation.

Although the case erector can handle other box sizes, including them would provide a more accurate estimate of annual savings. However, I understand there may be uncertainties in my project at this stage.

In my calculations, I used a daily box usage range of 1,500 to 4,500. Here's a breakdown of my approach:

- Freshways estimated weekly box usage at 10,000.
- Dividing by a 5-day workweek gives a daily average of 2,000 boxes.
- To account for potential variations, I used a broader range of 1,500 to 4,500 boxes per day in the calculator.

1 Enter the average number of cases you use per day*

Select the amount of cases closest to your required capacity

A > 1500 cases per day

B 1500 to 4500 cases per day

C > 5000 cases per day

For the "number of production days per year," I used 300, which seems like a reasonable assumption. It is only one shift per day. Freshways operates six days per week, which is why I believe 300 days per year is an appropriate estimate. My calculation is based on the average working days per year. However, it does not factor in potential overtime hours that may have been added to the actual working days in recent years. This needs to be considered for a more accurate representation of target operations.

2 Enter the number of production days per year*

Select the number closest to your yearly production days

A 250 production days per year

B 300 production days per year

C 350 production days per year

The next question the calculator asks is about the hourly labor rate.

The national minimum wage in Ireland since January 1st, 2024, is €12.70 per hour. However, I've chosen €15 based on the survey data.

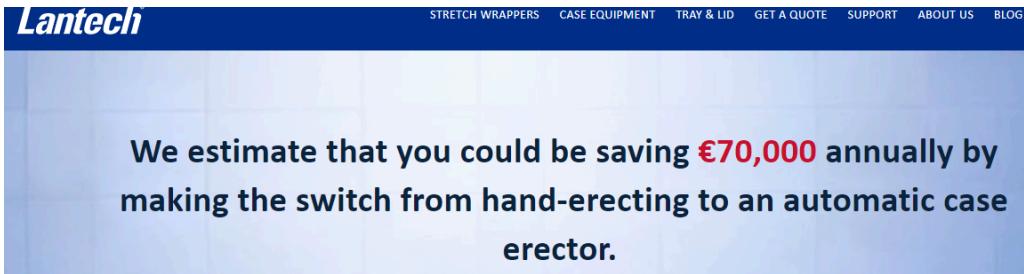
3> Enter your hourly labour rate *

Select the amount closest to your average labour wage

A €10 per hour

B €15 per hour

Lantech calculators estimate that Freshways could be saving €70,000 annually by making the switch from hand-erecting to an automatic case erector.



The screenshot shows the Lantech website with a calculator interface. The calculator has a black and orange design with buttons for C, ., -, +, x, and =. The background of the calculator area is light grey.

We estimate that you could be saving **€70,000 annually by making the switch from hand-erecting to an automatic case erector.**

The website suggests the C-300 or C-400 Case Erector, but these are entry-level machines. I've recommended the Lantech C-1000 Case Erector as a more suitable option for Freshways. The C-1000 is a better solution for medium-sized and large businesses because it can handle a wider range of box sizes, including sizes beyond my project box.

Calculate the annual savings version 2:



I have used the Lantech website to calculate the annual savings. However, I feel that the website may be somewhat biased toward the machine distributor. Therefore, I will proceed with a different approach to make the calculation more realistic. However, many factors need to be considered because I cannot rely on confident data from Freshways. Instead, I will need to use my own viewpoint. Nevertheless, this approach will help to understand how many elements need to be calculated to obtain accurate savings data.

- Labor Cost Saved:

Daily Labor Cost: We know the salary is 15 euros per hour. To find the daily cost, we need to know the number of working hours per day. Let's assume it's 8 hours (adjust this if it's different).

$$\text{Daily Labor Cost} = \text{Working Hours} * \text{Hourly Rate} =$$

$$8 \text{ hours/day} * €15/\text{hour} = €120/\text{day}$$

- Annual Labor Cost Saved:

Working Days per Year: We are given 300 working days per year.

Annual Labor Cost Saved:

$$\text{Daily Labor Cost} * \text{Working Days} =$$

$$\text{€120/day} * 300 \text{ days/year} = \text{€36,000/year}$$

- Considering Overtime (Optional):

If there's a chance of overtime work currently done by the replaced labor, you can factor that in for a more precise estimate.

Overtime Rate: Typically, overtime pay is 1.5 times the regular rate. So,

$$\text{Overtime Rate} = \text{€15/hour} * 1.5 = \text{€22.5/hour}$$

Overtime Hours per Week (estimate): Let's say it's 2 hours per week (adjust this based on your knowledge).

$$\text{Weekly Overtime Cost} = \text{Overtime Rate} * \text{Overtime Hours} =$$

$$\text{€22.5/hour} * 2 \text{ hours} = \text{€45/week}$$

Annual Overtime Cost =

$$\text{Weekly Overtime Cost} * \text{Working Weeks} =$$

$$\text{€45/week} * 52 \text{ weeks/year (assuming working all weeks)} = \text{€2,340/year}$$

Total Annual Labor Saved (including Overtime): €36,000/year (base labor) + €2,340/year (overtime) = €38,340/year

- Machine Costs:

Rotary Die Tool Cost: €1,000 (one-time cost)

Stereo Cost (2 Color Print Plate): €500 (one-time cost)

Machine Total Cost: €48,850 (one-time cost)

- Savings Calculation:

Annual Savings = Annual Labor Cost Saved - Machine Costs (excluding recurring costs like maintenance)

Without Overtime:

$$\text{Annual Savings} = \text{€36,000} - (\text{€1,000} + \text{€500} + \text{€48,850}) = -\text{€13,350} \text{ (In this scenario, the machine cost outweighs the annual labor savings)}$$

With Overtime:

$$\text{Annual Savings} = €38,340 - (€1,000 + €500 + €48,850) = -€11,010$$

(Including overtime, the savings are still negative)

Based on my calculations, the machine will likely pay for itself within two years. This calculation is based on the cost savings for a single box. However, we can assume the company will transition more old corrugated secondary packaging to the new design, which the machine can handle. Since Freshways uses other O201 style boxes, I am confident that the machine can recover its cost within a one-year timeframe.

8. Conclusion:

In conclusion, I have proposed implementing a new, more sustainable packaging design change from the FEFCO 0700 design to the FEFCO 0200 design. To achieve this change, I recommend that Freshways implement a new packaging machine. The new case erector can be seamlessly integrated into the production line and will significantly improve production speed due to its automation.

I have addressed the labor shortage in Ireland and the challenges associated with retaining and hiring employees. Automation is a key strategy for modern companies to become more cost-effective and future-proof. My project also delves into palletization, demonstrating how Freshways can optimize their storage system by storing more ready-made boxes on standard UK size pallets. This approach offers additional space-saving benefits.

I have also explored the potential benefits of using white board with a new, visible print for the secondary packaging. This change could significantly improve marketing and product visibility. Overall, this project offers a comprehensive solution to enhance Freshways' packaging efficiency, ensuring a competitive edge in the marketplace.

9. Future Enhancements:

If I had more time, I could gather additional information about the production line. This would involve analyzing all the machines and exploring how they can be connected to optimize packaging speed. This analysis could also identify the next major investment opportunity to further improve production efficiency. Additionally, I could research the variety of box sizes currently used and calculate the total cost of converting all secondary packaging to fit the new automatic case erector. A more detailed cost analysis could be conducted to quantify the potential savings generated by the new machine. Finally, I could delve into the logistics of production, exploring ways to optimize the flow of materials between the warehouse and the production line.

Reference:

1. Statista. (n.d.). *Ireland unemployment rate 2023*. [online] Available at: <https://www.statista.com/statistics/936027/monthly-unemployment-rate-ireland/#:~:text=The%20unemployment%20rate%20in%20the>.
2. Freshways. (n.d.). *About*. [online] Available at: <https://freshwaysfoodco.ie/about/> [Accessed 6 Apr. 2024].
3. www.linkedin.com. (n.d.). *Sandwich Market Research Report Provides thorough Industry Overview, which offers an In-Depth Analysis of Product Trends and New Market Divisions*. [online] Available at: https://www.linkedin.com/pulse/sandwich-market-research-report-provides-thorough-industry-xjzif/?trk=article-ssr-frontend-pulse_more-articles_related-content-card [Accessed 6 Apr. 2024].
4. Lantech Case Erectors. (n.d.). Available at: <https://npp.ie/wp-content/uploads/2023/04/Lantech-Case-Erectors-web-1-129.pdf> [Accessed 6 Apr. 2024].
5. Anon, (n.d.). *FEFCO 0700 | Diamond Box*. [online] Available at: <https://www.diamond-box.co.uk/fefco-box-codes/fefco-0700-ready-glued-cases/fefco-0700/> [Accessed 6 Apr. 2024].
6. Anon, (2019). *FEFCO Code - DBS Packaging: Decoding Packaging Excellence*. [online] Available at: <https://dbspackaging.com/fefco-code/> [Accessed 6 Apr. 2024].
7. www.esko.com. (n.d.). *ArtiosCAD: Structural Packaging Design Software, POP, Box Design - Esko*. [online] Available at: <https://www.esko.com/en/products/artioscad> [Accessed 13 Jun. 2021].
8. www.macarbox.com. (n.d.). *Highest productivity for the production of die-cut boxes | Macarbox*. [online] Available at: <https://www.macarbox.com/en/products/rotary-die-cutter> [Accessed 6 Apr. 2024].
9. www.bobst.com. (n.d.). *MASTERCUT 145 PER - Autoplaten® die-cutter - Overview | BOBST*. [online] Available at: <https://www.bobst.com/auen/products/flatbed-die-cutting/die-cutters/overview/machine/mastercut-145-per/> [Accessed 6 Apr. 2024].
10. s.r.o, S. textilní galanterie (n.d.). *Cardboard box 16.5x13.5x6.5 cm*. [online] STOKLASA Haberdashery and Fabrics. Available at:

- <https://www.stoklasa-eu.com/cardboard-box-16-5x13-5x6-5-cm-x145319> [Accessed 6 Apr. 2024].
11. www.treedim.com. (n.d.). *StackBuilder - Welcome*. [online] Available at: <https://www.treedim.com/stackbuilder/en/4-welcome>.
 12. Wikipedia. (2023). *Stereotype (printing)*. [online] Available at: [https://en.wikipedia.org/wiki/Stereotype_\(printing\)](https://en.wikipedia.org/wiki/Stereotype_(printing)) [Accessed 6 Apr. 2024].
 13. www.kongsbergsystems.com. (n.d.). *Kongsberg X24*. [online] Available at: <https://www.kongsbergsystems.com/en/cutting-systems/tables/kongsberg-x/x24> [Accessed 6 Apr. 2024].
 14. Imimg.com. (2024). Available at: <https://5.imimg.com/data5/SELLER/Default/2022/8/CT/QI/NE/16311733/flexo-photopolymer-stereo-500x500.jpg> [Accessed 6 Apr. 2024].
 15. Food and Drink Technology. (n.d.). *Heroic secondary packaging*. [online] Available at: <https://www.foodanddrinktechnology.com/news/14473/heroic-secondary-packaging/> [Accessed 6 Apr. 2024].
 16. Elopak. (n.d.). *Secondary packaging*. [online] Available at: <https://www.elopak.com/distribution/> [Accessed 6 Apr. 2024].
 17. Qualitytrade.com. (2024). Available at: https://img.qualitytrade.com/uploaded/2019/07/15/bcdb805da6eae3117c3c867220232c09_640.jpg [Accessed 6 Apr. 2024].
 18. www.dssmith.com. (n.d.). *Performance Grades List - Sheetfeeding*. [online] Available at: <https://www.dssmith.com/sheetfeeding/insights/information-downloads/material-guidance/performance-grades-list> [Accessed 6 Apr. 2024].
 19. STEREOPHONIX. (n.d.). *Die Cutting*. [online] Available at: <https://stereophonix.co.za/die-cutting/> [Accessed 6 Apr. 2024].
 20. Lantech (n.d.). *TP Case Savings Calculator*. [online] info.lantech.com. Available at: <https://info.lantech.com/case-savings-calculator-machine> [Accessed 6 Apr. 2024].