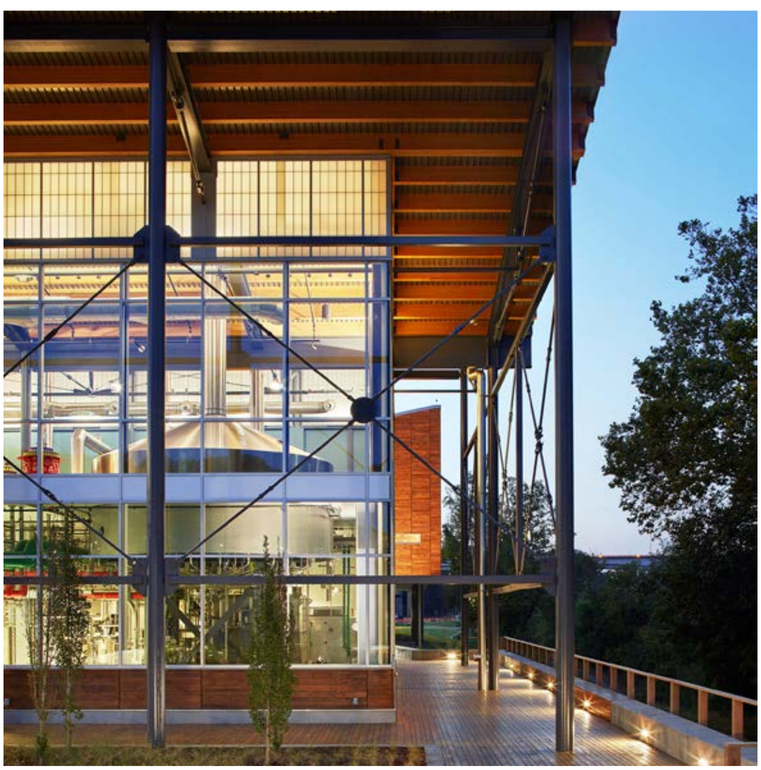
Brewers Association

Sustainable Design + Build Strategies for Craft Brewers



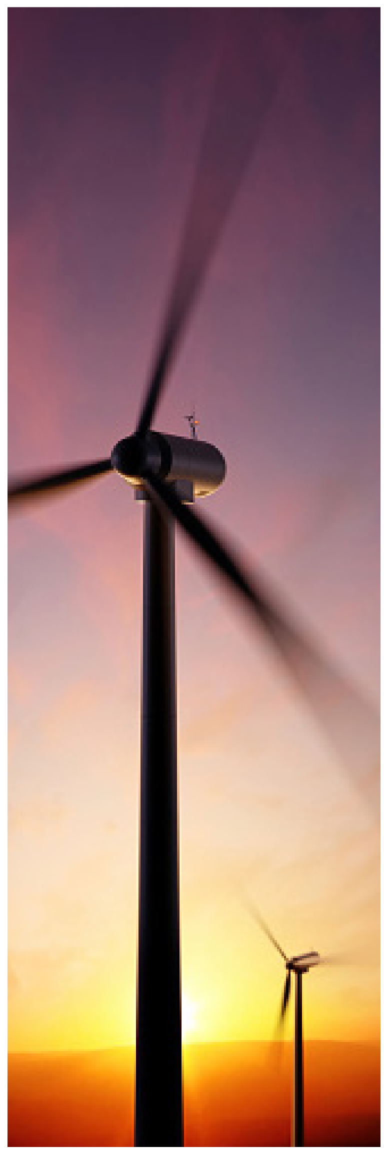


table of contents

Photos © Getty Images, Sierra Nevada Brewing Co. (cover, pages 8, 9, 15, 18), New Belgium Brewing Co. (pages 13, 22, 25) , and Brewery Vivant (page 7).

acknowledgements

This project would not have been possible without the support of many Brewers Association members. The case studies they provided illustrate the creativity and application of sustainability best practices in the craft brewing sector. Our particular thanks go to the following core review team members, who provided invaluable insight and direction throughout the development of this document:

Luke Truman, Allagash Brewing Company

Peter Kruger, Bear Republic Brewing Company

Chuck Skypeck, Brewers Association

Damon Scott, Brewers Association

Christian Ettinger, Hopworks Urban Brewery

Dana Villeneuve, New Belgium Brewing Company

Katie Wallace, New Belgium Brewing Company

Cheri Chastain, Sierra Nevada Brewing Company

Marcus Powers, Zipline Brewing Co.

We would also like to thank the sustainability management consulting team from Antea® Group who developed this manual and related tools, in particular Project Leaders John Stier and Nick Martin.

introduction

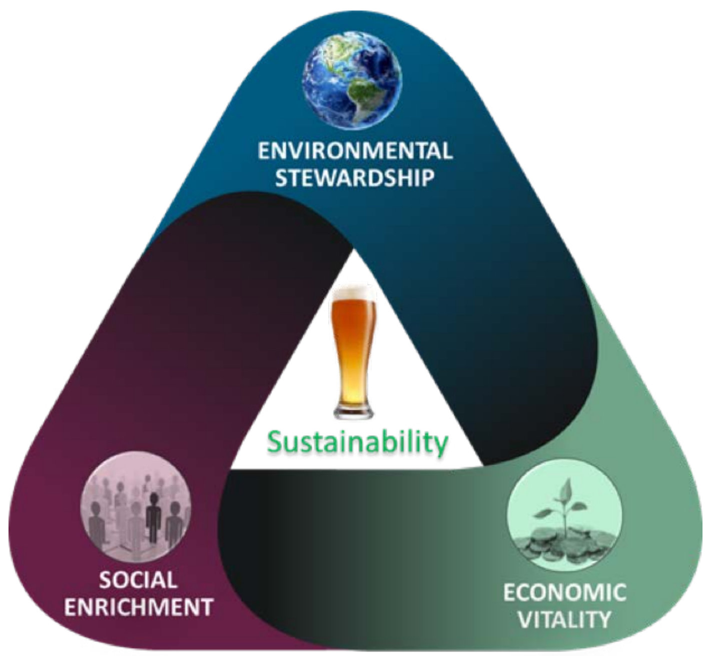
Craft brewers are an innovative and rapidly expanding segment of the greater brewing industry. Therefore, it is no surprise that creative strategies and solutions for designing, building, and commissioning facilities are gaining greater attention. Many things need to be taken into consideration when planning a new brewery or brewpub, or when expanding or renovating an existing operation. One topic that moves to the top of any checklist is how to construct a building that not only serves your business objectives, but is also constructed and operated in the most affordable and sustainable manner possible.

Owners and operators sometimes consider sustainable design and build practices during the design stage of the project, but once confronted with the overwhelming number of building codes, regulations, permits, fees and other items, combined with the desire to get to brewing and selling beer, they may table the idea of sustainability for future review. When integrated appropriately and early in the decision making process, sustainable design and build considerations can play a major role in achieving the overall objective, philosophy, and character of the brewery, brewpub, or restaurant.

This manual is a consolidated resource for sustainable design and build considerations specific to the craft brewing segment. The solutions outlined can apply to all breweries and brewpubs, regardless of location and operational size. Guidance is provided both for brewers who are just beginning and need some guidance on how to design a sustainable building for their operations, and for brewers and pub owners who are looking to enhance, expand, or renovate their operations and wish to incorporate green building elements into their designs. This manual should be utilized to influence and shape a business plan from a sustainable design and build perspective.

WHY Should A Craft Brewer Use This Manual?

Integrating sustainable design and build considerations into your brewery's business plan can provide a broad range of short- and long-term benefits. Maintaining a healthy balance between stewardship, social enrichment, and economic vitality is important to the future success of craft brewing. Finding an ideal balance of these variables can produce a win-win situation, more profitable products, and less harm to the environment!



Disclaimer: The following information provides suggestions that may or may not fit the needs of each specific brewery. It is not guaranteed that operating under the guidance of this manual will lead to any particular outcome or result.

The Top 5 Tips From Craft Brewers

#1: Formalize a team and set of partners who will passionately pursue sustainability. Involve them in the project from day one, especially those who will be working in the space to be built or upgraded. The concept of Integrated Design illustrates that investing a little more time and money earlier in the design process by bringing all the right stakeholders and perspectives into the conversation earlier saves significant money and time during construction and building operation. Don't make decisions in isolation; leverage broad perspectives on sustainability and the growing availability of innovations and technologies.

#2: The beverage industry has been a leader in sustainability, with a wealth of best practices and lessons learned worth exploring before you pursue any initiatives. Start with the Sustainability Manuals available from the Brewers Association: https://www.brewersassociation.org/best-practices/sustainability/ and follow up with specific breweries for guidance.

#3: Do not underestimate the property size and flexibility required by operations, especially from a material and waste management perspective.

#4: Focus on whole building or whole operations systems, thinking throughout your integration of sustainability considerations. This is not a linear process. Success requires thinking holistically from the start of the project and utilizing a team and partners (e.g., engineers, architects, and service providers) who understand such concepts and can integrate them into their ideas and recommendations.

#5: Form solid working relationships with local utilities and evaluate all potential incentives for sustainability initiatives. Many local, state, and national organizations provide financial incentives and/or accreditations that can be leveraged to build a stronger business case for sustainability. For example:

U.S. Green Building Council Leadership in Energy and Environmental Design (LEED): http://www.usgbc.org/leed

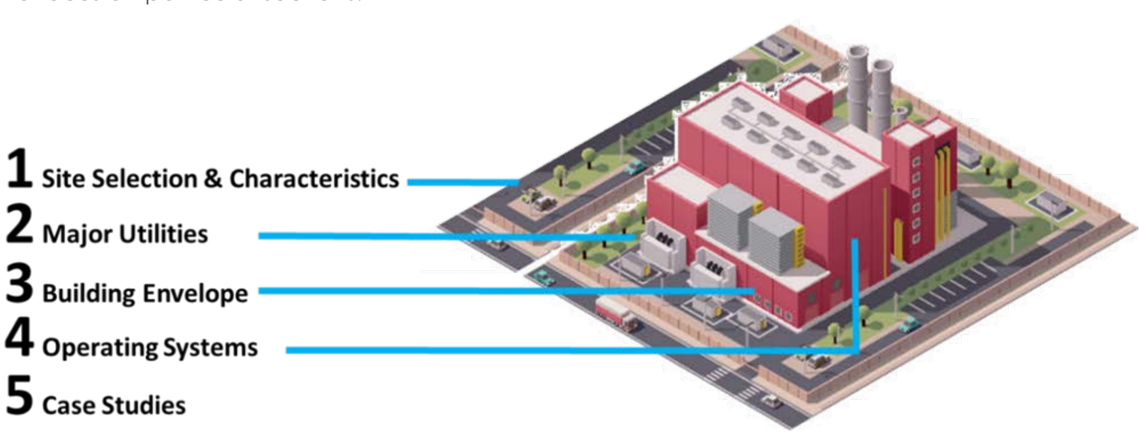
Database of State Incentives for Renewables & Efficiency: http://www.dsireusa.org/

EPA's ENERGY STAR program: https://www.energystar.gov/

Issue-specific Accreditations and Programs (e.g., http://www.salmonsafe.org)

HOW Is This Manual Organized?

This manual has been organized to share sustainable design and build considerations in the craft brewing segment with a wide range of potential users. Brewers will find big-picture considerations relevant to selecting the right site to process-level considerations to minimize water, energy, and waste on a daily basis. The manual can be utilized from start to finish, or brewers may choose to focus on particular sections.



section one

Site Selection & Characteristics

Section Taster

This section explores the following types of considerations:

- *Based on the business plan, what is the property footprint that will be required for the initial output? Future output?*
- *What are the primary functions of the location? Brewery operations only, or a tap room, gift shop, community function areas, brewpub, restaurant, etc.?*
- *What level of growth is expected for this given location?*
- *Where will the facility be located? An industrial park, a trendy urban area, or a greenfield location?*
- *Will the facility align or 'fit in' with the community persona? Will it lead an effort to change the community's persona?*

1.1 Site Selection

Site selection is considered by many to be one of the most—if not the most—important business decisions to make. Site selection will define the future and influence almost all other business decisions. While site selection will, in most cases, involve a broker or someone with extensive knowledge of the available properties within the given region, craft brewing has some unique aspects to consider.

Successful site selection projects result in the identification of a location with the optimal balance of brewer and/or pub owner-specific operating costs, business conditions, infrastructure, and risk. Identifying a location for a new brewery or brewpub is a balancing act. Finding the "sweet spot" involves a number of factors that will contribute to the brewer's competitive advantage, both now and in the future. A cost-competitive location is the first choice, but the site must also be close to key customers and growing markets. Local, state, and national economic development incentives, regulations, and tax structures will also need to be taken into consideration. There may also be environmental incentives that help to prioritize one location over another. Access to transportation infrastructure is important for goods to move in and out of your brewery, consumers to reach your location, and employees to easily access the facility. Finally, a skilled and educated workforce needs to be readily available to assist with keeping future operating costs in line.

Selecting a site is easier when a critical selection factors checklist has been developed. This checklist will be a combination of a number of items; however, the first section of the checklist should contain factors that will be absolute Go – No Go requirements. These "must-haves" should be clearly identified as absolutely essential so that candidate sites will not make a short list until these requirements have been identified. For example, delivery of quality municipal water and the capability to discharge a certain quantity of wastewater on a daily basis would be considered must-haves. A lack of the stated must-haves should rule out any further evaluation for a given location.

The rest of the list will contain items that are desirable, but are not absolute requirements. "Desirables" can be sacrificed or substituted if the "must-have" site conditions are satisfied, because finding a perfect site may not be realistic.

For general information on site location, you can refer to numerous resources on this topic. This section of the manual will focus on site selection and characteristics from a sustainable design and build perspective. After reading the section, please refer to the appendix for general and detailed checklists that may help you put together a site selection plan.

Site Selection Considerations

The selection process will involve multiple parties and require, in most cases, the involvement of real estate brokers, attorneys, developers, government officials, and contractors, just to name a few. To help manage the process, the following categories will need to be taken into account:

- **Scale of the project:** How large of a footprint will be needed to accommodate the brewery or brewpub and other facilities associated with the business plan? This information can come from many sources. Depending on the size of the project, an architect or a consulting or engineering firm may be needed to determine the proper size requirements for the planned business and future expansions.

Brewer's Corner!

Project scale is intentionally listed first in this list, because many brewers have shared examples of how failing to 'right-size' property caused issues once operations were underway, and during expansion. For instance, it is easy to underestimate property areas necessary for managing incoming raw materials, waste materials, keg storage, snow removal, and other needs. This is a big challenge, and one of the most underappreciated design considerations in early site selection.

  > Is there potential for expansion (warehouse, additional parking, offices, gift shop, etc.)? If so, is there additional property available in terms of adjacent land or buildings?

- **Type of Property:** There are four common property types:

  > ***Greenfield:*** A ground-up building, where the facility will be constructed on an open site. Some demo may be required and utilities might either exist or need to be installed.

  > ***Brownfield:*** Usually refers to sites that have a current or past history of land contamination. These sites may be less expensive to purchase; however, the cleanup or containment requirements need to be considered.

  > ***Rehabilitation:*** This construction process will take over an existing structure and repurpose the site for a new brewery or brewpub.

  > ***Historic Properties:*** Similar to rehabilitation construction, but these properties have additional restrictions and regulations to consider.

- **Location:** "Location, location, location" is the most famous statement in real estate for a reason! Second to footprint and type of construction, location might be the most important factor in site selection and the ultimate success of your business. Location takes into account the objectives of the business plan, future growth, business philosophy, and available finances. Location also brings an important characteristic and potential "vibe" to your facility in attracting your desired customer base. As a later section covers, it is also fundamental from a transportation and traffic perspective for goods coming in/out, employees, and customers.

- **Type of Construction:** New or rehabbed? This question may not be fully answerable at the start of the site selection process, but can be significantly impacted by selection decisions and should be considered as early as possible. The following are three key considerations from a sustainable design and build perspective:

  > ***Utilize Existing Space and Structures:*** Make utilization of existing space a high priority. Renovate and reuse vacant or abandoned buildings and sites. Consider a brownfield site if possible. Always work with the assumption that all future renovations will provide a solid foundation for prolonging, and if possible, expanding the life cycle of the building and site.

  > ***Protect the Natural Environment:*** If development of existing infrastructure is not possible and a greenfield site is the chosen option, avoid sites that will negatively impact the local or regional ecosystem, and strive to protect wetland and green space from development.

> ***Optimize Building Positioning:*** Evaluate how buildings will be located to optimize the use of natural elements for daylighting, ventilation, and solar or wind energy, and will enhance the landscaping that will surround the buildings.

- **New Purchase or Lease:** The cost of acquiring or leasing a location will need to be high on the list during the selection process. This factor will, in some cases, limit your location choices. Both short-term project finances and your long-term strategic business plan should be taken into account when making this choice.

Brewer's Corner!

A landlord-tenant arrangement can have implications on the type and extent of sustainable design, build, and retrofit opportunities. Breweries may encounter challenges or limitations on the ability to make improvements to someone else's property. Upfront discussions are critical with regard to the landlord's willingness to allow sustainability-driven projects and help fund or share costs, as well as timelines for potential purchase. Certain projects may not be feasible if the brewery has to relocate in the near future.

- **Major Utility Systems:** A brewery or brewpub cannot function, or ultimately succeed, without reliable and cost-effective utilities in terms of energy, fuel, water, and wastewater. Major utility systems are the focus of Section Two.

- **Zoning Restrictions:** Local zoning regulations may not always be obvious and can, if not addressed early, derail a project, or at the very least, extend the project schedule. Consulting with a local real estate broker, architect, consulting firm, or fellow breweries may help you understand local zoning requirements.

- **LEED and/or Green Building Considerations:** If a goal of the project is a facility that will be constructed to meet sustainable building methods, LEED criteria, or other green building requirements, the checklist should include these requirements for the site selection. For example, a possible site under consideration might need to meet the following criteria:

> Ample space for possible renewable energy sources onsite (e.g., photovoltaic array)
> Space for rainwater collection tanks
> Area to install sustainable landscaping and green space
> Proximity to public transportation
> Ample covered bike parking for employees and customers

1.2 Transportation and Traffic

Construction and post-construction transportation, parking, and traffic conditions are important enough to warrant separate consideration during the site selection process. Insufficient consideration of these aspects can have significant business impacts and derail the achievement of sustainable design aspirations. The following are key strategies to consider in optimizing transportation and traffic:

- **Available Transportation Options:** Evaluate nearby traffic patterns and determine if available transportation systems are friendly for bicycling, walking, or using mass transit to reach the site. Such inputs are key to identifying any challenges and the potential for integration of sustainable design aspects early in the site selection process. When conducting this evaluation, take into account unique operational needs, such as how potential impacts of material delivery and finished good shipments could be minimized. Would the site allow for optimal integration and/or layout of parking lots and roadways to enhance sustainability? For example, consider installing solar PV parking structures over parking areas to help reduce heat load and improve energy efficiency.

- **Desired Traffic Patterns/Flow:** Consider if a given site will allow for desired traffic patterns and flow, taking into account all aspects of operations (e.g., customers, employees, suppliers and service providers, finished goods). First, all regulations covering this activity at the site must be considered to ensure safety and minimize liabilities. Are there peak versus non-peak periods? Are traffic patterns different during construction? Weekends versus mid-week? If your business hosts special events, could there be any unique considerations or regulations on traffic patterns and flows?

- **Parking Considerations:** Parking considerations should assume that "less is better." Do not over-design parking areas. Provide no more than is estimated and make conservative provisions for future expansion if necessary. Parking areas add to the heat island effect, disrupt the landscape, and damage the available green space. Parking lot lighting can also add to the surrounding light pollution effect. If in an area that receives significant snow volumes annually, consider snow management and storage when designing your lot.

- **Impact on Traffic:** Consider all feeder routes and interchanges that may be impacted by new project construction and post-construction activities. Take into account construction traffic so that the surrounding areas are not adversely impacted by material and contractor traffic patterns and noise. Work to minimize traffic interruptions and ensure that all traffic activity is conducted in the safest manner possible during the construction and commissioning stages. Special focus should be given to the supply and finished goods truck traffic to ensure that the surrounding area is not negatively impacted by the increased flow. Work with local officials to address all traffic impacts and make agreements to provide for acceptable solutions.

- **Transportation Philosophy/Plan:** The above strategies are logically built into a transportation philosophy or plan that will be used to determine how employees, suppliers, finished goods, shippers, and customers will access the site. Pre- and post-construction conditions should both be considered. When considering the philosophy and plan, how could sustainable design aspects be integrated? For example, will the use of bicycles by employees and customers be encouraged? Plug-in electric cars? If so, what considerations need to be given to integrate multiple modes of transportation and drive the use of bicycle paths, parking stations, and so on? Another consideration might be whether the brewery or brewpub is located in an urban area that has close access to public transportation. To encourage use of those public services, you could include a well-lighted pathway from the bus stop or train station to your facility. Additionally, consider covered bike racks at the brewery and potentially sponsoring/building lean-tos at bus stops. The earlier you can gain some level of clarity on a transportation philosophy or plan, the more effectively such aspects can be considered during the site selection process.

1.3 Regulations and Codes

Regulations, codes, and permits are potentially hidden roadblocks that can surface in the site selection process. Being informed and understanding these considerations will impact the site selection and project design criteria. The involvement of government officials will allow the brewer to better understand the actions needed to address the design requirements and to properly operate the facility.

In most locations, the broker, or agent, and architect should have a good understanding of the permits, fees, building codes, and studies required to build the facility. Engineering and design firms should be able to provide the necessary information required for building codes and the natural conditions that will need to be considered for a given location. For example, if the site is located on a flood plain, the design firm should be able to provide information on the impact of pursuing this particular site.

Brewer's Corner!

Be sure to check local ordinances as you evaluate a potential project, because every location is unique. For example, one brewery was evaluating covering its parking lot with solar panels and found that local ordinances required a specified percentage of parking areas to be covered with trees. Since trees interfere with solar panels, the brewery was able to work with local regulators to adjust the ordinance to promote their project. The result was that the solar installation actually provided more shade than trees could have, which was a win-win!

In addition to specific regulations, codes, and permits, it is also important to understand the steps, time requirements, and costs for:

- Obtaining permits
- Conducting studies
- Meeting other regulations that will impact the project schedule and cost

The categories outlined above provide the framework for defining site selection criteria from a sustainable design and build perspective. Relevant criteria must be integrated with standard site selection requirements, project schedule, and capital allowance to drive an effective and comprehensive site selection search.

section two

Major Utilities

Section Taster

This section explores the following types of considerations:

- *How will the facility ensure a reliable and adequate water supply, including long-term availability?*
- *How will the facility manage wastewater treatment needs, both during and after construction?*
- *How will the facility source electricity and fuel?*
- *What must the facility owners consider when evaluating equipment demands versus building loads? What equipment demands should be given priority, such as refrigeration and heating loads? How is this balanced with building loads (process loads are 70+% of energy consumption, but domestic loads are still a big portion of your energy use)?*
- *What options exist, or may exist in the future, for installing onsite renewable energy sources and/or purchasing environmentally preferred green power from certified vendors?*

A brewery or brewpub cannot function, or ultimately succeed, without reliable and cost-effective utilities for energy, fuel, water, and wastewater. The type of service, capacity, and potential for future growth will need to be determined and incorporated as early as possible within decision-making processes, including site selection (Section One).

From a sustainable design and build perspective, the following types of considerations are critical:

- Questions concerning renewable energy, purchased green power, combined heat and power (CHP) applications, and energy efficiency will help determine the proper electrical service connection.
- Water reclamation and reuse applications will determine the amount of water that will need to be provided and disposed of.
- What type of systems will help determine the wastewater conditions? Will the location directly discharge? Will it discharge after primary treatment? After secondary treatment? With no treatment at all, and discharging to a land application site?

2.1 Recommended Process

When accounting for sustainable design and build aspects for incoming services utilities, the following process flow is recommended:

- ***Determine the Initial and Future Size of the Required Service Utilities:*** Take into account initial design as well as future expansion needs.
  - > The electrical power requirements should be a total calculation of the equipment kW needs, plus an estimated value for services based on square footage. When calculating power requirements for a new facility or expansion, approximately 3 watts per square foot is a good estimate for determining lighting and other miscellaneous domestic electrical loads.
  - > A brewpub or restaurant may consider single-phase service or three-phase, 208-volt service. Three-phase is considered the better option.
  - > Consider future growth plans when determining the services to a new facility. If the plan is to grow in a few years, it may be wise to invest in larger-scale services during the initial phase. If the expansion opportunity is more than a few years out, it would be wise to consult with the local utility to determine the impact of increasing the size of services and load that may be required for the expansion. The local utility company needs to be asked if the larger voltage and load requirements can be supplied by existing infrastructure, or if new infrastructure

> will be required to supply future needs. The question of electrical power is critical during site selection, because it can impact the future cost of expansion.

> Natural gas service is also critical and should follow a similar path to the considerations concerning electrical service.

- Engage Service Utility Providers: The team should discuss requirements with local electric, water, natural gas, and wastewater suppliers to determine if services can be supplied to the prospective location, and the potential impacts of providing these services. The intent is to determine whether the cost is lower at another location, the environmental impact for the services at this location, and the potential for expanding services in the future.

  There is no right or wrong at this stage of the investigation. The main purpose of the initial inquiry is to determine:

  > What, if any, limitations exist.

  > How these limitations will impact the project scope from a practical point of view. For example: Can the municipal wastewater system handle a 10,000 bbl brewery?

  > How these limitations will impact the project scope from a financial point of view. For example, at one location, a 10-inch water main needs to be installed for a distance of 2 miles at a cost of $1,000,000, and at another location, a 10-inch main exists at no additional cost. This fact may or may not determine the site selection, but the brewer would have the proper information necessary to make an informed decision.

- ***Evaluate Expansion and Pre-Investment:*** After the initial utilities are agreed upon, the team should focus efforts on discussing expansion and pre-investment. For example, if a second phase in three years will double the size of the brewery, should the project install a transformer and wiring now to accommodate this load increase? Or, would it be preferable to only make provisions for a second transformer, install ducts and conduits for wiring, and only allocate the transformer for now? This discussion will help the team decide the best option for the site. It will also allow the local utility to make informed decisions. Based on this example, the utility may decide to upgrade the service to handle the first and second phase loads at this time, because installing a larger service feed is less expensive than adding a second feeder or increasing the size of the existing feeder three years later.

This exercise is important no matter what the size of the project, whether you are installing a 1,000 bbl/year brewery, a brewpub, or a 100,000 bbl/year brewery.

Brewer's Corner!

Outlining the best possible service connections to the facility may lower future construction costs, provide more reliable service, and lower operating costs. For example, if only a 2000 kVA transformer needs to be installed to handle the load and space allocated for a future unit, it will be less expensive to operate that one unit than it would be to operate a 5000 kVA transformer at 50% load. Transformer losses are proportional to the size of the unit and will add to your operating cost until future growth requires a new unit.

2.2 Electrical

At a minimum, the electrical connection should be a 208-V, 3-phase, 4-wire system with at least a 200 amp service. The actual voltage level and ampere size will need to be determined based on anticipated operations at the location, electrical demand, and future potential growth.

Determining the electrical load of the facility will take into account the equipment, lighting, building systems, and human resource and warehouse power needs. This calculation will in all likelihood require knowledge of the system design, equipment specifications and operational procedures. From this information, the proper size will be determined.

After the power requirements are determined, the next issue is how power will be supplied to the site. The supply can take many forms and can consist of multiple methods. The best delivery source will depend on the following factors:

- Will combined heat and power be used?
- Will renewable energy be installed?
- Will the brewer purchase the power for the facility from a certified green power source?
- Will the direct connection to the local power grid be the only source?

Brewer's Corner!

Don't forget to consider backup generator options for when the power goes out (as it inevitably will at some point!) so that the brewery can still operate and not lose any beer.

The power supply can consist of any one or a combination of the items listed above. The power supply question in the past was simple; in most cases the customer contacted the local utility, passed on the load needs and load factor, and waited for the utility to dictate the type of service that was provided. Today, there are numerous choices for power supply to the facility. Cost, capacity, reliability, business philosophy, and other factors play a role in determining the type of power service necessary for a given facility.

The following list outlines the possible sources that are available for power delivery:

- **Grid power (regulated and de-regulated).** This is the simplest solution.

- **Grid power (certified green sources).** Simple installation, but you might pay a premium for electrical energy.

- **Combined heat and power sources (CHP)** (e.g., engines, micro-turbines, and fuel cells). Modest to difficult installation and higher capital cost, with additional maintenance required, but you may have the ability to lower fuel needs for boiler and hot water systems.

- **Renewable energy** (solar photovoltaic (PV), wind, geothermal, biomass, biogas, and other). Modest to difficult installation and higher capital cost, and intermediate source of power will in most cases require grid power or CHP to provide power needs when not in service.

From a sustainable design and build perspective, if a brewer wants to be less reliant on the power grid, the most common options are to:

- Incorporate energy efficiency into the building design to reduce the overall energy demand.

- Install a combination of renewable energy sources.

- Combine heat and power sources using fuel cells, micro-turbines, internal combustion engines, etc.

- Use grid power to provide a small amount of power and backup in the event that one or all of the other sources are inoperative.

- Combine renewable energy and grid power to supply the power needs, where the grid power must be contracted to be supplied by certified green sources.

As with much of the guidance in this manual, the best time to prepare a power delivery strategy for a sustainable brewery is at the beginning of the project and prior to site selection. No matter what path is taken, the strategy and discussion on the method of electrical energy supply will position the brewer to include the necessary capital cost for the electrical service in the project budget, provide reliable data for future operating costs, and provide a road map for future growth.

2.3 Natural Gas

Natural gas is the fuel of choice for breweries, brewpubs, and restaurants. If you are in a location that does not have a natural gas supply, then liquefied petroleum gas (LPG) or propane may be the best choice for your location.

Natural gas is normally used to fuel boilers, hot water heaters, direct-fire heaters, building heaters, and HVAC (heat, ventilation and air-conditioning) units. If CHP units are installed, natural gas can be used to fuel engines, fuel cells, and micro-turbines.

A natural gas connection must be sized based on the calculated natural gas demand, pressure requirements, and future growth considerations. The following parameters should be considered when discussing natural gas service with the local utility:

- Natural gas quantities
- Pressure requirements
- Connection points to the natural gas supply
- Contract requirements for the natural gas service

2.4 Renewable Energy

Sustainable design and build should incorporate a renewable energy strategy to help offset electrical, fuel, and heating costs, and to improve the environmental footprint. Renewable energy provides a direct path to creating a sustainable energy supply while reducing the costs associated with purchasing these services from the local provider.

Please note that renewable energy is classified many different ways and in most cases requires incentives or other financial instruments to compete with traditional energy sources. The business objectives and philosophy of the brewer or restaurant owner will determine if renewable energy sources are installed.

Brewer's Corner!

The key to a Renewable Energy Strategy is to find the optimal use of each renewable energy source available for a given location. Consider that most of the renewable sources, such as solar PV, wind, and thermal, provide only intermittent power. Depending on your hours of operation, additional traditional sources may need to be considered during the design process. Also, energy prices can be volatile and incentives can vary over time. Just because you evaluated options previously doesn't mean that the same fiscal conditions hold true today!

Commonly, renewable energy sources are pursued through two main approaches:

- ***Direct Purchase and Installation:*** The self-installed option requires the brewery or brewpub owner to determine if the source is a viable option for their site and then work with engineers, suppliers, and contractors to install the renewable energy source at the location. Such an approach needs to be taken into account during the design phase, so that the placement of the renewable energy source is compatible with the building design, and to ensure that other infrastructure requirements are taken into consideration.

- ***Purchase Power Agreement (PPA):*** This is an alternative method of financing for a renewable energy supply, where a third party will enter into an agreement with the owner of the brewery. The third party agrees to install a renewable energy source, and then sell the energy supplied to the owner for a fee over a given period of time. This option is a favorable path to installing renewable energy onsite because it usually requires little to no capital on the owner's part and can lock in an energy cost that is usually at or below the price of energy obtained from the local utility. The downside to a PPA is that for the third party supplier to provide a return on their investment, the brewery owner may need to enter into a 10-, 15-, or 20-year term

The following list includes common types of renewable energy technologies:

- ***Roof or Parking Lot Mounted Solar Photovoltaic (PV) Array:*** This technology requires a roof design that can support the array.

- ***Onsite Wind Generation:*** This technology requires that the wind energy source complies with local codes, which involves an environmental impact study, setbacks, etc.

- ***Wastewater Bioreactor:*** This technology involves the installation of bioreactors to treat wastewater and produce methane for combustion onsite. A proper location for the reactor is necessary to ensure that neighbors are not impacted by the application.

- ***Solar Hot Water System:*** This technology requires that the system size is calculated properly to ensure that the water can be used throughout the brewery. At the same time, you need to determine if additional fossil fuel sources of hot water will be required, or if the solar thermal system can handle the load. Alternatively, when geothermal systems are available and can provide the thermal requirements necessary for hot water, they may not be able to provide the necessary heat for the steam requirement.

Brewer's Corner!

A best practice is to incorporate effective heat recovery efforts before looking into solar thermal. Several breweries have discovered that they can recover enough heat that solar thermal is not practical or necessary.

2.5 Water Supply

Given its fundamental importance as a core ingredient in beer, water supply is a critical utility for any brewery, brewpub, or restaurant. A clean, reliable water source is a must, and, given the increasing number of water challenges faced by communities across the U.S., one that should not be taken for granted.

Brewer's Corner!

When evaluating renewable energy options with third-party partners, make sure to understand agreements on taking credit for GHG emission reductions. New agreement models are rapidly evolving, allowing greater ability for breweries to claim and retire renewable energy. Certificates (RECs).

The chemical composition of the available water will need to be evaluated to determine if any water treatment will be required for the type of beer being produced. For most locations, the water will be supplied by a local municipal water source. Others may choose groundwater from on- and/or off-site wells, if available.

When determining water supply requirements for a particular location, pressure, flow rate, and pipe capacity are three primary factors that should be addressed.

Water flow rate will depend on the process requirements and will need to be known at the time of the site selection. If the location requires a system pressure of 75 PSI at 40 GPM to ensure that the production requirements are met, and if the site being investigated only has 60 PSI pressure at 25 GPM, then this may not be an ideal site. It may not be possible to increase the pressure and flow rate, or the cost to increase the piping and other components to bring the pressure to 75 PSI at 40 GPM may be more than the project can bear.

Information on water supply requirements, both for current design and growth requirements, is absolutely necessary to ensure that the chosen location will be able to supply the production, cleaning, and ancillary service water requirements at the site now and in the future.

2.6 Wastewater Disposal

Wastewater disposal is another critical utility that must be considered as early as possible. In some cases, it may be more critical than addressing water supply. Breweries, brewpubs, and restaurants have special needs for wastewater disposal. Discharge flow is not the only parameter to consider; the biological oxygen demand (BOD), total suspended solids (TSS), and other components also need to be accounted for.

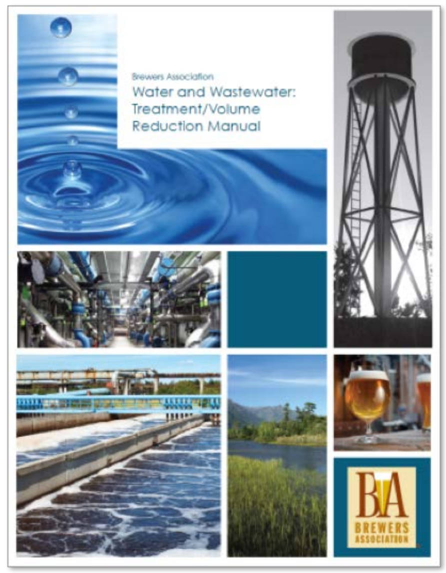
Wastewater treatment and discharge costs can be expensive. Therefore, it is critical to reduce the discharge flow as much as possible, to avoid high wastewater charges and ensure that present and future production needs can be achieved.

Reclaiming water from the operation prior to discharge will go a long way in offsetting discharge to the municipal wastewater treatment plant. Depending upon local and state regulations, the reclaimed water's chemical composition, and your onsite treatment capabilities, reclaimed water may be usable for irrigation, cooling, cleaning, and other processes.

Discussion points for wastewater systems should consist of the following:

- Flow rate of wastewater
- Maximum and minimum flow rates
- Highest and lowest anticipated temperatures of discharge
- Chemical makeup of the wastewater discharge
- Location of discharge points
- Discharge infrastructure requirements that are the responsibility of the site owner

For more information, refer to the *BA Water and Wastewater Sustainability Manual* and the *Wastewater Management Guidance Manual*.



section three

Building Envelope

Section Taster

This section explores the following types of considerations:

- *Can the building be located in a manner that will allow for optimizing natural lighting and reducing solar heat gains during the summer months, while at the same time maximizing these gains for the winter months?*
- *What type of aesthetics are the goal for the building envelope? Are you looking to excite and draw attention? Blend in with the surrounding community and natural environment? Finding the right balance between being architecturally unique for a given location, and yet not too far out of place, can be advantageous.*
- *What are the regulatory restraints that may impact location selection (i.e., building and zoning codes)?*

Building design can play a major role in the integration of sustainable design and build principles. To meet the vision and purpose of the owner, input from a number of different sources such as architects, engineers, constructors, and suppliers may be required to determine options for constructing, renovating, or retrofitting a building. A number of factors will contribute to these decisions, including location, environmental conditions, local codes, financial conditions, and the type of project (self-performed, design build, etc.). In any case, engineering design methods attributed to the building envelope are the foundation for a sustainable building.

Building Envelope

By definition, the building envelope includes all the parts of a structure that form the primary thermal layer between the exterior and interior components of the building. How the building envelope is engineered and constructed will inevitably determine the level of comfort, lighting, and HVAC systems that will be required for the structure, and the energy and water resources needed to supply and operate the structure.

When buildings are constructed or renovated, a whole-building perspective is preferred. This approach takes into account all the components that make up the features of the building and its construction in order to determine opportunities that will lead to a sustainable building that improves energy efficiency and provides the necessary comfort level for the building occupants.

Brewer's Corner!

Before designing an HVAC system for the building to satisfy the assumed heating and cooling requirements, it pays to engineer the considerations outlined within this section into designs. You may just find that the actual size of the HVAC system needed is reduced. While this approach might require more upfront time and effort, in the long run it will reduce the operating cost due to the fact that a more efficient, right-sized HVAC system was installed

While whole-building approaches are ideal, everyday building envelope components can be upgraded or replaced. Incorporating these options into the design while also ensuring that capital costs are optimized throughout the life cycle will help improve the overall energy efficiency of the building. The savings from installing these options will lower operating costs and environment footprint (less heat island impact) over the life of the building. At a high level, the following are commonly implemented design elements:

- ***High Reflective Materials:*** Install a high reflective roof (cool roof), walls, and windows to minimize heat infiltration into the building.

- ***Insulation:*** Install high levels of insulation in the foundation, walls, and roof to reduce heat losses in cold climates and to mitigate heat gain in hot climates. Utilize precast concrete insulated panels or structural insulated panels (SIPs) to help reduce the building's internal temperature during summer and retain the heat during winter.

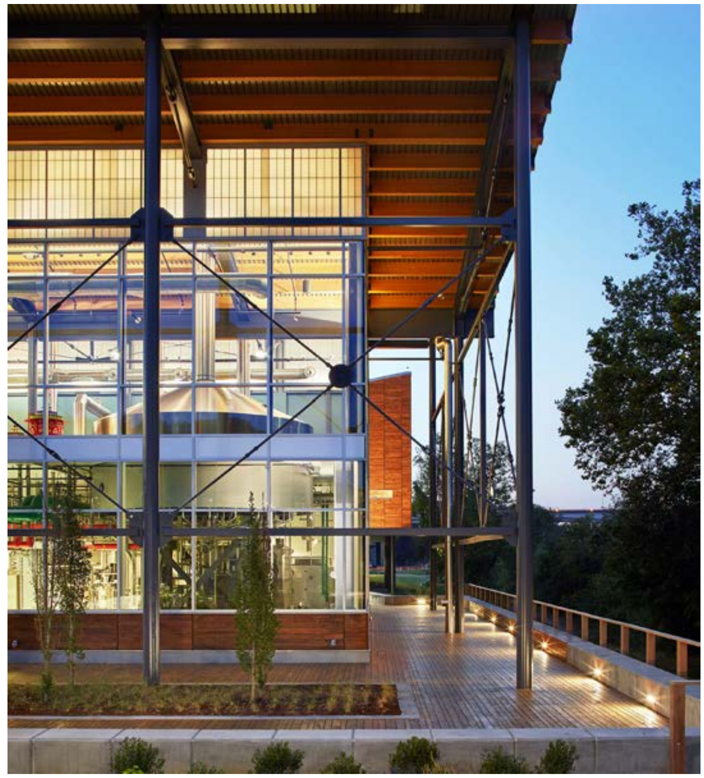
- ***Air Sealing:*** Ensure that air sealing practices are implemented to minimize air infiltration. This strategy must be paired with optimized ventilation control to satisfy fresh air requirements.

- ***High-Performance Window Systems:*** Install high-performance window systems that include glass, frames, and edge seals that lower the thermal transmittance for the entire assembly. Consider installing window attachments such as awnings or solar shields to further reduce thermal losses. Optimize glazing and shading on north and south surface areas to enhance daylighting while minimizing unwanted heat losses and gains.

- ***Building Position/Orientation:*** The optimal building orientation is in the east-west direction. Minimize the east and west surface areas to reduce exposure to direct sunlight. Proper orientation can also take advantage of natural daylight, sunlight heat, and ventilation.

- ***Integration of Renewable Energy:*** Investigate the use of renewable energy sources that can be easily integrated into the building design, such as solar PV or thermal heating applications on roofs, small wind turbines, and other renewable energy applications. Investigate the use of a solar wall on south-facing wall systems to take advantage of passive solar heating during winter. Consider radiant heating and cooling systems in lieu of forced air systems.

The type of energy-efficient solutions that will be included in the building design will depend on local climate, weather, availability of building materials, and local building codes.



3.1 Building Materials

Decisions made with regard to the type, quantity, and handling of building materials have many sustainable design and build aspects. Green building guidelines, LEED principles, and other sources can provide ample references to materials that should be considered for inclusion in your sustainable design and build project. For the purpose of this section, definitions and guidance focus on common brewery and brewpub-specific considerations:

- Minimize the use of non-renewable construction material and natural resources, such as energy and water, through efficient design, engineering, and construction stages. This contributes greatly to the sustainability of the project and the environment.

- When determining materials that will be used to construct the building and equipment, recycled resource-content engineered materials and resource-efficient composite type structural systems should be integrated wherever possible.

- Maximize the use of sustainably managed, bio-based materials that can be reused, or are considered renewable.

- Incorporate materials and systems that have been proven to provide strength, reliability, and durability while using less material than so-called standard applications.

- When considering systems that will make up the building shell, consider using engineered trusses, composite materials, and structural systems. Insulated structural panels, concrete forms, and frost protected shallow foundations should also be included in the design.

- Material waste that accumulates during the construction phase is inevitable. Focus on minimizing construction waste during the design phase by not over-designing a system or component, substituting wherever possible, and looking for ways to reuse waste elsewhere on the project. During construction, implement a recycling plan that will collect and recycle as much waste as possible.

Brewer's Corner!

Setting targets for recycling may offer incentives for the design and construction team during the project. For example, set a target of recycling 90% of the construction waste. If this target is set early, the design team will be challenged to include materials that have the potential to be recycled during the design stage, and the construction team will be focused on collecting and recycling discards properly.

- When defining materials that will be used on the project, specify the use of high recycled content materials wherever possible. Consider multiple sources such as fly ash, slag, and recycled concrete aggregate for concrete as well as other materials that go into floor tiles, countertops, carpet padding, etc. Consider the use of remanufactured or repurposed equipment for offices, conference rooms, and other applications.

- To reduce energy used to transport materials, reduce emissions, and support the local economy, consider locally manufactured materials.

3.2 Insulation

Proper insulation, coupled with making sure that the building is properly sealed, can improve energy efficiency by 20 to 30%. Insulation levels will vary depending on the climate and local weather conditions. Proper insulation will reduce heat loss during cold weather and prevent heat from entering the structure during hot weather. Insulation can also provide a low-cost means to maintaining a comfortable environment without incurring additional maintenance cost.

The function of the building also impacts insulation requirements. For example, a brewery with higher density heating and cooling processes, equipment, and personnel may need different layers of insulation for various areas than a restaurant that will not have process equipment but will need to provide a comfortable environment for its customers. Some brewery production areas can be incredibly hot and uncomfortable for brewers and visitors alike because the heat being emitted by the vessels was not given adequate consideration when designing the space's HVAC and ventilation strategies. Another example may be an existing building where conditions may require reducing floor space to install the necessary systems to accommodate additional levels of insulation. As with all design issues, these items will need to complete a life cycle cost analysis and benefit versus risk analysis. In the end, insulation is usually less expensive than operating an HVAC system more often.

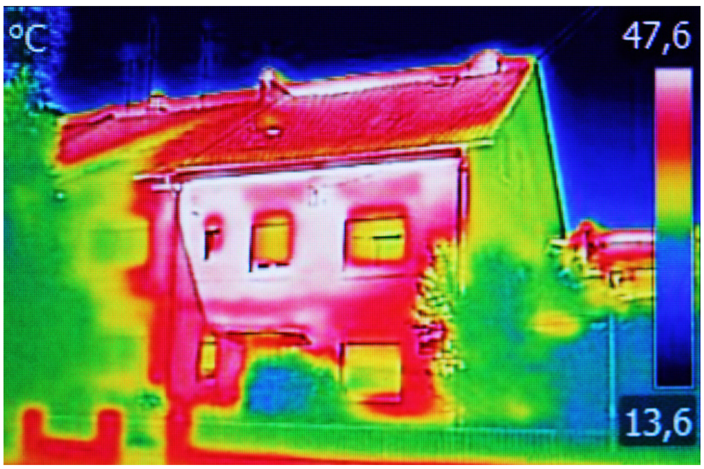
Proper insulation design will improve the energy efficiency of the building, but caution should be taken to ensure that your building envelope design does not include thermal bridges and other design elements that can result in excess condensation within the building envelope. Lowered energy losses require that condensation be evaporated that could damage the building envelope. Care should be taken during design to avoid these potential issues.

3.3 Air Sealing

In addition to proper levels of insulation, a properly sealed building and adequate ventilation for fresh air will also reduce the total energy used to maintain comfortable temperature levels. Proper air sealing coupled with correct amounts of insulation can improve energy efficiency for the building systems by 20 to 30%.

Normal air exchanges per hour are required by building codes for each new building or renovation. However, due to a building's construction, age, and other factors, more frequent air exchanges may occur than are required. All too often this infiltration and exfiltration of the air adds to the operating cost of HVAC systems, and more importantly upsets the comfort of the occupants. Air sealing is important during both the design and construction stages of a project.

During the design stage it is important to specify window, door, and wall construction techniques, and roof types to help minimize the air infiltration or leakage to the facility. At the same time, it is important to design the necessary ventilation equipment to ensure that the proper amount of fresh air is exchanged throughout the building. This balancing act may not eliminate all air leaks, but will definitely reduce unnecessary air leakage.



During the construction stage, it is just as important to ensure that all the components specified in the design are installed as required to minimize gaps and spaces that could result in air leakage. This will be a daunting task, especially for a renovation or retrofit project; however, with proper inspection, a majority of the potential problem areas can be identified and corrected.

Overall, buildings should be sealed as tightly as possible. However, care should be taken to ensure that proper ventilation is provided so that air quality does not deteriorate and to avoid the accumulation of unwanted combustion gases. Local code and engineering design requirements should specify the necessary fresh air requirements. In buildings that are using interior air for combustion applications such as boilers and hot water heaters, additional engineering design may be required to ensure that the air quality in the building is optimized. In some locations, dedicated air supplies may need to be provided to fossil fuel combustion equipment.

All joints, building penetrations, windows, and doors contribute to air leakage. Windows usually present the best opportunities for reducing air leakage. Normally these leaks are developed during the installation or replacement of windows. Windows that can be opened enhance the potential for problems and need special attention during the construction phase. Proper installation techniques including flashing, sealants, and insulation, such as expandable foam, can significantly lower the risk of air leakage.

3.4 Windows

Window design varies, depending on the building location, code requirements, and personal preference. Windows serve multiple functions, which need to be considered when choosing a window style and type. Windows provide occupants with a view of the outside world, let in daylight, and in some cases provide a means of egress. Normally, windows should let in as much light as possible, while maximizing heat gain in the winter and minimizing heat gain in the summer. Choosing the proper size, orientation, glazing, and frames will determine the balance of heat gains and losses as well as the amount of natural light that will be emitted. The following points outline common guidance from a sustainable design and build perspective:

- Avoid single pane window installations. Use double glazed, low-emissivity or triple glaze, with two layers of low-emissivity glass with low conductive frames.
- Specify window performance for a specific region.
- Only install the number of windows required to satisfy the project's objectives and function. Additional or unnecessary windows increase the risk of air leakage and temperature gains that could necessitate larger HVAC systems.
- Since north-facing walls do not receive direct sunlight in the Northern Hemisphere, they are ideal locations for glazing, to allow daylight into the spaces.
- Static glazing material will determine the amount of solar energy that is transmitted or rejected from a given space and improve the energy balance in the building. Static glazing does not impact the amount of natural light that enters the space.
- Consider window shading, either internally or externally, to address comfort issues.

3.5 Roofs

Sustainable designs for roofs fall into two basic categories: cool roofs with specialized heat-reflective material, and green roofs. In most cases, the owner will decide to install a reflective, non-black roof material in place of a green roof. The green roof has advantages that go beyond the normal function of a roof. For example, a green roof becomes a mechanism for capturing and filtering rainwater in addition to serving the necessary function of a roof. There is no right or wrong roof to install on your facility to enhance the energy efficiency component of the building envelope. The choice of the type of roof will focus on the location of the building, the construction criteria for the building, capital cost, and the sustainable building philosophy of the owner(s).

Consider the following attributes:

- Cool roofs utilize materials that are designed to reflect solar energy and absorb less heat than a standard roof.

- Reflective roofs are rated on a system that measures the solar reflectance (SR) and thermal emittance of the roof sample. The larger the SR factor, the more efficient the roofing material.

- Minimizing heat absorbed or transmitted through the roof reduces energy consumed by HVAC systems tasked with removing the additional heat.

- Cool roofs lower the heat island effect for the surrounding area as well.

Green roofs, on the other hand:

- Can be used in most locations but are ideally suited for urban buildings with flat or shallow-pit roofs.

- Can take multiple forms, ranging from a basic plant covering to a full blown garden or park environment.

- Provide not only insulation, thus lowering HVAC load, but also help to manage storm water runoff and allow building occupants to enjoy an engineered green space.

- May bring additional costs for roof installation and a roof maintenance program.

For both the reflective roof and the green roof, the project team should carefully assess the advantages and disadvantages of each system. Consult with designers and engineers to determine the best possible roofing solution for the project.

Both green roofs and rooftop renewable systems (such as solar PV panels) will require additional structural load capacity for the building and must therefore be planned for early.

3.6 Sustainable Landscape

An occasionally overlooked aspect of the building envelope is the site's landscaping needs and opportunities. Sustainable landscaping concepts need to be aligned with the overall objectives of a sustainable design and build project, and can have financial and aesthetic benefits worth pursuing. An example might be the positioning of trees to limit the amount of sun that hits the building, resulting in a reduction in energy used to cool the building. Methods introduced to capture and reuse storm water runoff will reduce the volume of potable water supplied to the site.

The following considerations should be evaluated to conserve water and protect the local watershed:

- Let existing natural flows and features of the land determine the best way to manage storm water.

- Study the site to ensure that key natural hydrological features remain intact and continue to serve as natural storm water retention, infiltration, and recharge systems. Keep existing native vegetation, forests, and other features that contribute to the natural water cycle for absorbing and disbursing rainwater.

- Include low-impact storm water technologies like rain gardens, open grassy swales, pervious concrete, and constructed wetlands.

- Install storm water capture systems for rainwater that will eventually leave the site. Ensure that this water is properly filtered and processed so that it can be held and released when required. Avoid the use of dry retention ponds as they have little beneficial impact on groundwater recharge, and in some cases, negatively impact the natural water cycle.

The following items outline other aspects of sustainable design that should be considered during the design process:

- Landscape design should align with building function, taking into account local weather and terrain conditions, and should be functional, cost-efficient, aesthetically pleasing, and maintainable. Design must also take care to preserve and enhance the surrounding area.

- Landscape design should focus on minimal resource input; only include that which is absolutely necessary and be sure to not over-design or pollute.

- Focus on incorporating the natural elements of the site to assist with collection and disbursement of storm water runoff; use bio-swales to reduce storm water runoff.

- Install systems to capture storm water and replenish the groundwater system wherever possible.

- Wherever reduction and replenishment are not adequate, seek out ways to collect the runoff and reuse it for irrigation, cooling tower makeup, or other grey water applications.

- Install engineered wetlands to act as bio-filters.

- Include methods and practices to preserve and enhance wildlife habitats that have been impacted due to the construction of your green project.

- Use sustainably harvested and recycled materials whenever possible for landscape structures, walls, decks, etc.

- Introduce soil management practices to ensure that the soil remains healthy.

- Consider the native environment when designing the landscape for the site. Focus on native plants, soil conditions, animal habitats, erosion control, hydrology, and climate to help determine the best design.

- Consult with landscape architects, contractors, arborists, wetland experts, erosion control experts, and other professionals to ensure that all aspects of the landscape design are optimized before construction begins.

section four

Operating Systems

Section Taster

This section explores the following considerations:

- *What opportunities exist to design or redesign operating systems to reduce, reuse, and/or recycle water as much as possible?*
- *How can the 'indoor environment' of the building be designed to optimize comfort, health, and sustainability?*
- *Are operating systems appropriately sized to match load requirements (e.g., pumps, motors, boilers)?*
- *Is the compressed air network designed to manage leaks, pressure drops, and miss-sized equipment?*
- *How can waste heat sources and consumers of heat in the facility be evaluated and matched?*
- *To what extent can high efficiency lighting be installed and/or natural lighting integrated into designs?*

This section outlines opportunities that can be implemented during the design phase of the project to enhance sustainability across all brewery, brewpub, and restaurant operations. For guidance on how to optimize operations post-construction or renovation, refer to the Brewers Association Sustainability Manuals: https://www.brewersassociation.org/best-practices/sustainability/.

Taking the time to implement the most efficient operating system, process equipment, and maintenance while still in the design, procurement, and construction phases will ensure that the brewery or brewpub will operate at the lowest sustainable cost possible and maintain cost optimizations long-term. By asking questions focused on the sustainable operation and engineering of the necessary equipment and practices needed to operate efficiently, the brewery or brewpub owner will experience lower operating costs from the start, rather than having to justify the installation of efficiency improvements down the road.

The fact that a sustainable and efficient operation is being designed at the beginning will not always mean that the capital cost will be lower. Engineering solutions intended to reduce energy and water usage should be evaluated to ensure that they meet or exceed all financial hurdles.

At times, the desire to start brewing and selling beer is so compelling that certain processes do not get the necessary attention at the start of the project. Failure to pay attention to these details from the start has a tendency to increase the long-term operating and capital costs. Unfortunately, the most efficient method or equipment item may not be the lowest cost; however, the premium cost at the design stage will undoubtedly be less expensive than years later, when the cost for adding the new efficient piece of equipment is compared against an installed asset.

As a simple example, let's consider a 25 HP fan operating at constant full speed five days per week. The cost of running this fan for an entire year would be:

25 HP x 0.746 kW/HP x 6240 hours x 0.075 kWh = $8,728

Now let's assume that this fan does NOT need to run constantly at full speed, so a variable frequency drive (VFD) could be used to achieve the following settings:

- 20% time at 100% speed
- 60% time at 80% speed
- 20% time at 60% speed

The resulting cost of running the same fan with these settings would be:

25 HP x 0.746 kW/hp x 1248 hours x 0.075/kWh x (1.00)3 = $1,746

25 HP x 0.746 kW/hp x 3744 hours x 0.075/kWh x (0.80)3 = $2,681

25 HP x 0.746 kW/hp x 1248 hours x 0.075/kWh x (0.60)3 = $377

The potential annual savings on only this one fan would be $8,728 – $4,804 = $3,924 per year.

The above example was sourced from: https://focusonenergy.com/sites/default/files/webinar_vsd_112911.pdf, which provides further detail and useful supplemental guidance on considering variable speed drives.

Taking the time to compare options on motors, fans, lighting, etc. and doing basic ROI calculations can result in significant ongoing (annual) operating cost reductions, plus other sustainability and reputational benefits.

Water Efficiency and Conservation

Energy design considerations are prevalent throughout this manual, but the importance of water efficiency and conservation should not take a back seat. Water is an increasingly precious resource, so being a water steward is a business imperative for all beverage companies despite water's relatively low purchase price.

Brewer's Corner!

When looking for water and wastewater reduction and optimization opportunities, it is important to always challenge the status quo ("this is the way it has always been done").

- *Is the process or activity necessary?*
- *Is it necessary to use water?*
- *Why does the process use so much water?*
- *Can the amount of water be reduced?*
- *Can lower quality water be used?*
- *Can water be recovered elsewhere?*
- *Is the process authorized and legal?*
- *Is it necessary to produce wastewater or effluent?*
- *Is clean water going down the drain?*
- *Is the discharge authorized and legal?*
- *Would it be cost effective to treat wastewater or effluent onsite for reuse?*

Operating design considerations should emphasize reducing water usage wherever possible. The less water you need to treat, the less pumping and energy use and the lower your cost. Aggressively reducing water will lower the impact on effluent flow, thus reducing the cost of discharging the water and lessening the impact on the local water treatment facility.

The objective should be to minimize the use of water everywhere possible, following the flow of water from incoming, through all process steps, and ultimately discharged. Challenge established norms set for water usage on all processes and applications that utilize water within the building and site. Seek alternatives for water use wherever possible:

Daily Activities: Instead of washing down a floor on a daily basis, determine if dry mopping or sweeping can be done one day and a wash done the next.

Equipment: Install low-flow plumbing devices on hoses, toilets, faucets, and other devices throughout the brewery and restaurant.

Operational Processes: Include metering as part of certain processes, such as CIP (clean in place) procedures, into the original design.

Brewer's Corner!

A common best practice is to capture knockout water for the next batch. Also, consider using heat-up water for CIP and recirculation for tank heat up, which will save water and energy!

Metering: Electronic metering will allow for continuous management and optimization, resulting in a lower operating cost. Metering is often overlooked during design and construction, but is a critical part of improvement and efficiency.

Of course, a number of these items will be site- and process-specific, but challenging the norm during the design stage costs nothing except time, and may lead to savings opportunities that are not readily apparent.

Water Reclaim and Reuse

Water can be recycled and used over and over again; for example, in chilled water and hot water HVAC loops, process cooling loops for compressors and chillers, or irrigation. Realistically, most of your water will only be used once and then flushed down a drain. An added benefit to reclaiming wastewater can be reusing the waste heat if the water being drained is at a temperature that will allow for heat recovery.

Potential sources of water that can be reclaimed and reused should be included in the design of the new project wherever possible:

- ***Pump seal water:*** If pump seals use water to maintain a seal and cannot be converted to a mechanical seal, then incorporating a collection system for this operation can save a significant amount of potentially clean water. For example, if a pump seal uses 1GPM of water and operates 10 hours/day for 250 days a year, that equates to 600 gallons a day or 150,000 gallons per year—for only one pump. This is usually clean water that can be used for cooling tower makeup, irrigation, or other grey water applications.

- ***Final rinse water after the CIP of tanks and lines:*** Capture and reuse it as the first rinse on the next CIP.

Brewer's Corner!

Always make sure to validate any changes to CIP with your quality department to ensure you do not have adverse impacts elsewhere. Quality and safety should always take precedent!

- ***Cooling water for centrifuges:*** Normally this water is discharged directly to a drain. Instead, consider capturing this water in a recycle loop with a filter and cooler.

4.1 Indoor Environmental

Sustainably designed buildings are intended to provide a healthy and comfortable space that occupants find enticing. Achieving such characteristics requires that focus be placed on indoor air quality, HVAC systems, access to natural ventilation and lighting, and reduction in noise pollution. As with all aspects of the whole building design, a number of the components that contribute to providing superior indoor environment conditions have already been highlighted in this manual. The following considerations attempt to tie components together and provide the design team with food for thought as they engineer the "indoor environmental" aspects of design:

- ***Occupant Well-Being:*** Overall design should focus on the safety, health, comfort, and performance of the occupants who will inhabit the space.

- ***Indoor Air Quality:*** Incorporate materials that do not contain, harbor, generate, or release particulates or gaseous contaminants into the atmosphere.

  > During construction, prepare a strategy that will ensure that dust and dirt are kept to the absolute minimum and are not introduced into the building ventilation and HVAC systems. The plan should also outline steps to protect construction equipment and materials from dirt, dust, rain, and other environmental factors that could cause items to mold or mildew.

  > Use environmentally friendly cleaning agents and avoid the use of any materials that can release volatile organic compounds (VOCs) or other harmful agents into the building atmosphere. Use ample quantities of fresh air to purge the building prior to commissioning the HVAC and ventilation control systems.

  > Provide a tobacco smoke-free building and take care to ensure that dedicated smoking areas (if allowed) are located so as to not allow smoke to infiltrate the building, and are positioned away from walkways and gathering places so that non-smokers will not have to walk through a smoking area.

  > Ensure that all heating, cooling, and ventilation equipment is operating as designed, all zones are properly controlled, and the systems within the building are balanced.

  > Include walk-off mats at all entries to reduce the introduction of dirt, dust, and other outdoor pollutants into the building.

- ***Natural Light and Ventilation:*** Consider adding as much natural light and ventilation to the building as possible. Starting with that focus will allow more thought to be put into the materials used to construct the building, seasonal variations in ambient weather conditions, and other factors that

influence lighting and HVAC systems. This approach may allow for a reduction in mechanical HVAC systems that need to be installed, saving significant capital operating costs.

> Maximizing natural light will mean optimizing the solar orientation of the building to ensure that as much natural light enters into the interior spaces as possible.

> Use openable windows and other means to increase natural air flow through the building.

> Engineer dedicated ventilation systems that operate independently of the other HVAC systems within the building.

> Provide the means to filter and treat ventilated air supplies to lower the amount of indoor and outdoor contaminants that may be introduced into the environment.

> Monitor the indoor air conditions to within an optimal range and provide systems that will detect anomalies and automatically respond to problematic temperature, humidity, and carbon dioxide issues when they occur.

> Design HVAC systems and controls that take into account seasonal conditions as well as all conditions that will affect temperature, humidity, and fresh air changes. These systems will need to be optimized in a way that will not impact the operation of the building and will take advantage of natural ventilation and lighting.

- ***Manage Solar Heat:*** Design the orientation of the building and provide necessary envelope building materials to reduce passive solar heat in the summer and maximize solar heat in the winter.

4.2 Steam / Hot Water Generation

Size your boiler or boilers to match your load requirements. If a spare boiler is required, investigate installing a rapid start boiler rather than running the spare during normal operation.

When producing hot water, consider the installation of low pressure hot water (LPHW) boilers instead of using steam heat exchangers. Low pressure hot water boilers operate at 95% efficiency compared to a steam boiler that operates at 80% to 83% efficiency. Please note that both LPHW and steam systems can be installed, resulting in less steam piping and steam heat exchangers. In some cases, alternatives can be used to produce hot water instead of using steam heaters.

For applications where steam boilers are in place or LPHWs are not feasible due to the size of the operation, consider high efficiency direct fired heaters, or instantaneous hot water heaters.

Additional considerations for boiler selection and design include:

- O_2 trim control with variable-speed drive combustion fan when installing new boilers
- Automatic boiler control
- Design the steam condensate return system to deliver 80% or more of the condensate back to the boiler feed water recovery system.

- Insulate all steam, hot water, and condensate piping as well as all control valves located on the boiler and on the steam, hot water, and condensate piping systems. All equipment with a surface temperature greater than 120 degrees F should be insulated. Blankets can be used on valves and flanges to allow for future maintenance.
- Install boiler feed water flow meters, makeup water flow meters, and condensate return meters to ensure that the maximum amount of condensate is being returned under normal operating conditions.

- In some cases, splitting the steam and hot water generation systems results in lower capital cost.

When purchasing a boiler, investigate installing heat recovery options such as flue gas economizers and consider whether to include blow-down heat recovery as part of the original purchase package.

Brewer's Corner!

Investigate the possibility of purchasing mash tuns, kettles, and hot liquor tanks with the entire tank jacketed. This may significantly reduce the load on the HVAC system, provide a more comfortable work space, and be much safer for visitors.

When installing mash tuns, brew kettles, and other steam heated vessels, always investigate the potential of installing stack heat recovery equipment to capture and reuse the heat being vented to the outside. This heat can be used to heat or preheat water and air applications within the brewery. Investigating these applications during the design phase of the project will allow for ample space for the auxiliary equipment, and in most cases the equipment can be provided by the brewing equipment manufacturer.

4.3 Pumping Systems

Size your pumps and motors to match the intended loads. Make necessary provisions to add on equipment for future expansion.

If possible, avoid installing future equipment until required. Pre-investment may include concrete pads and piping tie-ins in the initial design to avoid costly shutdowns in the future for connecting new pumps and piping modules. Avoid 90 degree angles and include more offset angles. This will minimize friction losses in the piping system.

If a pumping load varies, ask the engineer to consider variable-speed drive (VSD) applications in place of an automatic control valve; however, under certain operating conditions a VSD application may not be possible. On average, a pumping application that has a varying load will see a 20% or more energy efficiency improvement over an application controlled by an automatic control valve. This amount will vary depending on the application. Motors controlled by variable-speed drives should be rated for inverter duty. Install high-efficiency pumps and premium efficiency motors to power the pumps.

4.4 Refrigeration

In the brewery, refrigeration systems can be the largest electrical load. The refrigeration requirements will vary depending on the size of the installation, but the following highlights should be considered when designing a refrigeration system:

- Install the highest economically feasible coefficient of performance (COP) units. Just like the efficiency of power cycles, COP is defined as the ratio of the desired output to the required input. This is not considered efficiency, as the COP number is generally greater than 1. COP units are relevant for Freon, ammonia, and glycol systems. The kW/ton used should be as efficient as possible.

- Install variable-speed drives (VSD) on chillers, compressors, fan motors, and pumps associated with the refrigeration system. These applications are very important for systems that will operate at partial loads or vary their loads on a consistent basis.

- Utilize automatic control systems for all refrigeration systems, regardless of the size.

- When designing the equipment, consider future growth, but be cautious on sizing the equipment. Installing too much equipment will impact operating cost. A better choice would be to install pads, piping tie-ins, and future space for electrical equipment to accommodate new units when the load increases. This is preferable to installing a larger refrigeration unit that will operate at partial load all the time.

- Position the refrigeration equipment so that all hot exhaust air is vented outside and not into a room that will be air conditioned or ventilated.

4.5 Compressed Air Systems

Compressed air is the least efficient utility in a brewery. At best, for every 8 HP used to compress air, only 1 HP of usable product is produced. The rest is lost as heat due to compressing the air. Therefore, the best energy efficiency money spent is on the air system. Air leaks, pressure drops, and improperly sized equipment will contribute to excess operating costs well into the future. The following suggestions should be considered when designing a compressed air network:

- Map all loads that will require compressed air and determine if there are substitutes for compressed air. For example, air driven motors can be replaced with electric drives, and air knives on packaging equipment can be replaced with motor blower applications. Also, air driven silo vibrators may be replaced with electric drives.

- Determine the lowest possible air pressure that can be delivered to equipment designed to operate on compressed air. This will entail determining which pieces of equipment require the highest operating pressure and if they can be made to operate at a lower pressure. For example, operating a plant header pressure of 80 PSI over 100 PSI will lower the compressor energy operating cost by 10%. Also, if the system is designed to a maximum of 100 PSI instead of 120 PSI, lower capital cost may be incurred as well.

- Install compressed air piping in a manner that will reduce pressure drop. For example, minimize or eliminate 30, 45, and 90 degree angles wherever possible. Avoid using carbon steel pipe and galvanized pipe in compressed air systems. Consider aluminum and copper piping where possible.

- Consider designing the compressed air distribution network in a ring configuration with ample buffer tanks to reduce the impact of pressure drop on the system.

- Install variable-speed drives.

- Include leak detection devices to help locate compressed air leaks.

- Provide positive means of compressed air shut-offs to equipment, solenoid cabinets, and other applications so that when the equipment is shut down, the compressed air is automatically turned off. Exhaust hot air from the air compressor room outside; if you are located in a cool weather zone, the air can also be ducted into the interior building during the cold weather season using dampers.

- Bring outside cool air to the suction side of the air compressor.

- If water cooled air compressors are used, consider installing a heat exchanger on the compressor oil cooling water discharge to preheat boiler feed water or some other hot water source.

4.6 Heat Recovery

During the design phase of the project, have the engineering team assess all waste heat sources and all users of heat to determine if waste heat recovery applications can be used to heat or preheat water and air process flows.

- If the above exercise reveals an opportunity to utilize waste heat, include the necessary heat exchangers, piping, tanks, and pumps to capture and use the waste heat. This study, done early in the design, may result in smaller equipment sizes for boilers, heater, pumps, etc., resulting in lower capital costs.

- Heat recovery can be used to heat water for brewing, CIP, and cleaning as well as air for combustion heaters, boilers, and HVAC units.

- Equipment such as mash tuns, brew kettles, wort cooling, and boiler flue stacks should be reviewed to determine if waste heat can be reused in other applications.

- Investigate using solar thermal systems to heat or pre-heat hot water supplies for both process and HVAC applications.

- Arrange heat recovery equipment to avoid long pipe runs wherever possible.

4.7 Lighting Systems

- Install high efficiency lighting, preferably LED, for spaces such as production areas, offices, both front and back room areas of the restaurant, storage rooms, closets, warehouses, walk-in coolers and freezers, task lighting, and decorative/sign lighting.

- Include motion/occupancy sensors wherever possible, as well as photo sensors on outdoor lighting.

- If possible, install skylights to avoid electrical lighting during daylight hours.

- Install a building management system (BMS) to control lighting and HVAC when the operation is shutdown.

- Avoid over-lighting. Install only the amount of foot-candles necessary for the application. For example, a warehouse may require only 20 foot-candles whereas a production line may require 60. Only light areas that need it (e.g., no need to light the top of pallets on a pallet rack!).

- Consider installing advanced lighting controls that not only sense motion or daylight, but can also determine occupancy, heat, and light densities that will allow for dimming and precise zone control of interior lighting sources.

4.8 HVAC System

Heating, ventilation, and air conditioning (HVAC) systems within the brewery or restaurant can take on a number of different styles. Depending on the size of the installation, a central heating and cooling system may be used. This involves the use of chilled water, hot water, pumps, chillers, and air handlers to provide the necessary cooling and heating for a location. In most cases, this system is the most energy efficient to operate; however, the majority of installations rely on roof, ground, or wall mounted units to provide heating and cooling for a given location. In some cases, the unit will hold both a cooling coil as well as a heater to provide the required temperature control for a given area. Best practices for the overall HVAC system for a given location should take into account the following:

- Adherence to local building codes as well as American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) standards. ASHRAE standards will greatly enhance the overall efficiency of the HVAC design.

- Load calculations are imperative for a sustainable HVAC system. Over-sizing of HVAC equipment contributes to higher energy costs and, in some cases, increased maintenance cost. Load calculations need to take into account the building function, normal and abnormal loads, time frames, building construction, local environmental conditions, and other factors.

- Taking the time during the design stage to highlight each area's requirements and to install the proper sized equipment to control the zones will save energy. Define zones within the building that enhance the efficiency of the HVAC equipment as well as improve the zone comfort for the occupants.

- Consider multiple-stage heating so that only the required heat is in operation when needed.

- Define a duct work plan that minimizes duct length, bends, and obstructions. Use round duct rather than square duct wherever possible. Minimize the use of flexible duct and fiberglass duct.

- Locate HVAC in such a way as to shorten duct runs, allow ample space for maintenance, and provide adequate drainage.

- In climates that permit, install economizers on the units to take advantage of ambient conditions for free cooling when possible.

- Avoid placing cooling equipment in direct sunlight if possible.

- When considering equipment, purchase the highest coefficient of performance (COP) or seasonal energy efficiency ratio (SEER) unit that meets design and financial conditions. The higher the COP or SEER rating, the more energy efficient the unit is.

- Install the most efficient fan configuration possible. Where cooling or heating loads have the capability of being varied to match a given time of day or load condition, consider installing a VSD for fan control.

- If possible, use direct drive fans in place of belt fans. However, if belt fans are installed, consider installing a COG belt in lieu of a standard V-Belt.

- Air to air heat exchangers should be considered in locations where the exhaust air can be used to cool or heat the incoming air.

- Include differential pressure switches, gauges, or alarms in the design and equipment purchase to assist with changing out filters when required.

- If possible, install an HVAC control system that will allow for continuous monitoring and control of the entire system. This will enable automatic temperature control adjustments based on occupancy, time of day, or seasonal changes.

- If the location does not warrant a building management system, consider installing programmable temperature controls throughout the facility to provide temperature set-back control or to shut off units completely when no one is present or during off shifts and weekends.

section five

Case Studies

Construction Case Study: Transition from Small to Mid-Sized Brewery

This case study was submitted by a brewery that preferred to remain unnamed for purposes of publication in this manual. However, they were eager to share some of their experiences so that other brewers would benefit from their successes and mistakes. We have left the story in the brewers' own words to capture their emotions for what worked and what did not work.

Background

The building currently housing our brewery was christened in the spring of 2007 and has undergone four significant expansions, along with many smaller expansions to date. Our owner was certain the building was big enough to suffice for our volume demands until his retirement. It goes without saying that we feel very fortunate that he miscalculated. We also have leased offsite storage for secondary fermentation, shipping, and receiving, and a building devoted to experimental beer production. An additional leased building housing our maintenance shop was built in 2016.

Hindsight being what it is, we have a laundry list of completed projects we would approach differently today. One must consider that money was a lot tighter 10 years ago and we did not have access to the expertise we have gained with working knowledge and the hiring of specialized individuals. The most important thing we have learned is that extensive, inclusive planning is key to the long-term success of any construction project, whether green or not. We also shamelessly approach other breweries when looking for direction.

VFDs on Pumps

We moved away from single phase hard on/off CIP pumps on carts to pumps driven by 3 phase motors with single phase in/3 phase out VFDs. This was a tremendous improvement for dialing in each tank size's pressure needs for each CIP step and also resulted in improved safety, performance, efficiency, and equipment longevity.

Flowmeters and Valves

There are flowmeters on every hot and cold (not mixed) production water drop in the brewery. This allows us to have a very dialed-in CIP process so our chemical and water usages are dead-on every time. Initially we had flowmeters on individual drops with valves below the flowmeters. We discovered the hard way that sometimes flowmeters blow off of drops, so we moved the valves above the flowmeters. We also discovered we are not using both hot and cold simultaneously in some cases, such as brew vessels, which allowed us to tee hot and cold lines together upstream from the flowmeter and eliminate a flowmeter. Turbine flowmeters, instead of paddle meters, are used throughout the brewery because they are more consistent and less prone to failure. They are well worth the price difference.

Tile

Industrial tile now covers a significant percentage of our brewery floors. Thus far we have failed to destroy any of this tile, in spite of our best efforts. This tile has proven to be much more resistant to the harsh environment of a brewery than any sort of floor coating. The upfront costs are higher, but the investment is well worth it.

T5 HO to LED Retrofit

We have begun phasing out our T5 HO (high-output fluorescent tubes) ballasts and bulbs with low voltage drivers and LED lamps. This allows us to save a significant amount of energy without requiring the replacement of entire lighting fixtures. A four lamp retrofit costs under $200, without compromising light quality.

Before executing any lighting project, we investigate the ever-changing incentives available. We recently replaced 12 T-5 fixtures with LEDs for less than $75 a fixture, with individual occupancy sensors.

LED Lights

Beginning with our most recent expansion, we have committed to industrial LED lights for all light installations moving forward. They have proven to provide excellent light quality and programmability, along with being very resilient. This commitment streamlines purchasing so there is no confusion with any staff purchasing light fixtures.

Prior to implementing this program, we would have benefitted from at least committing to installing only LED lights in coolers, as fluorescent lights generate significant heat waste and prefer warmer operating environments.

Large Industrial Fans

A very large VFD driven industrial fan was installed above our kegging and bottling lines, and our secondary fermentation room. These fans allow for operators to at least feel cool in the summer months and can be adjusted to push warm air down without blowing on operators in the winter. They also allow for our secondary fermentation room to have an efficient, uniform temperature.

Bunker Construction

Although upfront costs are high, there is very little maintenance that goes into a concrete bunker. This design eliminates the need to build a structure around tanks, which reduces construction time and materials. The ceilings are low, allowing heat/cooling and lighting savings. We built a six- tank bunker in 2011 and have expanded it twice. We were able to reuse the insulated panel wall with the first expansion. Utility expansion when expanding a bunker is very easy and low cost.

Spent Grain Silo

We installed a vertical silo with an auger in 2012. This has allowed for a much cleaner system and environment and we have had very few issues to speak of. There is a long financial ROI with such a system, but the life and environmental improvements have been tremendous. This also generated a better relationship with environmental regulators, as it was a proof of priority.

Dust Collection System

A dust collection system was installed on our bulk silos in 2014. Aside from freezing gates, this system has been excellent. We tried everything from vent end caps with holes and filter element to filter bags to a drum vacuum. Previously, every time the silo was filled, a huge dust cloud was created, clogging air intake filters and chiller radiators, and entering the building. This was not environmentally sound and caused boiler damage, RTU damage, chiller compressor damage, etc. We are able to give the collected dust to a local farmer for livestock feed.

Removable Wall

In 2013, we added a 70 bbl brewhouse. Part of the building design was a removable wall that allowed us to stagger brew vessel installation and will allow us to expand our brewhouse with minimal disruption and waste.

Building Rebuild

We purchased an old building in 2012. In order to refurbish this building and make it more efficient, we added 2" foam board insulation throughout and covered it with galvanized corrugated roof panels. The panels look nice and have held up nicely to the brewing elements. More recently we covered the outside of the building with 2" insulated structural wall panels, essentially making the building look new. This saved waste and increased the R-value of the walls.

Shipping Storage

Considering that we are in the Northeast and have six months of cool weather, we installed a web interface control system on our largest refrigerated space, which is in our offsite warehouse. The system uses outdoor air to cool the space when the outdoor temperature is a mere 2 degrees cooler than desired inside. The system also employs high efficiency fans to circulate air when cooling is not active rather than the evaporator fans running 24/7. There is a real-time monitoring/control system that allows for remote access and energy tracking.

Bottling Hall Expansion

This is the first expansion where we dedicated ourselves to reducing our impact and planning for the future as much as possible. We did a fair amount of research to increase the use of recycled content wherever applicable and requested low flow plumbing fixtures (water-free urinals, low-flow toilets, and low-flow faucets in sinks and showers) and LED lights with motions throughout. We were able to find recycled carpet, recycled restroom dividers, and lab furniture, and recycled rolled-rubber flooring. We had a wall built from retired pallet planks and have a walkway/chandelier lit with filament light bulbs. We also designed the building to withstand the weight of a solar array, which was installed in 2016. This project showed us the importance of planning the minutest details as far ahead as possible. An in-house team of 12 employees did all of the research for this expansion.

Bottling Line and Keg Line Move

This project consisted of relocating our bottling line into a newly constructed space, and moving the keg line to the area previously occupied by our bottling line. Several of us from maintenance, production, and warehouse sat down on a regular basis leading up to this move to cover logistics, including making sure maintenance access and operator and warehouse ease/safety were at the top of the priority list. We were able to double the speed of our keg line, add a significant amount of infeed conveyor, and add a pallet wrapper. We were also able to significantly speed up our bottling line with less conveyor and add a full case x-ray and palletizer. The time spent in planning this project allowed for the commencement of the machines in their new spaces to be seamless. Future waste was reduced by ensuring the utilities are sized for our next expansion and that the supporting equipment was sized and located appropriately for the next expansion. We also took the opportunity to upgrade parts of each line we decided were design flaws and had been plaguing us for some time.

Low Traffic Lighting

All of the old high pressure sodium fixtures were replaced with 4-lamp, T5 HO fixtures before commissioning the new packaging area. This space has 35’ ceilings at its peak; however, we do not have a need or ability to forklift products anywhere near this height. Thus, we can lower our fixtures significantly and remove two lamps without compromising light quality. Had we considered this issue to begin with, we could have initially installed 4-lamp fixtures, but put them lower and run half the bulbs. We are prepared should we have to lift fixtures at a later date, because it is easy to coil and zip-tie wire whips and jack chain. As is, it will be disruptive and costly to rewire and lower 100 fixtures. We also installed the same fixtures in the cold shipping box. It would have been ideal to install LEDs in this space, because they do not generate much heat and operate better in lower temperatures.

With regards to motion sensors, we separated the high bay fixtures into banks of four, with two motion sensors on each bank. More recently, we added motion light switch sensors to the offices as well. These are a nice addition for after typical office hours, when both office and warehouse spaces see a lot less traffic.

In hindsight, we should have included motion sensors for the offices from the initial buildout, which would have been cheaper than retrofitting. Since it is much easier to raise lights than lower them, we should have zoned the storage lighting based on the projected layout of the storage space, and based lighting height on the maximum height we would typically stack pallets.

We have additional space that sees little production time, but is a vital part of every tour. The lights tended to be left on all day, every day, so we retrofitted every production fixture with a motion sensor. The project had a simple ROI of two years.

Building Automation System (BAS)

As our brewery has become more complicated, we have had to adapt our ways of monitoring. With time, we have added the capability of monitoring all and controlling some of our most critical pieces of equipment with this system. This allows us to get notified when a piece of equipment is down, such as a chiller, and allows us to maintain control of all occupied spaces which keeps folks from altering thermostat schedules. We are now moving toward using ignition on all new pieces of equipment. The key takeaway for a BAS is to plan it out as detailed as possible, be consistent, and give individual pieces of equipment logical, long-term titles.

New Construction

We followed the same model as our bottling line expansion but were able to learn from that project and avoid a few mistakes. We improved our waste diversion measures and were more diligent about ensuring our wishes are followed on fixtures, paint, landscaping, etc.

Sump Pump/Pit

When we installed our first pit and effluent tank, we did not expect to grow as quickly as we did. Prior to reworking this system, we were relying on a single three-quarter HP sump pump at the bottom of a narrow pit with a 100 gallon capacity before overflowing. The pump was activated by a simple float switch. The pipe leading into the pit was 6", as was the pipe leaving it. The lift pipe was 2", which led to a 3,000 gallon equalization tank. The wiring for this system is inaccessible and prone to moisture corrosion, causing regular breakdowns.

This pit should have been much larger to begin with, with several spaces for pumps, including plumbing for them. We should have put in an oversized electrical conduit and made sure it was at an accessible height. When pouring the pad for our tank, we should have made sure it was large enough and sufficiently reinforced to accommodate a much larger tank. An effluent flowmeter and automatic chemical dosing station would have improved the system as well.

In 2016, we installed a 30,000 gallon tank with 1,000 gallon pit, 5 HP lift pump and spare lift pump, accessible wiring for the pit pumps, a recirculation pump and spare recirculation pump, automatic pH monitoring and chemical injection, effluent flowmeter, and a very interactive control system to allow for self-buffering and trend monitoring.

Side-Streaming

An important effort we have made from a very early stage, which has expanded in complexity and success with growth, has been side-streaming our usable waste. It makes obvious sense to side-stream grain, as it is quite sought after. It is just as important for footprint reduction, though, to side-stream yeast, trub, and any other operational waste. A farmer uses our yeast and trub as a natural fertilizer on his hay fields, because it is very nutrient rich. We have successfully performed some trial runs with a commercial digester as well. There are also local farmers feeding yeast and trub to hogs, although cattle seem to dislike trub, and too much yeast can harm them. A farmer takes our chaff from our milling system and silo dust collection to feed hogs. We use a local composting company to compost fruit from beers and employee/event waste. We are also involved with a local group to help develop a system of connecting end users to our other usable waste products such as grain bags, slip sheets, ice packs, etc.

Glycol Lines

Initially, we ran our tank cooling lines out of PVC. We then transitioned from PVC to 1" copper, leaving the PVC in place. As we added tanks, we simply tied into the copper lines. This caused many cooling problems as end tanks were not getting cool due to air issues. The PVC and copper lines were recently completely removed and replaced with stainless lines, with a large loop that includes headers for tying in tanks. In the long run, we have spent much more money and generated a lot of waste because we tried to save a few dollars to begin with.

24 Volt System

We have used a 24 Volt AC power source to control tank cooling, and used simple thermostats to run solenoid valves on our glycol lines. We ran a heavy gauge loop and tied into it by scraping off the insulation where necessary, and daisy chained the power feed from controller to controller as necessary. This system was subject to constant failures and caused a small fire at one point. Although this system was relatively functional, it was not safe or sustainable. We have since transitioned to a control cabinet with air valves. Although this system is not the most sustainable option because it is air driven, it is much more reliable and allows for a central control station.

Dry Storage HVAC

We installed natural gas blower heaters to temper our dry storage area, but would have saved significantly on heating costs had we installed radiant heating instead. We also failed to have an energy audit on this space before moving in, and have since discovered that the insulation of the building is poor. When we decide to upgrade this building, it will be more disruptive and costly than insulating it from the beginning. It would have been ideal to have installed programmable thermostats in the dry storage area of this building.

Brewhouse Environmental Comfort

In our brewhouse, there is an economizing air exchange system that works only as an air warming system—there is no way to bypass the economizer. The brewhouse generates enough heat, due to the tops of our brew vessels not being insulated, that we have only been able to run this system in the dead of winter. We would have benefitted from using the money spent on this system to install more heat recapture systems and better insulate the vessels and piping. The windows in this area are subject to a lot of solar gain. We should have installed film in the initial buildout as well.

High Pressure Boilers

Currently, an oversized, on-demand, high pressure natural gas steam boiler runs our 70 bbl brewhouse. Although we are slowly moving to the point of optimal operation of this boiler, we should have installed a smaller boiler to begin with. This boiler has been running in short cycles for an extended period, causing issues one would expect with excessive ignition cycles, including inefficient operation.

We transitioned the rest of our equipment to use this steam source as well and installed a second boiler of equal size, running them in a lead-lag scenario. In doing this, we missed an opportunity to solve our short cycling issue, as each boiler provides more steam than our typical load requires.

Wiring

It may not seem like a sustainable building design issue, but being diligent about labeling electrical boxes is extremely important for the longevity of a system. Countless hours have been spent deciphering poorly labeled wiring, including a lot of piggyback work. We would have benefitted tremendously from putting in oversized wire troughs and conduit/extra conduit runs, and heavier than necessary gauged wires from the installation of our first electrical panel. We have since started to do so, which saves on labor and makes moving or installing equipment much easier. Having oversized wire troughs makes organization much simpler.

Chain and Disc

When our 70 bbl brewhouse was installed, we decided to run chain and disc conveyors to move bulk grain throughout the building. This system has been a great workhorse for us, although the automation was designed to run each step an excessive amount, causing unnecessary energy use and dry running (excessive wear and tear). The noise generated by a chain and disc system should be considered as well.

Air Exchange

The initial air exchange system and supporting infrastructure have been a constant headache. This system consists of an incoming duct, hard on/off blower, and an air sock spanning the brewery. There is also a hard on/off outgoing blower and duct. The footprint of this system is enormous, inefficient, and the duct work limits where tanks can be located and maintenance access to key areas. As we have grown, we have disconnected the outgoing blower so air is pushed out lower in the building. We are in the process of installing a VFD driven economizing system that will feed the air sock directly from the roof.

Air Lines

Much like our glycol lines, our air lines have been worked and reworked over time with growth. We have had to add buffer tanks on buffer tanks. This isn't a bad thing in itself, but we should have thought several expansions down the road when we installed the air infrastructure. For a little extra money, we could have built an oversized air supply header and kept it nice and organized, as far out of the way as possible. Installing a new buffer tank is not expensive in itself, but having to re-pipe a system to accommodate it is wasteful and costly, as is not having enough air when it is needed.

Water Lines

As with our glycol and air lines, we have worked and reworked our water lines. In the recent past, we took advantage of our 4" incoming line, which had been necked down to a 2" meter. We had a 2" header off of this system and kept pulling more water than we could make up, causing air to build up in lines and surges. In changing to a 4" meter and a larger header, along with increasing our pipe sizes leading to out bottling and keg lines, we were able to solve the issue. We are currently adding a cold water surge tank. Had we planned these projects in conjunction, or looked at incoming water like we do hot or chilled water, we may have been able to put off installing a new meter for some time and may have been able to plan for the phase beyond the cold water surge tank to reduce the need to rework the water lines again.

We have also treated our water needs growth much like our glycol needs growth and would have benefitted from much larger supply lines in a header style from the get-go. This would have saved a tremendous amount of money, supplies, and labor in the long run.

Landscaping, Parking, and Snow Management

Until recently, we looked at our landscaping as something that needs to look nice and be functional. We have not considered the relationship of our footprint with the greater ecosystem. We have been striving to be more educated on interactive/ecosystem supporting plants that require very little maintenance as well as invasive species reduction. We have also adopted a section of our local trails network, which has allowed for a better connection between employees and nature.

One area for concern is employee and customer parking, which always seems to be in low supply. We provide covered bike parking for employees, including tool and compressed air access. We have also installed an electric car (EV) charging station for employees, with one for customers in the near future.

We are in an area that gets ample snow, and have struggled to plan for snow management. We generally have to remove plowed snow piles at least once a winter, which generates unnecessary equipment emissions.

Motion Sensors Bunker

Our bunker is another area that sees a lot of traffic during some times, and little during others. Unfortunately, not enough planning went into this project and it had some considerable hiccups. The motions were initially put in as banks, with the sensors too far from the high traffic walkway. Thus, at time brewers were unable to see necessary distances, and sensors were missing people. Although we realized reduced savings by making the entire space two banks (zone 1, 12 fixtures; zone 2, 48 fixtures), we are seeing a big reduction in runtime with no safety issues or complaints.

This project speaks to the importance of involving the operator on the floor as an information resource, even with the smallest project.

Waste Management

There is no magic answer to this issue, but we have had huge success with streamlining all of our waste processes, including utilizing waste stations with consistent colors and bin sizes in each station. Reducing the number of stations to a minimum has been very helpful. We have also been very proactive about finding second homes for our waste streams rather than throwing things away or recycling them. We have found Craigslist to be a wonderful way to develop lasting relationships with various members of the community. This has allowed us to “donate” what we would normally throw away, helping community gardens, schools, farmers, caterers, and other breweries.

Fermenter Setup

Although it is normal for tanks to get moved on a regular basis, having our utility system initially designed for a dynamic and ever-growing tank farm would have been beneficial in numerous instances. We added a considerable amount of wire on each light fixture during the initial installation. This has been very helpful when moving tanks so fixtures don’t wind up hidden and no waste is generated, save for a zip tie or two. We have run our tank cooling system in stainless steel with valves containing sanitary ports at each tank, connecting the tanks with flexible lines. This allows us to move the tanks at will without draining the cooling system or cutting a single cooling line.

Additional Case Studies:

Flat Head Brewery: Our Story
http://flatheadlakebrewing.com/about-us/

Hawaiian Brewery Keeps Cool with IMPS
http://www.constructionspecifier.com/hawaiian-brewery-keeps-cool-with-imps/

Sustainability Helped Attract Brewery to Asheville
https://bsc.poole.ncsu.edu/library/article/sustainable-craft-brewing-earns-recognition-in-eastern-nc

Highland Brewery Goes Solar
https://www.highlandbrewing.com/about-us/sustainability

We hope that additional Brewing Association members will provide feedback on what worked and what did not work for them during design and build processes. As building practices and industry trends change, so will the content of this manual. Therefore, all input is welcome to make this a living, breathing knowledge base. Our hope is that this manual will help you to lower operating and capital costs where possible, provide a foundation for incorporating sustainable design and build practices into the projects under development, and help reduce the environmental footprint for the industry.

appendix a

Basic Site Selection Checklist

BASIC SITE SELECTION CHECKLIST		
PROJECT TYPE		
DESCRIPTION	***APPLICABLE***	***COMMENTS***
NEW BREWERY	Y / N	
NEW BREWPUB	Y / N	
EXPANSION PROJECT	Y / N	
RENOVATION	Y / N	
OTHER	Y / N	
LOCATION CONSIDERATIONS		
DESCRIPTION	***APPLICABLE***	***COMMENTS***
CUSTOMER BASE PROXIMITY	Y / N	
COMPETITOR PROXIMITY	Y / N	
PUBLIC TRANSPORTATION	Y / N	
VEHICLE TRAFFIC	Y / N	
TRUCK AND AUTO PARKING	Y / N	
NEIGHBOR PROXIMITY	Y / N	
GREEN BUILDING CAPABILITIES	Y / N	
ACCESS TO SITE	Y / N	
SITE ACCESS EASEMENT	Y / N	
SITE REQUIREMENTS		
DESCRIPTION	***INFO AVAIL***	***COMMENTS***
SITE SIZE REQUIREMENTS	Y / N	
SITE LEASED OR OWNED	Y / N	
TAX CONSIDERATIONS	Y / N	
INCENTIVIES AVAILABLE	Y / N	
ZONING REQUIREMENTS	Y / N	

BUILDING SIZE LIMITATIONS	Y / N	
SHAPE OF BUILDING LIMITATIONS	Y / N	
BUILDING(S) ORIENTATION	Y / N	
GREENFIELD	Y / N	
BROWNFIELD	Y / N	
HISTORIC	Y / N	
REHABILITATION	Y / N	
SITE / LOCATION IMPACTS		
DESCRIPTION	***INFO AVAIL***	***COMMENTS***
PREVIOUS USE DATA	Y / N	
SOIL HISTORY AVAILABLE	Y / N	
SOIL SAMPLES AVAILABLE	Y / N	
FILL EVIDENCE OR NOT	Y / N	
FLOOD DATA AVAILABLE	Y / N	
SETBACK REQUIREMENTS	Y / N	
AIR EMISSION REQUIREMENTS	Y / N	
NOISE REQUIREMENTS	Y / N	
LANDSCAPING REQUIREMENTS	Y / N	
BUILDING SIZE / HEIGHT RESTRICTIONS	Y / N	
TRAFFIC FLOW RESTRICTIONS	Y / N	
STREET OR HIGHWAY UPGRADES REQUIRED	Y / N	
CONSTRUCTION REQUIREMENTS	Y / N	
PERMITS (CONSTRUCTION, OCCUPANCY, OPERATIONS)	Y / N	
HOURS OF OPERATION	Y / N	
UTILITIES		
DESCRIPTION	***INFO AVAIL***	***COMMENTS***
ELECTRICAL SUPPLIER	Y / N	
ELECTRICAL CAPACITY	Y / N	
ELECTRICAL SUPPLY PRI VOLTS	Y / N	
ELECTRICAL SEC. VOLTS	Y / N	
ELECTRICAL SUPPLY LOCATION	Y / N	
ELECTRICAL SUPPLY CONNECTION	Y / N	
ELECTRICAL CONTRACT	Y / N	

NATURAL GAS SUPPLIER	Y / N	
NATURAL GAS PRESSURE	Y / N	
NATURAL GAS CAPACITY	Y / N	
NATURAL GAS CONNECTION	Y / N	
NATURAL GAS CONTRACT	Y / N	
WATER SUPPLY PROVIDER	Y / N	
WATER SUPPLY PRESSURE, AVAILABLE FLOW ETC.	Y / N	
WATER SUPPLY CHEMISTRY PARAMETERS	Y / N	
WATER SUPPLY LOCATION	Y / N	
WATER SUPPLY CONNECTION	Y / N	
WATER SUPPLY CONTRACT	Y / N	
WASTEWATER (WW) REQUIREMENTS	Y / N	
WW CHARGES & SURCHARGES	Y / N	
WW DISCHARGE FLOW LIMITATIONS	Y / N	
WW LIMITS & RESTRICTIONS	Y / N	
WW PIPE / SYSTEM CAPACITY	Y / N	
ANY WW PRETREATMENT REQ	Y / N	
STORM WATER DISCHARGE LIMITS	Y / N	
STORM WATER DISCHARGE CAPACITY	Y / N	
STORM WATER DISCHARGE LOCATION	Y / N	
UTILITY EASEMENT REQUIREMENTS / MAP	Y / N	

ADDITIONAL NOTES
I.E - SPECIAL CONDITIONS, FEES, ETC. AND ITEMS NOT COVERED IN LIST

appendix b

Detailed Site Selection Checklist

Site Selection Checklist Items

The areas that need to be considered when defining a site location are listed below. The list includes, but is not limited to, factors that should be considered during the site selection process. The factors will depend on the project type, size, and market conditions and not all of them may be required for each project under consideration.

- **Location Footprint**
  > Min / Max Property Area Requirements
    - What is the minimum and maximum square footage and dimensions (length, width, and height) required for the total project, including all buildings, green space, parking, etc.?
    - What type of configuration is required (e.g. square, rectangle, or other)?

  > Expansion Capabilities
    - Is there potential for growth? (Consider the availability of adjacent land or buildings.)
    - Is there the square footage required for expansion?
    - What type of expansion are you considering? This could be a warehouse, parking, production, office, gift shops, brewpub, etc.

  > Acquire a map of the area indicating all existing commercial, industrial, and residential buildings and areas.

  > Request monthly climate averages for the past three years.

- **The typical square footage requirements for standard sized brewpubs:**
  > 3 and 5 barrel Systems = 300 to 500 square feet

  > 7, 10, and 15 barrel Systems = 550 to 1,200 square feet

- **Location Preferences**
  > Urban, Rural, Small town, Semi-Urban

  > New site (Greenfield) Developed/ Undeveloped
    - Developed: Site is part of developed area; roads, sewers, water, and other services are installed and the area is zoned for your project type.
    - Undeveloped: Raw site with few to no utilities installed; roads are not in place and the area may or may not be zoned for your project application.
    - Greenfield: Locations need to take into account sustainability concerns for environmental, community, and land use impacts. They do, however, allow for more flexibility for implementing sustainable building practices because the design is starting with a clean slate.

  > Brownfield
    - A stressed property due to current or past contamination.
    - Locations can include industrial parks or urban areas.
    - Additional costs may be incurred to develop the property to match project requirements.
    - Sustainable building practices may be limited depending on brownfield conditions.

  > Rehabilitation / Existing Structure(s)
    - The existing structure either stands alone or is part of development area.
    - Infrastructure modifications may need to be made in order to accommodate utility services and parking areas.
    - Alignment of the brewing process, brewpubs, gift shops, etc. may be altered due to existing building configurations and will need to be taken into consideration when selecting an existing site for new construction.

- Changes to the process may involve equipment positioning that will increase the capital cost of the project, hamper future growth, or limit the type of sustainable building practices that may be installed. For example:
    - ◊ A former manufacturing facility has ample space for beer production but load bearing walls prevent an open floor plan for the brewing and fermentation processes, which will involve additional piping and platforms and will limit future fermentation tank locations.
    - ◊ A building's footprint is up rather than out, requiring the operation to be installed on multiple floors, with brewing on one floor and packaging on another. This configuration may involve additional piping and hamper process flow, lowering overall production efficiency. In some cases the location of equipment will involve hiring additional resources.
    - ◊ A current location is sized adequately for phase 1 production plans and can house the brewpub and gift shops. Phase 2 plans would require moving into adjacent buildings that may not be available for sale or may not be large enough to accommodate the Phase 2 plans.
    - ◊ An existing building has adequate space for planned operations and configurations, but the installation of a roof solar array will not be possible due to surrounding building heights, roof space limitations, or structural concerns. Rainwater reclamation will require the installation of storage tanks that will take up the footprint allocated for tank expansion.

> Historic Properties
- May have a historical designation or be eligible to receive one.
- A structure will have former uses and a history of existing structures or land.
- Local groups may need to be consulted.
- There may be a formal review process for developing the site.
- Changes made to the building may require the approval of governing parties for historic properties within a given locale.
- Building modification restrictions may not allow for architecture attributes that reflect the attitude or philosophy of the brewer.
- Historic property restrictions may limit the ability of the brewer to expand at the given site and should be taken into consideration during the site selection process.

Site Conditions

Site conditions will need to be taken into consideration after the type of construction or building parameters have been determined. Based on the information received during the site selection, the selection of location and building type may be altered. The following items are intended to help the brewer ask relevant questions when determining the site location for a brewery, brewpub, or restaurant.

- **Building(s) footprint:**
  - > Will the envisioned building footprint and style(s) match the footprint being considered as part of the business plan and objectives, taking into account initial design and future growth plans?
  - > Will the footprint be able to accommodate renewable energy sources, water capture, and reuse tanks?

- **Current land uses for greenfield projects:**
  - > What is the site's current use and how will the project impact that use?
  - > Will the addition of the project impact the contour or hydraulics of the land?
  - > Will the project impact endangered species or other natural elements that could entail protest or disagreements with property neighbors?
  - > Are there any special considerations that will need to be included in the project as a result of existing use criteria for the site?

- **Current building uses:**
  - > What is the condition of the facility: abandoned, occupied, single tenant, or multi-purpose?
  - > What is the projected impact on the existing building, and will this building impact require a modification to the business objective, site configuration, or business plan?

  - Will the building require special considerations to be taken into account during construction and/or normal operations?
  - Is the existing building suitable for future growth?
  - Can sustainable building practices and LEED requirements be installed at the given location without impacting the project financial plan?

- **Adjacent properties (residential, industrial, other uses)**
  - Can you identify adjacent property owners?
  - Will the project have a negative impact on the community?
  - Can you identify natural conditions that are adjacent to the property line and may impact the project? For example, rivers or streams that border the property line, open areas, or green zones that abut the site.
  - Are there any environmental impacts located adjacent to the property (landfills, compost stations, wastewater treatment facilities, etc.)?
  - Will the project involve any additional anticipated foot, auto, and truck traffic?
  - Can the project include aspects that will not only enhance the project, but benefit the community as well? For example:
    - A brewpub will provide a new business to a distressed community.
    - Shared green spaces will be developed that will allow for rain water collection.
    - The installation of solar array parking panels on adjacent parking spaces will contribute to a sustainable design.

- **Hazardous Materials or Contamination Sources**
  - Are there any current or past hazardous materials or contamination sources at the location?
  - If so, is remediation in progress or will it be required to access and develop the site?
  - Can you obtain soil reports, civil surveys, and other closure documents?

- **Traffic and Transportation**
  - Public transit
    - Can the nearest public transit routes, stops, and stations ensure adequate transportation for both customers and employees?

- **Traffic Analysis (materials, finished product, customers, and employees)**
    - What are the access points for raw material delivery for the facility?
    - How many service vehicles and delivery trucks will be accessing the property daily?
    - What is the anticipated traffic flow into and out of the facility and surrounding neighborhood?
    - Will additions or modifications need to be made to the access roads?
    - Will new traffic patterns negatively impact the community and if so, what changes need to be made to overcome these negative factors?
  - Employee access and parking
    - Is sufficient parking available to meet current and expansion workforce requirements?
    - Are there potential alternative energy (EV) charging locations (if necessary)?
  - Customer access and parking
    - What are the parking requirements for customers and site access for all individuals?
    - What issues may impact customer access to the site and facility?
    - What handicapped parking requirements are related to building entrances?
    - Are there potential alternative energy (EV) charging locations (if necessary)?
  - Connection to public streets, roads, highways
    - Are site access points sufficient, or will any additions or modifications need to be done before commissioning?
    - Are there potential alternative energy (EV) charging locations (if necessary)?

appendix c

Considering LEED

What is LEED?

Leadership in Energy and Environmental Design™ (LEED) is a green rating system developed and maintained by the United States Green Building Council (USGBC). According to the USGBC, LEED is the most widely used third-party verification for green buildings, with around 1.85 million square feet certified daily. LEED is applicable to all buildings—from homes to corporate headquarters—at all phases of development. Projects pursuing LEED certification earn points across several areas that address sustainability issues. Based on the number of points achieved, a project then receives one of four LEED rating levels: Certified, Silver, Gold, or Platinum. The USGBC has developed a valuable and comprehensive online toolkit: http://www.usgbc.org/leed/tools/leed/tools/.

Why Pursue LEED?

Building owners pursue LEED certification to achieve healthier, more productive places, reduce stress on the environment by encouraging energy and resource-efficient buildings, and achieve savings from increased building value, higher lease rates, and decreased utility costs. According to the USGBC website, LEED buildings:

Provide a Competitive Differentiator - 61% of corporate leaders believe that sustainability leads to market differentiation and improved financial performance.

Make for Happier Employees and Occupants - LEED-certified buildings are demonstrating increased recruitment, retention rates, and productivity benefits for employers. Currently, 2.5 million employees are experiencing better indoor environmental quality in LEED buildings.

Attract Tenants - Today's tenants understand and seek the benefits that LEED-certified spaces offer. The new Class A office space is green; lease-up rates for green buildings typically range from average to 20% above average.

Save Energy and Resources, Lower Operating Costs - From 2015-2018, LEED-certified buildings are estimated to generate as much as $1.2 billion in energy savings, $149.5 million in water savings, $715.3 million in maintenance savings, and $54.2 million in waste savings.

Are Cost Effective - A study of 562 PNC bank branches showed that compared to non-LEED-certified facilities, LEED-certified facilities annually opened up 458 more consumer deposit accounts and had $3,032,000 more in consumer deposit balance per facility per year and increased revenue.

Provide Public Relations Community Benefits - Adobe Systems, Inc., announced in 2006 that it had received three LEED Platinum awards for its headquarters towers; not only did it reap great publicity, but the firm showed that it had garnered a net present value return of almost twenty-to-one on its initial investment.

Increase Rental Rates - A recent study of the San Diego market showed that the overall vacancy rate for green buildings was 4% lower than for non-green properties — 11.7%, compared to 15.7% — and that LEED-certified buildings continued to command the highest rents.

Optimize Health - By bringing the good in — like clean air and access to daylight — and keeping the bad out — including harmful chemicals found in paints, finishing, and more — LEED creates healthy spaces. Buildings that optimize well-being are more important than ever.

Does LEED Make Sense for a Brewery, Brewpub, or Restaurant?

The decision to pursue LEED is unique to each individual business, whether you are building or operating a home, office building, or brewery. Given that LEED has been around for nearly 20 years, there is a significant amount of information, experiences, and case study materials available.. The following provide references specific to the brewing industry:

Green-Beer - Brewers big and small are turning to sustainable solutions to help save money and conserve resources. Profiles of the LEED experiences of Diageo and Sierra Nevada: http://plus.usgbc.org/green-beer/.

A list of buildings tagged as "breweries" that have achieved some level of LEED certification according to the USGBC: http://www.usgbc.org/projects?keys=brewery .

An article profiling that Sierra Nevada Brewing Co.'s location in Mills River, North Carolina became the first American production brewery to achieve the Leadership in Energy and Environmental Design's Platinum Certification, the highest tier offered by the U.S. Green Building Council: http://allaboutbeer.com/sierra-nevada-platinum-leed-certification/

appendix d

Select Web Links

- ENERGY STAR Guide Energy Efficiency Improvement and Cost Saving Opportunities for Breweries: https://www.energystar.gov/ia/business/industry/LBNL-50934.pdf
- Green Building and Design Magazine: http://gbdmagazine.com
- Whole Building Design Guide: A Program of the National Institute of Building Services: http://www.wbdg.org/
- U.S. Green Building Council: http://www.usgbc.org
- Research and Development Roadmap: Windows and Building Envelope: http://energy.gov/eere/buildings/downloads/research-and-development-roadmap-windows-and-building-envelope
- Tips: Energy Efficient Roofs: http://www.energy.gov/energysaver/tips-energy-efficient-roofs
- Eco Building Pulse: What is a Sustainable Roof?: http://www.ecobuildingpulse.com/news/what-is-a-sustainable-roof_o
- Heat Island Effect: http://www.epa.gov/heat-islands
- Energy-Performance-Based Acquisition for Commercial Buildings: https://buildingdata.energy.gov/cbrd/energy_based_acquisition/
- City of Portland, Office of Sustainable Development Tenant Improvement Guide – A Comprehensive Guide to High Performance Tenant Improvements: https://www.portlandoregon.gov/bps/52052
- Brownfield vs. Greenfield Sites: What are the Issues Involved?: http://www.geography.org.uk/download/GA_PRICTIdea16IssuesActivity.pdf