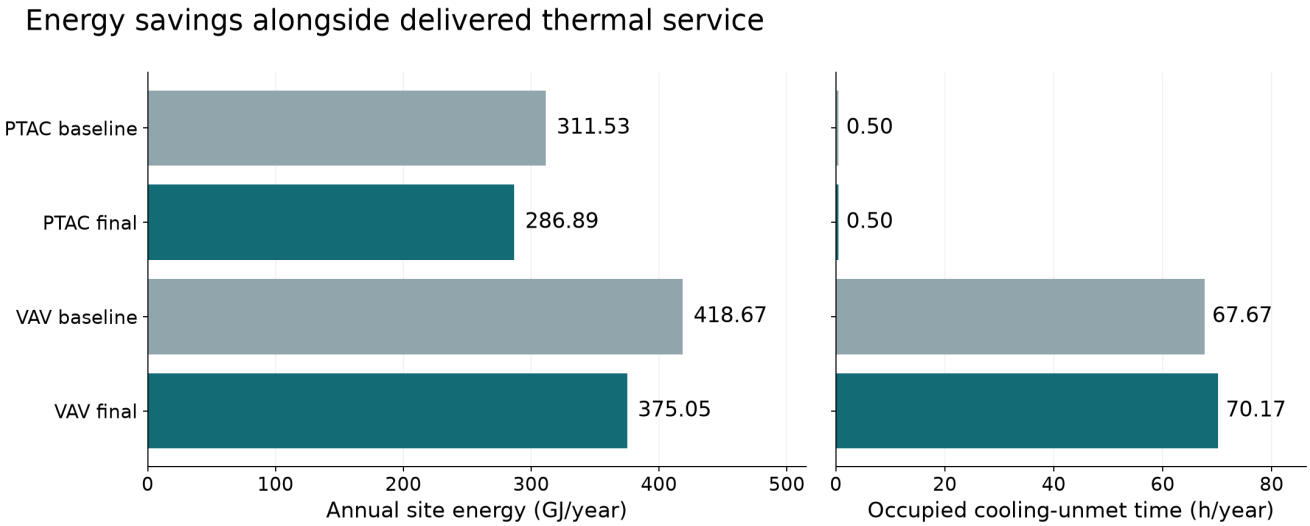
# EnergyPlus technical audit

**Reproduction, scientific interpretation and website corrections | 14 October 2026 | Version 01**

The main archived energy results are numerically reproducible. Thirteen original cases rerun with EnergyPlus 9.5 match their archived site-energy totals, occupied heating/cooling unmet hours and full tabulated end-use values at displayed precision. This validates reproduction of those outputs, not measured-building accuracy or every modeling assumption.

| Independent branch | Baseline → final (GJ/year) | Cooling unmet (h/year) |
|---|---|---|
| PTAC | 311.53 → 286.89 (−7.9%) | 0.50 → 0.50 |
| VAV | 418.67 → 375.05 (−10.4%) | 67.67 → 70.17 |

The VAV energy decrease is 43.62 GJ/year; occupied cooling-unmet time increases by 2.50 hours. Occupied heating-unmet time is zero in all four cases. No comfort acceptance criterion was found in the inspected study, assignment or model documentation. Neither a material comfort failure nor comfort compliance is established by these numbers.




Archived whole-facility outputs. PTAC: -7.9% energy, cooling unmet 0.50 to 0.50 h. VAV: -10.4% energy, cooling unmet 67.67 to 70.17 h (+2.50 h). Occupied heating unmet is 0.00 h for all four. Reporting tolerance is 0.556°C. Facility hours count any occupied zone, not summed zone-hours. No acceptance criterion was stated.

Required page corrections concern comparison boundaries, the PTAC 55°C axis error, the water-cooled VAV chiller, the combined infiltration/glazing transition, short-period heat-emissions units, rounded totals and the meaning of the conceptual hero. The original report remains a historical source.

# 1. Evidence and reproduction

The source tree contains 2,624 files. This audit parsed 170 original IDFs, 165 HTML/HTM result reports and 140 error logs, and inspected the report, assignment, comparison workbooks and the website source. A hash-preserving archive stores 738 selected source files, including 100 expanded IDFs. Original files were not modified. The final report (June 2022) and course presentation are copied separately with SHA-256 provenance.

Engine: EnergyPlus 9.5.0-de239b2e5f, matching the archived outputs. The official macOS ARM archive was obtained from the project release and its SHA-256 was checked against the published checksum: 6a52269130e254aea736cee6f2a7195a2559d4f4d50728b0a9a11b306c5446f1. The installed 24.2 version was not used to claim faithful reproduction.

Weather: the original EPW was not located. The recovered official TMY3 file is station 723650, Albuquerque Intl Arpt Isis, latitude 35.04°, longitude −106.62°, UTC−7, elevation 1,619 m. Its SHA-256 is 3ae569b62423979e1f5091d075848b6c332725764d183fd776de7aadda1970b1. Archived report headers call the station Albuquerque Intl Sunport. The reproduced outputs agree at table precision, but byte identity with the missing original EPW cannot be asserted.

The native ExpandObjects executable exited with signal 9 on this Mac. Attempts with unexpanded HVAC templates consequently failed and are retained as failed attempts. Successful HVAC reruns use byte-for-byte copies of the preserved .expidf files as standalone IDFs. VAV 2.1.COP is the COP-4 baseline; its template IDF is semantically identical to the saved 1.Baseline IDF. No fabricated or upgraded model was substituted.

The 13 verified simulations completed with zero severe errors, but retain warnings. Every run directory contains its copied model, command/provenance JSON, console, EnergyPlus report, SQL output, end marker and error log. data/reproduction.json compares original and new values; data/rerun_warnings.json records diagnostics. Early timeout/template-failure directories are not counted as verified results.

Sources: EnergyPlus 9.5 release; official Albuquerque TMY3 archive.

# 2. Numerical reproduction results

Each value below is identical in the archived and fresh report at the precision shown. All 13 full End Uses tables also match. These are independent checks of archived cases, not a newly optimized sequence.

| Case | Site energy GJ/year | Occupied heat unmet h | Occupied cool unmet h |
|---|---|---|---|
| Envelope reference | 363.95 | 9.17 | 1.33 |
| Selected 15 mm glazing | 353.72 | 3.00 | 0.00 |
| Infiltration + gap | 340.02 | 0.00 | 0.00 |
| Insulation | 354.51 | 6.33 | 0.00 |
| Lighting | 290.16 | 0.00 | 0.00 |
| Shading | 288.13 | 0.00 | 0.00 |
| File 3.Windows (other case) | 356.06 | 3.67 | 0.00 |
| PTAC baseline | 311.53 | 0.00 | 0.50 |
| PTAC COP 6 / 50°C | 296.72 | 0.00 | 0.50 |
| PTAC final | 286.89 | 0.00 | 0.50 |
| PTAC heating design 55°C | 295.95 | 0.00 | 0.50 |
| VAV baseline | 418.67 | 0.00 | 67.67 |
| VAV final | 375.05 | 0.00 | 70.17 |

Annual cases simulate 8,760 hours with a 10-minute zone timestep. Reported floor area is 511.16 m². Site energy is purchased/delivered fuel energy in GJ, not thermal load, source energy, carbon, cost or an efficiency ratio. Annual intensity converts as GJ × 1,000 / m². Rounding the area or fuel rows before conversion can shift the last displayed decimal.

The six retained envelope/load totals are 363.95, 354.51, 353.72, 340.02, 290.16 and 288.13 GJ/year. Their decrease is 75.82 GJ/year (20.8%). The original Figure 9 sums rounded component values and shows 353.73 and 288.14 at two stages, giving 75.81 GJ. This is a precision convention, not a material performance difference. New page text, charts, CSV and interactive totals use the raw Total Site Energy row consistently.

The filenames alone are insufficient provenance. In particular, 3.Windows.idf reproduces 356.06 GJ/year, not the selected-glazing result; a differently named 3.Windows.html shows another archived total. The dedicated case 14.Double_lowE_Argon15_lowE and its matching report are the verified source of the selected-glazing stage.

# 3. Model and comparison boundaries

The reference is the DOE post-1980 Small Office: one conditioned floor, a core and four perimeter zones, and an unconditioned attic. Gross WWR is 21.20% overall, 24.44% on the original south façade and 19.81% elsewhere. The SimpleGlazingSystem inputs are U=4.08816 W/(m²·K), SHGC=0.36 and unspecified visible transmittance. EnergyPlus derived glass outputs are U=4.092, SHGC=0.364 and VT=0.225. The draft 0.362 SHGC is not supported by the matching model output.

| Comparison set | Baseline/boundary | Interpretation |
|---|---|---|
| Envelope/load sequence | 363.95 GJ/year; scheduled heating 21/15.6°C, cooling 24/26.7°C | Original reference HVAC; saved load changes |
| PTAC sensitivity | 307.99 GJ/year; cooling schedule with setback | HVAC-row fuel intensity 145.09 MJ/m² |
| VAV sensitivity | 421.98 GJ/year; cooling schedule with setback | HVAC-row fuel intensity 368.09 MJ/m² |
| PTAC sizing/optimization | 311.53 GJ/year; constant 18/24°C heat/cool | Reference envelope and lighting loads |
| VAV sizing/optimization | 418.67 GJ/year; constant 18/24°C heat/cool | Reference envelope and lighting loads |
| Shading/orientation sweep | Distinct low-E/10 mm argon/clear glazing | Not the final cumulative glazing case |

PTAC uses single-speed DX cooling and hot-water coils supplied by a gas boiler. VAV uses a water-cooled electric chiller, a cooling-tower/condenser-water loop and hot-water heating from a gas boiler. The website draft’s air-cooled chiller description is incorrect. Original interface screenshots are valid starting-input evidence, not captures of final settings.

Sensitivity intensities are verified by summing the HVAC row’s energy-fuel columns in Utility Use Per Conditioned Floor Area. Do not include the water-volume column. PTAC: 145.09 baseline, 140.41 at COP 3.3, 137.26 at boiler efficiency 0.88. VAV: 368.09 baseline, 354.40 at COP 4.4, 360.53 at fan efficiency 0.77, 357.86 at boiler efficiency 0.88. These are not whole-site GJ and do not share the later optimization baselines.

The 20.8%, 7.9% and 10.4% decreases cannot be added or multiplied into a combined building saving. They belong to different model sets and thermostat/HVAC assumptions.

# 4. Envelope, glazing, shading and orientation

**Insulation.** The workbook sweep spans 2–50 cm at conductivity 0.049 W/(m·K). Its 8 cm case is 369.89 GJ/year, distinct from the 363.95 reference sequence. The retained model sets both wall and attic-floor insulation to 12 cm; original thicknesses were about 2.48 and 12.66 cm. This is not uniformly increasing every insulation layer from 8 to 12 cm, and it does not establish an economic optimum.

**Glazing and infiltration.** Selected case 14 is low-E/15 mm argon/low-E and gives 353.72 GJ/year. The next saved infiltration model also changes the gap to 10 mm. Its reference core infiltration was 0.36 ACH, perimeter infiltration used 0.001133 $m^3/(s \cdot m^2)$ of exterior surface area, and attic infiltration was 1.0 ACH. The new model uses scheduled 0.10 ACH in conditioned zones and 0.5 ACH in the attic. Therefore, the 13.70 GJ/year decrease is a combined change; uniform “0.35→0.10 ACH” and pure infiltration attribution are not supported.

**Lighting.** The 19.48→12 $W/m^2$ lighting change gives 340.02→290.16 GJ/year. Interior lighting falls 102.64→63.23, cooling 36.27→29.39 and fans 50.56→42.42 GJ/year, while heating rises 7.88→12.44. This is the largest saved-stage decrease (49.86 GJ), about 65.8% of the complete sequence decrease; this is sequential attribution, not an independently additive measure saving.

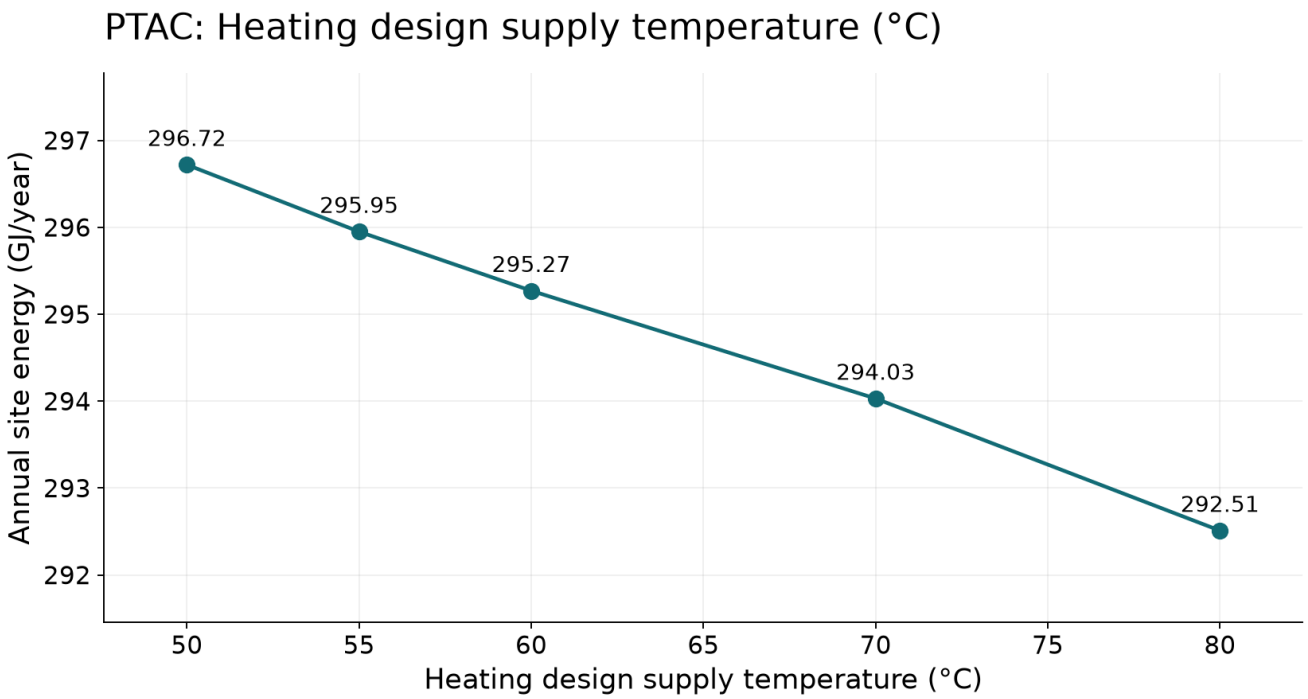
**Shading.** Final overhang depth is 1.2 m with 0.2 m side extensions on the original south and east openings. Four façade blind controls deploy interior Venetian blinds above 350 $W/m^2$ incident solar. Slat angle is fixed; the model does not continuously optimize blind angle. Final annual total is 288.13 GJ. The separate shading sweep’s clear inner pane differs from the final cumulative low-E inner pane, explaining why its retained total is different.

**Orientation.** East/North/West/South totals are 294.87/288.83/296.14/289.00 GJ/year. Original case labels correspond to Building North Axis 90°/180°/270°/0°. Orientation uses the same clear-inner-pane comparison basis as the separate shading sweep. The saved “South” model and final cumulative model differ in the two glazing construction definitions. Keep orientation separate from the six-stage total.

Full object-field differences are retained in data/comparison_diffs.json and data/model_diffs.json. A new controlled single-factor infiltration experiment would be needed to isolate causal contributions. This audit does not invent that unperformed result.

# 5. PTAC sweep reconciliation

The apparent PTAC heating-sweep discontinuity is a source-label error. The preceding COP-6/cooling-design-14°C case uses a heating design supply temperature of 50°C and gives 296.72 GJ/year. The first saved heating-sweep input uses 55°C in all five zone templates and the expanded model, giving 295.95 GJ/year. Both cases were freshly reproduced. The report/workbook labels that first sweep point 50°C.




The 50°C case is the preceding retained model (296.72 GJ). The first heating-sweep IDF and expanded model use 55°C (295.95 GJ), correcting the workbook/report axis label of 50°C. The 80°C raw Total Site Energy is 292.51 GJ; 292.52 is a rounded-component sum. Points represent discrete tested cases; connecting lines are guides only. The energy axis is cropped to show differences.

Corrected heating-design sequence: 50, 55, 60, 70, 80°C with 296.72, 295.95, 295.27, 294.03, 292.51 GJ/year. The 50°C point is explicitly the preceding retained case. The raw 292.51 total differs from the report's rounded-component sum 292.52. The subsequent boiler sweep holds the 80°C design input and reaches 286.89 GJ/year at nominal efficiency 94%.

The cooling-design sweep 14, 13.5, 13, 12.5, 12°C gives 296.72, 296.89, 297.06, 297.21, 297.36 GJ/year. Occupied cooling unmet hours are 0.50, 3.00, 13.83, 26.67, 48.50. These inputs specify sizing design supply temperatures, not zone thermostats or observed delivered air. The retained 14°C choice avoids the higher energy and unmet-hour response of those lower tested values.

Final PTAC settings: cooling COP 6; zone design cooling/heating supply 14/80°C; nominal boiler efficiency 0.94. Baseline and final occupied heating unmet time are zero, and occupied cooling unmet time remains 0.50 hours.

# 6. VAV, sizing and thermal-service criteria

The VAV branch uses COP 4 as its baseline. COP 6 gives 393.36 GJ/year. Fan total efficiency 0.90 gives 384.76, cooling-coil design setpoint 11.4°C gives 383.85 and boiler efficiency 0.94 gives 375.05. The zone cooling design supply temperature remains 12.8°C. These two temperature fields must not be conflated.

The final fan total efficiency and motor efficiency are both 0.90. EnergyPlus defines total fan efficiency as motor × impeller efficiency, implying an ideal impeller efficiency of 1.00. That endpoint is mathematically accepted by the input model but should be presented as an idealized sensitivity case, not realistic equipment selection or a proven procurement optimum. See EnergyPlus 9.5 Fan:VariableVolume.

| System | Matched sizing factor | GJ/year | Occupied cooling unmet h |
|---|---|---|---|
| PTAC | 0.8 | 312.09 | 72.67 |
| PTAC | 1.0 | 311.53 | 0.50 |
| PTAC | 1.2 | 310.95 | 0.00 |
| VAV | 0.8 | 383.02 | 440.17 |
| VAV | 1.0 | 418.67 | 67.67 |
| VAV | 1.2 | 461.68 | 2.17 |

Matched factors change zone/boiler sizing together for PTAC, and zone/boiler/chiller sizing together for VAV. The sizing values above are verified from archived reports; they were not all freshly rerun. The low-energy undersized VAV case delivers fewer cooling-setpoint hours, which must remain visible beside energy.

Both reporting tolerances are explicitly 0.556°C. Occupied heating/cooling unmet hours are facility elapsed time when any occupied zone violates the applicable setpoint tolerance. They are not sums across zones: final VAV zone cooling values sum to 72.17 h while the facility value is 70.17 h because violations can overlap. They also do not equal PMV, adaptive comfort, or the separate ASHRAE 55 simplified comfort summary.

The final VAV coil-design change increases occupied cooling unmet time from 67.67 to 70.17 h. No study-specific acceptance threshold is stated. Report the +2.50 h tradeoff without assigning statistical significance, material failure or compliance. See EnergyPlus thermostat output definitions and reporting tolerances.

# 7. Visual audit and page correction package

Twenty-one data-derived SVG/PNG figure pairs are supplied, with explicit axes, units, comparison sets and captions. Zero-based bars preserve magnitudes; cropped line-chart axes show sensitivity and are disclosed. Lines join tested points only. No statistical error bars, interpolation model or fabricated observations are introduced. The dense glazing and shading plots use readable horizontal comparisons; end-use tables remain available in the accompanying data.

The 24-entry website figure manifest was checked, including three authentic presentation images and two unused chart entries. The conceptual hero, three legacy report crops and the interactive sequence were also inventoried. All original chart crops are historical sources; use the new graphics for corrected findings. The authentic reference model and PTAC/VAV interface images remain useful with starting-input captions.

Small-office method runs cover February 20–27 and July 20–27 inclusive, 384 h. Their 64.44–65.94 GJ values are envelope-convection plus exfiltration heat emissions, not annual consumption. Large-office method runs cover 8,760 h with Albuquerque weather despite Denver filenames; their 8,831.72–10,201.21 GJ figures are envelope-convection heat emissions. Historical runtimes are seconds per simulation, not annual outputs, and are not current-machine benchmark evidence.

The multi-story conceptual cutaway does not depict the one-story reference model. Its decorative declining bars are not study data. Prefer the authentic reference-model image for the scientific page hero; otherwise state explicitly that the image and bars are conceptual. Do not infer geometry, equipment routing or quantitative performance from the illustration.

page_package/ contains review.patch, corrected energyStory.ts, energyFigures.json, energySequence.ts, EnergySequence.astro and energyplus-sequence.csv. corrections.json provides exact additional metadata/hero/resource instructions; baseline_hashes.json prevents silently replacing a changed canonical file. Apply or merge only in the canonical portfolio chat, review the resulting page and preserve the original PDF. No website source was edited by this audit.

figure_gallery.html presents every corrected figure, its caption, source paths and data. data/source_to_claim.csv links all figures to sources; data/narrative_claims.csv maps nonfigure findings; data/visual_inventory.json records dispositions and original asset hashes. All figure captions must accompany the plots.

# 8. Uncertainty, warnings and repeat procedure

The original and reproduced cases are deterministic scenarios, not calibrated predictions. No measured energy/comfort observations, input uncertainty distributions, repeatability statistics for historic timings, cost model or formal comfort criterion were supplied. Matching rounded tables does not establish byte-identical weather, timestep-level identity or external model validity. Parametric endpoints are not global optima.

All 13 accepted runs complete with zero severe errors. Warning totals include repeated events: reference envelope 442, final envelope 263, PTAC baseline/final 13 each, VAV baseline 10 and final 9. Envelope warnings include DX-coil low-temperature operation, possible coil frost/freeze, out-of-range psychrometric evaluations, a zero-power service-water pump, unused constructions and invalid output-meter requests. Final shading also warns about specifying both a shaded construction and shading material. HVAC branch warnings include extreme psychrometric evaluations and, for PTAC, low ambient DX operation. Their quantitative impact is not established by this reproduction audit.

Retain these diagnostics. Do not silently repair original controls or equipment and present revised results as the old study. A separately versioned model-development study could investigate coil availability, sizing/operating ranges, control definitions and plausible fan efficiencies, then quantify output changes. Such new scenarios are not fabricated here.

**Repeat without modifying sources.** Restore the numbered snapshot with scripts/restore_sources.py into a new short path (default /tmp/ep-src). Set EP_SOURCE_ROOT to that path. Use EnergyPlus 9.5.0-de239b2e5f and the supplied weather file. Set EP95_EXE to the executable and run scripts/reproduce.py --run. Each invocation creates a new timestamped folder, verifies input/weather hashes, runs the 13 cases and compares their displayed metrics.

scripts/extract.py rebuilds parsed reports and source hashes. scripts/figures.py rebuilds charts from original tables/workbook values; dependencies are Python, matplotlib, numpy and openpyxl. scripts/package.py prepares the review bundle from the inspected website baseline without changing it. scripts/report.py generates this audit and gallery. README.txt gives exact commands and source URLs. original_sources.zip includes a manifest that maps numbered members to original paths and hashes.

**Remaining limits and action status.** Exact original EPW bytes and direct template expansion remain unavailable; preserved expanded models and station-matched weather enabled successful numerical reproduction. Isolated attribution of the combined infiltration/glazing change remains unperformed. No external empirical validation or pass/fail comfort judgment is claimed. Canonical page integration and visual testing are a separate handoff action; deployment has not occurred.