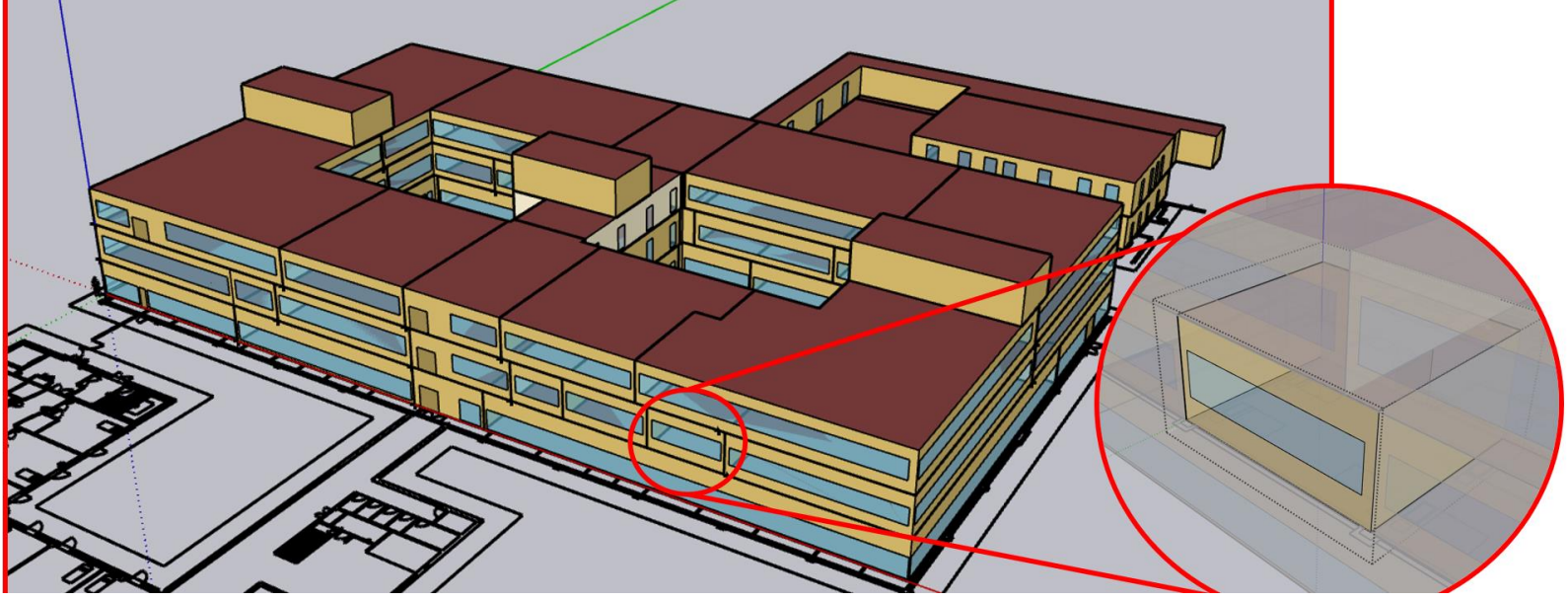


KEY FINDING At the existing supply flow, source-proximal extraction cut worst-case bystander exposure by **89.6%** and enabled a window-control scenario with a modelled net annual energy reduction of **31.2 MWh**.

Why this matters

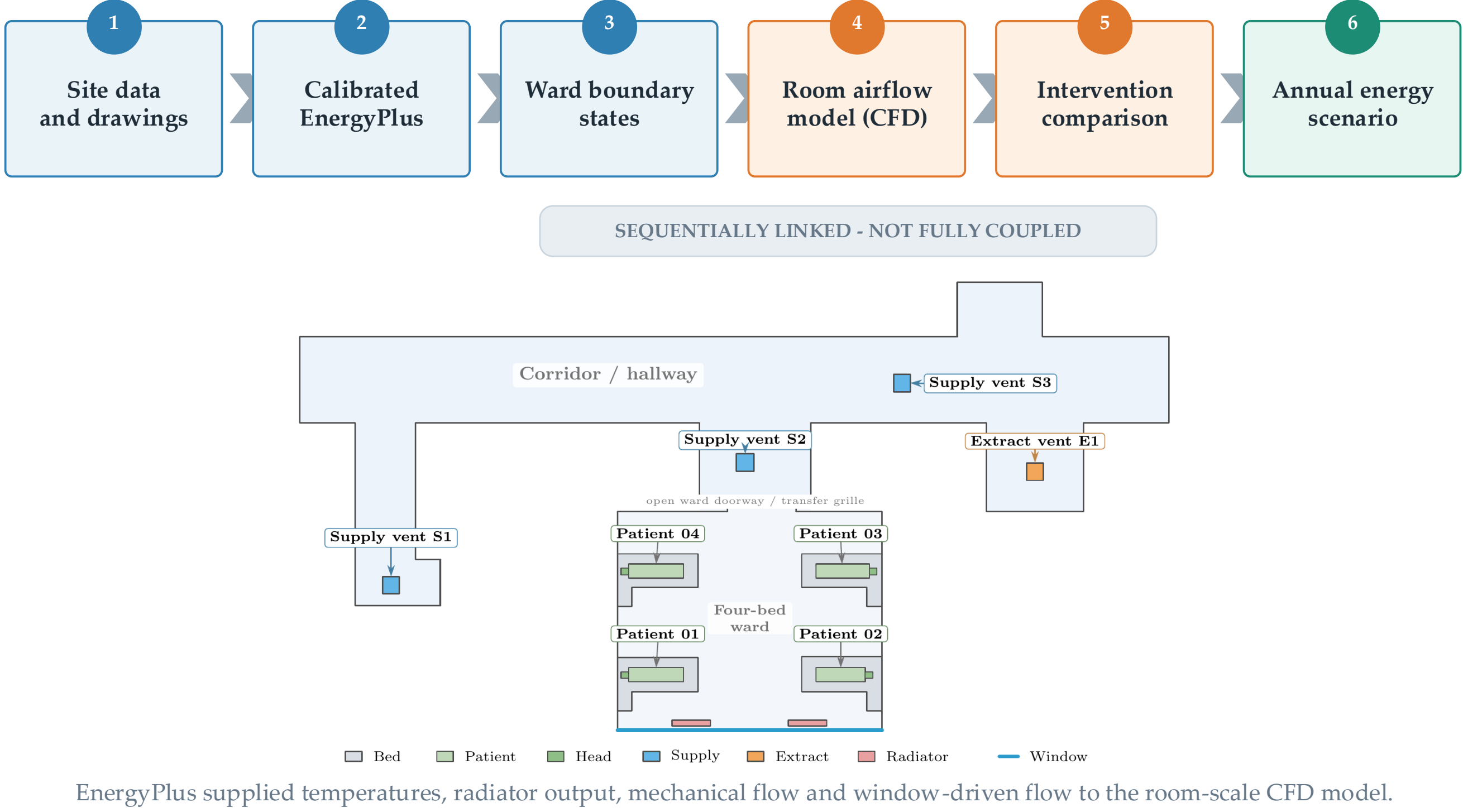


Hospitals are critical infrastructure: ventilation must limit exposure while avoiding unnecessary energy demand.

- General wards are specified at 6 air changes per hour (ACH).
- ACH measures air quantity - not the path from source to patient.
- Window-driven flow varies with weather; more outdoor air increases heating demand.

Can a better source-to-extract pathway outperform simply supplying more air?

From whole building to patient breathing zone



Exposure metric

$R_i = \frac{\text{local bystander tracer concentration}}{\text{ideal well-mixed 6 ACH concentration}}$

$R_i < 1$ LOWER | $R_i = 1$ EQUAL | $R_i > 1$ HIGHER

Comparative tracer benchmark - not an infection-risk or HTM compliance threshold.

Model credibility

5.0% monthly CVRMSE - electricity | 8.0% monthly CVRMSE - gas | 6.61M selected CFD cells

Five meshes; patient concentrations within 4.2% of the finest mesh. Numerically verified, but not experimentally validated.

Existing performance was inconsistent

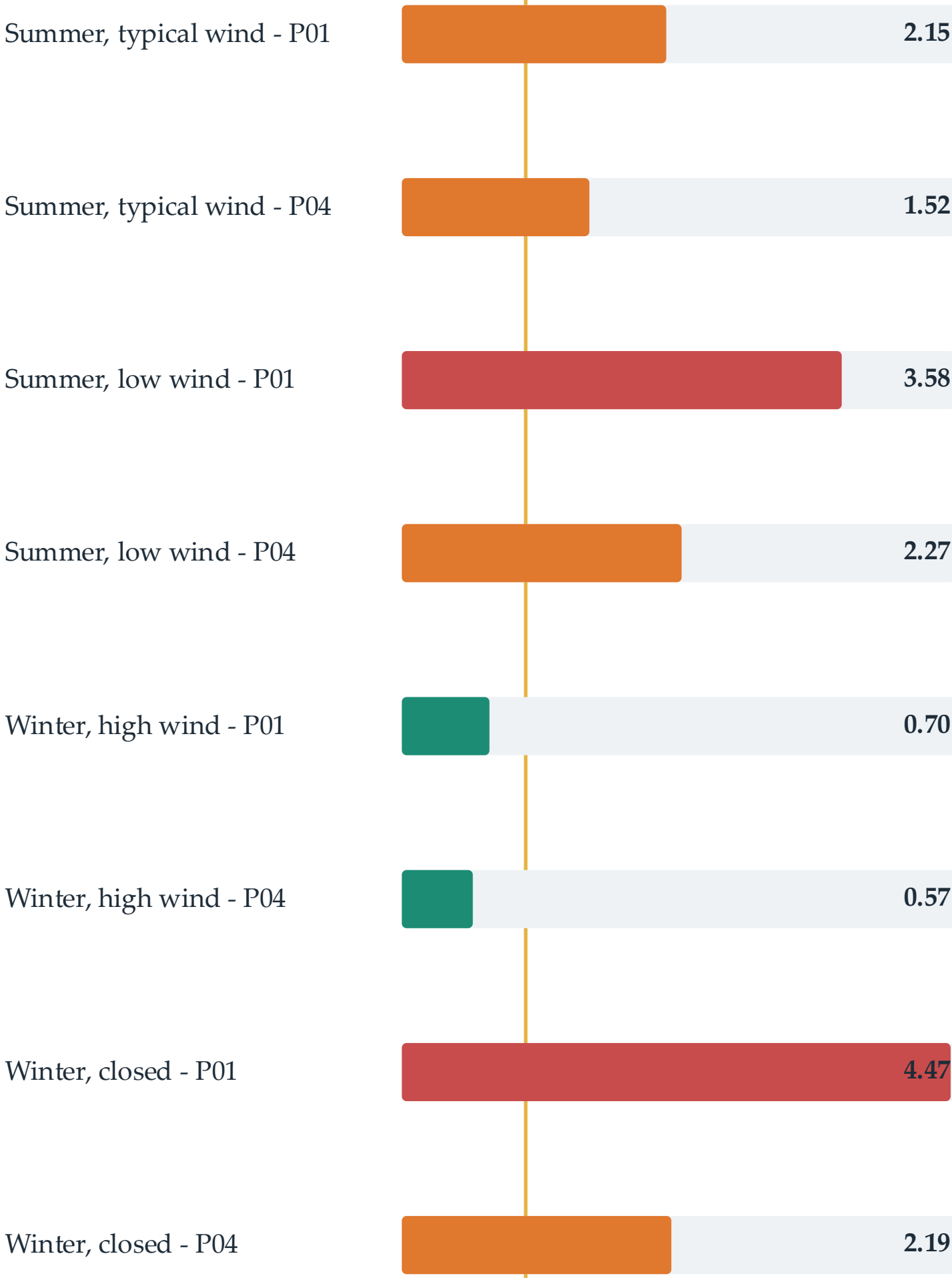
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selected scenarios had at least one $R_i > 1$

4.474

worst R_{max} - winter, closed window

Maximum bystander exposure by scenario



Two winter high-wind cases remained below the reference. The result is not that the ward is always poor - it is that exposure depends strongly on weather and source location.

More air helped - better airflow helped much more

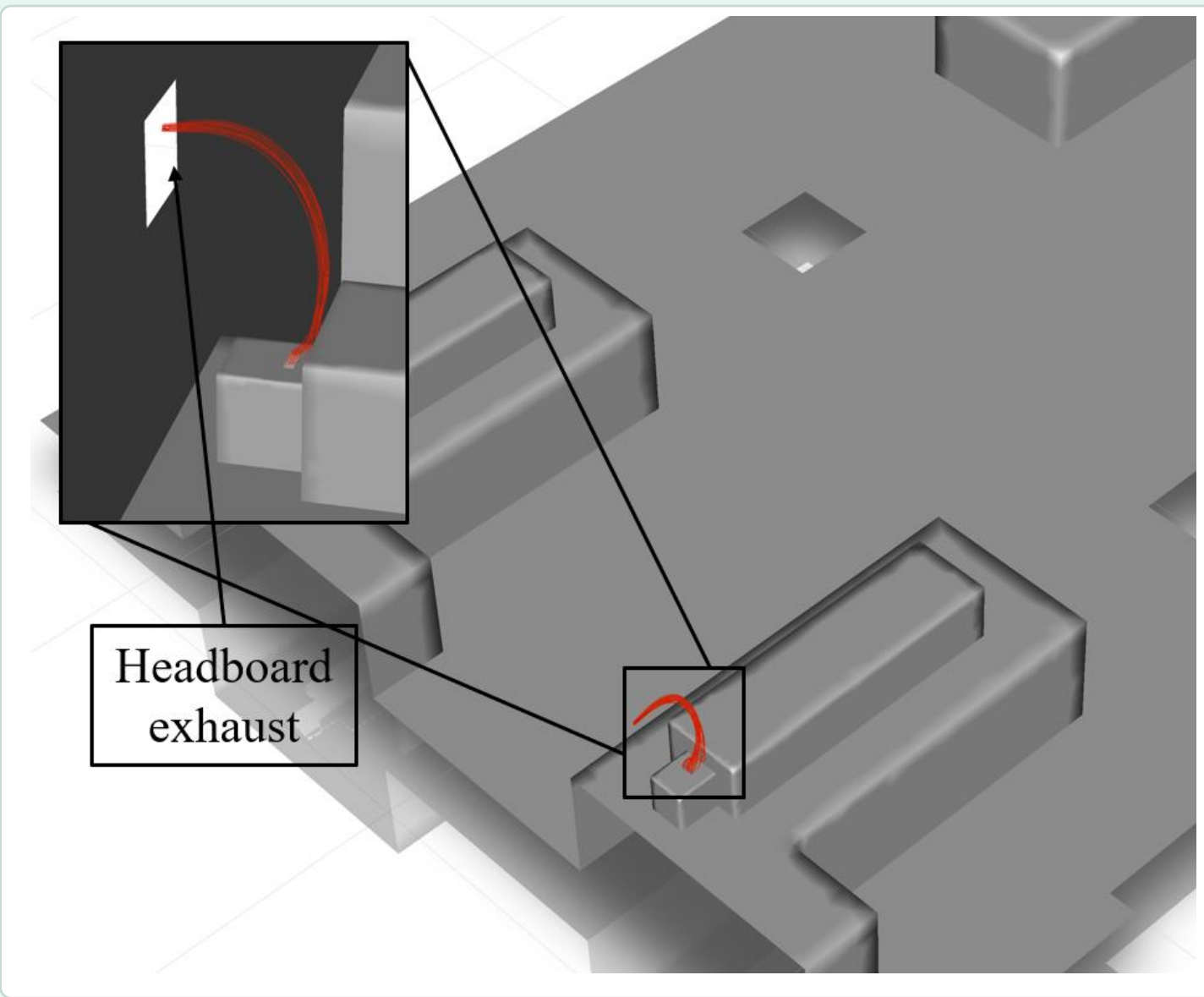
Same B7 winter closed-window condition, same Patient 01 source, same logarithmic tracer scale

lower tracer concentration | higher

EXISTING SUPPLY + HEADBOARD EXTRACTION

$R_{max} = 0.467$

89.6% reduction | $Q_0 = 34 \text{ L/s}$

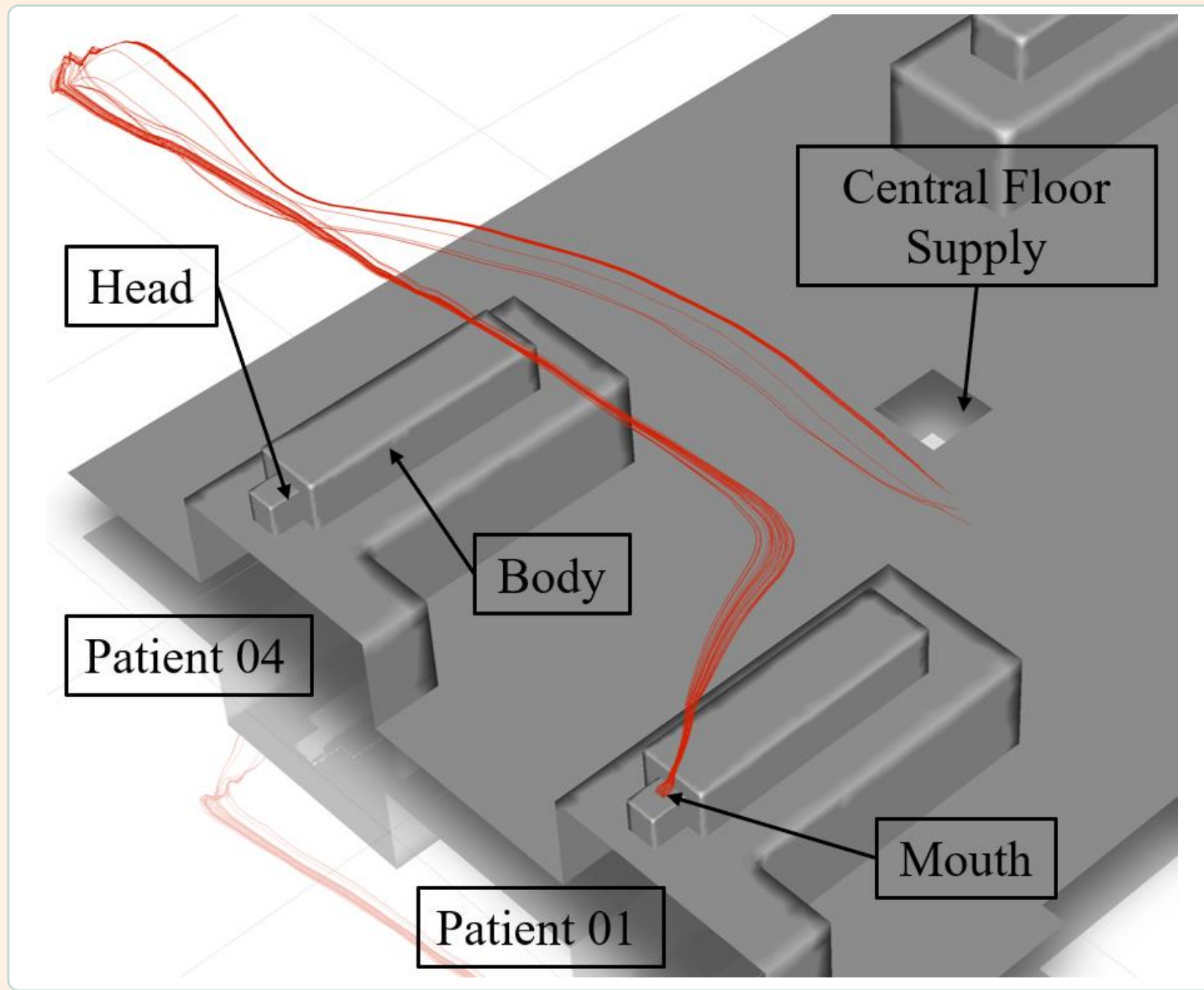


Intercepted close to source

CENTRAL FLOOR SUPPLY - 3x FLOW

$R_{max} = 1.990$

55.5% reduction | $3Q_0 = 102 \text{ L/s}$



Diluted after entering occupied zone

Where the contaminant travelled mattered more than the additional supply-air quantity.

Robust across the tested range

Every tested preferred-configuration bystander value remained below $R_i = 1$.

0.763

worst tested R_{max} - P02 to P03

0.467

B7 preferred-case R_{max}

< 1

all tested bystanders

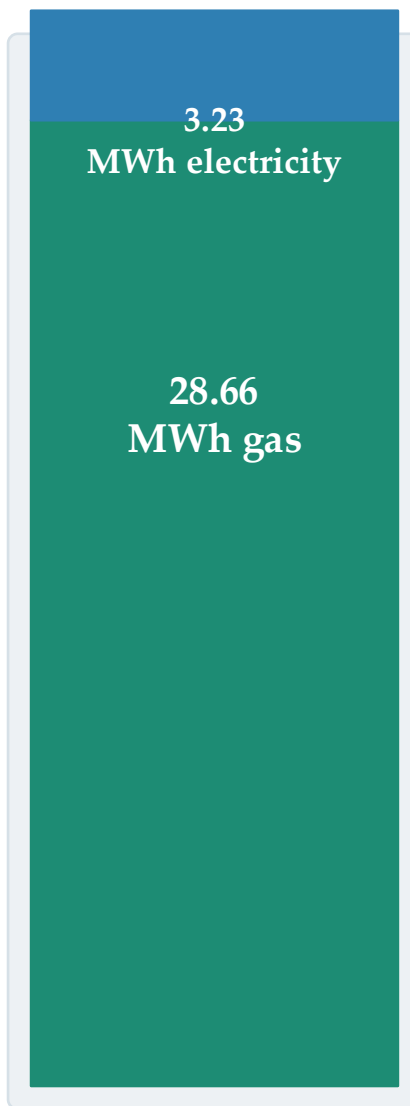
Winter closed-window source-receptor matrix

	P01	P02	P03	P04
P01	SRC	0.174	0.167	0.467
P02	0.352	SRC	0.763	0.342
P03	0.176	0.220	SRC	0.171
P04	0.185	0.157	0.150	SRC

Source patient | Higher values = greater relative exposure

Energy and implementation

Modelled annual difference from a revised ward window-control scenario



gross | Gas saving | Electricity | Fan allowance

31.18

MWh/year net

-0.70 MWh fan allowance

£2,077 indicative annual saving

2.8-6.6 year discounted payback

Scenario estimate - not a measured saving. Most of the reduction came from lower winter heating demand.

What this means for energy resilience

Resilience here means maintaining lower relative exposure across selected weather states while reducing dependence on energy-intensive outdoor-air conditioning.

- AIRFLOW Preferred layout remained below the reference in every tested case.
- WEATHER Less reliance on favourable wind and permissive window opening.
- ENERGY No increase in supply flow; lower modelled winter heating demand.

Ventilation quantity and contaminant-removal effectiveness are not interchangeable. More air helped - but controlling where the contaminant travelled helped much more.

NEXT: full-scale tracer validation | fan and duct design | thermal-comfort monitoring