Acceleration of energy model input

Summer internship defense 2023

Université de Strasbourg

Iman BARKAN , Wednesday, 23 August 2023

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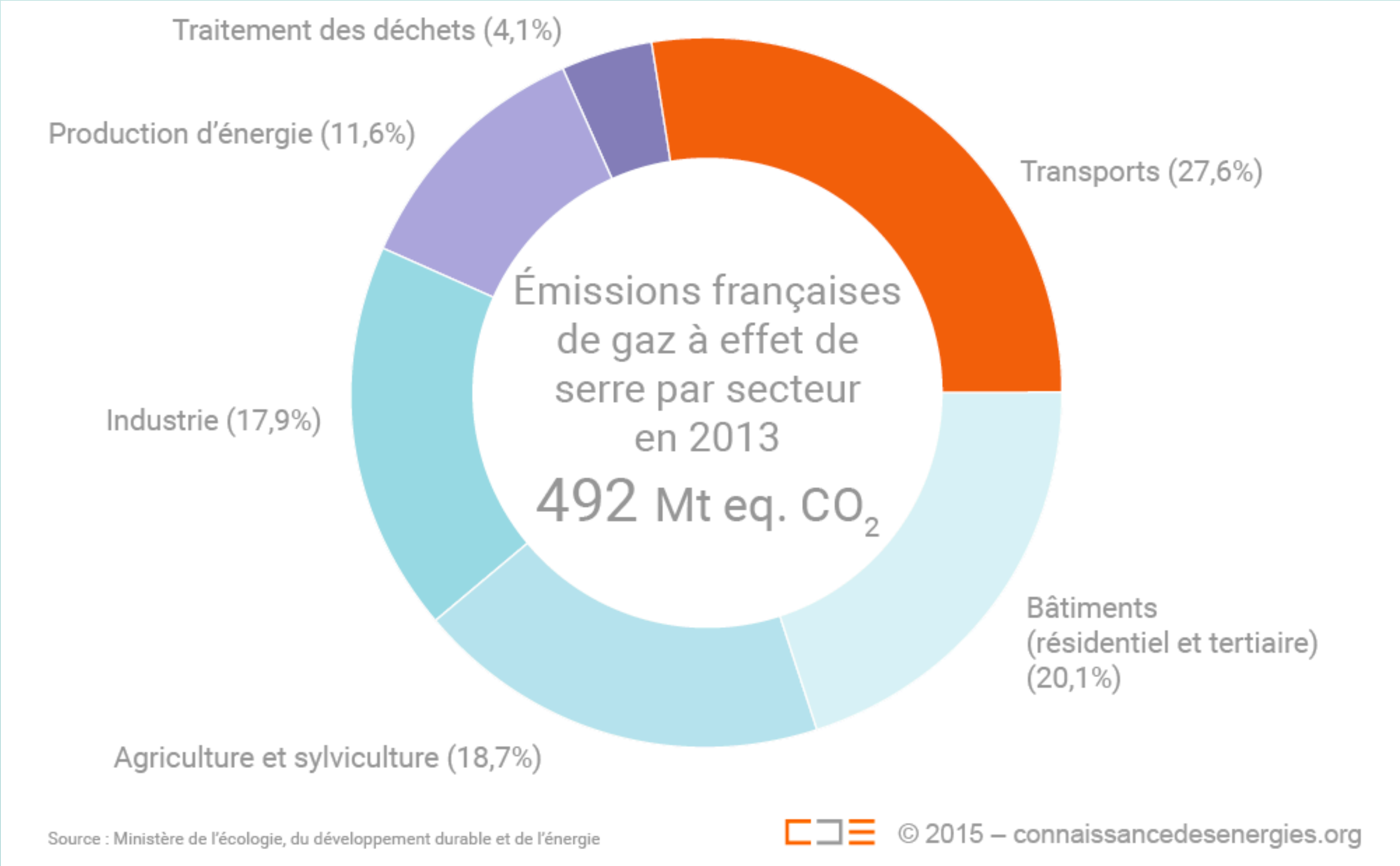
1- INTRODUCTION AND OBJECTIVES

Introduction

National Energy Conservation Context:

- Goal: Reduce energy consumption by 10% by 2024.
- Building industry in France:
  - ➡Major energy consumer.
  - ➡Accounts for 25% of national greenhouse gas emissions.



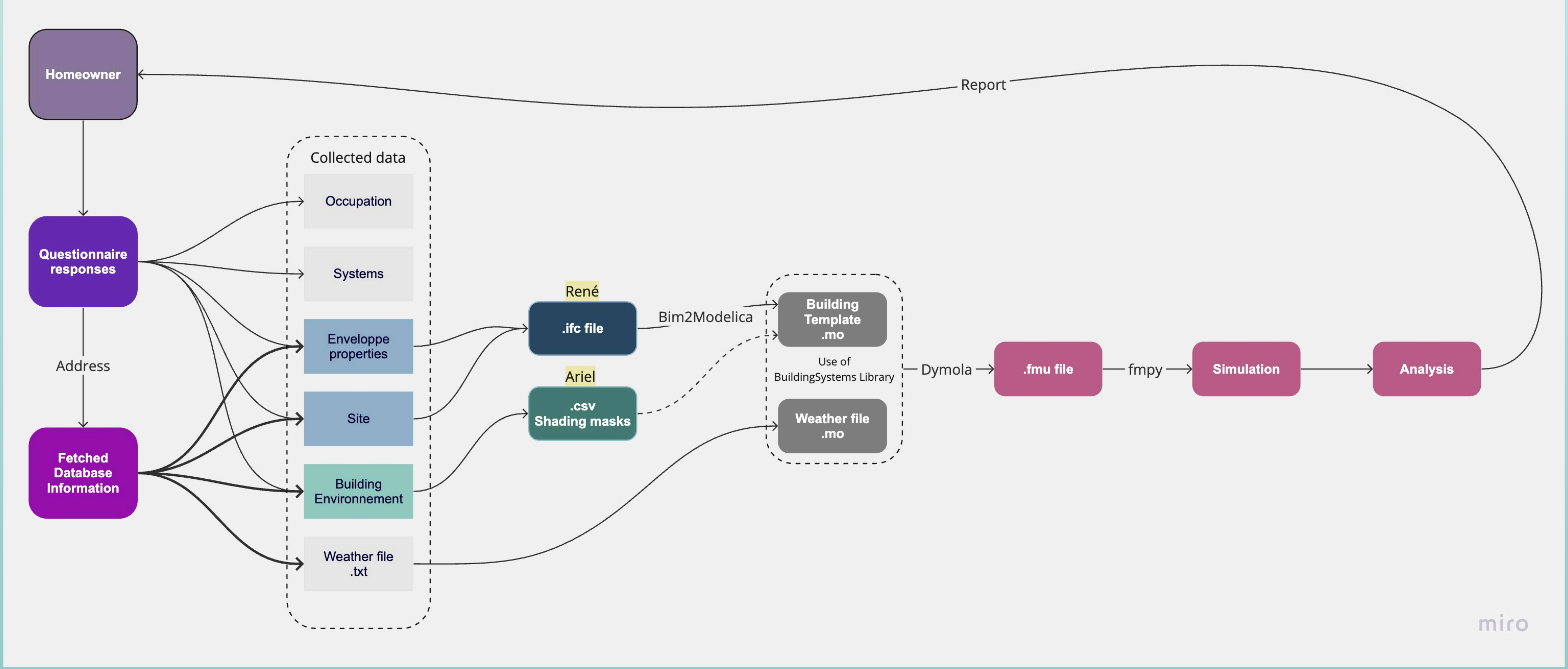
Cemosis & ILoomi Collaboration:

Main Goals:

✓ILoomi's comprehensive homeowner questionnaire development.

✓Automate creation of energy models at building scale using building geometry.

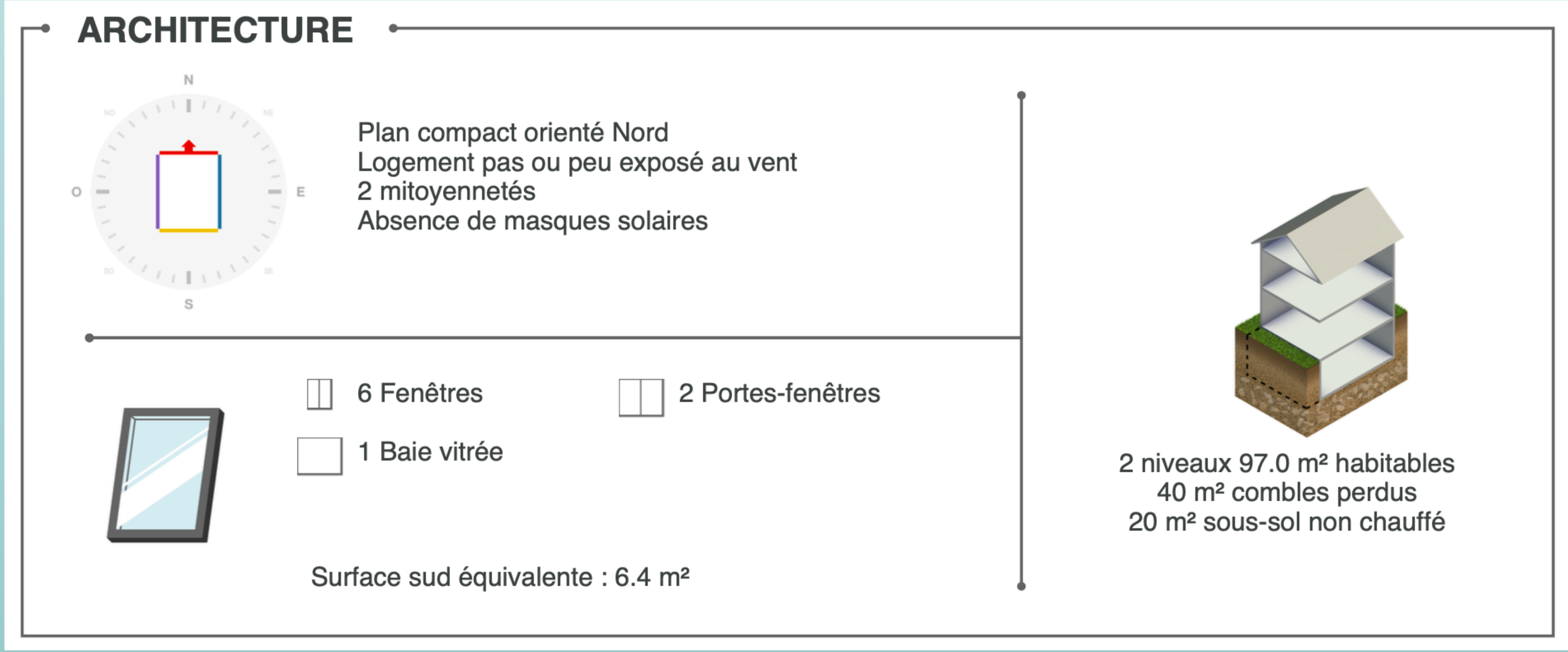
Workflow Diagram of the Energy Model Input Process



2- TEST CASE PRESENTATION

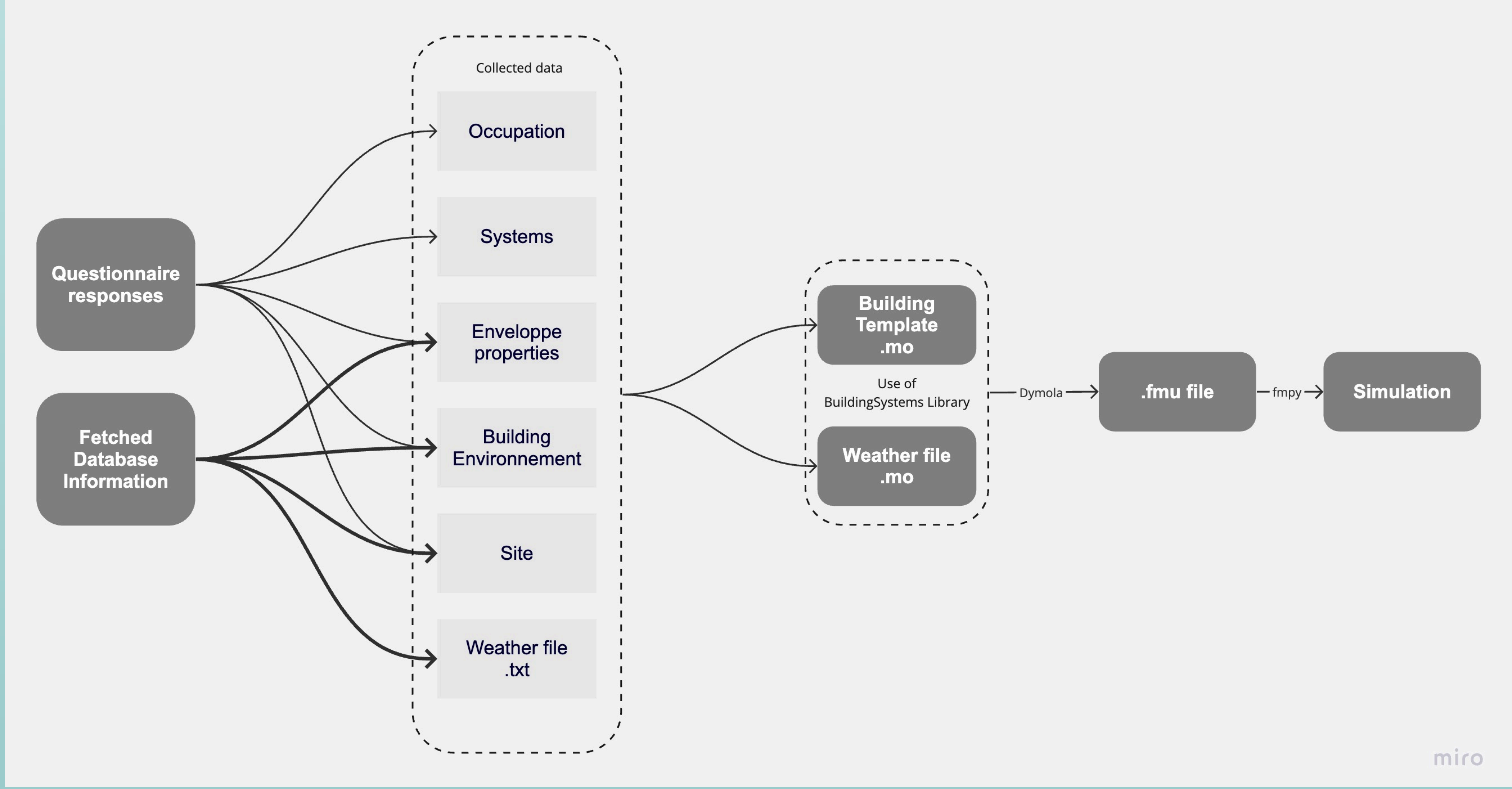
Introducing ILoomi's Single House Test Case

54 Av. de Paris, 59155 Faches-Thumesnil



Excerpt from the energy audit provided by iLoomi

3- BUILDING DATA COLLECTION



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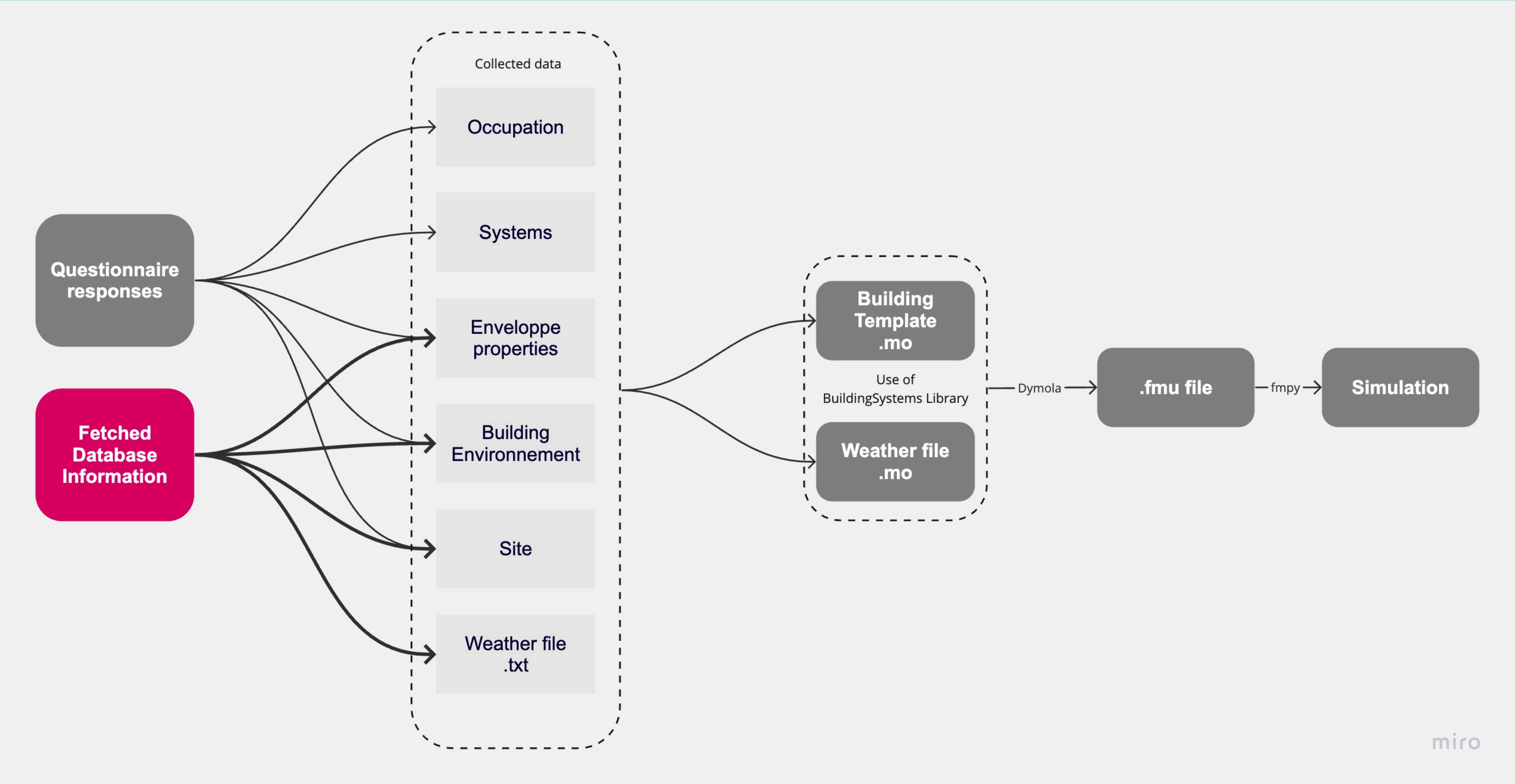
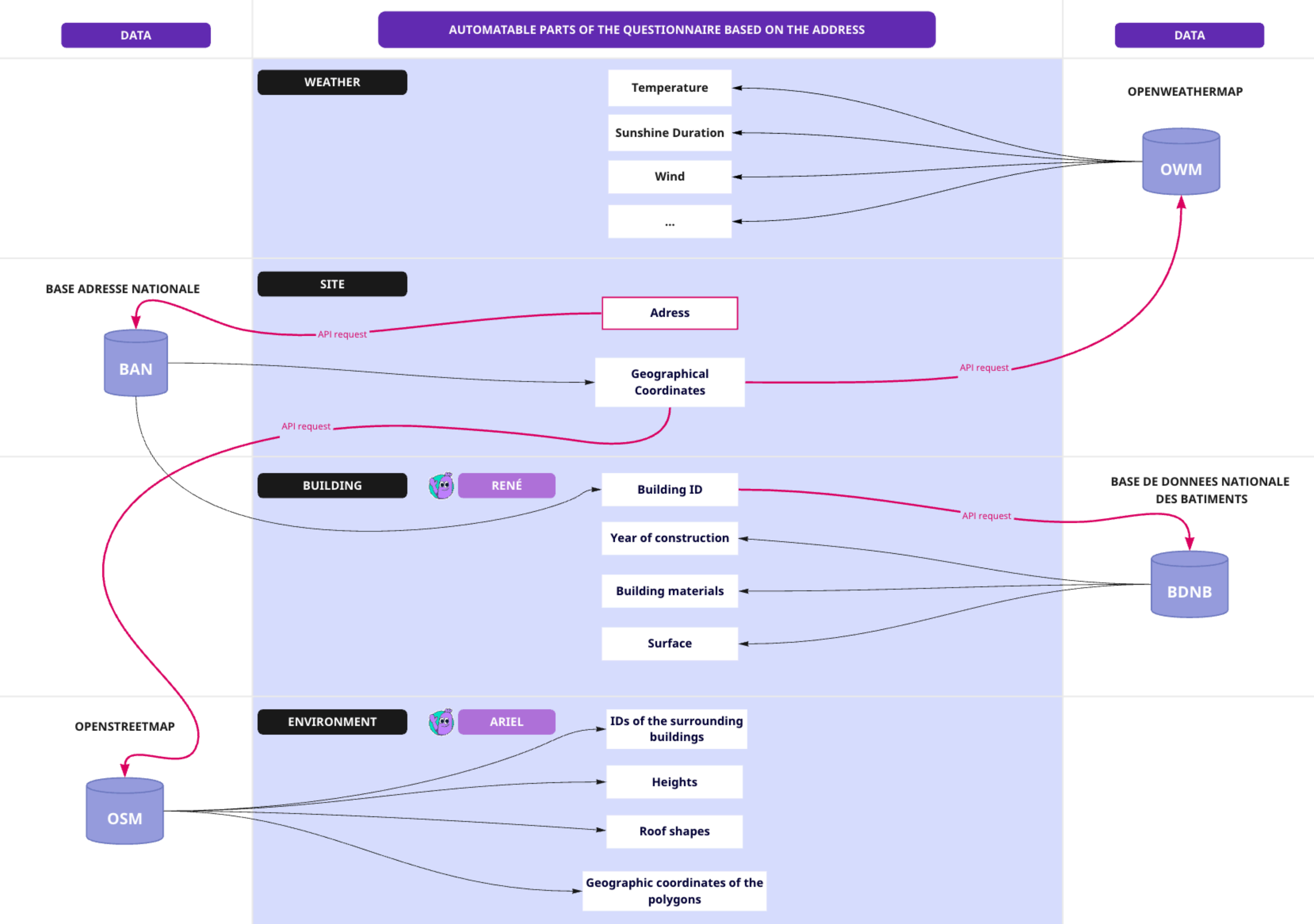
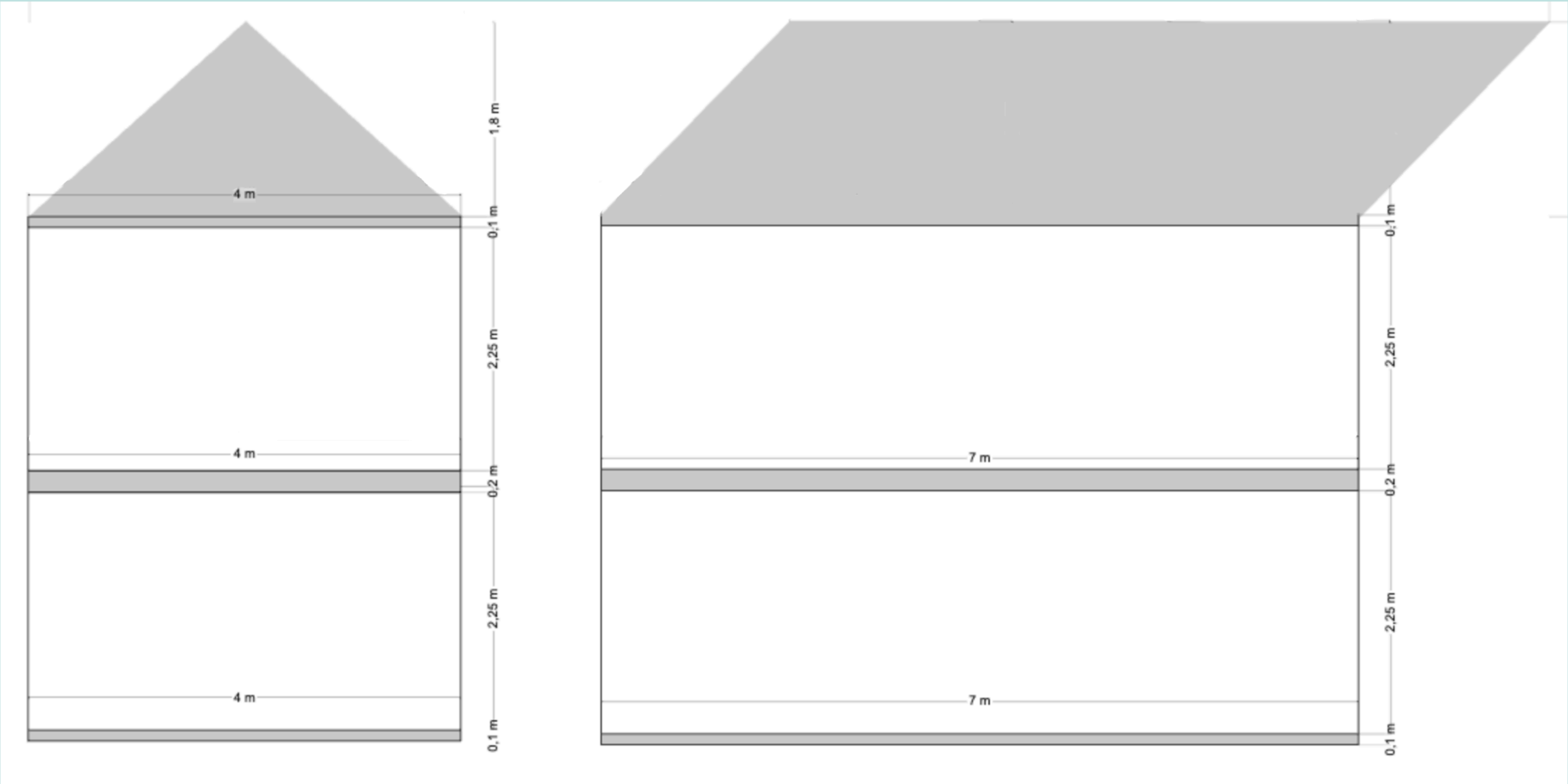


Overview of the automated data collection process

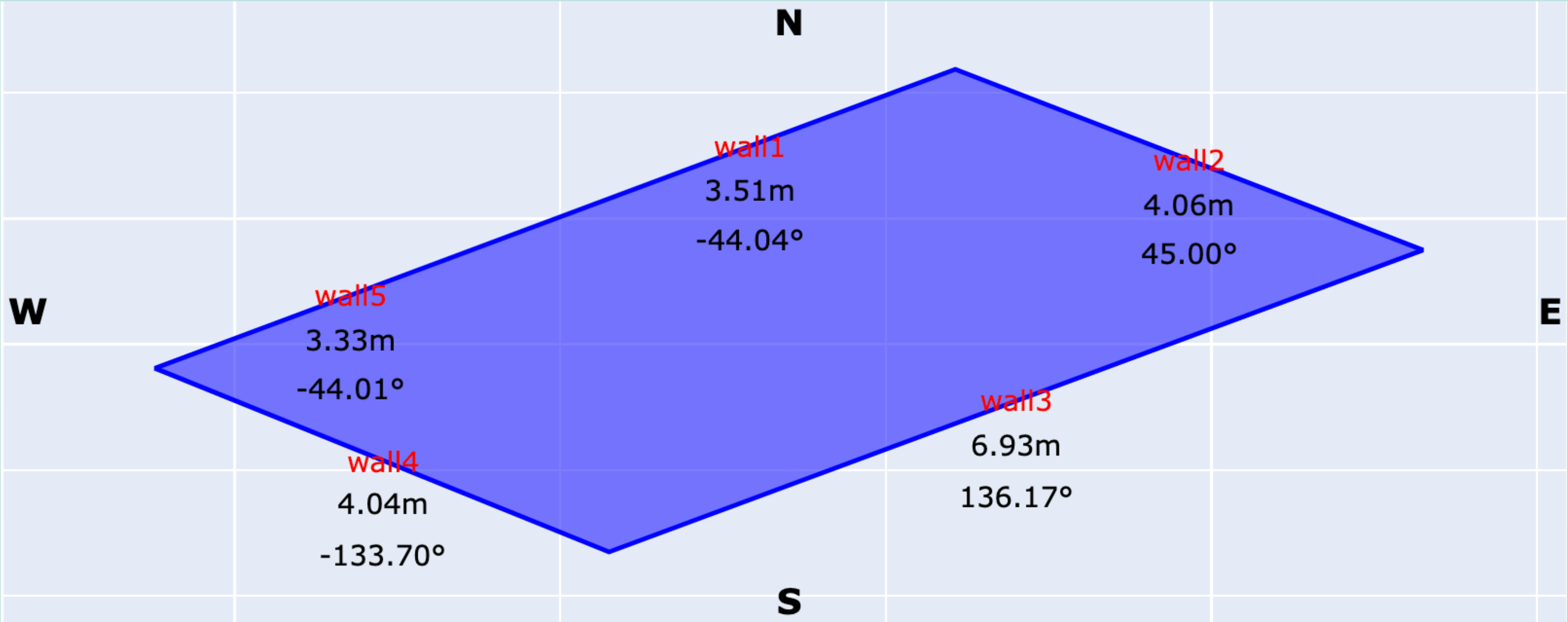


Additional details in the « Usage » subsection of the report

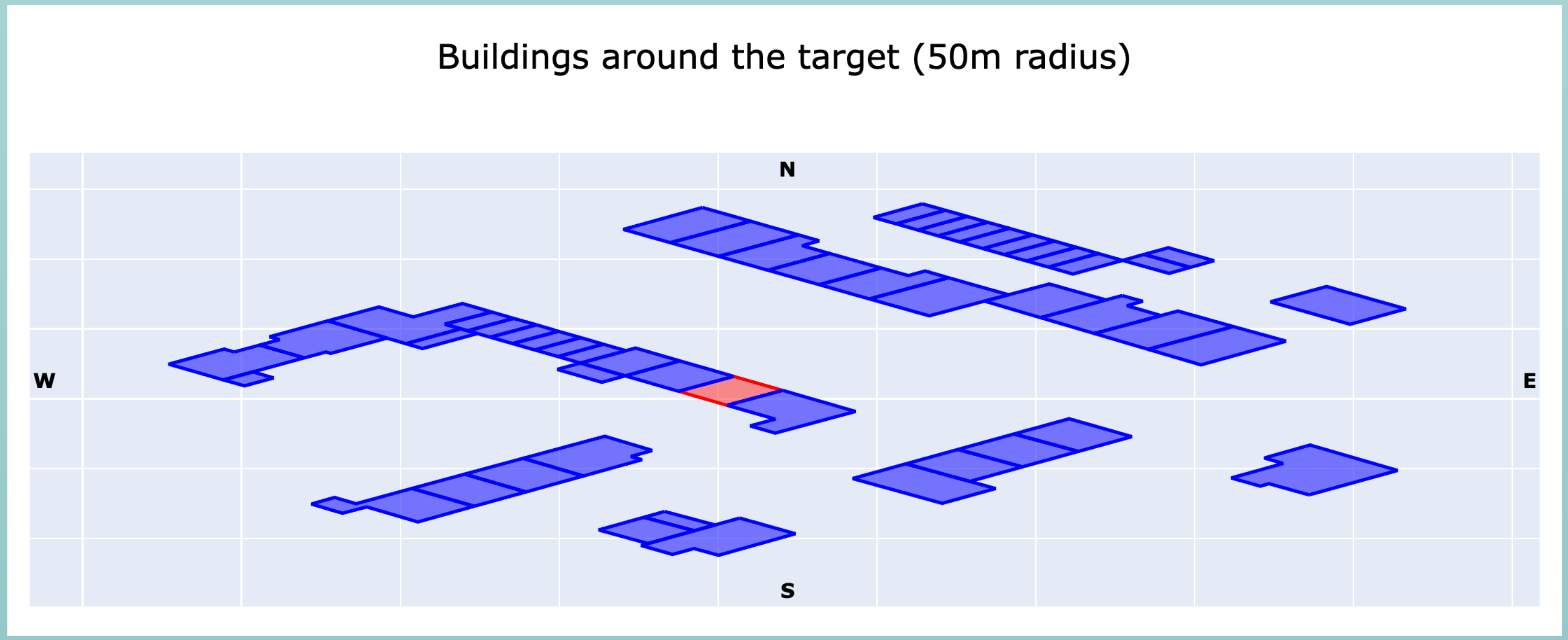
Descriptive plans of the studied piece



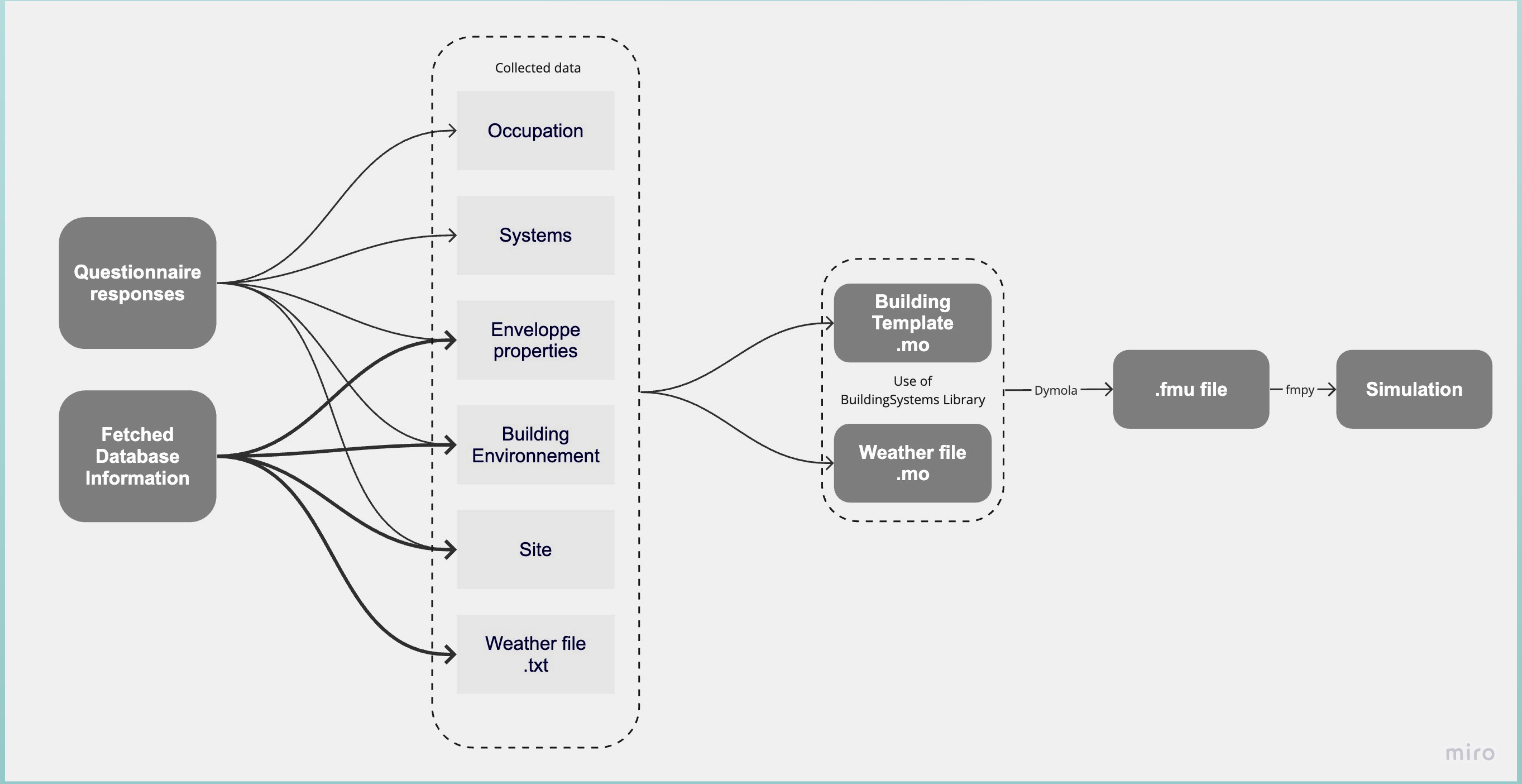
ILoomi's Test Case House: Front View and Side View of the House



Wall's orientation (Obtained with our `Building` Module)



4- MULTIZONE BUILDING MODEL



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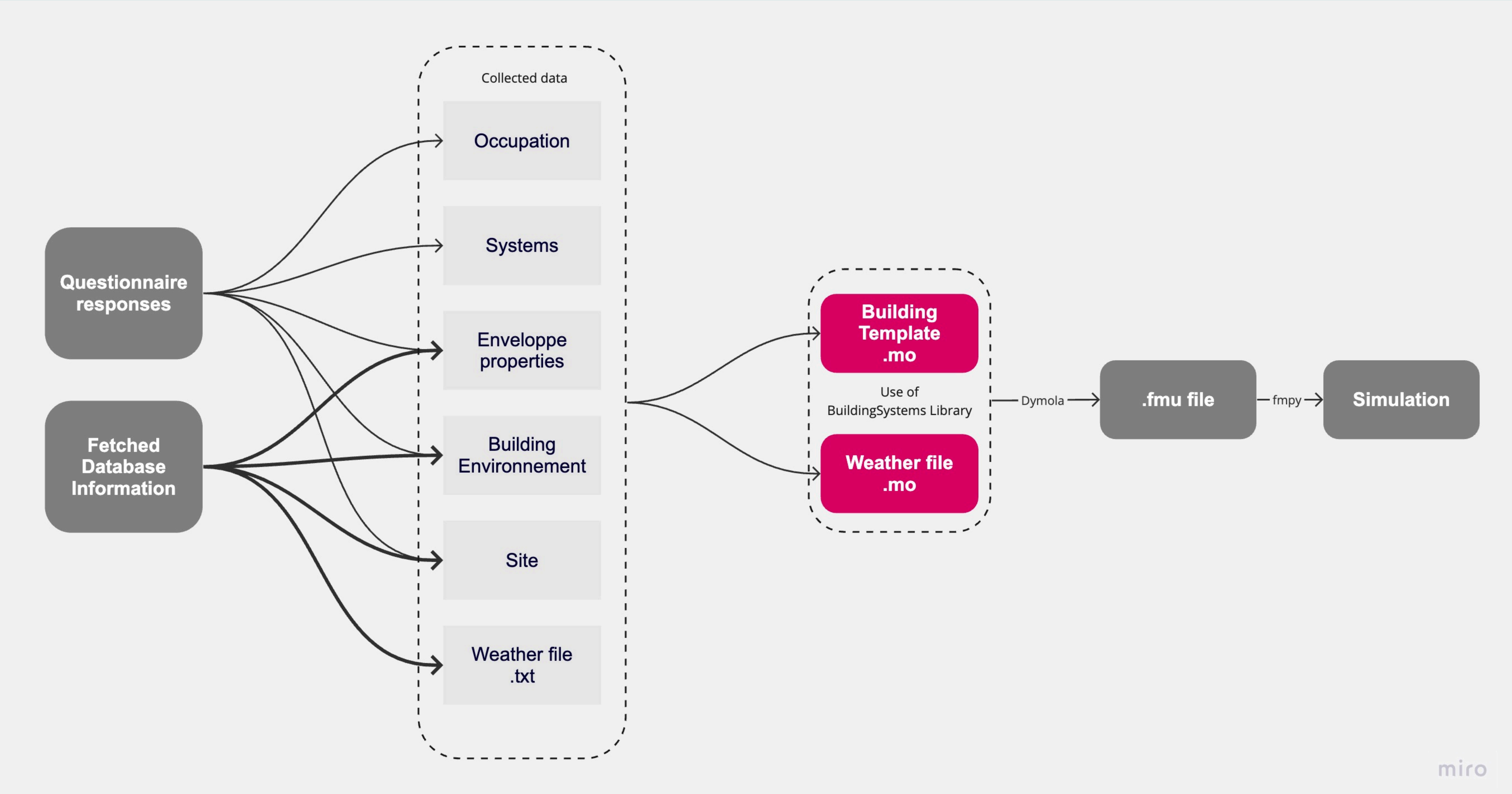


Thermal Modelisation

The heat transfer balance equation:

$$\begin{cases} m_i C p_i \dfrac{\partial T_i}{\partial t} = DFS + \sum_i h_{xij} S_i (T_j - T_i) + \Phi_i \\ m_i = \rho_i V_i \end{cases}$$

Where :

$DFS = \alpha_i G_i \left(W \cdot m^{-2}\right)$

- DFS : Solar Flux Density absorbed by the material (i)
- α_i : Absorptivity coefficient of the material (i)
- G_i : Solar flux density incident on the surface of the medium (i)
- Φ_i : Source or heat sink in ($W \cdot m^{-2}$)
- j : Index of the medium for which (T_j) is a potential connected to potential (T_i)
- h_{xij} : Heat transfer coefficient according to mode x (conduction, convection, or radiation) between mediums i and j in $W/(m^2 \cdot K)$
- S_i : Area of the considered section in m^2

Thermo-physical properties of materials:

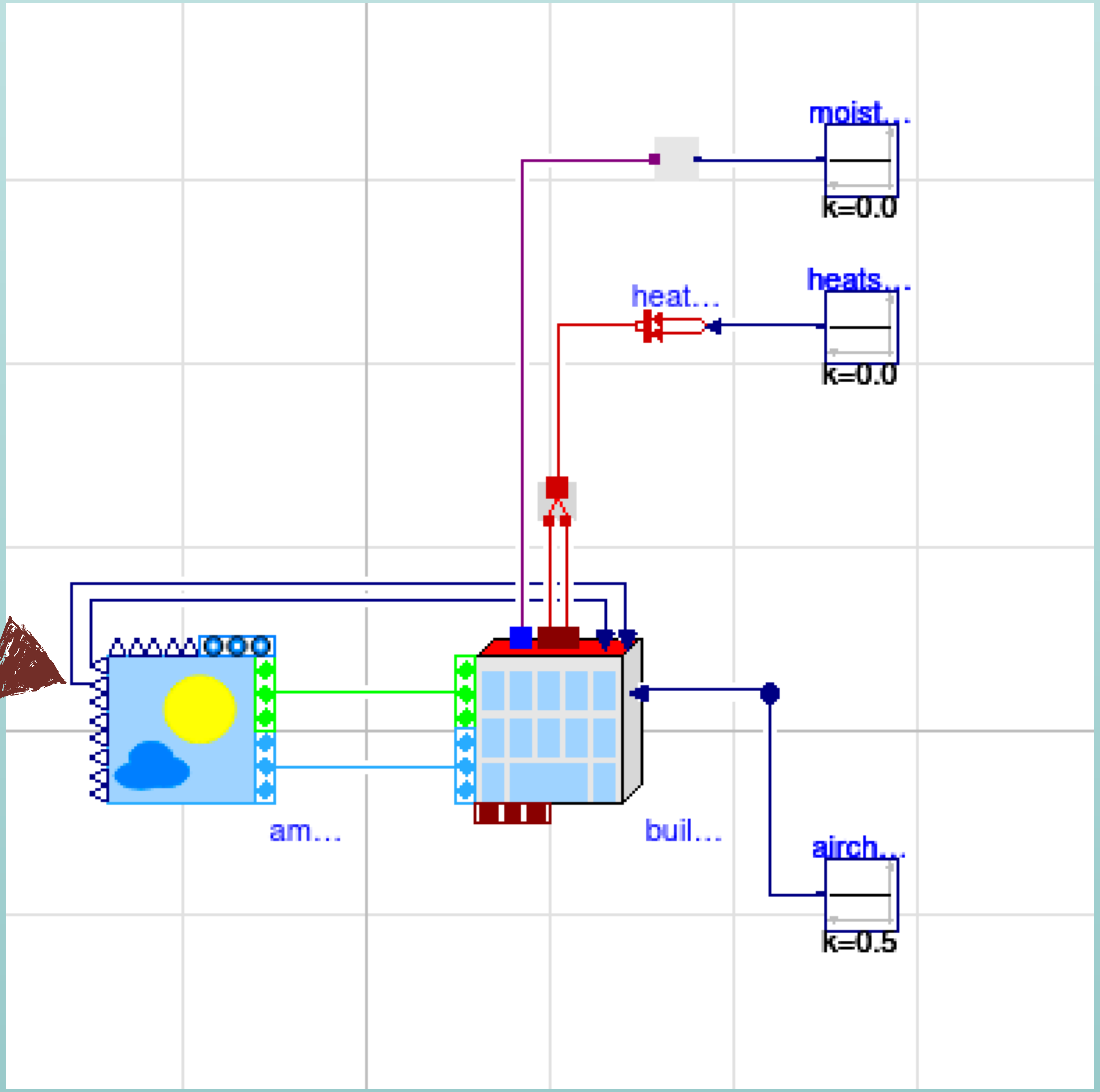
Construction	Material	Thermal Conductivity (W/mK)	Specific Heat Capacity (J/kgK)	Density (kg/m^3)
Walls	Brick	1.31	800	1700
Roofs	Terracotta Tiles	1.0	800	1400

Modelica's Thermal Model Implementation

IloomiBuildingTestCase_ASCII.mo

- Beam horizontal radiation
- Diffuse horizontal radiation
- Air temperature
- Wind speed
- Wind direction
- Relative humidity
- Cloud cover

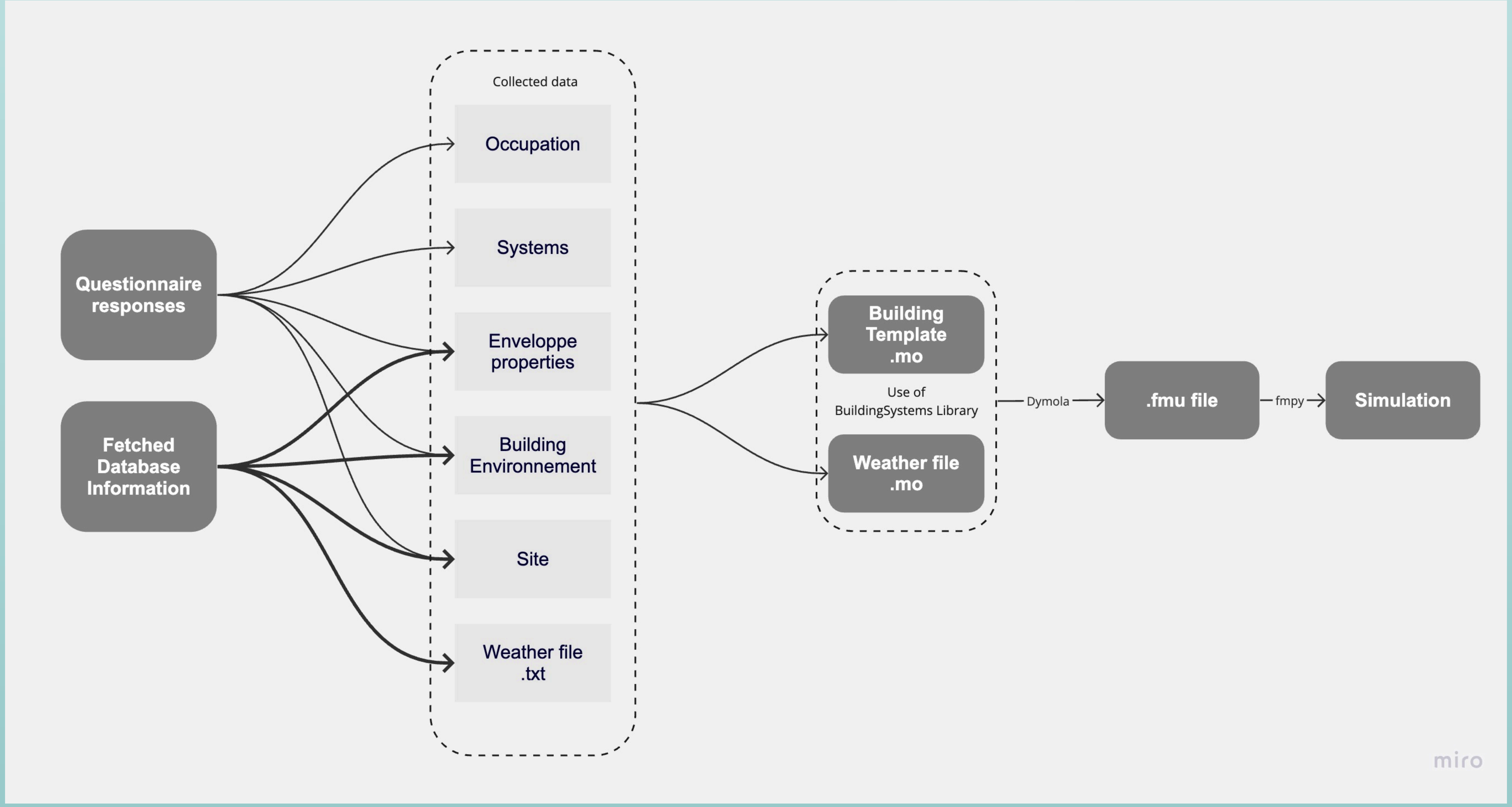
IloomiMultizoneTestCase.mo



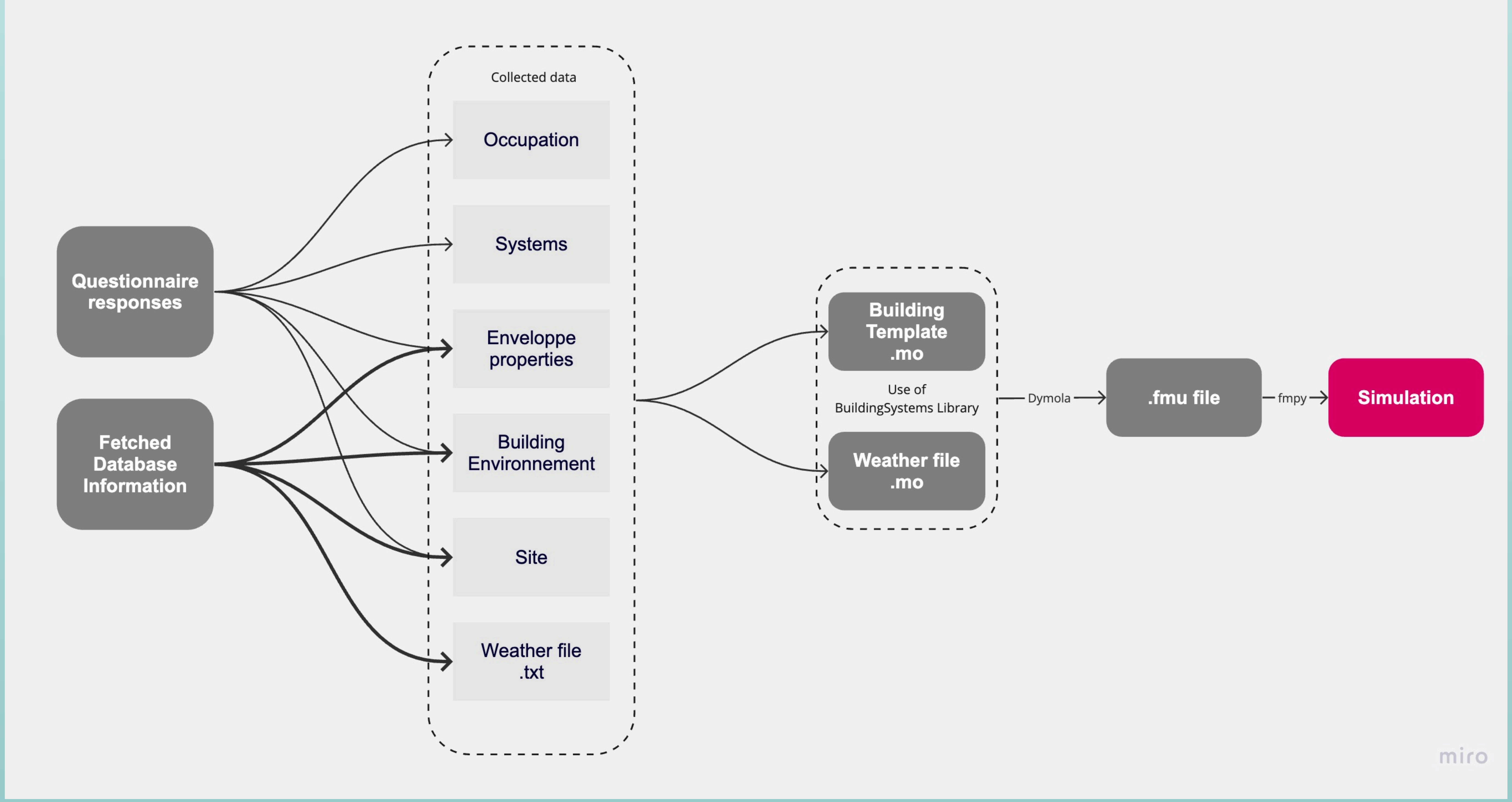
Graphical Representation of the 0D Model Captured in Dymola

Additional details in the « Numerical Modeling » subsection of the report

5- SIMULATION RESULTS AND ANALYSIS



5- SIMULATION RESULTS AND ANALYSIS



Simulation parameters

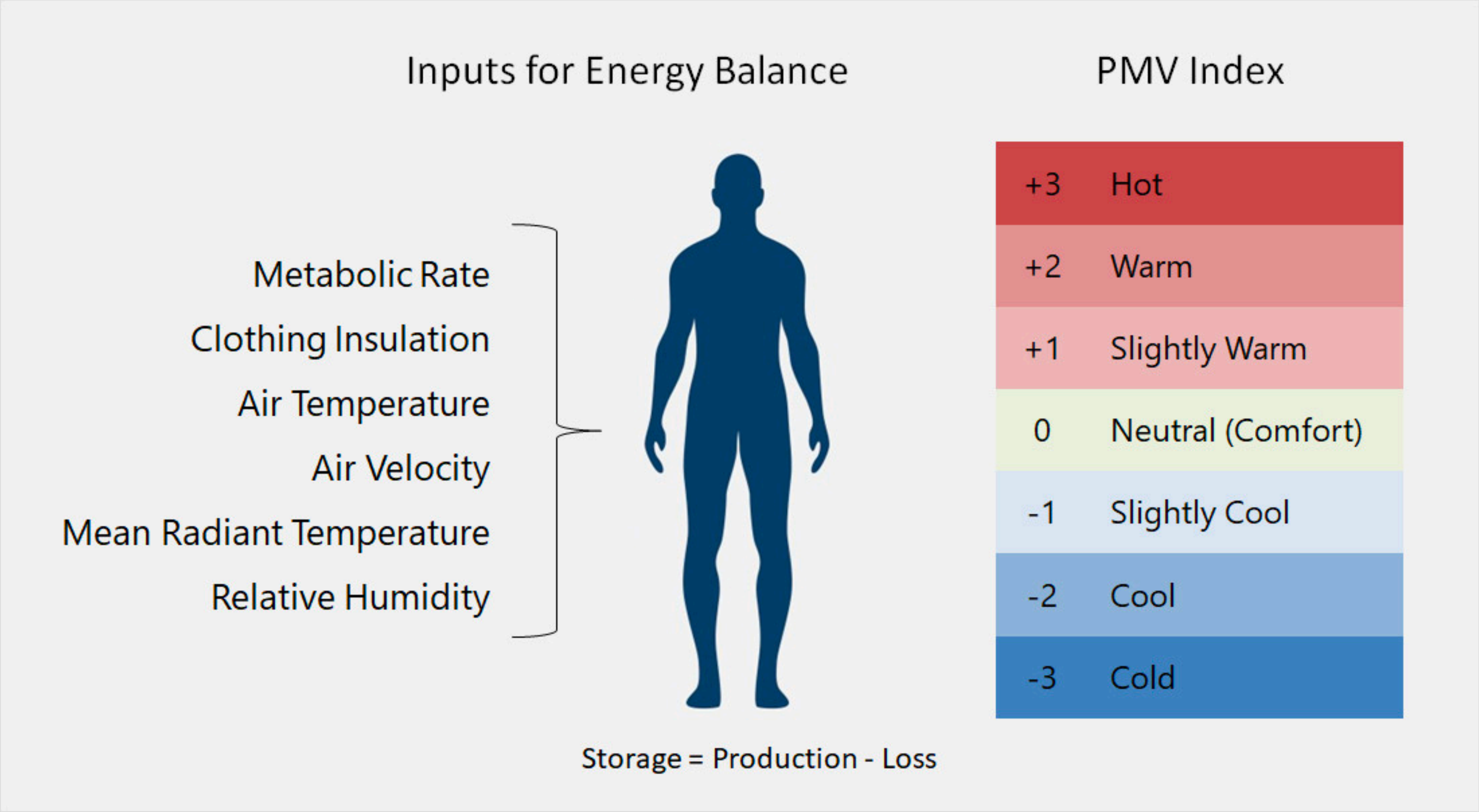
Parameters	Value
Wall Thickness	0.3 m
Roof Thickness	0.01 m
Clothing Insulation	0.5 clo
Metabolic Rate	1.2 met
T_start	20°C
Absortivity	0.5
Epsilon	0.9

Parameters	Value
Surface Temperatures	Off
Internal Heat Sources	On
Internal Moisture Sources	On
Air Paths	Off
Ventilation Rates	On
Ideal Heating & Cooling Loads	Off
Thermal Comfort	On
Hygrothermal Simulation	Off

Summary tables of the parameters used for the simulation

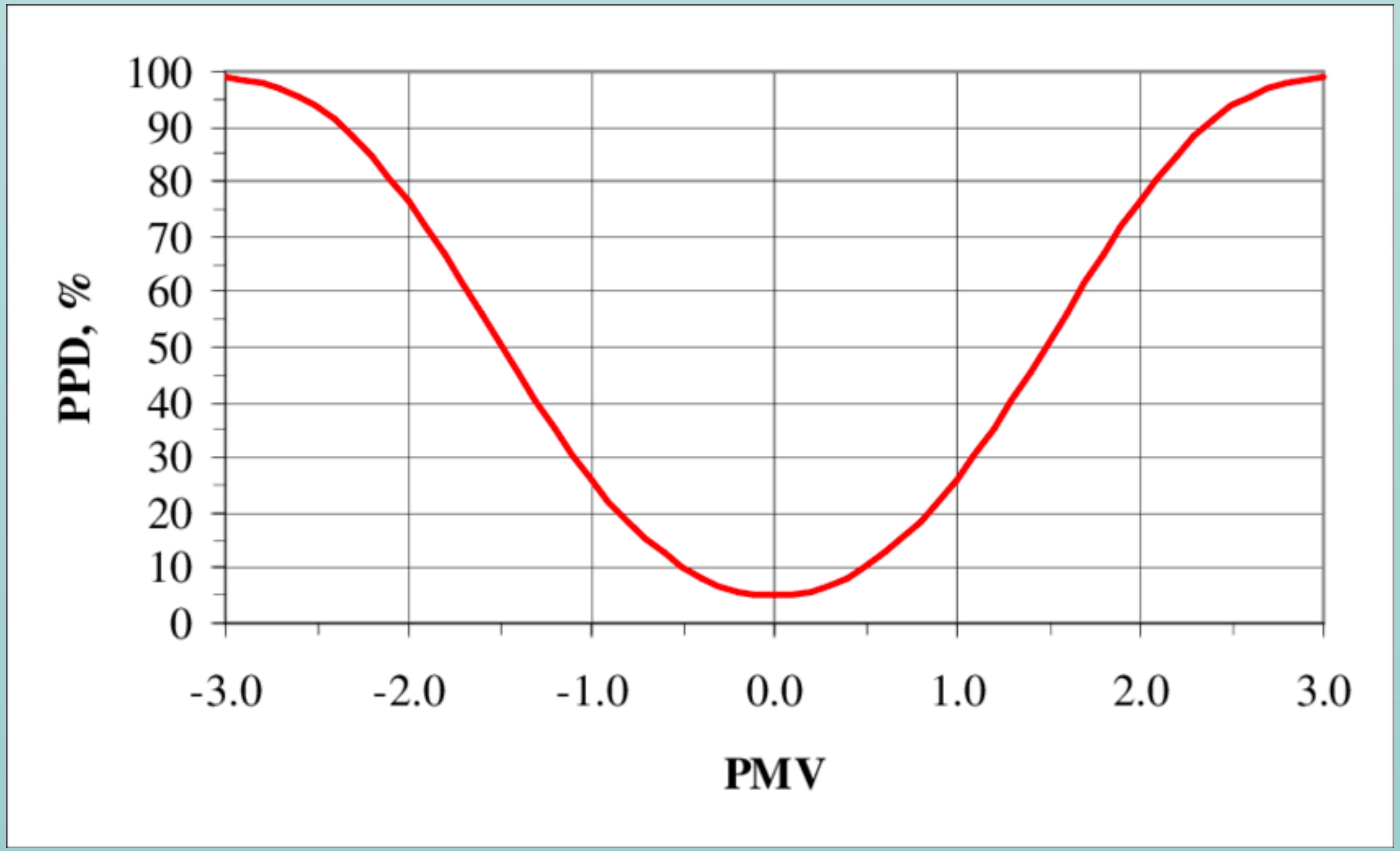
Thermal Comfort Indices: PMV and PPD

Predicted Mean Vote



The PMV scale from -3 (cold) to +3 (hot)

Predicted Percentage of Dissatisfied



Relationship between the predicted mean vote (PMV) and the percentage of dissatisfied (PPD)

Additional details in the « Thermal Comfort » subsection of the report

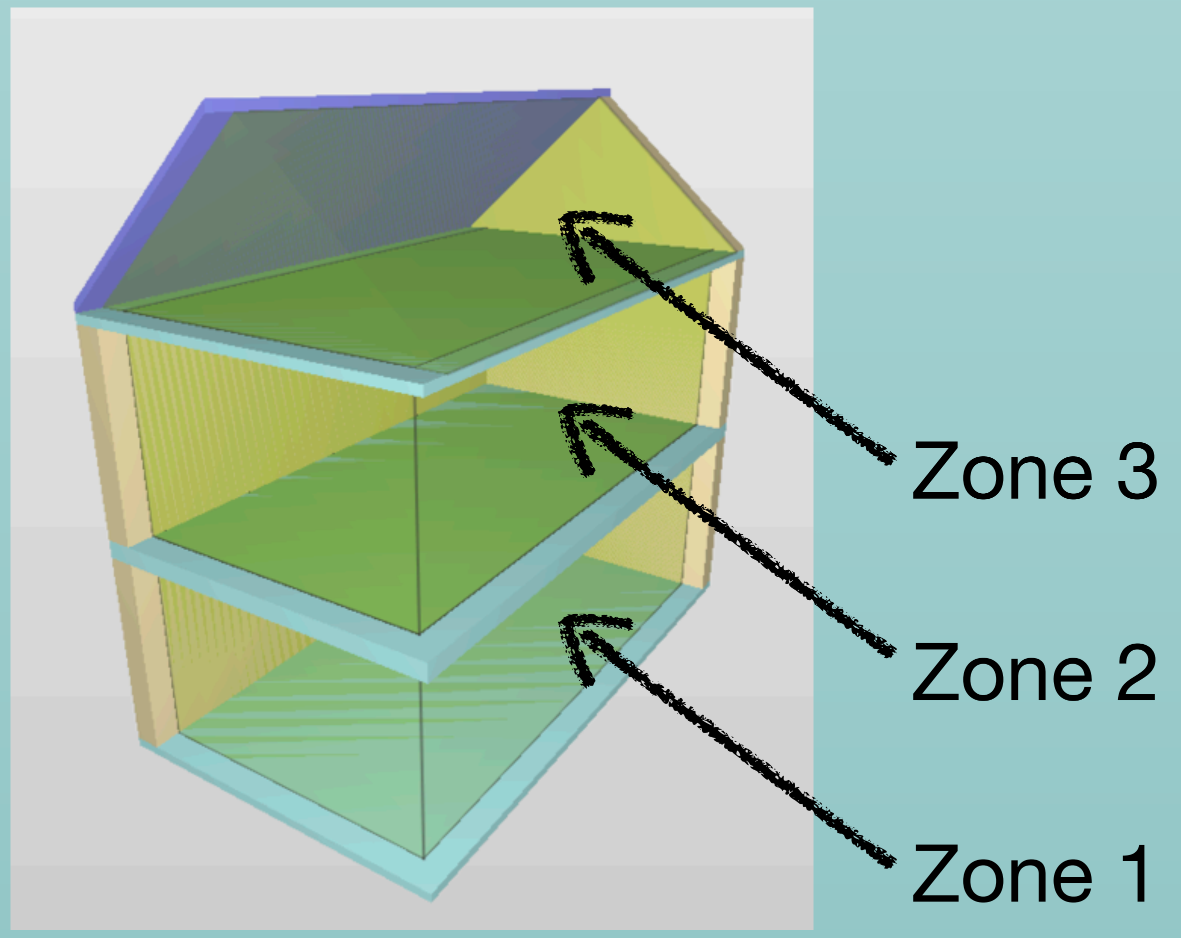
Temperature Profiles Analysis: July Results

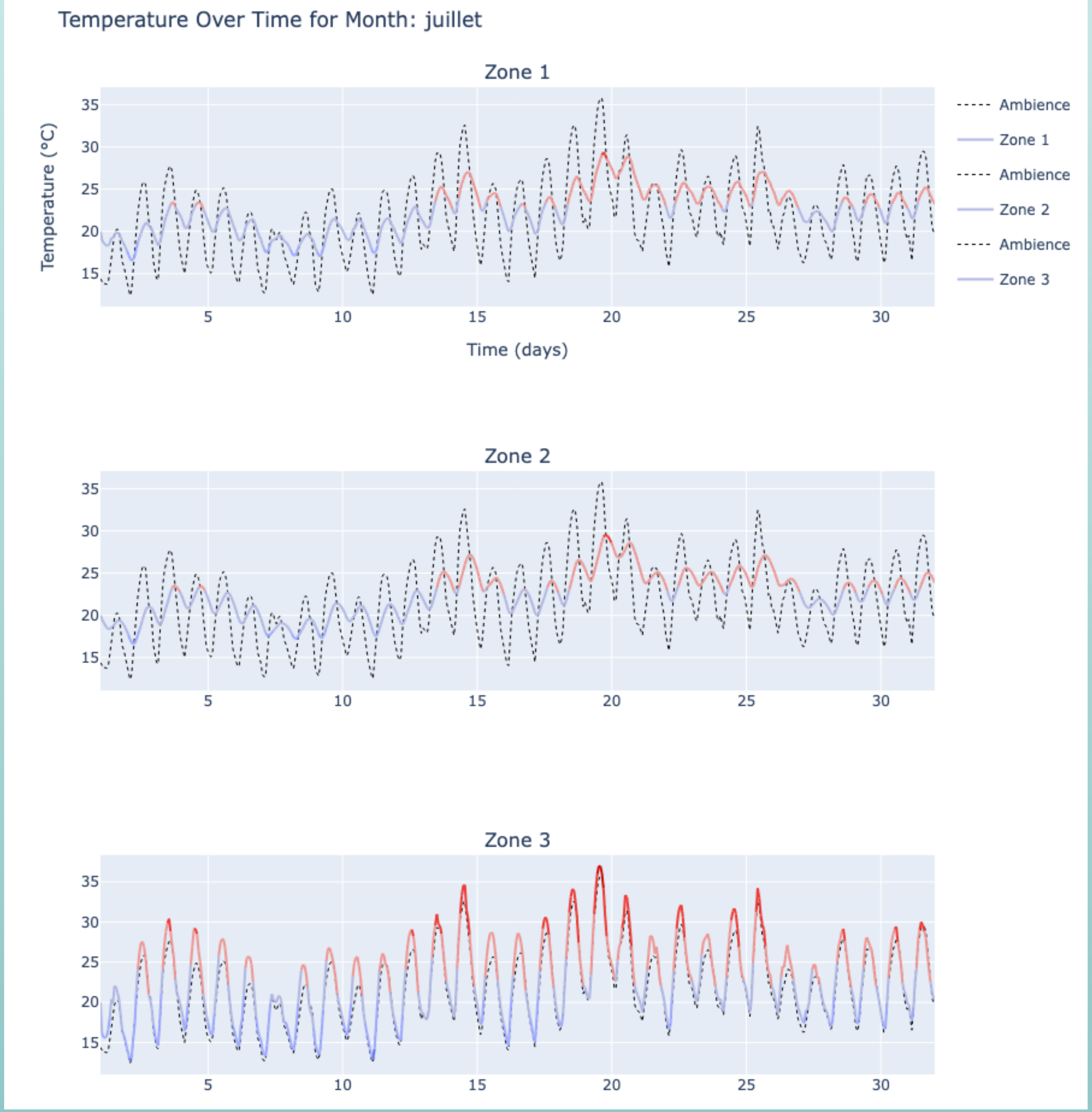
	Tmax °C	Tmin °C
Exterior Ambiance	35.77	12.39
Zone 1	29.07	16.54
Zone 2	29.52	16.61
Zone 3	36.95	12.80

ASHRAE* recommendations

Winter	Summer
20°C to 24°C	24°C to 26.5°C

*American Society of Heating, Refrigerating and Air-Conditioning Engineers





Zones Comparison : March

	Max Temperature °C	HR %	PPD	PMV
Exterior Ambiance	19.31	0.6	-	-
Zone 1	13.75	0.6	1	-3
Zone 2	14.18	0.6	1	-3
Zone 3	19.70	0.6	0.5	-1.55

ASHRAE* recommendations

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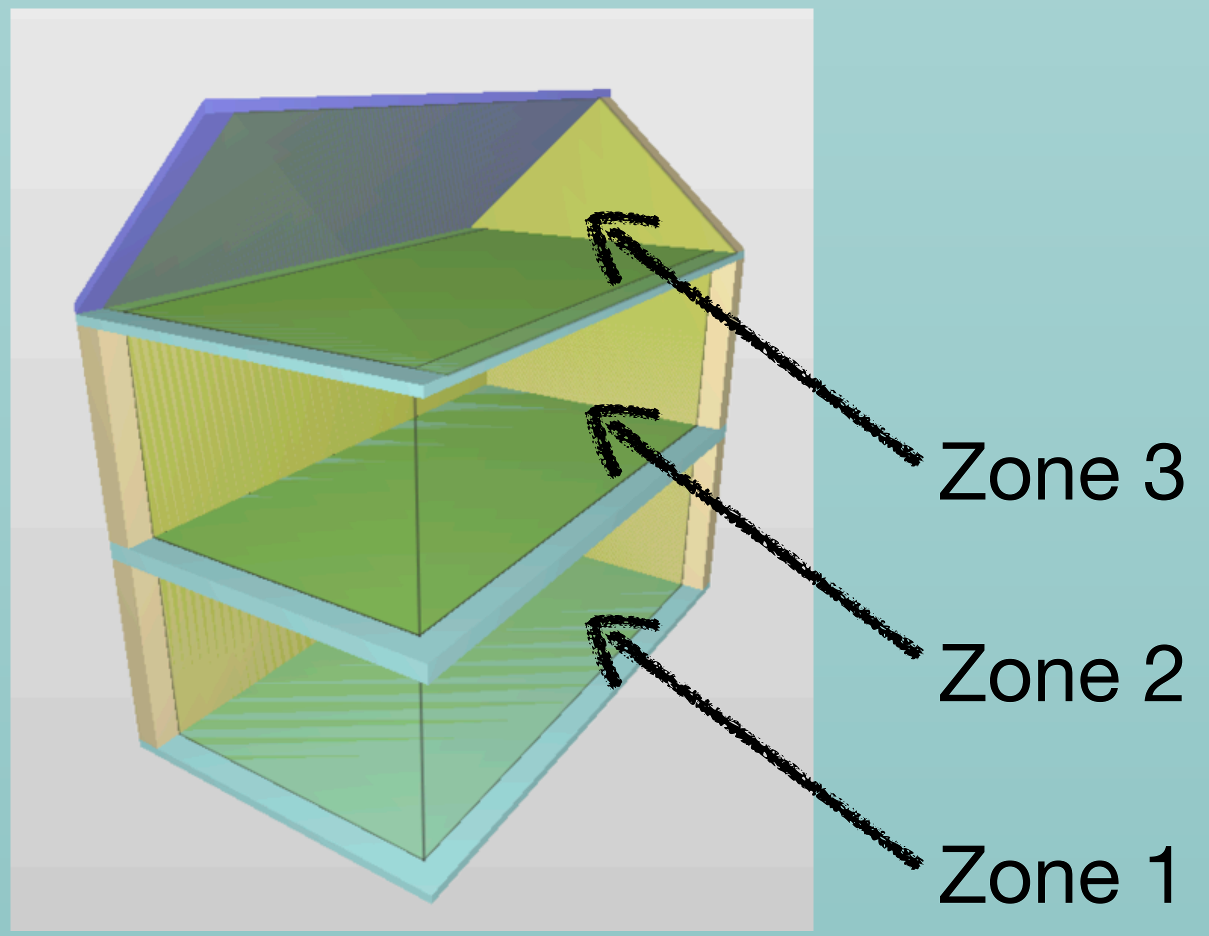
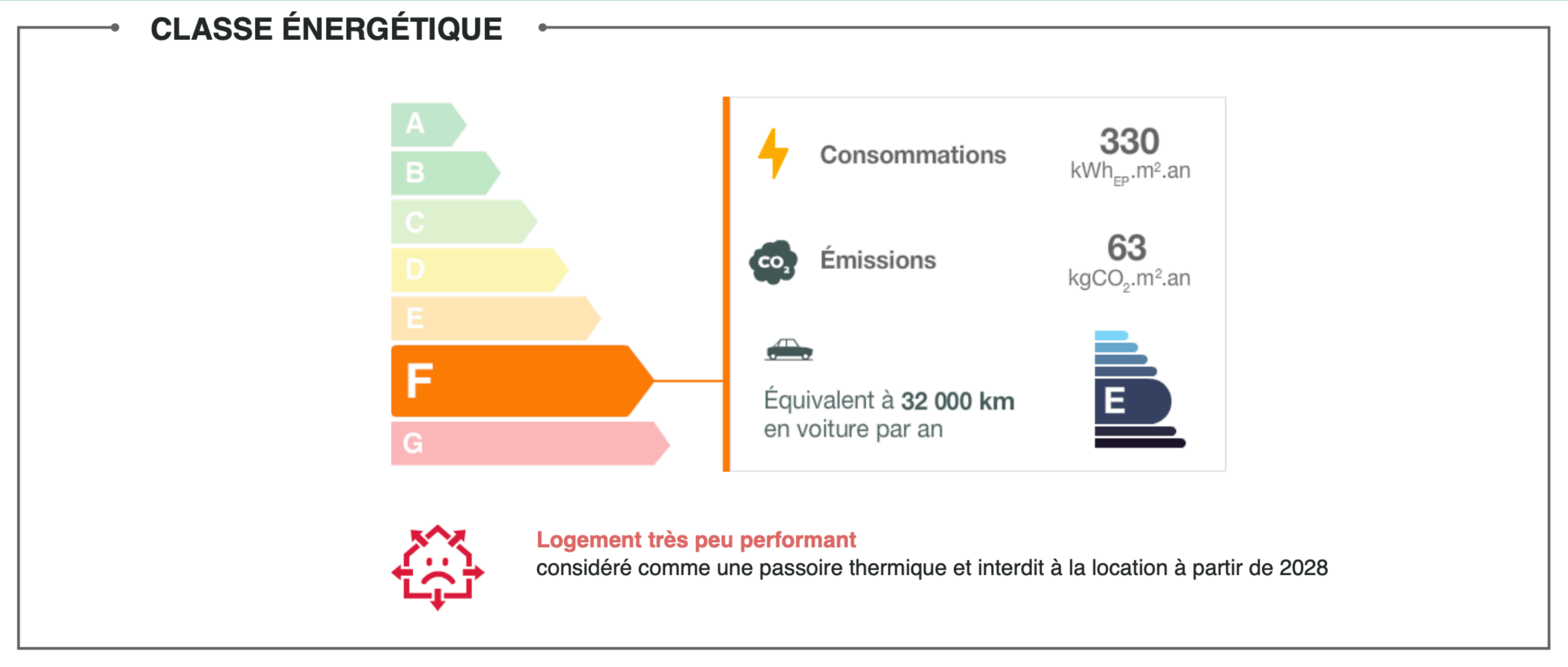


Building Thermal Behavior Analysis

Simulation carried out with CAP RENOV (Method 3CL-2021)



6- CONCLUSION AND PERSPECTIVES

Conclusion & Perspectives

✓ Successfully established an automatic thermal model to study building behavior.

✓ Simulations can now be initiated using the questionnaire and the building address.

✓ Gained experience using new tools and discovered the Buildingsystems library.

- Need to refine and label the home's energy consumption for optimal thermal comfort. Considering heating and cooling systems in the model and proposing insulation solutions.

- Incorporate solar masks in the model.

7- MY EXPERIENCE

References

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THANK YOU 😃