TECHNICAL MEMORANDUM

Infiltration Rate Converter

Methodology, EnergyPlus Implementation, and Deployment

To: University of Idaho Integrated Design Lab — Building Science / BSUG distribution
From: IDL Design Tools Development
Date: June 14, 2026
Re: Browser-based conversion of field airtightness metrics to EnergyPlus infiltration inputs

Summary. This memorandum documents the Infiltration Rate Converter, a browser-based tool developed by the Integrated Design Lab (IDL) to translate field-measured envelope airtightness into the infiltration inputs that EnergyPlus requires. It modernizes IDL's legacy conversion spreadsheets into a single interactive web tool, adds a weather-correlated coefficient mode based on the NIST infiltration correlations, and is deployed on idlboise.com with a companion landing page. The memo records the conversion methodology, the underlying references (PNNL-18898 and the NIST correlations), the EnergyPlus object mapping, the headless validation performed, and the tool's intended scope and limitations.

1. Purpose and rationale

A primary driver of building heating and cooling load is the infiltration rate — the uncontrolled exchange of conditioned indoor air with outdoor air through envelope leakage. Airtightness is measured in the field by pressurization (blower-door) testing, which reports leakage at a fixed reference pressure (50 Pa residential, 75 Pa commercial). Energy models, however, require an infiltration value referenced to natural pressure and modulated by weather. The conversion between the two is non-trivial and historically lived in IDL spreadsheets that were accurate but slow to use.

The broader motivation, consistent with IDL's climate-analysis tool suite, is that simplified and graphic analysis methods were largely abandoned not because they were inaccurate but because they were time-intensive. Re-implementing them as fast, browser-based tools restores them as practical instruments at the schematic design stage — before detailed simulation (EnergyPlus) is warranted. The Infiltration Rate Converter is the airtightness entry in that effort.

2. Definitions

Metric	Definition	EnergyPlus use
ACH_{50}	Complete air changes per hour with the building pressurized to 50 Pa; the blower-door metric common in residential testing.	— (converted first)
ACH_{nat}	The natural (untested-pressure) average air-change rate.	AirChanges/Hour method
I_{75}	Infiltration flow per unit exterior exposed surface area at 75 Pa (cfm/ft²); common in commercial work.	— (converted first)

Metric	Definition	EnergyPlus use
I_{design}	EnergyPlus design infiltration flow per exterior surface area at design conditions ($m^3/s \cdot m^2$).	Flow/ExteriorArea method

Note. EnergyPlus does not apply I_{design} statically; it modulates the design value every timestep by a coefficient equation in wind speed and indoor–outdoor temperature difference (Section 4).

3. Tool overview

The converter presents five modes within a single interface:

- **I_{75} → I_{design}**. Commercial 75 Pa leakage to the EnergyPlus design flow, with terrain adjustment (Section 4.1).
- **ACH_{50} → ACH_{nat}**. Blower-door air changes to a natural air-change rate via the LBL n-factor (Section 4.2).
- **Compare ACH ⇔ I**. Cross-checks the two pathways through building geometry so the results reconcile.
- **Reverse**. Works back from an EnergyPlus I_{design} value to the equivalent field I_{75}.
- **NIST coefficients**. Building-type and climate-specific A/B/D coefficients emitted as ready-to-paste EnergyPlus objects (Section 5).

4. Conversion methodology

4.1 I_{75} → I_design (PNNL DOE-2 method)

The I_{75} conversion follows PNNL's *Infiltration Modeling Guidelines for Commercial Building Energy Analysis* (PNNL-18898). PNNL recommends the DOE-2 linear wind-velocity model, in which the design value is referenced to a 10 mph (4.47 m/s) wind so that, at the design wind condition, the modeled infiltration equals I_{design}. As its headline example, PNNL converts a baseline leakage of 1.8 cfm/ft² (at 0.30 in. w.c. ≈ 75 Pa) to an EnergyPlus design input of 0.2016 cfm/ft² of exterior above-grade envelope area.

The tool generalizes this conversion and adds sensitivity to the terrain on which the building sits, applying the standard ASHRAE wind-profile categories (the wind-speed exponent α and boundary-layer thickness δ):

Category	α	δ (m)	Terrain
1	0.33	460	Large city centers
2	0.22	370	Urban and suburban, wooded
3	0.14	270	Open terrain, scattered obstructions (weather-station default)
4	0.10	210	Flat, unobstructed; open water

Worked example. For I_{75} = 1.8 cfm/ft² in open terrain (Category 3, α = 0.14), the tool returns I_{design} ≈ 0.189 cfm/ft² = 0.000958 $m^3/s \cdot m^2$, entered with the Flow/ExteriorArea method.

4.2 ACH_{50} → ACH_nat (LBL n-factor)

Blower-door ACH_{50} is converted to a natural air-change rate by dividing by the Lawrence Berkeley Laboratory (LBL) n-factor: $ACH_{nat} = ACH_{50} / n$. The n-factor is selected from the DOE / Energy Star Home

Sealing table by climate zone (1–4), wind shielding (well-shielded, normal, exposed), and number of stories. Because the LBL factor already yields an averaged natural rate, this value is entered in EnergyPlus with constant coefficients (A = 1; B = C = D = 0) — it is not re-modulated by the wind term.

4.3 Compare and Reverse

The Compare mode bridges the two metrics through building geometry (exterior surface area, volume, and floor area), expressing both as a common volumetric flow so the I_{75} and ACH_{50} pathways can be reconciled. The Reverse mode inverts the Section 4.1 relationship, recovering the field I_{75} implied by a given EnergyPlus I_{design} — useful for interpreting model inputs against test data.

5. EnergyPlus implementation

Both pathways feed the EnergyPlus object *ZoneInfiltration:DesignFlowRate*, which does not use the design value directly. Each timestep it computes:

$$Infiltration = I_{design} \cdot F_{schedule} \cdot [\, A + B|\Delta T| + CU + DU^2 \,]$$

where U is the zone-height wind speed and ΔT is the indoor–outdoor temperature difference. The coefficient set must match the value entered:

Coefficient set	A	B	C	D	Use for
DOE-2 (PNNL rec.)	0	0	0.224	0	I_{design}
Constant	1	0	0	0	ACH_{nat}
BLAST (E+ default — avoid)	0.606	0.0364	0.1177	0	—

Full PNNL recommendation — the schedule fraction. The DOE-2 coefficients are only half of PNNL-18898's recommendation. The report (Table 1, Note 2) also specifies the infiltration schedule fraction $F_{schedule}$: **1.0 when the HVAC system is off and 0.25 when it is in operation**, because mechanical pressurization suppresses envelope infiltration while the fans run. Omitting it overstates infiltration during occupied hours. EnergyPlus ships with the BLAST set as its example default; leaving that in place modulates the design value differently than the conversion assumes and is the most common source of error.

6. NIST weather-correlated coefficients mode

The fifth mode replaces the single DOE-2 wind term with building-type and climate-specific coefficients from the NIST infiltration correlations (Ng et al., 2018). These coefficients were fitted to multizone airflow (CONTAM) simulations of the DOE commercial prototype buildings, capturing wind, stack (temperature-difference) effect, and HVAC operation. Because wind pressure scales with the square of wind speed, C is set to zero and the equation reduces to:

$$Infiltration = I_{design} \cdot [\, A + B|\Delta T| + DU^2 \,]$$

The method is implemented as **two infiltration objects** per zone, switched by the HVAC fan schedule: an *Infiltration_On* object and an *Infiltration_Off* object (for which A = 0, since with the fans off the system-induced offset disappears). Five of the eleven prototype building types (Hospital, Large Hotel, Small Hotel, Highrise and Midrise Apartment) operate their HVAC continuously and therefore carry only the single system-on object.

Coverage and data source. The tool embeds the full published coefficient set — all eleven prototype building types, both envelope airtightness levels (with and without a continuous air barrier), and system-on / system-off states — drawn from the NIST dataset (DOI 10.18434/mds2-2598). For the I_{design} value, buildings without an air barrier use 0.00056896 m³/s·m² at 4 Pa (uniform across types); buildings with an air barrier use the per-building value from the dataset.

Idaho focus. The dataset provides one representative city per ASHRAE climate zone, which the tool maps to Idaho's zones: southern Idaho (5B) → CZ 5 (Chicago); eastern and upper Idaho (6B) → CZ 6 (Helena); the central mountains (zone 7) → CZ 7 (Duluth). Helena is itself a dry-cold 6B city, so it is a strong match for eastern Idaho; Chicago and Duluth are humid reference cities, reasonable for Idaho because infiltration is driven by wind and ΔT rather than humidity, but the values carry their reference-city weather (Section 8).

Illustrative coefficients. Medium Office, without an air barrier, across the three Idaho-relevant zones (A_{off} = 0 throughout):

Parameter	CZ 5 / 5B	CZ 6 / 6B	CZ 7 / Zone 7
I_{design}	0.00056896	0.00056896	0.00056896
A_{on}	-0.0444856	-0.0382128	-0.0505937
B_{on}	0.0055419	0.0042297	0.0058730
D_{on}	0.0295303	0.0206092	0.0262710
B_{off}	0.0154767	0.0139283	0.0142168
D_{off}	0.0344341	0.0263538	0.0298464

Each selection emits two complete `ZoneInfiltration:DesignFlowRate` objects with the coefficients above, C = 0, and the I_{design} flow, ready to copy into an IDF.

7. Validation

Consistent with IDL's tool-suite practice, the converter is validated headless (Playwright) before release. The current suite passes all checks, including:

- Reference conversions reproduce the source values — e.g. the I_{75} and ACH_{50} pathways, and the Compare and Reverse modes round-trip consistently.
- NIST coefficient look-ups verified against the dataset for the Idaho zones (CZ 5 and CZ 6), including the always-on case (Hospital emits a single object) and the per-building air-barrier I_design (e.g. Small Office, 0.00046801 m³/s·m²).
- Layout integrity: container render, control set, the six tab panels, and no horizontal overflow at a 390 px mobile width.

8. Scope and limitations

- **Schematic-stage tool.** It produces defensible early-design inputs, not a substitute for detailed whole-building simulation or for code-compliance calculations.

- **Wind vs. stack.** The I_{75} and ACH conversions account for horizontal wind pressure only; the legacy IDL page carried this caveat. The NIST coefficients mode additionally captures stack (buoyancy) effect through its $B \cdot |\Delta T|$ term and is the more complete representation.
- **Representative-city mapping.** The NIST coefficients are keyed to one city per climate zone. Applying CZ 5 (Chicago) and CZ 7 (Duluth) — humid references — to Idaho's 5B and zone 7 is reasonable but approximate; CZ 6 (Helena) is a genuine dry-cold match for eastern Idaho.
- **Building-type set.** The NIST mode is limited to the eleven DOE commercial prototype building types; it does not interpolate to arbitrary buildings.
- **Successor guidance.** PNNL-18898 has not been revised since 2009. The NIST correlations (2015–2019) are its methodological successor for commercial infiltration in EnergyPlus and are the basis of the Section 6 mode.

9. Deployment

The tool is a single self-contained HTML file deployed under the idlboise.com files directory and surfaced through a Drupal landing page on the *Infiltration Equations & Conversions* content node. The landing page embeds the live tool, links to it for full-screen use, and restates the definitions, methodology, and sources. Both follow IDL branding (University of Idaho Pride Gold, black headers, Cambria headings, Calibri body). The companion methodology guide documents the conversion mathematics in full and is maintained alongside this memo.

```
Tool:    /sites/default/files/design-tools/Infiltration_Rate_Converter/infiltration-converter.html
Landing: /content/infiltration-equations-conversions-0  (Drupal node body, Full HTML)
```

10. References

Gowri, K., Winiarski, D., & Jarnagin, R. (2009). *Infiltration Modeling Guidelines for Commercial Building Energy Analysis* (PNNL-18898). Pacific Northwest National Laboratory.

Ng, L. C., Ojeda Quiles, N., Dols, W. S., & Emmerich, S. J. (2018). Weather correlations to calculate infiltration rates for U.S. commercial building energy models. *Building and Environment*, *127*, 47–57. doi:10.1016/j.buildenv.2017.10.029.

National Institute of Standards and Technology. *Infiltration inputs dataset* (accompanying the NIST infiltration correlations). doi:10.18434/mds2-2598.

Ng, L. C., Persily, A. K., & Emmerich, S. J. (2014). *An Improved Method of Modeling Infiltration in Commercial Building Energy Models* (NIST Technical Note 1829).

U.S. Department of Energy. *EnergyPlus Input Output Reference* — ZoneInfiltration:DesignFlowRate.

Brown, G. Z., & DeKay, M. *Sun, Wind & Light: Architectural Design Strategies* (3rd ed.). — methodology context for IDL's climate-analysis tool suite.