Infiltration/Exfiltration

- Unintended outdoor air leaking into (infiltration) or out of (exfiltration) the building
- Empirically determined by performing a blower door test, where the building is pressurized and depressurized to reach a pressure differential (50Pa for houses). The flowrate to maintain that differential is the air leakage rate, expressed as the Power law

$$Q = C\,(\Delta P)^n$$

$$Q - flowrate\ \ in\ \frac{L}{s \cdot m^2}$$

$$C - flow\ coefficient\ in\ \frac{L}{s\, m^2 Pa^n}; building\ specific$$

$$\Delta P - pressure\ differtial\ in\ Pa$$

$$n - pressure\ coefficient\ (\sim 0.67\ for\ most\ buildings)$$

- Other ways to characterize the leakage is usually expressed as:
  - Air change per hour @ 50 Pa
  - Flow coefficient
  - Effective leakage area
- The effective leakage area converts the leakage rate of a building to an equivalent opening (i.e. summing the area of all cracks/gaps)

$$A_L = 10000 Q_{\Delta P} \frac{\sqrt{\rho/2\Delta P}}{C_d}$$

$$A_L - equivalent\ leakage\ area\ [cm^2]\ at\ \Delta P\ [Pa]$$

$$Q_{\Delta P} - air\ leakage\ rate\ at\ \Delta P\ [\frac{m^3}{s}]$$

$$\rho - density\ of\ the\ air\ \left[\frac{kg}{m^3}\right]$$

$$\Delta P_r C_d - discahrge\ coefficient = 1$$

Infiltration modelling OpenStudio

The infiltration is modelled using the effective leakage area model:

$$Infiltration = (F_{Schedule})\,\frac{A_L}{1000}\sqrt{C_s \Delta T + C_w (WindSpeed)^2}$$

$$F_{schedule} - is\ a\ schedule\ value\ (0\ to\ 1)\ [-]$$

$$A_L - equivalent\ leakage\ area\ [cm^2]\ at\ 4\ Pa$$

$$\Delta T - indoor - outdoor\ temperature\ difference$$

$$C_s\ and\ C_w - stack\ and\ wind\ coefficient\ [-]$$

This equation is different from the previous equation used to estimate the A_L based on blower door test results because this equation accounts for stack and wind effects in operation.

In order to use this model, the blower door test result 1 ACH @ 50 Pa needs to be translated into into $A_{L,\ 4\,Pa}$.

First, convert the ACH to a flowrate,

$$Volume\ of\ building\ (excl.garage) = 676.07\ m^3 \rightarrow\ Q_{50\,Pa} =\ 676.07\ \frac{m^3}{hr} = 0.188\ \frac{m^3}{s}$$

The blower door test results can be characterized as

$$Q_{50\,Pa} = C_{50}\ (10)^n$$

Similarly, the 4 Pa infiltration rate can be characterized as

$$Q_{4\,Pa} = C_4\ (4)^n$$

Some manipulation yields

$$\frac{Q_{50\,Pa}}{Q_{4\,Pa}} = \frac{C_{50}\ (50)^n}{C_4\ (4)^n}$$

Assume

$$C_{10} =\ C_4\ and\ n = 0.67$$

Then

$$Q_{4\,Pa} = Q_{50\,Pa}\ \frac{C_4\ (4)^n}{C_{50}\ (50)^n}$$

$$Q_{4\,Pa} = (0.188)\ \frac{4}{50}^{0.67}$$

$$Q_{4\,Pa} = 0.0346\ \frac{m^3}{s}$$

Substituting it into the equation for estimating the effective leakage area, yields

$$A_L = 134.052\ cm^2\ @\ 4Pa$$