✅ About Model Inputs

This is a machine learning model trained on building performance data to predict monthly total energy consumption and Energy Use Intensity (EUI). It evaluates how different building features, envelope properties, and operational factors influence energy usage.

📌 Building Type

The model uses numeric encoding for building type:

0 – Bungalow

1 – Detached

2 – Semi-Detached

3 – Terraced

📌 Input Parameters & Valid Ranges

The model accepts 13 building features, each with a defined and validated range:

Floor Insulation U-Value: 0.15 – 1.60

Door Insulation U-Value: 0.81 – 5.70

Roof Insulation U-Value: 0.07 – 2.28

Window Insulation U-Value: 0.73 – 5.75

Wall Insulation U-Value: 0.10 – 2.40

HVAC Efficiency (COP): 0.30 – 4.50

Domestic Hot Water Usage: 0.50 – 3.50

Lighting Density: 1 – 9

Occupancy Level: 1 – 6

Equipment Density: 1 – 21

Window-to-Wall Ratio (WWR): 0 – 70%

Total Building Area: 85.91 – 130.81 m^2

📌 How to Calculate U-Values (for Insulation Inputs)

Step 1 — Calculate thermal resistance of each layer

For every building material in the element (brick, plaster, insulation, etc.):

```
R = d / k
```

Where: -
d = thickness of the material (meters) **k** =
thermal conductivity (W/m·K)
Compute **R** for each layer individually.

Step 2 — Add internal & external surface resistances

Add surface resistances to obtain total thermal resistance:

```
Rt = Rsi + R1 + R2 + ... + Rse
```

Where: -
Rsi = internal surface resistance
Rse = external surface resistance

Step 3 — Compute U-Value (Thermal Transmittance)

Take the reciprocal of the total thermal resistance:

```
U = 1 / Rt
```

Unit: **W/(m²·K)**

U-Values directly impact predicted building energy consumption —[1]

better insulation generally results in lower monthly energy usage and improved performance category.

How to Calculate Window-To-Wall Ratio (WWR)

Calculating the **Window-to-Wall Ratio (WWR)** is a straightforward process, but it requires precise definitions of "wall area" to avoid the most common mistake: using the *net* wall area instead of the *gross* wall area.

The Formula

The standard formula for Window-to-Wall Ratio is:

$$WWR = \frac{\text{Total Glazing Area}}{\text{Gross Exterior Wall Area}}$$

To express this as a percentage, simply multiply the result by 100.

Step-by-Step Calculation Guide

Step 1: Measure the Total Glazing Area (A_g)

This is the total surface area of all window openings.[2]

- What to include: Standard practice (ASHRAE, LEED, and most building codes) requires you to measure the entire rough opening. This means you include the glass + the window frame + the sash.[3]
- Formula: Width of Window\Height of Window
- Summation: If you have multiple windows, calculate the area for each and add them together.

Step 2: Measure the Gross Exterior Wall Area (A_{wall})

This is the **most critical step**. The "Gross Wall Area" is the total surface area of the façade, **including** the windows.

- **What to include:** The solid opaque wall **PLUS** the window areas you calculated in Step 1.
- **Formula:** Total Width of Façade\Total Floor-to-Floor Height
- **Note:** Do not subtract the window openings.[5] Measure the wall as if it were one solid block without holes.

Step 3: Divide and convert

Divide the Total Glazing Area (Step 1) by the Gross Exterior Wall Area (Step 2)

📌 How to Calculate HVAC efficiency (COP)

Calculating the **Coefficient of Performance (COP)** for an HVAC system is a measure of how efficiently the system moves heat.

Unlike standard "efficiency" (which is usually a percentage under 100%), COP is a ratio that is almost always **greater than 1** (or 100%) because the system is moving heat rather than creating it from scratch.

The Formula

The basic formula for COP is:

$$COP = \frac{\text{Power Output(Heating or cooling)}}{\text{Power Input (Electricity)}}$$

Power Output: The amount of heat the system moves (cools or heats)

Power Input: The amount of electricity the system consumes to do that work.

Conversion Factor:

$$\text{Watt} \approx 3.14 \text{ BTU/hr}$$

BTU stands for **British Thermal Unit**.

Step-by-Step Calculation Example

Imagine you have a Heat Pump with the following specs:

- **Cooling Capacity:** 36,000 BTU/hr (often called a "3-ton" unit)
- **Power Consumption:** 3,000 Watts

Step 1: Convert Output to Watts

Since the input is in Watts, we must convert the 36,000 BTU/hr output into Watts.

$$36{,}000 \ \text{BTU/hr} \div 3.14 = 10.557 \quad \text{Watts (approx)}$$

Step 2: Divide Output by Input

$$COP = \frac{10{,}557 \ \text{Watts (Output)}}{3{,}000 \ \text{Watts (Input)}}$$

Step 3: Result

$$\text{COP} = 3.52$$

📌 How to Calculate Internal Loads

To calculate internal loads for building energy analysis or HVAC sizing, you need to quantify the heat generated by lights, people, equipment, and water heating.

Here is the step-by-step calculation guide for each category.

1. Lighting Power Density (LPD)

LPD represents the lighting load per unit of floor area.[1] It is a critical input for energy codes (like ASHRAE 90.1).[2]

- The Formula:

$$\text{LPD} = \frac{\text{Total Lighting Wattage (W)}}{\text{Gross Floor Area}(\text{m}^{2})}$$

- **How to Calculate:**
    1. **Sum the Wattage:** Add up the rated wattage of all fixtures in the space (include balast factors if applicable).[3]
    2. **Measure Area:** Determine the total floor area of the illuminated space.
    3. **Divide:** Divide the total watts by the total area.[4]
- Example:

An open office (1,000 ft^2) has 40 light fixtures, each rated at 25W.

$$\text{LPD} = \frac{40 \times 25\ \text{W}}{1{,}000\ \ \text{m}^2} = \frac{1{,}000\ \ \text{W}}{1{,}000\ \ \text{m}^2} = 1.0\ \text{W/m}^2$$

2. Equipment Power Density (EPD)

This measures the heat generated by "plug loads" like computers, printers, and screens.

- The Formula:

$$\text{EPD} = \frac{\text{Total Equipment Wattage (W)}}{\text{Total Floor Area }(\text{m}^{2})}$$

- **How to Calculate:**
    1. **List Equipment:** Count all computers, monitors, copiers, etc.
    2. **Apply Diversity Factor:** Equipment rarely runs at 100% nameplate rating simultaneously. A standard diversity factor (e.g., 50% to 75%) is usually applied to the nameplate wattage.
    3. Calculate:

$$\text{Total W} = (\text{Sum of Nameplate Watts}) \times \text{DIversity Factor}$$

- Example:

An office has 10 computers rated at 200W each. You estimate they run at 50% capacity on average.

$$\text{Load} = 10 \times 200\ \text{W} \times 0.50 = 1{,}000\ \text{W}$$

3. Domestic Hot water Usage:

Calculating Domestic Hot Water (DHW) usage in $L/m^2/day$ is rarely a direct input in building codes. Instead, it is a derived value calculated by combining the *occupancy density* (people per square meter) with the *usage per person*.

Here is the step-by-step method to calculate it.

The Formula

To get Liters per square meter per day ($L/m^2/day$), you combine two standard metrics:

$$\text{DHW}_{\text{area}} = \frac{\text{Daily Usage per Person(L/day)}}{\text{Area per Person }(\text{m}^{2\ /\text{person}})}$$

- Numerator: How much hot water one person uses (based on building type).
- Denominator: How much space one person occupies (Occupancy Density).

Example: Residential Apartment

- Usage: 80 Liters/person/day (Showers, cooking, laundry)
- Density: 1 person per 40 m^2

$$\mathrm{DHW}_{\mathrm{area}} = \frac{80\ \mathrm{L/person}}{40\ \mathrm{m}^2\ /\mathrm{person}} = 2.0\mathrm{L/m^2/day}$$

📌 How to Calculate Total Building Area

Calculating **Total Building Area**, often technically referred to as **Gross Floor Area (GFA)**, is the starting point for almost all energy and HVAC calculations.

It is generally defined as the sum of the floor areas of the spaces within the building, including basements, mezzanines, and intermediate-floored tiers.

How to Calculate It

The standard engineering method (ASHRAE/BOMA) measures from the **outside face** of the exterior walls.

The Formula

$$\text{Total Area} = \text{Number of Floors} \times (\text{Length} \times \text{Width})$$

✅ How the Model Works

Feature Extraction:

The user-provided input values are validated against the model's expected ranges.

Energy Prediction:

The machine learning model computes:

Monthly Total Energy Consumption (kWh)

Energy Use Intensity (EUI) in kWh/m² **Performance**

Classification:

Based on the EUI value, the system assigns a performance category:

Excellent

Moderate

Poor

Impact Analysis:

The model identifies factors contributing to high energy usage—such as poor insulation, low HVAC efficiency, or high internal loads. Personalized Recommendations:

The system provides targeted suggestions:

Improve insulation U-values

Reduce lighting/equipment density

Optimize HVAC systems

Adjust WWR or shading strategies

📌 Benefits

Understand your building's monthly energy performance
Find inefficiencies quickly
Receive tailored recommendations
Lower energy bills & operational costs
Make evidence-based decisions for retrofits and improvements they give me