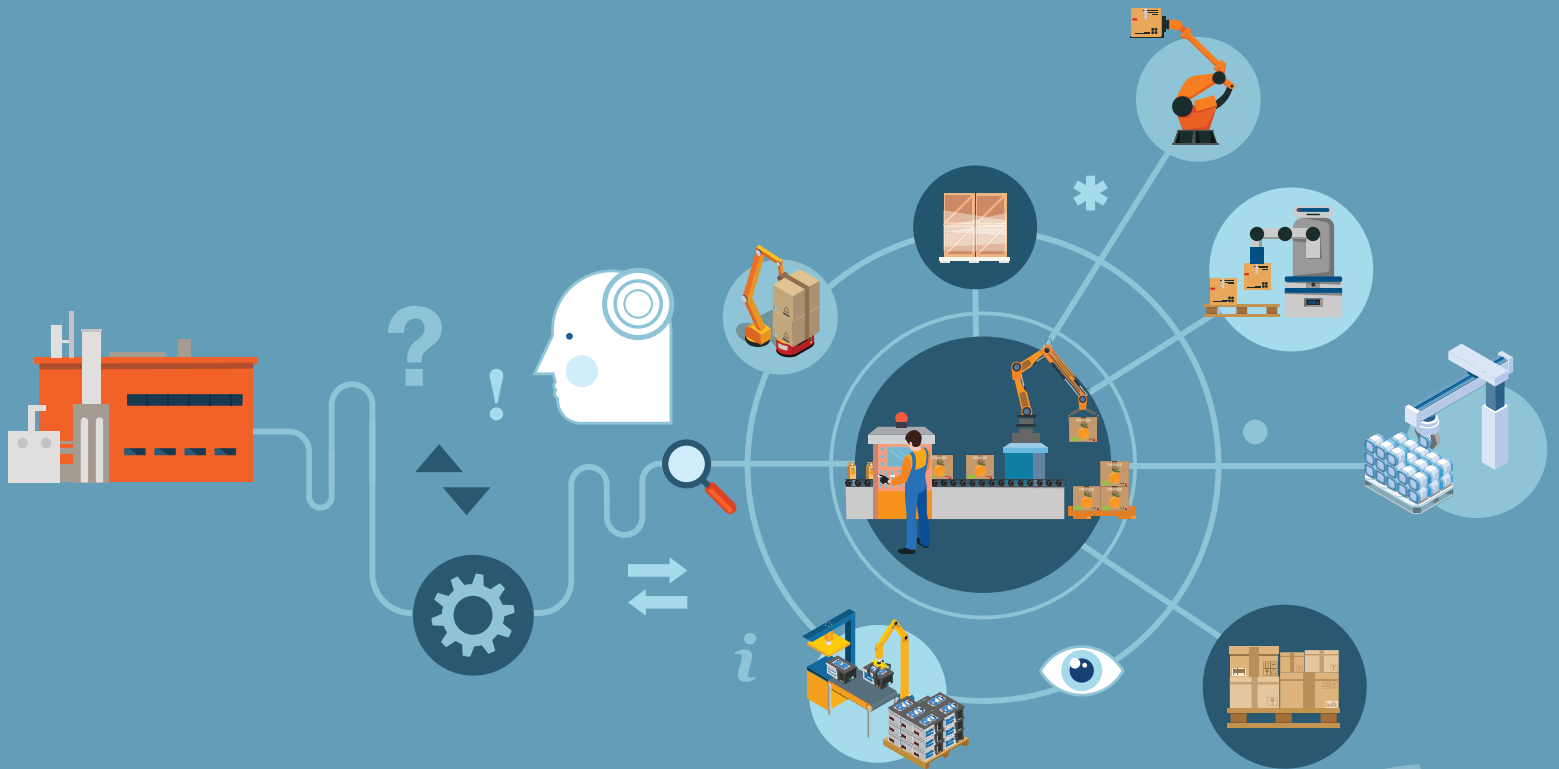


2021 End-of-Line Equipment Purchasing Trends and Design Insights



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We need machinery that is innovative and flexible for a variety of package handling, while still maintaining productivity with minimal maintenance.

– *Packaging Engineer,
Beverage Leader*



INTRODUCTION

Most Important Takeaways:

- 1 End-of-Line (EoL) machinery accounts for a large part of the packaging machinery market (46.8%) with steady growth forecast through 2026.
- 2 The pervasive trends of sustainability, supply chain visibility, SKU expansion, and labor shortages are all contributing positively to the demand for EoL equipment.
- 3 Automation and robotics play an important role in achieving production goals with significant opportunities for expanded implementation at EoL.
- 4 A strong majority of manufacturers (80%) predict their budgets for EoL equipment to grow in the coming years and look for help in justifying new purchases.
- 5 Manufacturers are explicitly seeking out more guidance from their OEM partners to help them navigate EoL packaging strategies.

Participating Industries*

The opinions and insights throughout the paper are derived from direct interviews and secondary resources in the following industries, as defined by the 2021 PMMI State of the Industry Report:

Participating Manufacturers (large, medium, and small) Interviewed by Industry:

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Beverage	20%
Food	20%
Household/Industrial/Agricultural	20%
Personal Care/Toiletries/Cosmetics	20%
Pharmaceuticals/Devices	20%

CMs/CPs (contract manufacturers/contract packagers) were interviewed in each industry.

Small and mid-size enterprises (SMEs) are referenced throughout the report.

**Detailed numerical breakdowns of the size of these industries by EoL machine types can be found in the appendices of this paper.*

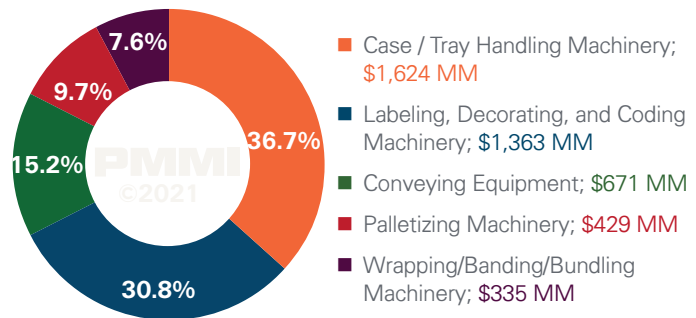
► End-of-Line Machinery: Sales Value

To begin the discussion on End-of-Line (EoL) machinery, this paper will first explore a brief overview of the EoL segments by sales for both machine and industry category. From this starting point, the paper will examine growth rates of each EoL machine category, highlight major industry trends that are affecting EoL equipment, explore the features of EoL equipment desired by end users, and outline what manufacturers most need from OEMs when evaluating EoL projects.

EoL Machinery Categories by Sales Value

EoL machinery represents one of the largest categories of equipment in the 2021 PMMI State of the Industry Report, accounting for a combined purchase total of \$4.42 billion (46.8% of all packaging equipment purchased, see Appendix A). In 2020, the largest EoL machine category was case/tray handling machinery, accounting for \$1.62 billion in sales (36.7% of all EoL purchases), followed closely by labeling/coding machinery, which totaled \$1.36 billion in sales (30.8% of all EoL purchases). Together, these two segments comprised a little over two-thirds (67.5%) of all EoL machinery sold by dollar value in 2020.

2020 EoL Equipment Sales Value (\$4.42 billion) by Machine Category*

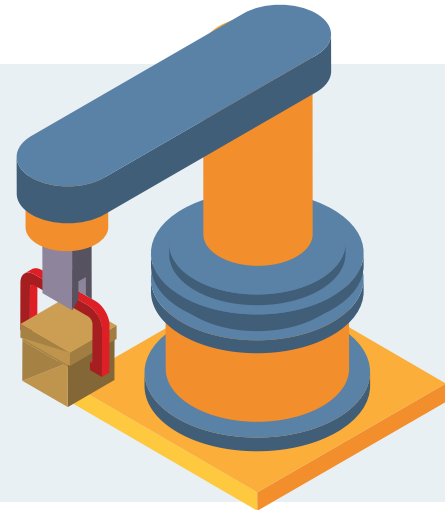


*Detailed calculations 2015 and 2020 equipment purchases; Appendix B, pg 27.
Source: 2021 PMMI State of the Industry Report

Summary of EoL Equipment Purchases from the 2021 PMMI State of the Industry Report:

- EoL machinery accounts for 46.8% of all domestic equipment purchases by dollar value (\$9.4 billion), which encompasses five machine categories.
- Two out of the five machinery categories - case/tray handling and labeling/coding – account for two-thirds of all EoL machinery sold by dollar value.
- The two largest industry groupings, food and beverage, purchase over half (57%) of all EoL equipment.

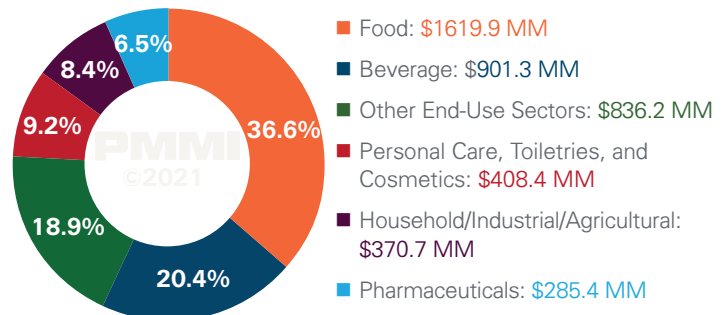
- EoL equipment categories grew at 6.5% CAGR 2015-2020.
- The overall average CAGR for all packaging machinery from 2020 to 2026 is forecast to be 5.13%, a good indication of future EoL growth.



EoL Machinery Sales Value by Industry Group

When EoL equipment purchases in 2020 are examined by industry the food group is the clear leader, purchasing a total of \$1.62 billion worth of EoL equipment, accounting for over a third of all EoL purchases. The food group dwarfed the second largest industry group – beverage - which reached \$901 million in sales. Combined, these two largest industry groupings comprised over half (57%) of all EoL equipment purchased in 2020.

2020 EoL Equipment Sales Value (\$4.42 billion) by Industry Group*



*Detailed calculations by machine type by industry group; Appendix C, pg 28.
Source: 2021 PMMI State of the Industry Report

► End-of-Line Machinery: Growth

EoL Equipment Categories: Historic Growth

EoL equipment makes up one of the largest groupings of packaging equipment, accounting for nearly half (46.8%) of all packaging machinery shipped in 2020 when examined by dollar value. On top of this, the historic growth rates for EoL equipment have been both healthy and stable, with the 2015-2020 CAGR of all EoL equipment categories combined sitting at a respectable 6.5%.

EoL Equipment CAGR of Sales Value by Machine Category* (2015-2020)

Case/Tray Handling	8.06%
Labeling, Decorating, and Coding	6.26%
Conveying Equipment	4.83%
Palletizing	5.52%
Wrapping/Banding/Bundling	5.12%

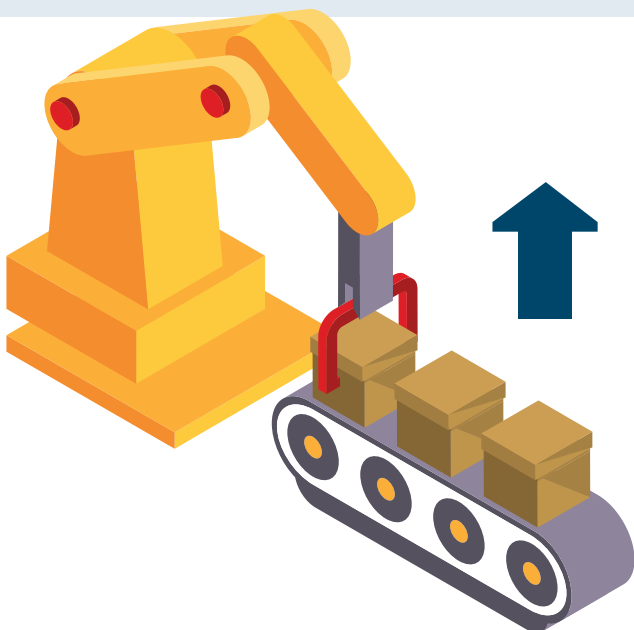
*CAGRs 2015-2020; Appendix B, pg 27.

Source: 2021 PMMI State of the Industry Report

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EoL machinery categories account for

46.8%
of the sales value of all packaging equipment in 2020



Five Machinery Categories*

A few of the equipment categories included in this report as EoL machinery - conveying, coding/labeling/marketing, and depalletizing - also have a presence in other areas of a packaging line. The five machinery categories included in this paper and defined by PMMI to be in the EoL space are:

- 1 Case/Tray Handling Machinery
- 2 Conveying Machinery
- 3 Labeling, Decorating, and Coding Machinery
- 4 Palletizing Machinery
- 5 Wrapping/Banding/Bundling Machinery

PMMI End-of-Line Packaging Definition

EoL packaging, often referred to as bulk, tertiary, or transit packaging, is used to group larger quantities of SKUs to transport them from point A to point B (e.g., from production facility to point of sale). During this stage, products are handled as distribution units. This type of packaging makes it easier to transport large and/or heavy loads safely and securely. In addition to helping prevent damage, it consequently facilitates the handling, storage, and transport of goods. An example of tertiary packaging is a stretch-wrapped pallet containing a quantity of cardboard boxes to enable efficient product shipping.



One key area that exists in the liminal space between secondary packaging and EoL equipment is case handling machinery. This class of equipment encompasses case forming, loading/packing, and sealing. For the purposes of this paper, case handling equipment is included in the EoL machinery segment.

**A thorough numerical breakdown of the size of each of these equipment segments, their subcategories, their historic growth rates, and their future growth projections can be found in the appendices at the end of this paper.*

► End-of-Line Machinery: Forecast

Packaging Machinery Purchase Forecast to 2026

Future CAGR projections for each EoL machinery category were not presented in the 2021 State of the Industry Report, but there are indications that the healthy past growth of the EoL segment will continue into the future. The 2021 PMMI State of the Industry report forecasts an overall average of 5.13% CAGR (2020-2026) for all packaging equipment purchases by industry (Appendix D). Since EoL machinery makes up just under half of all packaging machinery purchases, it would follow that EoL equipment can be expected to continue growing through 2026.

Forecast of the sales value of all packaging machinery:

} **5.13%**
CAGR
(2020-2026)

In addition to robust past sales growth and positive overall projections, the future growth of EoL machinery will likely be bolstered by a number of trends pervading the packaging industry. Factors such as a committed focus on sustainability, renewed emphasis on supply chain visibility, expanding SKU counts across CPG industries, and widespread labor shortages are all expected to contribute positively to the growth of EoL equipment into the future. While some trends, such as current supply chain struggles in the EoL equipment and EoL packaging material space could inhibit future growth, they are unlikely to fully offset the positive impacts of other EoL growth trends.



Extending Beyond the EoL Space

Autonomous Guided Vehicles (AGVs) are finding new uses in the manufacturing industry as a way to bridge the gap between EoL packaging operations and the warehouse. While not truly classified as a piece of EoL equipment, AGVs are operating in the transitional space where products move out of production and into storage/distribution. The newest advancements in AGVs have enabled these devices to be fully integrated into enterprise resource planning (ERP) systems, allowing them to communicate with EoL packaging equipment. This enables the automation of transporting goods into the warehouse, precisely timed as they complete their trip through the EoL space. This new breed of AGVs is increasing efficiency at manufacturers by ensuring that products are moved into the distribution supply chain in a timely manner, preventing backups in the EoL space that could interfere with continuous production.

EOL TRENDS AND IMPACTS

► Sustainability

Up and down the production line, one of the most pervasive and persistent trends in the packaging industry is sustainability. Driven by both consumer demands for more eco-friendly products and by manufacturers' goals to cut costs by reducing material and energy usage, sustainability has become one of the most consequential trends in the packaging industry. This is true for EoL equipment as well, where specific sustainability trends such as lightweighting, the use of recycled materials, and a general reduction in machine energy usage are driving new innovations in EoL machinery.



Lightweighting

One influential sustainability trend in packaging is the concept of lightweighting, whereby manufacturers seek to reduce their overall material usage by designing packaging that requires less material to produce. When it comes to EoL operations, lightweighting can be implemented in a wide variety of ways, including thinner films for wrapping, thinner/smaller labels, and secondary packaging with less empty space designed to maximize pallet stacking. Manufacturers in particular are driving the lightweighting trend as the cost savings become apparent: in some instances, eliminating empty space and fill waste can reduce fill material costs by up to 20%¹.

While these lightweighting strategies are all effective ways to cut down on overall material usage, they bring with them extra considerations for EoL equipment. Thinner packaging, films, and labels are ultimately less durable, requiring EoL machinery to adjust in kind. To compensate for this reduction in durability, EoL equipment should be designed to tolerate an array of material strengths, with an emphasis on delicate handling capabilities. For instance, OEMs will want to consider the strength tolerances of EoL wrapping/bundling machines to compensate for thinner films more prone to tearing and breakage. The ability to adjust to a variety of tolerances extends to automated handling equipment as well, with a need to accommodate thinner materials and a wider range of secondary packaging configurations.

Nearly
1 in 3

Manufacturers interviewed intend to use a greater percentage of recycled materials in their packaging formats.

Post-Consumer Recycled (PCR) Content Increasing

The PCR trend is being driven by two main factors: environmental impact and legislative regulations. On the one hand, savvy consumers are now seeking out packaging that is derived from recycled material as a way to decrease the environmental impact of their purchases. This desire for more eco-friendly packaging is more than just talk from consumers, with 60% to 70% of consumers across all industry types stating they would pay more for sustainable packaging.²

On the other hand, regions all over the world are passing new legislation aimed at reducing the amount of single use plastic, with one of the strategies being to encourage an expanded use of recycled materials. At the forefront of this movement is the EU, which passed a law in 2019 requiring bottles to be made from 25% recycled plastic by 2025, increasing to 30% by 2030³.

As a result of these dual pressures, the use of post-consumer recycled material is seeing steady adoption by manufacturers in the packaging space. This is evidenced by a recent compilation of data from a handful of the largest CPG companies in the US, who increased their PCR material use by a combined 22% in 2019⁴. This expanded use of PCR is also being driven by retailer brands: one of the single largest retailers in the US increased the use of PCR material on their packaging lines from just 0.5% in 2018 to 9% by the beginning of 2020⁵.

PCR Content Causing Machine Challenges

The growing use of PCR material for packaging creates additional challenges for manufacturers that should be factored into future machine design. PCR material is often lower quality than virgin materials, resulting in variances in opacity, thickness, and strength that can impact packaging lines. Materials with a hazy quality may be rejected by automated vision inspection, while thinner, less durable material may break or fail during processing. These hiccups on a packaging line can result in additional downtime and an increase in material waste, driving up costs for packagers utilizing PCR material.

To avoid these pitfalls, EoL packaging machines should strive for an increased range of tolerances in both handling and inspection that can be easily adjusted with little to no changeover, preferably right from a machine's HMI. In the most advanced operations, machines are also being equipped with AI-enhanced vision capabilities and machine learning functions to intelligently adapt to material variations. These nimbler packaging configurations can allow manufacturers to proactively adjust to the variances in PCR material to maximize uptime and improve their throughput efficiency.

INCREASING PCR CONTENT

Sustainability is important and we're using more compostable and PCR content materials.

— *Principal Engineer,
Large Carbonated Beverage Manufacturer*

We have made the decision to use film and corrugated materials that contain recycled content; we'll get started in about six months.

— *Packaging Engineer, Manufacturer of
Drugs and Medical Devices*

As the PCR content in corrugated increases, we need better vision equipment to detect any irregular case labeling due to the material variations.

— *Assistant Engineering Manager,
CM/CP Frozen Foods*

60%-70%

of consumers across all industry types state they would pay more for sustainable packaging.

AS PCR CONTENT INCREASES, MACHINE TOLERANCES MUST ADAPT

As the PCR content increases in corrugated, it challenges our equipment and requires more tooling modifications.

— *Technical Supervisor,
Leader in Personal Care*

We run 5 to 10 different sizes and as the PCR content increases in cartons and cases, the strength is weakened and it causes equipment problems.

— *Manufacturing Engineer,
Personal Care and Household Products*

Energy Reduction

Beyond material sustainability, 38% of manufacturers interviewed are seeking to reduce their energy usage as another component of their sustainability strategies. Some of these energy reduction strategies – such as utilizing more solar energy, reclaiming water, and upgrading HVAC systems – only indirectly impact EoL packaging, but many other approaches are directly related to machine and system modifications on packaging lines themselves. One approach is for manufacturers to seek out machines that are more energy efficient, utilizing less overall electricity and less power-hungry resources. EoL equipment designed with more precise motion, the integration of robotics, a reduction in reciprocating movement, and the integration of frequency controls for motorized movement are all energy reduction strategies that OEMs can explore. Even simple alterations to machine design, such as eliminating heat-based label application can have a lasting impact on overall energy usage. These equipment considerations can result in meaningful reductions in energy usage, such as shrink-wrapping systems that use up to 90% less energy when compared to older machinery.⁶

Another angle of energy reduction is to improve the efficiency of existing EoL machines through strategies such as timed shutdowns and regular maintenance. Production schedules are now factoring idle time into their energy reduction strategies, striving to shut machines down quickly between runs as a way to reduce electricity usage. As a result, EoL machines that can enter an idle mode but can be easily reawakened to resume production are becoming increasingly popular with end users.

Manufacturers are also looking to improve electricity efficiency by regularly maintaining and monitoring existing infrastructure, such as compressed air delivery systems still utilized in the EoL space. With air compressors generating \$3.2 billion worth of wasted energy on a yearly basis⁷ and packaging facilities able to reduce compressed air-related energy costs by as much as 40%⁸ through upgrades, maintenance, and monitoring, it is no wonder manufacturers are incorporating these strategies into their sustainability goals.

OEMs have an active role to play in achieving energy reduction benchmarks through the addition of integrated machine sensors and monitoring systems designed to flag inefficiencies and track usage.

ENERGY EFFICIENCIES

We are looking to implement compressed air shutdowns when not in use.

— *Robotics and Automation Manager,
Manufacturer of Dairy Products*

We are very mindful of sustainability and make decisions that are meaningful and impact the environment.

— *Sr. Director Packaging,
Manufacturer of OTC and Personal
Care Products*



► Supply Chain Visibility

Another key trend affecting the EoL packaging space is the need for product visibility in the supply chain. While this is driven by consumers for primary packaging, in the EoL packaging space greater product visibility is spurred on by a combination of regulations, retailer requests, and manufacturer logistics. These three primary forces are pushing manufacturers to expand their labeling on EoL packaging configurations to more efficiently and accurately track their products through the supply chain.

Regulations

There are two major regulations driving the need for increased supply chain visibility in the US: the Drug Quality and Security Act (DQSA) and the Food Safety Modernization Act (FSMA), affecting the pharmaceutical industry and the food and beverage industries respectively.



For pharmaceuticals, Title II of the DQSA, the Drug Supply Chain and Security Act (DSCSA), requires the complete serialization of products from the individual product level all the way up to pallets.



For food and beverage manufacturers, Section 204 of FSMA requires detailed production and distribution records to be kept in case of a product recall.

The end result of these two regulations is essentially the same for both pharmaceutical and food/beverage manufacturers: they must be able to maintain visibility of products - especially bulk bundles and pallets of products - as they move through the supply chain.

Retailer Requests

While regulations apply only to specific industries, retailer requests for enhanced product visibility in the supply chain impact a diverse array of CPG manufacturers. The largest retailers have enough influence that they can dictate new tertiary packaging arrangements and require additional visibility into the movement of products through their own supply chains. Interviewees noted that retailers were driving changes in pallet configurations, coding/marketing visibility, pallet labeling, traceability, and the expanded use of direct printing on EoL packaging. Typically, retailers are looking to gain additional insight into the movement of larger formats of products, such as pallets, so they can better plan their own inventory management and distribution systems.

Internal Manufacturer Logistics

Manufacturers are also seeking to gain more visibility into the supply chain as a way to better track their shipments and forecast their future production needs. The demands of just-in-time delivery have placed additional logistical expectations on producers across the CPG industry. Manufacturers must carefully track both their shipment and production schedules to ensure that clients receive the products they need exactly when they need them. While COVID-19 has caused a recent reevaluation of just-in-time practices, it remains an enduring strategy used by some of the most influential players in manufacturing and retail.

Large-Format Flexible Packaging

The production of large-format flexible packaging for products such as cement, dirt, and animal feed comes with additional challenges in the EoL space. Large-format flexible bags often require greater levels of machine adaptability and precision, especially when it comes to palletizing.

One effective strategy is the use of specialized robotics. Robotic palletizing for flexible bags is a reliable way to efficiently handle variations in weight caused by slight differences in filling levels. Modern robotic palletizers can also be equipped with programmable, intuitive HMIs and dynamic end-of-arm-tooling (EoAT) that allow manufacturers to quickly switch between a variety of bag sizes, weights, and materials, enabling one piece of equipment to accommodate numerous product types and formats. These robots are also able to create consistent, sturdy, and attractive pallet stacks, catering to the growing trend of large retailers placing stacked pallets directly on the sales floor.

RETAIL REQUESTS BRING ADDED CHANGE

We mainly need to comply with flexible pallet configurations as retailers ask for varying amounts of bags on each pallet load.

— *Packaging Engineering Manager, Agricultural Product Manufacturer*

We need flexibility in equipment to be able to switch easily between the varied pallet configurations requested by big box stores and the smaller batches requested from smaller retailers.

— *Manufacturing Engineer, Manufacturer of Home Goods and Personal Care Products*

Each retailer has varied requirements for strapping: the strength, the number of straps used, the thickness, and the tension required.

— *Packaging Engineering Manager, Household Products Manufacturer*

We are using more banding lately instead of stretch film since retailers want more flexible pallet configurations.

— *Manufacturing Manager, Manufacturer of Home Goods and Personal Care Products*

Greater Supply Chain Visibility

For contract packagers, being able to accommodate a variety of pallet configurations and conform to a number of different labeling requests is particularly important. 80% of contractors interviewed stated that pallet flexibility is being dictated by their retail accounts, while 60% noted that retail customers were requesting greater coding/marketing visibility on EoL packaging.

RETAIL REQUESTS BRING ADDED CHANGE

Retailers are asking for product traceability labeling on multiple sides of the case, as well as more flexible pallet configurations.

— *Sr. Packaging Engineer,
Large Juice Manufacturer*

Retailers are requesting two-sided labeling on all cases, so we have complied.

— *Robotics and Automation Manager,
Manufacturer of Dairy Products*

Retailers are asking for smaller case counts and easier to open cases to improve ergonomics for their warehouse workers.

— *Manufacturing Engineer, Manufacturer of
Home Goods and Personal Care Products*

Rising Use of Third Parties: Expanding Use of Contractors

The expansion of SKUs, surge in e-commerce, and the growth of CPG industries have all pushed brand manufacturers to rely more on contract manufacturers (CMs) and contract packagers (CPs) to manage expanding production levels. Manufacturers are also looking to CMs/CPs as a way to access packaging formats and logistics strategies that they do not have the capacity to handle in-house. This allows them to avoid buying additional machinery and designing additional packaging lines. Because CMs/CPs typically handle a wide variety of product and packaging types, they can benefit from EoL machinery that is highly flexible, compact, and capable of maximizing throughput with features such as automated changeovers and multi-function capability.

Greater product visibility is also an essential part of managing e-commerce and direct-to-consumer solutions for manufacturers, especially as they begin to set up their own channels for online purchasing. This is also true for manufacturers that outsource portions of their e-commerce production and distribution, as they must tightly track their product inventories to properly gauge available supply.

Supply Chain Visibility and EoL Equipment

These three main drivers of supply chain visibility – regulation, retailer requests, and manufacturer logistics – require packaging lines to adjust their EoL strategies. Specifically, all three of these requirements demand more labeling on tertiary packaging to enable more efficient tracking of bundled products through the supply chain. It also requires a more complete integration of EoL operations into a larger ERP system to accurately manage production, track shipments, and predict future distribution needs based on accumulated data. To achieve these new levels of supply chain visibility, many manufacturers are turning to enhanced labeling solutions such as QR codes, NFC labels, and RFID markers on their tertiary packaging formats. These smart labels provide more reliable and accurate visibility into both the production and distribution of products, preparing manufacturers to efficiently track their shipments in the event of a recall and enabling the accurate management of just-in-time delivery systems.

Enhanced Labeling

Enhanced labeling requirements have also created new manufacturer needs for labeling capabilities at the very end of the line. Label application is necessary after the accumulation and final securing of products on a pallet, such as placing a smart label on the outside of a wrapped pallet. For manufacturers, this means either new labeling equipment, or the integration of labeling capabilities into existing equipment at the end of the line. In addition to applying labels, manufacturers seeking to achieve greater supply chain visibility need a way to read those labels and log them into a centralized, integrated ERP system. This has created the need for vision inspection equipment at manufacturers that desire to fully integrate their packaging lines. In some cases, manufacturers are opting to combine these capabilities into one machine capable of carrying out multiple tasks, such as an integrated robotic palletizer equipped with vision capability to read and log labels.

OEMs should carefully factor these emerging supply chain realities into future machine designs and tailor integration services to address the need for greater supply chain visibility. Brand manufacturers need to expand labelling in the EoL space, with a way to efficiently read and log information. OEMs can help manufacturers achieve these goals by comprehensively planning line integration to extend all the way through to the terminus of the EoL space and by designing EoL machinery capable of performing several functions to smoothly incorporate enhanced labeling requirements.

► Expanding SKUs

One of the most dominant trends across CPG industries is the ever-expanding number of SKUs now being produced by manufacturers. It should be noted that this trend of SKU expansion was partially disrupted in select industries in 2020 by COVID-19, with some major manufacturers strategically trimming SKU counts to focus on growing demand for certain product segments. This was driven primarily by widespread supply chain disruption, most notably material availability and shipping logistics. This impact is expected to be short term, with SKU expansion predicted to pick back up if supply chain challenges continue to abate in the coming year.

There are numerous factors driving this increase in SKU counts – customized products, expansion of shape/size choices, diversification of distribution channels, growing packaging material options for single products – but the end result is the same for manufacturers: they are producing more products in a wider array of packaging formats. This explosion of product variety has created new challenges and requirements up and down the packaging line, with the EoL space being no exception. To accommodate these strains on production, manufacturers are seeking a new breed of EoL machinery that will carry emerging packaging strategies into the future.

EoL machines now need to be highly flexible to handle the rapid changing of SKUs within a single shift. To better streamline production, manufacturers are also turning to EoL equipment that integrates several different functions into a single machine. These improvements are ultimately rooted in an ongoing need to expand the level of automation and ease of integration in the EoL space. The technical supervisor at a leading beauty products manufacturer confirms that SKU increases are driving the need for new equipment and said, “We just had to purchase a new bundler due to a retailer requesting bundles of three to accommodate e-commerce shipments.”

Machine Flexibility

To accommodate expanding SKU counts, equipment in the EoL space needs to be highly flexible and adaptable to a variety of rapidly changing production realities. This is especially true for larger manufacturers, who must manage a dizzying array of products across numerous packaging lines. However, SMEs can also benefit from greater levels of machine flexibility as the rapid growth of SKUs trickles down throughout all CPG industries. Machine flexibility is also crucial for CMs/CPs as their role grows in the CPG space, driven in part by the added production strain placed on manufacturers.

Perhaps the most important aspect of machine flexibility in the EoL space is the ability to adapt to a wide variety of packaging shapes, sizes, and material types. The diversity of packaging formats has expanded significantly in the CPG space, and it is essential for EoL equipment to seamlessly handle this plethora of SKUs efficiently. Labeling machines, especially direct-print systems, need to be able to handle a wide variety of shapes and material types. Handling equipment must be capable of adapting to diverse packaging formats, including products packaged in PCR material that can vary in quality. Even wrapping and banding equipment must be highly flexible, capable of adjusting to an array of secondary packaging shapes and pallet configurations. In some instances, EoL machines must also be capable of utilizing print registered films to bundle products for movement through the supply chain.



E-Commerce Driving SKU Expansion

One of the key drivers behind the expansion of SKUs across manufacturing is the growing popularity of e-commerce. E-commerce often requires manufacturers to rethink their packaging formats, creating new designs that cater to the rougher and more frequent handling in e-commerce channels, as well as the space/weight efficiency requirements made more crucial by direct shipping.

COVID-19 dramatically accelerated the trend of e-commerce ordering in 2020, with online sales in the US growing 32.4% when compared to 2019. This trend is only increasing into 2021, with Q1 online sales up 39% when compared with Q1 2020, a growth rate that is higher than both Q3 and Q4 of 2020.⁹

FLEXIBILITY IS KEY

Feeding multiple lines into EoL requires more flexibility - we are using smart conveyors and robotic palletizers as a solution.

— Sr. Packaging Engineer,
Large Beverage Manufacturer

We are just starting to feed multiple lines down to one packing line; to alleviate bottlenecks, we need smarter lane diverters and conveyors.

— Robotics and Automation Manager,
Large Food Manufacturer

We are using print registered film for wrapping trays.

— Packaging Engineering Manager,
SME Flavorings and Ingredients

Print registered film is being used on multi-packs.

— Packaging Engineer,
Beverage Leader

ROBOTIC PREDICTIONS FOR EOL

We just finished a large project automating our palletizers and case packers at six facilities - 20% are robotic.

— *Sr. Packaging Engineer,
Large Juice Manufacturer*

We will be reaching 100% automation in the next two to three years for our end-of-line operations, with nearly three-fourths being robotic palletizing.

— *Director of Packaging Engineering,
Large Frozen Food Manufacturer*

Our EoL operates with nearly half robotics now and our new investments will be directed at achieving 100% robotics in the future; we will be placing an order for two robot projects in the first quarter of next year.

— *Technical Supervisor,
Leader in Personal Care*

We're moving toward more robotic case packing and palletizing to reduce our need for labor; cobots are too slow to implement at EoL for our operations.

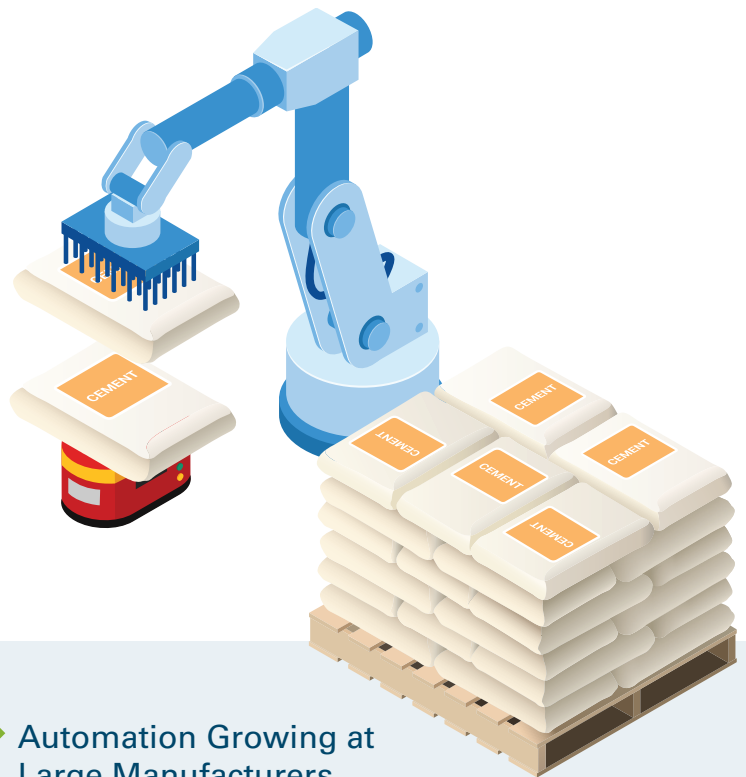
— *Robotics and Automation Manager,
Large Dairy Processor*

Cobots in EoL Operations

As their capabilities increase and costs decline, cobots are ready for tasks in the EoL space. Cobots can offer several advantages over traditional robotic solutions including a lower overall cost, eliminating the need for zoned safety barriers, and greater versatility in the range of tasks that can be performed. The newest generation of cobots have lengthened their reach and increased their lift capacity, making them better suited for applications at the end of the line. With usage of cobots low amongst manufacturers interviewed, OEMs have an opportunity to help customers identify applications where the implementation of cobots will bring added flexibility to EoL operations.

Machine Flexibility – Robots and Cobots as a Solution

A key method of achieving greater levels of machine flexibility in the EoL space is the integration of robots and cobots. This is particularly true for palletizing: while robots have long been used to construct pallets at the end of the line, their role is expanding as their capabilities improve. Robotic palletizers are ideal for consistently constructing stable pallet stacks that maximize space efficiency, allowing manufacturers to easily adapt to a variety of packaging formats, from flexible to rigid. Stacks constructed by robots can also more easily be arranged to retailers' specifications, enabling them to drop configured pallets directly onto the shopping floor. With integration and advanced HMI configurations, alterations to pallet construction can be changed on the fly, allowing EoL operations to seamlessly transfer from one product to the next by adjusting stack formations to the desired dimensions and configurations.



► Automation Growing at Large Manufacturers

Large manufacturers overwhelmingly stated that their goal in the next few years is to dramatically expand their levels of automation in EoL packaging, with many aiming for 100% automated processes. Many expect to achieve this goal by expanding their level of robotics in the EoL space. OEMs will have significant opportunities to assist large manufacturers with EoL robotics in the coming years by both supplying robot-based machines and by providing robotics integration services for EoL packaging operations.

Robot/Cobot Opportunities at SMEs and CMs/CPs

While larger manufacturers are well established with EoL robotics, there are many opportunities for OEMs to tap a segment of SMEs that are turning to robotic solutions in the EoL space. This is especially true for CM/CP operations, where robotic utilization is fairly low. The use of third-party manufacturing and packaging as a result of increased production variety is pushing some CMs/CPs to explore robotic solutions. SME operations are also a ripe target for the addition of cobots, as they are a versatile steppingstone toward fully robotic operations that can enhance flexibility while maximizing available floor space, a challenge that SMEs often struggle with. One analysis of the use of targeted robotics such as cobots found that their addition could reduce human labor idle times by as much as 85%, providing a significant boost to productive uptime.¹⁰

We are a personal care CM/CP and growing exponentially – we are adding more automation and robotics now on seven active lines and all of our new machines will be able to digitally transfer data.

— Operations Manager,
Small CM/CP Personal Care

We plan to add robotics to a fourth of our lines in the future - it would be our first implementation of robots.

— Director of Engineering and
Facilities, Small Pharma CDMO

► Robotics Underutilized at SMEs

While SMEs interviewed report very low levels of robotics usage in EoL packaging currently, they predict that their usage will grow in the coming years. This lower level of robotics usage could be seen as an opportunity for OEMs rather than a barrier. With the price of robotics steadily dropping and the availability of third-party integrators growing, there is a significant opportunity to further educate SME manufacturers on the gains that can be realized from EoL robotics, especially given that areas such as palletizing are typically the first to integrate robots.

Multi-Function Machines

An emerging strategy to manage production in the face of expanding SKU counts is the concept of multi-function machines, which combine several aspects of EoL packaging into one piece of equipment. While the concept of combining multiple machine functions into one unit is well established - such as machines that form, fill, and seal a pouch - multifunctionality is also spreading to EoL operations. For instance, stretch wrappers can now be equipped with label printing capabilities, combining wrapping and labeling into one smooth operation, with both an automated and semi-automated option available depending on the level of sophistication required.

The concept of multi-function machinery can be taken a step further with the use of pick-and-place robotics in the palletizing space. A robotic palletizer can pick cases off of a line, pass the cases through an integrated labeler that marks the package, move and orient the cases so that they can be scanned by vision inspection, and then deposit them onto a waiting pallet where they can ultimately be wrapped. In this way, the robotic palletizer is now performing several functions at once: picking cases, labeling, scanning, and creating a pallet stack.

► Automation Not Always Robotics

While robotics is one of the solutions available to manufacturers looking to automate their palletizing operations, it is by no means the only option. A variety of machine-based, non-robotic automation strategies exist which still accomplish fully automated palletizing and eliminate the need for manual or even semi-manual labor. Automated palletizers without robotics may be attractive to manufacturers as they are often less expensive than robotic units and do not require the same level of technical skills to install, program, and operate when compared to robot-based solutions.



INNOVATION FOR EOL

We are looking for new innovations for future EoL machinery such as more versatility to improve throughput and increased speeds to handle the growing number of products being packaged.

— *Packaging Engineer,
Medical Device Manufacturer*

We're looking at automating case coding and labeling and need a new machine to include remote access capability for repairs and troubleshooting.

— *Engineering Manager,
SME Copacker of Household Products*

A Place for Semi-Automatic and Manual Operations

Not all manufacturers have a need for fully automated machinery in their EoL operations. SMEs with lower levels of throughput or tight budgets may find that the hurdles to achieving highly automated operations outweigh the potential gains. For these manufacturers, semi-automated EoL equipment augmented by traditional manual labor might be a better fit. An example of this type of solution would be a conveyor fed pallet platform with an ergonomic lever that still requires human labor to manually construct the pallet stack. Another common semi-automatic piece of machinery in the EoL space is shrink wrappers, which require greater interaction by employees to load, unload, and select operating parameters. Some manufacturers may also opt for fully manual tasks at the end of the line, such as manually applying labels to wrapped pallet stacks. This is especially true for small manufacturers, who noted that 42% of their EoL operations are still conducted manually. There is no one-size-fits-all solution for EoL operations when it comes to the level of automation required to complete a task.

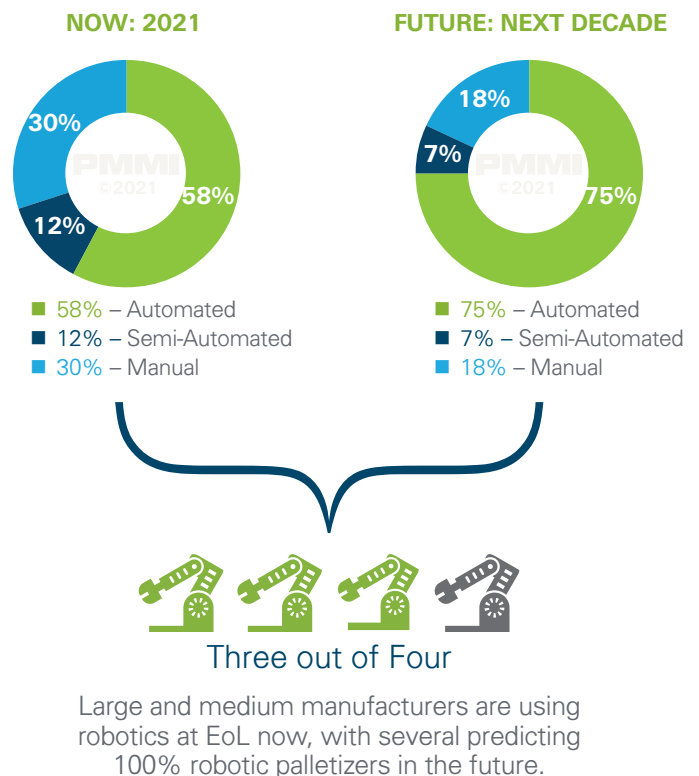
Multi-Function Machines (continued)

Multi-function machines free up additional space on the production floor by reducing the number of machines needed to accomplish EoL tasks, thereby reducing the number of transfers needed between equipment. This is especially vital for SMEs, as they are often challenged by a finite amount of space available for packaging lines. OEMs have an opportunity to harness this trend in multi-functionality and modularity by both designing machines that are able to combine several EoL tasks into one unit, and by proactively assisting manufacturers with identifying where tasks can be compressed into an adaptable piece of equipment. OEMs capable of designing these machines, identifying opportunities for their use, and integrating them into EoL operations will be best poised to harness this growing trend.

Automation and Integration

While greater machine flexibility and multifunction machines are important components of adjusting to growing production needs, the nuts and bolts of achieving greater overall production efficiency and adaptability lie in automation and integration strategies. Ultimately, the goal of manufacturers is to maximize both their uptime and throughput to accommodate the growing variety of packaging formats they are required to produce.

EoL Level of Packaging Automation*



*Overall combined average from all companies interviewed

MANUAL OPERATIONS AND THE PROGRESSION TO AUTOMATION

30% of our operations are still semi-automated, but we plan to be 100% automated in the near future and are continuously adding more robotics.

— *Principle Engineer,
Leader in Carbonated Beverages*

Variety packs require manual labor, so robotics are not feasible.

— *CEO/CFO,
SME Copacker of Beverage Products*

About a third of our EoL operations are automated now, and as we add lines we focus on reducing the need for manual labor.

— *Automation Manager,
Food Manufacturer*

Our operations at EoL are mostly manual but the plan is to be 80% automated in the future, with only one or two applications being considered for robotics.

— *Packaging Engineering,
SME Manufacturer of Medical
Devices*

Our EoL remains mostly manual due to the variety of packing needs for seasonal products, but we're starting to look at automating in the next few years.

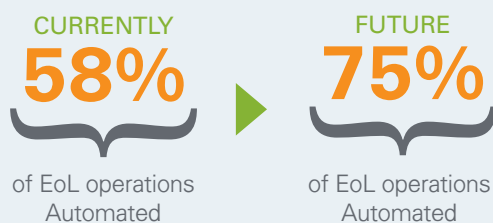
— *Sr. Packaging Engineer,
Healthcare Products Manufacturer*

Automation and Integration

Increasing uptime and throughput are essential to creating the most efficient production operations possible and both strategies are heavily intertwined. OEMs have a large role to play in achieving production maximization goals and should actively be developing and promoting automation and integration packages that cater to efficiency. OEMs should strive to reduce changeover times to their bare minimum by integrating automated changeover into their EoL equipment. OEMs can push tasks such as vision inspection in the EoL space to the highest efficiency possible through the use of advanced AI programming on their machine offerings. In addition, OEMs should consider offering predictive and preventive maintenance strategies, monitored and managed through the use of integrated smart sensors. OEMs can further distinguish themselves in the EoL space by offering design and integration services, ensuring that high-tech additions to EoL equipment function smoothly with the rest of a production line.

▶ Continuing to Expand Automation

Manufacturers interviewed in five market segments shared the extent of automation in their EoL operations. The overall average is:



Growth is driving our focus on automation; we need flexibility in our machines to accommodate a wide variety of customer packaging and we need simplified changeovers with minimal tooling.

— *Operations Manager,
SME CM/CP of Personal Care Products*

► Labor Shortages

A sweeping trend having a direct impact on EoL packaging operations is the ongoing labor shortage pervading CPG manufacturing industries. From large operations to SMEs, manufacturers in the CPG space have reported struggling with a general lack of available labor. These struggles have become even more acute in the last year, with COVID-19 erasing 1.4 million positions in 2020 alone.¹¹

The senior director of packaging at a large manufacturer of OTC and personal care products sums up the labor challenges that many manufacturers face by explaining: “Shortage of labor remains a big problem. We have many jobs that can’t be filled, so we’re using temp labor or contracted services. In the long run, it’s pushing us towards a future of automation to eliminate repetitive tasks and heavy lifting to ultimately improve worker safety.”

Skilled and Unskilled

The lack of available labor has impacted all aspects of manufacturing, from skilled to unskilled positions. For EoL operations, there is a lack of unskilled labor needed to perform manual tasks that have not been automated, such as stacking pallets and applying tertiary labels. To compensate for this shortage, manufacturers have turned to automation solutions in the EoL space, such as automated stretch wrappers and pick-and-place robotics. This has not fully solved the problem, however: while automation can replace unskilled labor effectively, the higher levels of technology required by automation result in more complex machines that require a higher level of skill to install, maintain, and operate. Because manufacturers also face a lack of skilled labor, installing automated equipment may solve one problem while creating another – a task can be automated, but the skill level of available employees may not be high enough to effectively operate newly automated machinery.

We are planning on doubling our level of automation in the future and some of that will include robotics to reduce our reliance on manual labor for packing.

— *Packaging Engineer, Large Manufacturer of Household and Chemical Products*

In the next two to five years, all new EoL equipment will be robotic, with the goal of eliminating all manual labor and transitioning to 100% robotics.

— *Principal Engineer, Leading Beverage Manufacturer*

We continue to advance our EoL operations toward more automation and robotics, reducing our reliance on manual labor from twenty people in the past to only three people now.

— *Sr. Director Packaging, Manufacturer of OTC and Personal Care Products*

► Automation Added to Overcome Labor Shortages

Manufacturers are increasing their levels of automation to overcome ongoing shortages of labor. Over half (58%) of companies interviewed stated they are adding more automation specifically to compensate for a dearth of qualified employees.

Opportunities at EoL

To overcome the labor conundrum, OEMs need to play an active role in assisting manufacturers with their automation and integration goals. OEMs can help by identifying areas of EoL operations where automation can be deployed to reduce a need for unskilled labor. This can be taken a step further by installing and fully integrating these EoL machines into the production line, removing the burden from manufacturers who may be struggling to find employees capable of performing those tasks. To compensate for the lack of skilled labor needed to operate automated equipment, OEMs can endeavor to simplify components such as HMIs and PLCs, making them intuitive and easy to use. In addition, OEMs should consider offering more extensive and frequent training to manufacturers, equipping their employees with the skills necessary to operate more sophisticated machinery. By positioning themselves as partners in automation and integration, OEMs can further develop ongoing relationships with their customers.

LACK OF LABOR HINDERS OPERATIONS

We will continue to implement more automation, but the bigger problem is finding the people who know how to operate and maintain machines with a higher level of automation.

— *CEO/CFO,*
SME Copacker of Beverage Products

We are only running our plant at 75% production capability now because we can't find quality people - it's driving the decision to install more automated equipment.

— *Assistant Engineering Manager,*
SME CM/CP of Frozen Foods

► Supply Chain Shortages

Two consequential side effects of the COVID-19 pandemic have been the disruption of supply chains and an increase in material costs. For both materials and machines, manufacturers are finding their traditional supply chains have been upended by the struggles created by COVID-19. This trend has directly impacted the EoL space, causing delays in delivery and creating new difficulties in consistently sourcing vital materials and components.

DELIVERY DELAYS DISRUPTING OPERATIONS

In general, there are delays on all equipment, materials, and parts due to COVID-19 and it doesn't appear to be ending soon.

— *Engineering Project Manager,*
Leading Manufacturer of Rx Drugs

Delays vary depending on the type of material, the type of machine, and the method used for delivery.

— *Sr. Packaging Engineer, Large Juice Manufacturer*

Shipping dates have been slipping and taking longer for things like PLCs and HMIs.

— *Robotics & Automation Manager,*
Large Dairy Food Processor

There is a shortage of components and we're experiencing long lead times for machine repairs.

— *Continuous Improvement Manager, Large Manufacturer of Shelf Stable and Frozen Foods*



SHORTAGES DISRUPT EoL OPERATIONS

We are experiencing delays on all EoL machinery: palletizers, conveyors, and coding equipment.

— *Packaging Engineering Manager,
Large Agriculture Products Manufacturer*

We have had to delay the start of a new end-of-line project by four to five months due to extended lead times on conveyors and palletizers.

— *Packaging Engineering Manager,
Flavoring and Ingredient Manufacturer*

We reevaluated packaging options and used contract packagers due to delays in cartoners, labelers, and vision systems.

— *Sr. Packaging Engineer, Large Healthcare
and Medical Device Manufacturer*

The material and component shortages are causing us to operate only four days a week and we've had some layoffs.

— *Packaging Engineer, Large Manufacturer
of Household Products and Chemicals*

MATERIAL SHORTAGES AND RISING COSTS

We are using as much PCR content as possible, but delivery dates have extended with a supply chain that's been disrupted by the pandemic.

— *Principle Engineer, Large Carbonated
Beverage Manufacturer*

We're experiencing long lead times and rising prices for corrugated for our EoL operations - we're having to order weeks in advance.

— *Engineering Manager,
SME Copacker of Household Products*

With material shortages increasing, we stock a large inventory for our hot fill bottles and order far in advance to avoid outages.

— *CEO/CFO,
SME Copacker of Beverage Products*

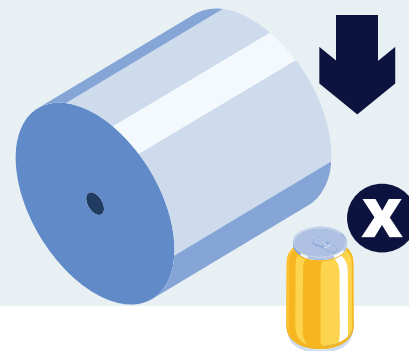
Equipment Shortages

On the machine sourcing side, manufacturers have reported that lead times have increased and certain componentry, such as specialized HMI and PLC equipment, is difficult to source in a timely manner. These delays are caused by a number of factors, all rooted in the COVID-19 pandemic: the widespread disruption of traditional shipping channels, a general lack of labor that has impacted OEMs' ability to produce machinery, and a sharp increase in demand for packaging equipment - especially machinery and components that incorporate higher levels of automation. While the overall increase in demand is a boon for OEMs (automated packaging machine sales increased by a record 12% in 2020),¹² the backlog of equipment is creating challenges for manufacturers trying to keep up with the increased demand for CPG goods coupled with a decreasing availability of labor. This is particularly important for the EoL space, where manufacturers are often looking to alleviate labor shortage issues by automating operations. The struggles with sourcing machines and componentry to achieve these higher levels of EoL automation have hampered manufacturers' plans to adjust their businesses in response to the COVID-19 pandemic.

Material Shortages

In addition to machine delays, manufacturers have reported widespread supply chain disruption in sourcing the basic materials needed for packaging. 65% of companies interviewed identified ongoing material shortages and extended lead times on delivery as current challenges to their daily operations. Like machine delays, this disruption is caused by both an increase in demand for packaging materials, as well as the breakdown of traditional supply chain channels for packaging materials across the globe. These supply chain difficulties have impacted almost all aspects of packaging, with some of the most significant disruption directly affecting the EoL packaging space: a lack of corrugated and shortages of the base resins used in plastic production (which has created a shortage in nearly all plastic packaging materials, including films). Manufacturers using PCR materials have been hit particularly hard, with supply disrupted by a combination of new recycling restrictions imposed by China, a decline in traditional sources of recycled material caused by the shuttering of offices and schools during COVID-19, and the accelerated closure of US recycling facilities during COVID-19. All of these factors have combined to create significant challenges for manufacturers as they struggle to balance demand against their ongoing supply chain issues.

Beverage companies have been hit particularly hard by challenges with sourcing materials: 100% of beverage manufacturers interviewed stated that they faced problematically long lead times for their packaging materials.



OEMs and the Supply Chain

To alleviate some of these supply chain challenges, OEMs should be upfront with their customers about what their lead times are likely to be: taking an honest approach can better assist manufacturers in planning for slowdowns in the supply chain. In addition, difficulties sourcing materials make it even more important for OEMs to offer flexible, adaptable EoL machinery that is capable of handling a wide variety of materials and material quality. With uncertainty surrounding the sourcing of packaging materials, manufacturers are having to take whatever they can get, making EoL equipment capable of handling variable quality and minimizing waste more important than ever.

STAY INFORMED ON LEAD TIMES

We bring our suppliers in at the start of line design so we know what the options are - we need upfront information on accurate lead times.

— Sr. Packaging Engineer,
Large Manufacturer of Healthcare and Medical Device Products

We have had to vary the materials we are using due to the shortages - we need to be more informed on realistic delivery.

— Director of Packaging Engineering,
Large Manufacturer of Frozen Foods

► Actionable Opportunities: Desired EoL Machine Attributes

When it comes to the next generation of EoL machinery, there are a number of key attributes that manufacturers look for when evaluating their options. While each manufacturer has specific needs unique to their operations, there are a number of broad machine attributes that end users agree are most desired.

Top Machine Attributes Desired on Future EoL Equipment

Ease of Integration	35%
Ease of Maintenance	31%
Expanded Flexibility	31%
Increased Throughput Speeds	19%
Decreased Footprint	19%

Exceeds 100% due to multiple answers

In general, manufacturers are looking for EoL machines that are capable of integrating seamlessly into existing operations, are easy to maintain, have a high degree of flexibility, and are compact enough to fit into limited floor space. In addition, manufacturers are striving to find machines that will assist them in increasing their overall throughput by making EoL packaging operations more efficient. To achieve these broad goals, there are a number of specific machine attributes OEMs should consider designing into their offerings.

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FASTER CHANGEOVER REMAINS A TOP PRIORITY

We want easier maintenance and quicker changeover tied into digital reporting for output performance, parts ordering, and other line details.

— *Principle Engineer,
Large Beverage Manufacturer*

Equipment needs to have toolless changeover, in some instances in less than ten minutes.

— *Robotics and Automation Manager,
Large Dairy Foods Processor*

Most lines run five to ten different sizes so new equipment should be agile, requiring no tooling to make adjustments that are preset to reference points.

— *Technical Supervisor, Leader in Personal Care*

AVOIDING BOTTLENECKS THROUGH ADAPTABILITY

Feeding multiple lines into EoL requires more flexibility - we are using smart conveyors and robotic palletizers.

— *Sr. Packaging Engineer, Large Juice Manufacturer*

To accommodate multiple lines feeding EoL we are using multiple solutions: lane diverters, smarter conveyors, modular conveyors, shorter conveyors, and overhead conveyors.

— *Packaging Engineer, Beverage Leader*

We are just starting to feed multiple lines down to one EoL packing line. To alleviate bottlenecks, we need smarter lane diverters and conveyors.

— *Robotics and Automation Manager,
Large Dairy Food Processor*

We are running two lines into robotic palletizers and using overhead conveyors for transport.

— *Packaging Engineer,
Large Household Product Manufacturer*

Our lines are constantly changing to accommodate reinvented product sizes and shapes.

— *Technical Supervisor, Leader in Personal Care*

We are having to repack, recarton, and palletize products for special markets and we're using lane diverters to avoid bottlenecks.

— *Sr. Director Packaging, Large OTC and
Personal Care Products Manufacturer*

Changeovers

A key to increasing throughput in the EoL space is designing machines that have fast, efficient changeovers. Faster changeovers – to accommodate changes such as type of wrapping material, pallet configuration, and EoAT handling needs - create the ability to handle a variety of different packaging formats seamlessly, allowing EoL machinery to adapt to a wider array of products and minimize downtime. To achieve faster, seamless changeover times and maximize uptime, OEMs should be looking to design features such as smarter motion control, easier integration into the ERP, and fully automated changeover to keep up with the flow of products on the packaging line.



Versatility: Sizes, Shapes, Materials, and Tolerances

Machines in the EoL space need to be highly adaptable to handle the ever-increasing number of products and changing packaging formats that are proliferating across CPG industries. Versatility is particularly important for EoL operations, given that 42% of companies interviewed stated they are feeding multiple production lines into one EoL packaging line. Flexible machinery, capable of handling and adjusting to a variety of packaging sizes, shapes, materials, and strength tolerances, will be better equipped to maximize uptime and remain highly productive and efficient into the future.

Modular and Mobile Equipment

With manufacturers strained by space restrictions, tight production schedules, and budget constraints, the need for modular and mobile machinery is only increasing. Compact and modular machinery plays a key role in alleviating production and logistics stresses that manufacturers must factor into their operational planning. OEMs should work towards making machines as space efficient and mobile as possible, allowing equipment to be easily integrated into a variety of EoL packaging configurations.

Intuitive Interfaces

To accommodate changing realities in the skill of available labor in manufacturing, it is crucial that machines be easy and intuitive to operate. One of the most important factors in this equation is designing interfaces that can be efficiently operated by less skilled employees, allowing day-to-day operations to continue functioning smoothly. OEMs should place emphasis on designing components such as simplified HMIs and PLCs, as well as expanding the availability of training and instruction programs to better equip employees with the skills they will need to operate advanced and automated machinery in the EoL space.

Machine Reliability Through Monitoring and Maintenance

One of the most important aspects for EoL equipment is overall machine reliability. Manufacturers need to be assured that their EoL equipment will perform consistently and efficiently to keep up with demanding production schedules. To improve overall reliability, many manufacturers are turning to predictive and preventive maintenance. To streamline these maintenance approaches, OEMs should consider the standard addition of integrated sensors into their machines that can make predictive and preventive maintenance programs more efficient and effective. In addition to sensors, OEMs should consider building remote monitoring capabilities into their machinery.

Currently, 58% of interviewed companies are utilizing some form of remote monitoring in their EoL operations. Remote monitoring and integrated sensors can augment predictive and preventive maintenance routines while simultaneously providing manufacturers with valuable production data, two crucial aspects of increasing overall machine reliability.

MACHINE DESIGN

To use our space more efficiently, we work with OEMs to preplan equipment designs to be more modular and mobile.

— *Robotics and Automation Manager,
Large Dairy Foods Processor*

We look for components on the machines we purchase that are tried and true.

— *Director of Engineering and Facilities,
SME Pharma Copacker*

We want the next generation of equipment to have easier access to maintenance areas and have built-in maintenance schedules on the HMI.

— *Engineering Manager,
SME Copacker of Household Products*

We measure the entire line for overall equipment efficiency and not individual pieces of equipment.

— *Engineering Project Manager,
Leader in Rx Drugs*

Maintenance as a Cost-Saving Strategy

In addition to improving machine reliability, manufacturers are realizing important cost savings through predictive and preventive maintenance regimens. 69% of companies interviewed stated that preventive maintenance sensors on machines could help them reduce costs, while 54% said the implementation of predictive analytics would reduce operational costs.



PREVENTIVE/PREDICTIVE MAINTENANCE AS A COST REDUCTION STRATEGY

More preventive monitoring is needed on equipment to coordinate along the entire line, reduce downtime, and minimize unscheduled maintenance costs.

— *Engineering Project Manager,
Leader in Rx Drugs*

Our strategy now is on preventive maintenance to help reduce costs on EoL equipment.

— *Manager of Packaging,
Large Snack Food Manufacturer*

Our focus to manage maintenance costs is better electronic maintenance systems like tracking hours, generating preventive maintenance plans, and inventory of spare parts.

— *Packaging Engineering Manager,
Flavor and Ingredient Manufacturer*

Preventive maintenance is key and requires additional training to collect the data regarding downtime.

— *Director of Engineering and Facilities,
CDMO Pharma*

REMOTE MONITORING TO IMPROVE MACHINE PERFORMANCE

The biggest impact smart technology will have on our business will be remote monitoring for machine troubleshooting.

— *Engineering Manager,
SME CP of Household Products*

Remote access for machine monitoring and troubleshooting will have the greatest impact for smaller operations in the short term.

— *Assistant Engineering Manager,
SME CM/CP of Frozen Food*

We may do more remote machine connectivity in the future for reporting on the machine performance and monitoring the controls.

— *Packaging Engineering,
Medical Device Manufacturer*



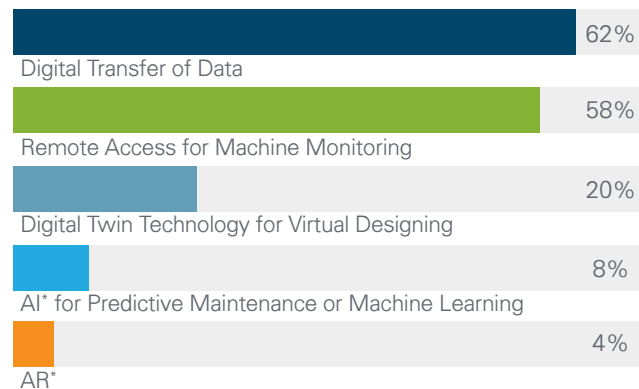
Integration and Connectivity

As production pressures continue to mount for manufacturers, it has become essential to maximize the efficiency of all machines in the packaging space. This also applies to EoL equipment, which is often tasked with handling products from a variety of lines, meaning schedules are tight and downtime must be minimized. The most effective way to smooth out these challenges is to increase the level of integration on machines, especially in the EoL space where planning, flexibility, and efficiency are key. 62% of companies interviewed cited the digital transfer of data across their operations as a key feature in their production planning that will have the biggest impact on operational efficiency in the future. With this in mind, OEMs should ensure that their new machine offerings come fully equipped with built-in machine sensors that can be easily integrated into an ERP system, enabling a deeper level of data collection and sharing.

Manufacturers explained they are looking for smarter components to easily integrate into a centralized management system - particularly coding and visual inspection equipment, which was mentioned by nearly half of manufacturers interviewed.

Percentage of Brand Manufacturers Using Smart Technologies Now at End-of-Line

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*AI (Artificial Intelligence)

*AR (Augmented Reality)

Exceeds 100% due to multiple answers

ADVANCED TECHNOLOGIES ARE STEADILY GAINING GROUND

We are collecting some data now regarding the weights of cheese, but would like to use AI in the future for the entire weighing process.

— *Robotics and Automation Manager, Large Dairy Foods Processor*

We are using smarter technologies and finding many practical solutions: AI for inspection systems and virtual models for new line design.

— *Sr. Director Packaging, Large Manufacturer of OTC and Personal Care Products*

We are using AI on one line and it will have the greatest impact on operations in the future.

— *Technical Supervisor, Leader in Personal Products*

We plan on using a virtual designing tool on our next project to build a new product line.

— *Manufacturing Engineer, Large Manufacturer of Home Goods and Personal Care Products*

► Standard versus Custom

While machine customization is a growing trend in primary and secondary packaging, some manufacturers interviewed stated that customization can be a hindrance in the EoL space. These manufacturers are looking for standardized equipment with standardized parts as a way to increase machine reliability: rather than relying on the longer lead times and tighter availability of customized parts, they prefer easy access to standardized components.

As the robotics and automation manager at a large dairy processing manufacturer put it: "We need OEMs to look at the entire line, with machines having common and standardized parts instead of highly customized machines."

The engineering project manager at a leader in Rx drugs agreed, "We seek OEM expertise soon after a new line design starts, but we try to avoid custom equipment and look for standardized machinery for easier maintenance."

▶ Throughput is the Most Important Machine Capability

The single most crucial factor for manufacturers when evaluating new EoL machine purchases is throughput, with 58% of interviewees stating that they weigh potential throughput over all other machine considerations. OEMs can better position themselves in the market by emphasizing throughput advantages that can be realized with their equipment.

THROUGHPUT AND TCO ARE CRUCIAL CONSIDERATIONS

We do a technical assessment and ask numerous questions to assure throughput rates are met to our specifications.

— *Sr. Director Packaging, Large OTC and Personal Care Products Manufacturer*

When evaluating the asset costs, total cost of ownership is key.

— *Sr. Packaging Engineer, Large Juice Manufacturer*

Total cost of ownership is the most important factor we consider when evaluating the machine cost from suppliers.

— *Director of Packaging Engineering, Large Frozen Food Manufacturer*

GROWING USE OF OEE

We calculate OEE on 80% of our machines and in the future, we'll be calculating OEE across all lines.

— *Principle Engineer, Large Carbonated Beverage Manufacturer*

OEE is calculated on only a few machines now but the plan is to more than double that in the future.

— *Robotics and Automation Manager, Large Dairy Foods Processor*

Over half of our machines calculate OEE now and the future goal is to be at 100%.

— *Packaging Engineer, Large Household Products Manufacturer*

▶ Actionable Opportunities: Information and Services Needed from OEMs

When it comes to evaluating new EoL machinery, there are a number of services that manufacturers desire from their OEM partners. Companies interviewed stated that they often look for specific pieces of information from OEMs when considering new purchases, such as:

- Detailed cost analyses
- The ability to assist with planning and designing new implementations
- Explanations of comprehensive integration capabilities
- The extent of training and instruction offered
- Key data on maintenance and repair schedules

80% of companies interviewed predict their capital budgets for EoL equipment will be increasing in the years to come, but they require assistance with understanding the benefits of new equipment as a way to justify machine purchases and upgrades. By being aware of these specific manufacturer needs, OEMs can better orient their capabilities and services to cater to customers seeking new equipment.

80%



Of manufacturers interviewed predict larger capital budgets for EoL equipment in the future.

Justifying Capital Expenditures

53% of companies interviewed noted that cost considerations are the primary hurdle they must overcome when justifying new EoL equipment. To assist manufacturers with justifying new EoL capital expenditures, OEMs can offer comprehensive cost analyses of machines, including total cost of ownership (TCO) and return on investment (ROI) projections. The majority of manufacturers say that overall cost calculations are crucial tools for justifying new EoL equipment purchases, with 58% saying TCO, purchase cost, and ROI are some of the most important factors that go into their purchasing decisions. Part of understanding cost considerations, especially ROI, is the concept of overall equipment efficiency (OEE). While 31% of manufacturers interviewed are calculating OEE on 50% or more of their machines, 61% stated that they intend to increase usage of OEE calculations in the future. OEMs should consider assisting manufacturers with these OEE calculations as a way to bolster their cost analysis information.

Top 5 Most Important Factors Manufacturers Interviewed Consider When Evaluating EoL Equipment Across Suppliers

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Throughput	58%
Total Cost of Ownership	31%
Footprint	31%
Purchase Price/Cost	27%
Prior Relationships	23%

Exceeds 100% due to multiple answers

Planning/Design Capabilities

Manufacturers are also looking to OEMs to actively assist in the planning and design of new EoL equipment additions and layouts. 83% of companies interviewed stated that they bring in OEM expertise less than six months into the design phase of a new EoL project. It is crucial that OEMs are available to offer their stores of knowledge and expertise early in the design process for EoL projects. One specific example cited by a manufacturer is the use of 3D modeling and digital twinning to plan, design, and simulate new machine additions to EoL lines. By actively engaging early in the design process, OEMs can cement trusted relationships with their manufacturing partners.

It is crucial that OEMs are available to offer their stores of knowledge and expertise early in the design process for EoL projects.

Integration Services

Manufacturers interviewed have stated they often struggle with planning and executing comprehensive integration strategies within their operations. With integration being a vital aspect of expanding automation and increasing overall operational efficiency, it is essential for many manufacturers that their operations be integrated. These integration challenges are further compounded by the ongoing lack of skilled labor, meaning that manufacturers struggle with acquiring new employees to make up for their lack of integration knowledge.

To address this challenge, manufacturers interviewed stated that they need additional, comprehensive integration services from OEMs, including planning an overall EoL integration strategy, identifying specific areas within EoL operations where integration is needed, and executing integration strategies through installations and improvements.

It should be noted that while the digital collection of data is a key to integrating operations, integration in general is a progressive transformation and not all companies are set up to manage, analyze, and utilize this approach effectively. OEMs have a role to play here as well in assisting manufacturers on the path toward greater integration.

We look for suppliers that can provide integration advice and services - we lack those skills internally.

— *Manufacturing Engineer,
Large Manufacturer of Home Goods
and Personal Care Products*

EARLY ENGAGEMENT WITH SUPPLIERS

We bring our suppliers in at the start of a line design so we know what the options are.

— *Sr. Packaging Engineer,
Large Manufacturer of Health Care
Products and Medical Devices*

Our operations are mostly manual now and we have plans to automate three filling lines next year; we're looking for U.S. partners to be totally involved with our automation projects and to provide quicker service.

— *Director of Engineering,
Small Manufacturer of Wellness Products*

OEMs are brought in rather early on an initial design, but it really depends on whether it's a new line or adding a piece of equipment to an existing line.

— *Director of Packaging Engineering,
Large Frozen Food Manufacturer*

About 50% of our EoL is robotics now and our goal is to use all robotics in the future.

— *Packaging Engineering Manager,
Leader in Agricultural Products*

INTEGRATION PARTNERS ARE CRUCIAL

We are growing rapidly and look to our OEM partners for new equipment and integration services due to our lack of internal expertise.

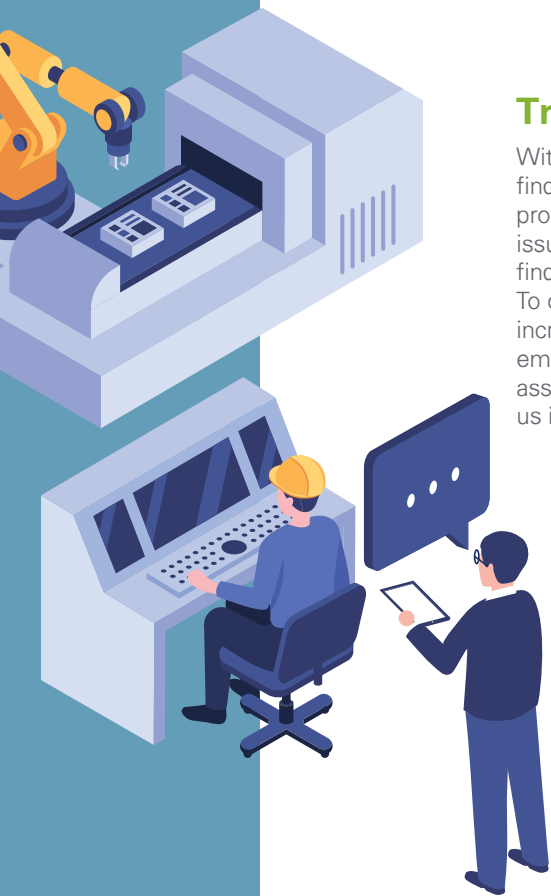
— *Principle Engineer,
Large Beverage Manufacturer*

In the near future, we will be looking for all end-of-line equipment for an entirely new line and want more integration services from our vendors. The more integration a vendor can do the better.

— *Director of Packaging Engineering,
Large Frozen Foods Manufacturer*

Our OEM partners need to have knowledge about the other machines installed along the line.

— *Engineering Manager, SME Copacker of
Household Products*



Training and Instruction

With the ongoing labor shortages in the manufacturing industry, companies are finding it increasingly difficult to recruit and retain the labor necessary to maintain production levels. While many have turned to automation as a way to alleviate this issue, the higher levels of automation on EoL equipment have created a new problem: finding employees with a high enough skill level to operate automated machinery. To overcome this challenge, manufacturers have requested that their OEM partners increase the amount of training they offer, including expanded courses for new employees and an increase in ongoing education to refresh employee skills. As an assistant engineering manager at a CM/CP summarized: “The greatest challenge for us in the year ahead is learning how to run and operate all of our new equipment.”

Manufacturers Forecast Their EoL Equipment Purchases in the Future

PMMI
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Palletizing (some robotic)	88%
Case /Tray Handling	73%
Labeling, Decorating and Coding	50%
Wrapping and Bundling	38%
Conveying	27%

Exceeds 100% due to multiple answers

► Collaborate For a Lasting Partnership

With healthy growth predicted for EoL packaging machinery and a number of trends positively influencing the EoL equipment market, OEMs operating in the EoL space will have significant opportunities in the future to form lasting partnerships. To best position themselves, OEMs should remain cognizant of the needs of manufacturers – from equipment flexibility to training – and carefully factor in the machine attributes manufacturers are most concerned with. Most importantly, OEMs should spend time communicating directly with their customers to understand their pain points and future needs.

► As Manufacturers Explore End-of-Line Strategies, Suppliers Should Keep in Mind the Critical Information Requested at the Onset of a Project:

- Machine Specifications
- Integration Capabilities
- Cost Estimates (Purchase, Maintenance, Training, Installation, etc)
- Timeframe Delivery/Availability
- Support/Service
- Aftermarket Services

Manufacturers face a number of challenging realities in the EoL packaging space and have explicitly requested that OEMs play a larger role in helping them navigate current and future projects by listening to their specific needs. By proactively offering advice and taking the time to thoroughly understand their customers’ operations and needs, OEMs can strengthen their account relationships and grow their business into the future.

► Appendix A – Value of Shipments of EoL Machine Purchases by Industry Compared to all Packaging Machinery (2020)

Value of Shipments: EoL Machine Categories as a Percentage of All Packaging Machines Purchased 2020			
Industry	All Packaging Equipment Purchases 2020 \$ MM	All EoL Equipment Purchases 2020 \$ MM	% of EoL Purchases, 2020
Beverage	\$1,972	\$901.3	45.7%
Food	\$3,802	\$1,619.9	42.6%
Household, Industrial & Agricultural Chemicals	\$805	\$370.7	46%
Personal Care, Toiletries & Cosmetics	\$679	\$408.4	60.1%
Pharmaceuticals	\$800	\$285.4	35.7%
Other End-User Sectors	\$1,389	\$836.2	60.2%
TOTALS	\$9,447	\$4,421.9	46.8%

Source: 2021 PMMI State of the Industry Report

► Appendix B: End-of-Line Machine Categories and Sub-Categories Value of Shipments 2015 and 2020

End-of-Line Machine Categories and Sub-Categories 2015 and 2020 Purchases and CAGRs	2015 Sales Value (\$ MM)	2020 Sales Value (\$ MM)	2015 - 2020 CAGR (%)
Group 1: Case / Tray Handling Machinery	\$1,102	\$1,624	8.06%
Case / Tray Sealing Machines	\$181	\$236	5.45%
Case / Tray Loading / Unloading Machines	\$333	\$527	9.62%
Case Erecting / Tray Forming Machines	\$259	\$369	7.34%
Case Group / Load and Close / Seal Machines	\$329	\$492	8.38%
Group 2: Conveying Machines	\$530	\$671	4.83%
Roller Conveyors	2018: \$185	\$208	6.03 (2 yrs)
Tabletop Chain Conveyors	2018: \$166	\$200	9.76 (2 yrs)
Belt Conveyors	2018: \$227	\$263	7.64 (2 yrs)
Group 3: Labeling, Decorating, and Coding Machinery	\$1,006	\$1,363	6.26%
Coding Machines	\$345	\$433	4.65%
Dating, Printing, Marking, Stamping and Imprinting Machines	\$260	\$338	5.39%
Labeling Machines (Product Identification, Decorating)	\$401	\$592	7.62%
Group 4: Palletizing Machinery	\$328	\$429	5.52%
Pallet Unitizing Machines	\$52	\$69	5.82%
Palletizing – Ancillary Machines	\$52	\$69	5.28%
Palletizing – Depalletizing Machines	\$224	\$291	5.37%
Group 5: Wrapping / Banding / Bundling Machinery	\$261	\$335	5.12%
Wrapping / Banding / Bundling Machines	\$261	\$335	5.12%
Total Value of Five Machine Categories	\$3,227 MM	\$4,422 MM	6.50%

Source: 2021 PMMI State of the Industry Report

► Appendix C – EoL Equipment Sales Value by Industry Category

Total ALL End-of-Line Machine Categories by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$901.3	20.4%
Food	\$1,619.9	36.6%
Household, Industrial & Agricultural Chemicals	\$370.7	8.4%
Personal Care, Toiletries & Cosmetics	\$408.4	9.2%
Pharmaceuticals	\$285.4	6.5%
Other End-User Sectors	\$836.2	18.9%
TOTALS	\$4,421.9	100%

Total Wrapping / Banding / Bundling Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$64.9	19.4%
Food	\$102.4	30.6%
Household, Industrial & Agricultural Chemicals	\$43	12.8%
Personal Care, Toiletries & Cosmetics	\$32.1	9.6%
Pharmaceuticals	\$8.3	2.5%
Other End-User Sectors	\$84.3	25.1%
TOTALS	\$335	100%

Case /Tray Sealing Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$25.7	10.9%
Food	\$95.4	40.4%
Household, Industrial & Agricultural Chemicals	\$10.2	4.3%
Personal Care, Toiletries & Cosmetics	\$22.7	9.6%
Pharmaceuticals	\$13	5.5%
Other End-User Sectors	\$69.1	29.3%
TOTALS	\$236.1	100%

Case /Tray Loading / Unloading Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$117.2	22.3%
Food	\$282.8	53.7%
Household, Industrial & Agricultural Chemicals	\$12.1	2.3%
Personal Care, Toiletries & Cosmetics	\$39.6	7.5%
Pharmaceuticals	\$20.3	3.9%
Other End-User Sectors	\$54.4	10.3%
TOTALS	\$526.4	100%

Case Erecting /Tray Forming Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$105.6	28.6%
Food	\$161.9	43.8%
Household, Industrial & Agricultural Chemicals	\$17.8	4.8%
Personal Care, Toiletries & Cosmetics	\$32.4	8.8%
Pharmaceuticals	\$10.2	2.8%
Other End-User Sectors	\$41.4	11.2%
TOTALS	\$369.3	100%

Case Group / Load and Close / Seal Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$143	29.1%
Food	\$210.4	42.8%
Household, Industrial & Agricultural Chemicals	\$24.1	4.9%
Personal Care, Toiletries & Cosmetics	\$11.9	2.4%
Pharmaceuticals	\$25.4	5.2%
Other End-User Sectors	\$77	15.6%
TOTALS	\$491.8	100%

Total Case /Tray Handling Category by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$391.5	24.1%
Food	\$750.5	46.2%
Household, Industrial & Agricultural Chemicals	\$64.2	4%
Personal Care, Toiletries & Cosmetics	\$106.6	6.6%
Pharmaceuticals	\$68.9	4.2%
Other End-User Sectors	\$241.9	14.9%
TOTALS	\$1,623.6	100%

Dating, Printing, Marking, Stamping and Imprinting Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$45.2	13.4%
Food	\$117.3	34.7%
Household, Industrial & Agricultural Chemicals	\$31.4	9.3%
Personal Care, Toiletries & Cosmetics	\$37.3	11%
Pharmaceuticals	\$42.8	12.6%
Other End-User Sectors	\$64.2	19%
TOTALS	\$338.2	100%

Labeling Machines (Product Identification, Decorating) by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$168.2	%28.4
Food	\$183.7	%31.1
Household, Industrial & Agricultural Chemicals	\$54.8	%9.3
Personal Care, Toiletries & Cosmetics	\$65.9	%11.1
Pharmaceuticals	\$42.5	%7.2
Other End-User Sectors	\$76.5	%12.9
TOTALS	\$591.6	%100

Coding Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$74	%17.1
Food	\$163.4	%37.8
Household, Industrial & Agricultural Chemicals	\$26.8	%6.2
Personal Care, Toiletries & Cosmetics	\$69.5	%16
Pharmaceuticals	\$30.4	%7
Other End-User Sectors	\$69	%15.9
TOTALS	\$433.1	%100

Total Labeling/Decorating/Coding by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$287.4	21.1%
Food	\$464.4	34%
Household, Industrial & Agricultural Chemicals	\$113	8.3%
Personal Care, Toiletries & Cosmetics	\$172.7	12.7%
Pharmaceuticals	\$115.7	8.5%
Other End-User Sectors	\$209.7	15.4%
TOTALS	\$1,362.9	100%

Roller Conveyors by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$34.2	16.4%
Food	\$59.1	28.3%
Household, Industrial & Agricultural Chemicals	\$24.3	11.7%
Personal Care, Toiletries & Cosmetics	\$10.1	4.8%
Pharmaceuticals	\$15.3	7.4%
Other End-User Sectors	\$65.4	31.4%
TOTALS	\$208.4	100%

Tabletop Chain Conveyors by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$28.7	14.3%
Food	\$51.5	25.7%
Household, Industrial & Agricultural Chemicals	\$26.2	13.1%
Personal Care, Toiletries & Cosmetics	\$11.8	5.9%
Pharmaceuticals	\$20.5	10.3%
Other End-User Sectors	\$61.4	30.7%
TOTALS	\$200.1	100%

Belt Conveyors by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$43.3	16.5%
Food	\$69.2	26.3%
Household, Industrial & Agricultural Chemicals	\$31.2	11.9%
Personal Care, Toiletries & Cosmetics	\$26.4	10%
Pharmaceuticals	\$15.2	5.8%
Other End-User Sectors	\$77.3	29.5%
TOTALS	\$262.6	100%

Total Conveying by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$106.2	15.8%
Food	\$179.8	26.8%
Household, Industrial & Agricultural Chemicals	\$81.7	12.2%
Personal Care, Toiletries & Cosmetics	\$48.3	7.2%
Pharmaceuticals	\$51	7.6%
Other End-User Sectors	\$204.1	30.4%
TOTALS	\$671.1	100%

Pallet Unitizing Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$4.9	7.1%
Food	\$12.5	18%
Household, Industrial & Agricultural Chemicals	\$14.7	21.2%
Personal Care, Toiletries & Cosmetics	\$9.9	14.3%
Pharmaceuticals	\$10.1	14.6%
Other End-User Sectors	\$17.2	24.8%
TOTALS	\$69.3	100%

Palletizing – Ancillary Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$8.8	12.8%
Food	\$18.2	26.4%
Household, Industrial & Agricultural Chemicals	\$12.2	17.7%
Personal Care, Toiletries & Cosmetics	\$12.2	17.6%
Pharmaceuticals	\$6.4	9.3%
Other End-User Sectors	\$11.2	16.2%
TOTALS	\$69	100%

Palletizing – Depalletizing Machines by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$37.6	12.9%
Food	\$92.1	31.7%
Household, Industrial & Agricultural Chemicals	\$41.9	14.4%
Personal Care, Toiletries & Cosmetics	\$26.6	9.1%
Pharmaceuticals	\$25	8.6%
Other End-User Sectors	\$67.8	23.3%
TOTALS	\$291	100%

Total Palletizing by Industry		
Industry	2020 \$ MM	2020 % Share
Beverage	\$51.3	12%
Food	\$122.8	28.6%
Household, Industrial & Agricultural Chemicals	\$68.8	16%
Personal Care, Toiletries & Cosmetics	\$48.7	11.3%
Pharmaceuticals	\$41.5	9.7%
Other End-User Sectors	\$96.2	22.4%
TOTALS	\$429.3	100%

Source: 2021 PMMI State of the Industry Report

Appendix D – Value of Shipments 2020 and Projections Through 2026

Total Value of Shipments Packaging Machinery – 2020			Projected Value of Shipments Packaging Machinery – 2026		
Industry	2020 \$ MM	2020 % Share	2026 \$ MM	2026 % Share	CAGR % 2020-2026
Beverage	\$1,972	20.9%	\$2,799	21.9%	6.1%
Food	\$3,802	40.2%	\$4,953	38.7%	4.5%
Household, Industrial & Agricultural Chemicals	\$805	8.5%	\$1,182	9.2%	6.6%
Personal Care, Toiletries & Cosmetics	\$679	7.2%	\$841	6.6%	3.6%
Pharmaceuticals	\$800	8.5%	\$1,239	9.7%	7.6%
Other End-User Sectors	\$1,389	14.7%	\$1,780	13.9%	4.2%
TOTALS	\$9,447	100%	\$12,794	100%	5.13%

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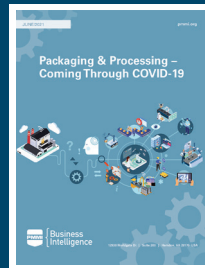
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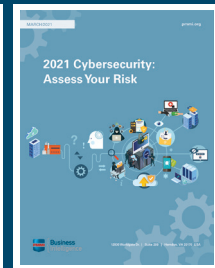
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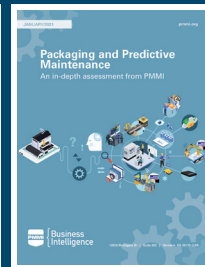
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