

TECHNICAL INTELLIGENCE BRIEF

FOOD, BEVERAGE, BREWING, DISTILLING & DAIRY EDITION

Yield • Recovery • Water •
Energy • Resource Value

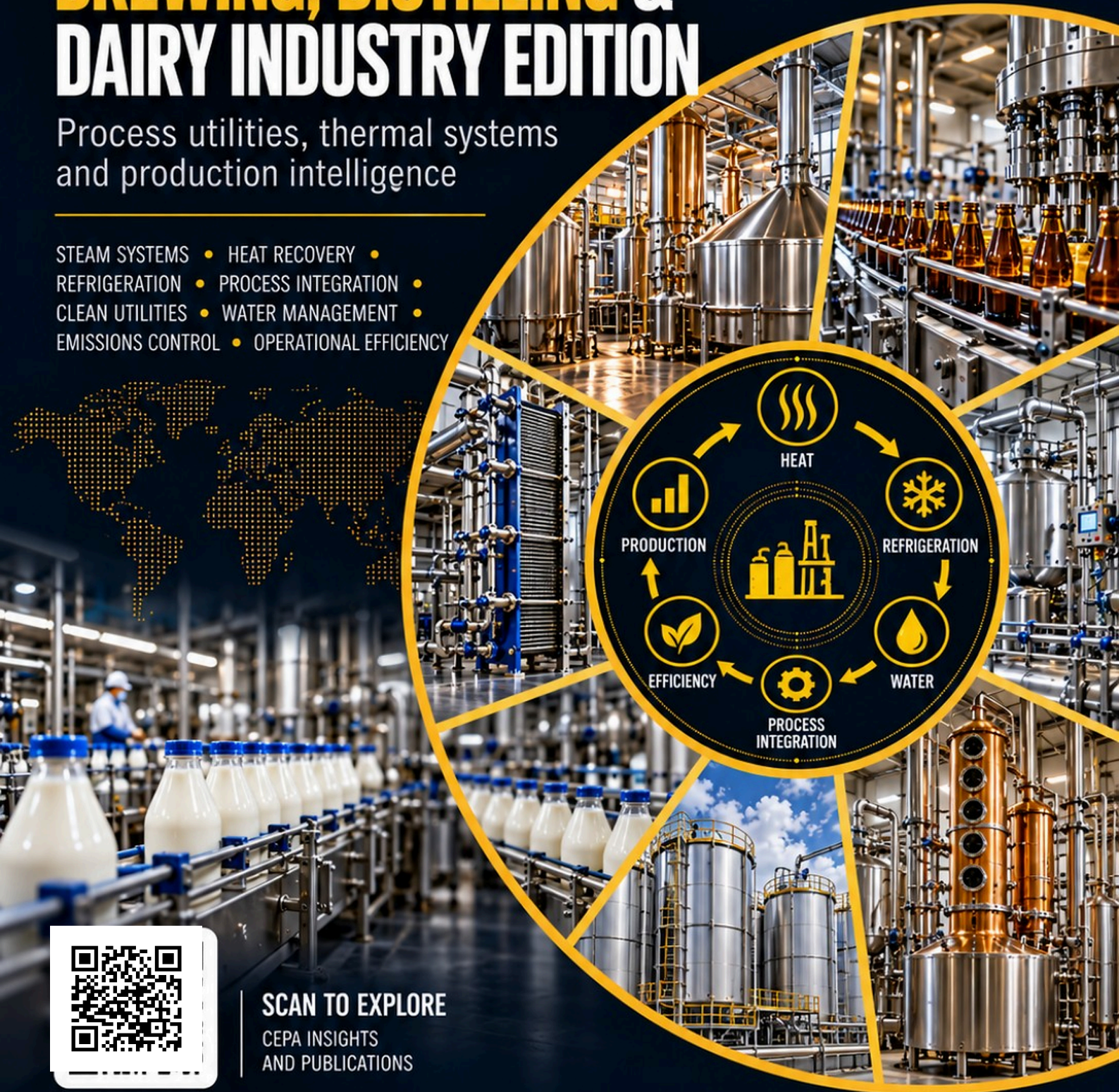


TECHNICAL INTELLIGENCE BRIEF

FOOD, BEVERAGE, BREWING, DISTILLING & DAIRY INDUSTRY EDITION

Process utilities, thermal systems
and production intelligence

STEAM SYSTEMS • HEAT RECOVERY •
REFRIGERATION • PROCESS INTEGRATION •
CLEAN UTILITIES • WATER MANAGEMENT •
EMISSIONS CONTROL • OPERATIONAL EFFICIENCY



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CEPA INSIGHTS
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CLEAN ENERGY FOR A MORE
RESOURCE EFFICIENT INDUSTRY

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Waste & Carbon Management

Publication control and complete-series boundary

CEPA-CL-FOODBEV003-P01

KEY

Issue 003 treats plant heat and cold as one controlled utility network; prior product-loss and water-reuse frameworks are continuity references only.

TECHNICAL BASIS

FOODBEV-001 already addressed yield/CIP/product-to-drain/wastewater/by-products, and FOODBEV-002 addressed source-to-end-use reuse, treatment and hygienic controls. The new scope begins with thermal energy entering, circulating through and leaving production systems.

DECISION INTERPRETATION

A thermal project is decision-grade only when source, sink, temperature level, duty, timing, process constraints and whole-system effects are explicit.

CONTROL ACTION

Adopt one plant thermal-system boundary and one utility/process energy map.

REQUIRED RECORDS

Fuel/electricity/steam/refrigeration meters; process flows; temperatures; production; operating states; heat-recovery records.

AUDIT / ESCALATION TRIGGER

Escalate savings claims that omit system boundary, production denominator or interactions with product safety/quality.

Sources: F3-EV-001...004; prior FOODBEV issues | Claim: CEPA-CL-FOODBEV003-P01

Executive findings: heat and cold as one utility system

CEPA-CL-FOODBEV003-P02

KEY

Thermal efficiency is optimized by managing generation, distribution, process demand, refrigeration and recoverable heat together—not by improving isolated components independently.

TECHNICAL BASIS

EU FDM BAT includes an energy-efficiency plan and common techniques such as burner control, cogeneration and heat recovery with heat exchangers and/or heat pumps including mechanical vapour recompression. DOE process-heating, steam and refrigeration guidance likewise emphasizes systems approaches because components and loads interact.

DECISION INTERPRETATION

Executives should first establish where heat is required, where heat is rejected, when those loads coincide, and what temperature/hygiene barriers control integration. Only then should equipment projects be ranked.

CONTROL ACTION

Create a thermal-utilities governance owner spanning process heat, steam and refrigeration.

REQUIRED RECORDS

Energy map; source/sink list; operating schedules; process constraints; quality/safety limits; maintenance data; costs.

AUDIT / ESCALATION TRIGGER

Escalate component paybacks that ignore upstream/downstream system effects or shift energy to another utility.

Sources: F3-EV-001...004 | Claim: CEPA-CL-FOODBEV003-P02

Plant thermal-system boundary

CEPA-CL-FOODBEV003-P03

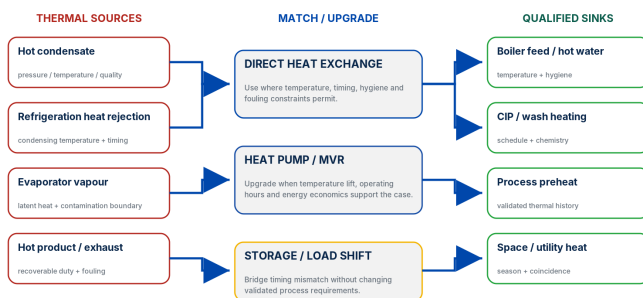
KEY

Thermal performance cannot be compared until the facility declares which energy inputs, distribution systems, process loads, refrigeration auxiliaries and recovered-energy flows are inside the calculation boundary.

Plant Thermal Source-Sink Map

Map temperature level, duty and timing before selecting equipment.

F3-V01



Sources: EU FOM BAT 2019/2031; U.S. DOE Process Heating, Steam, Refrigeration and Industrial Heat Pumps. Conceptual architecture; site temperatures, duties and schedules are required for project selection.

F3-V01_Thermal_Source_Sink_Map | Conceptual framework; no facility performance implied.

TECHNICAL BASIS

A plant may purchase fuel and electricity, generate steam/hot water, operate refrigeration compressors/pumps/fans, recover heat, and export or reject thermal energy. EU BAT specific-energy metrics combine heat and electricity for defined activities and activity rates; those definitions should not be mixed with utility-specific CEPA metrics without explanation.

DECISION INTERPRETATION

Use nested boundaries: plant final energy; utility-system energy; unit-operation energy; and product/process-normalized energy. This lets management distinguish conversion loss, distribution loss and process demand.

CONTROL ACTION

Publish a boundary diagram before publishing a thermal KPI.

REQUIRED RECORDS

Meters; fuel/energy bills; boiler and refrigeration logs; steam/hot-water flows; production data; inclusion/exclusion register.

AUDIT / ESCALATION TRIGGER

Escalate a trend or benchmark where the energy boundary or activity rate changes silently.

Sources: F3-EV-001, F3-EV-002..004 | Claim: CEPA-CL-FOODBEV003-P03

Heat-source and heat-sink map

CEPA-CL-FOODBEV003-P04

KEY

Useful heat recovery depends on matching heat sources to real sinks by temperature, duty, timing and sanitary separation—not merely finding a hot stream.

TECHNICAL BASIS

Typical sources can include hot exhaust, condensate, hot product/cooling streams, compressor discharge/desuperheating and refrigeration heat rejection. Sinks can include feed/product preheat, hot-water generation, boiler feedwater and other process duties. DOE process-heating guidance explicitly recommends process-flow and thermal-integration analysis.

DECISION INTERPRETATION

Each source/sink record should state supply/target temperature, heat capacity/duty, time profile, fouling/contamination risk, minimum separation and control response.

CONTROL ACTION

Create a source-sink register before calculating "recoverable heat."

REQUIRED RECORDS

Temperature/flow/load history; operating schedule; composition; exchanger barriers; product/hygiene constraints; current utility source.

AUDIT / ESCALATION TRIGGER

Escalate theoretical heat-recovery values that ignore temperature approach, timing or sanitary barrier requirements.

Sources: F3-EV-002; F3-EV-001 | Claim: CEPA-CL-FOODBEV003-P04

Thermal cascade and temperature quality

CEPA-CL-FOODBEV003-P05

KEY

One MWh of low-temperature heat is not interchangeable with one MWh of high-temperature process duty; temperature level determines technical usefulness and technology choice.

TECHNICAL BASIS

Heat can move spontaneously only across an adequate temperature driving force; raising low-grade heat to a higher useful temperature may require a heat pump, mechanical vapour recompression or another energy input. EU BAT recognizes heat exchangers, heat pumps and MVR among common energy-efficiency techniques.

DECISION INTERPRETATION

Prioritize direct recovery where source temperature and timing fit the sink; use temperature-lift technologies when the recovered source is stable and the added electricity/capital can be justified.

CONTROL ACTION

Classify sources/sinks by temperature band and required lift before assigning projects.

REQUIRED RECORDS

Supply/return/target temperatures; duty curves; minimum approach; heat-pump/MVR conditions; electricity price/emissions basis.

AUDIT / ESCALATION TRIGGER

Escalate claims that count low-grade rejected heat as fully recoverable useful heat.

Sources: F3-EV-001, F3-EV-002 | Claim: CEPA-CL-FOODBEV003-P05

Process-heating demand architecture

CEPA-CL-FOODBEV003-P06

KEY

The first efficiency question is how much heat the process actually requires at each temperature and time—not how much heat the boiler can generate.

TECHNICAL BASIS

Food and beverage loads can include cooking, pasteurisation, sterilisation, evaporation, drying, hot-water generation and CIP heating. DOE process-heating guidance identifies controls, insulation, combustion optimization, preheating and waste-heat recovery as system opportunities.

DECISION INTERPRETATION

Separate unavoidable process enthalpy from controllable losses: excess temperature, excess residence time, exhaust loss, standby, poor insulation and unnecessary reheating.

CONTROL ACTION

Create heat-demand curves for priority unit operations and segment by product family/operating mode.

REQUIRED RECORDS

Product flow; inlet/outlet temperature; heat capacity assumptions; steam/hot-water flow; cycle time; standby; production state.

AUDIT / ESCALATION TRIGGER

Escalate "energy intensity" without separating production demand from standby/changeover/nonproduction operation.

Sources: F3-EV-002; F3-EV-001 | Claim: CEPA-CL-FOODBEV003-P06

Steam-generation and distribution boundary

CEPA-CL-FOODBEV003-P07

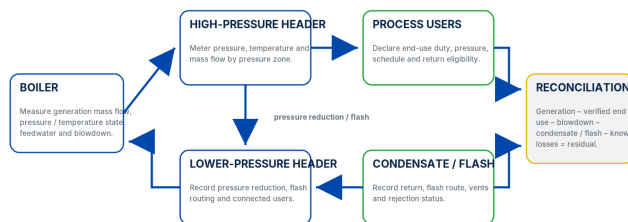
KEY

Steam-system efficiency is a supply-and-demand problem; boiler efficiency alone cannot describe the useful energy delivered to process.

Steam Mass / Enthalpy Reconciliation

A condensate-return percentage alone cannot locate network or end-use loss.

F3-V03



Source: U.S. DOE Better Plants steam-systems approach; CEPA pressure-zone reconciliation method. No universal flash fraction is assumed; pressure-specific steam-table data are required.

F3-V03_Steam_Reconciliation | Conceptual framework; no facility performance implied.

TECHNICAL BASIS

DOE steam guidance recommends a systems approach addressing both supply and demand. Opportunity areas include steam traps, insulation, economizers/waste-heat recovery and condensate/feedwater practices. Losses can occur in generation, distribution, pressure reduction, leaking traps, vents, blowdown and end-use control.

DECISION INTERPRETATION

Build a steam balance from fuel/feedwater through generated steam, distribution, end uses, flash/vent losses and condensate return. Keep mass balance and energy balance separate but linked.

CONTROL ACTION

Instrument the highest-flow headers and priority end users before capital optimisation.

REQUIRED RECORDS

Fuel; feedwater; steam flow/pressure/quality where available; trap survey; condensate return; blowdown; end-use loads.

AUDIT / ESCALATION TRIGGER

Escalate a steam saving based only on fuel consumption when production/load or condensate-return conditions changed.

Sources: F3-EV-003 | Claim: CEPA-CL-FOODBEV003-P07

Flash-steam pressure cascading and condensate segregation

CEPA-CL-FOODBEV003-P08

KEY

Once condensate return eligibility is established, the next thermal-control problem is preserving pressure and temperature value: condensate and flash steam should be managed as distinct energy-bearing streams rather than collapsed into one return percentage.

TECHNICAL BASIS

FOODBEV-002 already established the hygiene/contamination gate for boiler-feed and condensate return. This page begins after that gate. DOE steam-system guidance identifies condensate return, flash-steam recovery and pressure-management opportunities within a systems approach. When high-pressure condensate enters a lower-pressure receiver, part of its thermal content can appear as flash steam; whether that vapour is useful depends on pressure level, timing and a compatible heat demand.

DECISION INTERPRETATION

A plant can have a respectable condensate-return percentage and still discard useful thermal value through flash vents or poorly matched pressure levels. Segment clean eligible condensate by source pressure/temperature and show where flash steam is recovered, cascaded to a lower-pressure service, condensed, or vented. Do not treat a generic "maximize return" target as the optimization objective.

CONTROL ACTION

Create a pressure-level condensate/flash map and identify each receiver, flash destination, lower-pressure user and unavoidable vent/reject point.

REQUIRED RECORDS

Steam/header pressure; condensate source pressure and temperature; condensate mass/flow; receiver pressure; flash-steam destination; vent condition; make-up water; feedwater temperature; operating schedule; eligibility basis.

AUDIT / ESCALATION TRIGGER

Escalate when flash steam is routinely vented while a compatible lower-pressure heat sink exists, or when a pressure-cascade project ignores contamination, backpressure or process-control constraints.

Sources: F3-EV-003; FOODBEV-002 continuity; CEPA method | Claim: CEPA-CL-FOODBEV003-P08

Regenerative heat exchange

CEPA-CL-FOODBEV003-P09

KEY

Regeneration should recover heat across compatible process stages while preserving validated hygienic separation and required product thermal history.

TECHNICAL BASIS

EU food/drink/milk BAT includes heat-recovery techniques and dairy-specific regenerative heat-exchange measures. FDA's current 2025 PMO provides a concrete dairy example in which regenerator pressure relationships and automatic diversion logic protect the pasteurized side when required conditions are not maintained.

DECISION INTERPRETATION

A regeneration KPI is meaningful only with declared product/process boundary, exchanger configuration, temperatures/flows and hygiene-control design. The PMO example must not be generalized as a universal pressure rule for unrelated food processes.

CONTROL ACTION

Define an exchanger-specific recovery and hygiene verification plan and route all changes through product/food-safety management of change.

REQUIRED RECORDS

Hot/cold inlet/outlet temperatures; flows; pressure relationship where relevant; leakage/diversion controls; fouling/CIP state; validation record.

AUDIT / ESCALATION TRIGGER

Escalate a recovery project that lacks defined response to exchanger leakage or loss of hygienic separation.

Sources: F3-EV-001, F3-EV-006 | Claim: CEPA-CL-FOODBEV003-P09

Industrial refrigeration system boundary

CEPA-CL-FOODBEV003-P10

KEY

Refrigeration should be optimized as a system because compressor, evaporator, condenser, controls, defrost and auxiliary loads interact.

TECHNICAL BASIS

DOE Better Plants states that a system-level approach is the most effective way to generate impactful refrigeration savings. Changes in condensing pressure, suction conditions, evaporator performance, defrost, pumps/fans and load management can interact and shift performance elsewhere.

DECISION INTERPRETATION

Use declared system boundaries and operating states. kWh per tonne can be useful only when product mix, temperatures, ambient/reject conditions and included auxiliaries are controlled or segmented.

CONTROL ACTION

Establish a refrigeration KPI dictionary before comparing lines or plants.

REQUIRED RECORDS

Compressor energy; suction/discharge conditions; condenser/evaporator data; pumps/fans; defrost; ambient; production/cooling load.

AUDIT / ESCALATION TRIGGER

Escalate component-efficiency claims that increase total system energy or compromise temperature control.

Sources: F3-EV-004 | Claim: CEPA-CL-FOODBEV003-P10

Refrigeration heat rejection as a usable source

CEPA-CL-FOODBEV003-P11

KEY

Heat rejected by refrigeration is a potential source only when its temperature, timing and recoverable duty match a real plant sink.

TECHNICAL BASIS

Refrigeration removes heat from product/process spaces and rejects that heat plus compressor work at the condenser. Some facilities can recover desuperheat or condenser heat for hot-water/preheat duties, but usefulness is constrained by sink temperature, simultaneity, control stability, fouling and economics.

DECISION INTERPRETATION

Do not report "waste heat available" as "energy saved." Calculate technically available heat, useful matched heat, auxiliary/temperature-lift needs and displaced utility energy separately.

CONTROL ACTION

Screen refrigeration heat against the source-sink register and prioritize stable coincident sinks.

REQUIRED RECORDS

Condenser temperatures/flow; compressor energy; heat-rejection estimate; hot-water/process demand profile; heat-exchanger performance; backup utility use.

AUDIT / ESCALATION TRIGGER

Escalate projects whose claimed savings exceed the actual displaced utility energy.

Sources: F3-EV-004; F3-EV-002; CEPA method | Claim: CEPA-CL-FOODBEV003-P11

Heat pumps and mechanical vapour recompression

CEPA-CL-FOODBEV003-P12

KEY

Heat pumps and MVR are temperature-lift technologies; feasibility depends on source/sink temperature, required lift, operating hours, electricity/fuel economics and process integration.

TECHNICAL BASIS

EU BAT includes heat recovery with heat exchangers and/or heat pumps, including mechanical vapour recompression. DOE describes industrial heat pumps as active heat-recovery equipment that raises waste-heat temperature to a more useful level and notes that value depends on whether delivered heat can replace a purchased energy source and whether operating energy costs less than the energy displaced.

DECISION INTERPRETATION

Screen projects using source temperature, target temperature, lift, duty, annual coincidence, expected performance, fouling/process constraints and displaced utility. Keep vendor design values separate from measured operating performance.

CONTROL ACTION

Require an operating-envelope and integration study before using headline COP or payback values.

REQUIRED RECORDS

Source/sink temperatures; duty profiles; proposed COP/compressor power; operating hours; displaced fuel/steam; electricity price; controls; product constraints; maintenance.

AUDIT / ESCALATION TRIGGER

Escalate heat-pump/MVR economics based on nameplate COP without site temperature-lift and annual-load evidence.

Sources: F3-EV-001, F3-EV-002, F3-EV-008 | Claim: CEPA-CL-FOODBEV003-P12

Pasteurisation heat integration

CEPA-CL-FOODBEV003-P13

KEY

Regenerative heat exchange can reduce external heating and cooling duty, but hygienic pressure/flow safeguards remain controlling in regulated dairy pasteurisation systems.

TECHNICAL BASIS

EU food/drink/milk BAT identifies regenerative heat exchange in pasteurisation as an energy-efficiency technique. FDA's 2025 PMO specifies pressure-differential and sequence controls for milk regenerators, including diversion when required pressure relationships are not maintained.

DECISION INTERPRETATION

Treat the regenerator as both an energy-recovery device and a food-safety barrier. Energy optimisation cannot weaken differential-pressure, diversion or validation requirements.

CONTROL ACTION

Trend thermal regeneration together with pressure-control and pasteurisation compliance data.

REQUIRED RECORDS

Hot/cold inlet-outlet temperatures; flows; regeneration effectiveness; pressure differential; FDD/diversion events; sanitation/inspection records.

AUDIT / ESCALATION TRIGGER

Escalate energy projects that change exchanger hydraulics, pressure relationships or control logic without food-safety review.

Sources: F3-EV-001, F3-EV-006 | Claim: CEPA-CL-FOODBEV003-P13

Evaporation and concentration energy integration

CEPA-CL-FOODBEV003-P14

KEY

Evaporation projects should be evaluated as coupled heat-and-mass systems: feed preheating, vapour reuse, condensate, product concentration and fouling all affect useful energy performance.

TECHNICAL BASIS

EU BAT recognizes heat recovery, heat pumps and MVR as common energy techniques. In evaporative operations, recovered vapour can become a thermal resource when temperature lift, cleanliness and timing fit the process.

DECISION INTERPRETATION

Define the duty avoided at the sink rather than counting all vapour energy as recoverable. Product quality, fouling and condensate use determine practical value.

CONTROL ACTION

Map feed, vapour, condensate and product temperatures/flows and evaluate preheat/MVR opportunities.

REQUIRED RECORDS

Feed/product concentration; evaporation rate; pressures; temperatures; steam/electricity; condensate; fouling/cleaning cycle; quality constraints.

AUDIT / ESCALATION TRIGGER

Escalate savings estimates that ignore compressor electricity, fouling, non-condensables or product-temperature limits.

Sources: F3-EV-001, F3-EV-002 | Claim: CEPA-CL-FOODBEV003-P14

Drying and exhaust-heat recovery

CEPA-CL-FOODBEV003-P15

KEY

Dryer exhaust contains heat but also moisture, particulates and product-specific contaminants; recoverability depends on both temperature and exhaust quality.

TECHNICAL BASIS

Food/dairy BAT includes energy-efficient drying techniques. Generic process-heating guidance supports exhaust-heat recovery, but direct reuse of exhaust energy can be constrained by hygiene, fouling and dew-point corrosion.

DECISION INTERPRETATION

Separate theoretical sensible/latent heat from technically recoverable heat. Use indirect recovery where contamination risk prevents direct contact.

CONTROL ACTION

Characterize dryer exhaust and candidate sinks before selecting exchanger or heat-pump routes.

REQUIRED RECORDS

Exhaust flow; temperature/humidity; particulates; product; exchanger fouling; sink temperature; cleaning access; recovered duty.

AUDIT / ESCALATION TRIGGER

Escalate projects that count latent heat without a viable condensation/material-compatibility strategy.

Sources: F3-EV-001, F3-EV-002 | Claim: CEPA-CL-FOODBEV003-P15

Brewing and distilling thermal opportunities

CEPA-CL-FOODBEV003-P16

KEY

Brewing and distilling thermal optimisation should connect mashing/cooking, wort boil or distillation, hot-water demand, condensate and refrigeration rather than optimize each unit independently.

TECHNICAL BASIS

EU BAT for breweries includes energy-oriented techniques such as high-temperature mashing and reducing wort-boil evaporation; steam and heat-recovery systems add cross-unit opportunities. Distilling adds different vapour/condensation duties and must be evaluated separately.

DECISION INTERPRETATION

Use product/process-specific duty maps and avoid transferring brewery BAT ranges to distilleries or other beverage plants.

CONTROL ACTION

Build separate heat-source/sink profiles for brewing and distilling campaigns.

REQUIRED RECORDS

Steam/hot water; boil/evaporation rates; condensate; cooling water; refrigeration; batch schedule; product-quality limits.

AUDIT / ESCALATION TRIGGER

Escalate benchmarks that mix breweries, distilleries and beverage plants without aligned boundaries.

Sources: F3-EV-001, F3-EV-002, F3-EV-003 | Claim: CEPA-CL-FOODBEV003-P16

Dairy thermal system

CEPA-CL-FOODBEV003-P17

KEY

Dairy thermal efficiency is governed by the interaction of pasteurisation/UHT, evaporation, drying, hot water and refrigeration under strict hygienic controls.

TECHNICAL BASIS

EU BAT lists dairy-specific energy techniques including continuous pasteurisers, regenerative exchange, multistage drying and other efficiency measures. FDA PMO provides a current U.S. sanitary-control example for regenerative pasteurisation.

DECISION INTERPRETATION

Dairy heat integration should prioritize validated regeneration and source/sink matching while preserving product/medium separation and pressure-control requirements.

CONTROL ACTION

Create a dairy thermal map by product family and thermal treatment route.

REQUIRED RECORDS

Product flow/temperature; regeneration; UHT/pasteurisation mode; evaporation/drying; chilled-water/refrigeration; hot water; cleaning cycles.

AUDIT / ESCALATION TRIGGER

Escalate heat integration that crosses hygienic boundaries without validated exchanger/control design.

Sources: F3-EV-001, F3-EV-006 | Claim: CEPA-CL-FOODBEV003-P17

Beverage and aseptic heat-exchanger integrity

CEPA-CL-FOODBEV003-P18

KEY

Heat exchangers are energy devices and product-protection barriers; mechanical integrity and pressure relationships can be as important as heat-transfer effectiveness.

TECHNICAL BASIS

FDA guidance for dairy/aseptic systems highlights heat-exchanger and control integrity, while process-heating guidance focuses on thermal performance. Combining both views prevents efficiency projects from creating cross-contamination pathways.

DECISION INTERPRETATION

Track leak/pressure-control integrity and thermal performance in one change-control process.

CONTROL ACTION

Include hygienic risk review in exchanger replacement, plate addition, flow-rate and heat-recovery modifications.

REQUIRED RECORDS

Exchanger design; media; pressures; temperatures; leak tests; gasket/plate maintenance; diversion logic; product release criteria.

AUDIT / ESCALATION TRIGGER

Escalate unexplained pressure reversals, repeated gasket failures or efficiency changes linked to product deviations.

Sources: F3-EV-006; FDA aseptic/thermal-control context; F3-EV-002 | Claim: CEPA-CL-FOODBEV003-P18

CIP thermal demand and recovery interface

CEPA-CL-FOODBEV003-P19

KEY

CIP thermal energy should be managed as a timed utility demand with recovery opportunities, without repeating the prior issue's sanitation chemistry and product-loss controls.

TECHNICAL BASIS

Earlier FOODBEV work established CIP hygiene and loss-control boundaries. This issue adds thermal scheduling: hot-water generation, return temperatures, heat losses, idle holding, simultaneous demand and possible heat recovery from clean-enough streams.

DECISION INTERPRETATION

Optimize temperature generation/distribution first; do not reduce validated cleaning temperatures merely to improve energy intensity.

CONTROL ACTION

Create a CIP heat profile by circuit and schedule against process heat-recovery availability.

REQUIRED RECORDS

Circuit; setpoint/actual temperatures; flow; duration; return temperature; hot-water source; timing; validated minimums; recovered heat.

AUDIT / ESCALATION TRIGGER

Escalate energy savings attributed to lower temperature/time without sanitation validation.

Sources: F3-EV-002, F3-EV-003; FOODBEV-001 continuity | Claim: CEPA-CL-FOODBEV003-P19

Thermal storage and load shifting

CEPA-CL-FOODBEV003-P20

KEY

Thermal storage can decouple heat/cold generation from process timing and make intermittent recovery useful, but storage losses and temperature requirements must be explicit.

TECHNICAL BASIS

Hot-water tanks, chilled-water/glycol storage or phase-change systems can reduce peaks and improve equipment loading. The value depends on source/sink coincidence, storage temperature, stratification, losses and hygiene/quality boundaries.

DECISION INTERPRETATION

Treat storage as a timing tool, not free energy. Calculate energy stored/recovered and the generation/load consequences.

CONTROL ACTION

Evaluate storage where production schedules create repeatable temporal mismatch.

REQUIRED RECORDS

Volume/mass; temperatures; storage losses; charge/discharge rates; duty profile; peak demand; controls; water-quality/hygiene status where relevant.

AUDIT / ESCALATION TRIGGER

Escalate projects that count tank capacity rather than usable recoverable thermal energy.

Sources: F3-EV-002, F3-EV-004; CEPA method | Claim: CEPA-CL-FOODBEV003-P20

Pinch-style source-sink matching

CEPA-CL-FOODBEV003-P21

KEY

Heat integration should prioritize the best source-sink matches by temperature, duty and timing before selecting equipment.

TECHNICAL BASIS

Pinch-analysis principles formalize temperature feasibility and minimum utility demand. For CEPA publication purposes, the method is used as an engineering decision framework rather than as a claim that every plant requires a full formal pinch study.

DECISION INTERPRETATION

Match high-temperature sources to high-grade sinks first and prevent low-grade uses from consuming valuable high-grade heat where alternatives exist.

CONTROL ACTION

Build a source-sink matrix with temperature, duty, time overlap, hygiene class and distance.

REQUIRED RECORDS

Source/sink temperatures; heat capacity flow; schedule; minimum approach; distance; contamination class; utility costs.

AUDIT / ESCALATION TRIGGER

Escalate recovery projects selected before comparing competing source-sink matches.

Sources: F3-EV-002; CEPA engineering method | Claim: CEPA-CL-FOODBEV003-P21

Specific thermal-energy metrics

CEPA-CL-FOODBEV003-P22

KEY

Thermal performance must separate process heat, electricity and refrigeration while retaining a declared production denominator.

TECHNICAL BASIS

EU BAT defines specific energy consumption as final energy consumed relative to activity rate within defined sector boundaries. CEPA extends that discipline to utility sub-systems where meters permit.

DECISION INTERPRETATION

Report absolute energy and intensity together and segment by product family/thermal route before benchmarking.

CONTROL ACTION

Lock a utility-boundary and denominator dictionary before trending.

REQUIRED RECORDS

Fuel/steam/electricity; conversion factors; production mass/volume; operating hours; product mix; boundary; meter confidence.

AUDIT / ESCALATION TRIGGER

Escalate intensity improvements caused by product mix, denominator change or unmetered utility transfer.

Sources: F3-EV-001, F3-EV-002 | Claim: CEPA-CL-FOODBEV003-P22

Refrigeration metrics and load context

CEPA-CL-FOODBEV003-P23

KEY

Refrigeration kWh per tonne is useful only when cooling load, product temperature, ambient conditions and system boundary are understood.

TECHNICAL BASIS

DOE emphasizes system-level refrigeration optimization. Identical kWh/t can reflect different inlet temperatures, freezing/chilling duties, suction/condensing conditions or ambient heat rejection.

DECISION INTERPRETATION

Use intensity for trend control but diagnose performance with operating variables and load normalization.

CONTROL ACTION

Trend compressors plus declared auxiliaries and key pressure/temperature conditions.

REQUIRED RECORDS

kWh; tonnes; inlet/outlet temperature; suction/condensing pressure; ambient/wet-bulb; defrost; fan/pump status; product mix.

AUDIT / ESCALATION TRIGGER

Escalate comparisons across plants/seasons without cooling-load and boundary normalization.

Sources: F3-EV-004, F3-EV-005 | Claim: CEPA-CL-FOODBEV003-P23

Steam mass-and-enthalpy reconciliation and hidden-loss diagnostics

CEPA-CL-FOODBEV003-P24

KEY

A steam system should be reconciled by mass and thermal state across generation, pressure-level distribution, end use, blowdown, condensate, flash steam and known losses; boiler efficiency alone cannot locate distribution or end-use waste.

TECHNICAL BASIS

FOODBEV-002 addressed whether condensate can be returned safely and appropriately. This issue extends that baseline into utility-system diagnosis. DOE's steam-systems approach treats supply and demand together and identifies traps, insulation, economizers, blowdown heat recovery and condensate/flash recovery as interacting controls. A useful CEPA steam account therefore preserves pressure/temperature state and separates generation performance from distribution loss and process demand.

DECISION INTERPRETATION

Use one steam balance for each declared pressure zone or major user group. Compare steam generation with metered/estimated end-use demand, blowdown, condensate return, flash recovery and residual/unaccounted demand. Use make-up-water and condensate data as reconciliation cross-checks rather than presenting return percentage as the plant's primary steam KPI.

CONTROL ACTION

Establish a pressure-zone steam reconciliation with a defined residual and root-cause workflow for abnormal demand.

REQUIRED RECORDS

Fuel and boiler output; steam generation; header pressure/temperature; major-user steam flow; blowdown; trap/vent/leak observations; condensate mass/temperature; flash-steam recovery; make-up water; feedwater; production state; meter uncertainty.

AUDIT / ESCALATION TRIGGER

Escalate when steam demand rises without a matching production/thermal-load change, when make-up water and condensate records do not reconcile, or when boiler-efficiency improvement masks increasing distribution/end-use loss.

Sources: F3-EV-003; FOODBEV-002 continuity; CEPA quantitative method | Claim: CEPA-CL-FOODBEV003-P24

Heat-recovery effectiveness

CEPA-CL-FOODBEV003-P25

KEY

Heat-recovery performance should be measured by useful heat delivered to a qualified sink, not only by heat available at the source.

Heat-Recovery Value Cascade

A thermodynamic opportunity becomes a verified saving only after boundary, transfer and end-use checks.

F3-V10



LOSS / UNCERTAINTY LEDGER

Track temperature mismatch, non-coincident schedules, fouling, pump / compressor electricity, storage loss, control limits, hygiene constraints and baseline uncertainty. Do not call gross source heat an energy saving.

Sources: U.S. DOE process-heating / steam / industrial-heat-pump systems approach; CEPA energy-accounting method. No generic recovery percentage is assumed.

F3-V10_Heat_Recovery_Value_Cascade | Conceptual framework; no facility performance implied.

TECHNICAL BASIS

DOE partner case studies show implemented recovery from refrigeration, oxidizer/boiler exhaust and other sources, but their economics and savings are site-specific. CEPA therefore distinguishes available heat, transferred heat and actually displaced utility.

DECISION INTERPRETATION

Use "useful recovered duty" and "verified utility displacement" as separate quantities where data permit.

CONTROL ACTION

Meter or calculate source/sink temperatures and flows and reconcile displacement at the receiving utility.

REQUIRED RECORDS

Source duty; exchanger duty; sink duty; bypass; pump/fan/compressor energy; displaced steam/fuel/electricity; operating hours.

AUDIT / ESCALATION TRIGGER

Escalate projects that report nameplate recovery capacity as annual realized savings.

Sources: F3-EV-002, F3-EV-007; CEPA method | Claim: CEPA-CL-FOODBEV003-P25

Water-energy interactions

CEPA-CL-FOODBEV003-P26

KEY

Thermal optimisation can increase or decrease water use; the energy issue must disclose those interactions without reopening the prior water-reuse framework.

TECHNICAL BASIS

Cooling towers, evaporative condensers, once-through cooling, chilled-water loops, steam condensate and hot-water systems connect water and energy. DOE food-sector examples show some projects can reduce both, while others may trade one resource for another.

DECISION INTERPRETATION

Report utility changes jointly when a thermal project materially changes water withdrawal, evaporation, blowdown or wastewater.

CONTROL ACTION

Add water-impact screening to thermal project approval.

REQUIRED RECORDS

Cooling/boiler water; cycles/blowdown; evaporation; condensate; wastewater; kWh/fuel; production; project baseline.

AUDIT / ESCALATION TRIGGER

Escalate energy projects whose water burden is omitted from economics or resource claims.

Sources: F3-EV-001, F3-EV-004, F3-EV-005; FOODBEV-002 continuity | Claim: CEPA-CL-FOODBEV003-P26

Product quality and validated process window

CEPA-CL-FOODBEV003-P27

KEY

Thermal savings are acceptable only inside the validated product-safety and product-quality window for the specific process; changing time, temperature or cooling duty is not an efficiency measure if it invalidates required process performance.

TECHNICAL BASIS

Food/drink/milk BAT treats energy techniques within operating processes rather than as substitutes for product requirements. The 2025 PMO provides a current example of a validated thermal-control framework for Grade A milk/milk products, including required temperature/flow/pressure-control logic. Other products require their own applicable validation and quality criteria.

DECISION INTERPRETATION

Treat product safety and specification as hard constraints, then optimize utility delivery around them. Do not infer a generic time-temperature reduction from energy targets.

CONTROL ACTION

Link thermal KPIs to validated process limits, critical product-quality variables and deviation/rework data.

REQUIRED RECORDS

Product family; validated process limits; quality attributes; safety/validation record; deviations; rework/rejects; utility conditions.

AUDIT / ESCALATION TRIGGER

Escalate apparent energy savings associated with process-limit excursions, rising quality deviations or product loss.

Sources: F3-EV-001, F3-EV-006; CEPA method | Claim: CEPA-CL-FOODBEV003-P27

Food-safety and hygienic-design gate

CEPA-CL-FOODBEV003-P28

KEY

Heat integration across hygienic boundaries requires pressure, separation, cleanability and failure-response controls appropriate to the product and jurisdiction.

TECHNICAL BASIS

The 2025 PMO provides a concrete current example: milk regenerators use differential-pressure controls and automatic diversion logic. Other food systems require their own applicable sanitary design and validation rules.

DECISION INTERPRETATION

Use the dairy example as a control principle, not a universal 1-psi rule for unrelated processes.

CONTROL ACTION

Require food-safety engineering sign-off for new cross-process heat recovery and exchanger changes.

REQUIRED RECORDS

Media identities; pressure hierarchy; leak detection; hygienic design; validation; alarm/diversion logic; maintenance.

AUDIT / ESCALATION TRIGGER

Escalate direct/indirect heat recovery that lacks a documented contamination-failure analysis.

Sources: F3-EV-006; F3-EV-001 | Claim: CEPA-CL-FOODBEV003-P28

Refrigerant and heat-transfer-medium governance

CEPA-CL-FOODBEV003-P29

KEY

Thermal-system optimization must retain refrigerant/heat-transfer-medium identity, inventory and leakage/safety controls; energy performance does not override chemical/process safety.

TECHNICAL BASIS

Industrial refrigeration often uses ammonia and other refrigerants with distinct safety/environmental obligations. Secondary fluids can add pumping energy and heat-exchange approach losses.

DECISION INTERPRETATION

Include refrigerant/secondary-fluid impacts in system design and avoid technology-neutral efficiency claims without boundary definition.

CONTROL ACTION

Maintain refrigerant/medium inventory, leak/incident records and energy impact in the utility data model.

REQUIRED RECORDS

Refrigerant type/charge; leak/service records; secondary fluid; pumps; temperatures; safety systems; jurisdictional requirements.

AUDIT / ESCALATION TRIGGER

Escalate energy projects that materially change refrigerant charge/pressure or safety basis without formal management of change.

Sources: F3-EV-004, F3-EV-005; applicable safety/environmental rules | Claim: CEPA-CL-FOODBEV003-P29

Thermal-project economics

CEPA-CL-FOODBEV003-P30

KEY

Thermal economics must include realized operating hours, utility tariffs, maintenance, parasitic energy, product risk and avoided capacity-not just theoretical heat recovered.

Thermal Integration Screening Matrix

Screen the match before specifying equipment; no technology is automatically preferred.

F3-V11

	DIRECT HX	HEAT PUMP / MVR	STORAGE / SHIFT	NO PROJECT YET
Temperature match	match required	lift can bridge	not a temperature fix	redefine need
Schedule coincidence	same-time preferred	hours matter	can bridge timing	insufficient hours
Hygiene / separation	barrier / validation	barrier / validation	storage hygiene	unresolved risk
Fouling / cleanability	surface / cleaning	source HX matters	storage surfaces	unmanageable
Energy economics	avoided input > costs	COP + tariff + hours	loss + capacity cost	weak case
Control / validation	simple to complex	integration controls	charge / discharge	requirements unclear

Sources: U.S. DOE Process Heating, Industrial Heat Pumps, Steam and Refrigeration resources; CEPA screening method. Facility measurement and validation are required before project selection.

F3-V11_Thermal_Integration_Screening_Matrix | Conceptual framework; no facility performance implied.

TECHNICAL BASIS

DOE partner examples demonstrate site-specific payback opportunities, but those results are not transferable benchmarks. Temperature lift, source availability and sink demand dominate project economics.

DECISION INTERPRETATION

Use scenario ranges for production schedule and utility prices; separate measured savings from modelled savings.

CONTROL ACTION

Require a metering/verification plan before approving large CAPEX.

REQUIRED RECORDS

CAPEX; maintenance; source/sink hours; fuel/electricity/water prices; parasitic loads; avoided equipment/capacity; product risk; uncertainty.

AUDIT / ESCALATION TRIGGER

Escalate business cases built from design-point duty with no annual coincidence factor.

Sources: F3-EV-002..007; CEPA economics | Claim: CEPA-CL-FOODBEV003-P30

Thermal measurement architecture

CEPA-CL-FOODBEV003-P31

KEY

Thermal intelligence depends on synchronized flow, temperature, pressure and energy data linked to production state.

TECHNICAL BASIS

Meters alone are insufficient if timestamps, product family and operating mode are missing. Temporary measurement can close gaps before permanent instrumentation is justified.

DECISION INTERPRETATION

Prioritize measurement at high-duty sources/sinks and boundaries needed to verify savings.

CONTROL ACTION

Create a metering map with calibration/confidence and data ownership.

REQUIRED RECORDS

Meter ID; variable; units; location; sampling interval; calibration; historian link; production tag; uncertainty.

AUDIT / ESCALATION TRIGGER

Escalate savings calculations that combine unmatched time periods or uncalibrated/assumed flows.

Sources: F3-EV-001...006; CEPA evidence standard | Claim: CEPA-CL-FOODBEV003-P31

Executive thermal dashboard

CEPA-CL-FOODBEV003-P32

KEY

A thermal dashboard should show energy demand, useful recovery, system conditions and constraint compliance together.

TECHNICAL BASIS

Recommended layers: specific thermal energy, steam/condensate, refrigeration intensity, heat-recovery duty, source-sink availability, critical temperatures/pressures and project verification status.

DECISION INTERPRETATION

Keep legal/food-safety controls visually distinct from optimization targets.

CONTROL ACTION

Publish a controlled KPI dictionary and segment by product/line/utility.

REQUIRED RECORDS

Metric definitions; data source; owner; period; product mix; uncertainty; target/control limit; deviation action.

AUDIT / ESCALATION TRIGGER

Escalate dashboards that aggregate steam, electricity and recovered heat into a single unlabeled energy number.

Sources: F3-EV-001...007; CEPA metrics | Claim: CEPA-CL-FOODBEV003-P32

Thermal failure-mode register

CEPA-CL-FOODBEV003-P33

KEY

Recurring thermal losses should be coded by mechanism: leak, fouling, control drift, failed trap, pressure/temperature mismatch, defrost, standby, bypass or hygiene constraint.

TECHNICAL BASIS

A failure taxonomy connects utility waste to engineering action and prevents generic "high energy" diagnoses.

DECISION INTERPRETATION

Rank failure modes by verified annual energy/cost and operational risk.

CONTROL ACTION

Integrate maintenance and utility-event data into the action register.

REQUIRED RECORDS

Failure code; asset; time; condition; energy impact; product impact; corrective action; recurrence; verification.

AUDIT / ESCALATION TRIGGER

Escalate repeated high-impact failures or projects with no post-correction measurement.

Sources: F3-EV-002..006; CEPA method | Claim: CEPA-CL-FOODBEV003-P33

Thermal-investment screening matrix

CEPA-CL-FOODBEV003-P34

KEY

Projects should pass temperature feasibility, timing, hygiene/quality, operability and economics gates before ranking by headline energy savings.

TECHNICAL BASIS

A technically attractive source may be unavailable when the sink runs; a perfect temperature match may be disqualified by contamination risk; a large recovery duty may have excessive parasitic energy.

DECISION INTERPRETATION

Use hard disqualifiers first, then score qualified projects for value and uncertainty.

CONTROL ACTION

Standardize screening across heat exchanger, heat pump, MVR, storage, steam and refrigeration projects.

REQUIRED RECORDS

Source/sink duty; temperatures; timing; hygiene class; parasitics; CAPEX/OPEX; maintenance; product risk; confidence.

AUDIT / ESCALATION TRIGGER

Escalate project portfolios ranked only by theoretical MWh or simple payback.

Sources: F3-EV-001...007; CEPA method | Claim: CEPA-CL-FOODBEV003-P34

Thermal-project commissioning and measurement-verification sequence

CEPA-CL-FOODBEV003-P35

KEY

Thermal projects should progress through measured-baseline, functional/hygienic commissioning and persistence verification gates rather than a generic implementation calendar.

TECHNICAL BASIS

Gate A - Baseline: meter the source, sink, utility and production state long enough to define representative demand and variability. Gate B - Commission: verify heat-transfer duty, controls, product-quality/food-safety conditions, utility interactions and parasitic energy under defined operating states. Gate C - Persist: confirm realized utility displacement across representative production/seasonal conditions and reconcile maintenance, fouling and bypass effects.

DECISION INTERPRETATION

A project is not complete when the exchanger, heat pump or control change is installed; it is complete when useful recovered duty and sustained utility displacement are verified without compromising process constraints.

CONTROL ACTION

Attach a measurement-and-verification plan to every material thermal CAPEX project before procurement.

REQUIRED RECORDS

Baseline meter set; source/sink profiles; commissioning tests; hygiene/quality sign-off; parasitic loads; verified utility displacement; production normalization; persistence review.

AUDIT / ESCALATION TRIGGER

Escalate projects declared successful from design capacity, one short test or modelled savings without representative post-commissioning evidence.

Sources: F3-EV-001..006; CEPA method | Claim: CEPA-CL-FOODBEV003-P35

Source register, claim index and future-territory guard

CEPA-CL-FOODBEV003-P36

KEY

Issue 003 closes with a controlled source/claim register and protects future FOODBEV territory from being consumed by generic energy narrative.

TECHNICAL BASIS

The scope is industrial thermal integration. It does not re-teach product-to-drain/CIP loss, water-reuse treatment, general wastewater or broad carbon accounting except where a thermal project directly changes those variables.

DECISION INTERPRETATION

Future charters must compare against FOODBEV-001 through 003 and show a new decision surface.

CONTROL ACTION

Archive the complete-series novelty audit and open evidence questions.

REQUIRED RECORDS

Source URLs/locators; claim IDs; novelty lineage; metric dictionary; unresolved gaps; future-theme ledger.

AUDIT / ESCALATION TRIGGER

Escalate any final section that becomes generic energy efficiency without food/beverage process-specific decision value.

Sources: F3-EV-001...007; OPS-019 | Claim: CEPA-CL-FOODBEV003-P36

CEPA TECHNICAL INTELLIGENCE BRIEF | SOURCE REGISTER

Controlled source register

Official/current source spine used by this issue. Scope and applicability boundaries remain controlling.

F3-EV-001	Commission Implementing Decision (EU) 2019/2031 - Food, Drink and Milk BAT Annex; BAT 1, 2, 6 and sector-specific energy sections	eur-lex.europa.eu
F3-EV-002	U.S. DOE Better Plants - Process Heating Systems approach and heat-recovery context	betterbuildingssolutioncenter.energy.gov
F3-EV-003	U.S. DOE Better Plants - Steam Steam supply/demand and recovery measures	betterbuildingssolutioncenter.energy.gov
F3-EV-004	U.S. DOE Better Plants - Industrial Refrigeration System-level refrigeration optimization	betterbuildingssolutioncenter.energy.gov
F3-EV-005	U.S. DOE Better Plants - Process Cooling and HVAC Integrated cooling-system context	betterbuildingssolutioncenter.energy.gov
F3-EV-006	FDA 2025 Pasteurized Milk Ordinance Grade A dairy regenerator/interlock example	www.fda.gov
F3-EV-007	DOE Better Plants partner cases - Flowers Foods; PepsiCo; General Mills; J.R. Simplot Partner-reported implemented examples; site-specific only	betterbuildingssolutioncenter.energy.gov
F3-EV-008	U.S. DOE Onsite Energy Technologies - Industrial Heat Pumps Source/sink temperature and economics screening	betterbuildingssolutioncenter.energy.gov

F3-EV-007 exact partner-case locators (partner-reported; not universal benchmarks):

Flowers Foods: 40-year Old Bakery Conversion Prioritizes Energy and Water Performance
 PepsiCo: Condensing Economizer Installation
 General Mills: Cedar Rapids Heat Recovery
 J.R. Simplot Company: New Potato Processing Plant

betterbuildingssolutioncenter.energy.gov
betterbuildingssolutioncenter.energy.gov
betterbuildingssolutioncenter.energy.gov
betterbuildingssolutioncenter.energy.gov

Status sweep: 27 September 2026. Current-status/source-survivability check must be repeated at the T-3 release gate.

DECISION-GRADE TECHNICAL INTELLIGENCE

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