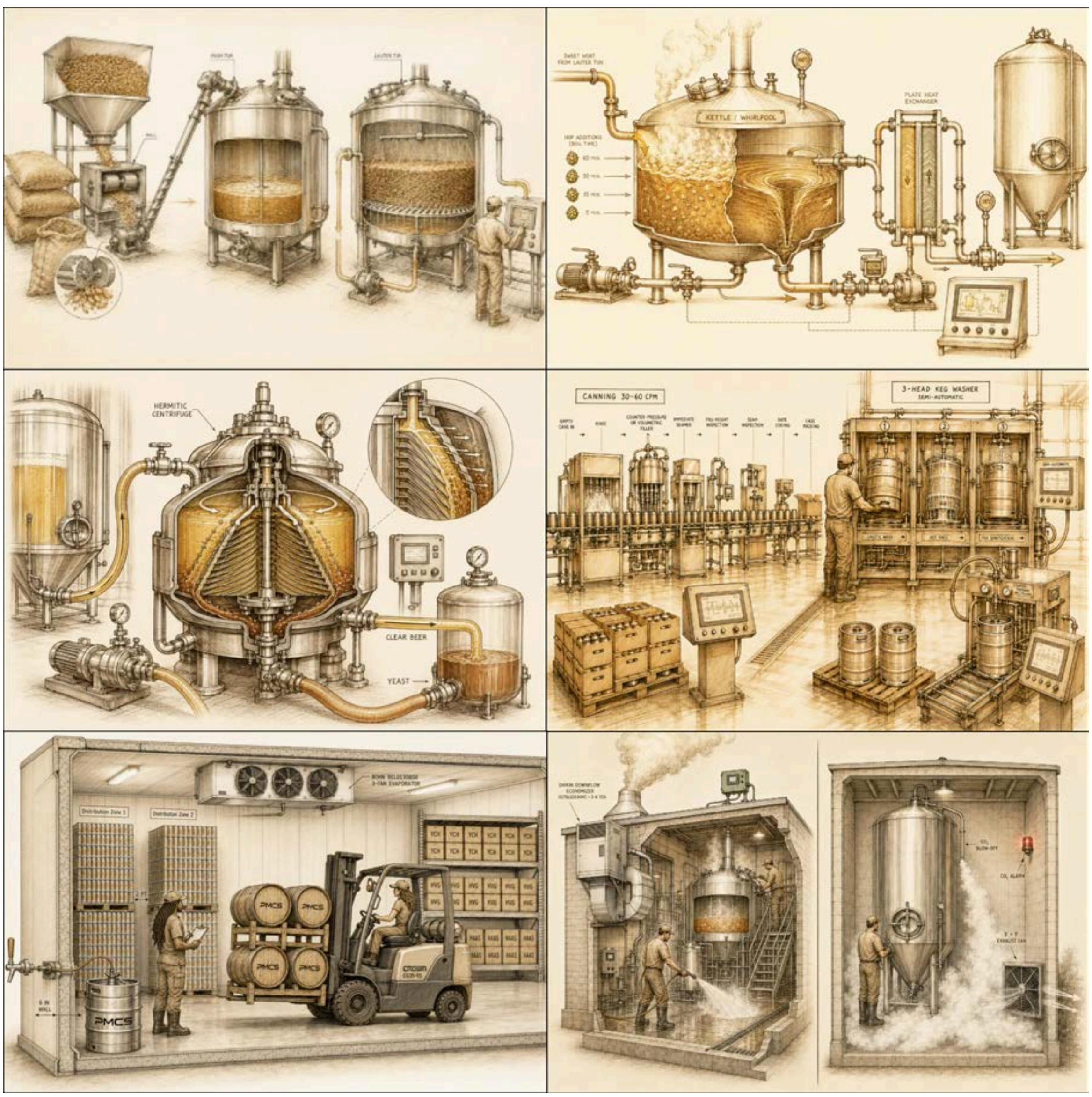
THE ANATOMY AND ELECTRICAL INFRASTRUCTURE OF A 30bbl BREWHOUSE

From grain handling to packaging and facility-support systems



Process overview: grain preparation to distribution

Executive Summary

A 30-barrel brewhouse is not simply a three-vessel brewing skid. It is an interconnected production facility whose reliability depends on coordinated grain handling, water treatment, process pumping, heating, refrigeration, compressed air, clarification, packaging, ventilation, cold storage and controls. The electrical service must therefore be designed around both connected load and the operating schedule that determines which loads coincide.

This guide uses a representative three-vessel arrangement: mash tun, lauter tun and combined kettle/whirlpool. It assumes steam or direct-fired heating rather than an electrically heated kettle; a 25–30 HP glycol chiller; six to eight cellar tanks; a hermetic disc-stack centrifuge; a 30–60 can-per-minute line; a three-head keg washer; a 3,500-square-foot tasting room; and separate production-area ventilation.

Primary engineering conclusion: The service entrance, transformer, distribution panels and feeders must be sized from manufacturer nameplate data, minimum circuit ampacity, maximum overcurrent protection, motor-starting method and a documented coincidence schedule. Adding individual running-current estimates is not an acceptable final design method.

Design Basis and Limitations

Planning values only. Current and horsepower ranges in this report are budgetary allowances, not construction specifications.
Voltage basis. North American equipment is compared at 208–240V and 460–480V, three-phase. Controls and small auxiliaries may operate at 120V or 24V.
Process basis. One 30bbl batch is approximately 930 US gallons before process and packaging losses.
Heating basis. The kettle is steam-fired or direct-fired. Electric kettle heating would materially increase service capacity.
Code basis. A licensed electrical engineer, mechanical engineer, fire-protection professional, and the authority having jurisdiction must approve the final design.

Recommended Reading Sequence

- Confirm the operating assumptions and production target.
- Follow the process from water and grain through brewing, clarification, and packaging.
- Review refrigeration, compressed air, HVAC, CO_2 safety, and cold storage as separate support systems.
- Use the consolidated load schedule to develop the service calculation and pilot measurement plan.

Contents

1. System Architecture and Operating Assumptions

The three-vessel configuration separates mash conversion and lautering while combining boiling and whirlpooling in one vessel. Compared with a two-vessel system, it improves process control and throughput. Compared with a four-vessel system, it reduces capital cost and floor area while retaining the principal production stages.

Semi-Automatic Operating Model

A programmable logic controller (PLC) and human-machine interface (HMI) manage temperature holds, timers, valve sequencing, pump permissives, alarms, and selected cleaning functions. The brewer still authorizes transfers, verifies process conditions, makes ingredient additions, and responds to deviations. This division of labor provides repeatability without the cost and complexity of fully automatic recipe execution.

Representative Facility Assumptions

Design item	Planning assumption	Electrical consequence
Brewhouse	30bbl; one or two brews on an active day	Multiple pumps and agitators; staged operation
Cellar	Six to eight 30/60bbl tanks	Continuous glycol pumping and periodic crash cooling
Packaging	30–60 (cpm) cans-per-minute; approx. 40% keg volume	Mixed-voltage line plus compressed air
Hospitality	3,500 sq ft tasting room	Separate comfort-HVAC zone
Cold storage	Production-dependent; two weeks used for example	Compressors, evaporators and possible defrost load

Operating schedule matters: The largest connected loads do not necessarily run together. A credible service calculation identifies normal, peak and contingency operating states rather than assuming either zero or 100% coincidence.

2. Water Treatment and Brewing-Water Delivery

Brewing water affects flavor, mash chemistry, equipment scaling, and cleaning performance. A representative treatment train may include softening, catalytic granular activated carbon, reverse osmosis, atmospheric storage, and a delivery pump. The final treatment arrangement must follow source-water analysis and the brewery's recipe strategy; reverse osmosis is not automatically required for every brewery.

Softener. Reduces calcium and magnesium hardness where scaling control is required.
Catalytic carbon. Reduces chlorine and chloramine that can create medicinal or plastic-like off-flavors.
Reverse osmosis. Provides a low-mineral base water that can be rebuilt to recipe specifications.
Storage and delivery. A 1,500–3,000-gallon atmospheric tank and an approximately 1–1.5 HP delivery pump are representative planning allowances.

Equipment	HP Planning	kW Planning
Street water pump (inbound)	1 – 1.5 HP	0.75 – 1.1 kW
RO water pump (outbound	1 – 1.5 HP	0.75 – 1.1 kW

3. Grain Storage, Milling and Conveyance

The grain path should be short, direct, and matched to the mash-in window. For a 30bbl batch, a mill capable of approximately 2,000–3,000 lbs./h provides useful operating margin. The grist case can buffer milled grain before mash-in, reducing the need to size every conveyor for an instantaneous transfer.

An outdoor silo may require no power for storage itself, but unloading augers, blowers, and loading systems do. Grain dust is combustible; the design professional and authority having jurisdiction must determine hazardous-location classification and dust-control requirements for the actual equipment and room. A blanket Class II, Division 1 designation should not be assumed without a documented classification study.

Equipment	HP Planning	kW Planning
Mill/crusher	3 – 7.5 HP	2.2 – 5.6 kW
Coreless flex auger	2 – 3 HP	1.5 – 2.2 kW
Silo unloading auger	1 – 1.5 HP	0.75 – 1.1 kW

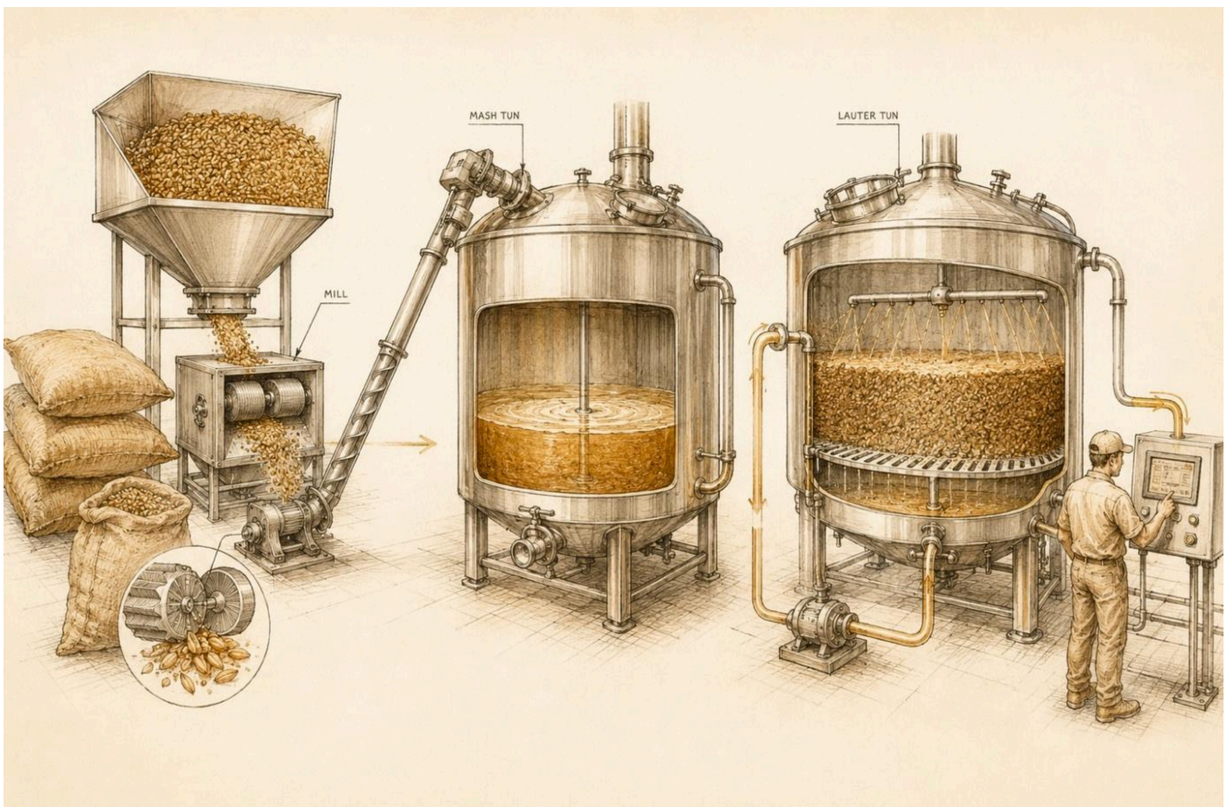


Figure 1. Grain preparation, mash conversion and lautering in a three-vessel brewhouse.

4. Mash Tun

During mash-in, crushed grain is combined with strike water. Enzymes convert starches into fermentable sugars during one or more temperature rests, commonly within approximately 148–158°F for many beer styles. A motorized mixer promotes uniform temperature and consistency while the controls maintain setpoints and timing.

High-gravity recipes, adjuncts, and future production growth can constrain mash volume. Specifying approximately 30% working-volume margin may be appropriate, but the correct margin must be based on the highest-gravity recipe and the manufacturer's usable-volume definition.

Mash-area load	HP Planning	kW Planning
Mixer/agitator	2 – 5 HP	1.5 – 3.7 kW
Hot-liquor transfer pump	1 – 2 HP	0.75 – 1.5 kW
Grain-slurry/wort pump	1.5 – 3 HP	1.1 – 2.2 kW
Controls and actuators	Low-voltage auxiliaries	Verify supply

5. Lauter Tun

The lauter tun separates sweet wort from spent grain. During vorlauf, wort is recirculated until the grain bed is established and the runoff clears. The brewer then balances runoff and sparge-water flow while protecting the bed from compaction. Vessel diameter, false-bottom area, and grain-bed depth are therefore as important as nominal volume.

Variable-speed control is useful for rakes and pumps because the correct flow changes during bed setting, runoff and spent-grain removal. A VFD can provide controlled acceleration and speed matching; it reduces starting stress but should not be described as eliminating all inrush or power-quality effects.

Lauter-area load	HP Planning	kW Planning
Rake/agitator/spent-grain drive	2 – 5 HP	01.5 – 3.7 kW
Wort/recirculation pump	1.5 – 3 HP	0.75 – 1.5 kW
Hot-liquor pump	1.5 – 3 HP	0.75 – 1.5 kW
Controls and actuators	120/240V auxiliaries	Verify supply

6. Combined Kettle/Whirlpool

The combined vessel performs two sequential functions. During the boil, the wort is sterilized, volatile compounds are driven off, hop compounds are extracted, and proteins coagulate into the hot break. The brewer must maintain adequate freeboard and boil control to manage foam and prevent boil-over.

After boiling, a tangential wort inlet creates the whirlpool. Trub and hop material collect near the center, allowing clearer wort to leave through a side outlet. The transfer path from whirlpool to heat exchanger marks the critical transition from the hot side to the sanitary cold side.

For a steam- or direct-fired kettle, the principal electrical loads are the wort/whirlpool pump, hot-liquor pump, controls, valves, and instrumentation. An electrically heated kettle is outside this design basis and would require a substantially larger service allowance.

Equipment	HP Planning	kW Planning
Circulation pump	1.5 – 3.0 HP	1.1 - 2.2 kW
Hot wort-out pump	1.5 – 3.0 HP	1.1 - 2.2 kW

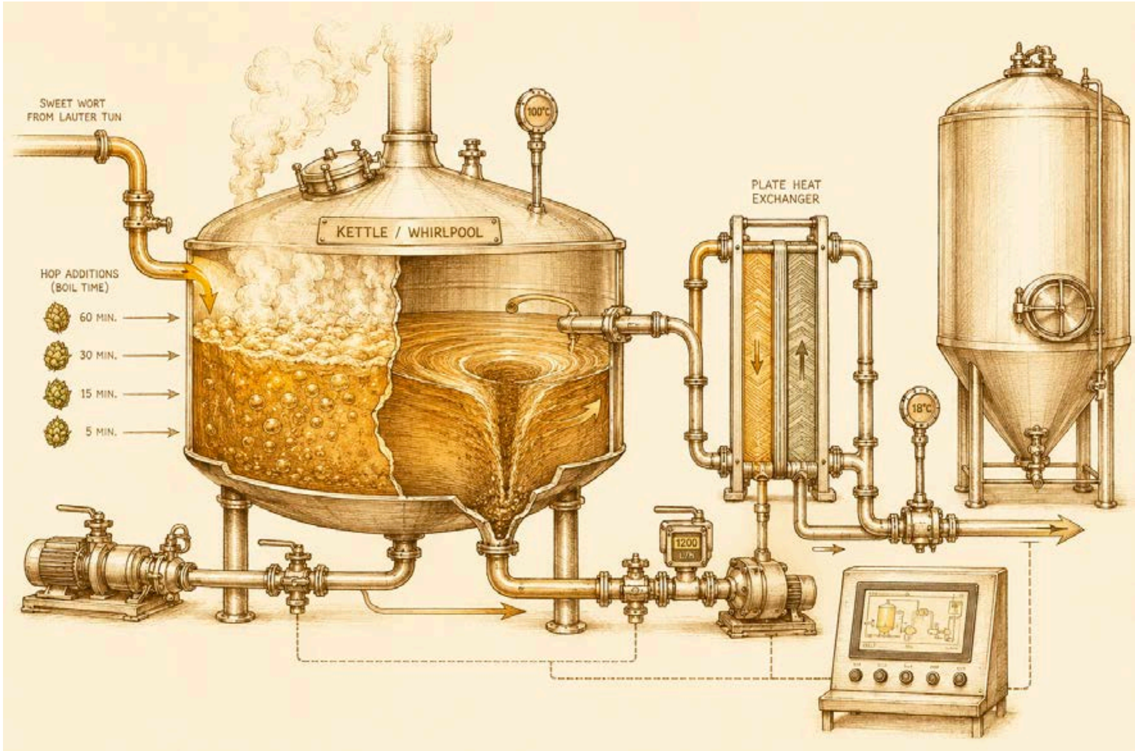


Figure 2. Combined kettle/whirlpool, plate heat exchanger and transfer to the cellar.

7. Heat Exchange, Glycol Chilling and Cellar Loads

The plate heat exchanger rapidly cools wort to the yeast-pitch temperature. The required refrigeration capacity depends on batch volume, knockout time, incoming water temperature, target wort temperature, cellar heat load, simultaneous crash cooling, and glycol-loop design.

Separate the Two Cooling Duties

Knockout load. A short-duration peak created while wort is cooled for transfer to the fermenter.
Cellar load. A continuing duty created by fermentation heat, tank temperature maintenance, and cold crashing.

A two-stage heat exchanger or a pre-chilled cold-liquor tank can reduce the instantaneous glycol demand. For the representative facility, 25–30 HP is a reasonable budgeting range, with a dual-compressor 30 HP arrangement offering useful staging and redundancy. The final selection must be calculated from the actual recipes, water temperatures, transfer rates, and tank schedule.

Chiller-related load	HP Planning	kW Planning
Glycol chiller package	25–30 HP; often dual compressor	18.6 – 22.4 kW
Standard circulation pump	2 – 3 HP	1.5 – 2.2 kW
High-head circulation pump	2 – 3 HP	1.5 – 2.2 kW
Controls and auxiliaries	Package dependent	Verify Supply

> **Reliability recommendation:** Use staged compressor control and verify locked-rotor current, minimum circuit ampacity and maximum overcurrent protection from the selected package. Where product exposure justifies it, consider modular or dual-compressor capacity so a single failure does not place the entire cellar at risk.

8. Clarification: Hermetic Disc-Stack Centrifuge

A hermetic disc-stack centrifuge clarifies beer without disposable filter media. Beer enters a sealed, liquid-full bowl and passes through a stack of conical discs; centrifugal force separates yeast and suspended solids from clarified beer. The sealed configuration helps limit oxygen pickup and can support product quality and shelf life.

For brewery duties in the approximate 30–60bbl/h range, a 15–20 HP installed motor and a VFD are representative. Planning power is approximately 11.2 – 14.9 kW, with higher current at lower supply voltage. Actual demand varies with bowl design, rotational speed, solids loading, and discharge cycle.

Equipment	HP Planning	kW Planning
Hermetic pump	15.0 – 20.0 HP	11.2 - 14.9 kW

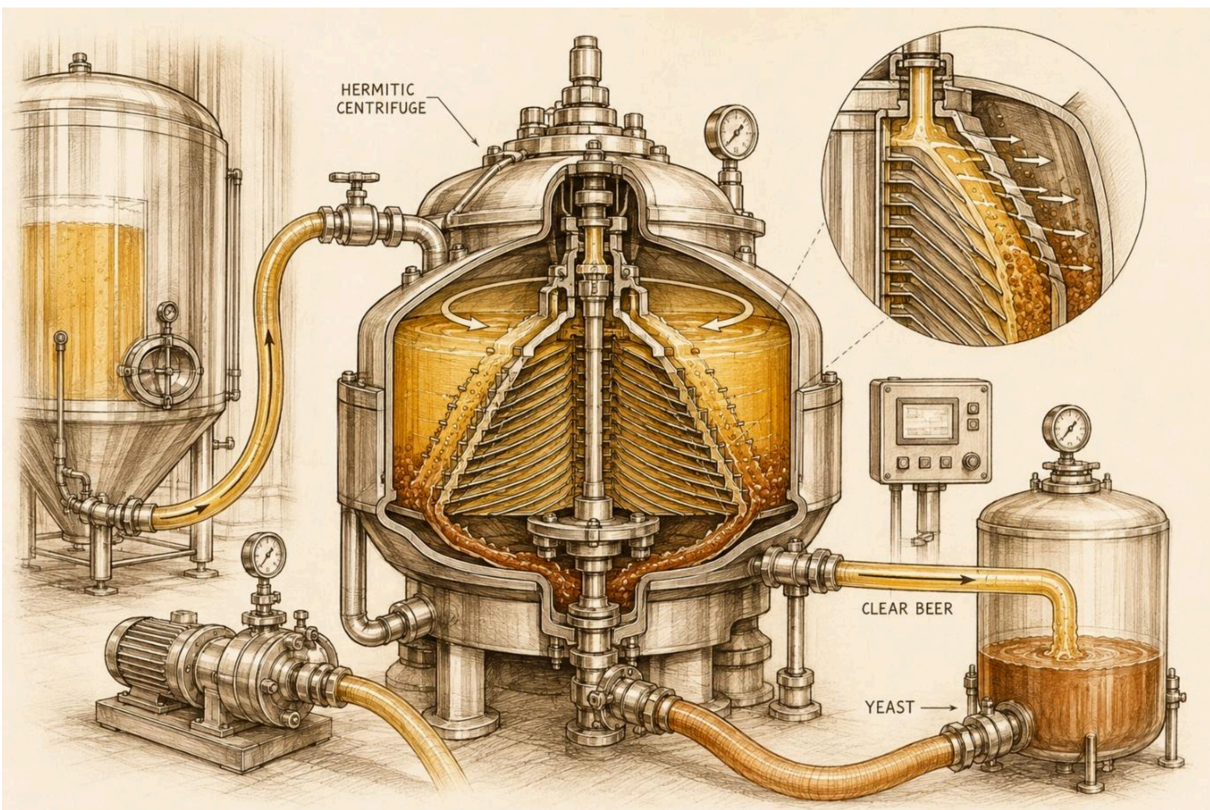


Figure 3. Hermetic disc-stack centrifuge used for beer clarification.

9. Packaging: Canning and Keg Washing

Automated Inline Canning

A 30–60 cpm line is a practical match for a 30bbl brewery. One 30bbl batch contains approximately 9,900 theoretical 12-ounce fills before process loss, package loss, and retained product. Production planning must therefore use the brewery's measured package yield.

The packaging system may include a depalletizer, rinser, filler/seamer, conveyors, inspection, date coding, labeling, and case packing. The main filler/seamer is only part of the load; the complete line commonly represents approximately 4.0 HP / 3.0 kW of mixed-voltage running load before the air compressor.

Semi-Automatic Three-Head Keg Washer

The operator loads and unloads kegs while the washer sequences caustic wash, rinse, sanitization, and purge steps. A three-tank configuration can segregate caustic, acid, and rinse/sanitizing duties. Chemical concentration, temperature, and replacement intervals must follow the chemical supplier and equipment manufacturer, not a universal cycle count.

A representative three-head washer draws approximately 11.0 HP at 208–240V, three-phase, with the heater and pumps creating a variable duty profile. Confirm whether the specified unit uses one shared pump or separate pumps and whether its heating load is electric, steam, or hot-water supplied.

Packaging-related load	HP Planning	kW Planning
Canning line	3.0 HP	2.2 kW
Ancillary canning equipment	1.0 HP	0.75 kW
Keg washer	11.0 HP	8.2 kW
Controls and auxiliaries	Package dependent	Verify Supply

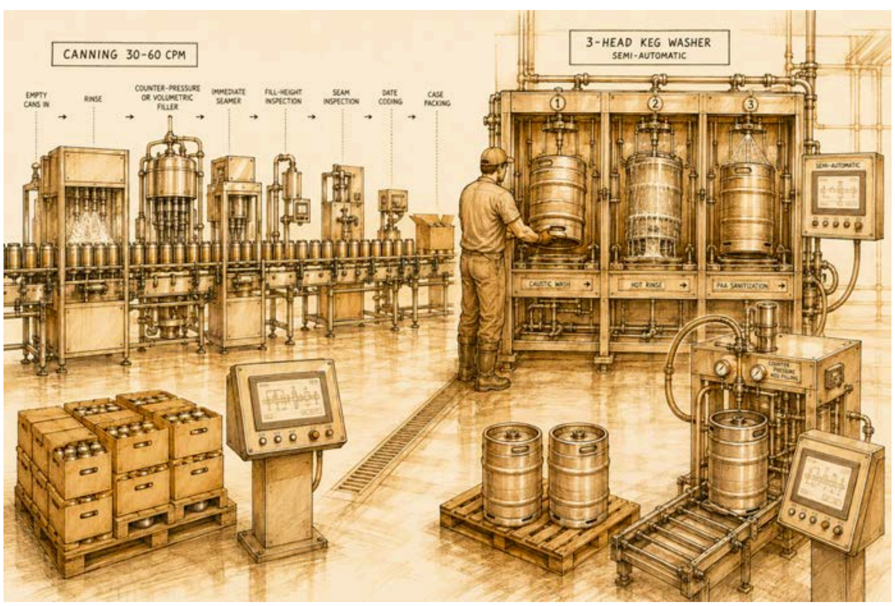


Figure 4. Automated canning and semi-automatic three-head keg washing.

10. Compressed-Air System

The canning line and keg washer can share a compressor only when flow, pressure, air quality, and operating overlap are explicitly defined. The correct compressor basis depends on whether the two systems are interlocked for sequential use or permitted to operate simultaneously.

Operating scenario	Planning	HP / kW Planning
Strictly sequential	Highest single consumer; typically about 16–23 CFM at 90 psi	Approximately 5 – 7.5 HP / 3.7 – 5.6 kW plus adequate receiver capacity
Potentially simultaneous	Combined demand; approximately 35–40+ CFM at 90 psi	Approximately 10 HP / 7.5 kW rotary screw compressor

Receiver. Use an appropriately sized receiver; often 80–120 gallons, to buffer rapid purge events.
Drying and filtration. Provide a refrigerated dryer, water separation, and filtration suitable for the canning equipment and food-production environment.
Distribution. Use approved compressed-air piping; do not use PVC.
Electrical allowance. A 10 HP compressor package with dryer is approximately 16–36A across common three-phase voltages.

11. Cold Storage and Finished-Goods Handling

Cold-storage size must be derived from production rate, package mix, days of inventory, pallet configuration, ceiling height, aisle requirements, and shipping cadence. A 400–600 sq ft cooler may support a smaller buffer inventory, but it is not adequate for two weeks of finished goods at 18,000bbl/year.

18,000bbl/year Example

At 18,000bbl/year, average production is approximately 346bbl/week. Two weeks of inventory is approximately 692bbl. At a 60% can and 40% keg split, this equates to about 72 can pallets and 69 single-layer half-barrel-keg pallet positions before racking and stacking efficiencies.

Storage strategy	Approximate floor area	Operational requirement
Three-tier pallet racking	1,100–1,300 sq ft	15+ ft clear height and reach truck
Two-tier/double stacking	1,800–2,100 sq ft	Approximately 12 ft clear height
Floor storage only	2,800–3,200 sq ft	Largest footprint and least flexibility

A representative 1,800–2,500 sq ft medium-temperature cooler may require approximately 60,000–90,000 BTU/h. Two independent 3–4 ton systems can provide staging and partial redundancy. Electrical design must include compressor starting current, evaporator fans, and any electric defrost load.

Figure 5. Walk-in cooler cutaway showing palletized can storage, keg dispensing, barrel handling, hop storage, and the ceiling-mounted evaporator

12. HVAC, Steam Management and CO_2 Safety

The tasting room and production brewhouse have fundamentally different loads and should be treated as separate zones. The tasting room is driven by occupancy, glazing, doors, and ventilation. The production space is driven by radiant heat, steam, washdown moisture, process exhaust, and CO_2.

Zone/system	Planning capacity	Planning HP / kW
3,500 sq ft tasting room HVAC	12–18 tons	18.0 – 27.0 HP / 13.4 – 20.1 kW
Production-area environmental HVAC	8–14 tons	14.0 - 21.0 HP / 10.4 – 15.6 kW
Kettle steam condenser/assisted exhaust	Fan plus controls	0.25 – 0.5 HP / 0.19 – 0.37 kW
Differential enthalpy economizer	Project-specific	0.13 – 0.25 HP / 1.0 – 0.19 kW
CO_2 exhaust	Fan plus controls	0.13 – 0.25 HP / 1.0 – 0.19 kW

Steam and Makeup Air

Capture kettle steam at the source and discharge or condense it through a properly engineered system. Allowing steam to enter the room can overwhelm the HVAC system's comfort settings, raise humidity, and increase the risk of condensation, corrosion, and mold. Exhaust volume and makeup air must be balanced to prevent excessive negative pressure, door problems, or combustion appliance back drafting.

Economizer Application

An economizer can use favorable outdoor conditions to reduce mechanical cooling. Dry-bulb control considers temperature; single-enthalpy control considers outdoor temperature and humidity; differential-enthalpy control compares indoor and outdoor conditions. Sensor location, calibration, damper leakage, freeze protection, and climate suitability determine whether the anticipated savings are achieved.

CO_2 Detection and Low-Level Exhaust

Fermentation and transfer operations can release carbon dioxide. Because CO_2 can accumulate in low areas and displace oxygen, detection, alarm annunciation, and mechanical exhaust must be designed as a dedicated life-safety system. Sensor and exhaust locations should follow the hazard assessment, room geometry, gas-release points, applicable codes, and manufacturer instructions, not a single universal mounting height.

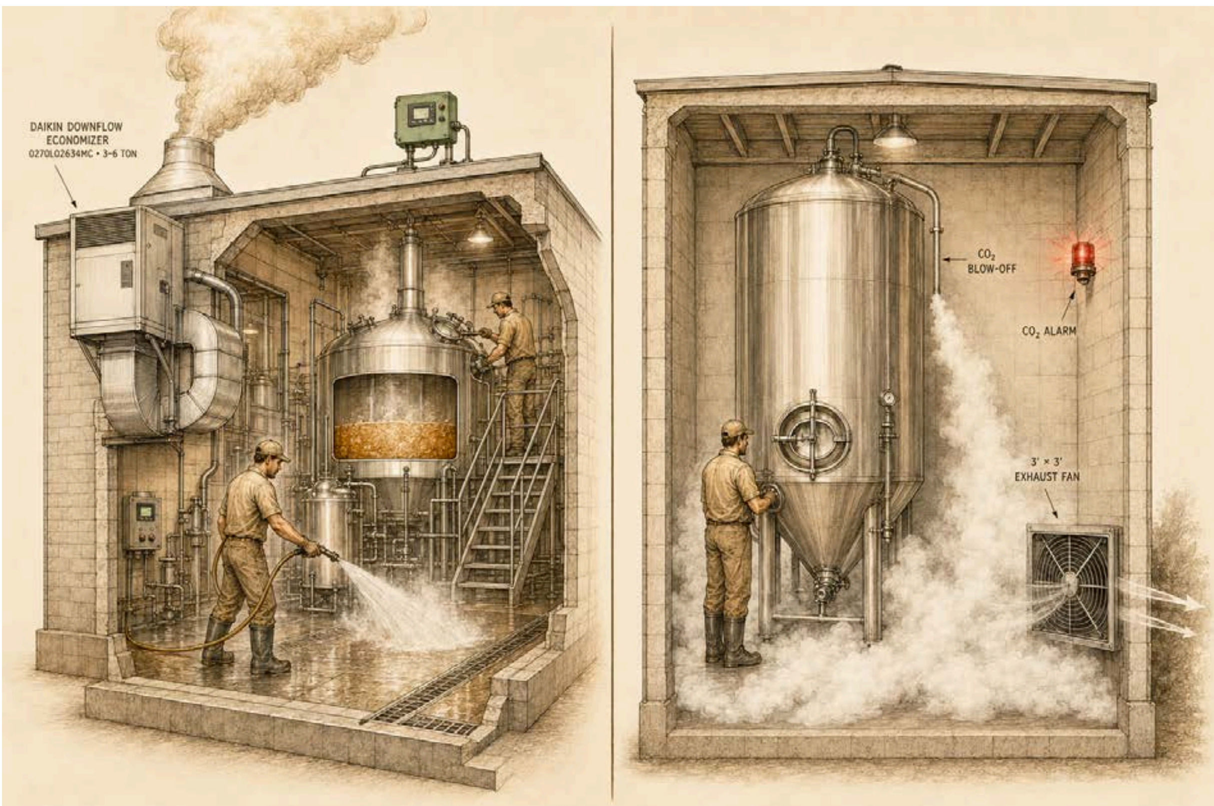


Figure 6. Economizer-assisted heat and moisture exhaust and dedicated high-level CO_2 detection and ventilation.

13. Controls, Power Quality and Voltage Compatibility

PLCs and HMIs coordinate process steps, but they do not replace electrical protection or power-quality engineering. Large compressors, pumps, centrifuges and packaging auxiliaries can create voltage drop, harmonic current, rapid load changes and nuisance trips if the distribution system is undersized or poorly coordinated.

- **Motor starting.** Use manufacturer data for locked-rotor current and starting method. VFDs and soft starters can reduce mechanical and electrical stress but must be selected and configured correctly.

- **Sensitive controls.** Separate control power where appropriate and evaluate surge protection, grounding, and voltage-drop performance.
- **Load measurement.** Record voltage, current, kW, kVA, kVAR, power factor, and voltage/current THD through representative brew, crash-cooling, packaging, and cleaning cycles.
- **Power-factor and harmonic review.** Evaluate the complete facility at the point of common coupling; do not infer system performance from one motor nameplate.

North American and International Equipment

European equipment commonly uses nominal 230/400V, 50Hz power, while North American industrial equipment commonly uses 460/480V, 60Hz or 208/240V systems. A VFD may allow a motor to operate at the required voltage and frequency, but it does not automatically make the entire skid compatible. Transformers, heaters, controls, contactors, fans, pumps, short-circuit ratings, and certifications must all be reviewed.

14. Consolidated Electrical Load-Planning Schedule

The schedule below consolidates the dispersed allowances into one planning view. Values are intentionally shown as ranges because manufacturer selection and supply voltage materially affect current. Loads at different voltages cannot be added arithmetically without converting to kVA and accounting for phase, efficiency, and power factor.

System	Planning HP / kW	Voltage basis	Coincidence/starting note
Water treatment and delivery	3 HP / 2.2 kW	208/480V 3φ	Generally steady while filling tanks
Grain mill and augers	10.5 HP / 2.2 kW	208/480V 3φ	Motor starts; intermittent
Mash and lauter pumps/drives	11.0 HP / 2.2 kW	208/480V 3φ	Sequenced; some overlap
Kettle/whirlpool auxiliaries	12.0 HP / 2.2 kW	208/480V 3φ	Amount/gravity of wort boiled, ABV
Glycol chiller package	30.0 HP / 2.2 kW	208/480V 3φ	Large cycling load; verify MCA/MOCP/LRA
Disc-stack centrifuge	20.0 HP / 2.2 kW	208/480V 3φ	VFD load; intermittent solids discharge
Canning line, excluding air	4.0 HP / 2.2 kW	208/480V 3φ	Multiple dedicated circuits
Air compressor and dryer	10.0 HP / 2.2 kW	208/480V 3φ	Continuous during packaging/keg washing
Tasting-room HVAC	27.0 HP / 2.2 kW	208/480V 3φ	Climate and occupancy dependent
Production HVAC	21.0 HP / 2.2 kW	208/480V 3φ	Separate from process exhaust
Economizer/exhaust	0.5 HP / 2.2 kW	208/480V 3φ	May run with HVAC and washdown
Cold-storage systems	12.0 HP / 2.2 kW	208/480V 3φ	Starting and defrost states
Silo unloading auger	1.5 HP / 2.2 kW	208/480V 3φ	Operates in conjunction with milling
Three-head keg washer	11.0 HP / 2.2 kW	208/240V 3φ	Heater and pump duty cycle
Three reach-in coolers	2.33 HP / 2.2 kW	120V 1φ	Dedicated branch circuits

Do not total this column: Convert every selected load to kVA from its actual nameplate data, then apply the documented operating scenarios. The final service calculation must include continuous-load treatment, demand factors where permitted, voltage drop, motor contribution, fault current and future capacity.

15. Power Factor: True / Displacement / Distortion

Power factor determines how effectively a brewery converts the electrical capacity delivered by the utility into useful mechanical, thermal, and process work. Modern breweries require more than the traditional kW/kVA discussion because their electrical systems contain both induction loads, which shift current out of phase with voltage, and nonlinear electronic loads, which distort the current waveform. The complete measure is true power factor.

15.1 The 3 Power-Factor Measures

True power factor (PF_T or PF_{TOT}) is the ratio of real power to apparent power at the measurement point:

True PF = kW / kVA

Real power (kW) performs useful work. Apparent power (kVA) represents the total RMS voltage-current capacity that cables, transformers, switchgear, and the utility must carry. Reactive power (kVAR) is associated primarily with phase displacement. Harmonic current adds to RMS current and kVA without producing equivalent useful output.

When the supply voltage is substantially sinusoidal, true power factor can be expressed as the product of two components:

True PF = Displacement PF x Distortion PF

This relationship matters because correcting only displacement power factor can leave a brewery with significant harmonic current, heating, and occupied capacity. Conversely, reducing harmonic distortion does not correct an inductive phase angle. Both components must be measured and managed.

15.2 The Traditional Beer Analogy

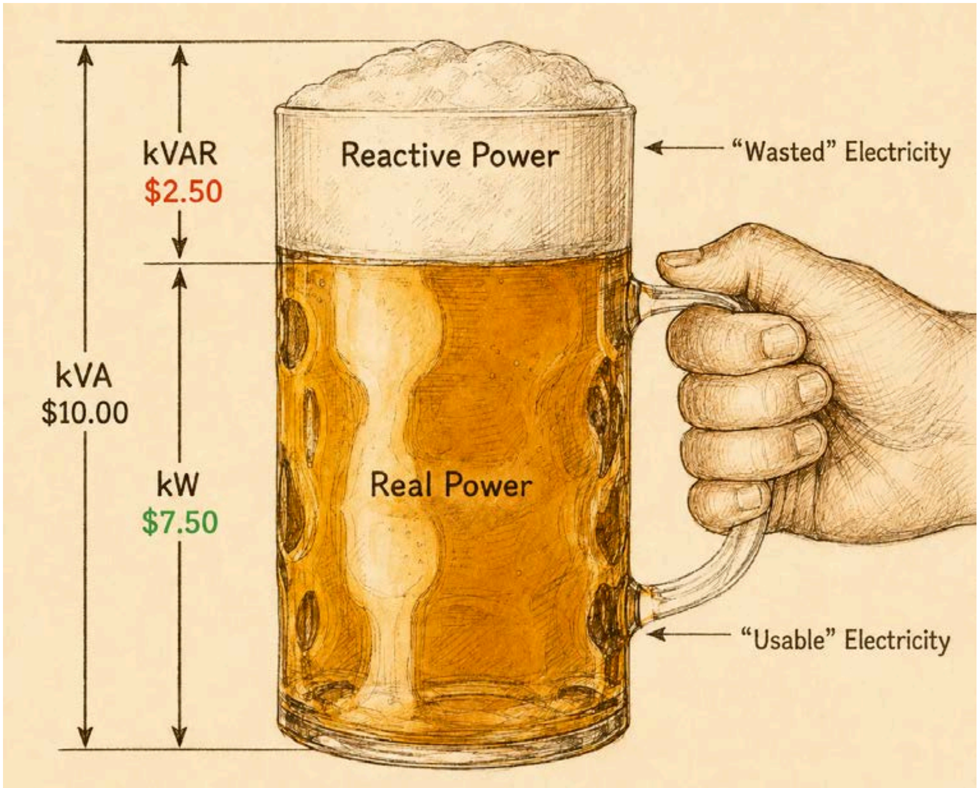


Figure 7. Traditional beer analogy: useful kW, reactive kVAR and total kVA.

In the traditional analogy, the beer is active power (kW), the foam is reactive power (kVAR), and the entire mug is apparent power (kVA). Reducing foam lets the mug hold more useful beer. This accurately explains displacement-related reactive power, but it does not show waveform distortion. Harmonics create an additional electrical burden carried in RMS current and kVA, even when the visible "foam" appears controlled. If displacement PF is 0.707 and current THD is 50%, the corresponding distortion factor is approximately 0.894. The resulting true PF is approximately 0.632:

0.707 x 0.894 = 0.632 true PF

At the same useful kW, a true PF of 0.632 requires materially more kVA and RMS current than a true PF above 0.95. The exact current depends on system voltage and phase configuration, but the operational consequence is consistent: more current, more I^2R loss, more voltage drops, and less available capacity.

15.3 Displacement Power Factor

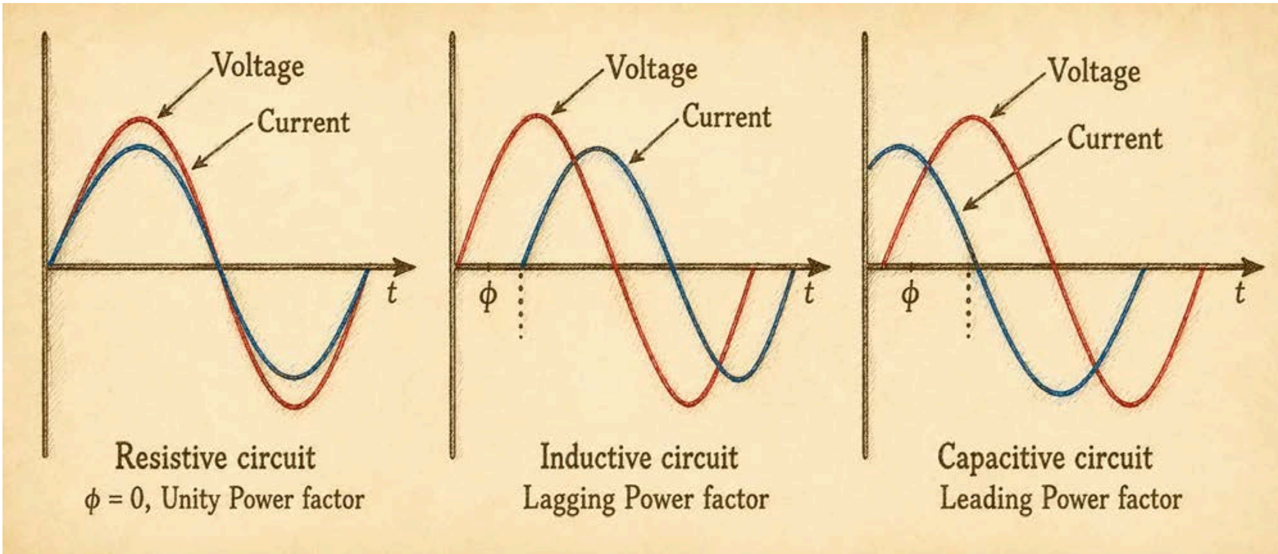


Figure 8. Displacement power factor: resistive, inductive-lagging and capacitive-leading relationships.

Displacement power factor is the cosine of the phase angle between the fundamental-frequency voltage and current: PFD = cos(phi). A resistive load has voltage and current in phase and a displacement PF near 1.0. Induction motors, transformers, contactor coils and magnetic ballasts normally cause current to lag voltage. Excessive capacitance can make current lead voltage.

Brewery effects of low displacement PF include:

- Higher line current for the same useful kW, increasing conductor, transformer and switchgear loading.
- Higher I^2R heating in feeders, busways, transformer windings, motor circuits and connections.
- Greater voltage drops during motor loading and starting, increasing the risk of contactor dropout, PLC/HMI resets and nuisance trips.
- Reduced available kVA capacity for production expansion, additional cellar tanks, packaging equipment or refrigeration.
- Possible utility demand or power-factor charges where the tariff measures kVA, kVAR, or low PF.

Fixed or switched capacitor banks address fundamental reactive power but do not inherently reduce harmonic current. If capacitors are applied without a harmonic and resonance study, they can interact with system inductance, amplify specific harmonics, overcorrect at light load, or create maintenance and switching concerns. Brewery loads vary throughout the day, so correction must follow the actual operating state rather than a single nameplate calculation.

15.4 Distortion Power Factor

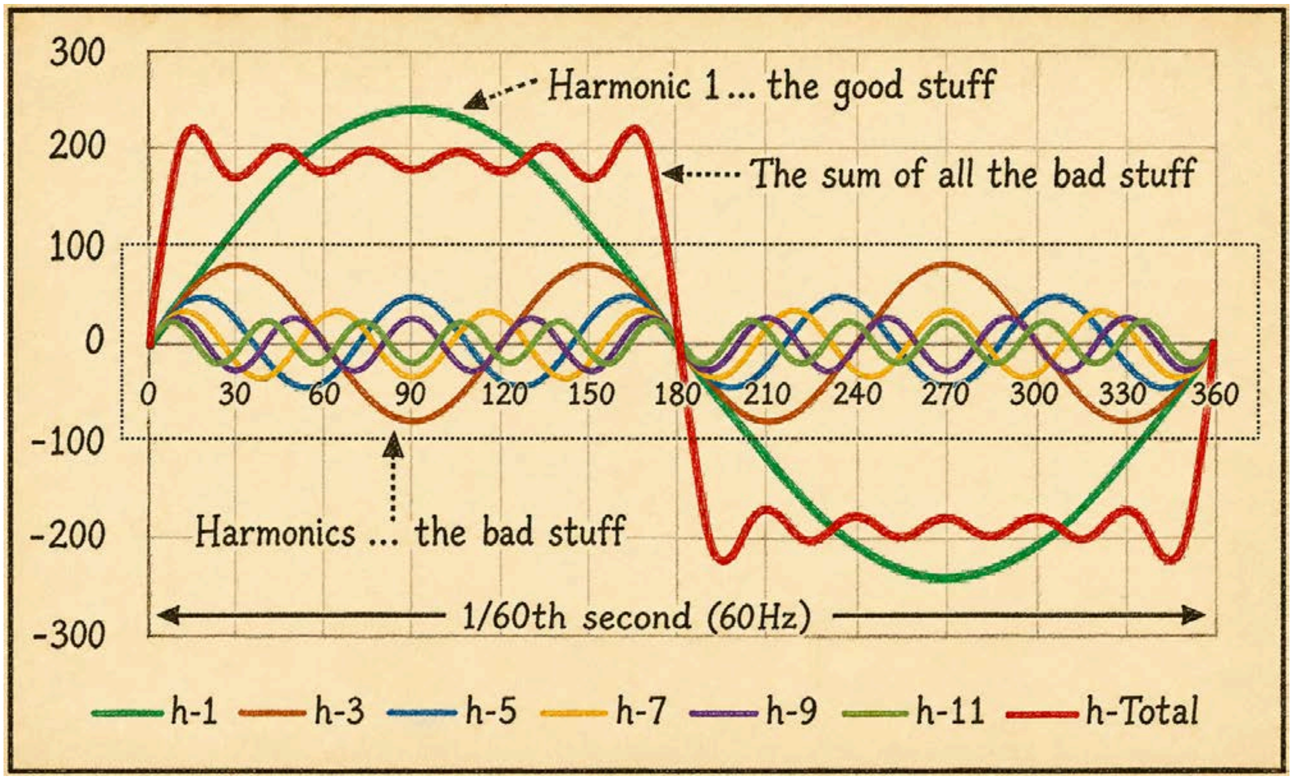


Figure 9. Distortion power factor: the fundamental waveform and the RMS contribution of harmonic currents.

Distortion power factor quantifies the reduction in power factor caused by nonsinusoidal current. With a substantially sinusoidal voltage, it can be approximated by:

$$\textbf{Distortion PF} = I_{1,rms} / I_{rms} = 1 / (\sqrt{1 + THDi^2})$$

The fundamental current is the 50/60 Hz component associated with useful power transfer. Harmonic currents at the 3rd, 5th, 7th, 9th, 11^{th}, and higher orders add to the total RMS current. Individual harmonic effects depend on sequence, magnitude, phase, system impedance, and equipment susceptibility.

Distortion in a brewery is commonly produced by VFD input rectifiers, servo drives, switch-mode power supplies, LED drivers, UPS systems, battery chargers, electronic refrigeration controls, EC motors, office/point-of-sale equipment and some welding or maintenance loads. The principal effects are:

- Additional RMS current and I^2R heating in phase conductors, transformer windings, busways and protective devices.
- Neutral heating from triplen harmonics in four-wire systems serving single-phase electronic loads.
- Transformer derating, higher eddy-current losses and increased acoustic or thermal stress.
- Motor heating, torque pulsation and reduced life when voltage distortion reaches motor terminals.
- Capacitor-bank resonance, fuse operation or premature capacitor failure.
- Control errors, communication problems, metering errors and nuisance operation of protective devices.
- Distorted voltage at the point of common coupling when harmonic current flows through system impedance, affecting other brewery equipment.

15.5 Effects Across the Brewing Process

Power-factor conditions change as equipment starts, stops, stages, and changes speed. A facility-wide measurement at the point of common coupling must therefore be correlated with the production schedule. The following process review identifies the dominant exposure from grain receipt through packaged-product storage.

Process stage	Principal electrical loads	Displacement PF effects	Distortion/true PF effects
Water treatment and delivery	RO pumps, softener controls, tank-transfer pumps	Induction motors and transformers draw magnetizing current; lightly loaded pumps can have poor PFD.	VFDs, rectifiers and electronic controls add THDi. Extra RMS current heats feeders and reduces pump-panel capacity.
Grain storage, milling and conveyance	Mill, silo auger, flex auger, dust collection	Across-the-line motor starts create high current and voltage dip; lightly loaded motors reduce PFD.	VFD-controlled conveyors and dust systems can inject 5th/7th harmonics. Distortion can affect scales, interlocks/motor protection.
Mash tun	Mixer/agitator, hot-liquor and wort pumps, actuators	Motor magnetizing VAR and changing mechanical load reduce PFD; starts may overlap during mash-in.	VFD speed control and PLC power supplies add harmonics. Voltage distortion can stress motors and disrupt temperature/valve sequencing.
Lauter tun	Rake drive, recirculation/wort pump, hot-liquor pump	Low-speed or lightly loaded drives can operate at reduced PFD; multiple pumps may overlap during runoff and sparging.	VFDs create current distortion; harmonic and voltage effects can cause torque ripple, heating or unstable sensitive controls.
Kettle and whirlpool	Wort/whirlpool pump, hot-liquor pump, burner/steam controls	Pump motors create lagging VAR; restart during transfer can cause voltage drop.	Electronic burner controls, VFD pumps and instrumentation add distortion; poor true PF consumes capacity even when heating is not electric.
Heat exchange and cellar	Transfer pumps, glycol circulation pumps, tank solenoids	Pump motors add reactive current; simultaneous knockout and cellar circulation increase kVA.	Drive and control harmonics can disturb sensors and communications; increased RMS current raises losses during long fermentation cycles.
Glycol refrigeration	Compressors, condenser fans, pumps, crankcase heaters	Compressors are major lagging loads; starting and staging can dominate facility kVA voltage drop.	VFD compressors and EC fans add harmonics. Distortion increases transformer/cable heating and can affect refrigeration controls.
Disc-stack centrifuge	15-20 HP high-speed motor, VFD, control skid	The motor requires magnetizing current; acceleration and changing bowl load affect PFD and kVA.	The VFD is a concentrated nonlinear load. Harmonics increase RMS current and can affect nearby instruments unless impedance and grounding are controlled.
Canning and labeling	Conveyors, filler/seamer, servos, labeler, coder, inspection	Small motors collectively draw lagging VAR; stop-start operation causes rapid PF changes.	Servo drives, switch-mode supplies and VFDs create broad-spectrum harmonics that can interfere with sensors, inspection and communications.
Keg washing and sanitation	Pumps, electric heaters, valves and controls	Heaters are near-unity PFD, but pumps are inductive. Duty-cycle overlap creates a changing composite PF.	Electronic temperature controls and drives add distortion; high RMS current and heat can shorten panel-component life in washdown environments.
Compressed air	Rotary-screw compressor, dryer, condensate controls	The compressor is a major induction load; unload operation may consume current at poor efficiency and PFD.	VFD compressors and electronic dryers add harmonics. Added RMS current increases feeder & TX losses during packaging.
Cold storage	Compressors, evaporator/condenser fans, defrost and controls	Cycling compressors create VAR lagging, starts & volt drop; defrost heaters temporarily improve composite PFD but raise kW.	EC fans and inverter compressors add THDi. Distortion and heat threaten controls whose failure can expose finished product.

HVAC, exhaust and CO_2 safety	Compressors, supply/exhaust fans, economizer actuators, sensors	Large HVAC motors add reactive demand and may coincide with refrigeration and hospitality peaks.	VFD fans, EC motors, LED lighting and controls add distortion. Sensitive CO_2 detection and PLC/HMI circuits require stable, clean power.
Hospitality and support	Tasting-room HVAC, lighting, kitchen, POS, office and IT	HVAC and kitchen motors add lagging VAR; diversified single-phase loads create phase imbalance.	LED drivers, computers, displays, UPS and chargers create triplen harmonics and neutral current, reducing facility true PF.

15.6 Why True Power Factor Matters Operationally

True PF best represents the brewery's total electrical burden on a balanced three-phase system; current is approximately $I = kW / (\sqrt{3} \times kV \times \text{True PF})$. At constant kW and voltage, current rises as true PF falls. Because resistive losses are proportional to I^2R, even a moderate current reduction can produce a disproportionately larger reduction in conductor and transformer losses.

The brewery consequences extend beyond the utility bill:

- OPEX: avoidable kVA/kVAR charges, higher electrical losses, added cooling demand, nuisance shutdowns, troubleshooting, and premature component replacement.
- CAPEX: reduced spare capacity can force earlier transformer, service, switchboard, feeder, generator, UPS, or distribution upgrades.
- Production: voltage instability and control faults can interrupt mash timing, wort transfer, fermentation cooling, centrifuge operation, packaging, and sanitation cycles.
- Product protection: refrigeration or control interruptions can compromise temperature control, package quality, and finished-goods storage.
- Reliability: excess heat accelerates insulation aging, degrades capacitors and power electronics, and reduces the service life of motors and controls.

15.7 Correction and Verification Strategy

Power-factor improvement must address the measured cause. Traditional capacitor correction can reduce lagging fundamental kVAR but does not, by itself, correct waveform distortion, stabilize voltage, or eliminate starting events. Harmonic filters can reduce selected harmonic currents but must be designed for the actual spectrum and system impedance. An integrated power management control system is intended to coordinate displacement correction, harmonic mitigation, voltage stabilization, and real-time measurement; final claims must be verified at the brewery under matched operating conditions.

Recommended measurement and verification:

- Measure all 3-phases at the point of common coupling and at major nonlinear or cyclic loads.
- Record volts, amps, kW, kWh, kVA, kVAh, kVAR, kVARh, true PF, displacement PF, THDv and THDi at 15-minute intervals or faster; use higher-speed waveform capture for harmonic diagnosis.
- Correlate electrical data with milling, mash-in, lautering, boil/whirlpool, knockout, fermentation cooling, crash cooling, centrifuge, canning, keg washing, sanitation, hospitality, and cold-storage.
- Compare matched pre- and post-correction production periods. Normalize for barrels brewed, package count, ambient temperature, occupancy, and equipment schedule.
- Verify current reduction, voltage stability, harmonic spectrum, true PF, thermal response, and production reliability rather than relying on a single panel display or one instantaneous reading.

Engineering caution: The simple product True PF = Displacement PF x Distortion PF assumes a substantially sinusoidal supply voltage. When voltage distortion is significant, harmonic active power and cross-frequency interactions require an instrument that calculates true RMS values and total real power directly. Review final correction equipment for system resonance, short-circuit duty, protection coordination, grounding, manufacturer requirements, and applicable codes.

16. Recommended Engineering Workflow

1. Freeze the production basis: brews per day, annual barrels, package split, cellar count, inventory days, and expansion target.
2. Obtain equipment submittals showing voltage, phase, full-load current, MCA, MOCP, LRA, heater load, control voltage, and short-circuit current rating.
3. Create an operating-state matrix covering brew-day production, knockout, crash cooling, canning, keg washing, sanitation, cold storage, hospitality peak, and contingency operation.
4. Convert each load to kW and kVA at the selected voltage and apply only defensible coincidence or demand factors.
5. Model voltage drops/motor starting at the service, transformer, switchboard, and remote panels.
6. Review power factor, harmonics, phase balance, grounding, surge protection, and sensitive PLC/HMI power.
7. Coordinate mechanical ventilation, makeup air, combustion safety, steam capture, CO_2 detection, and emergency exhaust.
8. Commission the facility with interval measurements and compare actual operating states with the design model.

Measurement Plan for Optimization

For an existing brewery or pilot installation, collect at least three representative operating days before and after the intervention. The interval dataset should include three-phase voltage and current, kW, kWh, kVA, kVAh, kVAR, kVARh, power factor, voltage THDv, and current THDi. Align measurements with the production schedule so that improvements are not mistaken for changes in brewing or packaging activity.

16. Conclusion

A successful 30bbl brewery integrates process capacity with electrical and mechanical infrastructure. The mash tun, lauter tun and combined kettle/whirlpool establish the brewing sequence, but reliable production depends equally on water treatment, refrigeration, compressed air, clarification, packaging, ventilation, CO_2 protection and cold storage. The strongest design is not the one with the largest service or the lowest first cost. It is the design that documents operating coincidence, controls starting demand, protects sensitive automation, preserves redundancy where product is at risk, and leaves deliberate capacity for growth. That approach reduces avoidable capital expense, limits operating cost, and creates a measurable basis for future power-quality and efficiency improvements.

Final recommendation: Complete the equipment schedule and operating-state matrix before selecting the service entrance or ordering major electrical distribution equipment. This single step prevents both expensive oversizing and costly late-stage capacity corrections.

Appendix A. Planning References

- Brewers Association, Draught Beer Quality Manual and brewery technical resources: https://www.brewersassociation.org
- U.S. Department of Energy, Improving Motor and Drive System Performance: A Sourcebook for Industry: *https://www.energy.gov/eere/amo/motor-systems*
- U.S. Department of Energy, Improving Compressed Air System Performance: A Sourcebook for Industry: https://www.energy.gov/eere/amo/compressed-air-systems
- Occupational Safety and Health Administration, Technical Manual and oxygen-deficiency guidance: https://www.osha.gov/otm
- National Fire Protection Association, combustible-dust and electrical standards: https://www.nfpa.org
- Applicable equipment manufacturers' current submittals, installation manuals, and nameplate data.
- Applicable editions of the National Electrical Code, mechanical code, fire code, and local amendments as adopted by the authority having jurisdiction.

This planning guide is not a substitute for stamped construction documents, equipment submittals, code review, process validation, or commissioning.

Authors

Christopher B. Johnson, MSEE - christopherbjohnson@icloud.com

Founder/Owner: SixTen Brewing February 2014 – July 2024 Tampa, FL

- Entrepreneur, owner, operator, and brewmaster of a craft brewery
- Planned, designed, and installed the brewhouse
- Developed new beers/beverages, brewed for in-house and distribution sales, and managed brewery operations
- Managed customers, suppliers, distributors, and employees
- Monitored product quality, won 2 GABF gold medals and many state medals
- Coordinated brewing and community events for 100 to 2,500 attendees
- Public relations for 4 local live TV shows annually
- Raised thousands of dollars for local charities. (Life Path Hospice, Greyhound rescue, Feeding Tampa Bay, Tampa PD Christmas bicycle program, River Tower Foundation)

Michael C. Beaton, BSEE – michael.beaton@pmcspower.com

Founder/Owner: PMCS Power January 2026 - Present Johns Creek, GA

- Power Management & Control
- Energy Efficiency
- Power Quality


PMCS Bar
PMCS Bar
W 10 ST
7 AV
LIGHTING CIRCUITS
KITCHEN LOADS
ELECTRICAL INTAKE
DISTRIBUTION BOARD
POWER MANAGEMENT PMCS


PMCS Pub
PMCS Pub
LIGHTING CIRCUITS
KITCHEN LOADS
POWER MANAGEMENT PMCS
DISTRIBUTION BOARD
ELECTRICAL INTAKE