

# A Hamburg energy twin: a simulated Agent-Based Modeling approach.

Research project - Current progression

March – May 2025



HafenCity  
Universität  
Hamburg

**City Science Lab**  
A Cooperation with the MIT Media Lab



Chanattan Sok, Rico Herzog and Arnaud Grignard

# **City Science Lab HafenCity Universität**

## **Hamburg, Germany**

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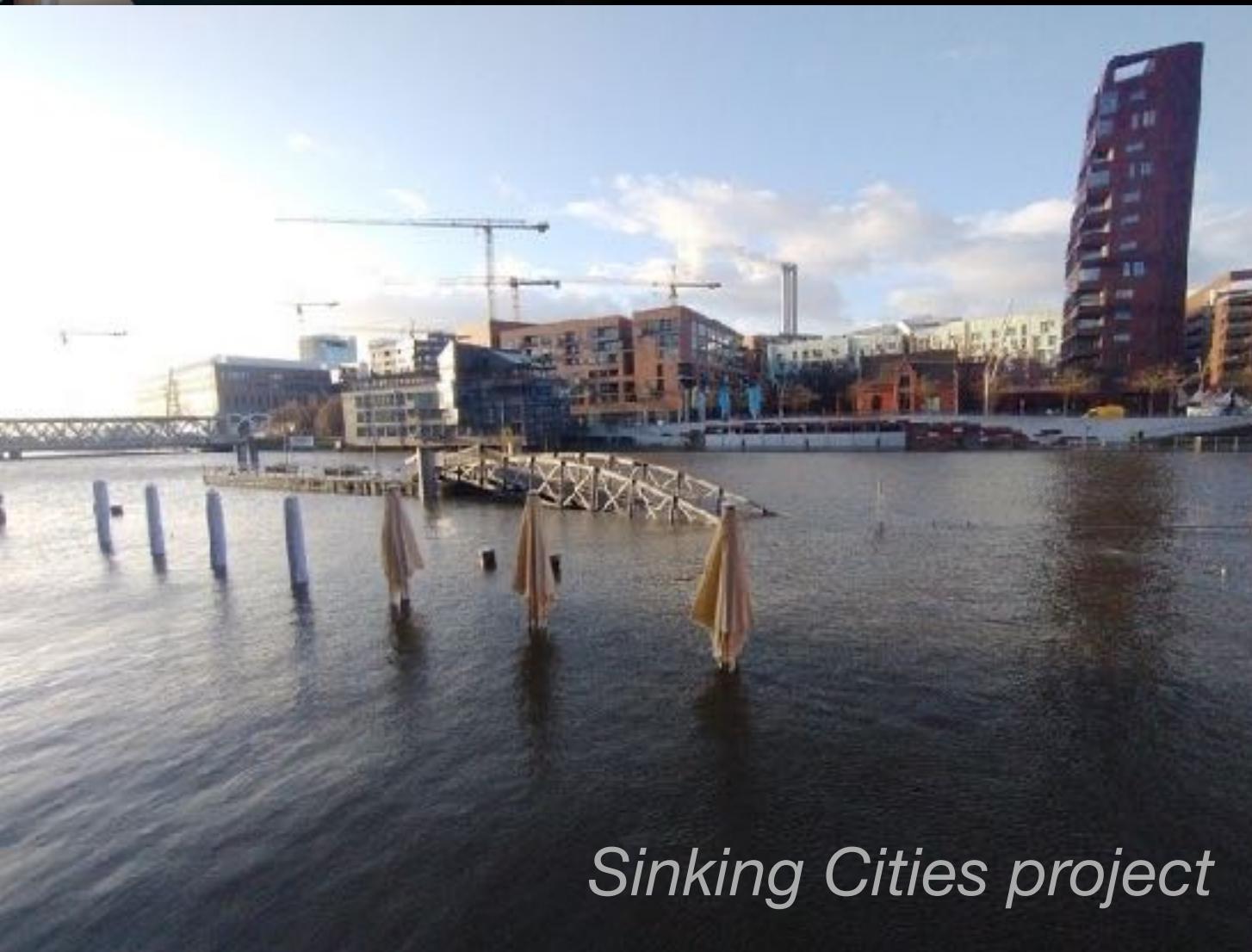


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## Hamburg, Germany



The "*Connected Urban Twins*" project develops data-driven digital twins to support sustainable urban transformation.



*Sinking Cities project*

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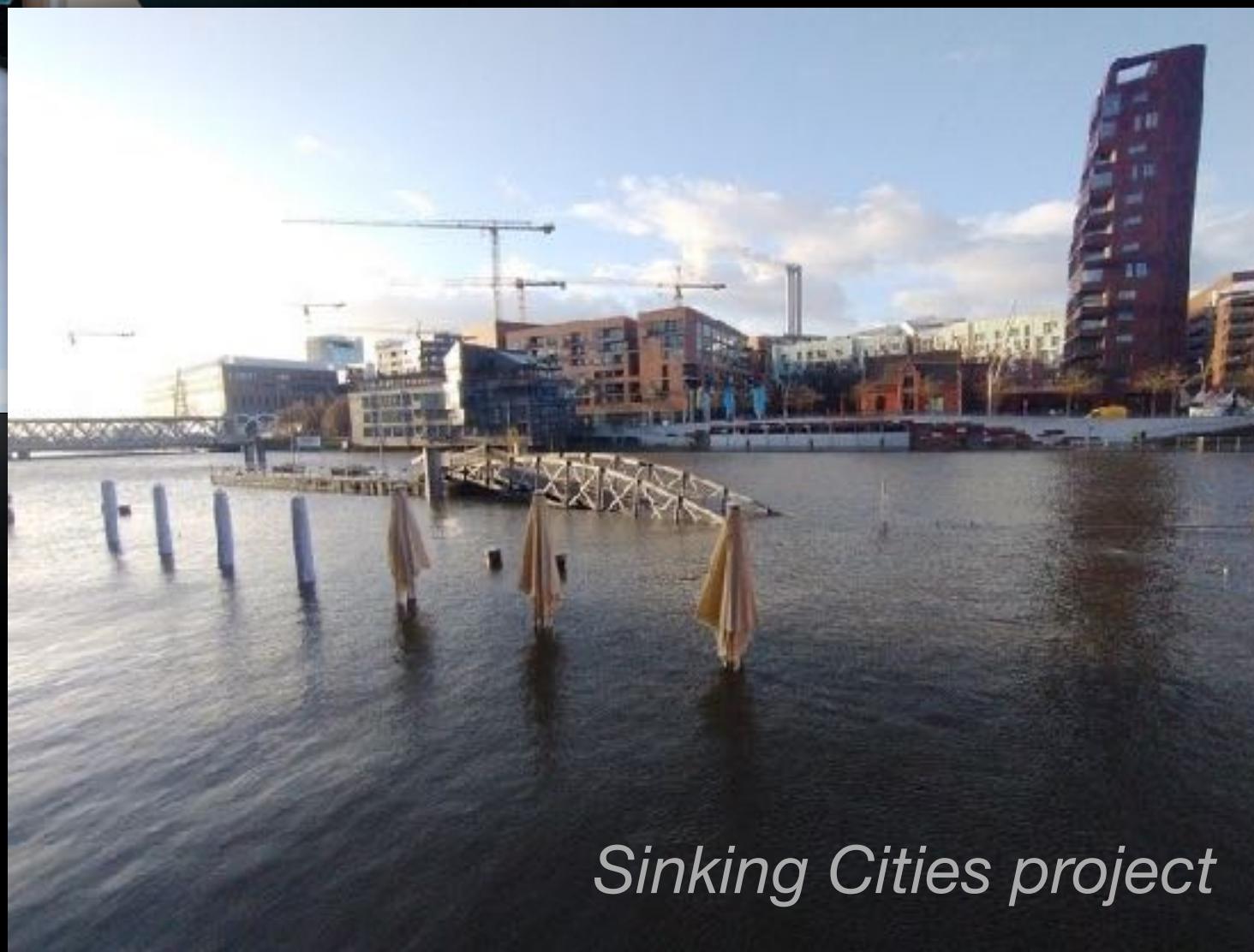
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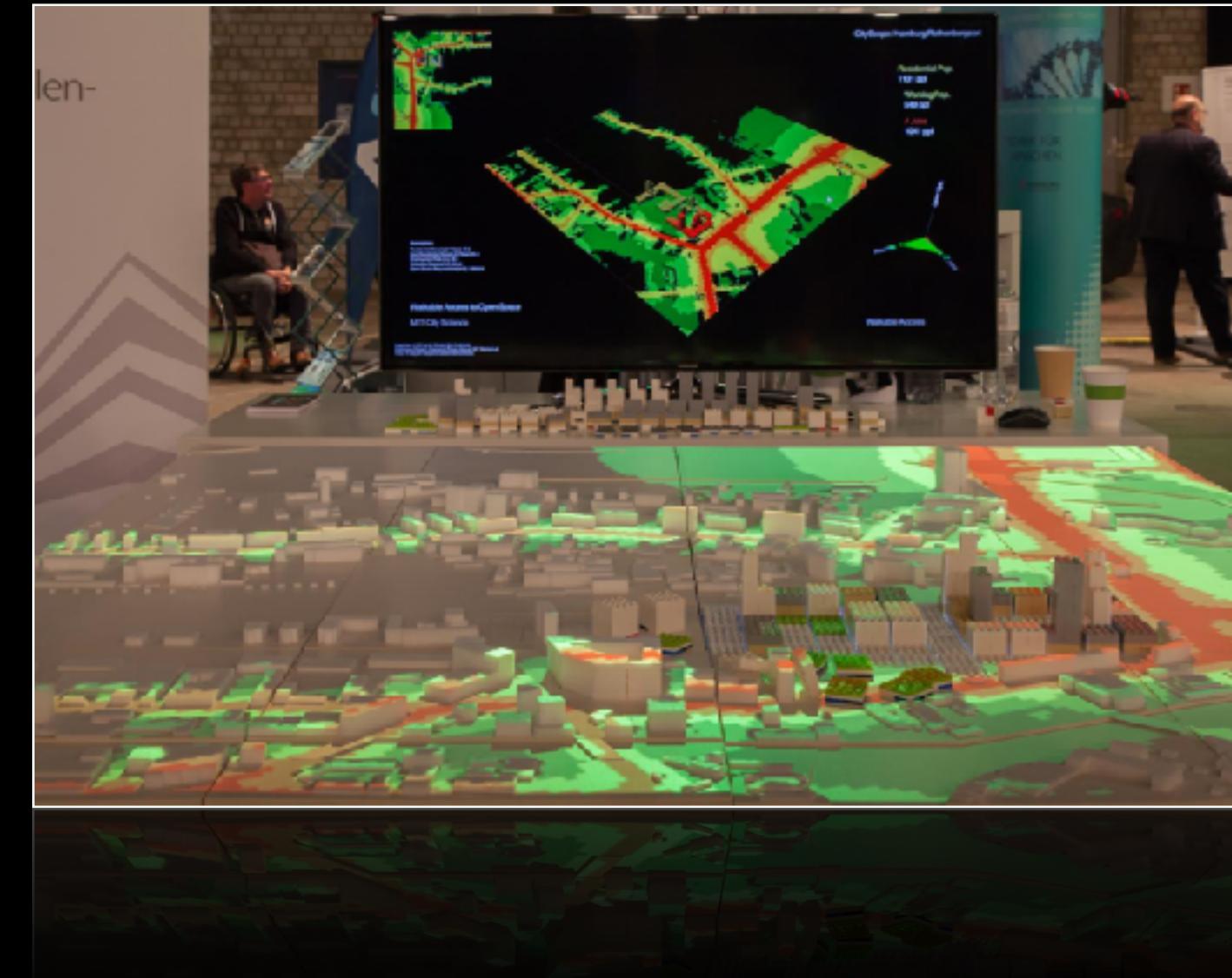
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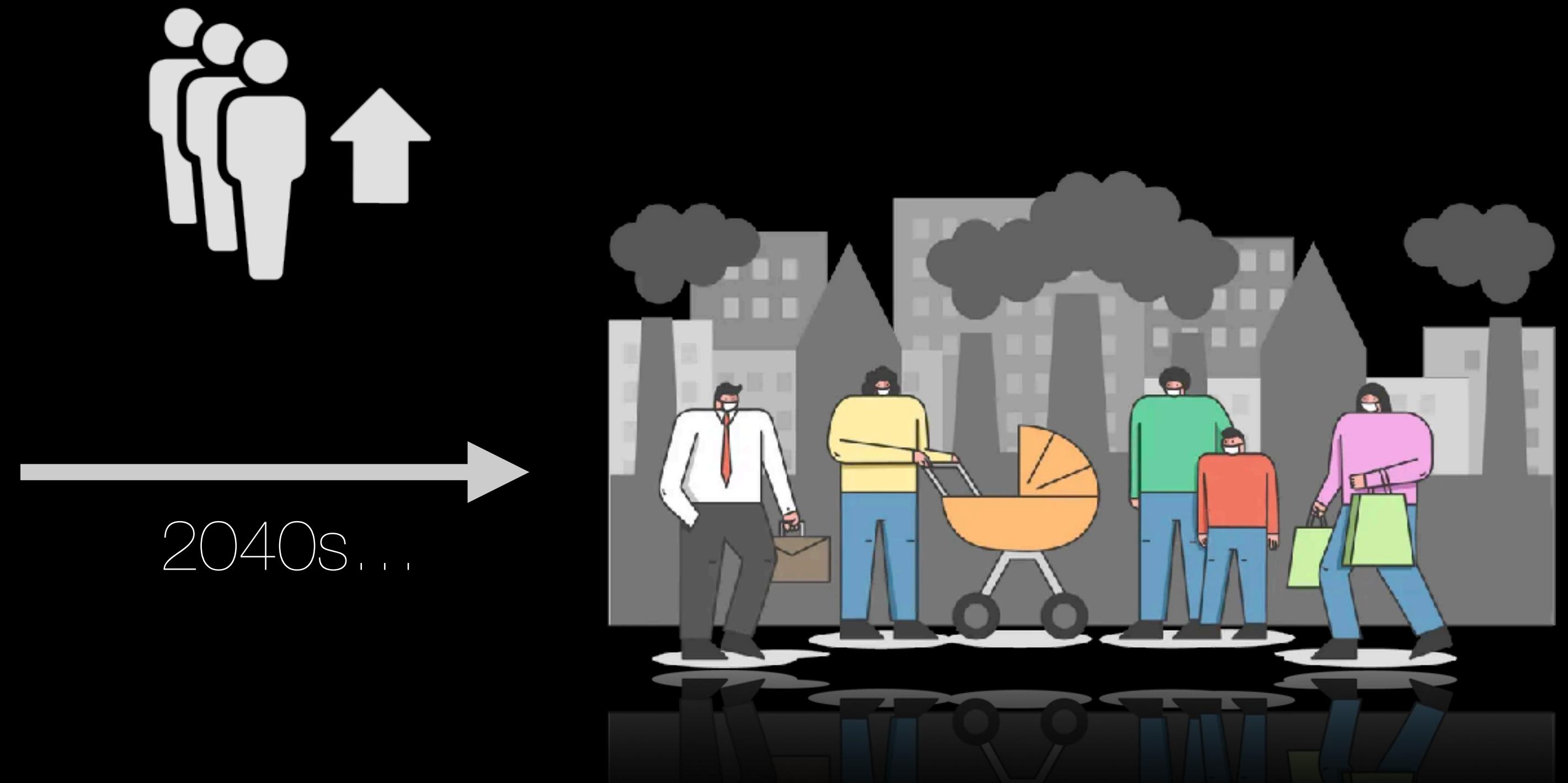
The CUT project fosters

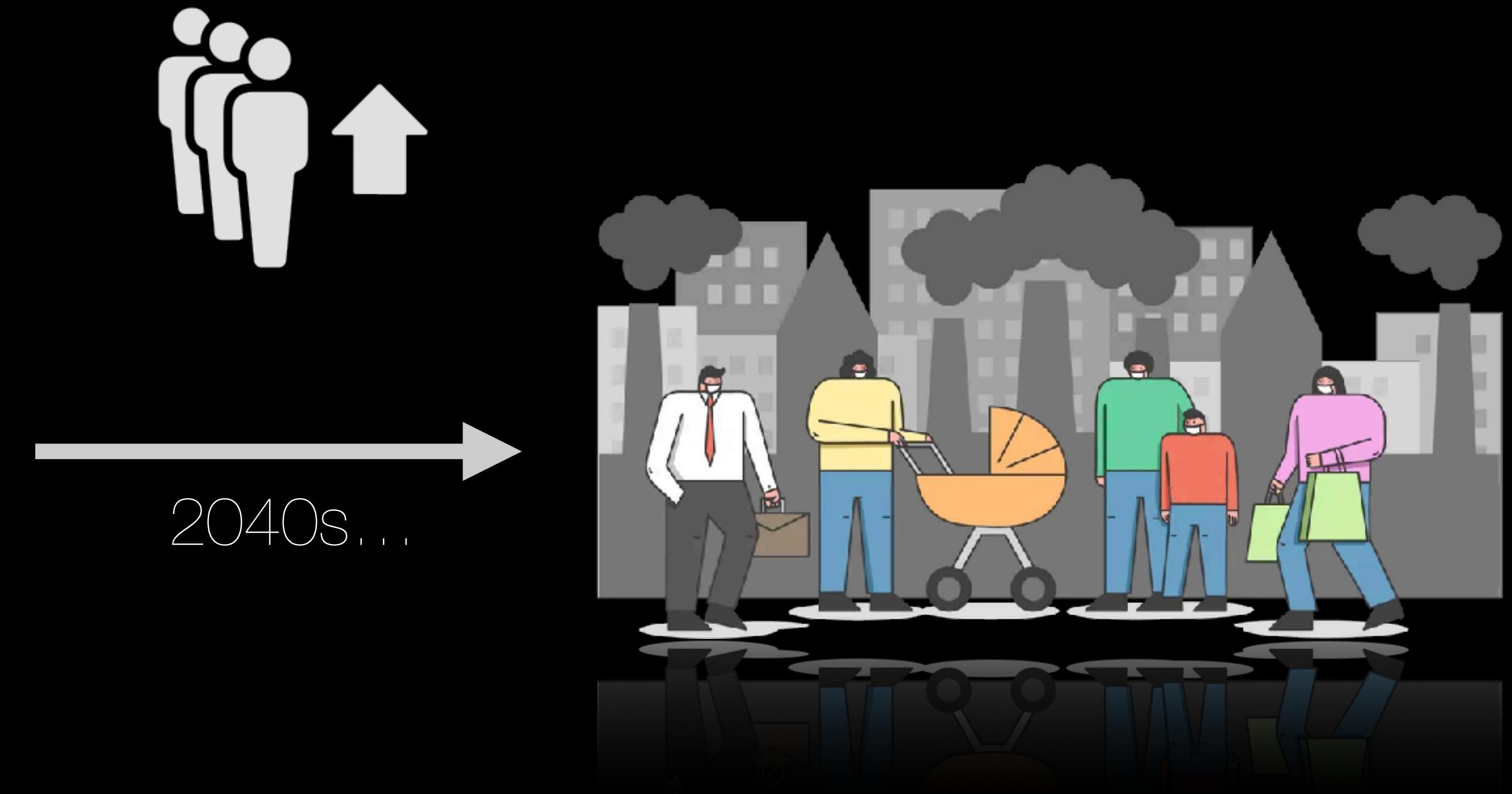
- Cross-sector collaboration
- Citizen participation
- Open-source, replicable solutions for integrated urban development.











Focus on buildings in Hamburg

# Hamburg

A modern city of **755 km<sup>2</sup>** with **> 1.8 million inhabitants**

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# BUKEA

Office for the Environment, Climate, Energy and Agriculture

The screenshot shows the homepage of the BUKEA website. At the top, there is a navigation bar with links for Accessibility, Sign language, Easy language, Help, Search, and EN. On the right side of the navigation bar is the 'hamburg.de' logo with a red castle tower icon. Below the navigation bar, there is a large blue banner featuring the red castle tower icon and the text 'About us'. Underneath the banner, the text 'To help make Hamburg climate-neutral. Combining Hamburg's growth and urban development with a green city.' is displayed. Below this, the text 'The authority introduces itself' is visible. A large image of a modern, colorful, curved building is shown at the bottom left. A small circular icon with a person symbol is located in the bottom right corner.

Accessibility Sign language Easy language Help Search EN

hamburg.de

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hamburg.de

Accessibility Sign language Easy language Help Search EN

Topics

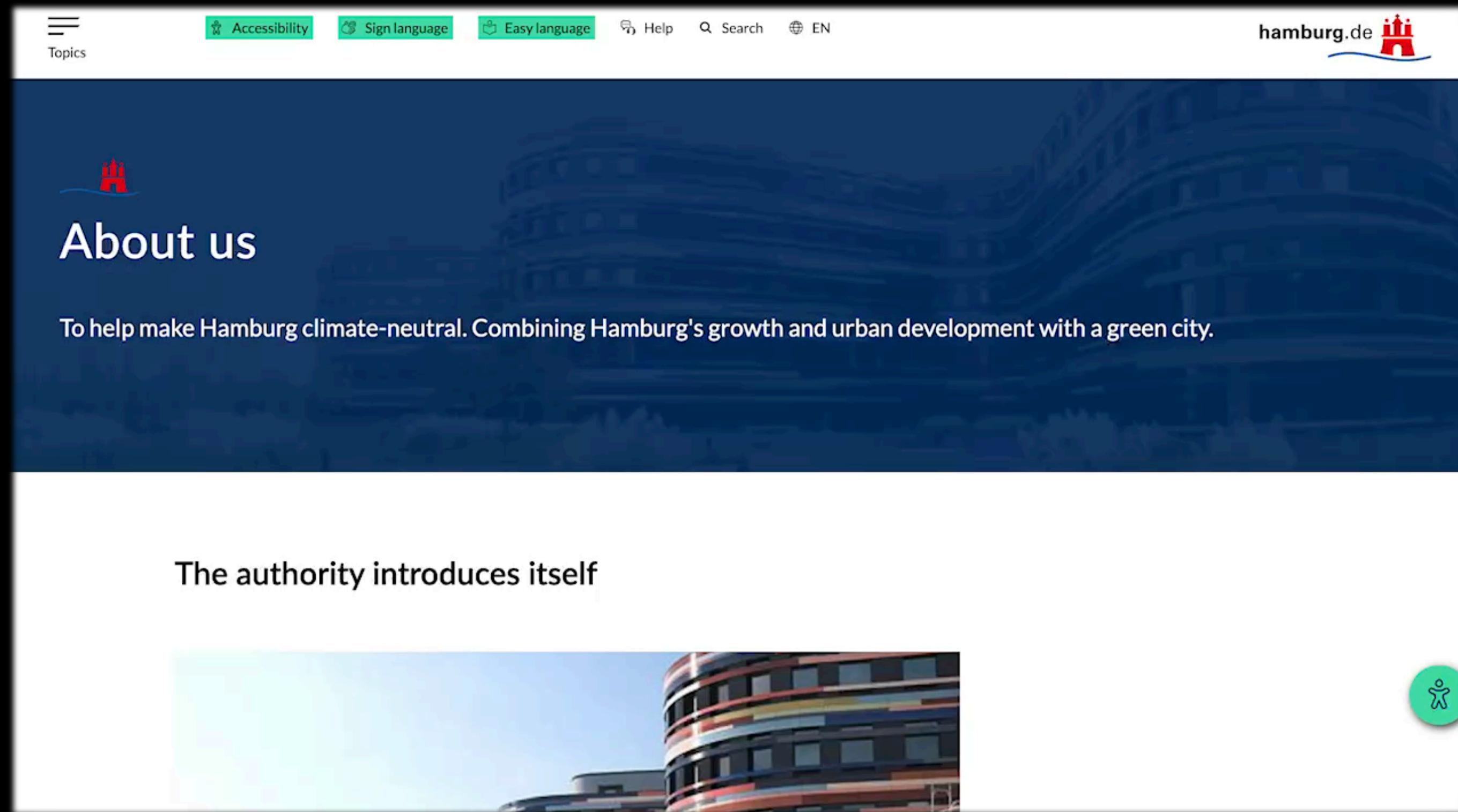
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hamburg.de

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**Law-making on *building standards*  
when subject to decision.**

**All *public*-owned *non-residential buildings* comply.**



# Main question: Demolition vs Retrofitting

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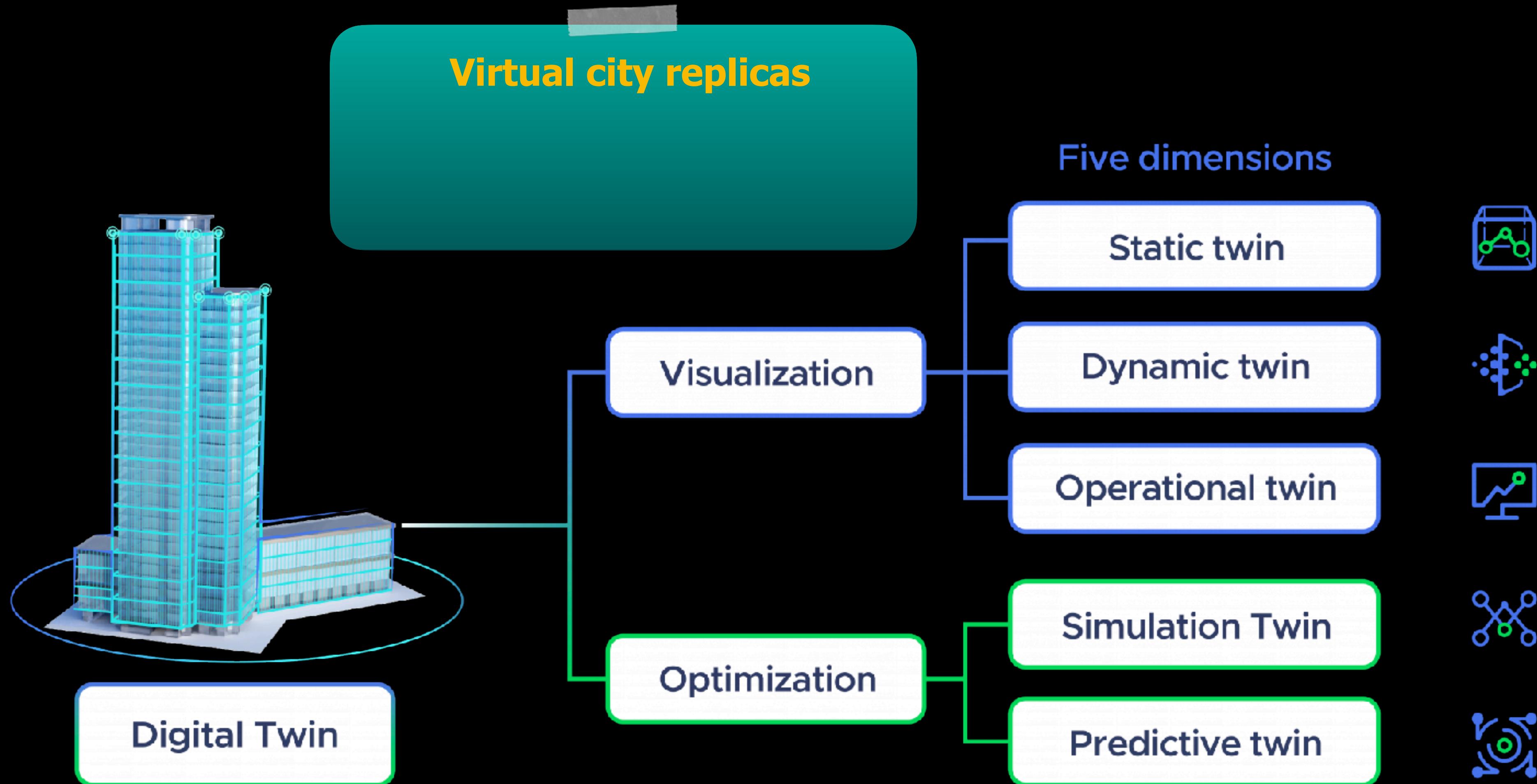
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Focus on (operational) energy emissions on  
public non-residential (e.g., schools, ...) buildings

# Digital Urban Twin

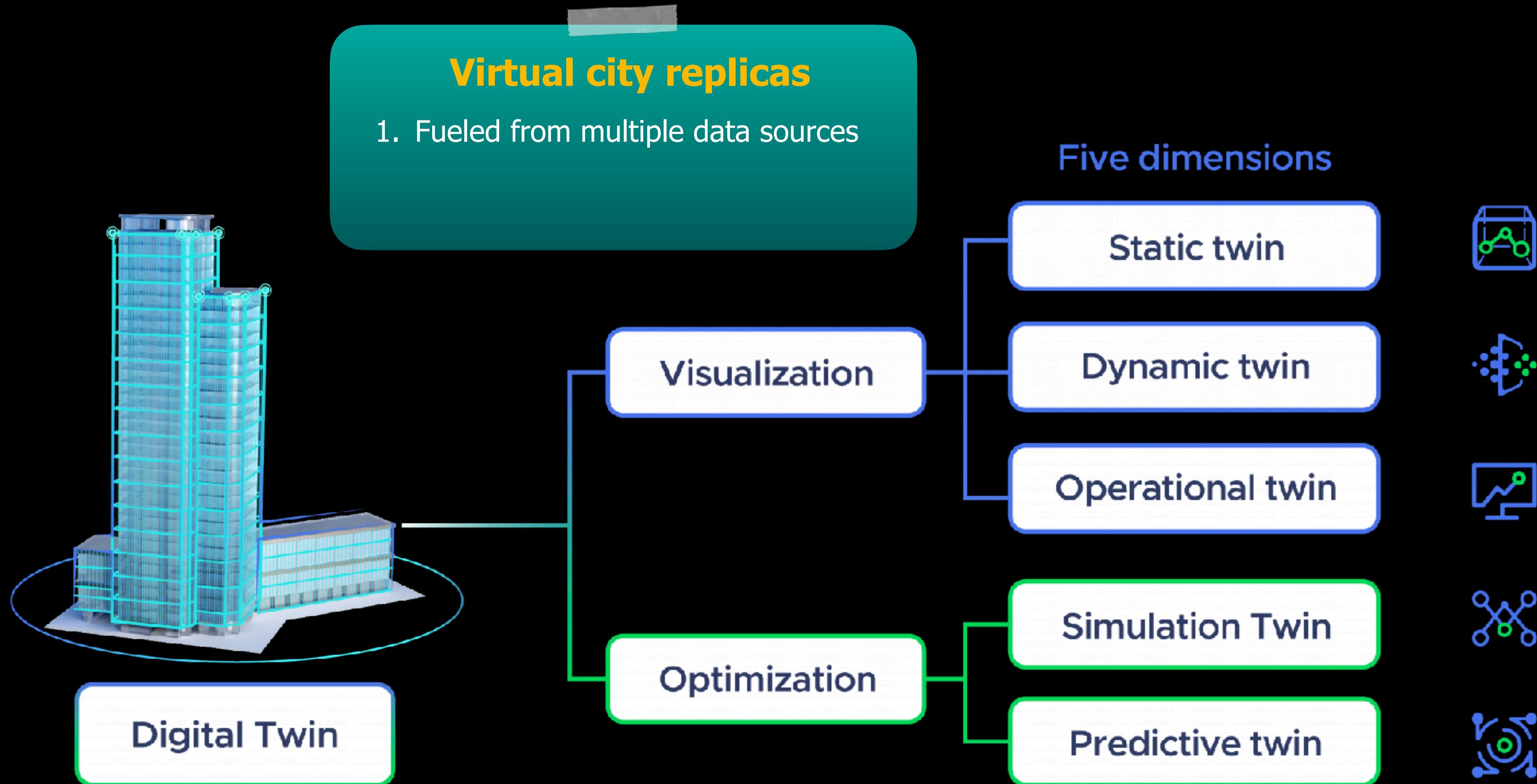
<https://www.akila3d.com>

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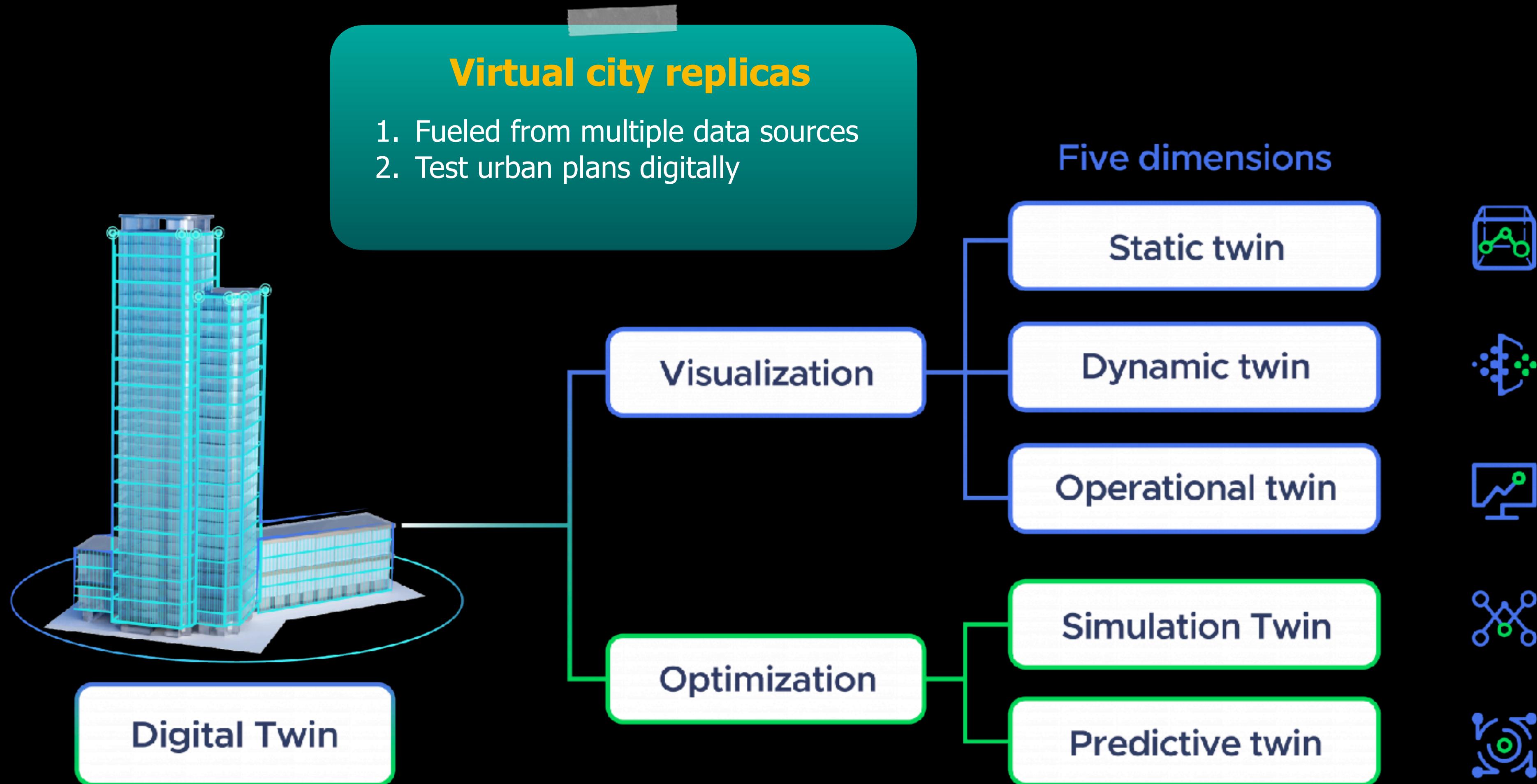
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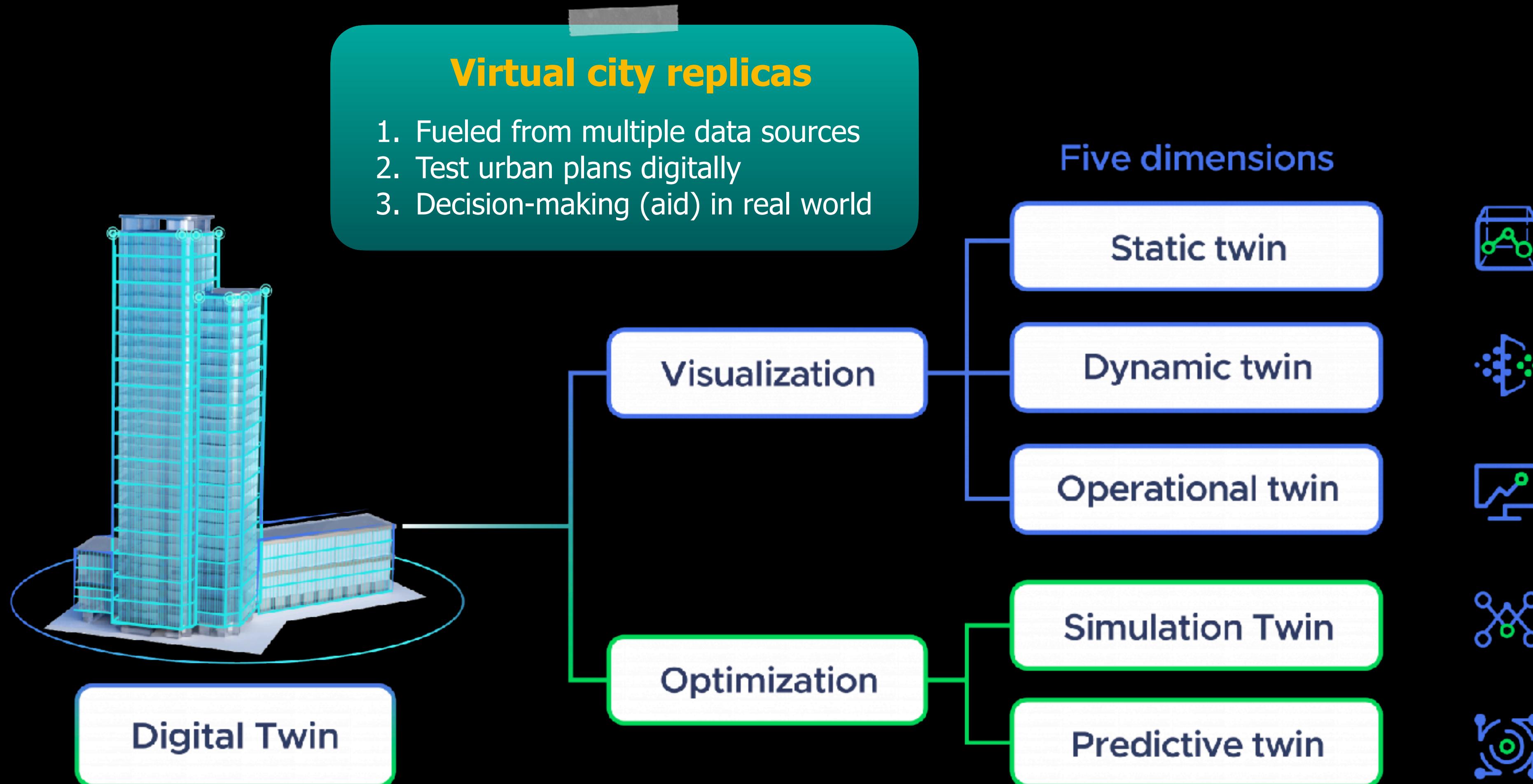
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Tough battle on gathering data & fitting to the model

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*Through the collaboration with BUKEA: law decision on building standards*

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- An average cost of 6M euros per industrial building demolition-reconstruction

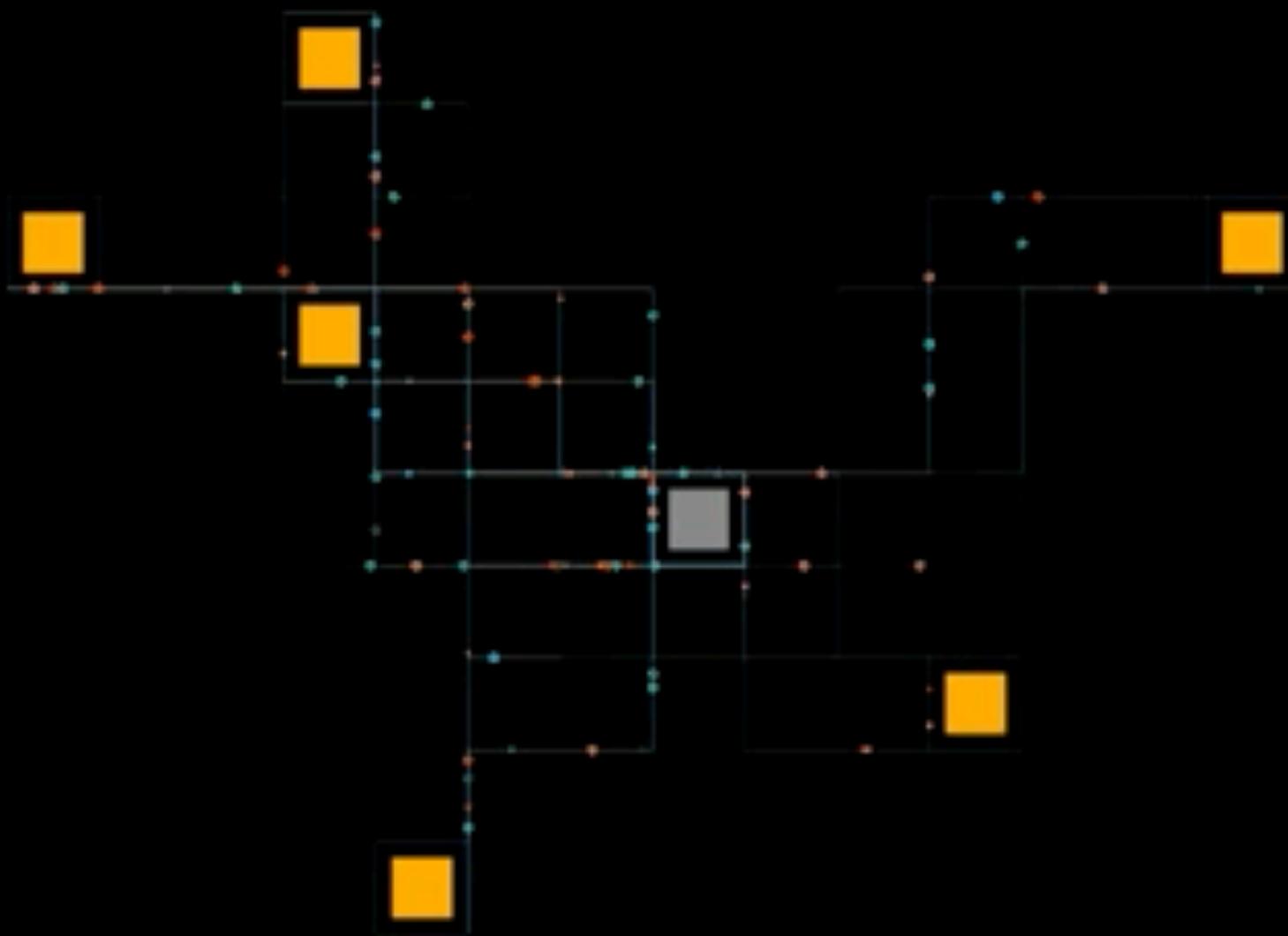
# Simulation tool

Case study with GAMA Platform



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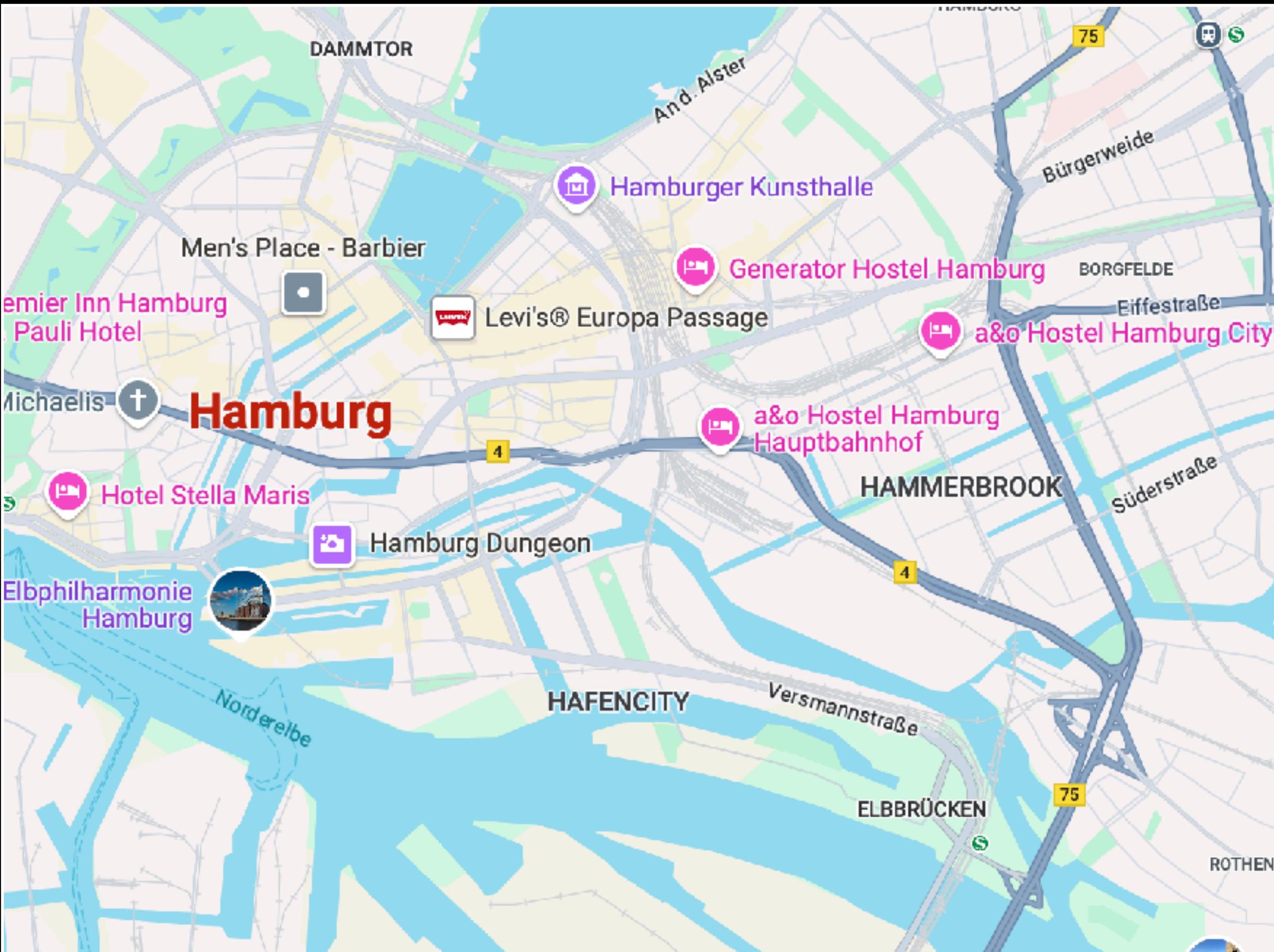
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Arnaud Grignard - URBAvability - Gama 1.8 Platform Cooper Hewitt Prototype

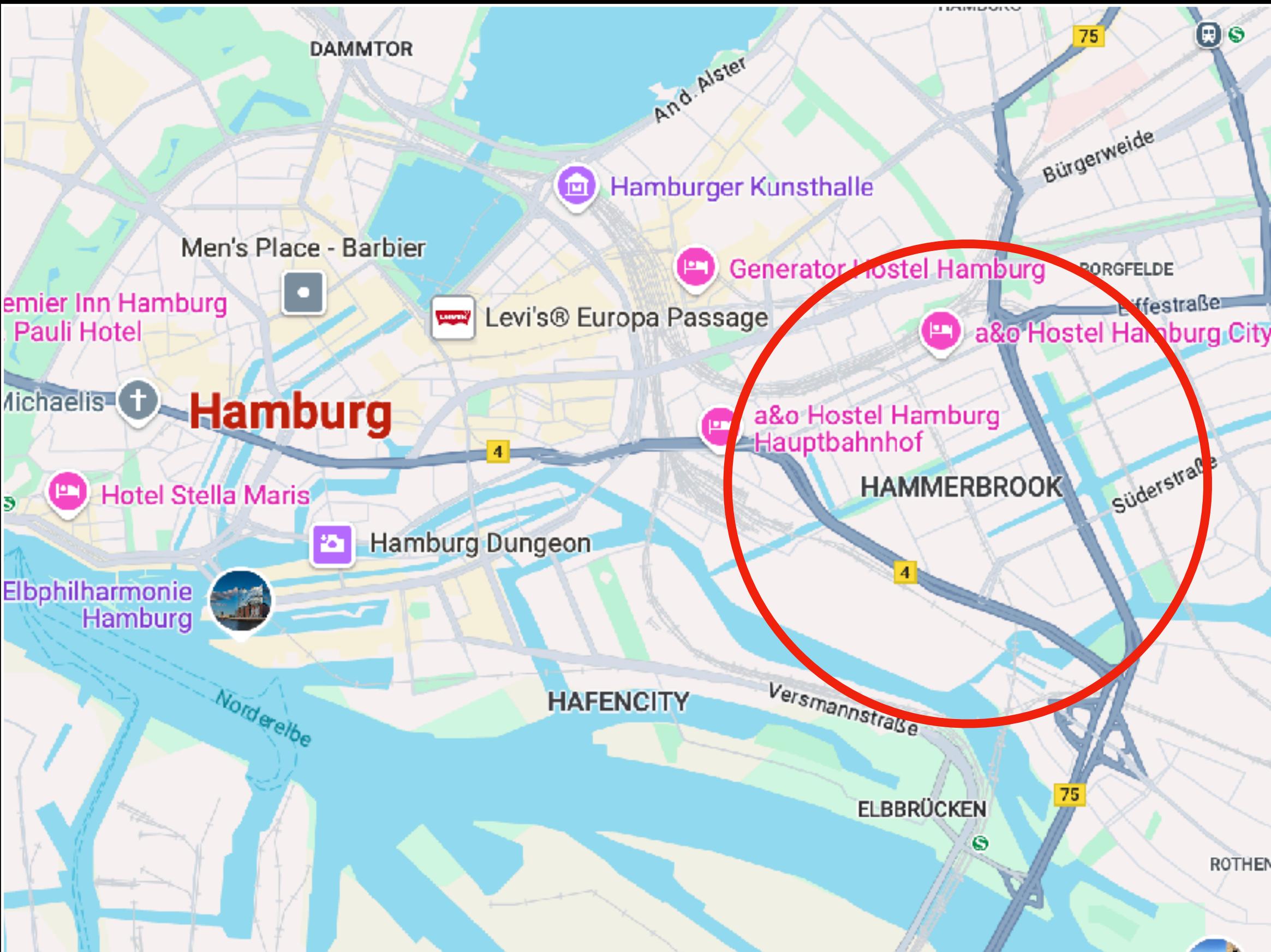
# Hammerbrook

## An industrial district



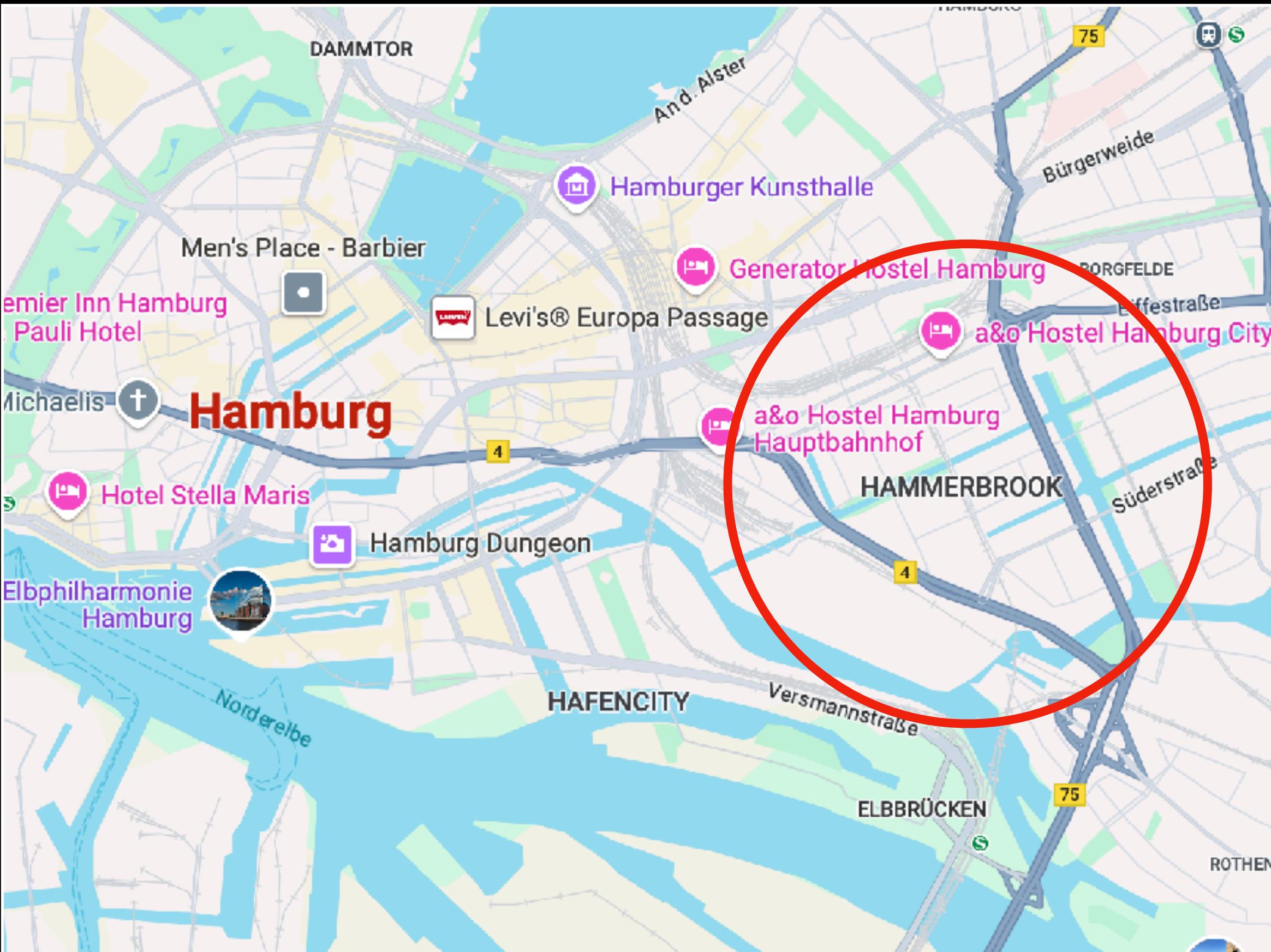
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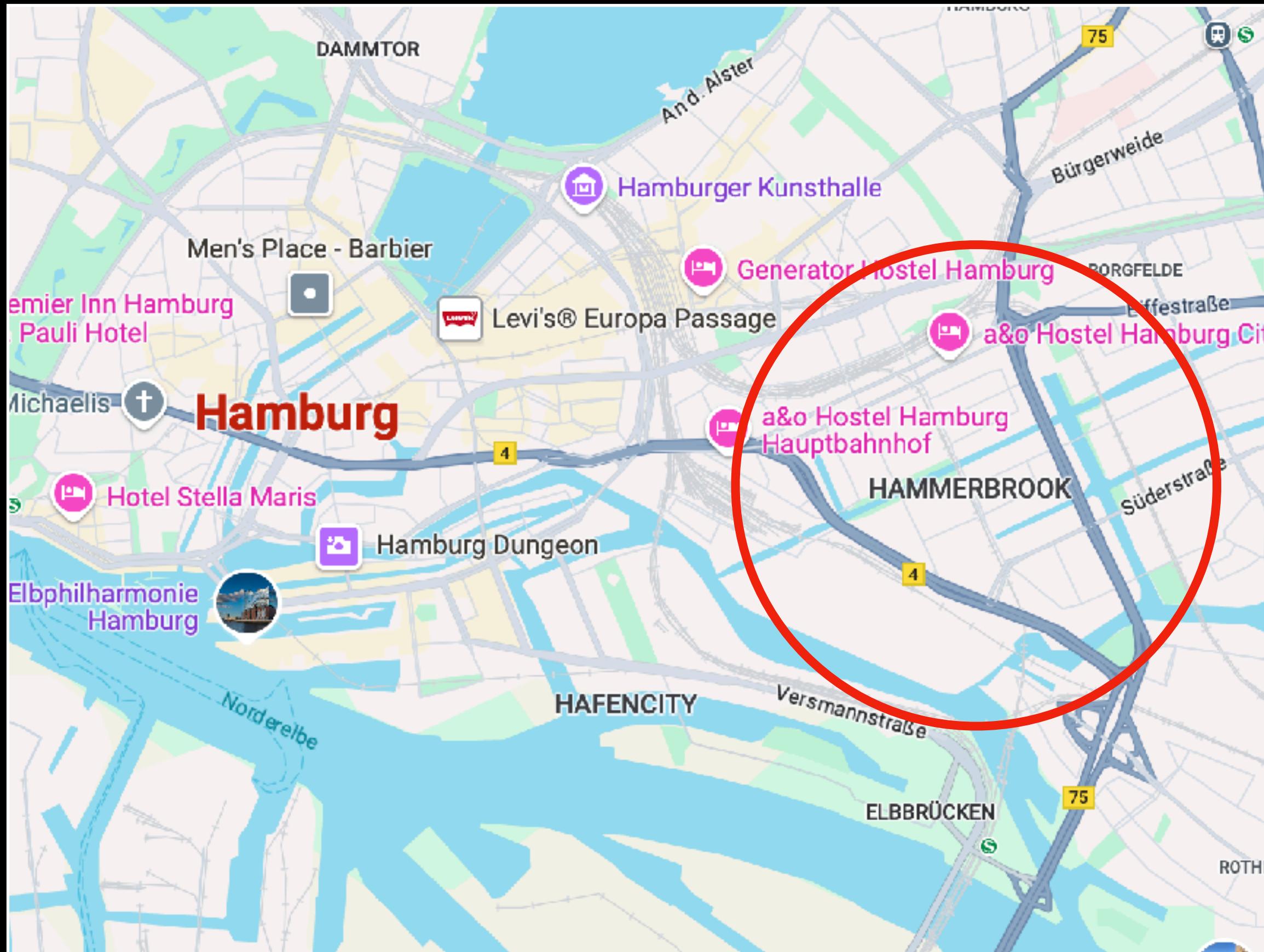
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District-flexible

# Hammerbrook

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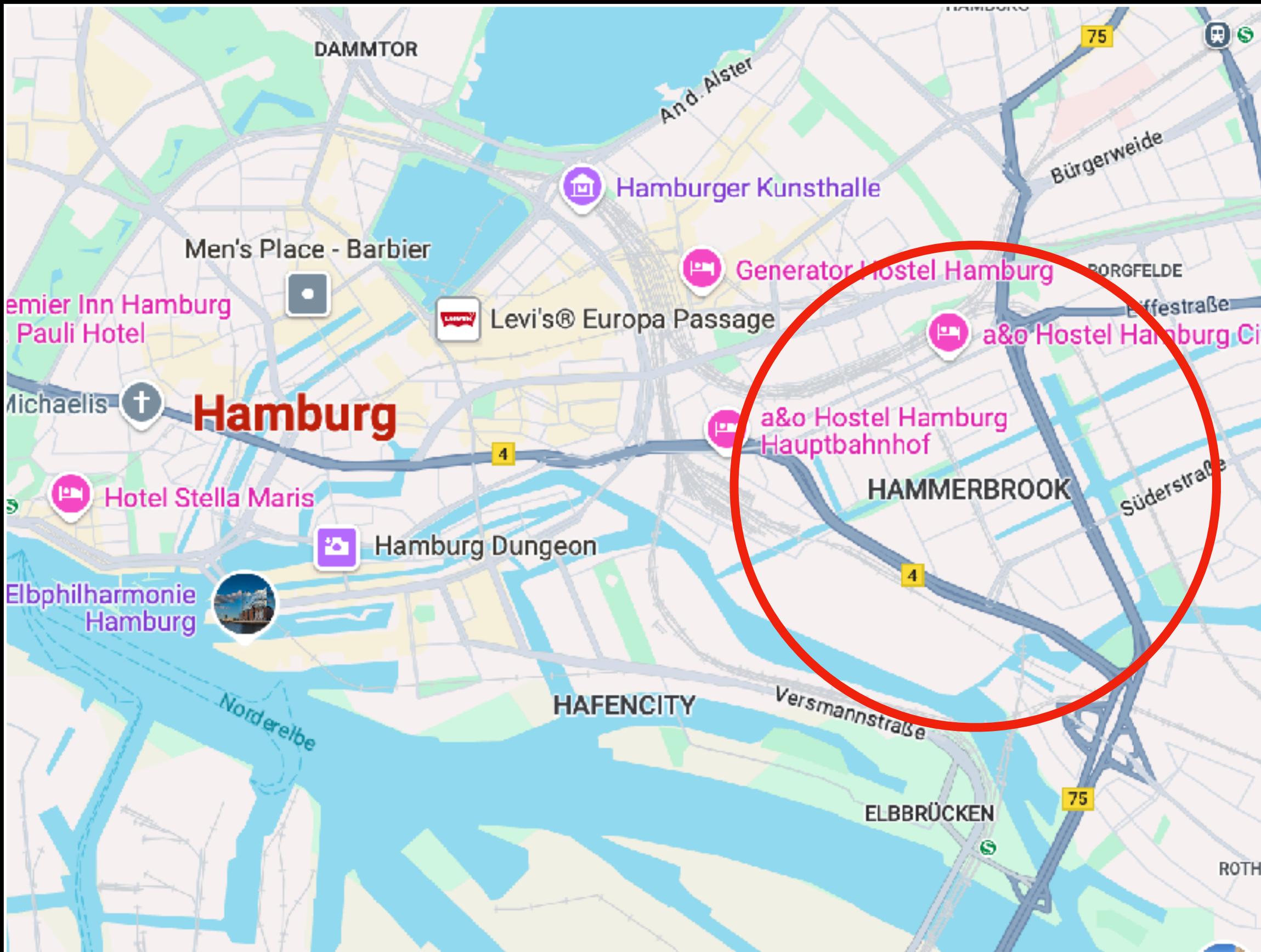


District-flexible

Choose an area of Hamburg to simulate  
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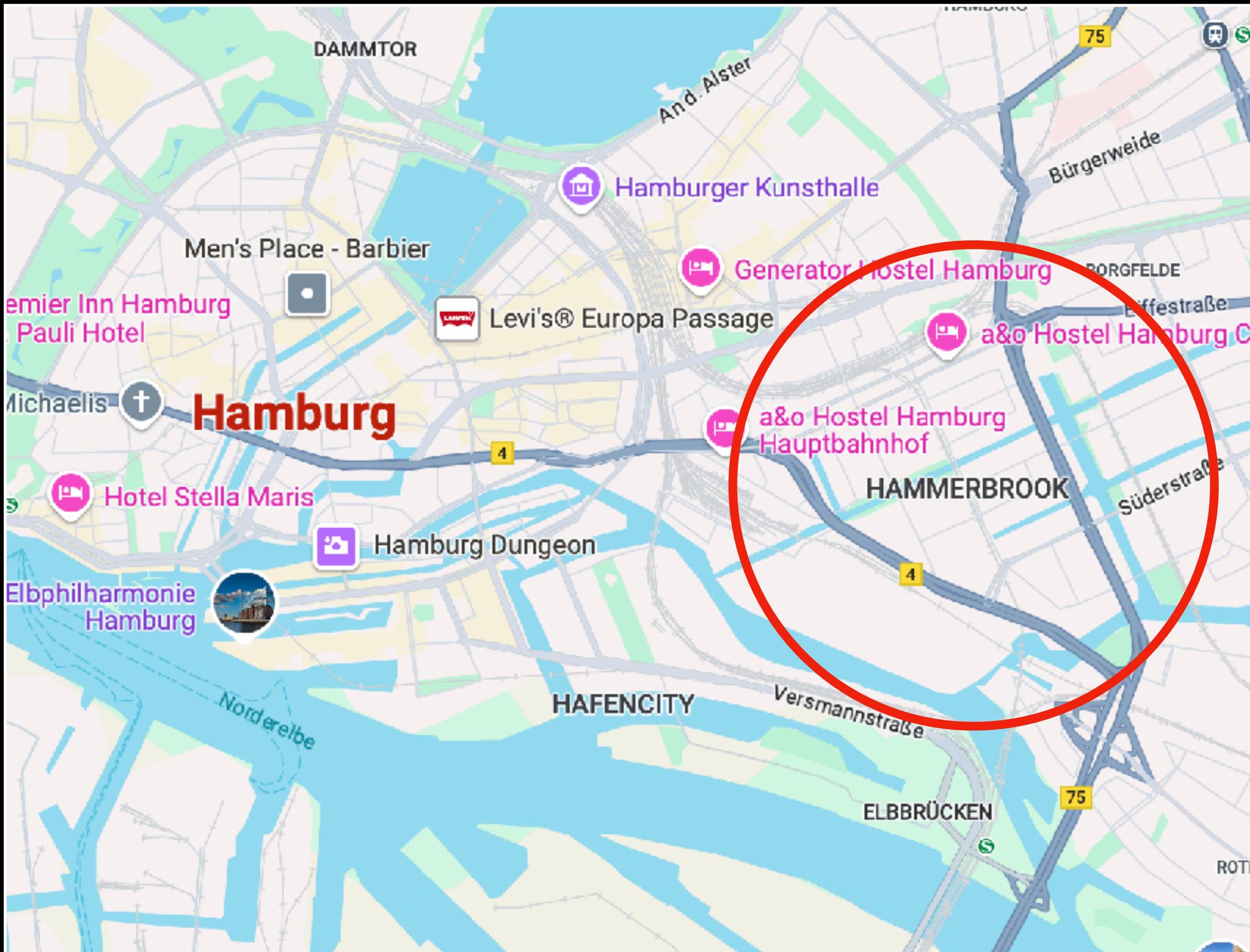
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Generic model applicable to  
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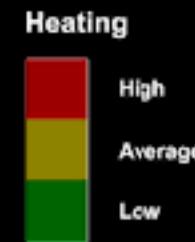
~ 10000 buildings for  
reasonable computations

# **Hammerbrook simulated**

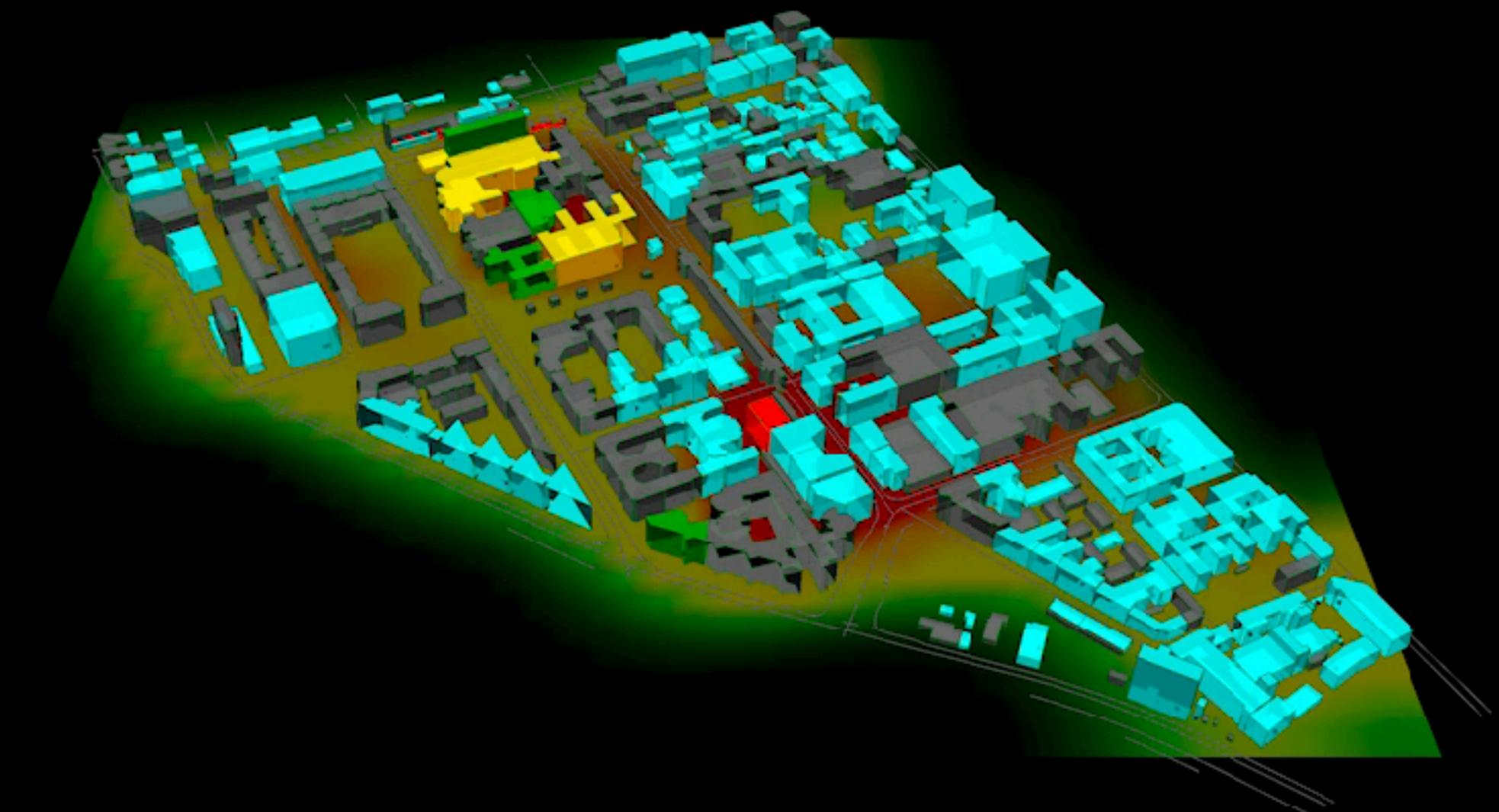
GAMA Platform - Demolition vs Retrofitting by 2040s

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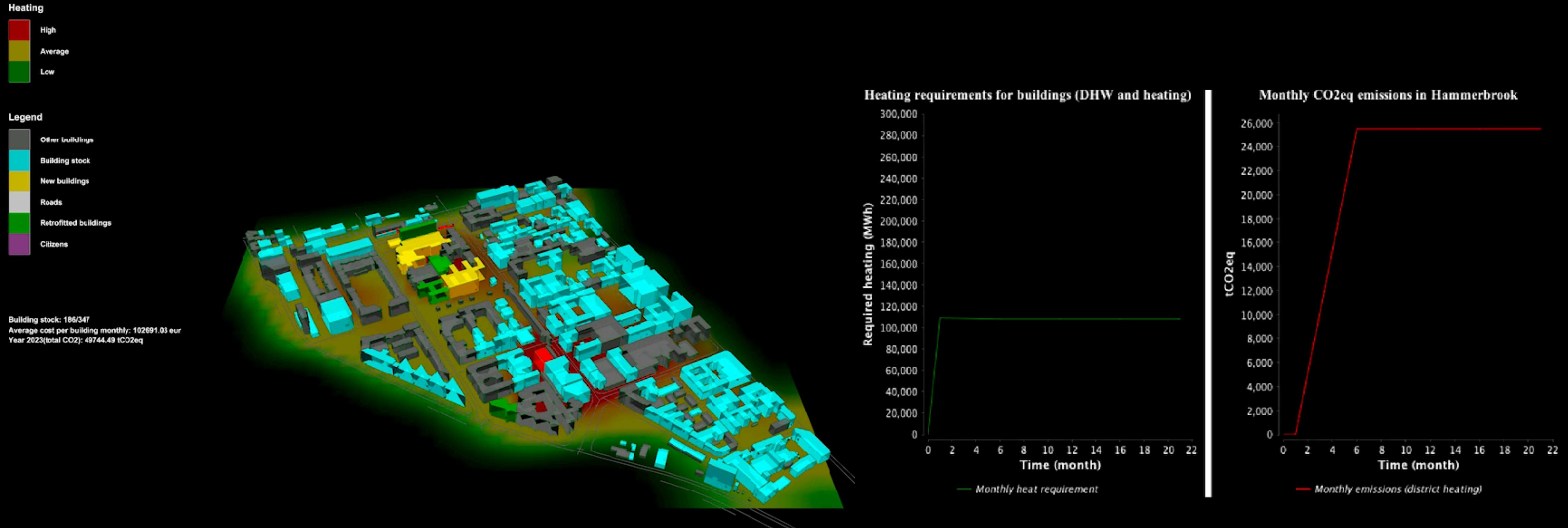
Building stock: 186/347  
Average cost per building monthly: 102691.03 eur  
Year 2023(total CO<sub>2</sub>): 49744.49 tCO<sub>2</sub>eq



Red buildings are demolished and rebuilt - Green buildings are retrofitted (floor extension, energy renovation)

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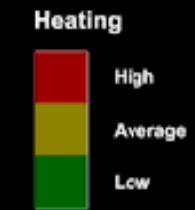
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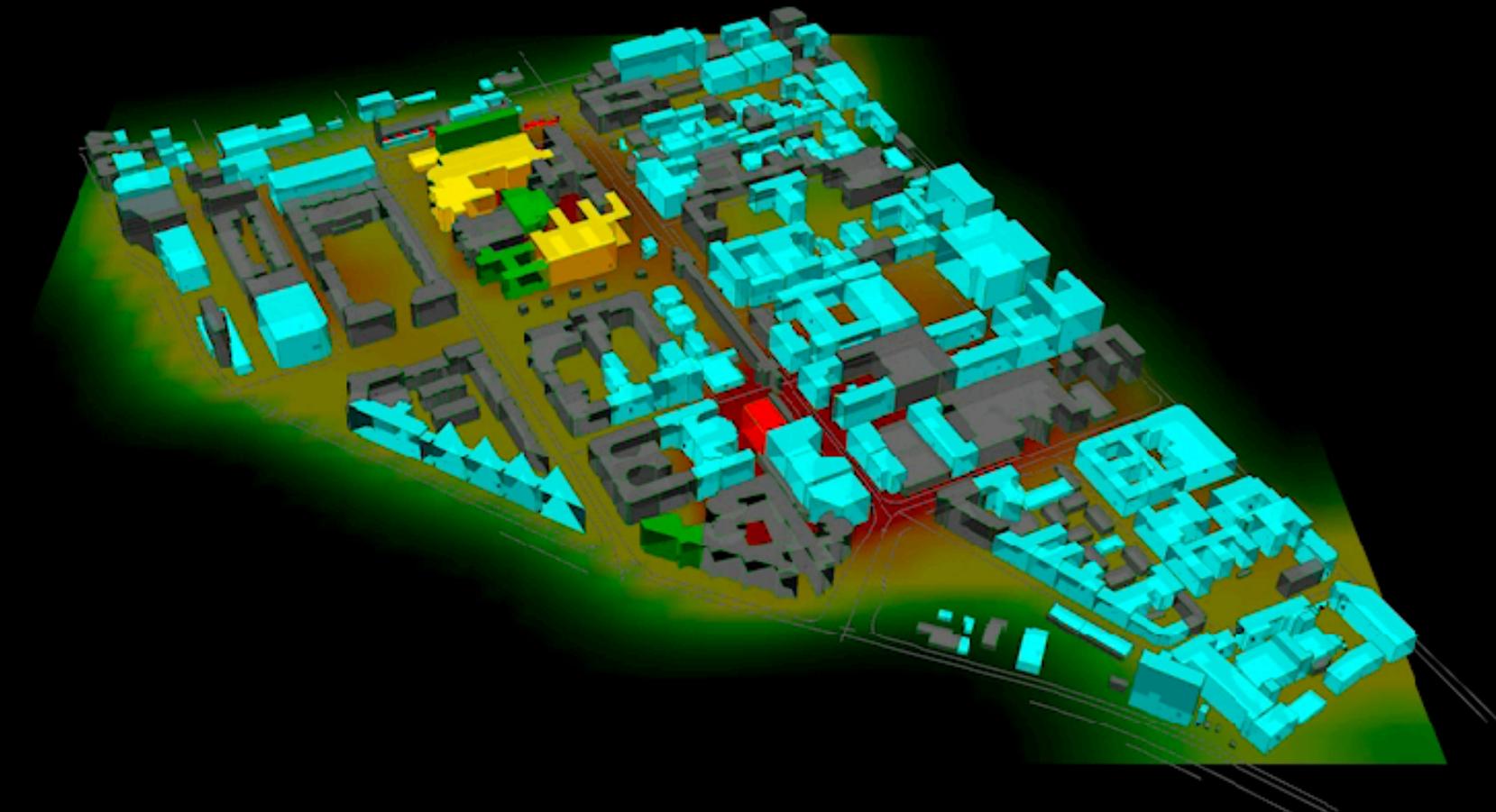
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Legend

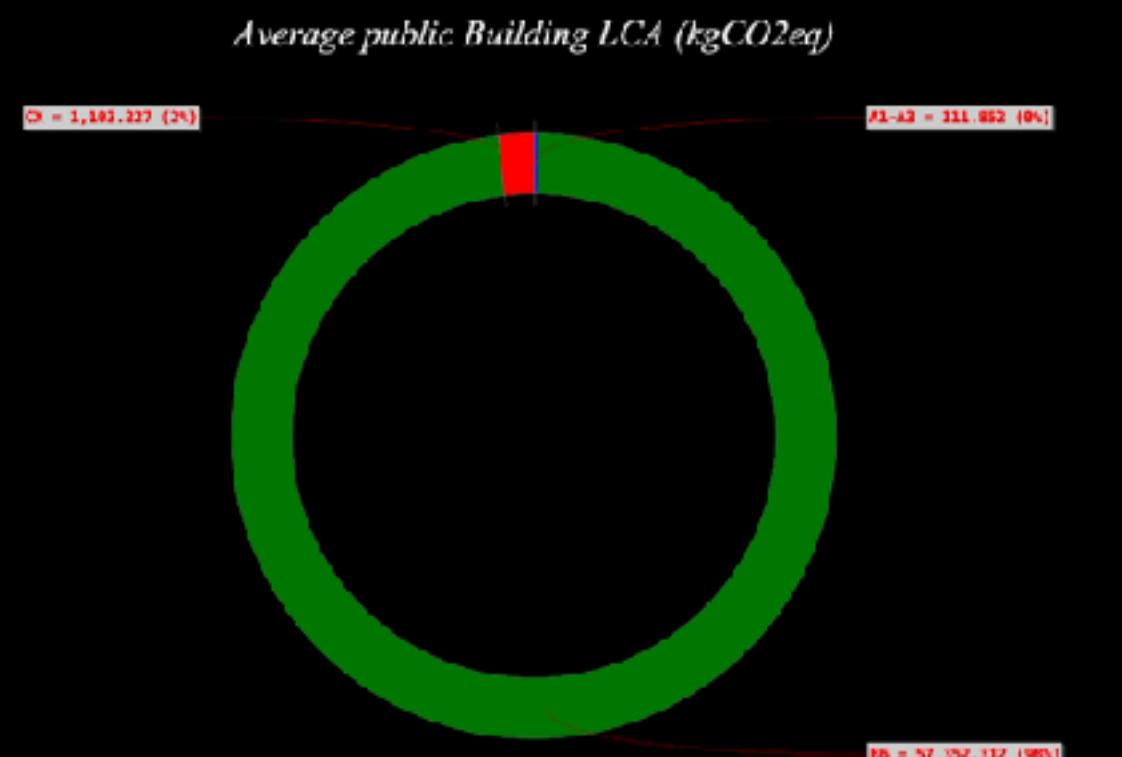
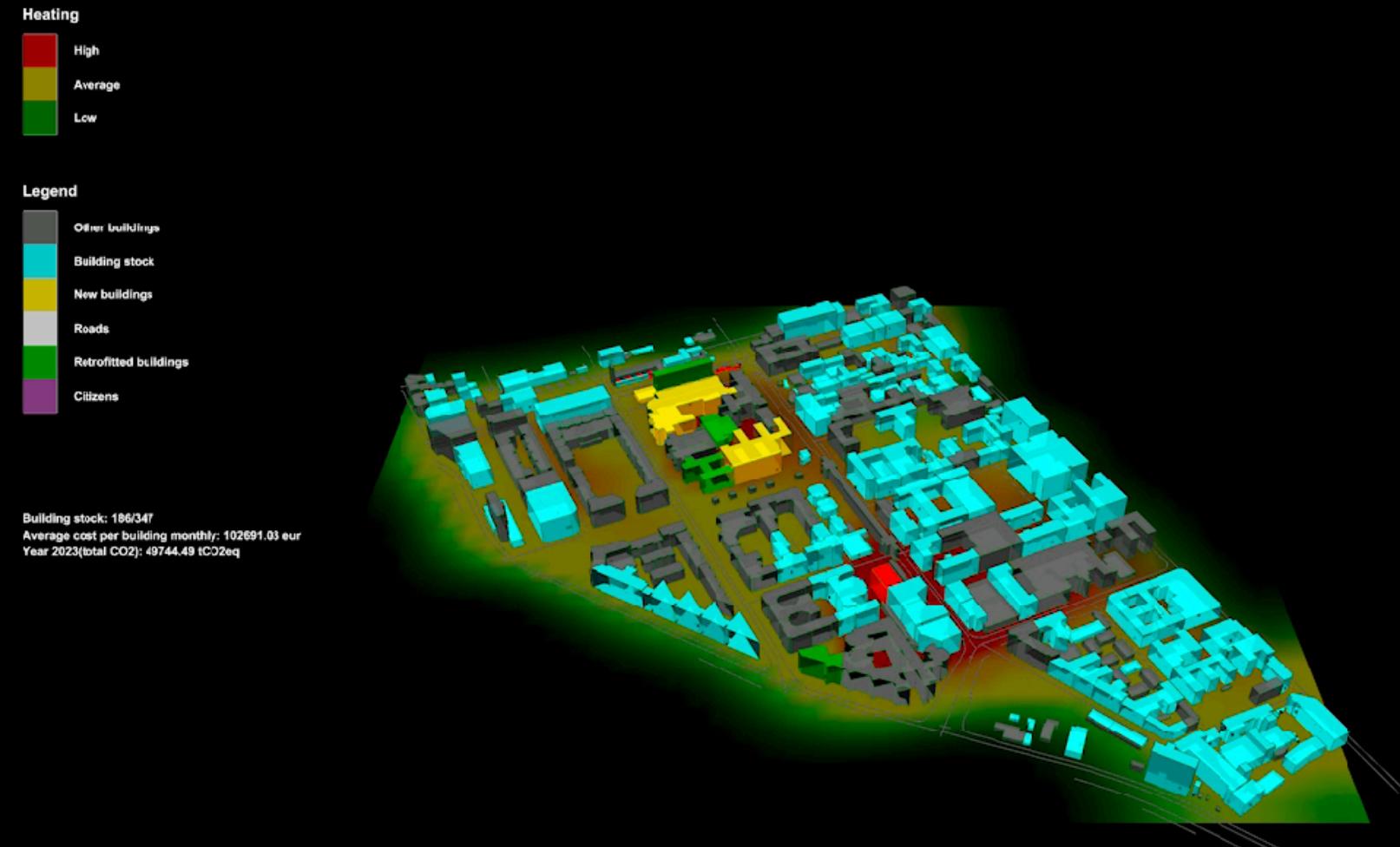


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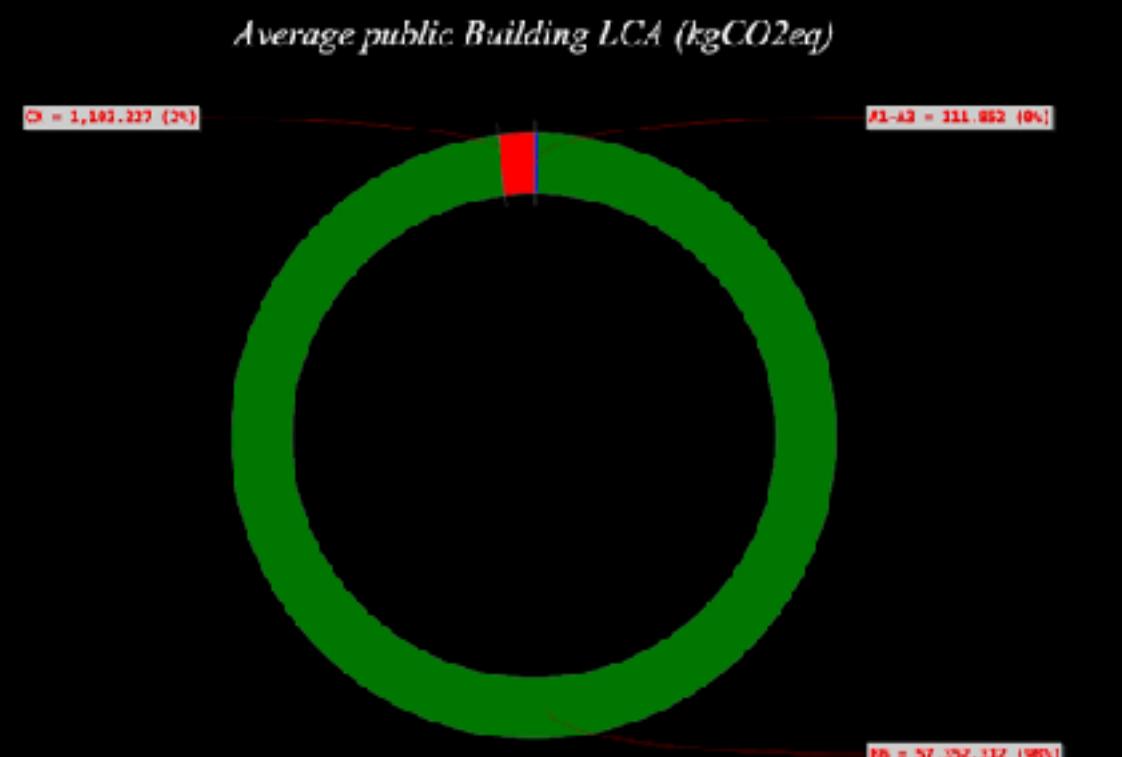
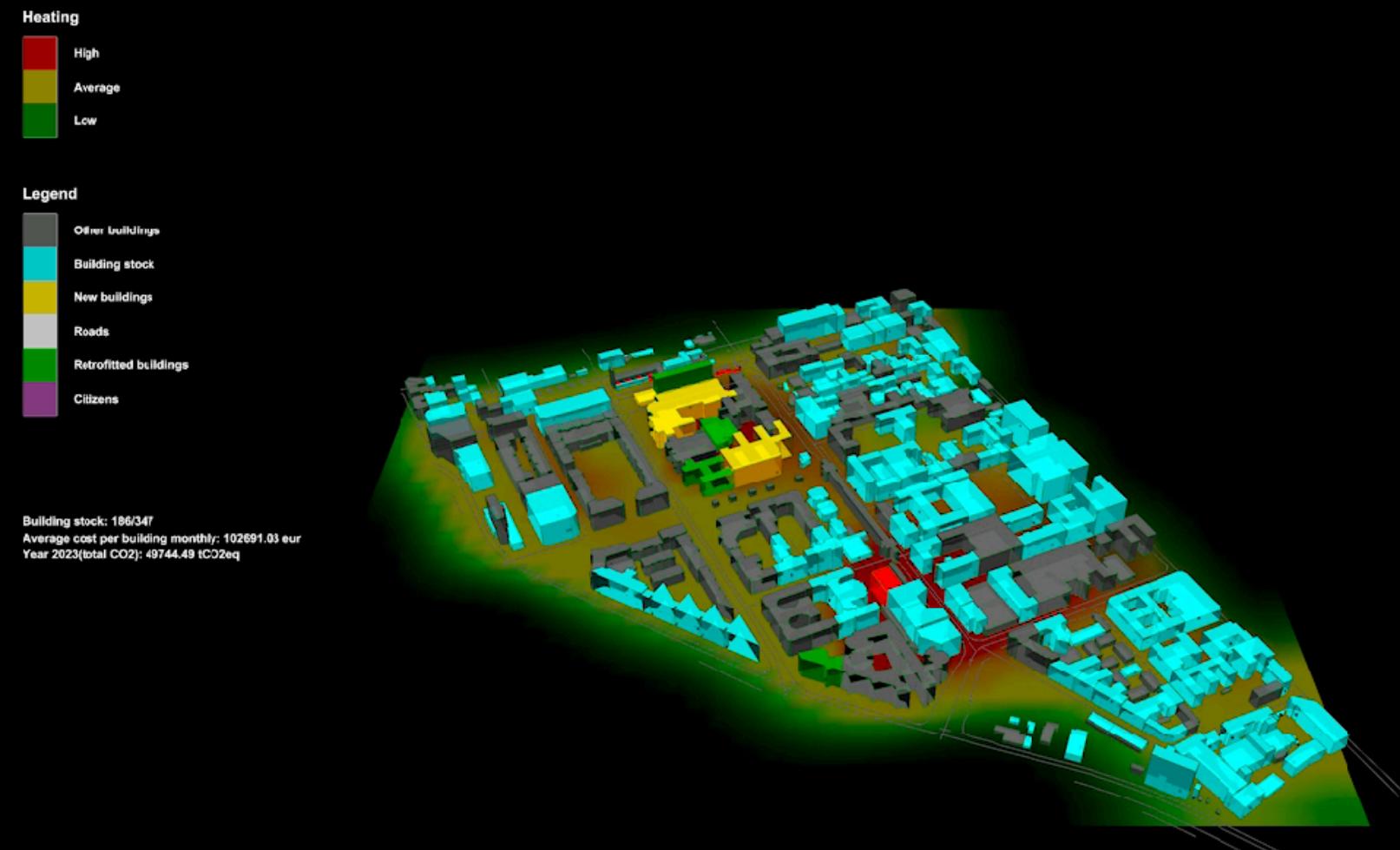


A small digital twin

- Per-building energy-use (heating, electricity)
- LCA of buildings simulated (e.g., demolition)
- Enhanced GIS-based data (3D, 2D, statistics)
- Policy levers assessment through custom scenarios
- Assessment of average costs of operations
- Citizen-owner agent modeling for decision-making

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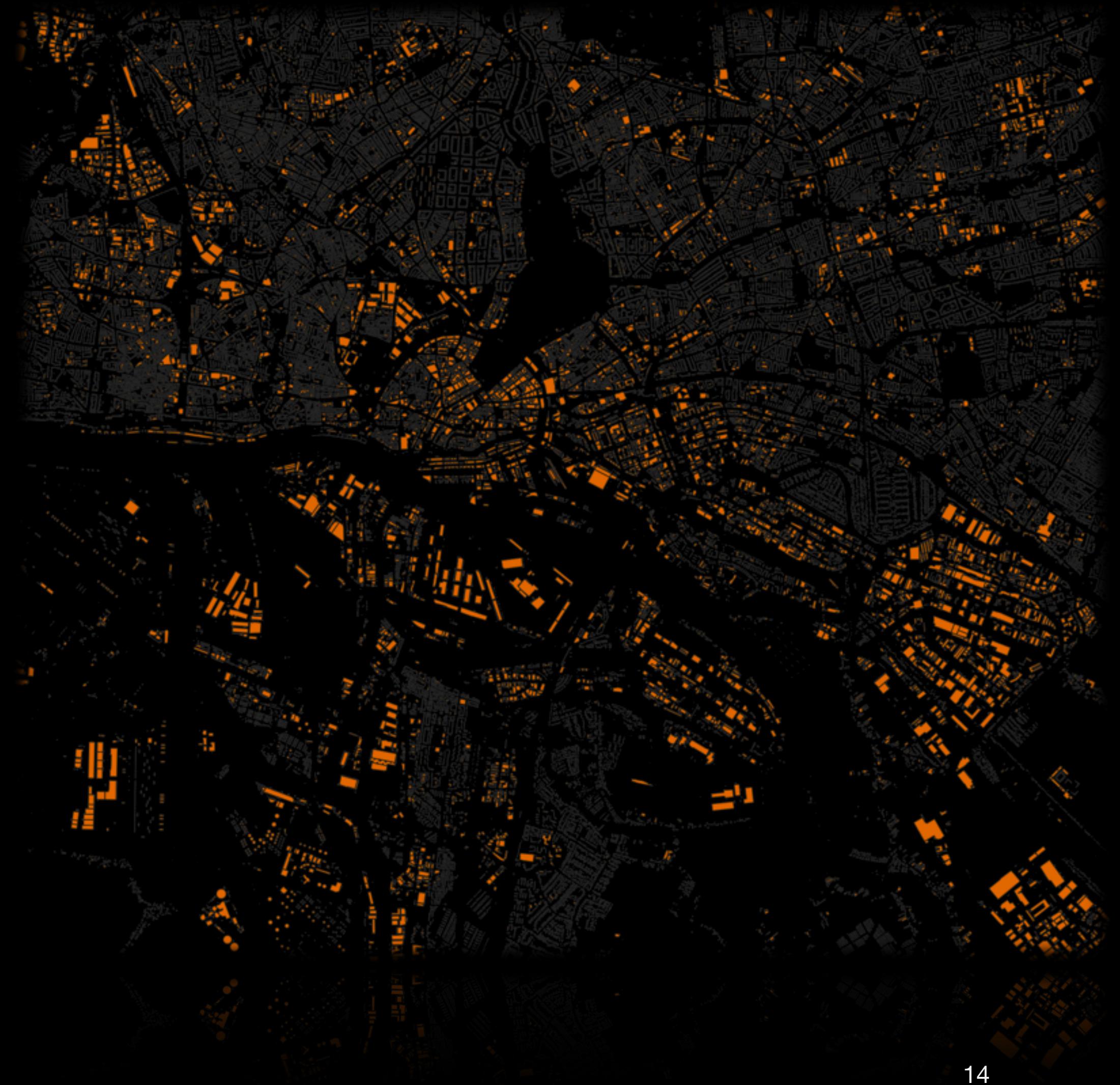


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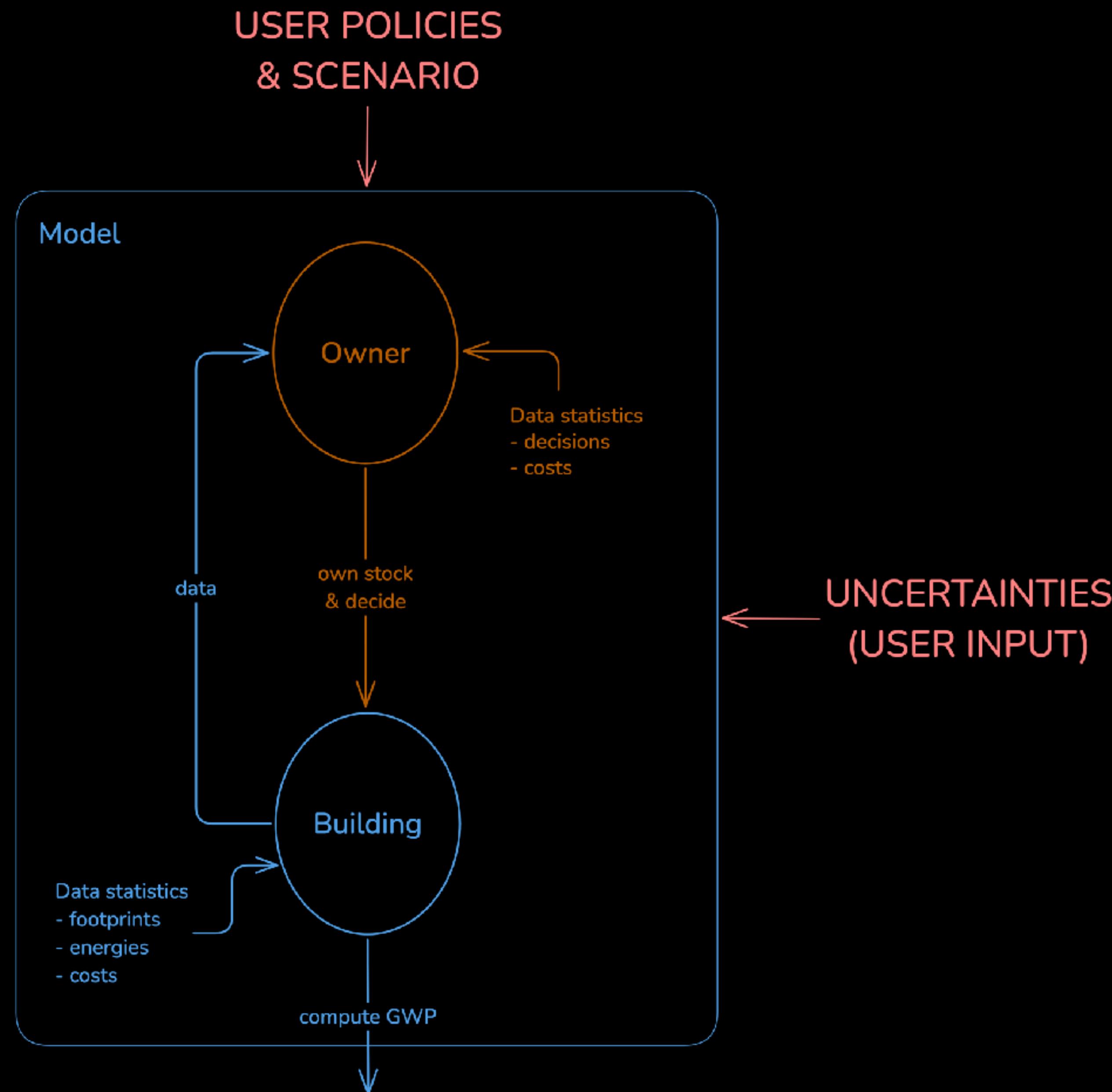
> 350.000 buildings

+ 20 h

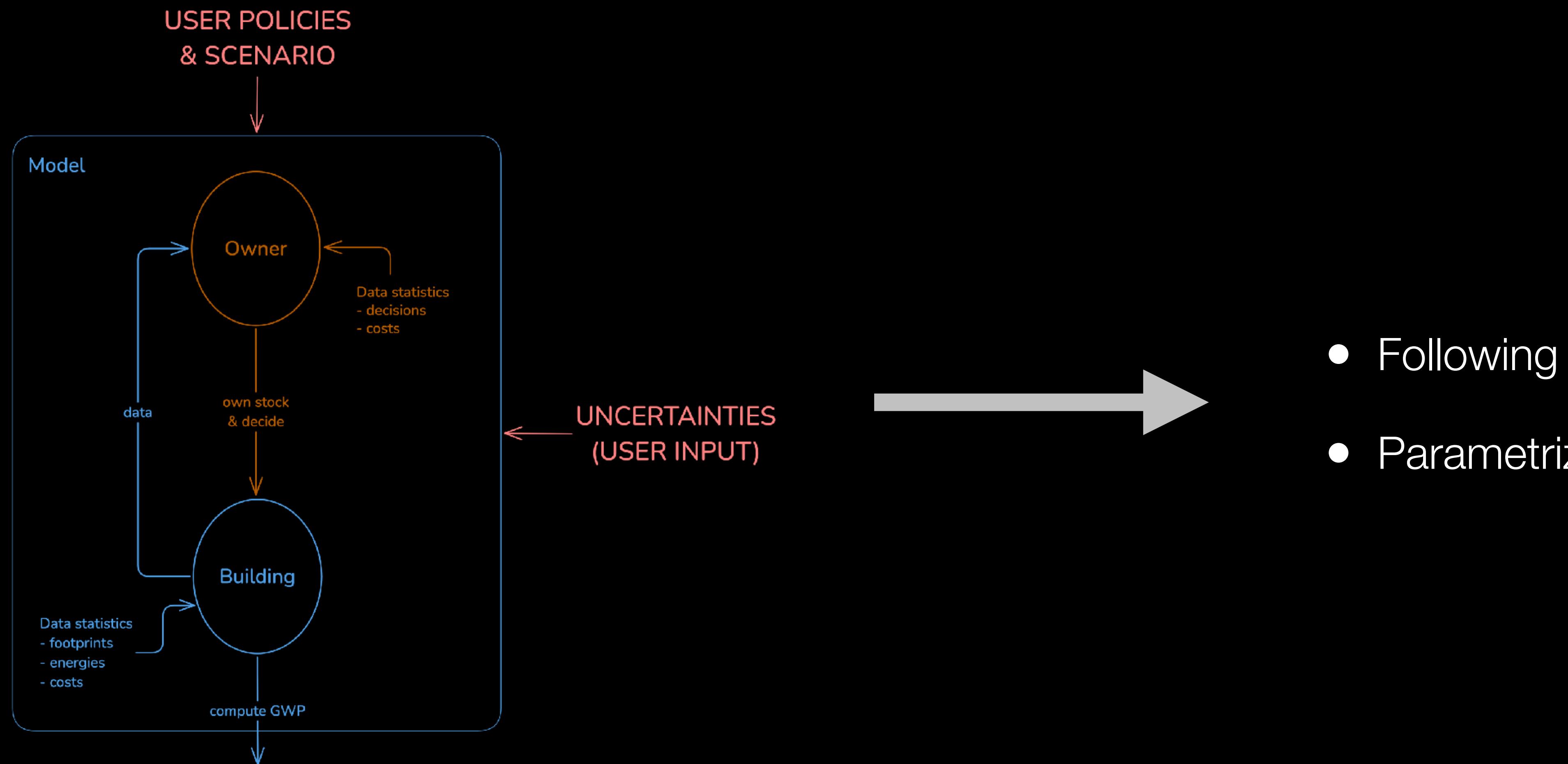
to launch simulation

## Agent-Based Modeling [statistics]

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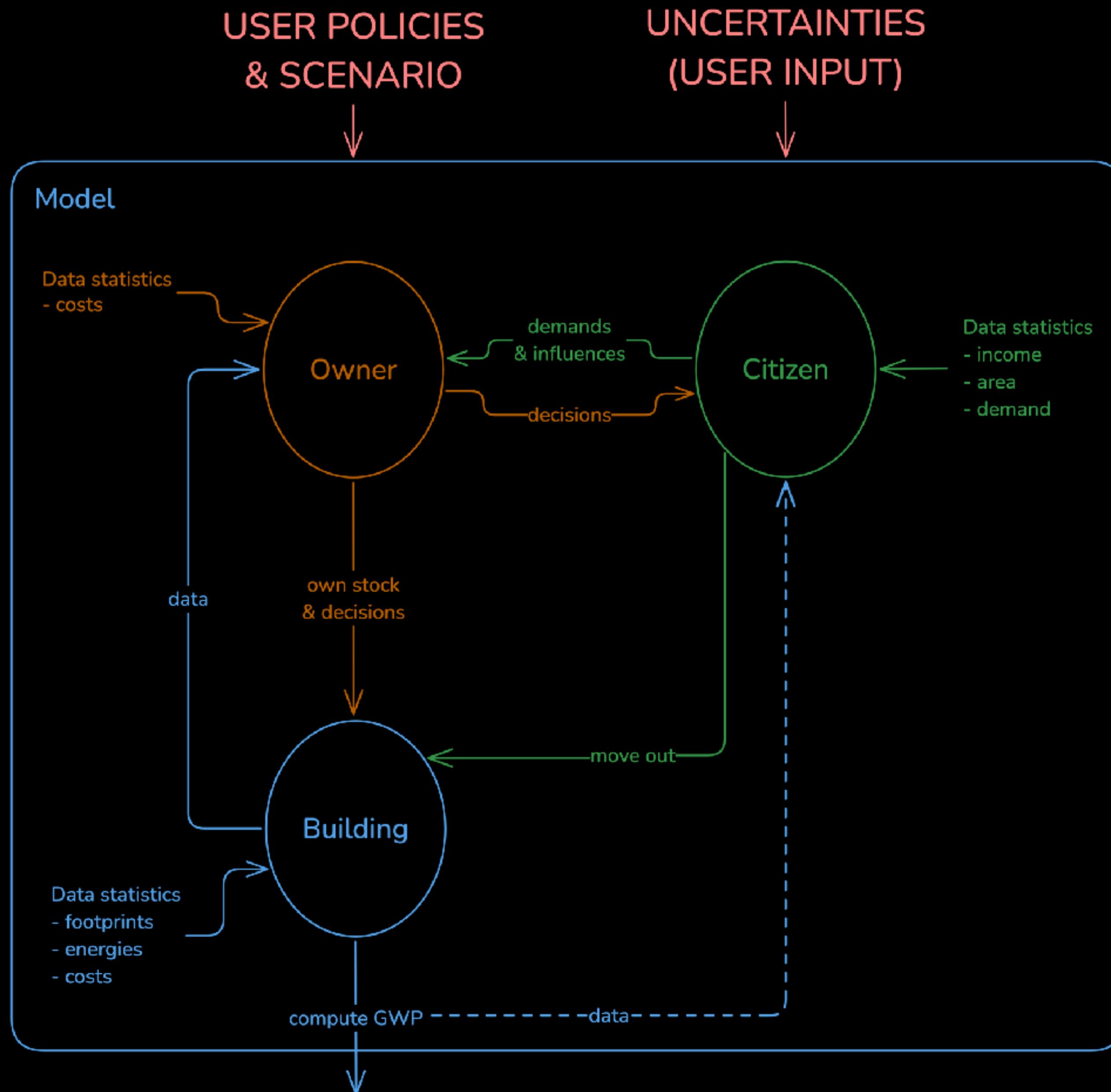
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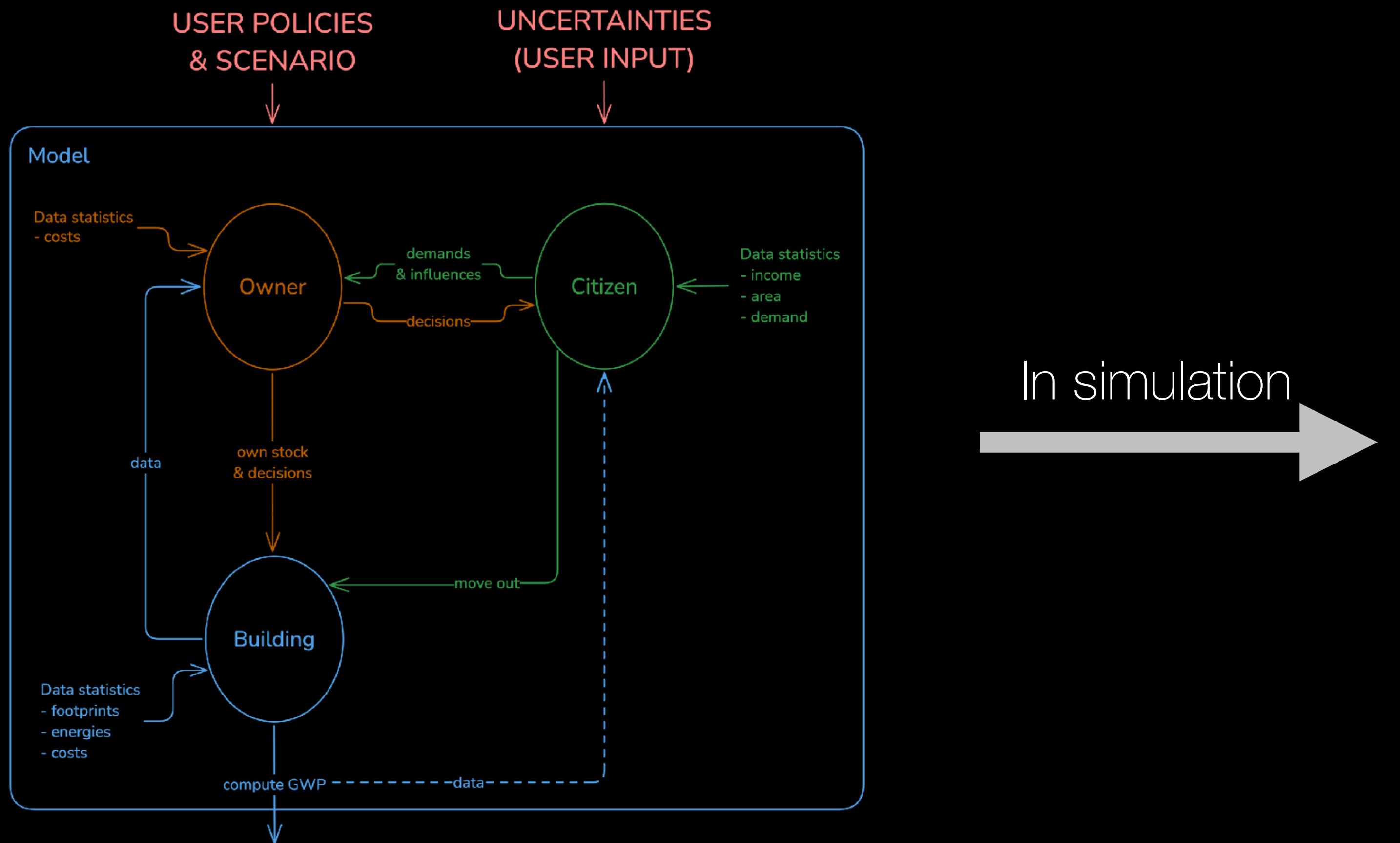
- Following real trends
- Parametrized



## Agent-Based Modeling [automated decision-making]



### **Agent-Based Modeling [automated decision-making]**



- Automated decision-making
- Parametrized
- Powered by real data statistics

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For each scenario

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**Main KPI**  
CO<sub>2</sub>eq/building m<sup>2</sup>

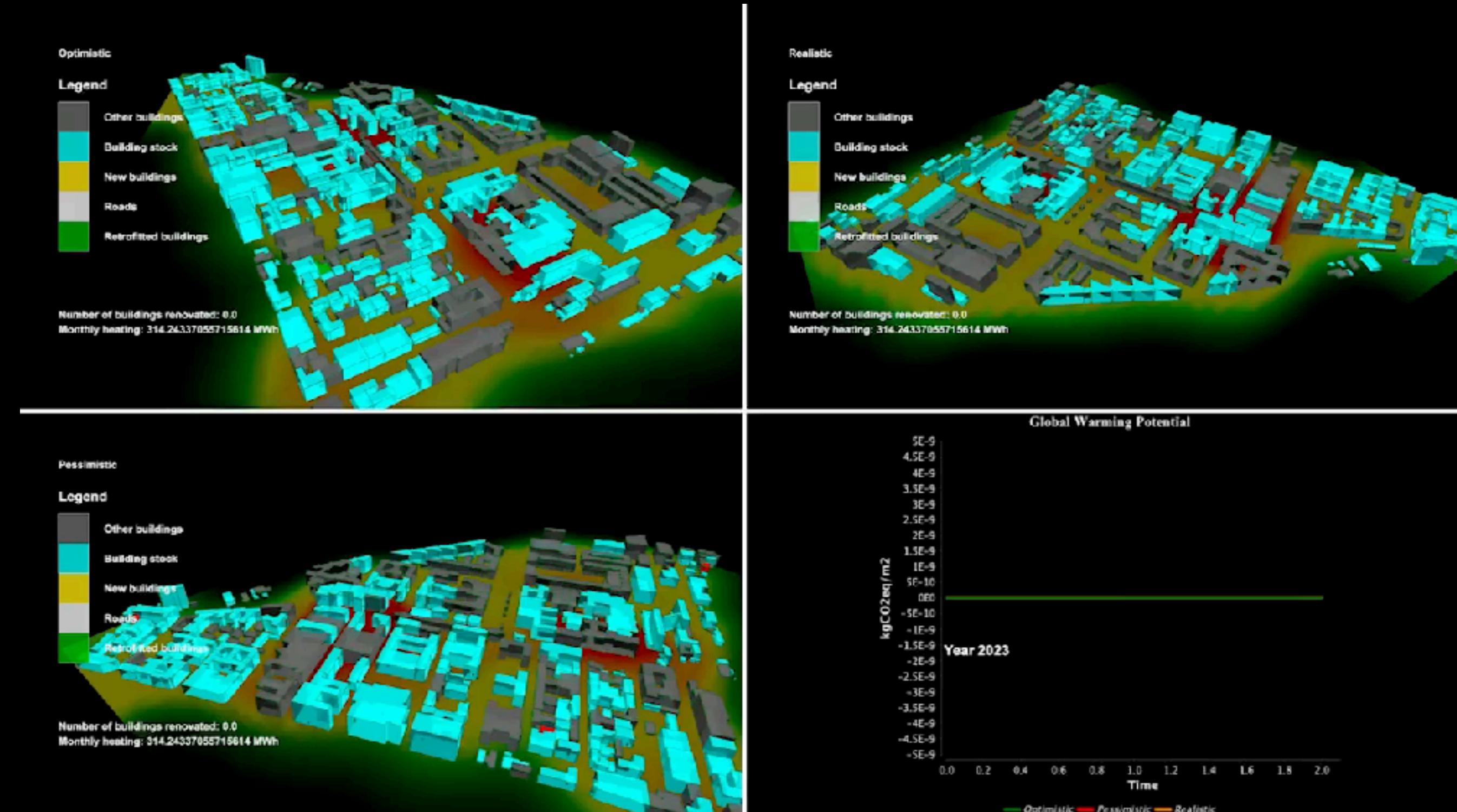
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- Operational emissions dominate embodied emissions: renovating is better by 2040s



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- **Fostered collaborations** with an Authority for future applications



# What's next

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- Integration to the Urban Model Platform
- Refined dynamics and intelligible outputs
- Detailed policies and more complex scenarios



HafenCity  
Universität  
Hamburg

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A Cooperation with the MIT Media Lab



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