



Cold Storage Automation: Leveraging Advanced Technologies to Meet Increasing Demand

With cold storage industry growth projected at 4.5% by 2023 due to increased consumer demand, food producers are under a lot of pressure to evaluate where their products are produced versus where they are consumed. The farther away from the consumer, the more points in the supply chain before being consumed. The use of automated systems, intelligent software, strategic fulfillment design and a widespread, diverse network are all tactics for helping today's cold chain professionals manage their operations.

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What is cold chain?

Simply put, the cold chain is comprised of a network of food producers, as well as storage, transportation and distribution providers which ensure fresh and frozen food reaches consumers.

Automating a cold storage operation has common considerations such as the unique operational requirements, technology selection, and building design.

Frozen food supply is heavily reliant on managing the process of refrigerating, freezing, and defrosting, therefore the goods are strictly managed throughout this process from farm to consumer. When it comes to refrigerated and frozen storage facilities, the four most common types are:

- Pre-production
- Hub
- Distribution center
- Post-production

Pre-production facilities are typically close to the site of raw materials and in some cases attached directly to the plant. The next phase of the process is to transport the materials to a hub, which serves a much broader customer base. After the hub, goods continue toward a distribution center. This distribution center might serve a major retailer or an in-network producer. In both cases, packaging automation and sortation equipment are common in these facilities. A post-production facility serves as a refrigerated or frozen storage location where product waits until it's needed. This is the final stop before reaching the consumer or retailer. To ensure quick access and fresh goods, post-production facilities are located within the markets they are serving.



As you can imagine, the cold chain is inherently inefficient: It's not always feasible to locate large production sources or raw materials close to major markets, or for producers to have small-scale, distributed production centers. Back in July 2020, The Center for Urban Education about Sustainable Agriculture estimated that the average meal in the US travels 1,500 miles from farm to plate.

Added to that, the amount of energy used in these facilities is significantly higher compared to any other industrial space. For example, Walmart, stated in 2018 that its refrigeration systems account for 30 to 50% of their overall energy usage. Research shows that refrigerated warehouses consume an average of 24.9 kilowatt-hours (kWH) of electricity per square foot each year. On the other hand, traditional warehouses consume about 6.1 kWH per year.

How can cold chain supply professionals prepare for the expected growth? By mitigating the factors stated above and leveraging the right material handling automation, the future of the cold chain will be transformed. It will assist in increasing efficiency in an otherwise inefficient supply chain, while injecting cost savings throughout the process. This paper will detail specifics involved in considering automation as well as which automation technologies might be best.

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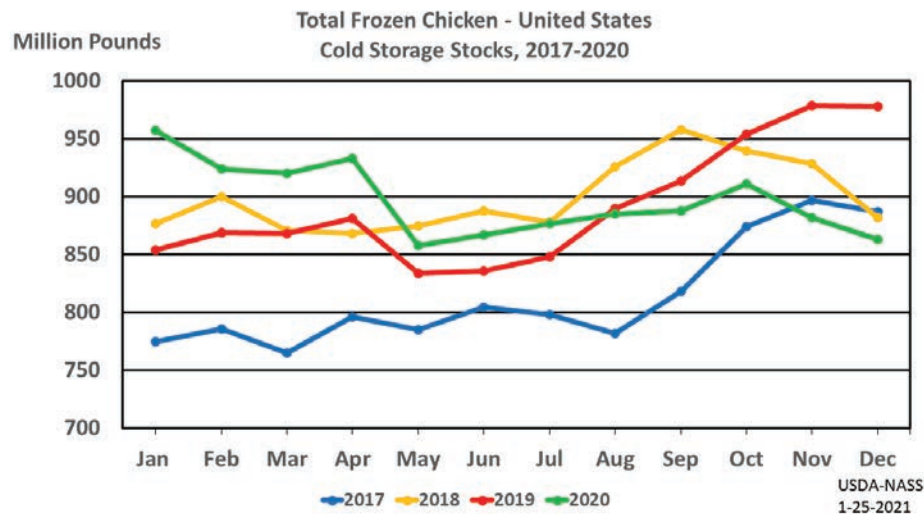
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Market Considerations

Analysts expect the cold storage sector to grow at a compound annual growth rate of 4.5% by 2023 as the demand is ever increasing. Population increase has historically been a driving force for cold storage growth, however, recently the industry's upward trend has shown to outpace the population indicator. Past and current data supports this trajectory. The year 2020, while an outlier in unusual circumstance because of the 2019 Novel Coronavirus pandemic, has further driven trends towards a continued increase in frozen goods that, experts say, will last.

Prior and throughout the pandemic, the ecommerce and food and beverage industries were seeing a shift towards microfulfillment centers (MFCs) for rapid, convenient deliveries. In 2020 this market skyrocketed due to its convenience and social distancing benefits. Industry research shows a 58.6% overall growth in ecommerce from 2019 to 2020 (this includes multi-outlet and grocer) as compared to a 22% increase from 2018 to 2019.

Looking at grocery specifically, the highest growth rate was seen in frozen goods -- fruit, appetizers and snacks, and processed poultry. Spend has increased the most on Frozen seafood, ice in frozen seafood, ice cream and novelties, frozen entrees and prepared food. How does this compare to fresh produce? Sales of frozen fruits and vegetables grew 15.6%, ahead of an 8.2% gain for fresh produce.

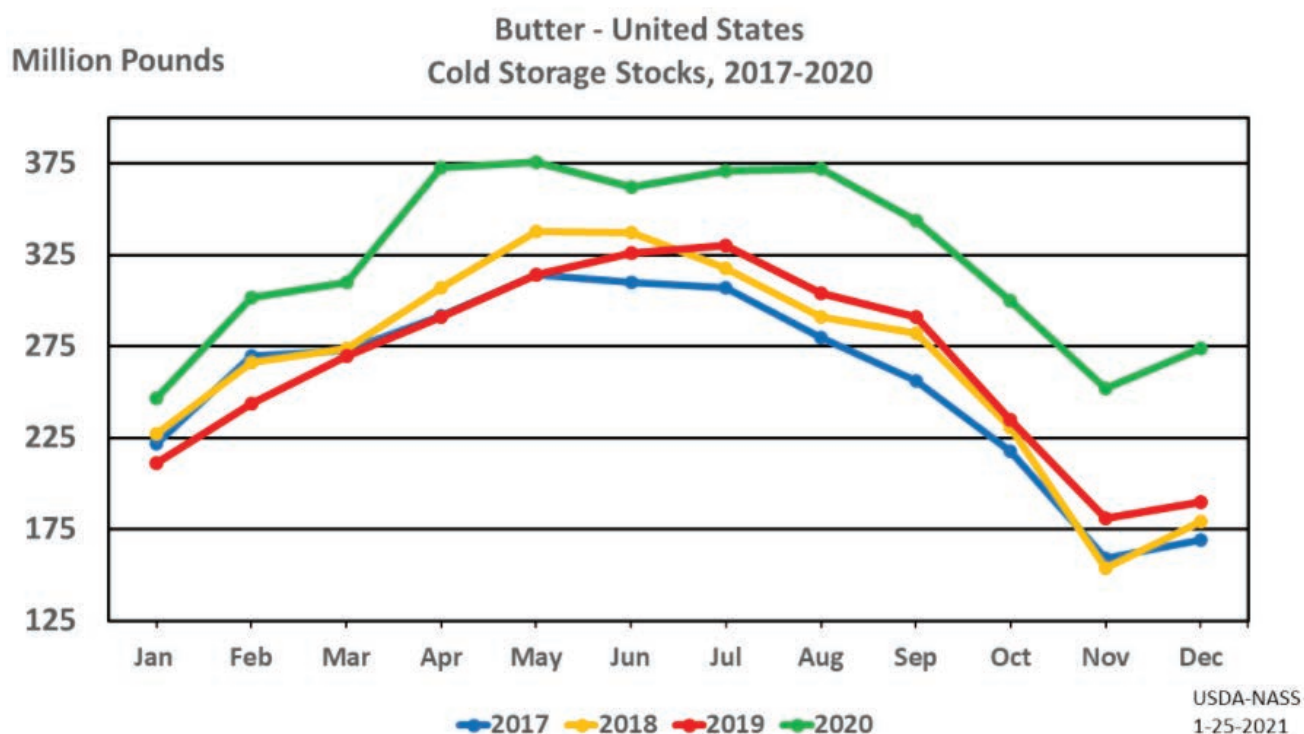


Source: USDA



By looking closer at the sudden rise, details show that frozen sales saw a large spike of 70% in March, when news of the pandemic and “stay at home” orders were implemented. That shift can’t be ignored. Frozen food increased throughout the year; a large 17% (\$1.4 billion) increase in August-September.

On a monthly basis, the USDA collects and publishes end of month stock of meat, dairy, fruits, vegetables, in public and private refrigerated warehouses. Reports mirror the upward trend reflected in frozen food sales growth. Frozen vegetables, for example, saw a 6% increase in warehouse stock compared to 2019; and dairy products like cheese and butter were up 6% and 44% respectively. Seasonally, we consume more or less of each of these products throughout the year but there is clear year-over-year growth in both warehouse stock and sales.



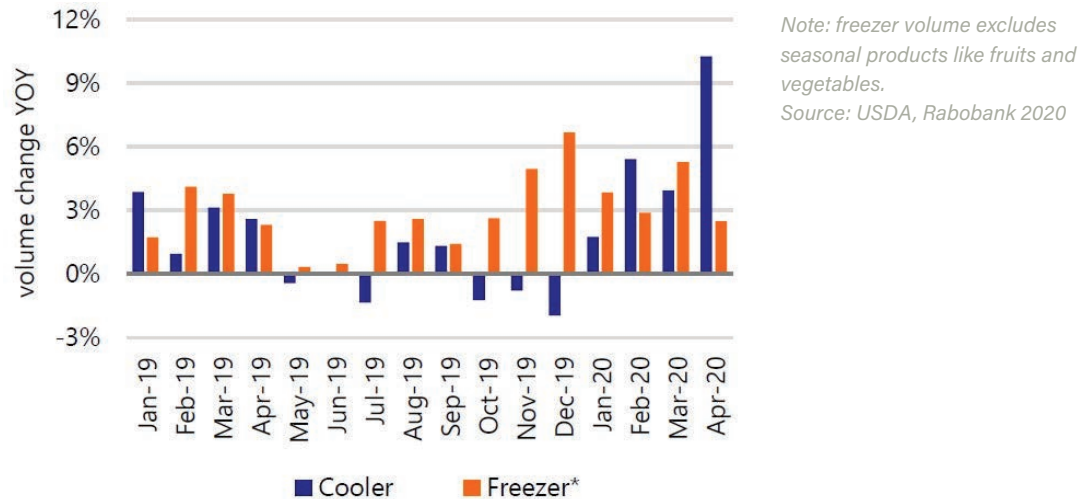
Source: USDA

What is the driving factor? Convenience, quality, relevance and a greater variety of goods, according to industry studies and data. Some experts attribute this to the “pantry stocking effect” of stocking up on goods that have a long shelf-life but with limited residential freezer space this means there’s only so much that can be stored at one time. Frozen goods and prepared foods also mean increased meal options are attractive for those looking at alternatives to dining out. Online shopping and curbside pick-up only add to these conveniences.

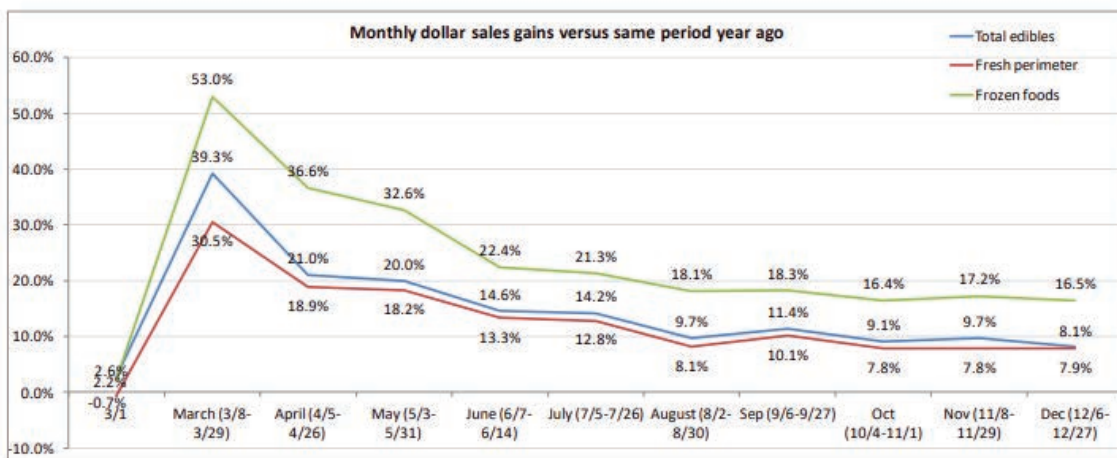
What does the data mean for cold storage?

This presents an obvious challenge for storage providers as the amount of inventory as well as the relative speed of that product fluctuate throughout the seasons.

Figure 1: US cold storage volume change YOY, cooler and freezer, January 2019-April 2020



While the surging increase in market demand and sales for frozen and refrigerated foods is on the rise, US freezer and cooler volume rose by 2.5% and 10.3% respectively in April 2020, compared to a year earlier. Reported capacity data shows that the average year-over-year growth from January 2018 through September 2020 was 1.6% for freezer and 3.8% for cooler space.



Source: IRI, Integrated Fresh, Total US, MULO, 4 week view % change vs. year ago

Sales data (see graph) in frozen foods is proving strong, consistent demand. Growth in omni-channel adoption and microfulfillment has already accelerated an increased demand to support urban and suburban grocery stores with specialized cold chain infrastructure. These nearby temperature-controlled facilities will help to provide additional capacity and more centralized planning. Automation technology only further helps to meet the fast demand and achieve accuracy where errors mean product loss. Frozen or refrigerated returned goods likely cannot be resold because it's unknown if or how long the products had been in ambient temperature, creating quality control risks.

There is a greater need to increase the shelf life of goods and invest in the technology that will support these efforts. As the technology used within this space becomes more capable, better connected, and better controlled, it will unlock new business opportunities.



Key Criteria for Cold Storage Automation

There are significant barriers to entry in the cold storage sector as there is substantial initial investment costs for construction. The “cold” aspect of cold storage requires specific materials that can tolerate low or variances in temperature, space to accommodate equipment and locations that promote efficient fulfillment. This makes it very difficult for smaller operators to break into the market or compete with larger companies.

In general, aspects to consider include:

- Costs to build a cold storage facility are typically 2-3x when compared to a conventional warehouse.
- The average age of cold storage facilities in the US is 34 years.
- Operational considerations
 - Temperature requirements
 - Operating hours
 - Order profile
 - Facility location



Many items specific to cold chain's unique operations can impact the ability and level to which companies can automate.

- Do you have multiple temperature storage zones you need to maintain, for example, a cooler and a freezer?
- How many shifts or hours do you need to run?
- What does your typical order profile look like?
- Are orders primarily in full pallet quantities?
- Do you have full layer orders and the need for mixed layer building?
- What about case level orders?



Breaking down each area of concern:

Location and Site Selection

Facility location is an important factor. The location can greatly impact access to the necessary labor market. Labor costs can be a huge driver toward automation, as the low temperature environment means associates have limited amount of time in the freezer. Productivity and efficiencies in general become much lower compared to a conventional warehouse due to the limited time they can spend in the freezer environment.

A facility's location can also influence the type of **automation system** configuration it can house. Due to the high operational costs, utilization of the vertical cube is important. Building as tall as possible is extremely common for these types of systems. What are the local building height restrictions? For example, being located close to airports or major cities may bring specific regulations that limit your building height. Height may also impact property set-back lines and could require adjustments to the ideal site configuration. Conducting studies help to generate a strategic design that takes into account the network, operation and location considerations to help identify problematic issues, how to avoid them or help find a more suitable location.

Cooler and freezer warehouses are almost always built-to-suit. These are high performance buildings, and there are specialty builders that focus solely on this type of construction. Rack supported structures enable you to build much higher than a conventional building at a better price point and enable better cubic density within the storage racking, as there are no building columns. If an automated pallet storage system is something that would suit your operation, you typically want to build as tall as you can. If the system would not benefit from fully automated pallet movement, conventional buildings designed for the freezer or refrigerated requirements would be suitable.

An additional challenge that some face in this industry is **flexibility**. As product mix changes over time, the required storage temperature could change as well. If this is a risk, companies should consider a convertible style building that could operate at different temperatures if change is needed in the future. It might be set up to be a refrigerated space now and could be converted to a freezer in the future. Similarly, the automation equipment would also need to be designed to suit this adaptability.





On the construction side, builders of these high-performance built-to-suit buildings say, “the speed to market is huge; it’s like an arms race.” This race includes incorporating automated material handling systems such as mixed case palletizing and piece picking for direct-to-customer home delivery. Research from 2020 estimates that the demand for cold storage space will rise by 100 million square feet during the next five years, a 47% increase.



Driven by a shift in ecommerce growth, there is a push in grocery distribution for automation, given the speed to market required which is increasing demand for grocery **microfulfillment centers** (MFCs). Due to the specialization needed for constructing these buildings, construction experts estimate that it takes five months longer to build than a standard warehouse.

Temperature

Another consideration in cold storage automation is that equipment might experience condensation build up, freezing, or fogging, based on where it is located within the facility. There can be temperature gradients at locations near doors, and it might require heated lenses or heated enclosures to ensure optical sensors work properly.

Energy efficiency also plays a factor. Ultimately, energy used by the material handling equipment is put out into the facility as heat. The amount of heat load generated by the equipment into the freezer is a very important consideration. Not only are the operational costs for these facilities already very high due to the refrigeration requirements, but the additional energy required to power the automation as well as the amount of heat load generated can become taxing.



The most innovative manufacturers have worked to optimize the energy use of their machines. For example, on a stacker crane that moves both vertical and horizontal, they use a common drive link with a single power supply and single power module for both drives. This allows one movement to benefit from the regenerative energy from the other in real time.

Additional developments have been made to store the surplus regenerative energy that is captured during the cycle that might not have been consumed immediately. It can be stored and used by the system in the future.

Technology & Automated Systems

When it comes to technology suited for cold storage automation, nearly all typical equipment in a conventional warehouse can be found in freezer warehouses. However, the equipment is specially designed with the temperature environment in mind, which does mean it's almost always more expensive.

Depending on the operation, goods might be stored in static racking within a low-bay conventional freezer building. If the throughput or inventory is high enough, the pallets might be stored with an **automated storage and retrieval system (ASRS)**. This system can utilize unit-load cranes, or potentially pallet shuttles to facilitate the storage and retrieval of products. For smaller, lighter goods, a mini load crane or case shuttle might be used. These can help rapidly retrieve and sequence items as they are fed to downstream processes for mixed case palletizing and order fulfillment.

- **ASRS unit-load cranes:** cost-effectively engineered to handle unitized loads in and out of high-density storage. There are a variety of horizontal and vertical speed options, and lightweight cranes mean acceleration is variable as well. These allow for load stability and low noise levels while maintaining the fastest possible operational speeds. Picker workstations are significantly more ergonomic within the goods to person functionality, and operations get real-time inventory control and constant communication to reduce lost productivity.
- **Pallet shuttles:** These use a cart system to transport pallets quickly through deep-lane storage units. Some options include lift capabilities to move pallets vertically. These carts make it possible to store, retrieve and manage products quickly and efficiently. In freezer areas where temperatures are in the negative, this is an ideal solution to maintain worker comfort and provide greater configurability than traditional forklifts.
- **Mini-load shuttle:** Designed to store and retrieve small items in less space and time, they include lightweight alloys that increase speed and offer lower costs associated with installation, operation and maintenance. Much like unit-load cranes, they offer ergonomic workstations, variable speeds and acceleration, as well as added load stability and low sound levels. They can be built at many different heights, are easy for operators to be trained on, and have a footprint as narrow as 7-feet which means it can be installed close to the factory or warehouse use point.





- **Automated forklifts (AGFs):** A massive facility overhaul comes with large costs that some operators might not be able to budget. Analysis and studies also realize that inventory might not move fast enough to fully benefit from an automated storage and retrieval system. An automated forklift on the other hand can be a great improvement for these operations without requiring massive overhaul or investment.
- **Robotic picking and palletizing:** Full layer picking is another strategy that has made its way into cold storage environments. Robots can strategically pick one or more layers off a pallet to build what is often referred to as a “rainbow pallet” or “mixed SKU” pallet based on the customer’s order. This is an increasingly common request among smaller companies that need a wider variety of SKUs to fill customer orders. They may request a full pallet of one product but only a layer or two of another. Robots are flexible and can make cold storage warehouses more adaptable to market changes.



Intelligent Software

In a cold storage environment, efficiency encompasses energy use, reducing movement in and out of freezer areas to maintain temperatures, strategic packing to reduce product loss, inventory tracking, optimal workflows for employee comfort in cold zones, and the overall order fulfillment process. Integrated software is the key to a successful automated material handling system.

Warehouse software can give you the visibility needed to make the decisions that are crucial, particularly in a freezer environment. With a variety of software solution options available, you can combine existing software or implement a total solution. Either way, you’ll be able to better leverage automated technology for a smarter and more cost-efficient cold storage warehouse.



- **WMS: Warehouse Management System (WMS)** provides a suite of applications that enable an operation to plan processes within the warehouse, increasing efficiency. This software can manage receiving, returns, quality control, waving, picking and pack and ship. It also includes inventory management offering replenishment and cycle count, paired with business intelligence equipped to monitor workflow and give an eagle’s-eye view of the entire operation.

- **WCS: The Warehouse Control System** (WCS) system works to orchestrate material and information flow, organizing order fulfillment and material handling equipment processes. It provides a single central interface to host the entire system from any variety of vendors and will react to feedback from automation and equipment to adjust workflows. The WCS monitors warehouse performance to track workflow and system uptime as well as providing alerts to possible problems.
- **WES: The Warehouse Execution System** (WES) combines WCS and WMS functions to coordinate labor and equipment inside a highly automated facility. Dynamic optimization through real-time inputs allow operators to apply knowledge gained from reports to optimize operations in a distribution center. It is also hardware-independent and features modular architecture, which keeps the system flexible. Generated data can provide predictive analysis and issue detection to ensure peak operation.

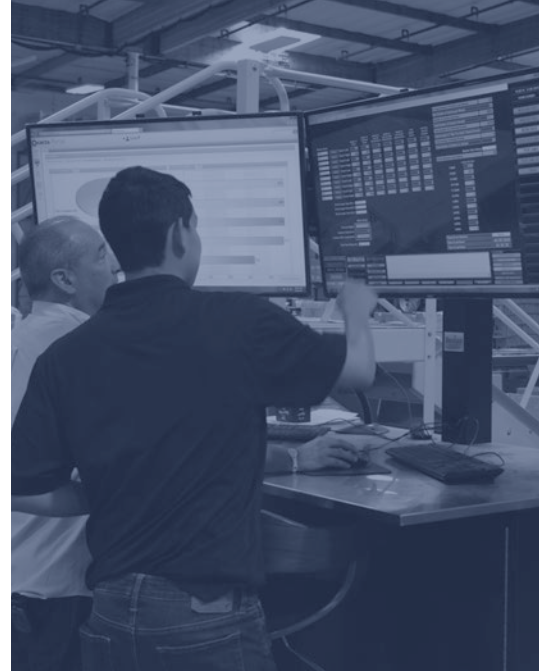
Some software suites can interface with any host system or can be implemented as a complete solution. This provides increased flexibility in technology selection, reduced inefficiencies, and powerful analytics to monitor labor and automation equipment. Software solutions help drive the most ROI benefits from your automated systems.

Consulting: Strategic Fulfillment Design

An efficient, high-return cold chain operation must begin with a detailed consulting study. Consultants are a key aspect for making decisions around the naturally increased cost of cold chain, as well as specific requirements in relation to temperature or municipality requirements.

Data collected during consulting is needed when considering every aspect involved in a cold storage operation – from location all the way to technology selection, a **Facilities Master Plan** will begin with project planning to define requirements and goals, source suppliers, and design the system to determine final layout and validate equipment selection to ensure strong ROI. The final step is project implementation – if desired, expert consultants can provide a true “turn-key” facility by offering project management, review and supervision, as well as support upon start-up.

If an entirely new facility is not needed, an **engineering consulting survey and study** will give a customized road map for improving the current operation. Once data is gathered, consultants forecast changes based on growth or new requirements and provide recommendations to improve the facility overall. Consultants will define, measure, analyze, design and validate the entire facility.





To address issues within a network, a **supply chain network design study** may be necessary to achieve the highest efficiency throughout the entire network. Having a supply chain efficient enough to respond to the constantly changing market needs can mean the difference in spending or saving – millions of dollars – when shipping and volume patterns change. Costs can also rise if the network is not optimized for current requirements.

These detailed studies reduce overall costs, improves customer service, offers contingency, and what-if planning and analysis to ensure alternative measures are available. This keeps your operations adaptable and competitive in an industry that is on the rise.

Case Study: Automation Technology Drives Cold Storage Flexibility

A major temperature-controlled warehousing and transportation company recently worked with Bastian Solutions to build and automate a warehouse in the southern US to expand its storage potential in the metropolitan area chosen.

While many cold storage facilities are plant attached and driven by the customer's needs, the company decided to build a standalone, privately owned facility with a goal to contract out the storage space to support the rapid growth in cold chain distribution.

Key Technologies and Features:

- Exacta Warehouse Execution System (WES)
- Full-layer robotic EoAT picking
- 140-foot-tall ASRS deep-lane unit load crane
- Automated case shuttle
- Case conveyor
- Gantry crane system
- Pallet support board system
- -10° F pallet and case storage zones
- 35° F load, unload and picking areas



This facility is a rack-supported, 172,000 square foot space that features two storage zones to accommodate the customer's objective of flexibility to meet any future client needs. This means support for both pallet and case fulfillment, and in some situations, layer and mixed pallets. One of two -10° F rated zones includes a 140-foot tall, deep lane, unit load ASRS with 47,000 pallet positions. The second features conventional storage with case shuttles and two gantry crane systems. The picking area, 35° F to accommodate employee comfort, includes manual picking stations.



Having storage and robotics in such a cold facility added a new layer of difficulty, particularly with fire suppression. The company knew that adding a classic fire suppression system would limit the amount of storage space. The facility also features a unique hypoxic, or oxygen-reduced solution for the frozen 'rooms', which feature double doors and vestibules for temperature management at each entrance to the storage area. This unique system limits the oxygen in the room to the point that any spark or flame would not have enough fuel to ignite. The solution provides safety assurances, space efficiency, and the accompanying features help lock in cold temperatures for increased energy cost savings.

Upon arrival at the facility, pallets are automatically inspected to determine if pallet support boards (PSBs) are needed and are then unloaded into the deep lane, unit load ASRS. Bastian Solutions' Exacta warehouse execution system (WES) software tracks the pallets that head to storage until orders are placed.

Orders from this facility can range from a few cases to a pallet layer, or full pallet. Exacta routes full pallet orders from the ASRS to the truck loading area. Layer orders, on the other hand, are put on a monorail, sent to the manual de-wrap where the necessary layers are unwrapped. A robotic EoAT will pick the layer onto the order pallet, creating a "rainbow pallet" of mixed SKUs. All the while the donor pallet heads back to the high-bay storage area to await other partial-pallet or case orders. The order pallet proceeds on to the monorail system to either have additional, manually picked items added, or to be finalized, wrapped and shipped.

Case orders are managed by an automated case conveyor and case shuttle system within the -10° F storage and picking areas. If only a few cases are ordered, the gantry crane will pick a full layer from the donor pallet to a descrambler, which will prepare the cases to be transported to the case shuttle and to the 35° F manual case picking area. Here, the operators add them to pallets before they head to wrap and ship. The WES batches and routes orders, increasing efficiencies in productivity and energy consumption.

This cold-storage facility was designed to leverage its metropolitan-area location and maximize the degree to which it can provide flexibility for clients. Automation technology implemented with dense storage capabilities allow them to do just that.

The ASRS makes use of the most vertical space available which maximizes the number of clients and product that the facility can manage. The integration with Exacta helps not only to track and protect inventory but to also efficiently gather products for fulfillment with flexibility to complete tasks in batches for multiple clients. Adding an automated layer gantry picking system and case shuttle allows them to adjust as ecommerce grocery and other markets change and adjust, driving the need for a wider variety of products in varying quantities. With this versatility in mind, Bastian Solutions experts work to implement an automated system that can strategically build pallets. Products are handled gently and stacked by weight and size to reduce the potential for product loss while also improving shipping costs with premium palletizing.



Conclusion

Extending food shelf life and closing the gap between consumer and food producers has always been a top challenge. That's even more true today with continuous driving forces in ecommerce, particularly in food and grocery, that have moved the timeframes from a few days to next day and even same-day order fulfillment.

It's abundantly clear that strategic planning for cold storage facilities is absolutely necessary to stay competitive, reduce product loss, and make the most of these significant investments. Unlike traditional warehouses, the frigid environments take a tremendous toll on equipment and careful planning of supporting items like pallets or wheels, which can be easily damaged if not properly cold-rated or regularly inspected, is vital. "Proper engineering studies and testing of equipment can make a difference between on-time, on-budget projects that meet the expected throughput and functions," says Robert Humphry, Manager of System Sales at Bastian Solutions. Bastian Solutions experts can work with you to set up a test of components, materials, and technologies at our facility.

Knowing exactly what kind of cold storage environment you need for your facility – refrigerator, freezer or both – as well as the type of picking you expect to do – pallets, layers, cases, or a combination – also helps to identify optimal layouts, the ideal technology, and make adjustments for work needed to ensure operator comfort. Manual picking zones for example can have temperature adjustments to make zones more comfortable for employees, leaving room for maximum optimization of the dedicated frozen storage space.

"The need for fast fulfillment of shelf-stable goods, and labor considerations in these frigid spaces is creating a big push for automation," says Humphry. "It's no longer a 'what if we add automation' but 'what kind of automation technology'" Automation reduces expenses and cost for labor, especially if you run your system in a three-shift operation. Optimizing for storage density in the freezer zone is key for clients to have the right amount of inventory within the market area. "The driver there is that clients don't want to be paying for frozen space that they can't utilize for storage. Optimizing the density is key for them," says Humphry. For example, automated material handling systems like ASRS are used to maximize densities, robotic mix case palletizing and piece picking systems for ecommerce fulfillment.

Humphrey summarizes the embrace of cold storage automation: "Flexibility in cold storage and maximum throughput is the goal for many clients. Automation helps to leverage goods to person technologies, which is needed to help drive those efficiencies. A lot of companies are rapidly adjusting their supply chain to meet the market demands. They need to be out front to grab market share."





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