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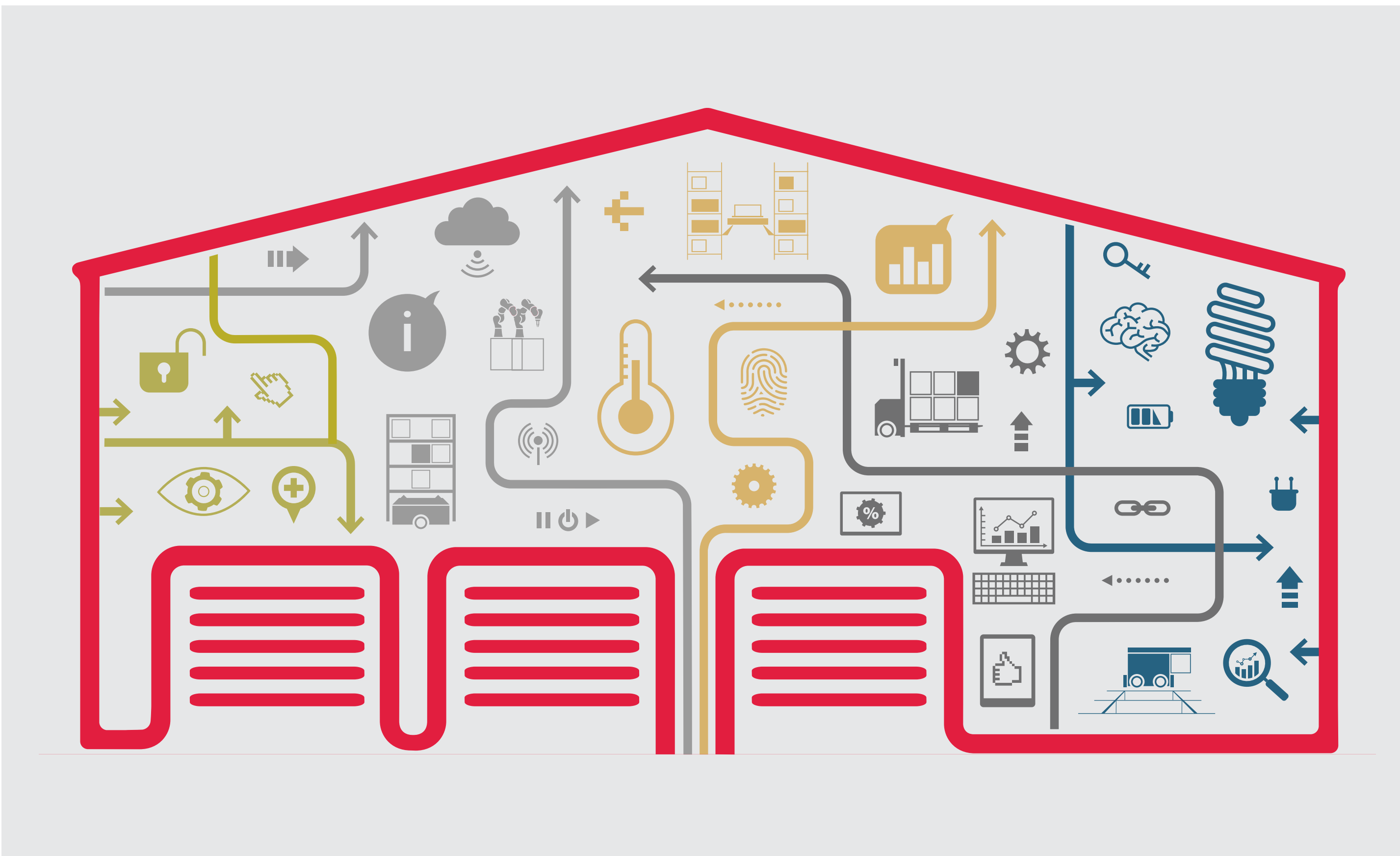
ENERGY EFFICIENCY IN AUTOMATED DISTRIBUTION FACILITIES



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INTRODUCTION

The advances in warehouse automation, which have enabled the tremendous improvements in order picking, order accuracy and speed of throughput required to keep pace with omni-channel fulfillment and distributed order management, have also increased the energy demands required to run these facilities. Add to this the continual increases in energy costs, power quality issues and tightening pollution regulations, and the need for optimizing energy usage in distribution operations has never been greater.

Fortunately, concurrent with these advances in logistics automation, has been a steady evolution of innovation to more efficiently manage energy utilization and capitalize on energy recuperation in these distribution facilities. Some of these key innovations incorporate redesigned equipment utilizing lightweight materials; speed reduction during low-load periods; low-voltage variable-speed drives; energy recuperation and sharing; avoidance of equipment simultaneous peaks; high-density product storage; and integrated system energy management.

TRACKING ENERGY CONSUMPTION

The ability to measure, visualize and track energy consumption throughout the distribution facility in real time provides an unparalleled level of transparency into energy usage, and allows the distribution systems to operate in a very energy-efficient manner.

Power monitoring devices positioned throughout the material handling equipment (MHE), connected via Ethernet or the Internet of Things (IoT), provide real-time information about energy usage. The power monitoring devices provide operators with a power consumption picture including amps, voltage, and the power factor, sequencing in total numbers for each phase and current. With this capability, power consumption calculations and measurement for each area of the distribution facility, even for each drive and motor, can be presented to the operators via an HMI. If an area is not running efficiently, operators will be able to see where the inefficiency is located and make adjustments accordingly.

"We spend considerable time with our client companies to measure, to analyze and to report on energy performance," said Marcus Wilcox, CEO of Cascade Energy (www.cascadeenergy.com), an industrial energy management firm based in Portland, Oregon. 'This starts right at the utility meter measuring the facility's entire power draw, then measuring processes and subsystems, then specific equipment, then right down to the I/O. These measurements are of real-time energy consumption. We then take key independent variables, like production fluctuations and weather, and factor these in to create a baseline model of energy consumption."

"Then, subsequent real-time energy consumption, right down to the I/O, can be compared to this baseline, and actions taken to strengthen or remedy the energy usage at specific systems or devices," added Wilcox. "The consistent challenge is not about the ability to gather data, but is almost always about the analytics, and making that data meaningful and actionable."

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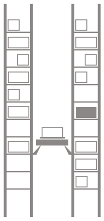
INTEGRATED ENERGY MANAGEMENT CONTROLS

One of the more interesting systems at play in automated distribution centers is the concept of integrated energy management controls. Once the power consumption values have been established for each automated system, subsystem and I/O, integrated energy management controls link the energy performance of these automated warehouse material handling systems – like automated storage and retrieval system (ASRS) cranes, conveying systems, lifts and shuttle systems – to these systems' actual real-time energy needs.

"Basically, these different systems and subsystems are connected via Ethernet or IoT, and they are communicating and sharing a power budget," said Samuel Schaerer, Controls Development Manager with Swisslog Warehouse and Distribution Solutions Technology Center, located in Buchs, Switzerland. "Their controllers are looking ahead the next 5 seconds, and they can tell each other what amount of energy each system, subsystem and axis is producing or using. The controllers can then coordinate and optimize the distribution (sharing) of harvested power from one system, subsystem or axis to another. They can also coordinate the delay and start functions of associated systems to again optimize the use of harvested energy, as well as minimize peaks in power draw caused by simultaneous machine starts."

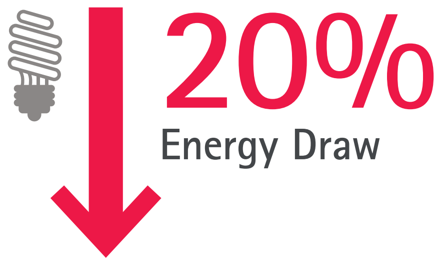
ENERGY RECUPERATION AND SHARING



ASRS cranes, mini-load cranes, shuttle systems and conveyor lifts have the capacity to generate electricity. Using their motors as a generator they contribute energy from friction when braking on downward vertical motion. The energy recuperation can account for approximately 3 percent from conveyor lifts, and 7 – 10 percent from ASRS cranes, mini-load cranes and shuttle systems. This recuperated energy, when shared, can then have significant impacts on reducing energy draw.

With ASRS cranes, for example, the recuperated energy generated from the vertical-axis downward motion of the crane's carriage can be redirected, or shared, to offset the comparatively heavier energy draw from the concurrent horizontal-axis motion of the crane. With this capability in play, total ASRS energy draw can be reduced by up to 20 percent.

Such a high percentage reduction in energy draw is also feasible with shuttle systems by coordinating the movements of shuttles, and timing the acceleration of one shuttle to the breaking profile of another shuttle. This permits one shuttle's energy recuperation to be shared with the other. This energy-sharing interplay can realize up to a 20 percent reduction in total shuttle system energy draw.



AVOIDANCE OF SIMULTANEOUS POWER PEAKS

Simultaneous peaks occur when a series of cranes, conveyors and other automated systems with high-rated drives are started up at the same time. A delay of a few seconds between two cranes, for example, will not significantly affect throughput requirements, hence a simultaneous start-up is not necessary. Avoidance of simultaneous peak energy draw leads to a less costly power, as well as less costly power distribution, permitting smaller transformers to be used which can decrease hardware costs.

"Much research and engineering is still ongoing regarding integrated energy management controls for the many highly-automated material handling systems used in distribution," explained Schaerer. "Controls for high-energy-consuming systems, such as ASRS cranes and mini-load cranes have now been standardized for energy recuperation and sharing, and with pallet cranes for minimization of simultaneous power peaks. Energy controls to support other systems, like shuttles and automated conveyors, are still under development."

REDUCED CONVEYOR SPEEDS DURING LOW-THROUGHPUT PERIODS

Research into power utilization by automated conveyor systems, with both AC and DC 24-volt variable-speed drives, has demonstrated that fluctuations in power consumption are directly related to the speed of the conveyor. When conveyor speed is slowed, less energy is required by the conveyor to operate. During low-throughput periods, providing variable-speed drives are used, if the speed of the conveyors is reduced then significant energy savings can be realized, particularly on larger systems where thousands of feet of powered conveyor is in use.

"In automated conveying systems, the greatest amount of energy is consumed while the conveyor is running, not during initial acceleration," added Schaerer. "Control systems that permit conveyor sections to be automatically turned on and off depending on whether throughput is occurring, or not, are inherently more energy efficient."

Such an energy-efficient system can operate in a look-ahead mode or dual-zone mode, where the system is looking at multiple zones ahead for what is happening through a combination of photo eyes to determine if the conveyor should continue or stop. Controlled through Ethernet or IoT, the system is capable of selectively turning on and off specific conveyor zones or sections of conveyor, or even a specific motor controlling a singular roller, if desired.

WEIGHT REDUCTION AND ENERGY-OPTIMIZED DESIGN

In recent years, a number of material handling manufacturers have literally gone back to the drawing board and reengineered many of their material handling systems from the ground up to reduce weight loads, while maintaining the systems' structural integrity and load-carrying ratings. A few of these systems are, for example, automated guided vehicles (AGVs), which some manufacturers have cut their vehicle weight by 30 percent without any reduction in load-carrying capability. Significant savings here on vehicle energy draw from lithium batteries, keeping these AGVs on the floor longer and reducing battery cycles.

Another system that has undergone extensive redesign to reduce weight is automated storage and retrieval stacker cranes for high-bays. Also add to this mini-load cranes used for high-bays, for case picks. Some manufacturers have completely reengineered and rebuilt their cranes, incorporating lighter weight materials and components, achieving up to a 20 percent weight reduction with no loss in load carrying capability. This equates directly to significant reductions in energy draw, as cranes are typically big consumers of power. These more energy-efficient cranes are a big benefit for distribution operations with considerable high-bay storage.

"Those distribution operations that have most aggressively implemented energy management systems have one overriding characteristic in common," explained Wilcox. "They have a senior-level management commitment to energy reduction, encompassing specific targets and very clearly defined action plans, with high-value key performance indicators (KPIs) to manage their energy spend."

This commitment is nowhere more evident in distribution than within deep-freeze and chilled warehousing operations.

Refrigerated warehousing is not only an expanding sector, it is also the most energy intensive, specifically deep-freeze facilities. In effect, deep-freeze warehouses are giant insulated freezers which extract heat to produce a cold environment. The removal of that heat comes at a hefty energy cost.

Energy is the #2 Warehouse Expense

"In cold-chain warehouses, energy is the number-two expense behind labor," continued Wilcox.

"This is unusual, compared to most other industries where energy ranks much lower."

"In public refrigerated warehouses, refrigeration uses 65 – 75 percent of total energy use," said Wilcox. "In food distribution and grocery warehouses, refrigeration uses about 50 percent of total energy use."

"Automation in refrigerated warehouses not only permits goods to be moved more rapidly and safely through the facility, but from an energy-management standpoint can significantly cut the energy draw for refrigeration," added Wilcox. "Equally important is that the energy draw for automation can then be reduced by optimizing the material handling equipment (MHE) systems for energy efficiency, and energy recuperation and sharing."

Traditional warehouses with 40 foot ceiling heights are heavy on roof and floor square footage, not the most energy-efficient design for refrigerated warehouses, given that the roof is the most direct source for heat from solar energy, compared to lesser amounts entering the facility through the structure's walls. If the facility is a deep-freeze warehouse it will have a heated floor, which also contributes heat into the space. These heat sources add to the refrigeration load required to pull the heat out of the warehouse.

IARW® International Association of Refrigerated Warehouses

The escalating demand for frozen food products worldwide has made refrigerated warehousing a continually expanding sector for distribution. A study published by the International Association of Refrigerated Warehouses (IARW), the *2016 IARW Global Cold Storage Capacity Report,* shows that 210 million cubic feet of refrigerated space was added to North American warehouses from 2014 to 2016, representing a 2.3 percent annualized growth rate. Worldwide, 1.7 billion cubic feet of refrigerated space was added to warehouses from 2014 to 2016, with an annualized growth rate in cubic footage of 4.2 percent.

HIGH-BAY ENERGY EFFICIENCY FOR CHILLED AND DEEP-FREEZE WAREHOUSING

The most energy-efficient building configuration for refrigerated warehouses is one where the ceiling and floor footprints are minimized to reduce heat entering the space. In effect, high-bay warehouses with ceiling heights of 100 – 120 feet. High-bays also facilitate a more cubic design for product storage, which not only optimizes space utilization, but increases inventory density resulting in greater retention of cold.

High-bays optimize cubic space usage, not only by their vertical pallet-stacking capability, but also by minimizing aisle cubic footage. By eliminating the need for forklift trucks, aisles can be made more narrow, allowing space for more pallet storage positions.

"Chilled high-bay warehouses can reduce refrigeration load by as much as 20 percent compared to low-bay facilities," said Jay Kell, Vice President of Republic Refrigeration (www.republicrefrigeration.com), a leading supplier of refrigeration design and installation services for industrial and distribution facilities, based in Monroe, North Carolina. "That would equate to a 10 – 15 percent decrease in electrical power draw in the refrigeration system, which is a considerable energy cost reduction.

"In deep-freeze high-bay facilities the reduction in refrigeration load and energy draw would be even greater," added Kell. "As much as a 20 percent cut in power draw could be realized with a high-bay configuration. In both chilled and deep-freeze high-bay warehouses, capital costs for refrigeration equipment would be reduced as well, when compared to a conventional low-bay structure."

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> - Jay Kell, *Vice President of Republic Refrigeration*

Automated Storage and Retrieval Cranes
Managing the product load within refrigerated, deep-freeze and ambient-temperature high bays are the ASRS cranes for pallet loads, and mini-load cranes for handling cases.

The most advanced ASRS operating in high-bay refrigerated warehouses provide a uniquely flexible and modular design, equipped with multi-load remote pallet handling capability which is ideal for chilled and deep-freeze warehouse environments down to -18 degrees F. These systems allow configuration to the right storage and retrieval need for almost any application, and provide single-deep, double-deep, triple-deep and multi-deep storage. Using a satellite remote unit, a pallet can be run 40 feet into the racking – as much as 10 pallets deep, and then return back to the ASRS crane, which can be performing these functions up to 140 feet above the warehouse floor.

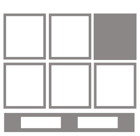
The latest ASRS cranes can carry payloads of 11,000 pounds, traveling at vertical speeds of 325 feet-per-minute (FPM) and achieving horizontal travel speeds of 787 FPM. They are designed to deliver energy efficiency in deep-freeze storage because of their flexibility and optimization for peak throughput, performing many moves in and out of the racking. These modern systems reduce energy consumption by operating at variable speeds depending on the demand load in the warehouse, and generating and harvesting electricity from lowering their lift carriages,

High-Bay Robotic Pallet Shuttles

Robotic pallet shuttles for high-bay storage in deep-freeze, chilled and ambient-temperature warehouses are capable of storing pallet loads in the highest density configurations, at heights up to 100 feet without the use of ASRS. The system energy efficiency is not determined by energy recuperation or sharing, but rather by the inherent low energy requirements of its robotic automated pallet retrieval and delivery shuttle vehicles, which are powered by a 5 HP motor, compared to a 50 HP motor on ASRS cranes. When compared to energy use of ASRS cranes, factoring in energy recuperation and energy sharing, high-bay robotic pallet shuttle systems consume 70 percent less energy – making them highly energy-efficient systems for high-bay pallet storage and retrieval.

"Energy consumption rates are a top-level consideration in high-bay warehouses," said Mohan Ramankutty, Director of Engineering for Swisslog. "ASRS cranes have been the longstanding workhorse for high-throughput automated pallet movement in these facilities, as well as the biggest users of power."

Robotic pallet shuttle systems, like the Swisslog PowerStore® system, employ low-footprint pallet lifts, instead of aisles, and enable pallet locations to store 20 pallets deep. Consequently, these systems provide the industry's most dense automated pallet storage, which delivers improved cold retention in high-bay cold-storage facilities.



"These pallet shuttle systems present an alternative option for high-bay distribution that greatly reduces energy requirements," added Ramankutty. "While maintaining pallet throughput levels comparable to that of ASRS cranes, the cost per pallet move is 33 percent less, because of the reduced

33%
Cost per Pallet Move

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ENERGY EFFICIENT GOODS-TO-PERSON PICKING FOR SMALL-ORDER REFRIGERATED PRODUCTS

No sector of automated distribution has seen as much metamorphosis over the past decade as automated goods-to-person solutions for fulfillment of light goods in small-quantity orders. Necessitated by the dramatic market shift imposed by online and mobile-device ordering, automated goods-to-person systems have evolved to meet changing market demands in every consumer and manufacturing sector.

These systems are ideal for securely handling high-value, small-order products that need to be refrigerated, such as nutraceuticals and pharmaceuticals, which require stringent track-and-trace control and documentation.

Most automated goods-to-person picking systems deliver high pick rates, improved order accuracy, flexibility, uptime reliability and dense storage capacity for handling light-load totes, trays and cartons.

As with every other sector of automated distribution, energy consumption and efficiency is a critical requirement. The most efficient shuttle and robotics systems have been engineered to reduce carrier weight and optimize weight/payload ratios for lessened energy requirements.

Energy recuperation from braking and lifting of the carrier vehicles, and energy sharing are designed into most of these goods-to-person solutions. These energy-efficient capabilities can reduce energy use by 20 percent. Since these systems provide dense storage capacity, they are also ideal for minimizing refrigeration energy costs, when compared to manual small-quantity picking in traditional refrigerated warehouses.

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SMART ENERGY MANAGEMENT

The importance of reducing energy consumption and better management of energy utilization becomes a more critical issue as energy costs escalate and logistics operations are pressured to lower operating costs without loss of productivity. This is driving the evolution of more energy-efficient material handling systems, along with the analytic tools and controls to optimize their operation.

When energy-efficient automation, analytics and controls are implemented into a distribution facility, the energy and cost savings potential can be considerable. This is particularly evident in refrigerated and deep-freeze warehouses, where refrigeration draw and automation energy draw are interrelated. The selection of automation can have a direct impact on the size of the facility required for refrigeration or deep-freeze. Such as with ASRS-supported high-bay cold storage versus a low-bay warehouse, or the use of an automated goods-to-person solution in a refrigerated environment in place of a manual picking operation – these solutions would permit a direct and significant impact on the energy draw required for refrigeration.

These energy-efficient developments being integrated into material handling systems enable a truly optimized capability for maintaining high-throughput production coupled with smart energy management. There is no question but that this combination is a winner for any distribution operation.

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