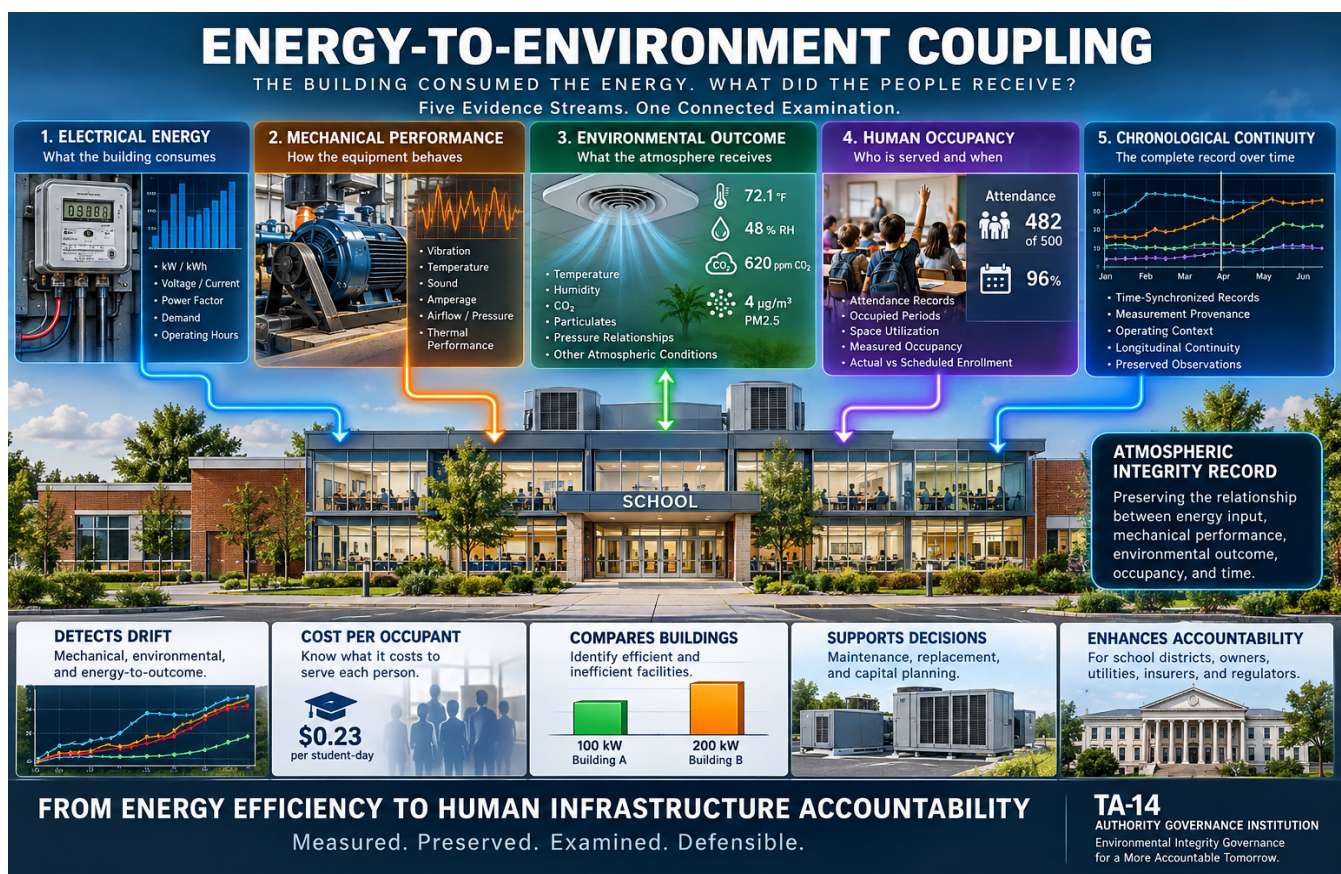


ENERGY-TO-ENVIRONMENT COUPLING

Measuring what the building consumes, what the equipment does, and what the atmosphere delivers.

TA-14 AUTHORITY GOVERNANCE INSTITUTION

Environmental Integrity Governance | Atmospheric Integrity Records | Mechanical Performance | Energy Accountability



EXPANDED TECHNICAL EDITION — OCTOBER 2026

Based on the February 2026 Energy-to-Environment Coupling architecture. Independent, vendor-neutral technical reference. All numerical examples are illustrative.

The Building Consumed the Energy. What Did the People Receive?

Buildings are routinely evaluated by electricity consumption, utility expenses, equipment efficiency, and operating costs.

But these measurements leave a fundamental question unanswered:

What environmental service did the building actually deliver in exchange for the energy it consumed?

A building may use less electricity while delivering inadequate ventilation.

A cooling system may consume the same electrical power while producing less cooling.

A fan may continue operating while vibration increases and delivered airflow decreases.

A school may spend thousands of dollars conditioning occupied spaces without possessing sufficient evidence to establish the environmental conditions its students experienced.

These are not simply energy-efficiency questions.

They are questions of mechanical performance, environmental integrity, human exposure, and institutional accountability.

Energy-to-Environment Coupling establishes an evidentiary relationship between what a building consumes, what its equipment does, what its environment receives, and what occupants experience.

The relationship is preserved through Atmospheric Integrity Records (AIR) and examined under the TA-14 governance architecture.

01 — FIVE CONNECTED EVIDENCE STREAMS

Energy-to-Environment Coupling requires five distinguishable streams of evidence.

A. Electrical Energy

Measurements may include real power (kW), accumulated energy (kWh), voltage, current, power factor, electrical demand, operating hours, and equipment operating modes.

These measurements establish the electrical input.

B. Mechanical Performance

Equipment-mounted and system-level instrumentation may measure vibration, temperature, acoustic signatures, amperage, refrigerant conditions, airflow, static pressure, fan speed, compressor operation, and heat-transfer performance.

These measurements describe how equipment behaves.

C. Environmental Outcome

Environmental sensors may measure temperature, humidity, CO₂, PM2.5, PM10, selected VOC indicators, pressure relationships, and other relevant atmospheric conditions.

These observations describe conditions within the measured spaces.

D. Human Occupancy

Occupancy evidence may include attendance counts, occupied periods, space utilization, room assignments, and appropriately collected occupancy measurements.

These records help establish how many people were served, when spaces were occupied, and which environmental observations are relevant.

Attendance alone does not establish a person's precise location or actual exposure.

E. Chronological Continuity

Every stream must be associated with a defensible chronology.

Time synchronization, measurement provenance, equipment identity, sensor placement, operating context, data quality, and record continuity determine whether observations can be meaningfully compared.

Five evidence streams. One connected examination. No substitution of inference for observation.

02 — THE ATMOSPHERIC INTEGRITY RECORD

An Atmospheric Integrity Record is not merely a collection of sensor readings.

It is an evidentiary structure designed to preserve observations, source relationships, chronology, and continuity.

An AIR-associated evidence package may connect:

- Mechanical equipment measurements
- Electrical consumption measurements
- Indoor environmental measurements
- Outdoor environmental conditions
- Occupancy information
- Equipment operating states
- Maintenance and intervention events
- Relevant calibration and measurement-quality information

The objective is not to force every measurement into one sensor or one database.

The objective is to preserve an examinable relationship between independent evidence sources.

Each observation should retain its original measurement, source identity, unit, timestamp, relevant context, and quality information.

Derived calculations must remain distinguishable from original observations.

Corrections and normalization must not silently overwrite raw records.

The record preserves what was observed. Interpretation explains what the observations may mean. Governance determines whether the evidence is sufficient for a proposed consequence.

03 — MECHANICAL DRIFT

Mechanical systems change as they operate.

Filters accumulate particles.

Coils foul.

Bearings wear.

Fan performance changes.

Dampers lose calibration.

Refrigerant-side conditions change.

Control sequences may be modified.

These developments do not always produce immediate equipment failure.

They may instead produce gradual changes in vibration, heat, sound, electrical demand, pressure, airflow, or thermal performance.

Illustrative example

A supply fan initially delivers its required airflow with stable vibration and electrical demand.

Months later, records show increased vibration, higher motor temperature, and reduced airflow at comparable operating conditions.

The system continues operating.

No catastrophic fault has occurred.

Nevertheless, the preserved measurements provide evidence of changing mechanical behavior.

The cause remains subject to examination. Increased vibration alone does not establish bearing failure, and reduced airflow may have several explanations.

AIR makes the developing pattern available for technical examination without converting the observation into an unsupported diagnosis.

04 — ENVIRONMENTAL DRIFT

Mechanical equipment exists to deliver a service.

For HVAC systems, that service may include thermal conditioning, ventilation, humidity management, air movement, filtration, and pressure control.

Environmental drift occurs when measured conditions change relative to an established performance basis.

Examples include increasing humidity excursions, unstable temperature control, declining ventilation-related performance, increasing particulate concentrations, or deteriorating room-pressure relationships.

Environmental drift may occur even when mechanical equipment appears to be operating normally.

A building automation system can report that a fan is running without establishing that sufficient outdoor air reaches occupied spaces.

A thermostat can report an acceptable temperature without establishing acceptable particulate concentrations.

A filter can be installed without establishing the particulate reduction actually achieved.

Equipment operation is not proof of environmental delivery.

The environmental evidence must be examined independently.

05 — ENERGY-TO-OUTCOME DRIFT

Energy-to-outcome drift examines whether the energy required to deliver a defined service changes over time.

Consider a hypothetical cooling system.

Measurement	Baseline	Later examination
Electrical power	8 kW	8 kW
Delivered cooling	96,000 Btuh	80,000 Btuh
Measured efficiency	12 Btu/Wh	10 Btu/Wh

The system consumes the same electrical power but delivers approximately 16.7% less cooling at the measured operating points.

This indicates a reduction in measured thermal efficiency.

It does not independently establish why that reduction occurred.

Weather, loads, equipment operating modes, measurement uncertainty, and other conditions must be considered.

Environmental outcomes must also be examined separately from cooling capacity.

A system can deliver cooling while failing to provide intended ventilation or filtration.

The broader coupling question is therefore:

How much electrical energy is required to deliver a defined, verified combination of mechanical and environmental services under comparable conditions?

06 — THREE FORMS OF DRIFT

The architecture distinguishes three related but independent phenomena.

Mechanical drift: Changes in equipment condition or physical operating behavior.

Environmental drift: Changes in the atmospheric conditions delivered to occupied or controlled spaces.

Energy-to-outcome drift: Changes in the energy required to produce a defined service.

These changes may occur together or separately.

A system may maintain acceptable indoor conditions while consuming progressively more electricity.

A system may consume less electricity because ventilation has been reduced.

A system may develop a mechanical abnormality without immediately affecting the occupied environment.

A building may experience deteriorating indoor air quality because of external pollution or occupant activities rather than equipment degradation.

The purpose of coupling is not to assume that every environmental change is caused by the mechanical system.

It is to preserve enough evidence to examine the relationship.

07 — CONTINUITY, COMPARABILITY, AND ADMISSIBILITY

Buildings operate under changing conditions.

Outdoor temperatures change.

Humidity changes.

Occupancy changes.

Equipment loads change.

Control modes change.

Consequently, a valid longitudinal comparison requires more than two readings taken on different dates.

Relevant operating conditions must be established.

Where normalization or adjustment is justified, the adjusted results must remain separate from the raw observations.

For example, weather-normalized electricity consumption may be useful for comparing two operating periods.

But the normalization method, assumptions, version, and uncertainty must be disclosed.

The original meter observations remain preserved.

A derived classification cannot rewrite the underlying evidence.

Drift classification

An interpretation layer may classify examined performance as:

- Stable
- Emerging drift
- Economically degrading
- Economically compromised

These classifications require defined criteria, appropriate tolerances, versioned methods, and admissible supporting evidence.

A classification is not itself authorization to repair, replace, or alter equipment.

08 — FROM COMPUTATION TO AUTHORIZED ACTION

The architecture separates measurement, preservation, interpretation, and execution.

Instrument Layer: Sensors and meters observe physical conditions.

Recorder Layer: AIR preserves measurements, provenance, chronology, and continuity.

Computation Layer: Admissible Computation Architecture (ACA) examines whether calculations and derived relationships are valid within their stated boundaries.

Interpretation Layer: Performance models may identify drift, anomalies, and potential causes.

Governance Layer: Applicable authority, admissible evidence, and established standing are examined.

Execution Boundary: Admissible Execution Architecture (AEA) and Execution Authority Boundary Architecture (EABA) govern whether a proposed action may proceed within its authorized scope.

The available dispositions are ALLOW, HOLD, DENY, and ESCALATE.

A model identifying increased vibration does not automatically authorize equipment replacement.

A CO₂ reading does not automatically authorize unrestricted changes to ventilation.

A rising energy cost does not automatically justify reducing environmental service.

Capability is not authority. A recommendation is not an authorized consequence.

09 — THE COST OF ENVIRONMENTAL SERVICE PER OCCUPANT

Schools introduce an especially important application.

School districts maintain attendance records and incur substantial energy expenses to operate occupied buildings.

With suitable evidence, these records can support calculations of energy cost per occupied student-day.

Illustrative school comparison

Measurement	School A	School B
Electricity consumed	30,000 kWh	60,000 kWh
Electricity cost	\$4,500	\$9,000
Student attendance-days	20,000	20,000
Electricity cost per attendance-day	\$0.225	\$0.450

School B incurs twice the electricity cost per attendance-day.

That is an economic observation—not proof that School B is less efficient or provides worse environmental protection.

A valid environmental-service comparison must establish which energy costs are attributable to relevant systems, which spaces were occupied, what conditions were delivered, and whether the buildings faced comparable demands.

Beyond attendance

A more detailed examination can relate occupied person-hours to time-aligned environmental measurements.

For example, a district could calculate the percentage of measured occupied classroom-hours during which defined temperature, humidity, ventilation-related, or particulate criteria were satisfied.

Those results could then be examined alongside allocated energy consumption.

Such calculations provide a stronger foundation for understanding the resources required to deliver documented environmental conditions.

They do not prove that individual students were protected from illness or that every student's personal exposure was known.

Privacy-preserving aggregate attendance and occupancy records should be preferred wherever individual identity is unnecessary.

The institutional question becomes: What did the school spend, what environmental service did it deliver, and how many occupied person-hours were served under verified conditions?

10 — BUILDING, PORTFOLIO, AND GRID-LEVEL COMPARABILITY

Energy-to-Environment Coupling can also support comparisons across buildings.

Two schools may have similar floor areas, construction types, occupancy patterns, and equipment systems.

Yet one may consume substantially more electricity.

The difference may arise from equipment degradation, control strategy, operating schedules, ventilation demand, weather exposure, maintenance conditions, or other factors.

Electricity consumption alone cannot identify the explanation.

A coupled evidence examination can compare:

- Electricity per unit of delivered thermal service
- Fan energy relative to airflow and pressure duty
- Energy per occupied person-hour
- Environmental compliance during occupied periods
- Mechanical condition and degradation trends
- Maintenance and intervention outcomes

Comparisons require consistent measurement boundaries and transparent adjustments for meaningful differences.

Utility and grid applications

With appropriate participation, metering, interoperability, and data-sharing arrangements, utilities and public authorities could examine aggregate building performance.

They could identify buildings consuming unusually high amounts of energy relative to verified environmental services.

They could distinguish opportunities for reducing waste from reductions that might compromise occupant conditions.

They could also evaluate whether efficiency investments produced sustained improvements.

This is not a claim that AIR automatically reveals every building's performance from utility meter data.

Grid-level examination requires sufficient building-side environmental and mechanical evidence, lawful access, and appropriate comparison methods.

11 — INSTITUTIONAL AND REGULATORY ACCOUNTABILITY

Preserved energy, mechanical, environmental, and occupancy evidence could support several institutional functions.

School Districts

Examine environmental service delivery, compare facilities, investigate persistent deficiencies, and prioritize maintenance or capital investment.

Healthcare Facilities

Evaluate mechanical reliability and relevant environmental conditions in spaces with defined operational requirements.

Property Owners

Identify degradation, examine performance persistence, and support replacement decisions with longitudinal evidence.

Utilities

Evaluate energy-service relationships and opportunities to improve performance without sacrificing defined environmental outcomes.

Insurers

Examine documented equipment conditions, maintenance history, and environmental performance within applicable underwriting or risk-assessment frameworks.

Regulators

Review preserved evidence against applicable standards, requirements, and legal authorities.

AIR does not independently establish regulatory compliance.

It provides an evidentiary foundation that an authorized institution may examine.

A regulatory determination still requires applicable standards, jurisdiction, validated methods, appropriate standing, and due process.

The record can support accountability. It does not appoint itself the regulator.

12 — HUMAN INFRASTRUCTURE ACCOUNTABILITY

A building is more than a collection of energy-consuming machines.

It is infrastructure that supports human activity.

Its systems consume resources to deliver physical conditions required for occupancy and operation.

Energy-to-Environment Coupling makes that relationship examinable.

The building consumed the energy.

The equipment performed the work.

The atmosphere received the result.

People experienced the conditions.

The record must preserve the relationship.

The objective is not simply to minimize energy consumption.

It is to establish the resources required to deliver defined, verified environmental services—and identify where mechanical degradation, environmental deterioration, or unnecessary energy expenditure changes that relationship.

A building that consumes less energy while failing to maintain required environmental conditions has not necessarily improved.

A building that consumes more energy may be meeting a legitimate demand—or may be experiencing degradation.

The distinction requires evidence.

This is the transition from energy efficiency as a standalone metric to environmental service accountability as a measurable institutional responsibility.

THE GOVERNING QUESTION

Does this proposed consequence have sufficient Admissible Evidence, Applicable Authority, and Established Standing to become reality NOW?

Energy-to-Environment Coupling provides a way to examine the relationship between consumption and delivery.

Atmospheric Integrity Records preserve the underlying observations.

ACA examines computation.

AEA and EABA establish boundaries for consequential action.

No admissible evidence. No admissible execution.

TA-14 AUTHORITY GOVERNANCE INSTITUTION

Independent technical architecture for environmental evidence, mechanical performance, and accountable execution.

This publication describes an evidentiary and governance architecture. Illustrative numerical examples are hypothetical. Implementation requires suitable instrumentation, validated measurement methods, defined performance criteria, and applicable institutional authority.

Original architectural foundation: February 2026. Expanded technical edition: October 2026.

TECHNICAL IMPLEMENTATION NOTES

Measurement boundaries

Declare whether electrical readings cover a single component, HVAC subsystem, or whole building. Record energy allocation rules; do not attribute all utility consumption to atmospheric conditioning.

Time alignment

Document sampling interval, clock synchronization, missing intervals, and aggregation method. Align energy, equipment, occupancy, and environmental observations before comparison.

Thermal efficiency calculation

For a defined operating point: $EER \text{ (Btu/Wh)} = \text{delivered cooling (Btu/h)} \div \text{real electrical input (W)}$. A rate in Btu/h is not an energy total in Btu.

Occupied-service economics

Electricity cost per attendance-day = $\text{allocated electricity cost} \div \text{recorded attendance-days}$. For measured environmental-service cost, further establish occupied space-time and applicable condition criteria.

Governance disposition

Flag insufficient provenance, unsuitable comparisons, or missing authorization as HOLD or ESCALATE as appropriate. A drift score does not authorize intervention.

Publication note. This architecture does not itself certify regulatory compliance, individual exposure, disease prevention, or causation. Original measurements and adjusted comparisons must remain distinguishable.