

Data Centre CFD Analysis

Case-study review report - DC-00 synthetic data-hall test room, London

Hexanta case-study pack cfd-data-centre-r1. Prepared from preserved evidence only; nothing was re-simulated.

Status: NOT ENGINEERING VALIDATED. Native CFD runs converged, but the validation gates for mass conservation, energy balance, boundary read-back, physical plausibility and mesh sensitivity FAILED for both designs. **Engineering approval: OUTSTANDING - no engineer review or approval recorded.** Annual energy figures are SIMULATED WITH ASSUMED EQUIPMENT MODEL and are not a validated saving.

Software: IESVE 2026 (ApacheSim dynamic simulation and MicroFlo CFD) under a **trial licence for internal evaluation only** (expired 2026-10-25), driven by Hexanta automation on a Windows test machine. Every number below is read from the evidence folder cfd-DC00-20261024-r2 (study files, solver logs, simulation exports) unless another folder is named.

1. Purpose

An automation proof of concept: drive a dynamic thermal simulation and a room CFD model end to end without manual steps, then compare a baseline cooling layout with an optimised one for rack inlet temperatures and annual cooling-system electricity. The work's own acceptance: "DC-00 is accepted as an automation proof of concept, not as an engineering-validated energy-saving study."

2. Case (synthetic)

Item	Value	Status
Room	6.0 x 4.8 x 3.0 m, single-storey hall, no glazing	ASSUMED
Racks	4 racks (2 rows of 2, hot/cold aisle), 600 x 1200 x 2000 mm	GENERIC ASSUMPTION
IT load	10 kW per rack, 40 kW total	GIVEN
Rack air temperature rise	12 K -> 0.691 m3/s per rack	GENERIC ASSUMPTION
Supply air	18 °C	ASSUMED
Baseline DC00B	floor supply 3.3167 m3/s (1.20 x IT airflow); one ceiling extract above the cold aisle	design input
Optimised DC00O	floor supply 2.9022 m3/s (1.05 x IT airflow); two extracts of 1.451 m3/s over the hot aisles	design input
Location / weather	London (synthetic site); IESVE weather as configured	ASSUMED

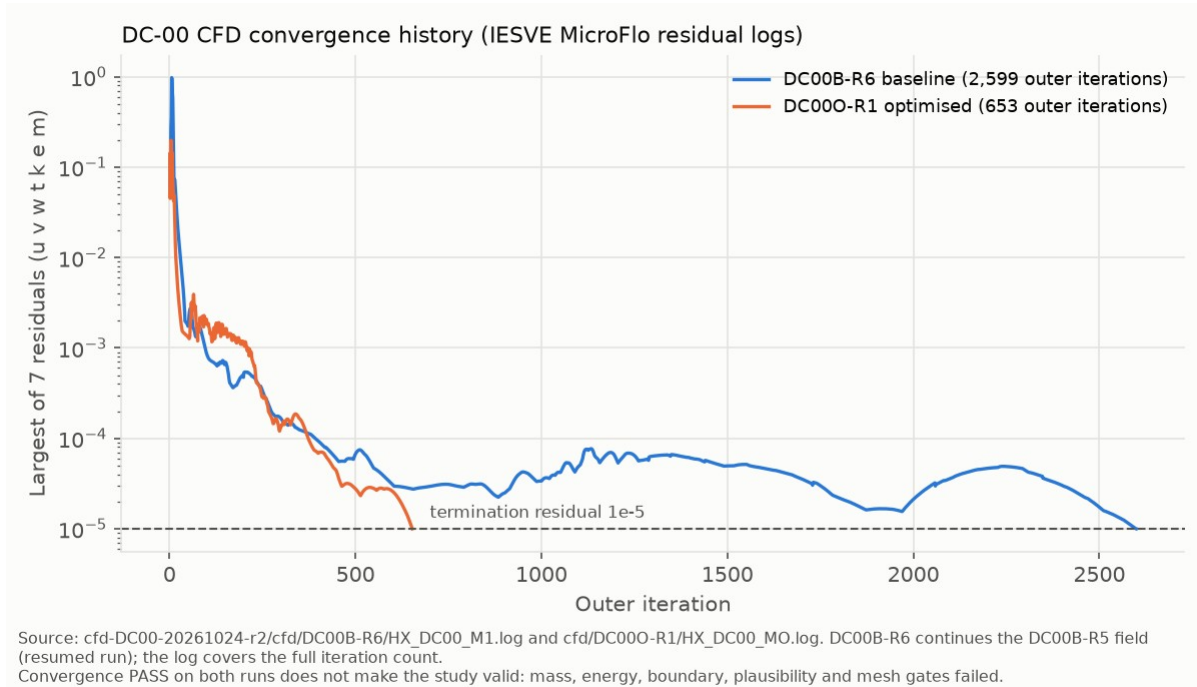
3. CFD model set-up

Item	Value
Rack representation	0 W solid blocks; front face extract 0.691 m3/s; rear face supply 0.691 m3/s at 32.0 °C (iterated from 30 °C)
Surfaces / initial	walls 28 °C; initial 24 °C
Turbulence model	k-epsilon
Base grid	0.1 m: 60 x 48 x 30 = 86,400 cells, maximum aspect ratio 1:1
Mesh study grids	refined 0.075 m: 80 x 63 x 39 = 196,560 cells; coarse 0.133 m: 44 x 35 x 22 = 33,880 cells
Note	the case file lists a 0.2 m base cell size (ASSUMED); the solved models used 0.1 m
Solver	inner iterations 3, false time step 0.0987, relaxation 1, termination residual 1e-5 on all 7 residuals
Monitors	solver cell monitors 0.05 m in front of each inlet face at 0.35 / 1.05 / 1.75 m (A01, B01) and 1.05 m (A02, B02); extract-plane monitors at 2.85 m

4. Runs

Run	Result	Role
DC00B-R1	ABORTED	automation fault (log file lock); exploratory

DC00B-R2	NOT CONVERGED	superseded (resumed R1 field, 30 °C exhaust)
DC00B-R3	NOT CONVERGED	superseded (1500 iterations; rack heat -16 % at 30 °C exhaust)
DC00B-R4	converged, edit not applied	superseded (resume kept the 30 °C boundary)
DC00B-R5	NOT CONVERGED (strict)	final baseline field for figures; t 1.73e-5, e 1.65e-5 vs 1e-5; monitors steady
DC00B-R6	PASS (converged, 2,599 it)	FINAL BASELINE: R5 resumed, same boundaries; inlets within 0.02 K of R5
DC00O-R1	PASS (converged, 653 it)	FINAL OPTIMISED
DC00O-R1b/c/d	PASS (read-out)	monitor read-outs (1 iteration resume)
DC00O-F1	PASS (converged, 830 it)	refined grid 0.075 m, 196,560 cells
DC00O-C1	PASS (converged, 517 it)	coarse grid 0.133 m, 33,880 cells



5. Validation gates (computed by the Hexanta CFD gate)

Overall: NOT ENGINEERING VALIDATED. Both designs fail 5 of 8 gate checks.

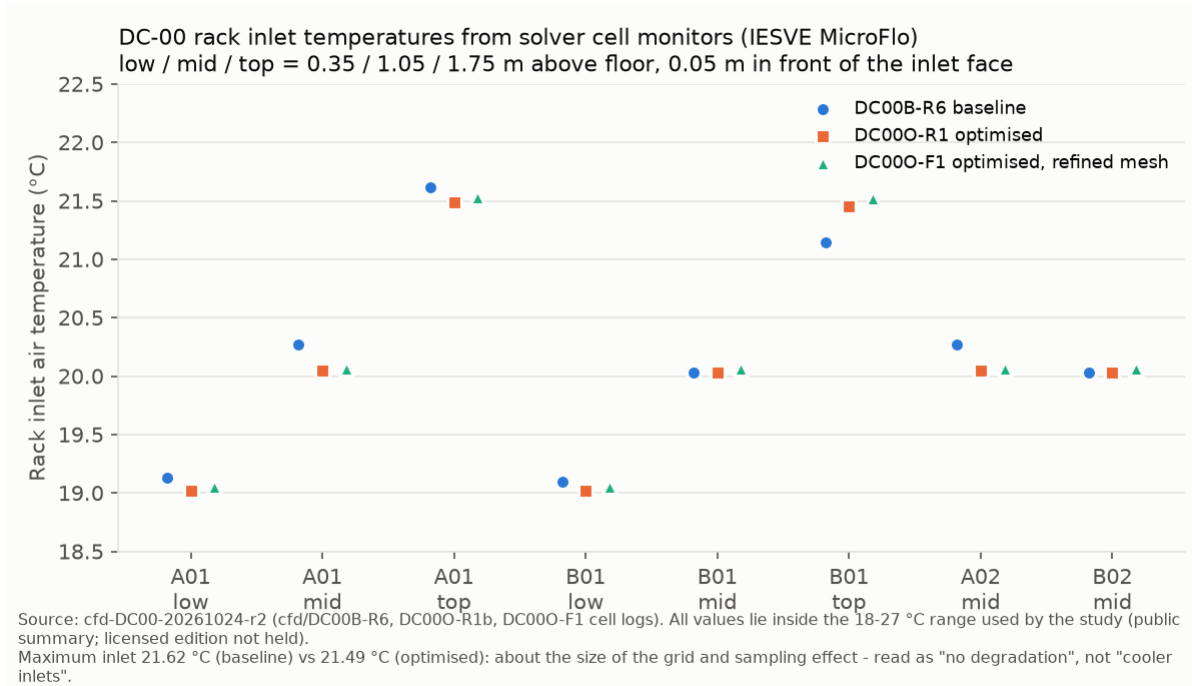
Gate check	DC00B (R6)	DC00O (R1)	Basis
convergence	PASS	PASS	7 residuals at 1e-5, monitors steady
mass conservation	FAIL	FAIL	flows are prescribed boundaries; no solver flow report
energy balance	FAIL (gap -25.5 %, sampled)	FAIL (gap -7.5 %, sampled)	extract temperatures sampled, not solver-reported
boundary consistency	FAIL	FAIL	boundary values not read back programmatically
rack inlets complete	PASS	PASS	all 4 racks monitored
physical plausibility	FAIL	FAIL	no field export available
grid quality	PASS	PASS	within limits (aspect 1:1)
mesh sensitivity	FAIL (single grid)	FAIL (top inlets not monotonic)	see mesh study

6. Rack inlet temperatures (solver cell monitors, °C)

Run	Rack	low	mid	top	max	represented heat kW	vs 10 kW
DC00B-R6	A01	19.13	20.27	21.62	21.62	9.72	-2.8 %
DC00B-R6	B01	19.09	20.03	21.14	21.14	9.93	-0.7 %
DC00B-R6	A02	-	20.27	-	20.27	9.77	-2.3 %

DC00B-R6	B02	-	20.03	-	20.03	9.98	-0.2 %
DC00O-R1	A01	19.02	20.05	21.49	21.49	9.85	-1.5 %
DC00O-R1	B01	19.02	20.03	21.45	21.45	9.86	-1.4 %
DC00O-R1	A02	-	20.05	-	20.05	9.96	-0.4 %
DC00O-R1	B02	-	20.03	-	20.03	9.97	-0.3 %
DC00O-F1	A01	19.05	20.07	21.53	21.53	9.82	-1.8 %
DC00O-F1	B01	19.05	20.06	21.53	21.53	9.82	-1.8 %
DC00O-F1	A02	-	20.07	-	20.07	9.95	-0.5 %
DC00O-F1	B02	-	20.06	-	20.06	9.95	-0.5 %

All monitored inlets lie inside the 18-27 °C range used by the study (from a public summary; licensed edition not held). Maximum inlet: 21.62 °C baseline, 21.49 °C optimised, 21.53 °C refined mesh.



7. Mesh study (optimised design, temperature)

Two-grid comparison (86,400 vs 196,560 cells): all points within the ASSUMED tolerances $|dT| \leq 0.2$ K and speed ≤ 10 % - PASS. Three-grid GCI (Celik et al. 2008): PARTIAL - low and mid inlets monotonic, top inlets not monotonic. The gate check is FAIL. The baseline was solved on one grid only.

Point	T fine / base / coarse (°C)	Behaviour	GCI (fine)	Spread
A01-low	19.05 / 19.02 / 18.93	monotonic	± 0.032 K	0.12 K
A01-mid	20.07 / 20.05 / 19.91	monotonic	± 0.005 K	0.16 K
A01-top	21.53 / 21.49 / 21.46	divergent	n/a (not monotonic)	0.07 K
B01-low	19.05 / 19.02 / 18.93	monotonic	± 0.032 K	0.12 K
B01-mid	20.06 / 20.03 / 19.90	monotonic	± 0.017 K	0.16 K
B01-top	21.53 / 21.45 / 21.44	divergent	n/a (not monotonic)	0.08 K
A02-mid	20.07 / 20.05 / 19.91	monotonic	± 0.005 K	0.16 K
B02-mid	20.06 / 20.03 / 19.90	monotonic	± 0.016 K	0.16 K
hotA	32.00 / 32.00 / 32.00	monotonic	± 0.000 K	0.00 K
hotB	32.00 / 32.00 / 32.00	monotonic	± 0.000 K	0.00 K
jet centre	18.35 / 18.49 / 18.97	monotonic	± 0.097 K	0.62 K

8. Room energy balance (sampled at the extract plane)

Case	Samples	Extract T, velocity-weighted (°C)	Heat removed (kW)	Represented rack heat (kW)	Gap
DC00O base grid	21	28.48	36.67	39.64	-7.5 %
DC00O refined	18	28.55	36.92	39.54	-6.6 %

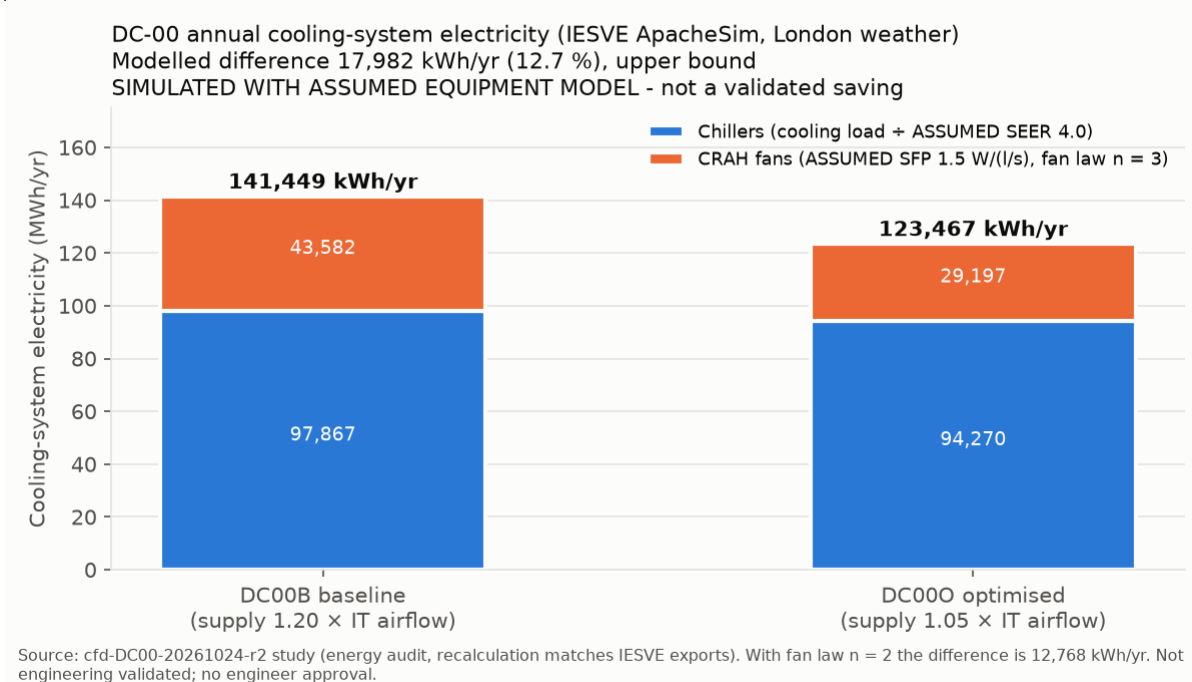
grid

DC00B (R6) 16 25.33 29.33 39.39 -25.5 %
NOT ESTABLISHED. The solver exports no field data; the balance is estimated from point samples 0.15 m below the extract face. The baseline samples lie inside the impinging supply jet and cannot represent the face mean. Wall exchange with the 28 °C surfaces is bounded at about 1.4 kW (ASSUMED 4 K air-surface difference).

9. Annual energy (IESVE ApacheSim) and audit

Quantity	DC00B	DC000	Source / status
Supply airflow (l/s)	3,316.7	2,902.2	design input (1.20 / 1.05 x IT airflow)
Fan power (W)	4,975.1	3,332.9	ASSUMED SFP 1.5 W/(l/s), fan law n = 3
Annual cooling load (kWh/yr)	391,466	377,081	IESVE ApacheSim (simulated)
Chiller electricity (kWh/yr)	97,867	94,270	load / ASSUMED SEER 4.0
Fan electricity (kWh/yr)	43,582	29,197	ASSUMED fan model integrated by IESVE
Cooling-system electricity (kWh/yr)	141,449	123,467	sum; recalculation matches IESVE

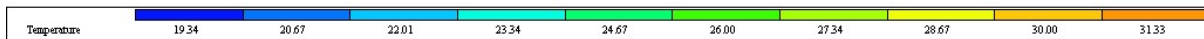
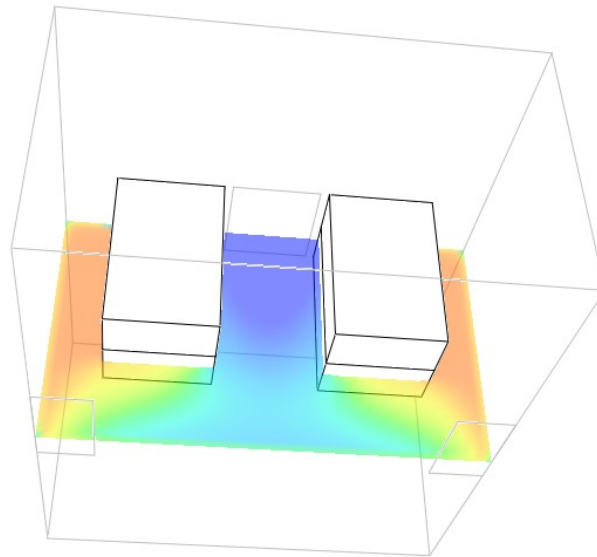
Modelled difference: **17,982 kWh/yr (12.7 % of cooling-system electricity), GBP 4,495/yr at an ASSUMED 0.25 GBP/kWh**. SIMULATED WITH ASSUMED EQUIPMENT MODEL - not a validated saving. With fan law n = 3 this is an upper bound; n = 2.5 gives 15,462 kWh/yr and n = 2 gives 12,768 kWh/yr. The saving depends entirely on the ASSUMED fan model; no simulation determined fan or chiller efficiency. Apache's whole-building total difference (32,368 kWh/yr) is not valid: it counts the fan saving twice.



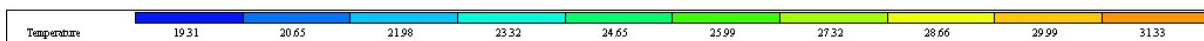
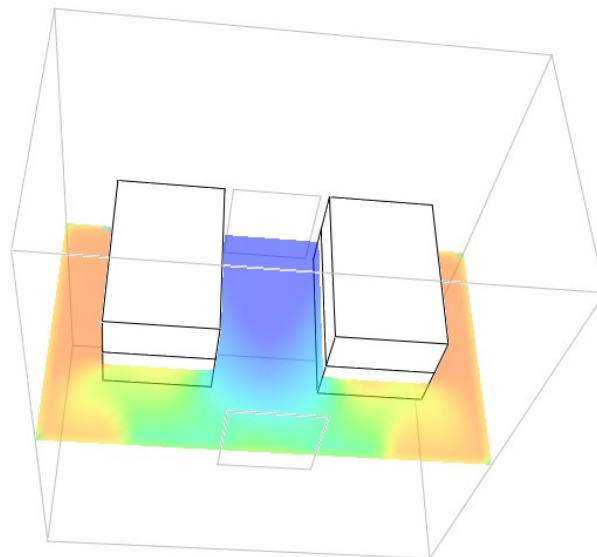
Related: DC-01 (synthetic 20 x 12 x 4 m hall, 10 racks x 10 kW) annual simulation N1F was accepted at software level (build, input and physics gates PASS): cooling-system electricity 352,337 kWh/yr with the same ASSUMED efficiencies (evidence folder cfd-DC01-N1-DSM-20261024). Attempts N1D and N1E were rejected by the gates. No CFD was run for DC-01.

10. Selected CFD images (cropped native viewer output)

Final optimised field DC000-R1, vertical slice x = 2.75 m, filled temperature. The two warmest colour-key cells were cropped off with an operating-system overlay; full native scale 19.34-34.00 °C.



Baseline field DC00B-R5, same slice (R6 differs by at most 0.02 K at the monitors). Scale 19.31-34.00 °C.



11. Limitations (as stated by the work)

- Actual equipment performance curves are not modelled: seasonal efficiency (SEER 4.0), specific fan power (1.5 W/(l/s)) and the fan law exponent ($n = 3$) are ASSUMED.
- Racks are 0 W solid blocks with face boundaries and an imposed 32 °C exhaust temperature: heat output follows inlet temperature, faces are uniform, no bypass or leakage is modelled.
- No complete CFD mass and energy balance: the solver gives no flow report or field export; the energy balance is estimated from point samples only.
- The baseline was solved on one grid only; on the optimised design the top-inlet values are not monotonic over three grids.
- No independent solver benchmark and no measured case have been compared.
- The annual model is a single zone held at 28 °C with a fixed seasonal efficiency; it responds to airflow only through fan power. Annual cooling energy is not validated.
- Boundary values were read back from screenshots and table cells, not programmatically.
- The 18-27 °C rack-inlet range is taken from a public summary; the licensed current edition of the guideline is not held.
- The electricity tariff (0.25 GBP/kWh) is an ASSUMED placeholder.
- The CFD and annual simulations ran under an IESVE 2026 trial licence for internal evaluation only (licence expired 2026-10-25).

12. Not claimed

- The study is not engineering validated and has no engineer review or approval.
- The 17,982 kWh/yr (12.7 %) difference is not a validated saving: it is SIMULATED WITH ASSUMED EQUIPMENT MODEL and an upper bound (fan law $n = 2$ gives 12,768 kWh/yr).
- The optimised design is not shown to give cooler rack inlets: 21.62 °C vs 21.49 °C is about the size of the grid and sampling effect. The defensible statement is 'no degradation with 12.5 % less supply air'.
- Mass and energy balance and full mesh independence were not demonstrated.
- No CFD was run for the larger DC-01 room, and no real data centre, client or site was modelled: all data are synthetic.
- No compliance with any licensed design guideline is claimed.
- The CFD was solved by IESVE MicroFlo, not by a Hexanta solver; Hexanta prepared inputs, drove the software, parsed outputs and applied the validation gates.
- Apache's whole-building total difference (32,368 kWh/yr) is not a saving: it counts the fan saving twice.

13. Evidence

Folder	Role	SHA256SUMS (sha256 of the manifest file)
cfD-DC00-20261024-r2	final DC-00 evidence (1,758 files)	6e1715a8d12990e0831d3fd20054b76cd0cf5bf40951d0349172967f6af21e7c
cfD-DC00-20261024	SUPERSEDED by r2 (212 files)	6911696e9521f536d35129ed7a6a223dbf4542ad42ab3cbfc0b89249e3b514dd
cfD-DC01-N1-DSM-20261024	DC-01 annual simulation (219 files)	8a000b9d6b210592a6337c43ae110183f029c73ff626f50419c89e1f79491cf9

All checksum manifests re-verified with 0 failures on 2026-10-25. Study file: `cfD-DC00-20261024-r2/study-manifest.study.md` (sha256 3a1534d76fb30a625b8822e59dda7535164048b2f5d7150a96be2383cc808879).