# Processing Food and Beverage While Saving the Planet

## WHITE PAPER

BARNUM
MECHANICAL INC

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## Introduction

Consumers are driving more Food and Beverage (F&B) companies to adopt sustainable practices for their entire supply chain, from how the ingredients are grown to the disposal methods of the packaging. The Harvard Business Review reported in 2019[i] that 71% of consumers are actively buying more environmentally friendly products than they did five years before. And nowhere is that more prevalent than in F&B as consumers correlate their own food choices with environmental sustainability.

As F&B companies implement business practices which promote sustainability, they are looking for ways to tie their efforts back to profits. One of the most common approaches for companies is linking their brand to the health of the planet. This is typically accomplished through advertising and labeling, but pragmatic companies understand that savvy consumers are researching beyond the superficial and demanding more transparency in environmental reporting.

Today many consumers rely on mobile Apps such as *Certified Humane* and *How Good* to help them make better informed buying decisions on the spot while shopping. And consumers are driving the adoption of blockchain technology throughout F&B to make supply chain information more accessible.

There are regulatory drivers too. Federal, state, and local governments are implementing more environmental regulations than ever before, and F&B processors are viewed as high-value targets for enforcement. The good news is that many F&B processors are leading the way in developing innovative strategies for reducing waste and creating sustainable solutions. You can too!

## Defining Your Goals

We have arranged this paper into functional sections to make it easy to focus on specific goals such as reducing electrical or water usage. While Barnum Mechanical Inc. (BMI) often recommends designing an entire end-to-end process which reduces or eliminates all waste, we realize that goal is impractical for many processors. We suggest you begin with understanding your high-level goals, and then breaking them down into manageable projects. For example, do you want to:

1. Reduce energy usage or become completely carbon neutral?
2. Reduce solid waste or adopt a zero-waste business model?
3. Reduce water usage or clean your wastewater so well that it can be re turned directly to the natural environment?

Each of these strategies can be implemented given enough time and money but goals such as becoming carbon neutral involve areas outside the process system and link back to your supply chain. Nevertheless, there are many projects which can substantially reduce your environmental impact which are within the process system itself. That is where BMI can help.

## Overcoming the Barriers to Sustainability

The biggest barriers to implementing change, especially those which require capital investment, are financial. Luckily for you, analysis has repeatedly demonstrated the financial benefits of continuous improvement in manufacturing. Sustainability is a continuous improvement initiative and googling “continuous improvement” will result in innumerable studies on the cost benefits of implementing the system. More importantly, there is a cost of not adopting “lean and green” practices. Simply put, each process utility input

(water, electrical, natural gas and compressed air) cost money, and each byproduct output (waste) cost money. The reduction or elimination of either input or output saves money.

## Process Design for Efficiency

Here are some of the ways your process design (or re-design) can significantly improve your sustainability rating.

Your process should be designed for efficiency from bulk ingredient receiving through finished goods storage. Your process designer should ensure your process:

- Is energy efficient
- Reuses energy where possible
- Minimizes water usage
- Minimizes chemical usage
- Prevents product waste
- Eliminates operational inefficiencies, bottlenecks, and redundant process steps
- Identifies the key performance indicators (KPIs) you can rely on and which reflect the goals of increasing efficiency, sustainability, and measures Overall Equipment Effectiveness (OEE)

### Your Production Footprint

Many processors plan for growth and set aside space for expansion but going "green" challenges the basic assumption that more space is good. Environmental studies have demonstrated that space, both vertical and horizontal take an environmental toll. So, while we do recommend planning for future growth, we also recommend using the smallest footprint possible for processing. This can be achieved by:

- Optimizing the process flow
- Optimizing storage space
- Using appropriately sized equipment

There are many other benefits and production gains which can be accomplished through careful analysis of your unique process. The key is to satisfy your existing needs and design a system for today which can accommodate future growth.

### Designed to Ensure Power Quality

Even slight power disruptions or spikes or sags in voltage can interrupt processing, disrupt machines or refrigeration, and result in product being burnt, spoiled, or otherwise contaminated. Another major concern of spikes and sags are damage to electronics. Improper shutdowns for smart machines can damage internal systems and corrupt machine and process data. Your plant should be designed to ensure power quality is closely monitored and equipped with electronic protective systems to prevent unexpected surges or interruptions– all of which can take a toll on your environmental impact.

### Carbon Neutrality

Food production is responsible for one-quarter of the world's greenhouse gas emissions.[ii] Most of the emissions come from livestock, crop production, supply chain transportation and packaging. Nevertheless, F&B processing contributes to emissions through two main areas:

1. Energy use (water, electricity, natural gas, compressed air)
2. Food waste

To reduce your carbon emissions or achieve carbon neutrality, your process system should be designed to reduce energy use and eliminate waste. For specific information on achieving these goals, reference the Utilities and Waste sections in this whitepaper.

### Product Rework

Approximately one-third of the food processed world-wide is lost or wasted.[iii] Much of it is lost in transport and transfer but a significant portion is lost during processing. Losses occur due to:

- Spillage
- Inefficient changeover processes
- Process control issues
- Out of spec product(s)
- Microbial contamination
- Labeling issues (recalls for undeclared ingredients)
- Operator errors

There are potential solutions such as:

- Reintroducing ingredients by adding a percent of clean unadulterated "waste" ingredients back into the product. For example, a snack cake company might capture crumbs and add those crumbs back into a new production run as part of the recipe
- Converting product waste into another product such as converting broken rice kernels into rice flour
- Products which have been contaminated can sometimes be dried to kill the contaminates and converted to animal nutrition or fertilizer
- Converting waste into an energy source to power the plant

A better approach is ensuring your process is designed to prevent product waste from occurring in the first place. For example, your process design should:

- Prevent food from spilling or dropping to the floor
- Include a flexible reintroduction area if rework is possible
- Include a drying process if moisture is a problem, or a mill for reintroduction of out-of-spec product
- Use sensors and automation to ensure your product maintains critical specifications during processing
- Use automation to minimize waste during ingredient additions and product transitions

Strategic process engineering combined with innovation in the process design can prevent product waste and provide solutions for converting waste into value-added products or energy.

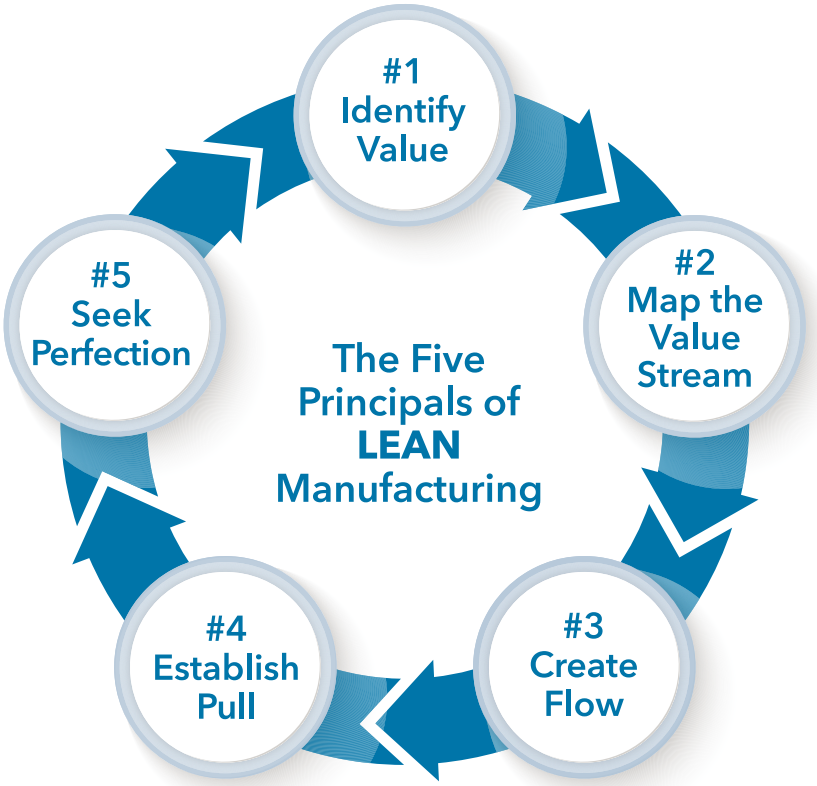
## Operation and Process Procedures

Your process system can be designed for efficiency, monitored, and automated, but your process procedures or lack of adherence to the procedures can ruin the best laid plans and undermine everything. A clear SOP, intuitive operator interfaces, and automation interlocks can ensure that procedures are followed.

## LEAN[iv] and Green Production Methodologies

Much has been written about LEAN's principles and we will not go into them here. It is enough to say that continuous improvement helps make sustainability goals more financially feasible. Over-production, overstock of ingredients with short shelf life, excessive delays between batching and processing, all contribute to waste, increase your environmental footprint, and hurt your bottom line.

Implementing LEAN techniques will remove any steps in production or the value stream which waste time, energy, or product. Analysis of your process and implementing LEAN continuous improvement principles will allow you to uncover the underlying causes of lost production time and waste. And correcting the underlying causes will significantly reduce your cost of goods sold (COGS).




***A lean and green approach to reduce waste, improve quality.***

*Source: The Lean Enterprise Institute*

"Green" manufacturing describes techniques in which F&B processors:

- Use fewer natural resources
- Reduce pollution and emissions
- Reduce waste
- Recycle and reuse materials in their processes

Selecting green partners such as BMI, coupled with implementing LEAN production principles, will ensure process efficiency and control over your environmental footprint.

## Automated Control Systems

F&B processors face innumerable challenges such as short ingredient / product life, adhering to the Food Safety Modernization Act (FSMA) regulations, maintaining quality, increasing productivity, and gaining visibility into the production process. One of the most important elements of process efficiency is the speed in which data – especially alert data– is stored, analyzed, and acted upon.

Many processors use automated control systems with hundreds, even thousands, of sensors and control points which collect and store data. The key is to blend and conceptualize the data into a usable format to help processors get process insights and real time visibility. Automated control systems can also provide reporting and analysis of:

- Plant metrics and KPIs
- OEE
- Cycle time and Takt time[v]
- Productivity
- Quality of finished goods
- Energy efficiency
- Fault alarm analytics
- Predictive Maintenance (PdM)

But data sitting in storage does not help processors. Your automated control system must provide an analytical framework which identifies patterns and applies methods, algorithms, and procedures to extrapolate actionable information for the process operators. Operators, plant managers, production managers, engineers and maintenance managers should be able to use the data to answer questions such as:

- Why is Line A producing 16% fewer units than the identical Line B?
- Why has our OEE decreased?
- Why do I have 5% more waste this month?

Here are few examples of ways in which using automated controls can help reduce your environmental footprint:

- Automated control of process time and temperature reduces product spoilage and waste
- Automated batching minimizes operator errors (which reduces spoilage and waste)
- Automated recipe changes ensure accuracy and reduce changeover time
- Automated clean-in-place (CIP) systems minimize water and chemical usage, and the time required for cleaning

These are just a few of the ways in which automated controls can significantly reduce your environmental footprint and benefit your bottom line. Automated control systems help:

- Identify and reduce waste
- Minimize downtime
- Reduce energy consumption
- Reduce process problems

While it might seem as if identifying minute incremental differences will not result in much savings, even the smallest percentage gain or loss can increase profitability and the cumulative impact can be sizeable.

## Equipment

Rising energy costs have altered the economics of food processing and processors are making energy investments to create savings. We now think of energy efficiency as a standard requirement not something new or modern. But many processors still need to evolve their mindset from function efficiency to system efficiency. The process system should be designed for high efficiency and avoid the piecemeal mixing and matching of individual equipment such as installing pumps and motors which operate at low efficiencies.

To achieve system efficiencies processors must develop a comprehensive energy-saving program which addresses issues such as:

- Identifying which equipment uses the most / least energy
- Lowering pressures, plugging air leaks, installing accurately sized pumps and motors
- Keeping equipment in the best condition possible to achieve energy efficiency targets
- Requiring staff to evaluate equipment based on the total cost of ownership in lieu of lowest initial cost

Studies show that equipment age at more than half of America's F&B food processing plants exceeds 20 years[vi] and during the last 20 years equipment has been significantly optimized for greater efficiency. We have highlighted a few equipment energy-hogs in this section. We have not attempted to address each type of equipment used in processing, only those which represent the bulk of the energy consumed in processing plants.

## Motors

Today, motors account for 65-75% of electric consumption in F&B.[vii] How many motors do you have? Are they efficient? How much energy could you save if they were all five, ten, or even twenty-five percent more efficient? The purchase price of a motor reflects a fraction of its actual cost. At least 97% of the motor costs incurred are from electrical consumption over the motor's service life.[viii] Installing a higher efficiency motor, even one only a few percentage points higher, will immediately result in saving electricity and reducing electricity costs.

Motors with variable frequency drives (VFDs) have huge advantages over fixed drive motors including:

- Energy savings
- Increased motor longevity
- Reduced power line disturbances
- Reduced risk of motor damage during start up and stop (less downtime)
- Increased ability to precisely control fluid handling processes
- Ability to fine tune process parameters by varying motor speeds

Efficiency ratings for today's electric motors make the cost difference between premium and standard motors negligible.

But to many processors, an uptick in efficiency is less meaningful than measurable reliability and productivity gains. We do not believe you need to choose between the two as you can select high-efficiency motors with above average reliability and the return on investment may be faster than you expect. BMI can help you select the best motors and drives for your application.

## Cooling

Precise temperature control is essential to F&B and often requires special cooling equipment such as heat exchangers, chilled water systems, ammonia chilling systems, glycol chillers or ice banks. The economics of cooling is tied to the type of equipment selected as well as the water and energy used to power the cooling system. To save both water and energy it is vital to select the right equipment, vessels, piping and controls for your process and cooling needs. The system should be operationally safe, reliable, efficient, affordable, and easy to maintain and clean. The system should also include fail-safes to prevent damage from occurring due to an equipment failure on the production line – such as, heating coils or a diversion system to prevent chilled products from freezing in the event of a pump failure.

Many processing facilities have cooling towers to provide cooling to hydraulics, chiller condensers and other process equipment. In some plants a single cooling system may serve several processes with different process loads and requirements. Often a centralized chiller runs at the coolest temperature needed overall– if one application needs 40°F process water, the entire system runs at that setpoint. This results in wasted energy for those applications with less stringent requirements.

Today, there are intelligent process cooling methods which are designed to meet individual cooling loads using closed-loop systems rather than open cooling towers and although the technology does use water, the system is exceptionally water efficient. The result can be as much as a 90% reduction in water usage when compared to conventional evaporative cooling towers. Closed-loop systems recirculate water, minimizing maintenance issues and eliminating the cost associated with water disposal and treatment.

To ensure there is always enough cooling capacity, many chiller systems are over-sized and designed to use the maximum possible heat load at 100% production capacity of the process equipment. But in many cases, the production equipment is not operating at maximum capacity which results in wasted energy. Choosing multiple staged compressors, modular units, or variable refrigerant flow (VFR) compressors, coupled with variable-speed compressor motors can dramatically lower energy consumption.

Ice banks employ load shifting by storing cooling capacity at night when electricity is generated at a lower cost and using it the next day for cooling processes. Lower nighttime temperatures allow refrigeration equipment to operate more efficiently and reduce energy consumption.

When determining the best cooling design for your processes, it is vital to look for ways to re-use and re-capture heat.

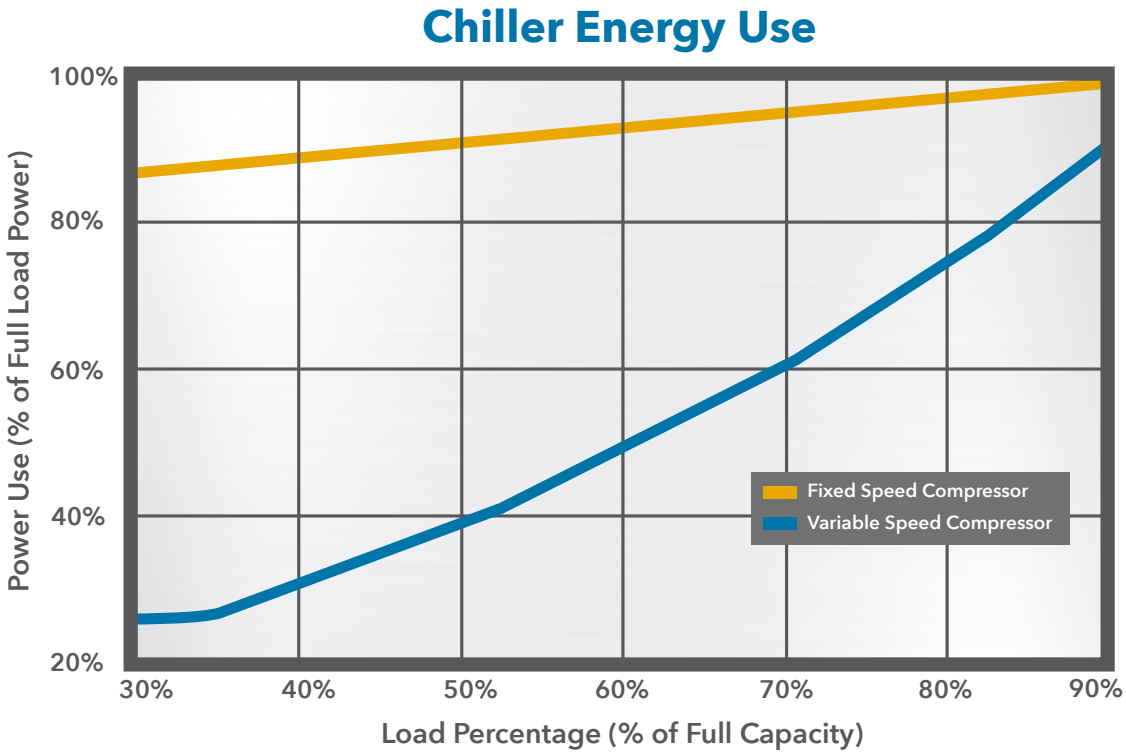



Chart reprinted from *Processing Magazine*, February 12, 2020, "*Three Ways to Reduce Costs in Your Processing Cooling Systems,*" by Bob Smith.

Using a design that reuses or regenerates heat will reduce electricity and running costs. For example, a pasteurization and cooling system could use the heat removed from the product during the cooling phase to supplement the heat input used for thermal processing. The choices for cooling equipment are ever-expanding, making it even more difficult to determine which is the best to meet your process applications. We can help with that.

## Dust Collectors

Like a lot of equipment, the initial purchase price is just the tip of the iceberg. The true cost comes from the energy consumed and the consumables required to keep the equipment at peak performance.

Dust collectors consume energy the entire time they run with the largest electrical load allocated to the fan motor. The energy consumption is directly proportional to the volume of air moving through the system. When the filters are new, the fan will move more air than is required to capture dust which wastes energy. As the filters become loaded with dust particles, the fan motor must work harder to keep the airflow high enough to capture the dust particles. But despite the airflow needed to collect the dust, many systems use the same volume of air 100% of the time. Modern systems use VFD motors to electronically control the fan speed based on the volume of air required. These automated systems sense the changes in airflow and pressure drops, and automatically reduce or increase the fan speed. The automation saves energy and manual labor.

Another key area where dust collectors consume energy is in the use of compressed air to pulse-clean the filter. Selecting a system with high-efficiency filter cartridges can reduce the amount of compressed air required by as much as 50% over less efficient filters.

Filter cartridges are an area of concern for environmentally-conscience companies. While it may be tempting to use lower-cost standard filters, that decision will add to the landfill and increase your overall energy consumption. When selecting a system, it is important to evaluate not just the cost of the filter cartridges, but the total cost of the cartridges required to clean the required volume of air. Lastly, you will want to consider the cost of filter disposal.

## Insulation

Energy consumption is a major expense for processors using piping for transmission of gases or liquids and there is no doubt that insulation helps reduce energy waste. Application temperature, installation environment and durability are vital considerations for system efficiency and to the quality of the product flowing through the system. Material selection and the ability to properly install the insulation are key factors in system design and require careful consideration. Irregularly shaped components such as pumps, valves and flow meters require special attention due to the mass to be heated, as well as large surface areas. Insulation should not be an afterthought and in a perfect world it should be part of your comprehensive system design and your sustainability efforts.

## Other Equipment

When evaluating ways to reduce your environmental footprint, it is easy to overlook the basic equipment often used in receiving, conveying, and transporting ingredients.  Carts, corrugated totes, and their plastic liners are somewhat reusable but often wear out. Replacing these with more durable alternatives will help you achieve your waste reduction goals.

F&B requires a high degree of corrosion resistance for the equipment used in the production environment. Many ingredients are challenging for the equipment in the long run and can take their toll on most metals. Specifying stainless steel lifters at points of corrosion will ensure long-lasting durability.

## Avoiding the "Gotcha"

There are many considerations when selecting equipment and it is sometimes hard to see the impact of one decision on another. When comparing equipment choices, remember to avoid the problem of selecting equipment which reduces power usage but increases water usage, or reduces water usage but increases carbon emissions. We recommend creating an equipment selection comparison table which lists the environmental areas you are trying to improve.

Energy costs are significant and often represent as much as 20% of the COGS in F&B processing, but proactively managing energy consumption can yield as much as a 10%-20% improvement. For a company with $10 million in COGS that represents $2 million in energy cost and $200,000 to $400,000 in annual savings potential.

## Utilities

Industry uses more than one-third of all energy consumed in the U. S. and the U.S. wastes more energy than it uses– a total of 58% of its energy is wasted.[ix] Utility companies and government regulators continue to push industrial users to reduce waste, conserve, and even create their own energy. Today many companies are looking for ways to make older systems more efficient while balancing the demands of today's production requirements.

Many companies view energy efficiency as a key part of their sustainability efforts, but production will always require energy and there is no simple path to complete energy efficiency.

Nevertheless, key strategies for achieving a more energy efficient process include:

- Reducing consumption
- Recapturing and re-using energy such as heat
- Using renewable energy such as solar

## Utility Monitoring and Reporting

It is easy to say that processors should monitor utility usage and analyze the data to improve efficiency but implementing such a system requires specialized skills. Fortunately, for each utility there are numerous types of metering instrumentation which measure and electronically report the usage data into a SCADA[X] system. These systems can monitor and analyze usage (input and output) for:

- Water
- Steam
- Electricity
- Natural Gas
- Wastewater
- Emissions

Although monitoring and reporting can be done manually, using wireless sensors and meters which communicate with a SCADA system is the most reliable, efficient, and least labor-intensive method. Other advantages of using a SCADA system include:

- Reliable data storage in a central repository (with automated backup)
- Ability to create custom reporting
- Ability to create automated reporting
- Ability to send real-time alerts (such as leaks or equipment failures)
- Ability to compare your own usage data to that of the municipality's invoice to ensure you are not being overcharged
- They can be used to facilitate Title 21 CFR Part 11 or other regulatory compliance

*"I know of a plant that installed cheap totalizing flow meters to every water use point so they could track water consumption to figure out ways to minimize usage. They had an employee walk around the entire plant every morning to reset each totalizer and then at pre-determined intervals throughout the day, he had to walk around and manually log the usage at each point. I can't imagine what he did with all the data, but this lasted only a week before they abandoned the effort."*

Doug Cornwell, Controls Engineering Manager, Barnum Mechanical Inc.

## Begin with an Energy Audit

The first step in achieving energy efficiency is the formation of an energy management team. At minimum, the team should consist of these personnel:

- Process engineering
- Automation and controls engineering
- Process operations
- Maintenance

F&B processors should begin with the basics and not try to fix everything all at once. We recommend developing a comprehensive energy program designed to generate savings over the long term. To get a clear picture and define your goals, you need to begin with a detailed energy audit of your current system. Plant drawings, process maps and measurements of energy consumption at key points of the process system are the basis for creating benchmarks for improvement.

Your team should establish energy baseline(s) by monitoring consumption during normal processing runs, energy spikes, peak hours, weekend use, idle time, and offline hours.
The baseline(s) will allow your team to identify the parameters to be measured and the areas where improvements can be made.

The team should also monitor, analyze, and control the electrical distribution systems. Real time analysis is imperative to achieving operational efficiencies and quality service, and today smart meters and SCADA systems make this possible. Controls automation and application-specific SCADA systems go beyond monitoring energy usage to ensuring energy efficiency.

We have broken this section into the four utilities– electricity, natural gas, water, and compressed air to allow you to easily focus on specific targets or goals.

## Electricity

Electricity is the most common source of energy used in F&B.

### *Common Causes of Electricity Waste in F&B*

- Allowing equipment and motors to run while not in use
- Using conventional motors in lieu of VFD motors which adjust to actual demand
- Using motors with more horsepower than required by the application
- Running equipment at higher pressure(s) than necessary
- Failing to maintain equipment in optimal running condition

### *Electrical Demand Reduction Strategies*

Soaring energy cost and the surety that the cost will climb even higher have had a dramatic impact on the economics of F&B processing. Some processors are moving from natural gas to electricity and powering their operations with renewable energy sources to save money and reduce carbon emissions. Capital projects to add, replace, or modify equipment for heat recovery, energy conservation and energy control optimization can have a huge impact on your plant's energy efficiency.

Whichever energy demand reduction strategy you choose, it should include:

- Measuring consumption over time
- Graphing the variation over time (load profiling)
- Determining the cost of leaving equipment running when not in use versus the cost of starting and stopping motors
- Demand management to control electrical loads and avoid demand cost penalties
- Adding co-generation solutions
- Adding backup energy solutions
- Analysis of energy use for each type of motor (to determine the cost benefit of switching to more efficient motors)

### *Improving Electrical Efficiency*

Ways to improve your efficiency factors include:

- Utilizing speed and load-altering devices to automate the delivery of ingredients and materials from one process to another
- Automatically powering up equipment only when it is needed
- Converting to equipment with lower carbon emissions such as electrode boilers

### *Electrifying with Renewable Energy*

Renewable energy is the dominate source of new power generation today. There are currently seven sources of renewable energy[xi] and one of these – solar– has emerged as the best option for F&B.

Installing solar arrays is an easy approach to providing renewable electricity without adding to your carbon emissions. The arrays can be installed on the ground, on building roofs and there are even floating systems which can be installed on ponds.

## Natural Gas

Natural gas is ubiquitous in F&B and despite the constant fluctuation in gas prices, it remains the most energy efficient choice for applications requiring steam and other forms of heat production such as thermal processing.

### *Common Causes of Natural Gas Waste in F&B*

- Running heating equipment such as ovens while not in use
- Heating at higher temperatures than required for the application
- Failure to maintain equipment in optimal running condition
- Failure to conduct regular leak detection/repair at all connection points
- Failure to conduct comparative usage checks on a regular basis

*Natural Gas Demand Reduction Strategies*

Natural gas prices are notorious for swinging wildly from high to low, and back again. But even with low prices, processors should do what they can to reduce demand and waste. Adding, replacing, or modifying equipment for heat recovery, energy conservation and energy control optimization can have a huge impact on your plant's energy efficiency.

Whichever demand reduction strategy you choose, it should include:

- Measuring consumption over time
- Graphing the variation over time (load profiling)
- Monitoring for leak detection
- Assessing equipment to determine which are the most and least efficient

*Improving Natural Gas Efficiency*

Ways to improve your efficiency factors include:

- Converting to more efficient equipment
- Using automated control systems to maximize efficiency
- Recapturing and reusing heat in closed-loop systems such as boilers, kettle stacks and fermentation tanks

## Water

Water is a precious commodity and represents a significant opportunity for reducing the environmental impact of F&B processing. Today, the average brewery uses eight liters of water to produce one liter of beer. But brewers such as the Sierra Nevada Brewing Company have achieved an astounding 2:1 ratio. They achieved the reduction by systematically mapping water usage and questioning the necessity of using water at every point within their process.

The huge reduction in water usage had the additional benefit of reducing the amount of electricity and natural gas used to heat, cool, pump, store, clean and dispose of the wastewater.

*Common Causes of Water Waste in F&B*

- Using inefficient process equipment (such as high-flow, low-pressure vessel spray devices)
- Leaks, spills, and over-filling
- Using water where it is unnecessary such as washing down floors which could be swept or cleaned by other methods
- Letting water flow when not in use
- Clean discharge to effluent
- Not using automatic turnoff valves on hoses and nozzles

*Water Demand Reduction Strategies*

- Adjust water flow to just what is needed
- Meter volumes to prevent overflows
- Recirculate water for vacuum pumps through closed-loop systems
- Pipe pump seal water in series to recapture the water which would otherwise leak
- Adopt pigging systems to reduce the amount of chase water used

*Improving Water Efficiency*

- Switch to more water-efficient equipment such as high-pressure nozzles
- Automate CIP to optimize water usage
- Recapture and reuse water for steam, CIP, exterior washing, landscaping and toilets
- Return condensate for steam systems
- Treat water for reuse in steam systems
- Change to low-water or waterless processes and procedures
- Create a system for leak detection and notification for connection points such as tank overflow valves

## Compressed Air

Compressed air is universal in F&B processing, but it is often overlooked when analyzing energy cost and energy waste.

*Importance of Measuring System Demand*
Just as with any other utility, it is important to measure system demand by establishing your baseload requirements and creating a demand profile to determine where and how waste is occurring. To reflect actual system demand, the demand should be measured using a flow meter installed downstream of air treatment equipment and dry storage. The demand profile will facilitate proper equipment sizing and the ability to determine the best motors for your application(s).

*Sizing the Equipment*
The equipment should be sized to support the actual demand for the given application(s). Too often processors size their equipment to accommodate the overall system demand, versus the demand for a specific application. This results in over-sized and over-consuming systems.

*Choosing the Right Motor Control*
Fixed speed motors use a constant rate of electricity regardless of the actual demand required. Variable speed motors use varying rates of electricity based on actual demand. It might seem that your system should use only variable speed motors to save electricity, but when it comes to compressed air, a combination of fixed and variable speed motors is the most efficient. To avoid control gaps, the fixed motors will supply the baseload needs and the variable speed motors will supply more when the demand is higher. Your system designer can help you select the automated motor controls you need to optimize your system.

*Automated Master Controller*
The key to managing demand changes in a multiple compressor system is the automated master controller. The automated controller should:

- Monitor demand changes for each compressor
- Maintain the most effective pressure for all pressure bands
- Monitor the starting frequency of each compressor in the system and be able to quickly switch to stand-by (and not to idle mode) when required

*Importance of Leak Monitoring*
The U.S. Department of Energy estimates the average leakage rate for compressed air systems is 25%. With compressed air systems accounting for an estimated $5 billion in energy used per year, that is a lot of lost air and wasted electricity. Air leaks waste energy, cause pressure fluctuations, impact productivity and decrease equipment life.

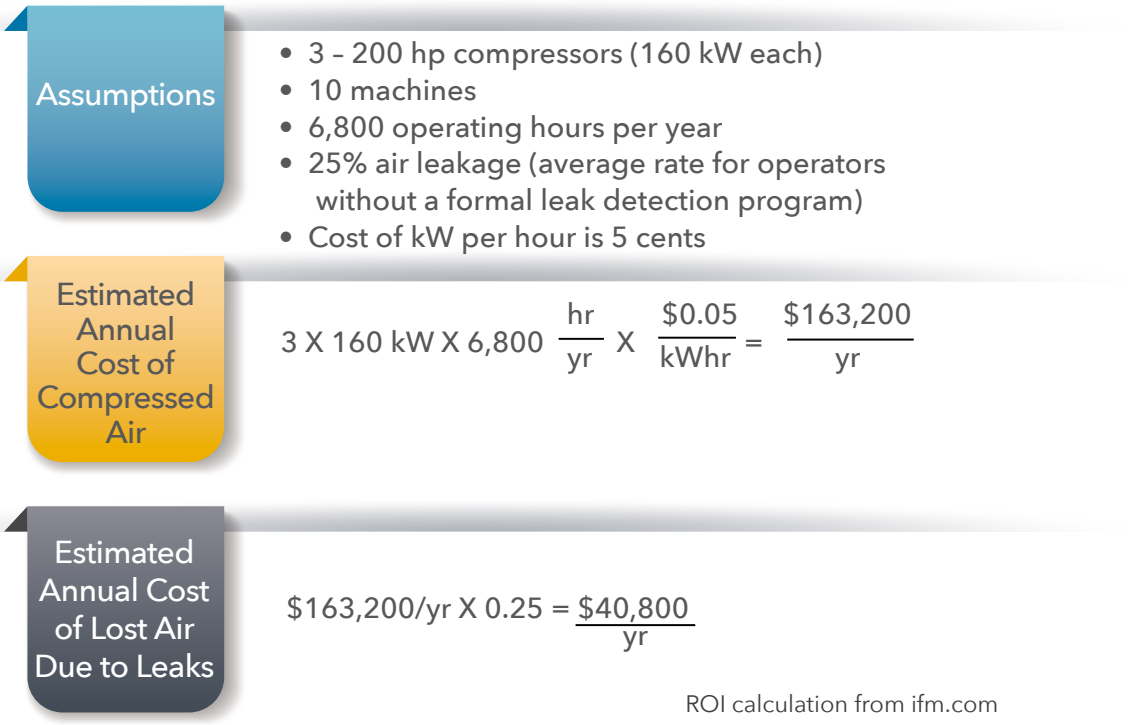
Lowering system pressure will lessen the leak load and use less energy to produce compressed air. *For every 2 PSI reduction in system pressure there is a 1% reduction in energy usage*.

The common places where leaks are found include:

- Shut-off valves
- Fittings and pipe joints
- Disconnects
- Brittle, non-durable flex hoses
- Filters, regulators, and lubricators
- Condensate traps

One of the most cost-effective ways to reduce energy cost is to develop an ongoing leak detection program to monitor and repair leaks on a consistent basis. Leak detection can be performed by the old-fashioned "listen & feel" or soapy water methods, but the most effective method is performing an ultrasonic leak audit. These audits can be performed by your compressed air equipment supplier and will quickly recoup the expense of the audit in energy savings. In some areas, the audit cost may even be subsidized by local utility programs.

## ROI Calculation of Annual Cost of Air Compressor Leaks for Medium-size Manufacturing Plant




ROI calculation from ifm.com

*Heat Recovery*

Most of the electrical energy used by air compressors is converted into heat and as much as 96% of this energy is available for recovery.[xii] Recovering the heat can help you achieve significant energy savings as well as lowering the $CO_2$ emissions of your plant. Applications for using the recovered heat include:

- General process heat
- Feeding central heating systems
- Feeding CIP systems

*Oil-Free versus Oil-Lubricated Compressor Systems*

F&B safety regulations require that end-products be protected against contaminates such as oils found in ambient air and concentrated oils from compressed air systems. The oil which is produced by oil-flooded systems, or concentrated by compression, can feed microbial growth and lead to contamination.

Many F&B processors use Class 0 oil-free air compressors to ensure they are not introducing contaminates into their products. Others use less expensive oil-flooded systems and rely on filtration to remove contaminates.

There are many options for direct and indirect applications, including different systems for filtering out the contaminates which should be considered.

*Compressed Air Condensate*

All compressed air systems pull moisture out of the air and create condensate. The amount of condensate can be significant requiring daily maintenance or an automated drainage system. The condensate will be contaminated by the oil in ambient air, or oil introduced by oil-flooded systems. In any case, the condensate must be treated prior to discharge.

When selecting your compressed air system, it is imperative to understand the cost of oil/water separation and treatment, as well as the fiscal and environmental cost of disposal. Processors should compare the total cost of ownership for different types of treatment systems. A low-entry system price can be overshadowed by the cost of filtration cartridges and disposal.

## Waste

Solid waste from F&B processing and packaging is one of today's biggest environmental challenges. Consumers are demanding, and municipalities are requiring processors to substantially reduce waste on a scale never seen before. The current system is inefficient and the relentless political and economic shift towards sustainability can seem overwhelming.

The good news is that many F&B processors are pioneering innovative and financially sustainable solutions which can improve the health of the planet. Many companies are implementing zero-waste business models and many others are investing in biodegradable plastics and an improved recycling infrastructure. In this section we address some of the ways in which processors can move toward sustainability by reducing waste.

### Product Loss

According to *Food Engineering Magazine*, after fruits and vegetables, meat and dairy are the most wasted edible products.[xiii] The majority of food spoilage is linked to inadequate chilling, specifically, failing to maintain the cold chain. Processors can take steps to ensure that food maintains the optimum temperature throughout the process, from bulk ingredient handling through packaging and storage. Here are the key steps to ensuring adequate temperature control:

- Selecting the right processing equipment (raw storage tanks with cooling media, chillers, glycol systems) for the food or beverage being processed
- Using temperature sensors and automated control systems to ensure the equipment is maintaining the correct temperature and sending alerts when it is not
- Programming the system to automatically divert product and alert operations when processing temperatures go outside of the predefined temperature range
- Ensuring that piping, pumps, and valves are properly insulated to prevent temperature drops during product movement
- Adding backup energy solutions to prevent power disruptions from the grid which can cause process problems

### Spill Containment

Another common cause of product waste is spillage and overfilling. Here are some measures which can be adopted to prevent them.

- Create a leak detection program to inspect pipes, tanks, pumps, and valves on a regular basis
- Audit the process and map each area where spillage occurs. If spills cannot be prevented, create a sanitary means of reintroducing the product back upstream
- Use mass metering to prevent overflows

- Removing manual transfers by incorporating pumps, hard lines and swing panels or valve manifolds.
- Locating sequential process equipment as close as possible or better incorporating multiple processes within one piece of equipment or skid
- Commission high-accuracy sensors/ instruments and quick-response control valves
- As product viscosity increases, so does the challenge of completely evacuating vessels, process equipment and piping. Often some product is left behind or it is diluted. To reduce spillage from evacuation, select the most efficient and controllable pump/ conveyance system for the unique product viscosity When using water or air to push product, use conductivity and turbidity sensors to identify changes in fluid types
- Every time product is transferred from one vessel/system to another, some is left behind. To prevent waste and spillage, chose equipment which minimizes shadows and areas where product does not freely flow into drain or transfer piping such as scrape surface, steep cone and fully draining
- In packaging there can be some spillage due to improper equipment set up or timing. If possible, chose packaging equipment with which it is easy to switch products. Train staff to accurately adjust the fill heights as efficiently as possible
- Dry ingredients, especially light or fluffy ingredients are very difficult to load without spilling or wafting over the side. Wetting ingredients before/during dumping can help. Use oversized hoppers and receiving vessels to eliminate overflow. Design and install enclosed material handling equipment (conveyors) and incorporating operator height (waist level) dumping stations can also help prevent spills
- Waste occurs when a batch is rejected by quality control (QC). Use root cause analysis to determine where and why product became out of spec
- Test early in the process to ensure the product stays within spec
- Minimize excessive piping runs and dead legs
- Re-assess process SOPs to limit human error

## Waste Streams

F&B processors are challenged with disposing of numerous waste streams such as:

- Vegetable matter (seeds, pits, skin)
- Trim and animal carcasses
- Bulk-ingredient packaging
- Condensate
- Wastewater
- Packaging for utility support products, lubricants, and chemicals

There are many options for waste disposal, but the most important is preventing the waste from occurring in the first place. Processors should proactively reduce waste by mapping how each waste stream is created and taking steps to prevent the waste. Here are some of the ways in which processors are preventing waste:

- Buying package-free bulk ingredients which can be delivered directly into tanks
- Buying bulk ingredients in reusable containers which are returned to the supplier
- Separating waste streams (dewatering) to allow for recycle (such as draining weak wort from spent grain and selling the grain to a farmer or nursery)

Regardless of what you do to reduce waste streams, there will be waste in F&B processing. However, *its only waste if you waste it.* Today there are many innovative processors successfully operating zero-waste business models.

The underlying principle of the model is that all the waste is put to productive use via such methods as:

- Food recovery
- Food rescue
- Recycling
- Treating and reusing or releasing wastewater back into the environment
- Anaerobic digestion
- Biogas and other fuels
- Composting

## Food Recovery

Food recovery is the process of re-capturing out-of-spec product, contaminated product, or over-production product and re-using it within the process or converting it into another product such as pet food. Many processors have systems for reintroducing product into the production line (when possible), but it is worth re-examining all the places where food is discarded to ensure it is not unnecessarily wasted.

## Food Rescue

Food rescue is the donation of the food, generally through community organizations such as The Food Recovery Network. If your process generates waste-food which can be reused, then this method is often the easiest and the most economical to implement.

## Recycling

Food waste is not technically recycled but can be treated and converted into other uses. However, recycling is still an important way to reduce solid waste in F&B. Processors should work with their suppliers to ensure that all packaging can be returned to the supplier or to a recycling center (and actually be recycled). The cost associated with recycling, such as collecting, storing, and transporting should be lower than the cost of waste disposal.

Processors can also reduce the waste going to the landfill by using recyclable equipment and supplies. Here are some examples:

- Using equipment with washable filters (in lieu of disposable filters)
- Using stainless steel carts and totes (in lieu of plastic)
- Switching from disposable to reusable personal protective equipment (PPE)

## Treating Wastewater and Anaerobic Digestors

Many municipalities require processors to reduce biochemical oxygen demand (BOD) and pretreat wastewater before sending the effluent to the municipal plant. Many processors are using modular anaerobic digesters which can remove up to 99% of contaminates from industrial wastewater. Installing this equipment allows processors to recycle the water back into their other processes such as their CIP systems and steam generation. The digestor equipment is built into the process design and is automated, monitored, and controlled by sensors and software to ensure maximum efficiency.

## Converting Solid Waste and Biomass to Energy

Anaerobic digestion is a natural process which digests materials and produces biogas or fuel (such as methane or ethanol) byproducts. Such biomass produced approximately five percent of the total primary energy usage in the United States in 2019. [xiv] Processors can collect the byproducts and use them to drive microturbines and create electricity. This solution is practical and cost effective for many mid-to-large processors. BMI can help provide an environmental analysis, cost analysis, and equipment selection for implementing these solutions.

## Creating New Products from Waste

Another important way to reduce waste is to convert the waste into something usable. Some processors convert their product waste into other food products such as collecting fragmented pieces and converting them into flours or pastes. Others are converting it to animal feed, compost and even fragrances.

On the surface it may seem impractical, but many processors are successfully working with farms and nurseries to create beneficial uses for waste streams. The solutions they are creating benefit the environment and reduce cost for both parties.

## Packaging

Depending on which study you choose to believe, packaging makes up approximately two-thirds of the solid waste in F&B. And although this paper is focused on eliminating waste from the processing of food and beverage, we would be remiss to entirely pass over the topic.

Innumerable sources cite that somewhere between 60–71% of consumers are concerned enough to make buying decisions based on environmentally friendly packaging. Nowhere is that more prevalent than in the real concerns of single-use plastic. Consumers and processors alike are looking for innovative and sustainable packaging options.

F&B packaging is outside the sanitary processing scope, but it should remain a key area of discovery and innovation for reducing your environmental impact.

## Pollution

Your efforts to reduce your dependence on utilities, (electricity, gas, water and compressed air) will also reduce the amount of pollution you create or return to the environment. Your sustainability team will want to map your system to identify areas that use chemicals or create pollution, and then develop a plan to reduce them. There are numerous pollution prevention techniques including:

- Optimize CIP processes and chemical parameters
- Optimize washdown, cleaning, and sanitation
- Extend the useful life of heat transfer fluids
- Extend the useful life of lubricants
- Prevent the release of ammonia in refrigeration
- Use $CO_2$ in cleaning
- Use dry steam cleaning
- Reduced compressed air usage
- Use economizers on oven exhausts
- Optimize chiller performance
- Convert from individual refrigeration condensing to compressor refrigeration systems
- Use refrigerant-free (evaporative) cooling
- Install heat recovery system(s)
- Implement modular, on-demand steam boilers
- Use thermal storage and transfer processes
- Insulate chilled water systems
- Use flash steam
- Reduce the use of pesticides
- Generate nitrogen on site
- Prevent (rather than treat) mold and bacteria

## Corporate Responsibility

A key shift for many corporations is the move toward "corporate values." With today's eco-sensitive consumers, companies must take a public stand on values such as environmental preservation and sustainability.

To increase market share and minimize expenses, many F&B processors have addressed sustainability issues by:

- Reformulating products with more sustainable ingredients
- Requiring suppliers to use sustainable growing practices such as organic farming
- Eliminating or reducing harmful byproducts
- Improving transportation efficiencies
- Requiring suppliers to comply with fair labor standards
- Improving manufacturing processes

## Management Buy-in

The journey to environmental preservation and sustainability requires collaboration between management, engineering, and operations. The most straightforward approach for management is the rethinking the basic assumptions about your entire supply chain and processing principles. This may sound overwhelming but following LEAN manufacturing processes helps break the project into small doable tasks. LEAN manufacturing is the key to sustainable success and when LEAN principles meet sustainability there will be significant financial benefits.

## Employee Ownership

To integrate sustainability as part of core processes and daily responsibilities, a corporation must empower employees and hold them accountable for green initiatives. Today, Sustainability Managers create and enforce supplier codes of conduct, purchase organic ingredients, and constantly measure and monitor utility usage.

## Employee Communications

Communicating the status of your sustainability efforts should be done on a regular basis to ensure the team and the entire employee base are well informed on the status of the sustainability initiatives. Regular reporting reinforces the company commitment to the initiatives and often spurs other money or resource-saving ideas.

It may be necessary to identify several ways of communicating with different levels of the organization. For example, department heads may benefit from cost projection reports while operations personnel may benefit from strategic signage such as *"We have reduced our water consumption by 10%. We are working toward a 35% reduction. How can you help?"*

Typical communications techniques include:

- Management reports
- Status meetings
- Employee newsletters or email blasts
- Posters
- KPI scoreboards
- Company events to celebrate milestones

Management should continually reinforce sustainability priorities and promote employee buy-in by acknowledging and rewarding employee achievements.

Typical reinforcement activities include:

- Formal recognition at employee meetings, in the company newsletter or social media postings. (It is important to reward cost-saving ideas even when they are not feasible or implemented. This helps employees feel their input is valuable.)
- Departmental competitions
- Continuous improvement suggestion programs
- Company celebrations to mark milestone achievements
- Cash bonuses or other incentives

## Summary

Today, as never before in history, processors can implement techniques which will help to sustain mother nature, connect with eco-conscience employees and customers, and improve your bottom line. The research and resources are here. The time is now. You can do it, and we can help.

# Endnotes

[i] *Harvard Business Review*, Marketing Research: "*Actually, Consumers Do Buy Sustainable Products,*" by Tensie Whelan and Randi Kronthal-Sacco, June 19, 2019

[ii] "*Reducing Food's Environmental Impacts Through Producers and Consumers*," by Joseph Poore and Thomas Nemecek, *Science*, June 10, 2018, Vol 360, Issue 6392.

[iii] "*Better Processing to Reduce Food Waste Streams*," by Dvijal Patel, June 2018, *Food Engineering Magazine*.

[iv] The Toyota Way is a set of principles and behaviors that underlie the Toyota Motor Corporation's managerial approach and production system. Toyota first summed up its philosophy, values, and manufacturing ideals in 2001, calling it The Toyota Way 2001. The system has now been adopted throughout manufacturing and is currently known as "continuous improvement" and "LEAN principles."

[v] Takt time is the average time between the start of production of one unit and the start of production of the next unit.

[vi] Advanced Technology Services, Inc. "*What to Know About Predictive Maintenance and Food Processing*," 2019.

[vii] Power Electronics, *Green Technology, More Efficient Motors*, by John Malinoski.

[viii] Power Electronics*, Green Technology, More Efficient Motors*, by John Malinoski.

[ix] "*Estimated Energy Consumption*," Lawrence Livermore Labs, 2017.

[x] Supervisory control and data acquisition system.

[xi] Solar, wind, hydroelectric, ocean energy, geothermal, biomass, and hydrogen.

[xii] Kaeser Compressors, "*Air Compressor Heat Recovery*," 2020

[xiii] "*Better Processing to Reduce Food Waste Streams*," by Dvijal Patel, June 2018, *Food Engineering Magazine*.

[xiv] U.S. Energy Information Administration

## For More Information

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## About Barnum Mechanical Inc.

Barnum Mechanical Inc. (BMI) is a forward-thinking design-build firm specializing in the food, beverage and specialty process industries. BMI is known for superior design, project management and installation services. BMI has operated throughout the United States since 1980.

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