What to Do Before Breaking Ground on a Plant-Based Foods Processing Plant.

WHITE PAPER

BARNUM MECHANICAL INC.

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Introduction

There are different design considerations for building a plant-based processing plant. Most processors restrict their product categories (beverages, sauces, yogurts) within a given plant. This practice limits the number of bulk ingredients, the potential allergens, and the type of equipment necessary to process the product(s). Many plant-based foods– especially plant-base proteins– have substantially more ingredients than other foods. The material handling characteristics of those ingredients can vary widely from free flowing, to difficult, to cohesive.

According to Paul Thamann, senior project architect at Hixson Architecture & Engineering, "Facilities for plant-based proteins combine the dust and airborne allergen issues of a bakery, with the raw and ready-to-eat (RTE) separation of a meat plant, and the unique raw ingredient list that would rival a prepared foods facility."[1] When defining your production needs, the raw ingredient and front-end formulations are where the biggest differences appear.

The diverse ingredient types require different storage conditions, material handling needs, allergen cross-contamination risks, and clear separation of raw and RTE processes. The powder-based protein base ingredients require a dry ingredient handling system upstream of the mixing operations, separation from the wet processing areas, appropriate dust management equipment, and multiple cleaning procedures.

This whitepaper addresses what to do before building a new processing plant (or refurbishing an existing plant) and the unique challenges associated with processing plant-based foods.

Build your team. Cement your plans.

The design and construction of a new food and beverage (F&B) processing plant is a complex undertaking. To do the best job possible, everyone involved must work to create the most efficient and reliable system while working within the constraints of budgets and timelines. With the pace of change today, versatility and adaptability are crucial features in a new processing system. The same must apply to the physical plant which will be built or renovated to house the process. The goal is to make the most of today's best technologies, while simultaneously anticipating tomorrow's innovations.

View your plant and process as a cohesive unit, and design them as such.

It is vital to let the process design drive the building design, otherwise the process will be inefficient or there will be costly change orders. Experience has taught us that when the detailed design is collaboratively developed between the general contractor, the process design-builder and the owner, the result will more closely align with the owner's vision.

[1] Food Engineering Magazine, Plant-based Protein Market Offers Potential for Product, Processing Innovation, April 2020.

Reduce costs by solving problems upfront.

The further you get into the construction process, the more expensive it is to make a change. Construction experts estimate that change order cost increases can average 8 – 14 percent of the original contract price. That is big money. Engaging your entire team early can prevent costly change orders.

Barnum Mechanical uses the Progressive Design-Build method where the detailed design work and project construction run in parallel. This method reduces change orders and significantly increases delivery speed.

This early involvement ensures a deeper understanding of the owner's goals, budget, time frames and constraints, speeds up decision-making and reduces implementation time. The detailed process design and the building design will be developed by the owner, process designer, architect and general contractor. This collaborative unit has the best possible chance to deliver a plant which facilitates maximum process efficiency and accommodates growth and flexibility in the decades to come.

Experience counts.

Producing plant-based proteins requires complex equipment and processes. It is imperative to select a process design firm who understands the chemical engineering principles of plant-based foods and the complexities of FDA and USDA facility design.

According to the Design-Build Institute of America (DBIA) the progressive design-build method reduces cost growth (change orders) by more than 5% and increases delivery speed by 33% on average when compared to the traditional design-build method.

Your architect and general contractor need to know early.

The process design impacts the equipment and utilities selection. The process, equipment, and utilities all impact the building design. Each process is unique, and each element of the process has a direct impact on the building design specifications.

The design of your building should facilitate process and traffic flow, and optimize the space for maintenance, storage, access, and growth. It is important to select an experienced process design firm and it is equally important to select an architect and general contractor with demonstrated expertise in F&B standards and regulations.

Your initial team should consist of:

- Owner
- Process Designer
- Architect
- General Contractor

For example:

- Using powders in your process may require a separate production room with adequate air filtration, as well as headroom for the transport mode which will move and lift the powder for loading
- Powders and dusts are sometimes combustible which impacts the process design and equipment specification, especially when installing an electrical system in that environment
- Processing peanuts, legumes or other allergens has a significant impact on building design to avoid cross contamination

Equipment selection impacts both the utility support systems and the building design.

The overall function(s) of the equipment should be versatile, easy to clean, and facilitate the ability to perform quick product changeovers. The process design will specify the equipment required to support the process. Different types of systems and equipment call for different approaches and design considerations, and evaluating the various options is complex.

It is vital that plant-based processors partner with process designers who have extensive experience in material handling and processing of both dry and wet ingredients. There are different processes for each relative to equipment/lines, raw material and processing environment and the versatility of the equipment to handle all these differences is critical.

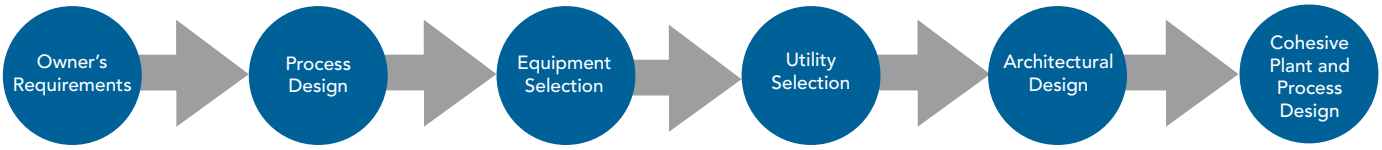
Utility support systems

Each type of utility system adds equipment and requires distribution and connection points. Here are a few considerations for planning utility support systems:

Steam boilers and condensate recovery systems are ubiquitous in F&B. These systems may require their own room which is large enough for multiple boilers. A common approach is to use a centrally located boiler room and to pipe the steam to where it is needed and return the condensate.

Advance planning is essential to an efficient and well-designed steam and condensate return system, and can dramatically reduce fuel and water costs. It can also reduce labor costs due to quicker processing.

Interconnected Decisions



Almost every processing system requires compressed air, necessitating ample space for the air compressor(s). Compressors are noisy and many processors store their compressors outside in protected spaces or in separate rooms, and pipe to multiple application points throughout the plant.

Processes which require nitrogen or CO_2 will need either a generator or liquid storage tanks paired with an evaporator. The nitrogen/CO_2 generator requires indoor space near the compressed air receiver tank while a liquid supply and evaporator require a protective outdoor space on a concrete pad.

Processes requiring hot water will need either natural gas for steam or electric heaters. Electric heaters may be required in locations where natural gas cannot be routed and they generally need to be positioned near where the hot water is needed.

It is imperative to accurately design and size the chiller system to manage potential load fluctuations and future expansion. Chilled water requires ice banks or chillers. Ice banks are limited to 34° F or warmer and require more space. Conventional chillers may use glycol and are requisite for processes which require temperatures below 34 °F. Both options require outdoor space and a piping distribution system.

Wastewater management

Your product consumers are among the most environmentally sensitive and will likely research your company reputation. Water is a precious resource and most processes require wastewater management and or treatment. The options vary from filtration methodologies to anaerobic digestion. Most solutions entail specialized equipment, dedicated piping and storage tanks which can be installed indoors or out, and even settling ponds.

Your process engineers will help you identify water/sewer municipality requirements, find the most suitable treatment system, and the appropriate piping for process waste.

Biosolids management

Plant-based protein facilities produce a high volume of waste. Biosolids and their disposal are highly regulated, and many processors are employing specialized solutions such as biorefinery to reduce the associated storage, transportation, and energy costs. Some processors are proactively using their biosolids to produce other products such as fertilizer, compost, or animal feed. These innovative solutions are environmentally sustainable and can be integrated into plant operations with planning at the early stages of process design.

Energy recovery

Energy recovery is vital to reducing electrical costs. In addition to selecting high-efficiency equipment, processors are recapturing heat in closed-loop systems and using it to heat water for processes such as clean in place (CIP). There are numerous techniques for energy recovery such as BTU exchange and product-to-product regen for reheating and cooling. Each of these techniques requires equipment and space.

Employing micro turbines and solar arrays can provide sustainable electricity and significantly reduce costs. As with wastewater and biosolids management, these solutions must be built into the process design and the architectural design of the plant or space should be set aside for future integration.

Chemical storage and distribution

Your chemical storage and distribution processes can have a significant impact on your process layout and the design of your plant. Chemicals can be stored in large tanks and piped to their use points, or they can be stored

in drums and manually distributed to their usage locations. Chemical storage rooms may have unique requirements due to corrosives and the potential need for secondary containment. In any case, chemical storage and distribution should be built into the process and architectural design.

Automated control systems

As you plan your process, you will want to evaluate the level of automation you want to include today– and then imagine what you might want to automate tomorrow. If your initial plan has limited automation, you may want to plan for the infrastructure you will need as you add automation. Typical considerations include:

- Electrical and communication network backbone and distribution points
- Wireless and local area network requirements
- Server storage (which requires climate-controlled room or enclosures)
- Determining peak electrical loads to ensure the building's electrical service is suitable for the application

Food safety regulations such as 21 CFR part 11 and ANSI/ISA-88 have a significant impact on how and what your control system tracks and records. Processors need to determine which regulations will apply to determine if they need electronic signatures or batch process control.

Bulk ingredient and material handling requires forethought.

Bulk ingredients and their delivery methods vary widely so the plant may need to accommodate everything from bulk bags to liquid tanker trucks. If you use bulk bags, you will need high ceilings to accommodate the unloader, and a layout which allows enough space to navigate forklifts. Liquids often arrive via tanker trucks which can deliver more than 11,000 gallons per delivery. The liquids can be stored in jacketed tanks outside and pumped inside later or pumped directly inside at the time of delivery.

Sizing the delivery system to meet the required flowrates involves factoring in the number of use-points, the length of piping required and more. Advance planning will optimize your delivery system efficiency. Food and beverage architects and builders routinely devise creative solutions for meeting floor-space and ceiling-height demands and the earlier they can contribute their insight, the better-designed the plant.

Powders and Dust

Many plant-based protein powders are produced during a spray drying process. Sticky and cohesive plant-based powders have difficult flow characteristics which must be accommodated with an appropriate transfer system. These organic powders create a higher safety risk due to their smaller particle size and the minimum energy required to ignite (MEI). These factors impact the process design and equipment selection as proper handling of combustible dust is critical to developing a safe and efficient process.

Allergens

If your goal is to have zero allergen claims on your packaging, your facility may require duplicated and segregated spaces to maintain allergen separation from raw materials to package. Soy has been the leading plant-based protein for decades and it is among the "Big 8" allergens in the U.S. As new plant proteins are developed, some surprising new allergy risks have been identified. The most concerning is protein-rich legumes such as peas which are estimated to impact about five percent of people who are allergic to peanuts.

Preventing cross contamination takes preparation.

Part of the planning includes taking steps to prevent cross contamination. This will require mapping the product flow from receiving through finished goods and all the steps along the way. With the product flow mapped out, look for intersections and create a plan for avoiding contamination in those areas. Some processes require separate rooms and even separate air filtration.

Your process designer and architect can work together to ensure there is ample space and a reliable and efficient process for preventing cross contamination.

DNA, Genealogy and Traceability

The same consumers who are driving the demand for plant-based foods are insisting on clean label, verified and traceable products. The ability to identify exactly what is in plant-based foods is a powerful tool for selling your products. The use of DNA-based methodologies for verification has been greatly improved by the application of Next Generation Sequencing (NGS) techniques.

Your Standard Operating Procedures (SOPs) should address current Good Manufacturing Practices (cGMP) for your sampling methodology and ingredient traceability. Your control system should include serialization software which tracks products from raw materials to finished goods. The serialized data should be stored in a noneditable data historian and be available for reporting.

This data can be used internally or converted into customer-facing data which is reflected on your product labels.

Piping and connectivity

Most sanitary process equipment is connected by piping which runs over, under, and around the equipment. In some cases catwalks and access platforms are required. The process designers will ensure the process design prevents piping traps, dead legs, and hard-to-clean-or-maintain areas. To ensure the most efficient process, the building should be designed to accommodate the process and not the other way around.

Transport and operator paths

Creating the most efficient and reliable system requires planning the paths in which people and materials are moved from point-to-point. Including the paths in your planning will ensure enough space and optimize your process design.

Maintenance and inspection access

Access points for maintenance and inspections are easy to overlook, but expensive to refurbish or create on the fly. Access points must be designed into the process and maintenance paths to ensure that maintenance can be performed as efficiently as possible.

Storage

Some processes do not require much storage as the product is moved through the plant and shipped out within hours. Other processes require storage for months as the product matures. Your architect and general contractor will need to plan accordingly.

Cleaning and CIP

Cleaning and CIP functions are critical to safe production, and careful design will reduce labor costs, process downtime, water and chemical usage. Your facility should be easy to clean and easy to inspect by regulating agencies. All cleaning processes should be determined and mapped to ensure accessibility as well as water availability and proper drainage. Water/sewer municipalities have different regulations for trade effluent and drainage systems may require separate drains for clean and dirty discharge.

Each operation is unique and must be specified to best meet the needs of the process. For example, some CIP systems require a centrally located stationery CIP skid, or a mobile CIP tank which is rolled to where it is needed. Other operations may require multiple-tank and/or multi-circuit systems to clean multiple processes at once. Multiple- tank systems may be quite large and are often housed in separate rooms, away from the processing equipment.

Growth and expansion

Consider the ways your plant and its processes may expand or transform in the future. To prevent costly upgrades, your process designer should size piping, utilities and electrical, networks, control systems, production, and storage space for your future needs.

The piping and instrumentation diagram (P&ID) depict the process but does not necessarily help the team envision the space requirements. For that, the process must be translated into a functional digital 3D model.

The 3D model will reflect the space requirements for:

- Process equipment
- Utilities
- Automated control systems
- Bulk ingredient handling and storage
- Cross contamination prevention
- Piping and connectivity
- Transport paths
- Maintenance access
- Storage
- Cleaning and CIP
- Growth and expansion

All equipment and functions should be mapped and planned for maximum process efficiency. The layout should identify possibilities for future expansion of plant capacity.

More efficient and productive today. More possibilities in the future.

Plant-based foods represent one of the most exciting marketing opportunities in F&B and the changes are coming fast and furious. Assembling the right team before you break ground or embark on an expansion will protect your investment and ensure your production goals are achieved. Their collaboration is instrumental in delivering a plant with maximum process efficiency today while accommodating for growth and flexibility in the decades to come. While you cannot know exactly what the future will bring, planning for greater possibilities can save you considerable time and money in the future.

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ABOUT THE AUTHOR

Brian Schatzman is a Project Development Manager at Barnum Mechanical Inc. (BMI). He has a BS in Marine Engineering from the California Maritime Academy. Prior to joining BMI in 2007, he worked in the ice cream and yogurt industries. Brian enjoys meeting customers and helping them accomplish their goals.

CONTACT: brian@barnummech.com / (916) 663-5326

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 forsuperior design, project management and installation services. BMI has operated throughout the United States since 1980.

BARNUM
MECHANICAL INC.

3260 Penryn Road • Loomis, CA 95650

(800) 922-7686

barnummech.com • info@barnummech.com

General Engineering Contractor
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