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Automated Shared-Wall Boundary Resolution for EnergyPlus Simulations at District Level

Richard Dean Morales

23 June 2026



Funded by



In collaboration with



My Research: Indoor Overheating & Urban Resilience .

- ▲ Overheating events in highly dense areas due to **Urban Heat Island** represent acute heat strain and health hazards for vulnerable citizens.
- ✍ We apply **Urban Building Energy Modeling (UBEM)** for indoor thermal comfort simulations
- 🛡 Simulating **thermal comfort** correctly depends on appropriate urban models.

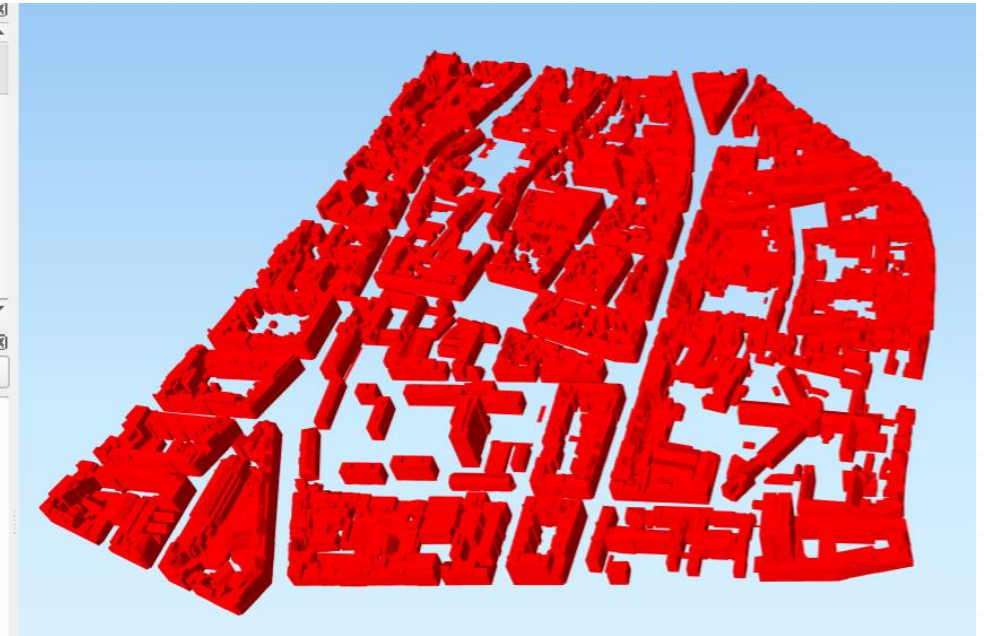
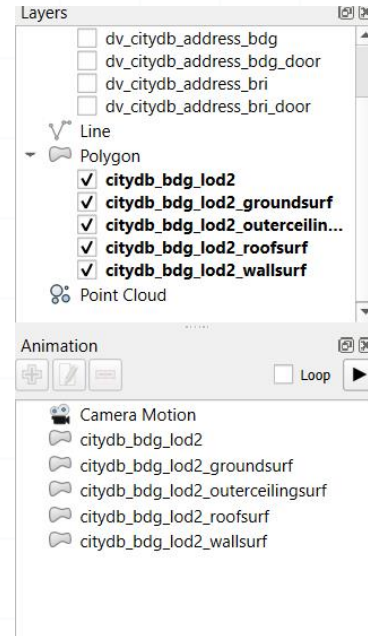


Funded by **fwo**

Use of LOD2 CityGML models .



Case study as visualised in Google Earth (2025)



CityGML file as visualised in QGIS

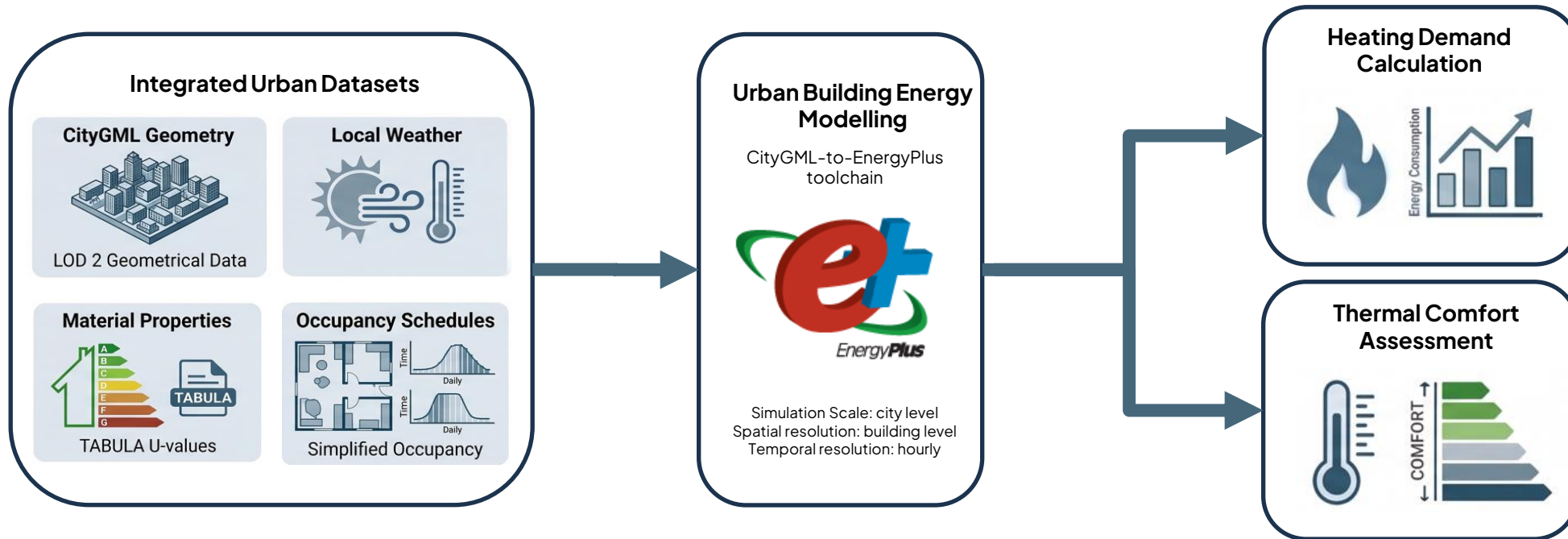
Simulation Parameters Matrix

Test Location: Sint Andries, Antwerp,

Database Source: City of Antwerp LOD2 CityGML

Translation Framework: Custom Python-based CityGML-to-epJSON parser

The Translation Pipeline: CityGML to epJSON .



<https://github.com/PalaDean/citygml-parser>



1. Semantic Parser

Ingests geometric solids and links relevant metadata constraints directly from localized CityGML XML nodes into a structured Python spatial dictionary.



2. Geometry Matcher

Converts coordinates to regional projection lines, matches spatial boundaries to corresponding zones, and structures adjacent thermal interface matrices.

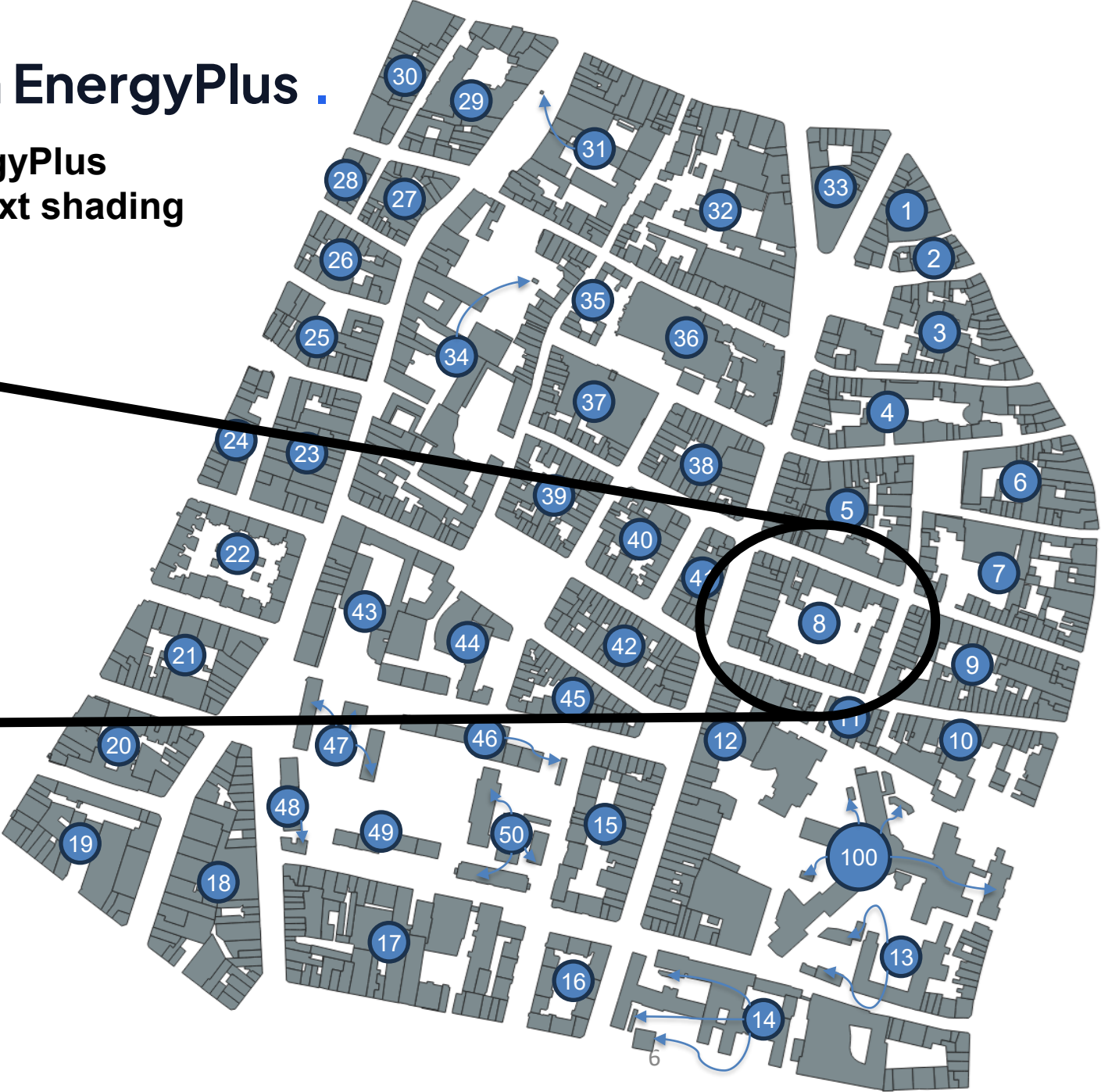
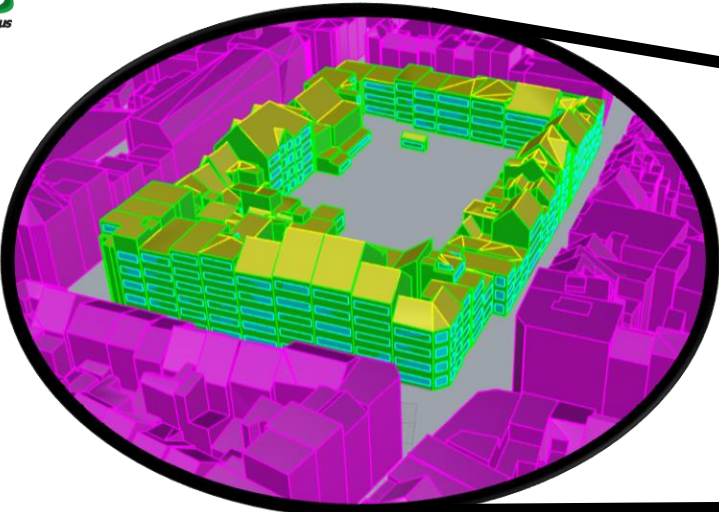


3. epJSON Exporter

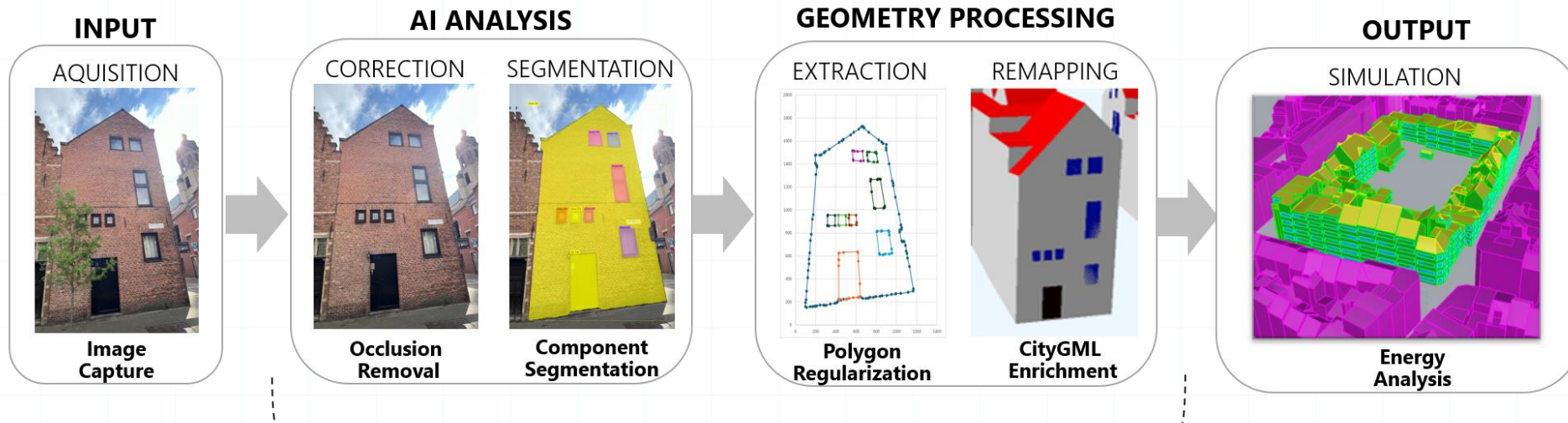
Compiles material models, operational profiles, and boundary matrices straight into precise 'epJSON' configuration syntax.

Physics-based models with EnergyPlus .

Building Energy Simulation using EnergyPlus happening by block and consider context shading



From Energy Analysis to Thermal Comfort.



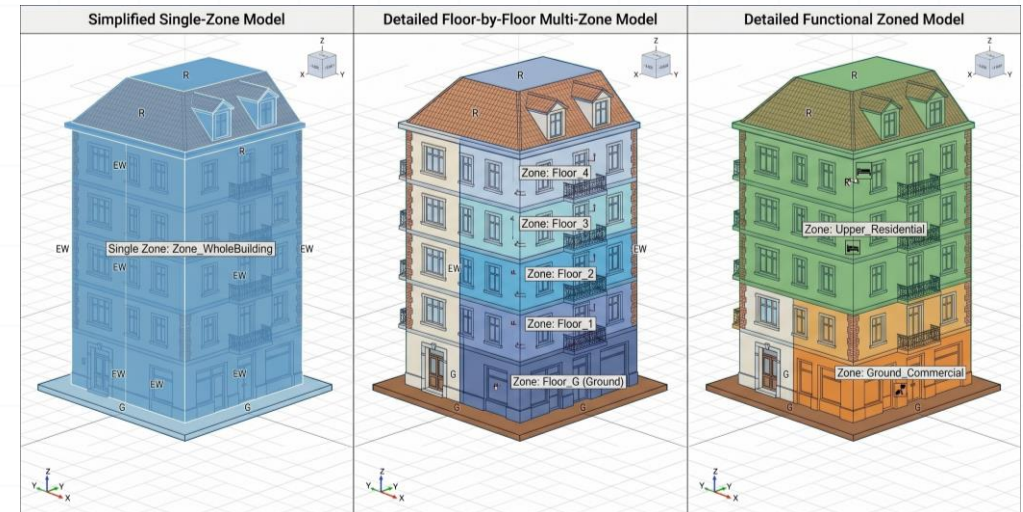
*Automated Digital Twin Integration
Image-to-3D Mapping*

Modelling multiple significant elements such as:

- window openings
- thermal zonings
- **shared boundaries**

I focus on finding that ‘sweet spot’ where **modelling complexity** meets **automated scalability** at the urban level.

The goal is to strike the perfect balance between computational time and **simulation accuracy**.



The Problem in Shared Walls: Misleading Adiabatic Simplifications .

Traditional urban modeling relies on simplified models on surface boundaries, falsely treating **shared walls** as **completely insulated** or in **adiabatic conditions**.

- ❗ **Dimensional Mismatch:** Historic row structures feature highly asymmetrical shapes, offsets, and exposed structural sections.
- ❗ **Misassigned Conditions:** Naive tools treat overlapping vertical coordinates as adiabatic, neglecting the physical boundaries.
- ❗ **Dynamic Heat Flux:** Varying internal gains and local setpoints across walls violate adiabatic rules.





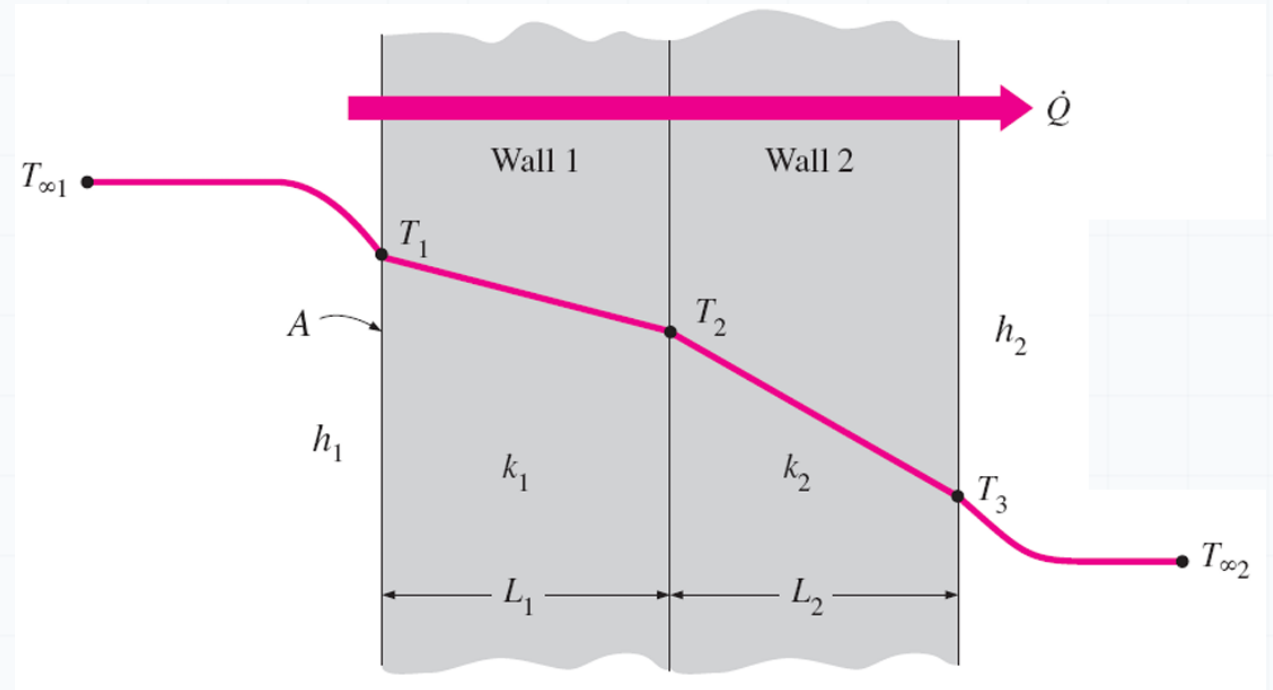
Quantifying Geometric and Thermal Fidelity .

"Does the explicit modeling of **shared-wall geometric intersections** in high spatial detail significantly alter district-level energy demands and individual indoor comfort predictions?"

CORE RESEARCH FOCUS & HYPOTHESES TESTING

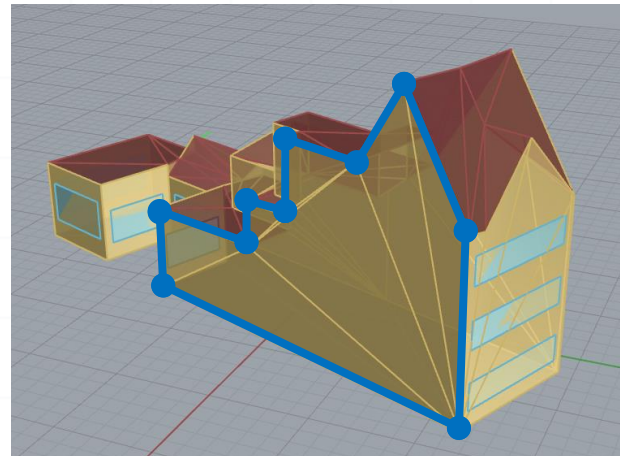
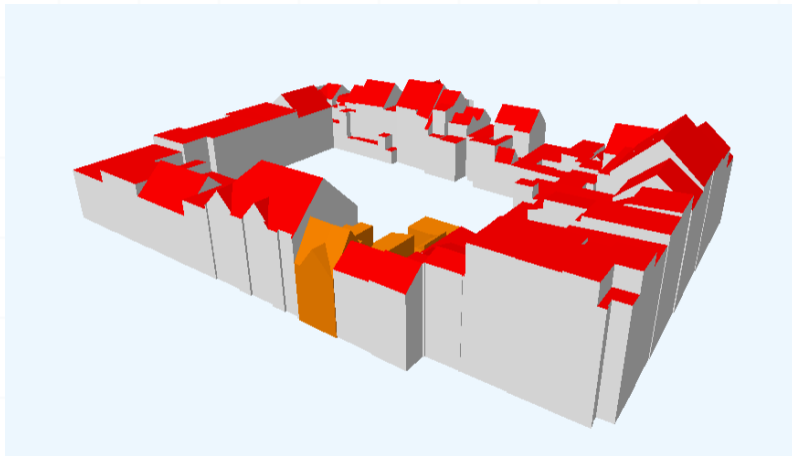
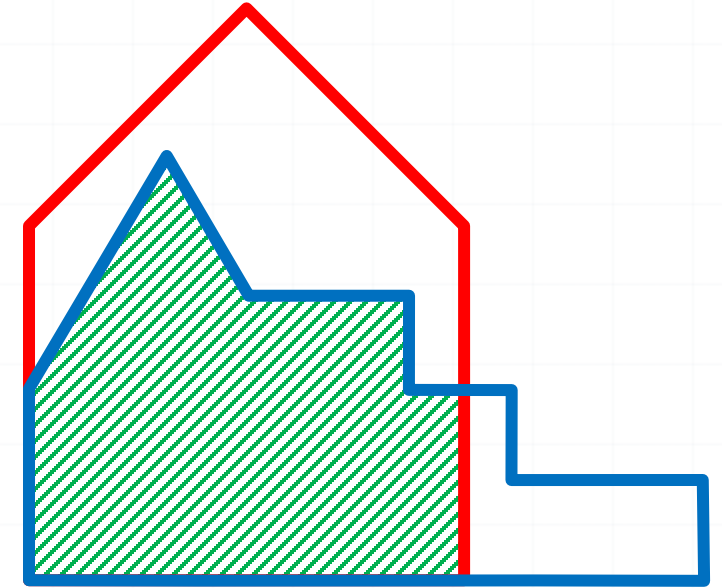
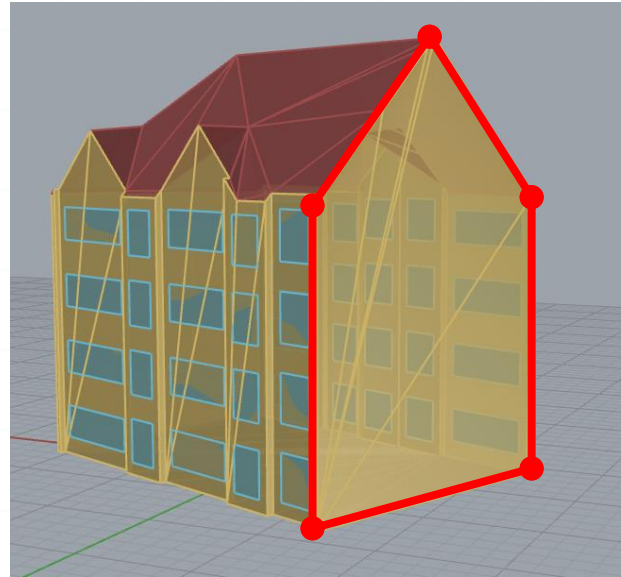
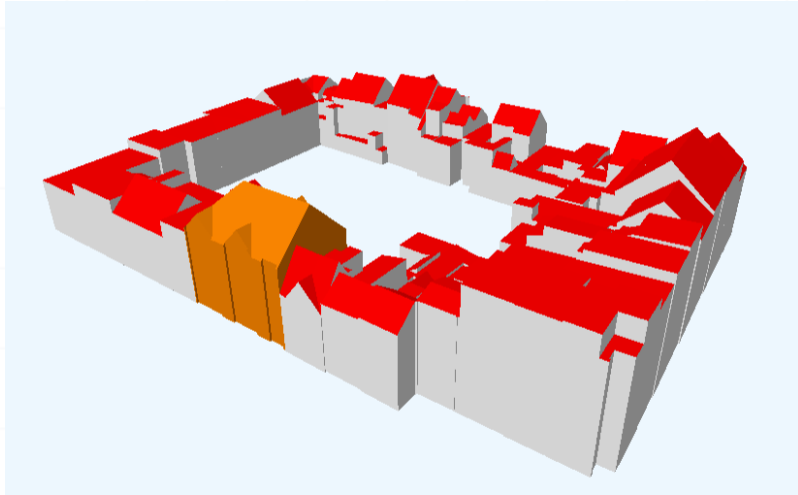
Surface boundary condition is applicable for Party Walls .

- Enables conduction through multilayer constructions (e.g., brick, insulation, gypsum)
- Ensures **energy balance** between buildings
- Supports realistic thermal bridging and heating/cooling load predictions



Source: Carreto (2007). Steady Heat Transfer with Conduction and Convection. Heat transfer. Mechanical Engineering 375

Surface Matching in EnergyPlus.



Surface Matching requires:

- Identical surface area
- Matching vertex coordinates

city-shared-walls

github.com/PalaDean/city-shared-walls

README

City Shared Walls Project

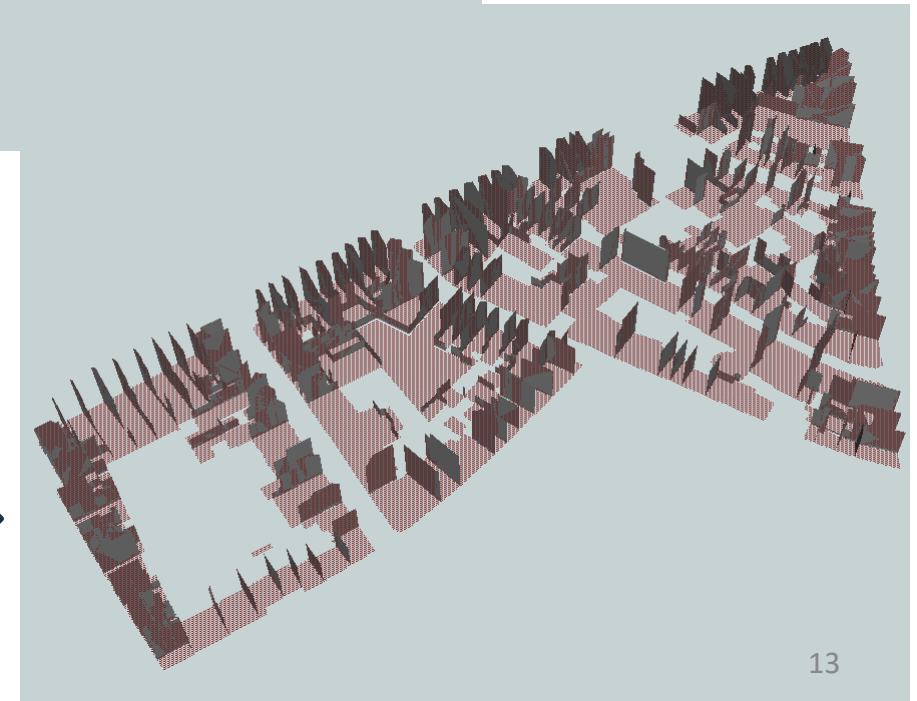
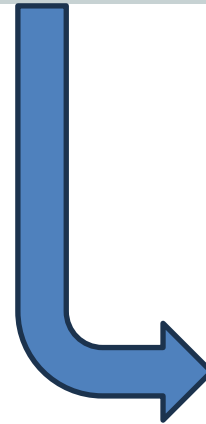
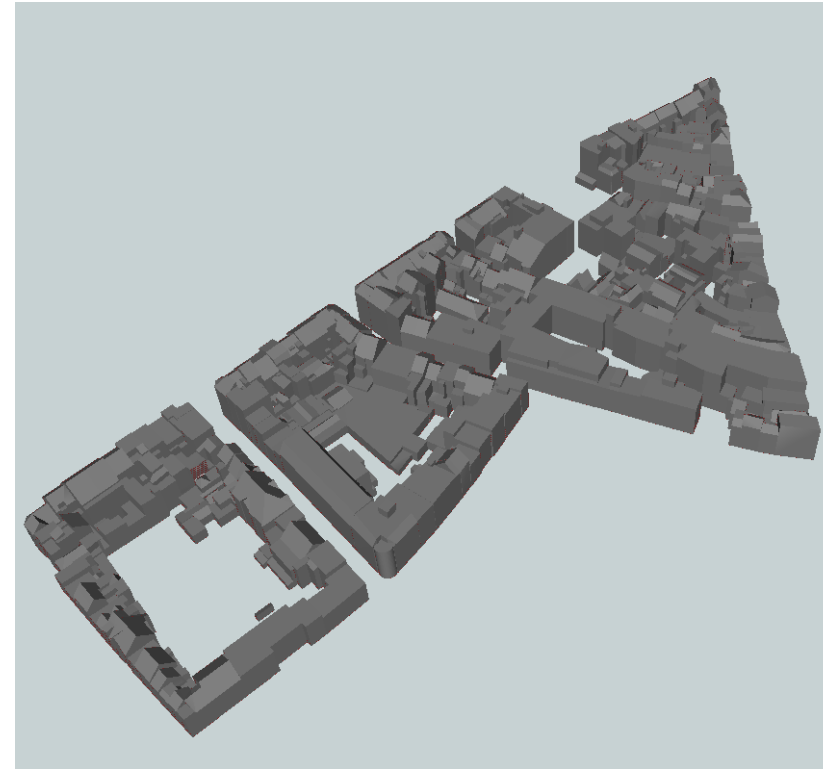
The City Shared Walls project is a sophisticated Python-based tool designed to identify and process shared walls between adjacent buildings in a 3DCityDB instance. It performs a detailed geometric analysis to decompose existing `bldg:WallSurface` geometries into shared (`bldg:InteriorWallSurface`) and non-shared (`bldg:WallSurface`) parts, ensuring topological correctness and watertightness.

The primary goal is to produce semantically correct CityGML data where interior walls are explicitly defined and enriched with attributes detailing their shared status. This is crucial for applications like energy modeling, noise propagation, and indoor navigation.

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 - Step 2: Adjacency Analysis
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 - Step 5: Final Output Generation
- Project Structure
- Setup and Configuration
 - Environment Requirements
 - Initial Configuration
- Future Work

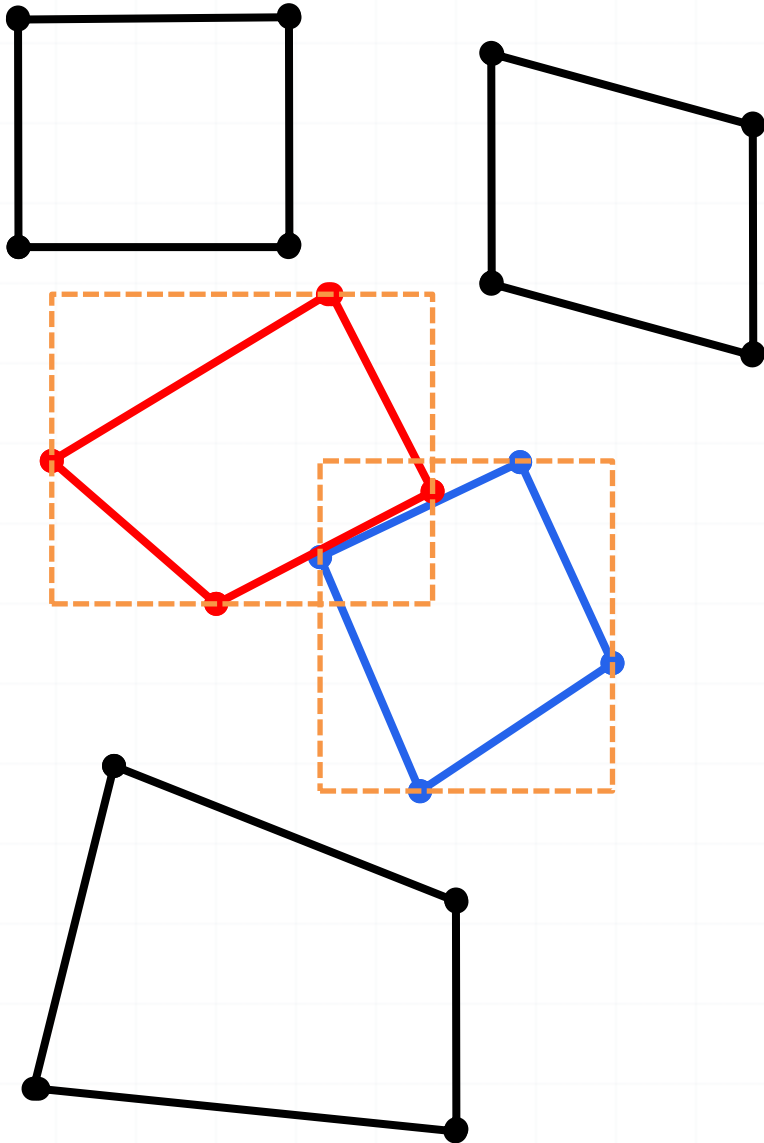
<https://github.com/PalaDean/city-shared-walls>



CityGML Requirements Input Validation.

Validation Metrics	Raw Municipal Data	Raw Municipal Data - Healed with CityDoctor	Raw Municipal Data - Healed with CityDoctor - Targeted pre-processing
Buildings	1,473	1,473	1,429
Valid Buildings (%)	836 (56.75%)	1,330 (90.29%)	1,425 (99.72%)
Invalid Buildings (%)	637 (43.25%)	143 (9.71%)	4 (0.28%)
Building Parts	0	0	0
Solids	1,473	1,473	1,429
MultiSurfaces	16,280	24,567	26,987
Polygons	27,197	27,192	26,987
├─ GroundSurface	953	1,468	1,429
├─ RoofSurface	5,749	8,277	8,557
├─ WallSurface	11,580	16,824	17,001
└─ without thematic surface	8,915	623	0

Adjacency Detection .



Phase 1: Site-Level Filtering (Building Proximity)

Goal: Narrow down the search space.

Logic: Identify all GroundSurfaces.

- Apply a **Bounding Box check** with a 0.1m buffer.
- Only buildings whose ground footprints intersect/clash are flagged as **Candidate Building Pairs**.

Phase 2: Surface-Level Filtering (Spatial Analysis)

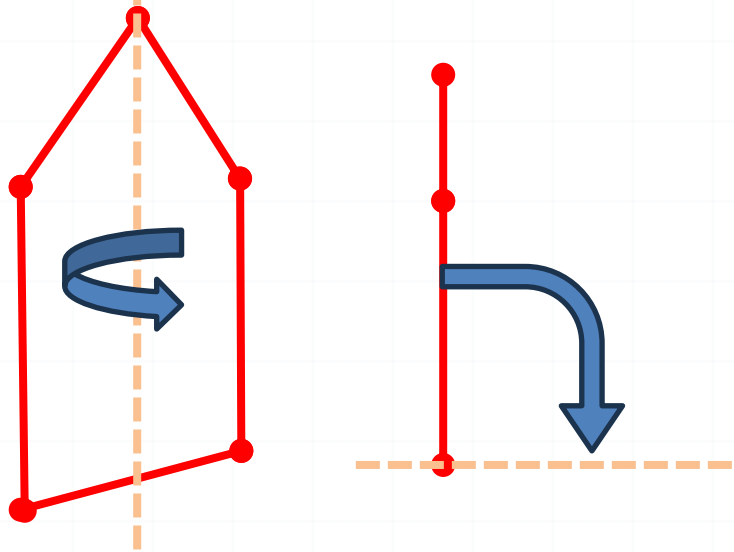
Goal: Extract "Face-to-Face" wall pairs.

Logic:

- For each WallSurface in the candidate building pairs:
- Calculate the **dot product** ($D = \vec{n}_A \cdot \vec{n}_B$) of the unit normal vectors.
- Measure the **perpendicular distance** between planes

Filter: Keep only pairs where ($D \approx -1.0$) (anti-parallel) within a **5-degree angular tolerance** and perpendicular distance $< 0.1m$.

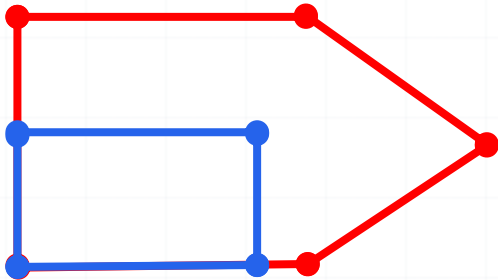
3D-to-2D-to-3D Intersector Algorithm .



$$T = R_{azimuth} \cdot R_{tilt} \cdot T_{trans}$$

1. Get the transformation matrix (T) of **Subject Wall** from its plane to the 2D horizontal ($Z = 0$)

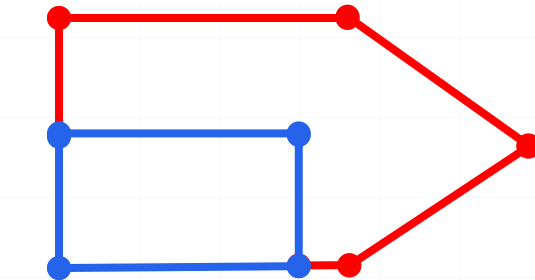
TOP VIEW



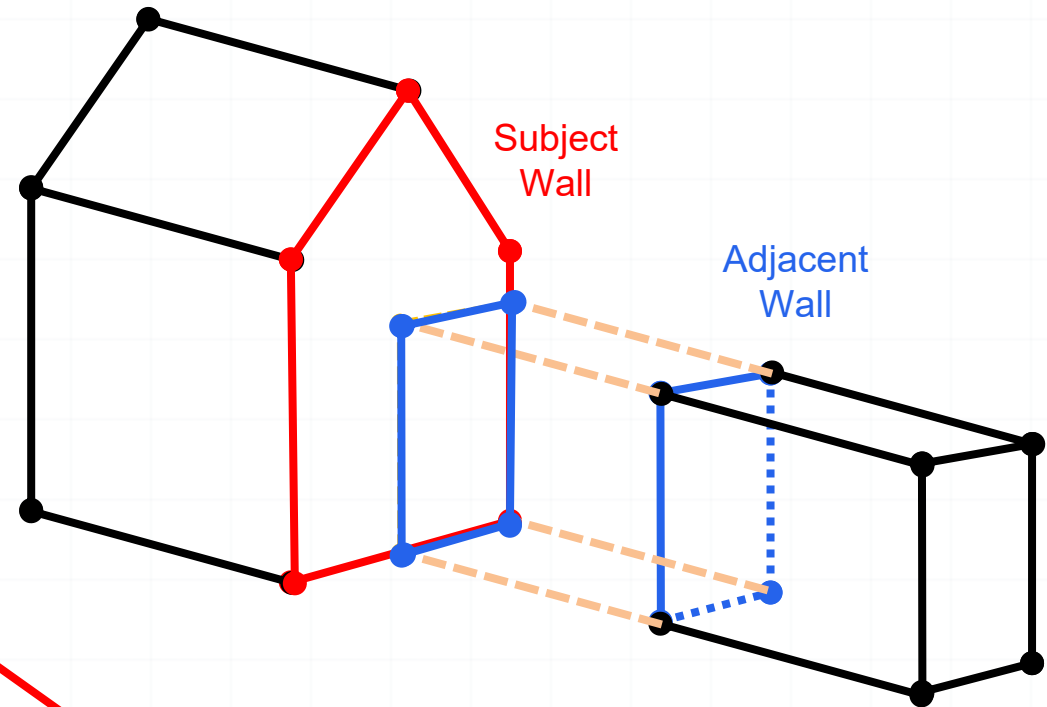
FRONT VIEW



2. Apply the transformation matrix to both **Subject Wall** and **Adjacent Wall**



3. Force ($Z = 0$) to the transformed **Adjacent Wall**

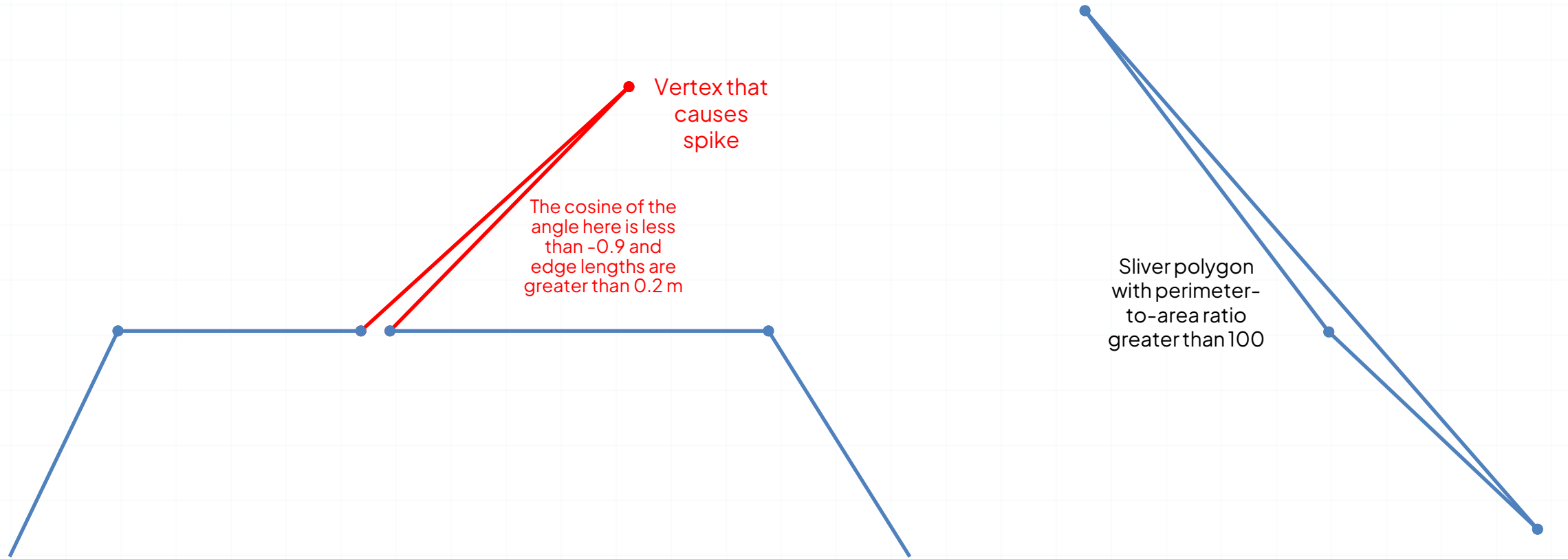


4. Get the 2D `intersection` and 2D `difference`

5. If the intersection is $< 0.1 \text{ m}^2$, force it to no intersection, and difference = original polygon

6. Revert the decomposed shapes to 3D using the inverse of the transformation matrix (T^{-1}) from 1

Some problematic polygons after intersection .

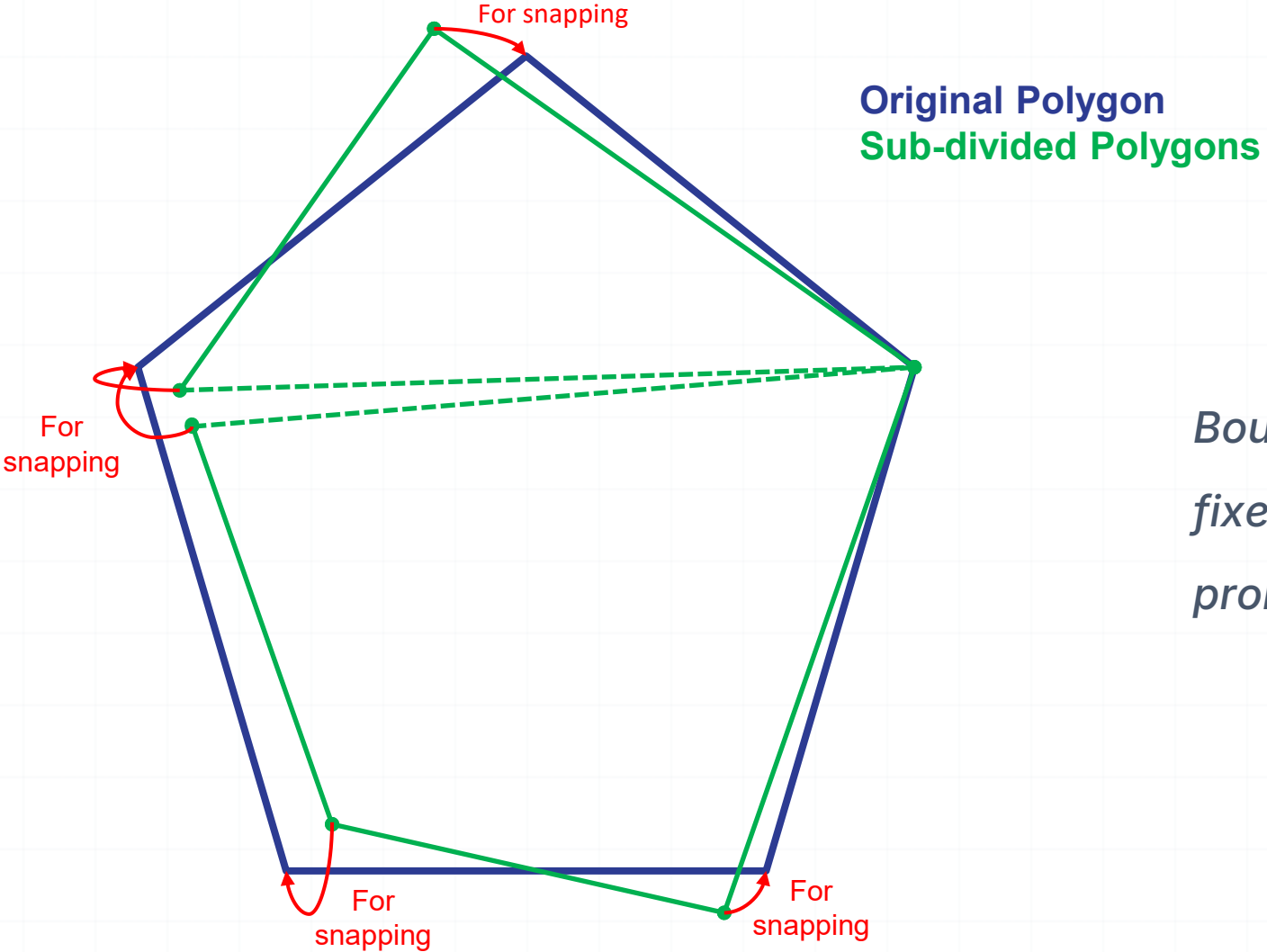


32 spike vertices removed for the case study

219 sliver polygons removed for the case study

Problematic polygons are some geometric artifacts resulting from Python Shapely 'intersection' and 'difference' functions

Boundary Snapping .

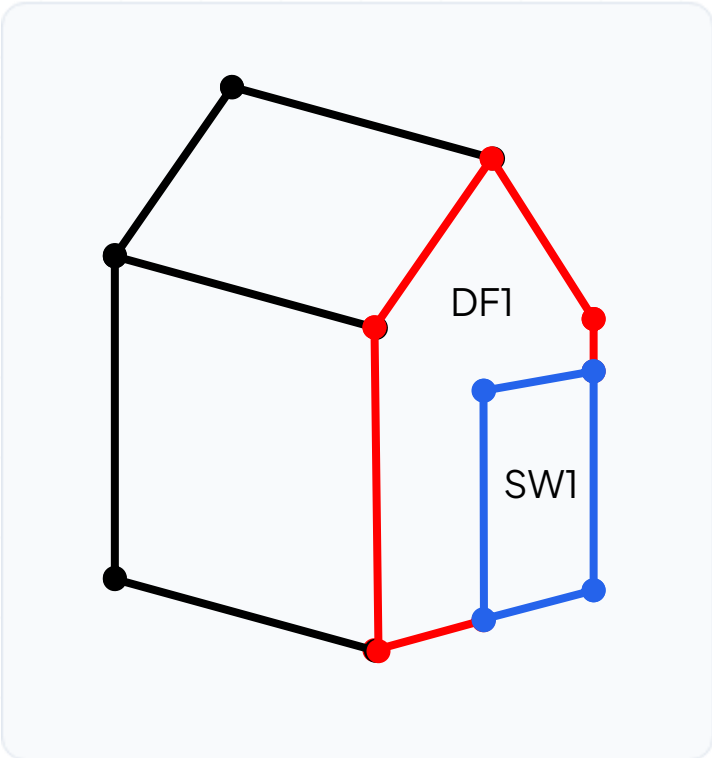


Original Polygon
Sub-divided Polygons

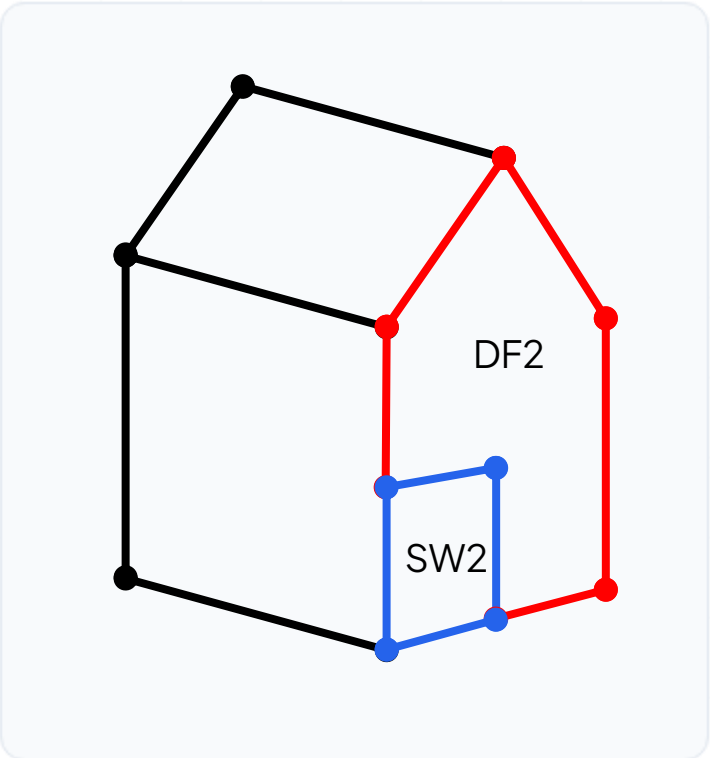
Boundary snapping generally fixes the deleted artifacts / problematic polygons

Multiple Intersections .

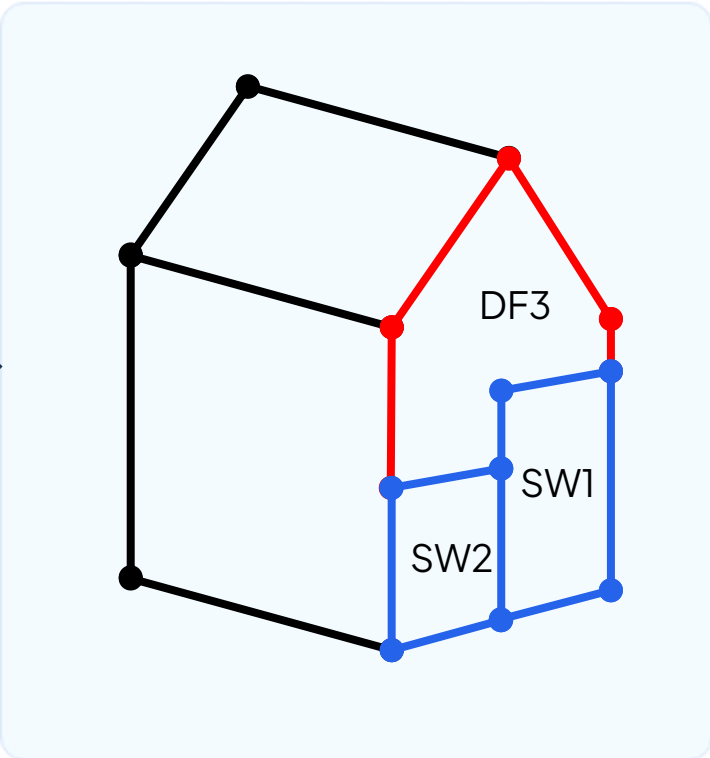
INTERSECTION 1



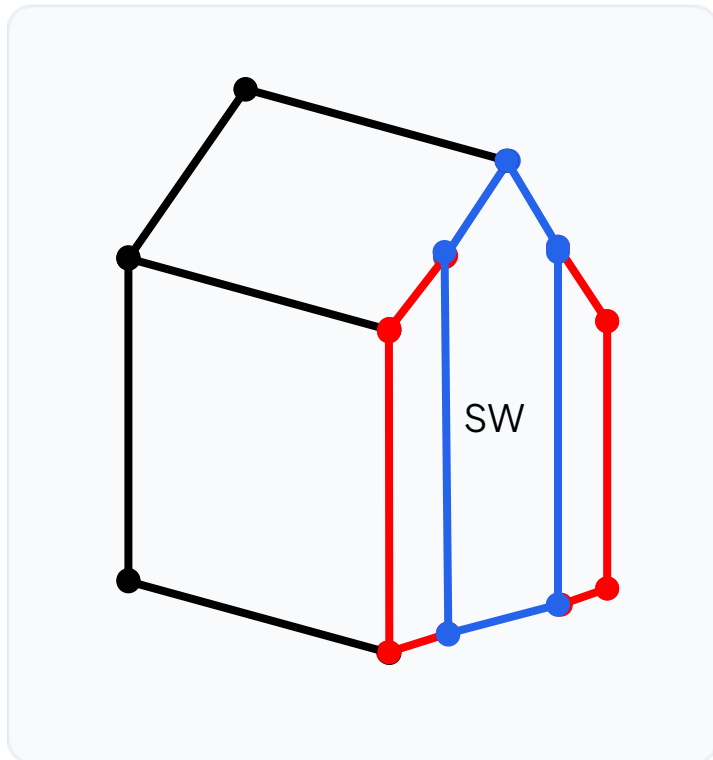
INTERSECTION 2



TO BE STORED IN CITYGML

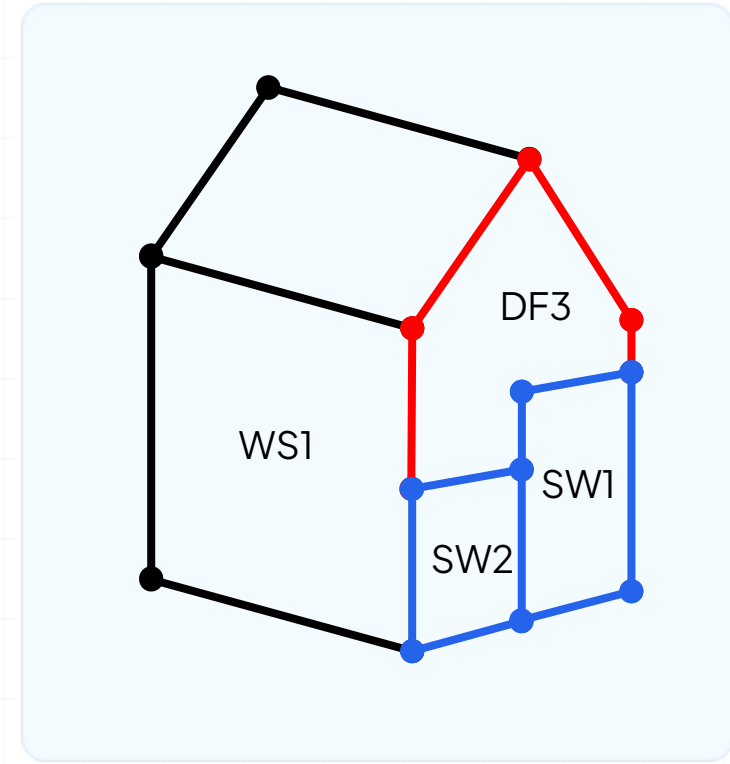
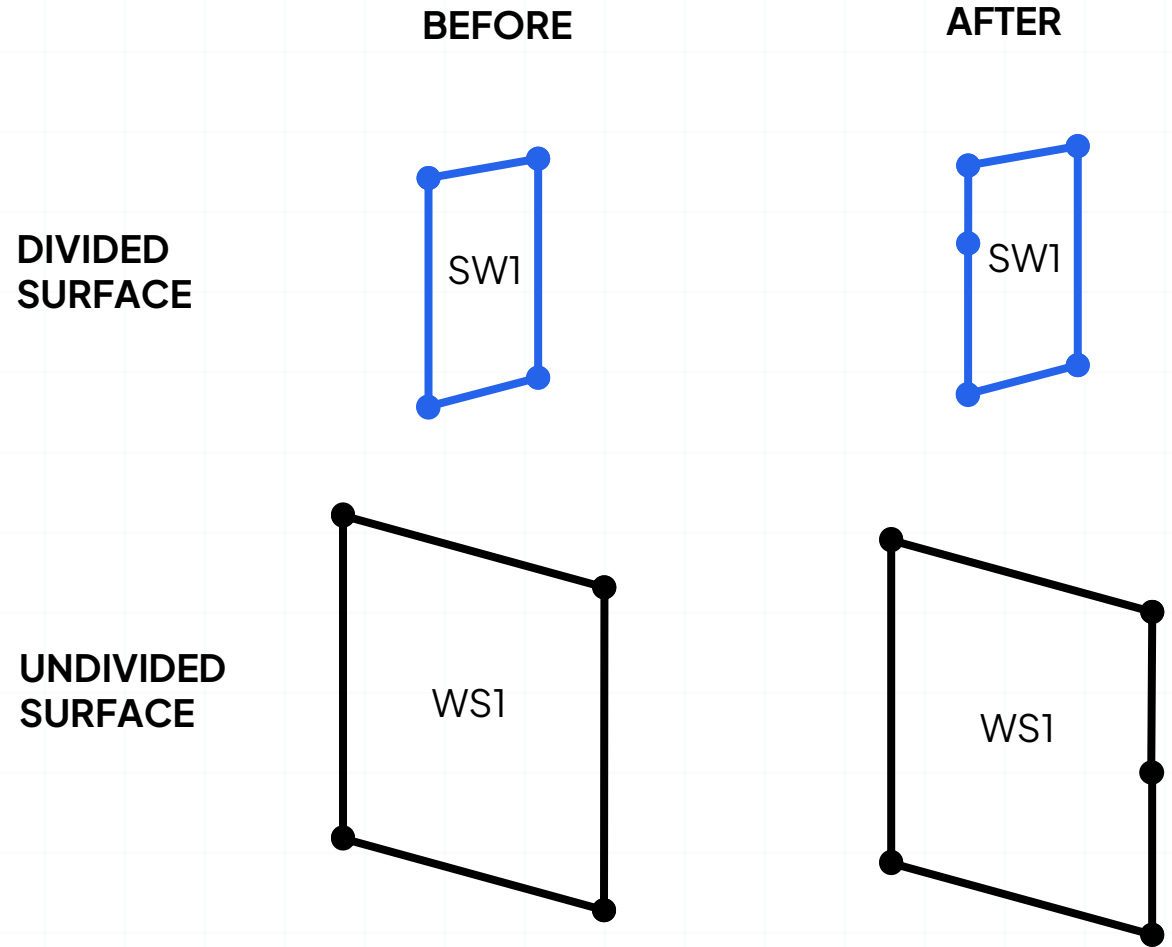


Multiple Differences.



Decompose MultiPolygons
into individual Polygons

Vertex Unifications.



undivided surfaces healed 3,363

Semantic Enrichment.

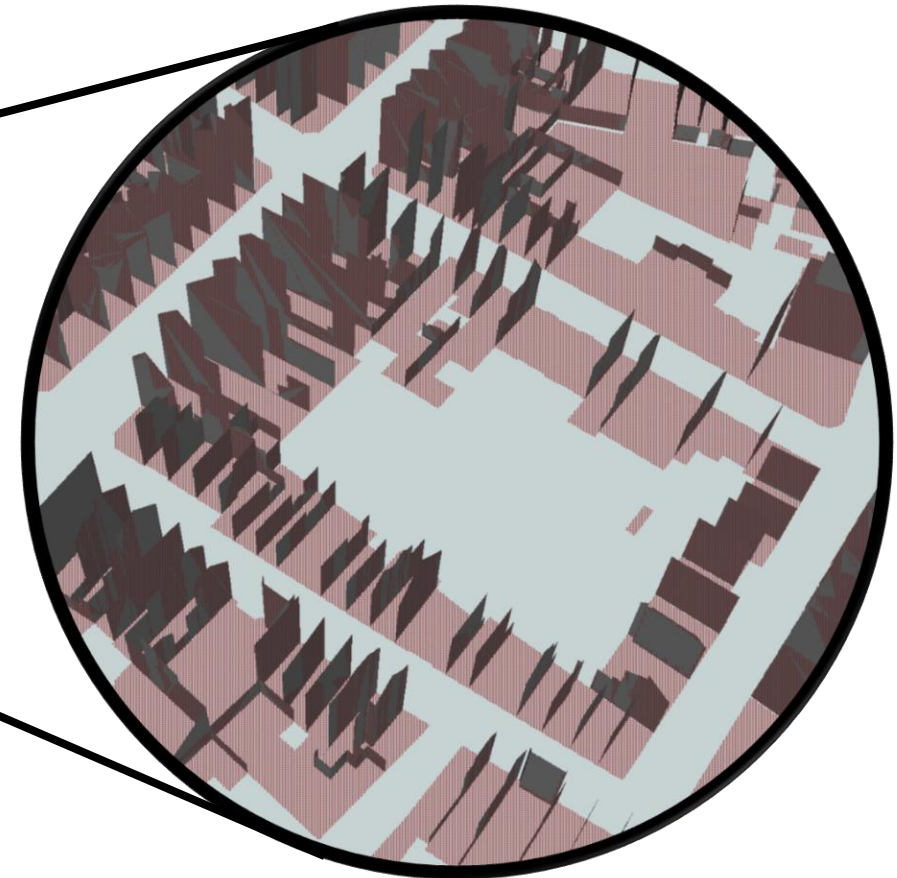
CityGML

```
<bldg:boundedBy>
  <bldg:WallSurface gml:id="UUID_d6c1d451-4d60-4016-b2f7-6744bf865881">
    <gen:intAttribute name="isShared">
      <gen:value>1</gen:value>
    </gen:intAttribute>
    <gen:uriAttribute name="adjacentWallSurface">
      <gen:value>#UUID_0f023366-85c1-430c-b665-9e1acc5d1452</gen:value>
    </gen:uriAttribute>
  </bldg:WallSurface>
</bldg:boundedBy>
```

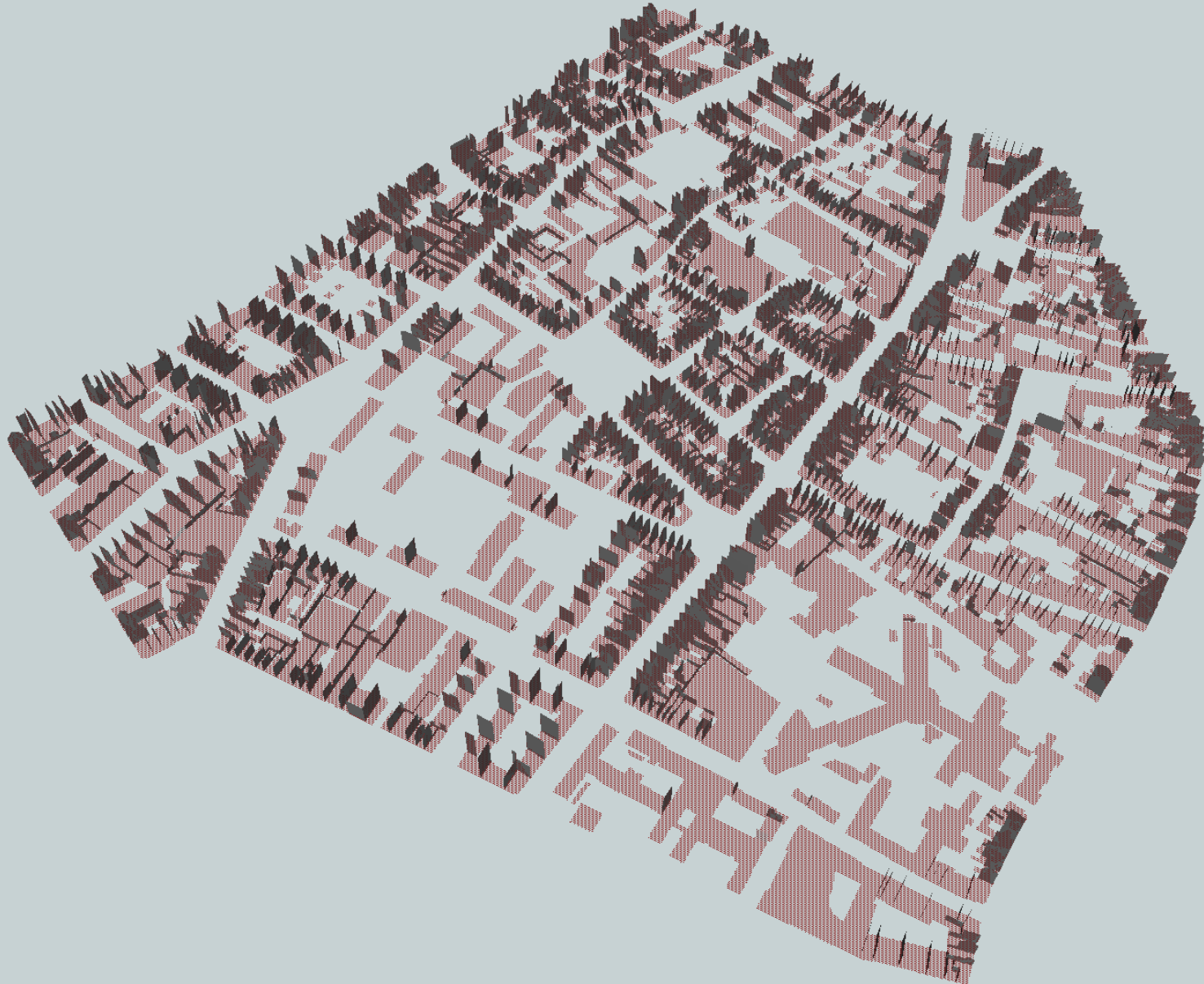
EnergyPlus epJSON

```
    "outside_boundary_condition": "Surface",
    "outside_boundary_condition_object": "WallSurface_UUID_8bf7a1bc-cc91-4438-a49e-652c558f9d3e",
    "is_shared": true,
    "sun_exposure": "NoSun",
    "wind_exposure": "NoWind"
  },
```

Intersection Results for Antwerp City, Belgium .






Intersection Results for Antwerp City, Belgium



Metric	Value
initial wall surfaces	17,001
candidate wall pairs	14,644
attempted intersections	14,644
~zero intersections filtered	7,978
decomposed shared parts	6,661
decomposed difference parts	4,283
<i>-- after internal geometric fixing --</i>	
final intersection surfaces	6,634
final difference surfaces	5,965

Validation Metrics	Input Data	After Intersection	After Intersection + healed with CityDoctor
Buildings	1,429	1,429	1,429
Valid Buildings (%)	1,425 (99.72%)	1,192 (83.41%)	1,307 (91.46%)
Invalid Buildings (%)	4 (0.28%)	237 (16.59%)	122 (8.54%)
Building Parts	0	0	0
Solids	1,429	1,429	1,429
MultiSurfaces	26,987	33,486	33,414
Polygons	26,987	33,486	33,524
├─ GroundSurface	1,429	1,429	1,425
├─ RoofSurface	8,557	8,557	8,558
├─ WallSurface	17,001		
└─ shared / party wall surface	0	6,617	6,589
└─ outdoor condition	17,001	16,883	16,932
└─ without thematic surface	0	0	20

Geometric Paradigms: CityGML vs. EnergyPlus .

Structural Parameter	LOD2 CityGML Standards	EnergyPlus Requirements (UBEM)
 Solid	Requires strict watertight GML solid closures.	Watertightness is only used of Volume calculation – this can be overridden by plugging in pre-calculated volume
 Surface Planarity	Allows some tolerance in planarity	Perfect Planarity
 Surface Vertices	Vertex unification is required for solid enclosure	Demands exact boundary matches with reversed vertex orientation for surface matching of shared boundaries

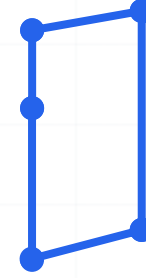
**** Warning **** ProcessSurfaceVertices: Possible non-planar surface:"WALLSURFACE_UUID_174AA0FC-FEFB-4AFE-A75E-5A2F5D2F7AA9", Max "out of line"=9.48308E-004 at Vertex # 4

**** Severe **** ProcessSurfaceVertices: Suspected non-planar surface:"WALLSURFACE_UUID_403BE7F9-B08D-4FAB-8F75-FDD680284F3E", Max "out of line"=1.04781E-002 at Vertex # 6

DIVIDED SURFACE



**BEFORE
vertex
unification**



**AFTER
vertex
unification**

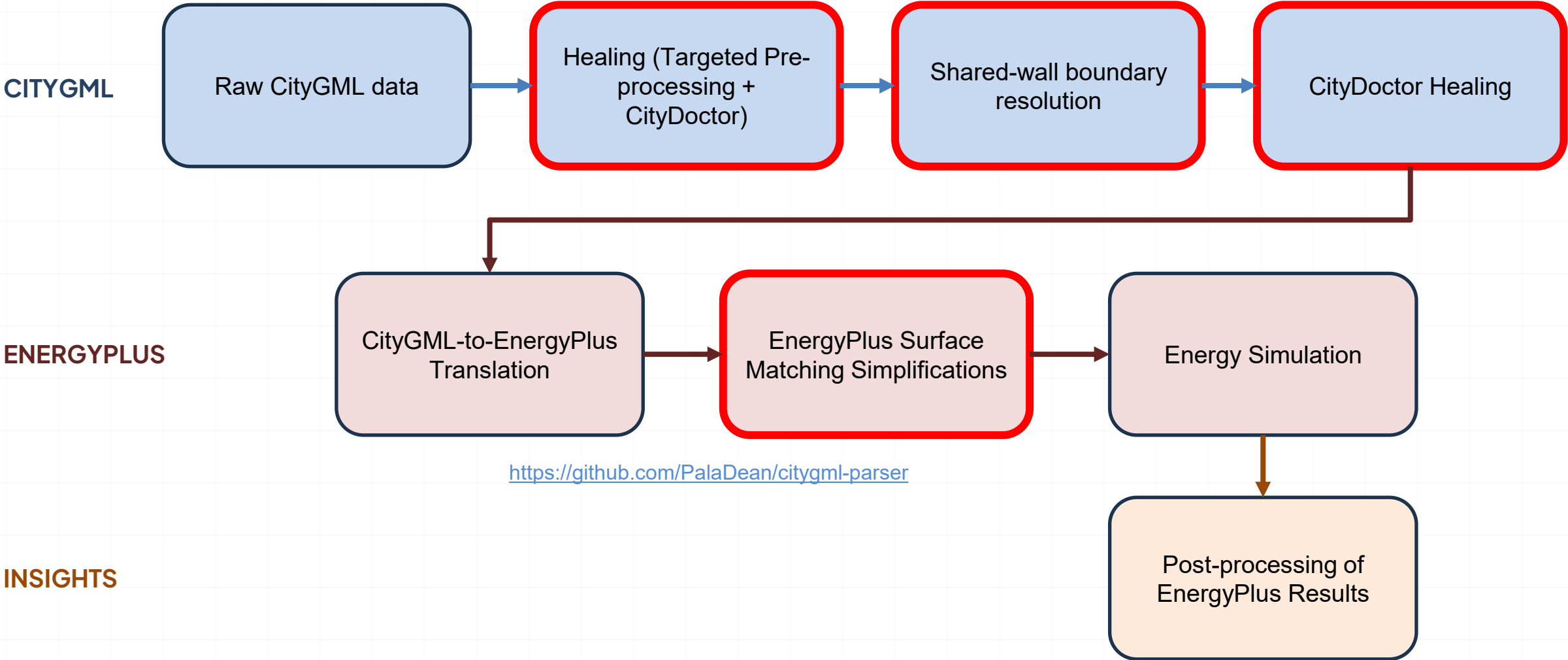


**BEFORE
surface
matching in
EnergyPlus**

**AFTER
surface
matching in
EnergyPlus**

From CityGML to actionable insights .

<https://github.com/PalaDean/city-shared-walls>



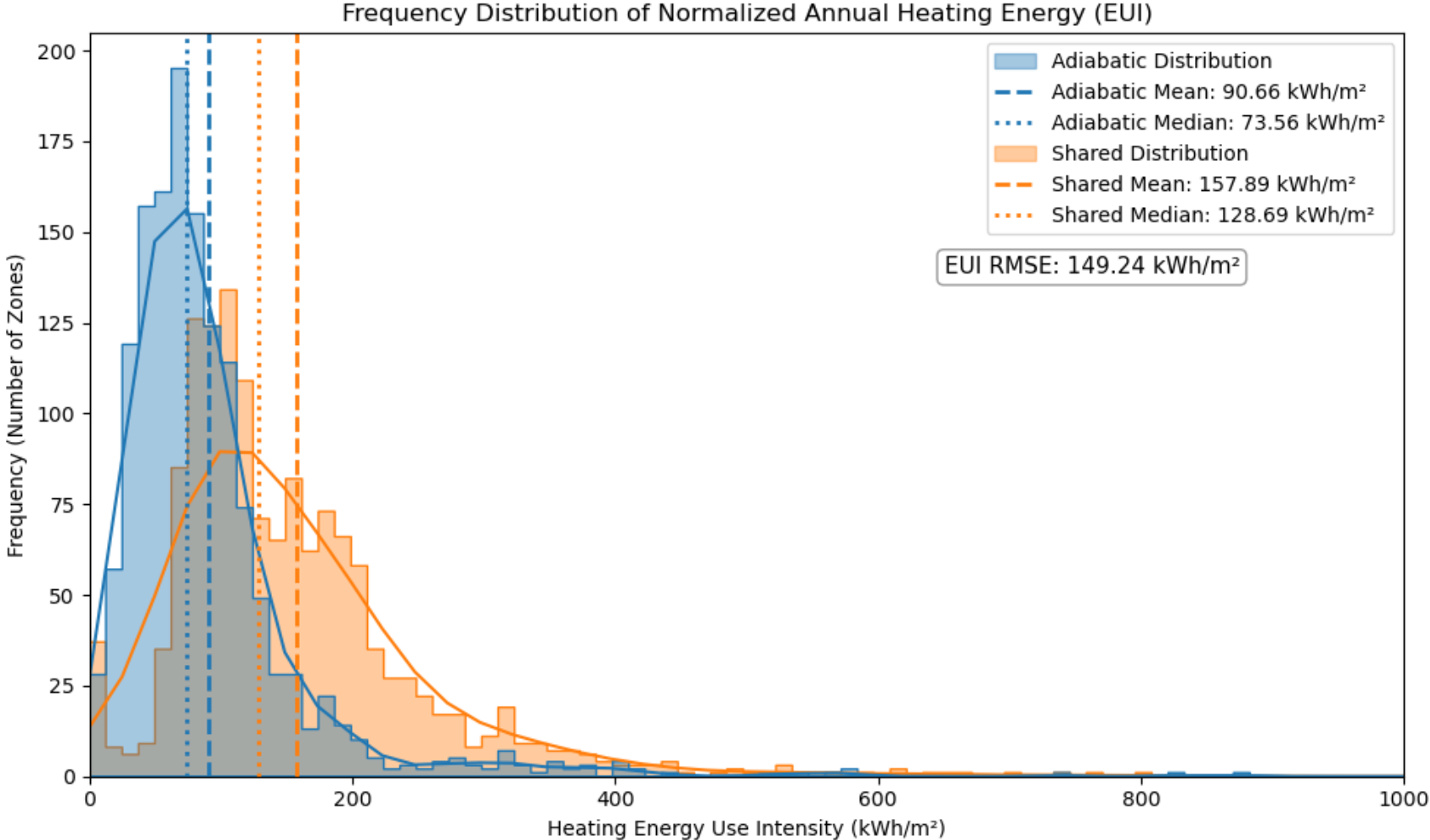
<https://github.com/PalaDean/citygml-parser>

Validity: CityGML vs. EnergyPlus .

VALIDITY	Valid CityGML	Invalid CityGML
Valid EnergyPlus Simulation	1,239	110
Invalid EnergyPlus Simulation*	68	12

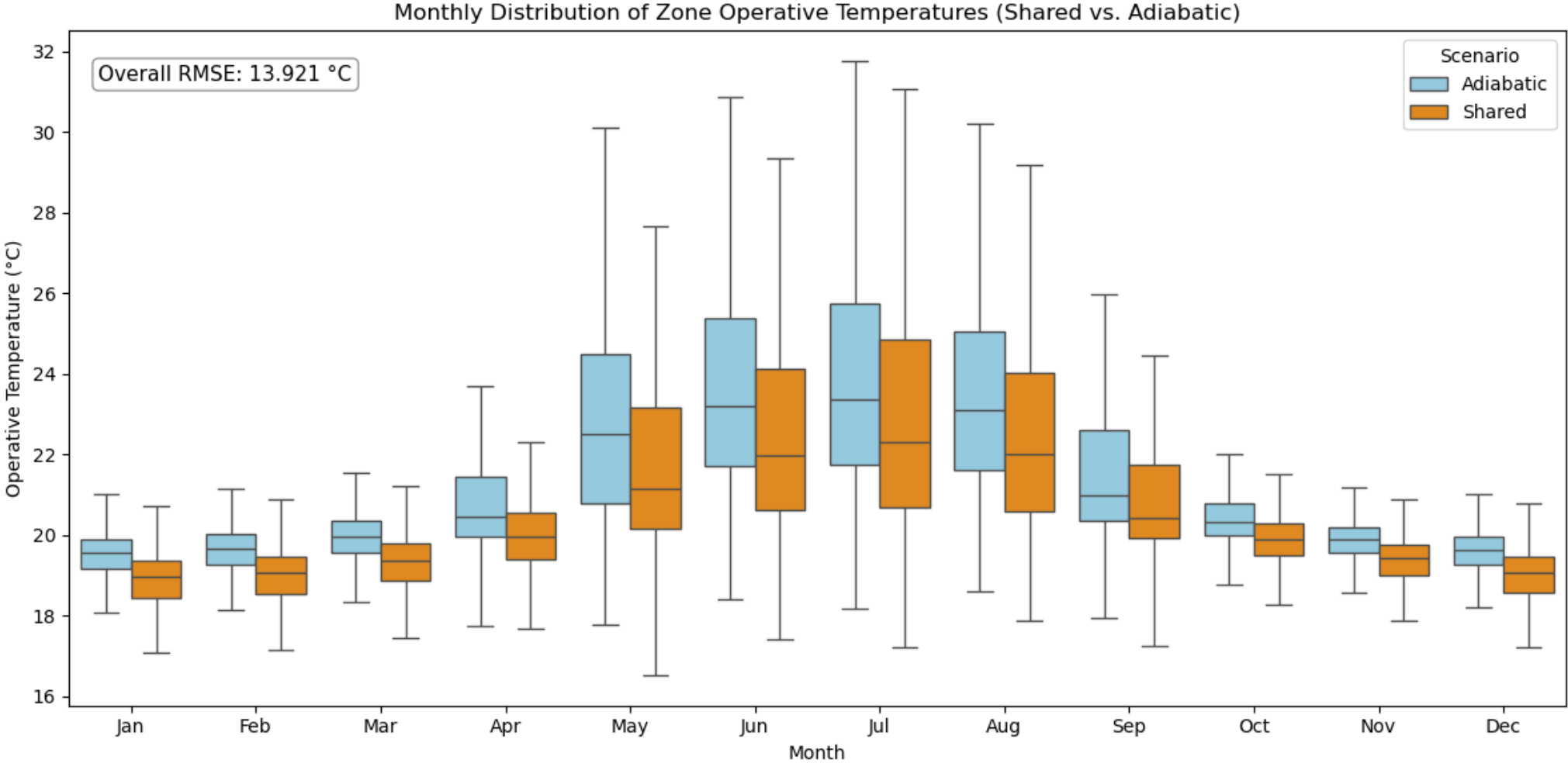
*For surface heat transfer calculations only. The walls were converted to the original polygon and in adiabatic conditions for the simulation to run.

Comparative Analysis: Heating Demand



Simplified adiabatic models systematically underestimate heating loads.

Comparative Analysis: Mean Indoor Operative Temperature.



Simplified adiabatic models systematically overestimate mean indoor operative temperature.

Future Horizons.

From CityGML to decomposed Shared Walls to EnergyPlus translation to Surface Matching to Performance Simulations

1

Q1: Stress-Test

Validate the algorithm for other datasets.

2

Q2: Scalability

Integrating parallel computation to parse entire metropolitan building registers efficiently.

3

Q3: Energy ADE

Embedding shared-wall geometric calculations directly inside the CityGML Core structure and Energy ADE.

4

Q4: Heat Flow

Calculate the actual heat transfer flowing on shared wall surfaces

Thank you

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Let's connect on LinkedIn