1. Thermal Transmittance (U-value) for Multi-layer Walls

October 5, 2025

The most basic calculation is for the thermal transmittance of building elements in contact with external air (walls, roofs, etc.), which uses the formula U = 1/RT, where RT is the total thermal resistance.

[2]:
```python
import numpy as np
# import pandas as pd

import sys
# print(sys.path)
sys.path.append("..")
from pycte import ureg, Quantity

def calculate_wall_u_value(layers, position="vertical"):
    """
    Calculate the U-value of a wall with multiple layers

    Parameters:
    layers: list of tuples (thickness in m, thermal conductivity in W/mK)
    position: "vertical", "horizontal_upward", "horizontal_downward"

    Returns:
    U-value in W/m²K
    """
    # Define surface resistances based on position
    # default is vertical
    Rsi = 0.13  # Interior surface resistance
    Rse = 0.04  # Exterior surface resistance
    if position == "vertical":
        Rsi = 0.13  # Interior surface resistance
        Rse = 0.04  # Exterior surface resistance
    elif position == "horizontal_upward":
        Rsi = 0.10
        Rse = 0.04
    elif position == "horizontal_downward":
        Rsi = 0.17
        Rse = 0.04
```

```
    # Calculate resistance of each layer
    layer_resistances = [thickness/conductivity for thickness, conductivity in␣
 ↪layers]

    # Calculate total resistance
    RT = Rsi + sum(layer_resistances) + Rse

    # Calculate U-value
    U = 1 / RT

    return U
```

```
['C:\\Python313', 'C:\\Python313\\Scripts', 'C:\\Python313\\DLLs',
'C:\\Python313\\python313.zip', 'C:\\Python313\\Lib', '',
'C:\\Python313\\Lib\\site-packages', 'C:\\Python313\\Lib\\site-packages\\win32',
'C:\\Python313\\Lib\\site-packages\\win32\\lib', 'C:\\Python313\\Lib\\site-
packages\\Pythonwin']
```

[3]:
```
# Example wall composition (thickness in m, thermal conductivity in W/mK)
wall_layers = [
    (0.015, 0.35),    # Interior plaster
    (0.11, 0.52),     # Brick
    (0.05, 0.031),    # Thermal insulation
    (0.11, 0.52),     # Exterior brick
    (0.015, 0.8)      # Exterior mortar
]

u_value = calculate_wall_u_value(wall_layers)
print(f"Wall U-value: {u_value:.3f} W/m²K")
```

```
Wall U-value: 0.441 W/m²K
```