WHY DOES THIS HIGH-CONTAINMENT LABORATORY USE SO MUCH ENERGY?

Diagnostic Guide
GD-004

Technical diagnostic guide on airflow, pressure, envelope performance, and energy demand throughout the life cycle

Practical guide for distinguishing energy demand justified by containment from avoidable load created by leakage, overventilation, control instability, zoning, and system inefficiency.

HIGH ENERGY USE IS A SYMPTOM. FIRST IDENTIFY WHAT IS DRIVING THE LOAD.

This guide was created for high-containment facilities whose energy use appears excessive, but where reducing mechanical capacity without first understanding the containment basis could create another problem.

Why we developed it

High-containment laboratories can have substantial and persistent energy demand. Exhaust, outdoor-air conditioning, pressure control, filtration, redundancy, heat loads, and extended operating schedules may be technically justified by the containment strategy.

However, high consumption can also reflect avoidable conditions: excessive airflow, oversized zones, envelope leakage, high static pressure, unnecessary operating hours, control instability, or mechanical systems compensating for unresolved architectural problems.

The purpose of this guide is to distinguish those categories before an energy-reduction measure alters a containment function.

Who can use it

It is intended for facility managers, engineers, sustainability teams, biosafety personnel, operators, and institutional authorities evaluating energy performance in high-containment laboratories.

It is especially useful when considering airflow reductions, conversion to VAV, energy recovery, equipment replacement, Net Zero strategies, or other measures that interact with containment.

PRACTICAL USE

Begin by establishing the energy baseline and operating schedule. Then identify loads directly associated with containment, determine whether they exceed what the accepted basis requires, and trace the technical reason before selecting an optimization measure.

The objective is not to reduce energy at any cost. It is to eliminate unnecessary load while preserving the containment functions that justify the remaining demand.

01	02	03	04
BASELINE	ATTRIBUTE	CORRECT	OPTIMIZE

HOW THIS GUIDE MAY BE USED — AND WHAT IT DOES NOT AUTHORIZE

This guide is a general diagnostic orientation tool. It is designed to help structure technical questions, organize evidence, and define what requires a more specific evaluation.

Acceptable use

It may be used to:

- structure preliminary technical investigations;
- prepare internal reviews and multidisciplinary discussions;
- identify missing information, measurements, and documentation;
- support definition of the scope of a subsequent evaluation;
- serve as educational material and for internal technical reference.

It does not constitute

This guide does not constitute a design, specification, energy model, operating procedure, acceptance criterion, certification, compliance determination, authorization for modification or operation, or a site-specific recommendation.

Technical and operational decisions

No airflow reduction, setpoint modification, filtration change, energy-recovery measure, intervention on critical systems, continuation of operation, or return to service should be based solely on this guide.

Applicable technical basis

The content should be interpreted together with the risk assessment, Basis of Design, as-built documentation, commissioning criteria, regulatory requirements, manufacturer instructions, institutional procedures, and other site-specific documentation.

Competent personnel

Changes that may affect functions critical to containment should be evaluated, designed, executed, and verified by appropriately qualified personnel, with clearly defined authority to approve the new condition.

Responsibility

BioLab Solutions assumes no responsibility for decisions, modifications, interventions, or actions carried out outside a site-specific evaluation and without review by competent personnel.

01 Establish the actual energy baseline

"The laboratory uses a lot of energy" is not yet a diagnostic condition.

The first task is to determine when, where, and through which systems energy is being consumed.

Operating schedule

- 24/7 systems;
- extended operation;
- night/weekend setback where permitted;
- maintenance modes;
- seasonal differences.

Major electrical loads

- supply and exhaust fans;
- pumps;
- laboratory equipment;
- autoclaves/EDS;
- controls and support systems.

Thermal loads

- outdoor-air conditioning;
- reheat;
- equipment heat;
- occupancy;
- humidity control where applicable.

Evidence

- utility bills;
- submetering;
- BMS trends;
- fan speed;
- airflow data;
- temperature/humidity trends.

> **Baseline question:** which systems are responsible for the persistent load, and how does that load change with occupancy, weather, and operating mode?

BASELINE QUALITY

NORMALIZE THE DATA BEFORE LABELING THE FACILITY INEFFICIENT

Consumption should be compared against operating conditions, not only against a monthly utility total or a benchmark for conventional buildings.

Define the measurement boundary

- whole building or laboratory suite;
- electricity, gas, steam, chilled/hot water;
- shared central-plant loads;
- tenant or process loads outside the containment system.

Normalize for operation

- occupied versus unoccupied hours;
- number of active rooms;
- equipment/process schedule;
- changes in throughput;
- maintenance or shutdown periods.

Normalize for weather

- outdoor temperature and humidity;
- seasonal cooling/heating demand;
- periods of extreme weather;
- changes in outdoor-air conditions during the comparison period.

Use benchmarks cautiously

Energy-use intensity can support comparisons, but a high-containment laboratory should not be judged against offices, cleanrooms, or general laboratories without considering containment scope, airflow strategy, process loads, and operating schedule.

> **Baseline objective:** create a reference that distinguishes load originating in design from deterioration, operational change, or avoidable system behavior.

02 Separate justified containment load from avoidable load

Not all high energy use is inefficiency.

Load driver	Diagnostic question
Required exhaust	Is the exhaust quantity linked to pressure control, hazardous processes, primary containment, or applicable criteria?
Outdoor air	Is the volume required by the containment/ventilation strategy, or is it higher because of inherited assumptions or poor balancing?
Filtration	Is static pressure consistent with the required filtration architecture and the current condition of the filters?
Redundancy	Does the installed redundancy preserve a defined containment function, and is its operating sequence efficient?
Pressure margin	Is the margin necessary for stable directional airflow, or is airflow compensating for excessive leakage?
Conditioned volume	Do all spaces receiving high-containment conditioning actually need to remain within the controlled zone?
Operating hours	Must all systems remain continuously at full load, or can they vary through approved modes?

ENERGY OPTIMIZATION BEGINS BY DISTINGUISHING REQUIRED LOAD FROM AVOIDABLE LOAD.

03

Review whether airflow is greater than the system actually requires

Airflow affects both fan energy and the heating/cooling load associated with every volume of air moved.

High ACH values may be technically justified in some spaces. They should not automatically be assumed to be a containment requirement.

Review the basis for airflow

- pressure relationship;
- heat removal;
- dilution need;
- equipment exhaust;
- recovery requirement;
- occupancy;
- applicable standards or institutional criteria.

Look for inherited numbers

Ask whether current ACH or CFM values were derived from the work and the system or carried over from a precedent, a generic interpretation of a standard, or a previous operating convention.

If airflow is reduced, pressure stability, directional airflow, thermal performance, and response to disturbances must still be demonstrated.

> A significant reduction can save energy. It can also reveal that the envelope or control system depended on excess air to remain stable.

04

Review the envelope before reducing airflow

Leakage can turn a boundary problem into a permanent fan-energy penalty.

A room with increased uncontrolled leakage may be kept negative by increasing exhaust. Negative pressure still depends on makeup air entering through designed transfer paths and unavoidable leakage, but growth in uncontrolled leakage can create a permanent airflow and energy penalty.

Review leakage paths

- doors and seals;
- wall/ceiling joints;
- penetrations;
- utility interfaces;
- pass-throughs;
- equipment interfaces;
- recent modifications.

Compare the current airflow required to maintain pressure with commissioning or baseline values when available.

Structural efficiency

If the same pressure relationship now requires more exhaust than before, investigate envelope condition and system resistance before normalizing the new airflow as the baseline.

Correcting leakage can reduce compensating airflow and improve control margin.

A FAN SHOULD NOT PERMANENTLY COMPENSATE FOR AN UNRESOLVED ENVELOPE.

05

Examine static pressure and filtration load

Moving air through high-resistance systems has energy consequences throughout the life cycle.

Filters

Review filter type, loading, pressure differential, and replacement condition. Confirm the documented function of each installed stage before considering any change to the filtration architecture.

HEPA housings

Evaluate pressure drop together with required integrity, isolation, and testability. A lower-resistance alternative is relevant only if it preserves the containment function.

Ductwork and dampers

Look for excessive velocity, closed dampers, restrictive transitions, unnecessary fittings, or poor balancing that force the fan to operate at higher pressure.

Fan operating point

Compare current speed and static pressure with design and commissioning conditions. A system operating near its maximum may indicate increased resistance or altered airflow demand.

Diagnostic principle: reduce unnecessary resistance where possible; do not remove required containment barriers simply because they consume energy.

06 Review zoning and conditioned volume

Every additional cubic meter within a high-demand zone creates recurring conditioning and airflow obligations.

Energy load can be created upstream by where the containment boundary was drawn.

Questions

- Are support spaces unnecessarily located within the highest-demand zone?
- Do corridors or service areas receive the same conditioning criteria as active spaces?
- Could functions be separated without compromising workflow or containment?
- Has the use of any room changed since design?

Retrofit reality

Changing zoning in an operating facility can be complex and is not always justified.

The diagnostic value remains important: it helps determine whether high demand is a consequence of the original architecture rather than a problem that can be solved by replacing equipment.

THE CONTAINMENT SCOPE CREATES CONDITIONED VOLUME. CONDITIONED VOLUME CREATES LIFE-CYCLE LOAD.

CONTROL BEHAVIOR

IS THE SYSTEM USING ENERGY TO FIGHT ITSELF?

Hunting between supply and exhaust

Competing control loops may repeatedly increase and decrease airflow while attempting to recover the same pressure relationship.

Simultaneous cooling and reheat

High outdoor-air volumes, dehumidification, and unnecessarily tight temperature or humidity controls can create significant cooling and reheat demand, especially when setpoints and sequences are poorly coordinated.

Excessively conservative pressure margins

Differentials greater than required by the accepted strategy can increase airflow demand and fan energy.

Poor setback logic

Systems may remain in full occupied mode when there is no activity, even where a validated reduced mode could be acceptable.

Redundancy operando sin necesidad

Backup architecture may consume additional energy if equipment operates in parallel without a functional requirement.

Control changes without reverification

Energy-saving logic can introduce pressure instability if implemented without functional testing.

> Control optimization can produce significant savings, but only after defining the required containment state and its transitional behavior.

07

Review schedules and reduced modes

Continuous full-load operation should be justified by the containment and operating model.

Some high-containment functions may require continuous operation. Others may permit controlled reduced states when the laboratory is unoccupied or inactive.

Before considering setback

- define which pressure relationships must persist;
- identify exhaust systems that cannot be reduced;
- confirm temperature/humidity limits;
- define alarm behavior;
- consider equipment and process requirements;
- define recovery to occupied mode.

Reduced mode should be a designed state

A setback is not simply lowering fan speed at night.

It should be a defined operating condition, with acceptance criteria, control logic, and functional verification.

08 Evaluate energy recovery within containment limits

Recovery potential depends on stream isolation, pressure control, and maintenance risk.

Energy recovery can reduce heating and cooling demand, but the strategy must preserve the required separation between potentially contaminated and clean airstreams.

Review

- exhaust contamination potential;
- filtration location;
- cross-leakage characteristics;
- pressure relationships;
- additional system resistance;
- maintenance access;
- failure behavior.

Indirect recovery

Run-around coils and other physically separated systems may be viable when supported by the containment strategy and technical design.

The energy benefit should be evaluated together with pump/fan penalties, additional maintenance, and life-cycle complexity.

> **RECOVERY IS USEFUL ONLY WHEN THE SAVINGS DO NOT CREATE A NEW CONTAINMENT DEPENDENCY THAT CANNOT BE CONTROLLED.**

VERIFY BOTH THE SAVINGS AND THE CONTAINMENT STATE

An energy measure is not complete when fan speed, airflow, or consumption decreases. The new operating state must demonstrate the containment functions affected by the change.

Containment verification may include

- pressure hierarchy and directional airflow;
- door disturbance and recovery;
- alarm and interlock behavior;
- fan/control authority at the new operating point;
- relevant failure and transition states;
- temperature/humidity or process limits;
- affected filtration or treatment functions.

Energy verification should confirm

- actual schedule after the change;
- measured airflow/fan speed or equipment state;
- utility consumption or submetering over a representative period;
- normalization for weather/operation when needed;
- absence of offsetting penalties such as increased reheat, pumping energy, or unstable control.

> **Optimization hierarchy**
>
> Correct failures and drift → eliminate unnecessary load → optimize controls and schedules → consider appropriate recovery → evaluate renewable generation against the minimized and justified baseline.

> **A LOWER ENERGY NUMBER IS USEFUL ONLY IF THE ACCEPTED CONTAINMENT CONDITION REMAINS DEMONSTRABLE.**

COMMON DIAGNOSTIC ERRORS

WHAT NOT TO DO FIRST

Do not reduce ACH because the number "looks high."

First establish what function the airflow serves: pressure, heat removal, dilution, process exhaust, or another function.

Do not remove filtration simply to reduce static pressure.

Confirm whether the filtration stage is required by the risk and exhaust strategy.

Do not install energy recovery by analogy with an office building.

Evaluate stream isolation, leakage, maintenance exposure, and effects on pressure control.

Do not assume high consumption means inefficient equipment.

The dominant load may have been created upstream by airflow, zoning, or envelope decisions.

Do not widen pressure limits to make lower airflow work.

Acceptance criteria should not be changed simply to fit an energy target.

Do not treat renewable generation as a correction for inefficiency.

Generation can offset consumption; it does not eliminate unnecessary mechanical load.

> **REDUCE THE LOAD THAT IS UNNECESSARY. PRESERVE THE LOAD THAT THE CONTAINMENT STRATEGY ACTUALLY REQUIRES.**

DIAGNOSTIC SEQUENCE

WHY DOES THE FACILITY USE SO MUCH ENERGY?

01

Is there a credible energy baseline and operating schedule?

No → establish consumption, schedules, and major system loads.

Yes → continue.

02

Can the main load be linked to a defined containment or operating requirement?

No or uncertain → trace the design basis before optimizing.

Yes → continue.

03

Is airflow greater than necessary to meet those requirements?

Yes → determine whether the cause is inherited ACH, leakage, control margin, or heat load.

No → continue.

04

Is static pressure or resistance unnecessarily high?

Yes → review filters, ductwork, dampers, housings, and the fan operating point.

No → continue.

05

Do zoning, schedules, or controls create avoidable demand?

Yes → develop a controlled optimization strategy and test the new state.

No → continue.

06

Has the remaining demand been minimized within justified containment constraints?

No → continue system-level optimization.

Yes → evaluate recovery and renewables against the remaining baseline.

WHAT TO COLLECT BEFORE RECOMMENDING CHANGES

Energy data

- utility history;
- submetering;
- peak demand;
- seasonal patterns;
- operating schedules.

Air systems

- supply/exhaust CFM;
- ACH;
- fan speed;
- static pressure;
- filter DP;
- damper position.

Containment basis

- risk assumptions;
- pressure strategy;
- filtration requirements;
- redundancia;
- required operating modes.

Physical condition

- envelope leakage;
- zoning;
- equipment loads;
- control sequences;
- maintenance history.

Review objective: show which loads are required, which are avoidable, and what verification will be necessary if the system is modified.

BEFORE REDUCING ENERGY DEMAND

Use this list as a review filter. A checked item does not constitute acceptance; each item should be interpreted against the risk basis, site configuration, and applicable criteria.

□ Define a normalized energy baseline: measurement boundary, period, operating hours, occupancy, active loads, and relevant conditions.

□ Separate energy demand technically justified by containment from potentially avoidable load.

□ Compare airflow quantities and pressure differentials with the actual functional need, not only with historical values.

□ Review envelope leakage and air transfers that may be forcing the system to move more air than necessary.

□ Evaluate static pressure, damper position, fan speed, filter losses, and signs of operation near the control limit.

□ Review zoning, schedules, reduced modes, and spaces that remain active without demonstrated operational need.

□ Identify thermal or process loads being compensated for by increased ventilation when that is not the optimal solution.

□ Define the proposed measure and the containment function that could be affected before modifying airflow quantities, pressures, or redundancy.

□ After any optimization, reverify pressure, directionality, alarms, control, recovery, and energy performance.

Technical-use note: This review list is a diagnostic support tool. It does not establish site-specific acceptance criteria, does not replace risk assessment or professional judgment, does not constitute certification, and does not authorize operation or return to service.

If the review identifies a condition requiring site-specific evaluation, BioLab Solutions can support technical assessment, verification, and definition of the required evidence.

RELATED BIOLAB RESOURCES

EXPLORE AIRFLOW, ENVELOPES, AND LIFE-CYCLE ENERGY IN GREATER DEPTH

NT-010–012
Directional airflow, pressure cascades, and ACH

NT-014–017
HVAC control, exhaust authority, redundancy, and control hierarchy

NT-021–024
Envelope continuity and airtightness

NT-039
Life-cycle drift in containment systems

NT-045
Sustainability as a containment dependency

NT-046
Net Zero as a system outcome

NT-047
Limits of energy recovery in high-containment laboratories

NT-048
Life-cycle energy in containment facilities

BIOLAB DIAGNOSTIC GUIDES

Brief technical resources organized around real containment problems rather than isolated disciplines.

Series concept: symptom → system → evidence → restoration.

CLOSING DIAGNOSTIC PRINCIPLE

THE MOST EFFECTIVE ENERGY SAVING MAY BE AN UPSTREAM TECHNICAL CORRECTION.

High-containment facilities typically use more energy than conventional spaces because their operating requirements are different.

The diagnostic task is to determine how much of that demand is inherent to the accepted strategy and how much was added by leakage, excess airflow, resistance, zoning, control behavior, or operating assumptions.

When those structural drivers are understood, optimization becomes more precise. The objective is a facility that maintains justified containment performance without more mechanical load than that performance requires.

BIOLAB SOLUTIONS

Independent technical support for planning, design, commissioning, assessment, and life-cycle management of high-containment laboratories.

For a site-specific evaluation, BioLab Solutions can support technical review, verification, and definition of evidence criteria.

LOAD → CAUSE → CONTAINMENT BASIS → OPTIMIZATION