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Towards Context & Climate Sensitive Urban Design An integrated simulation and parametric design approach

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Towards Context & Climate Sensitive Urban Design

An integrated simulation and parametric design approach

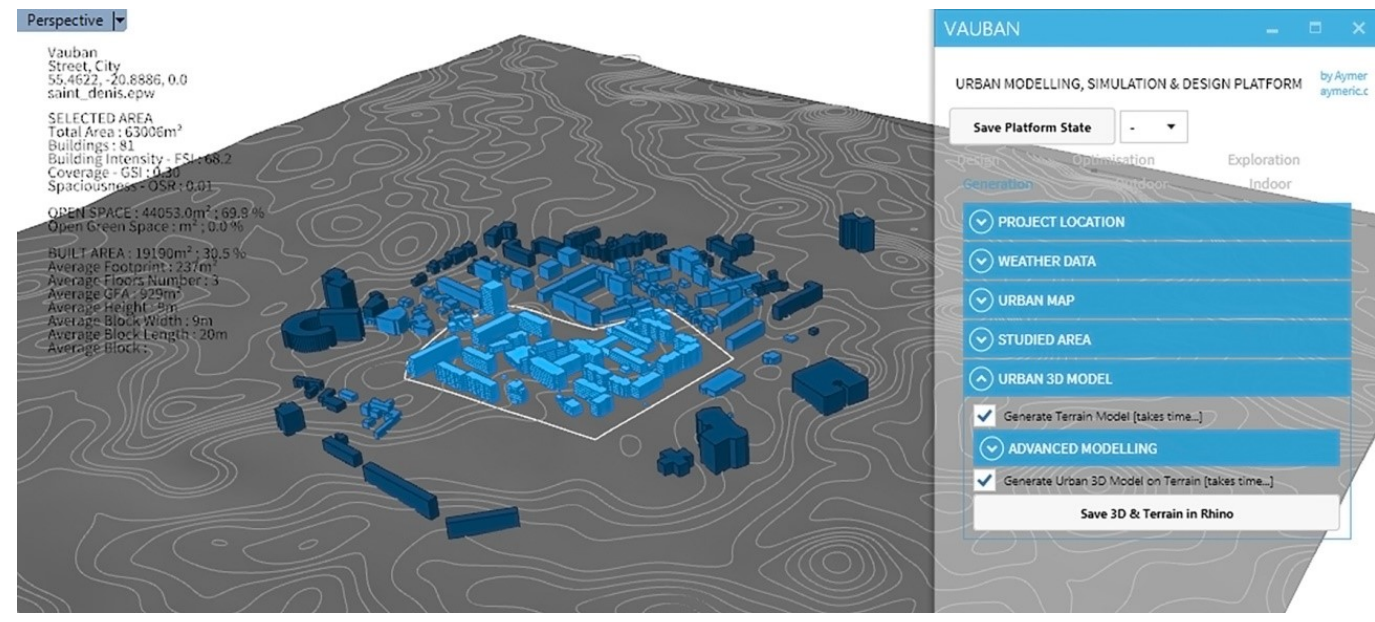
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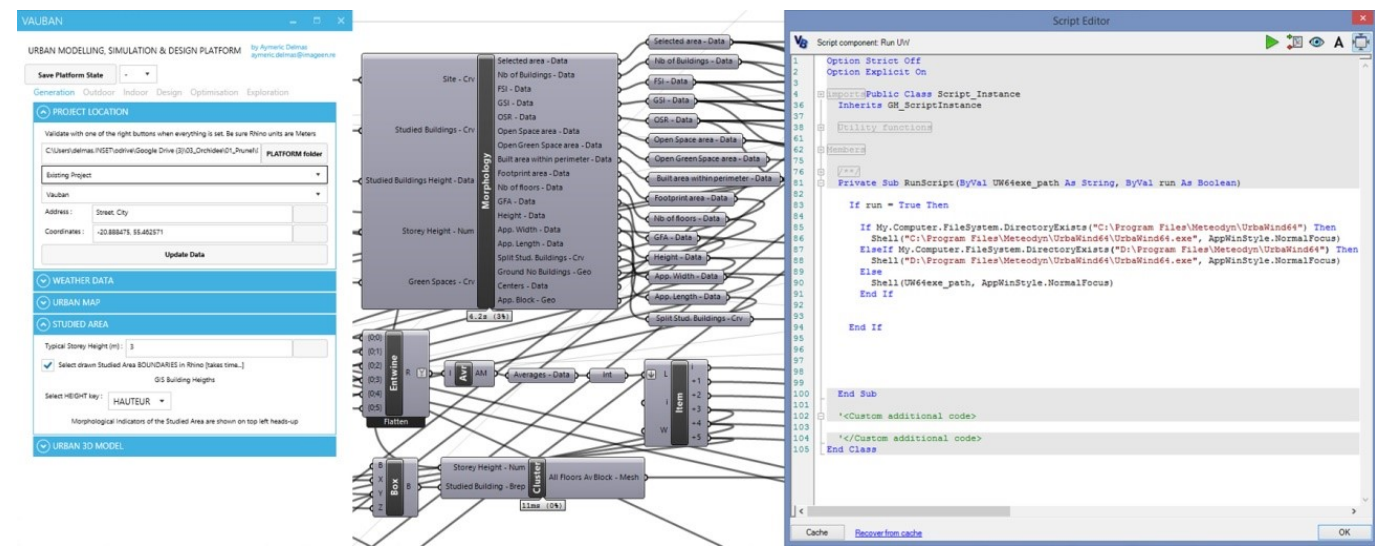
DESIGN PLATFORM & FRAMEWORK

Supporting urban bioclimatic design

To implement the concept of integrated design, an urban **modelling, simulation and design** platform was developed. It embeds a design framework built upon the strengths of **parametric modelling** and existing **building performance simulation tools**.

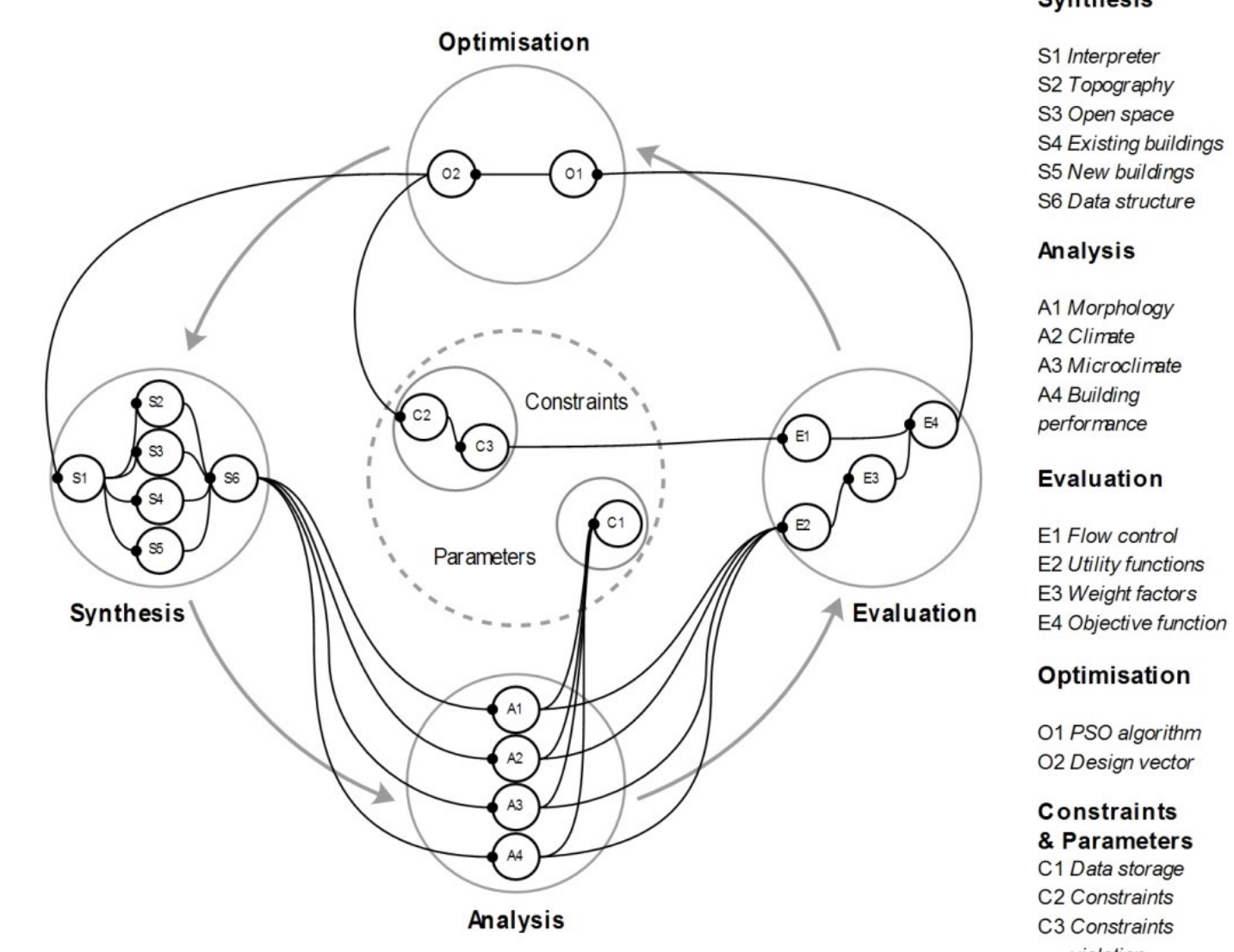


Platform overview
 Rhino's viewport integrated user interface and urban 3D model



Platform levels of transparency
 User interface, directed acyclic graph and textual code

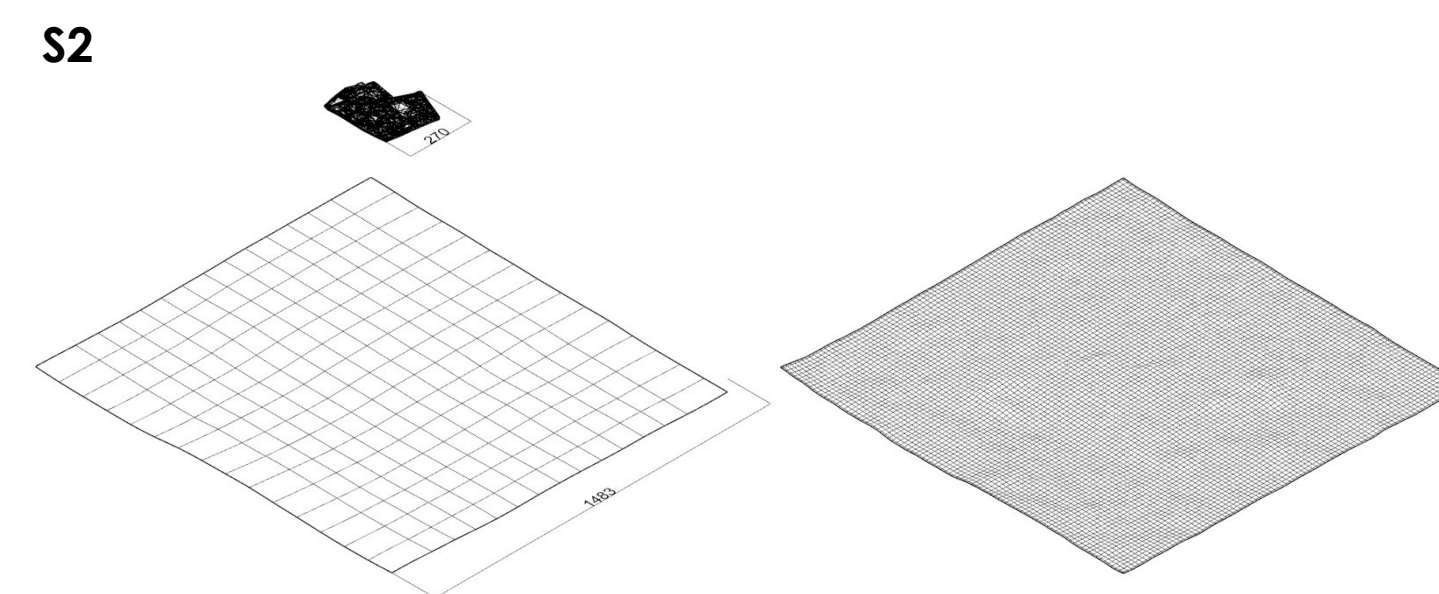
The **centralisation** of the synthesis, analysis, evaluation and optimisation **activities** in a single interface helps to support the integrated design concept. Data exchange and treatment allow **informing** both the simulation tools and the design process in terms of context and climate consideration.



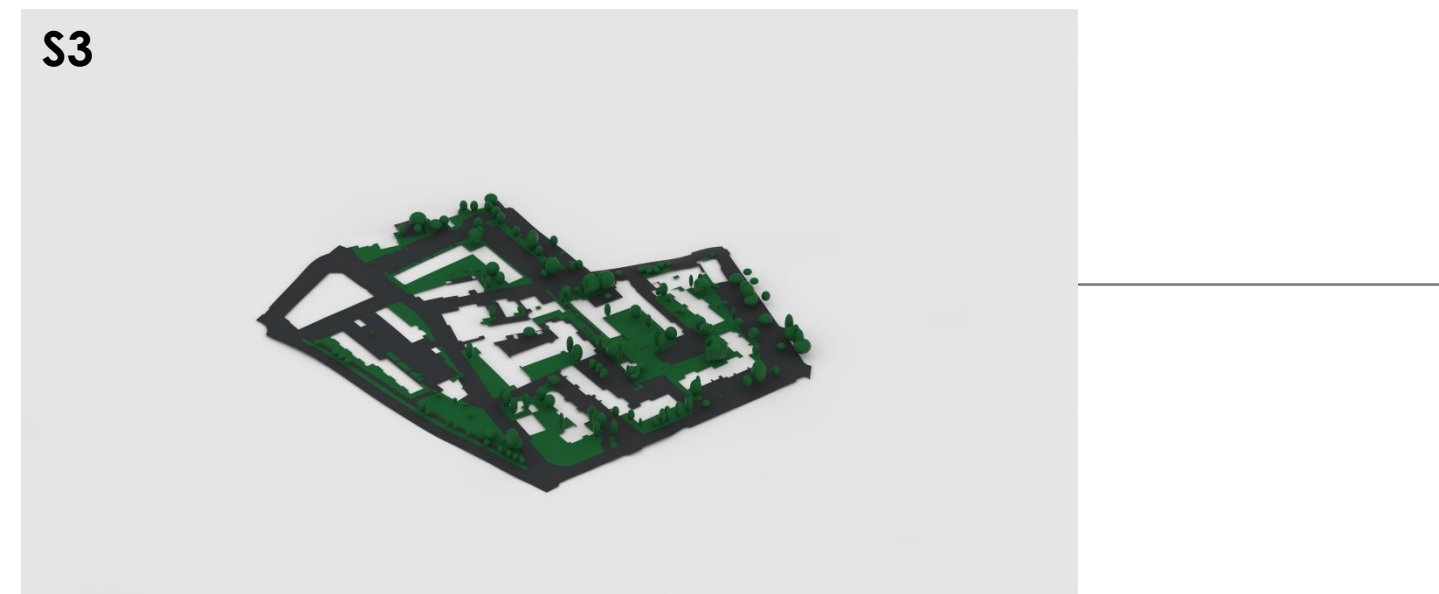
Design framework
 The context and climate sensitive urban design framework

SYNTHESIS

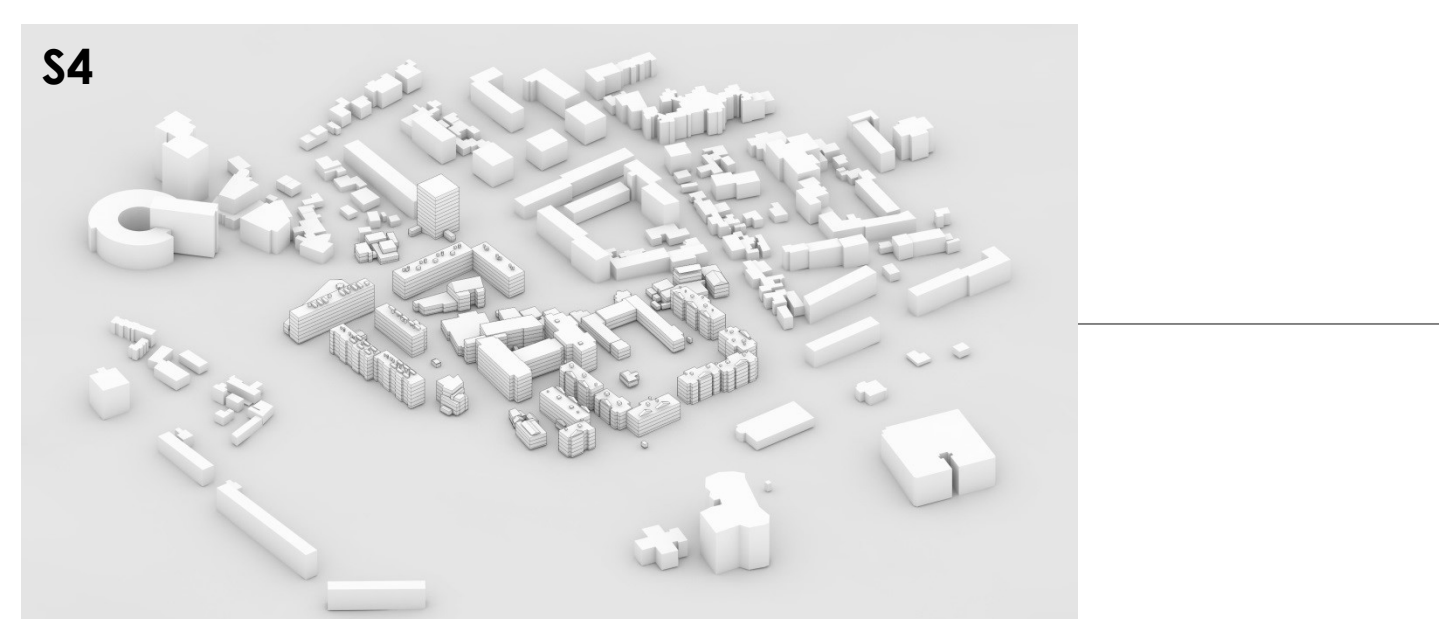
Parametric generation of the urban environment



Topography
 A sampling script allows matching measured elevation (3m grid) of the studied area with larger satellite elevation of the surrounding terrain (SRTM 30m grid)

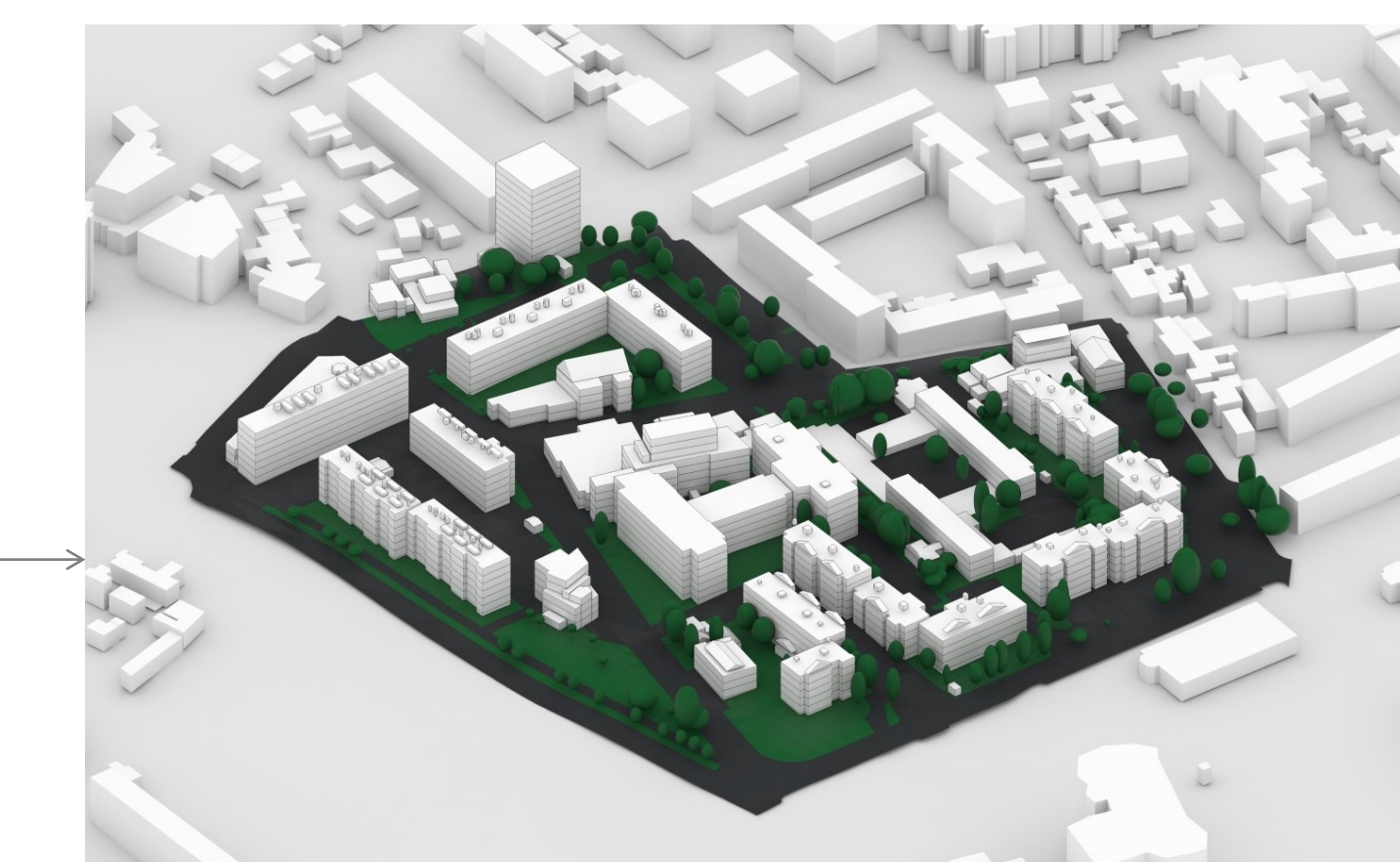


Open spaces & natural elements
 are modelled based on measurements (or GIS data) of their boundaries. Trees are modelled as ovoids based on surveyed characteristics (height, width, density)

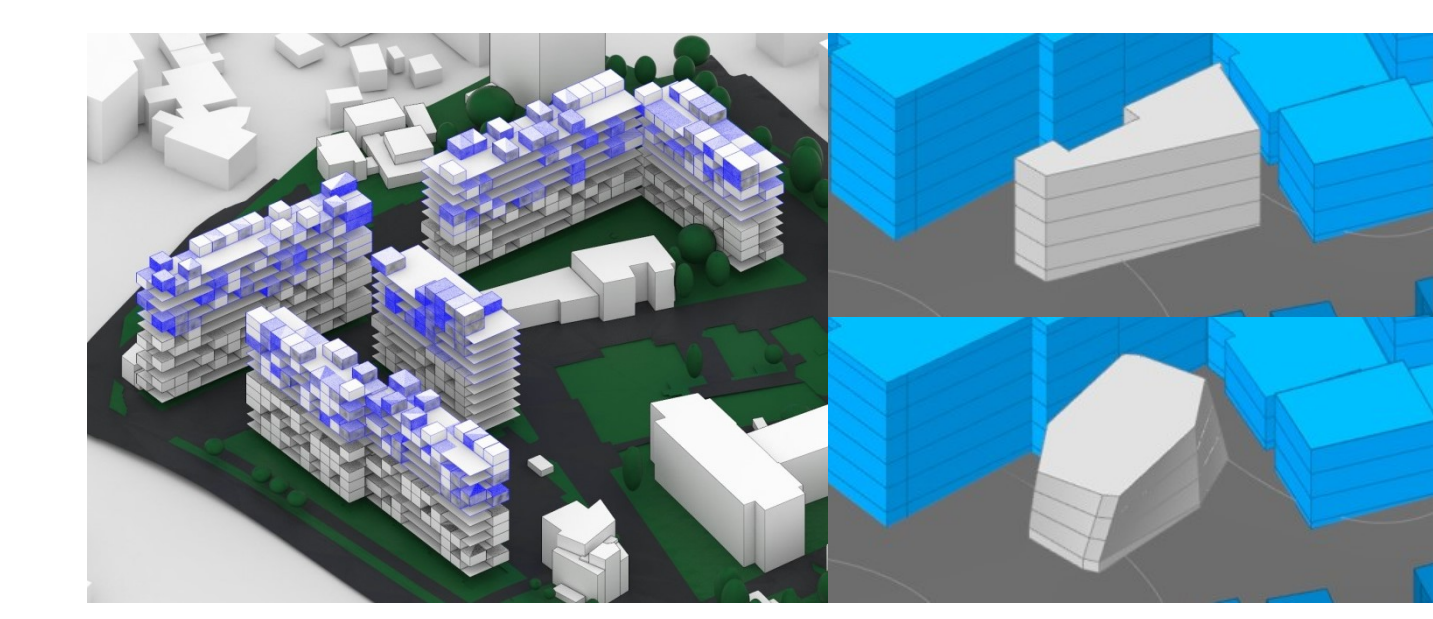


Buildings
 are modelled based on their footprints and heights. Surrounding buildings of the area of interest are selected based on height and distance criteria

The parametric modelling capacities of the software pair Rhinoceros-Grasshopper are used to generate a synthesis model of **interrelated urban elements**. Topography, buildings, open spaces and natural elements are connected with each other in an algorithmic relation.



Combined urban 3D model
 Vauban neighbourhood, case study located in St-Denis, La Réunion

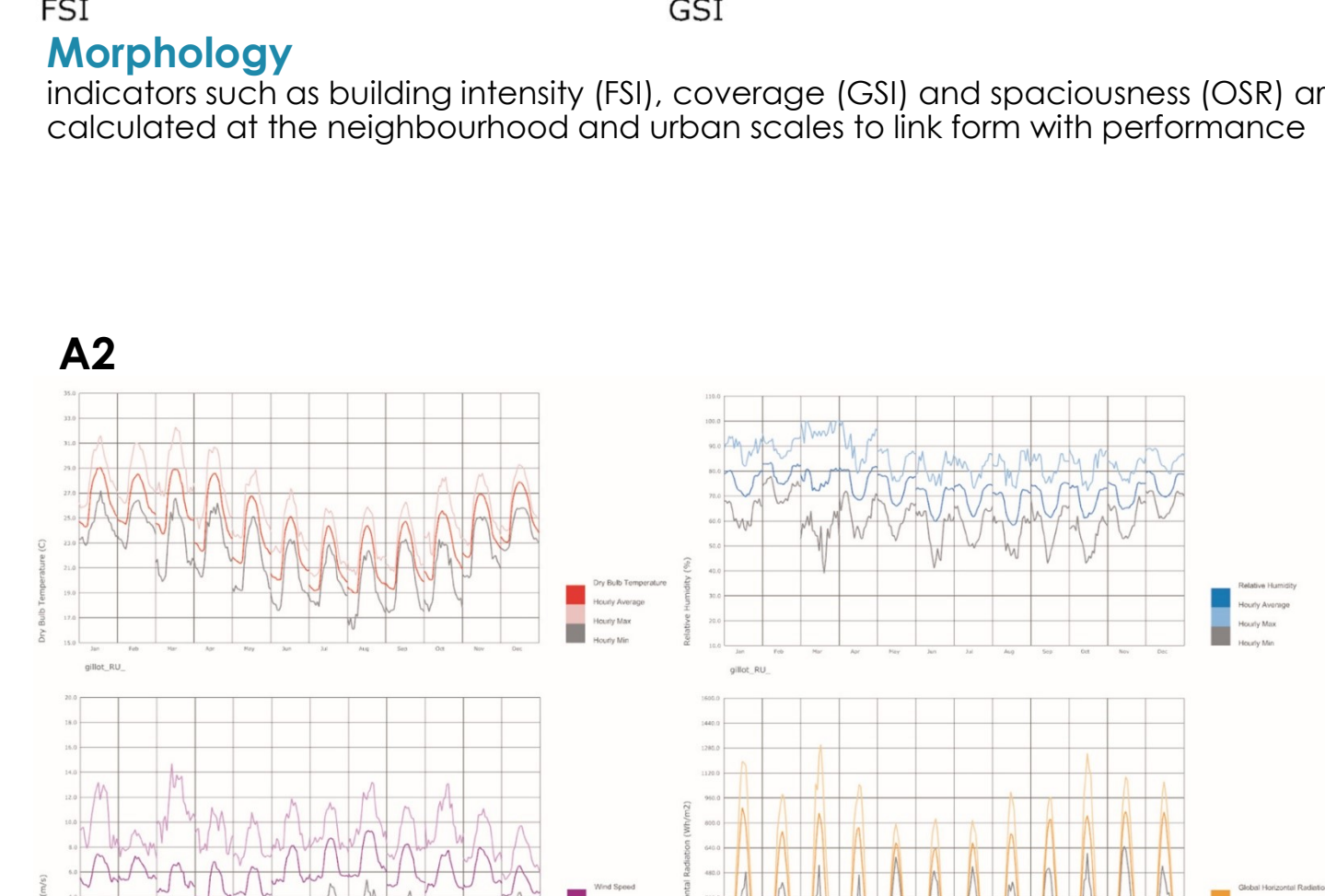
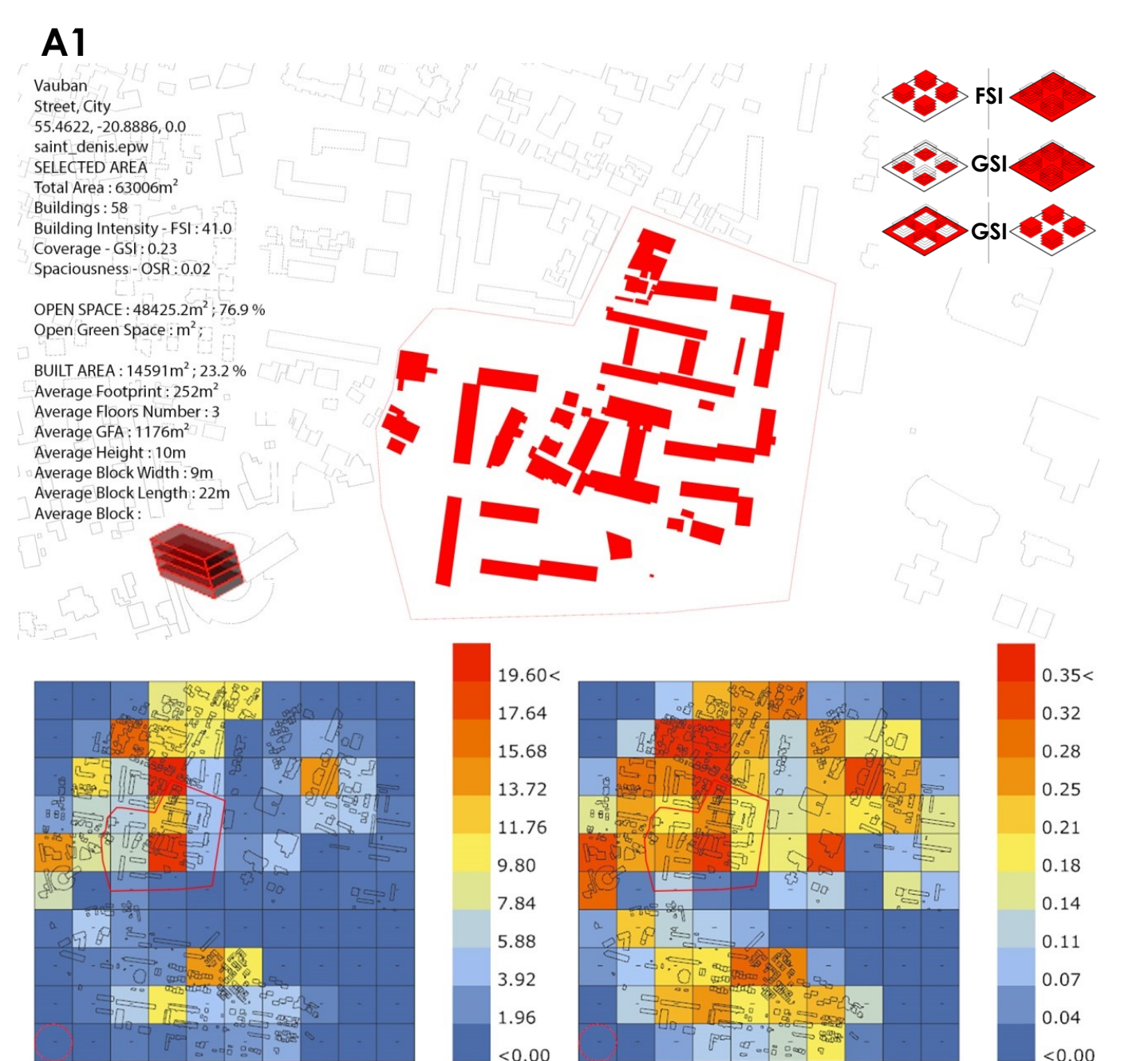


Bioclimatic strategies & new building blocks
 Generative definitions of context sensitive blocks and urban interventions are integrated and can be optimised

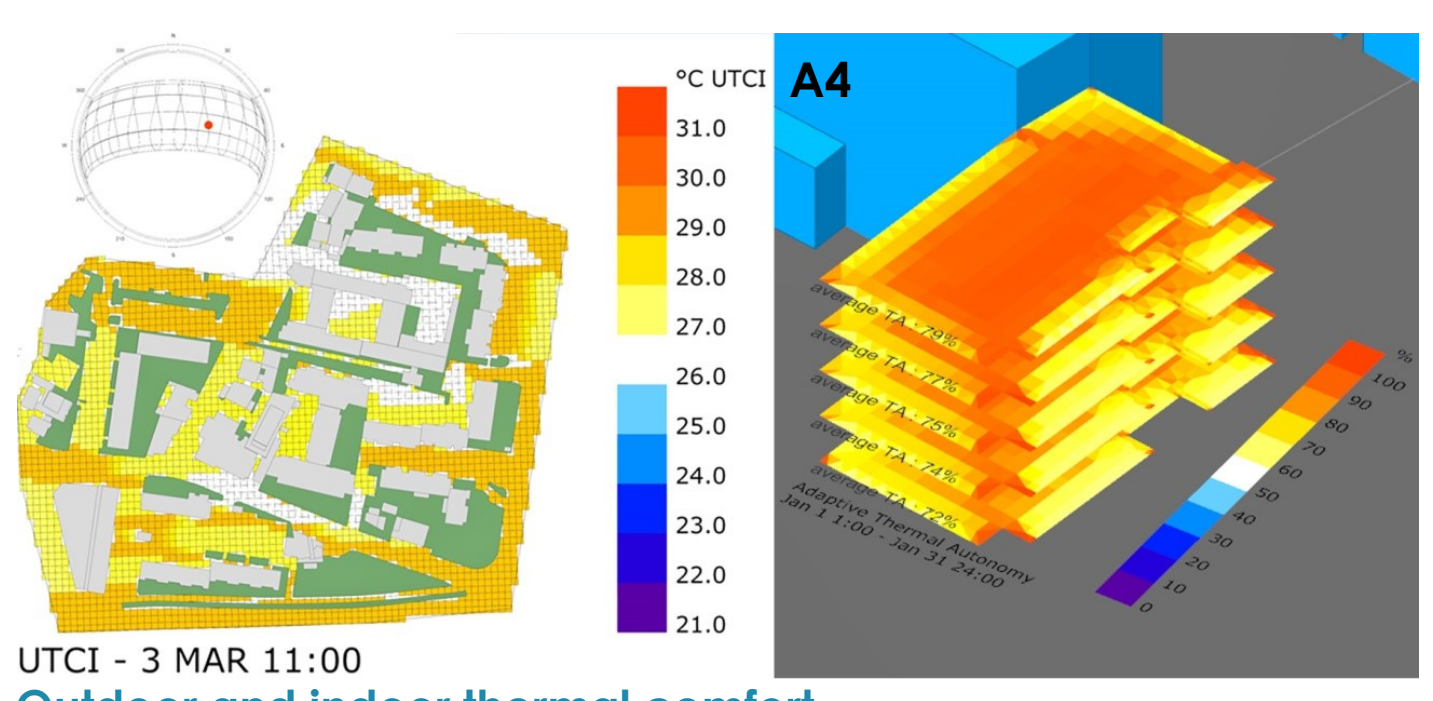
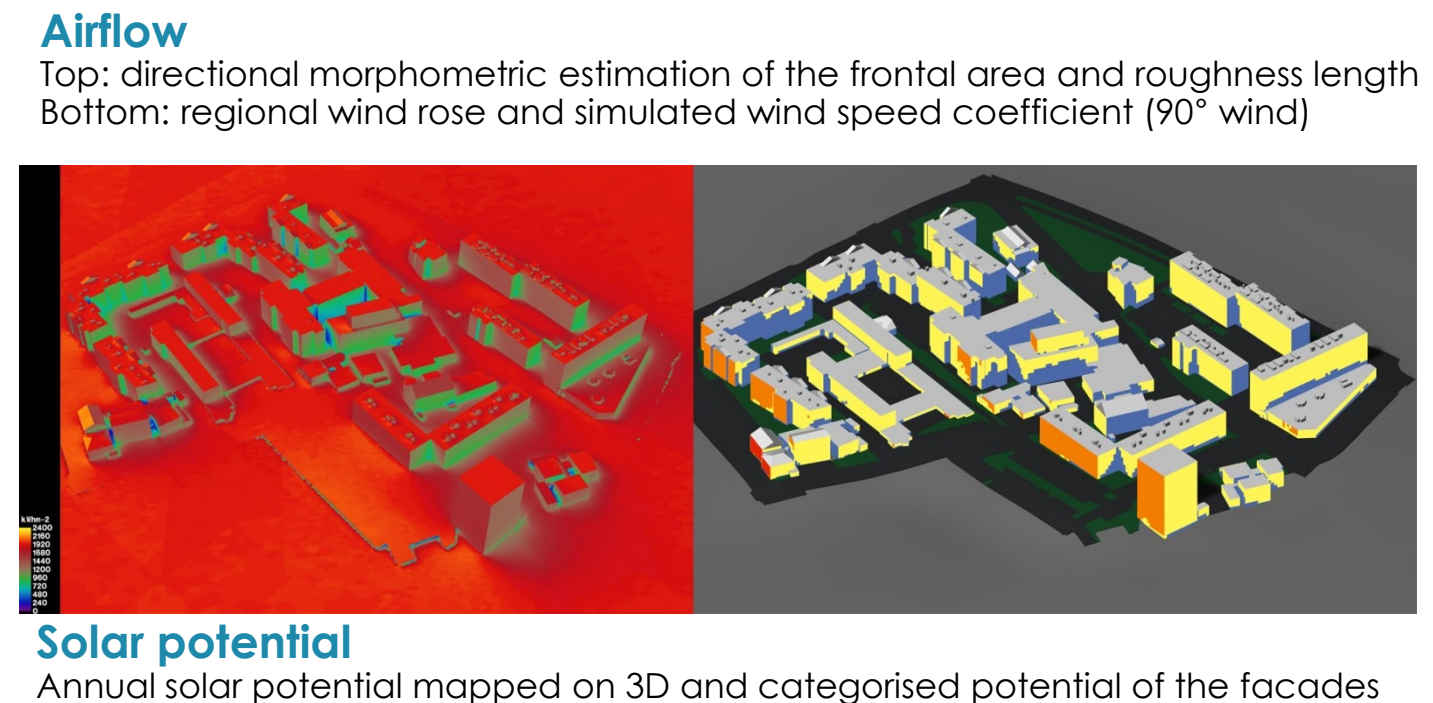
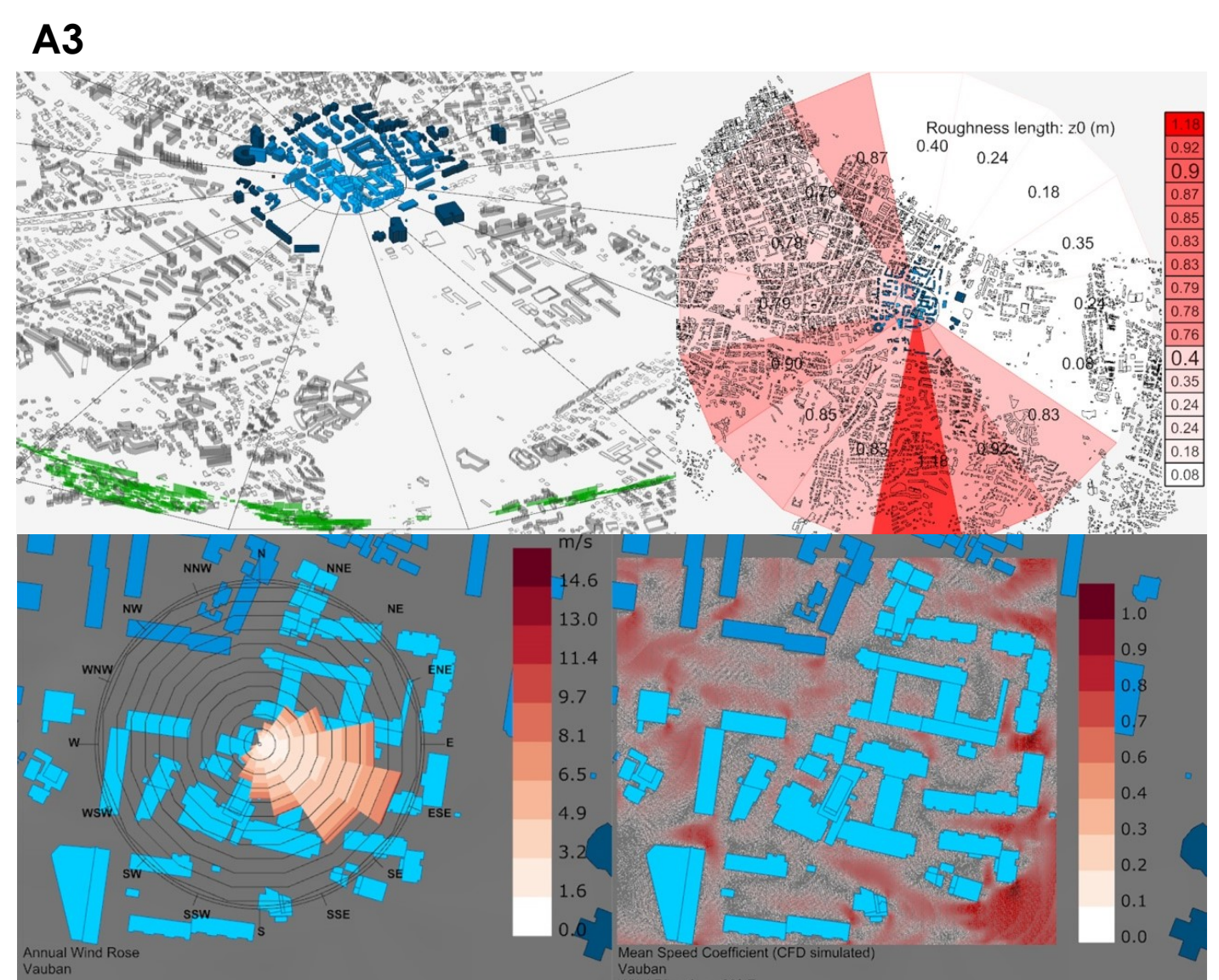
ANALYSIS

& simulation of the outdoor and indoor conditions

The **complex relationships** between **form** and **environmental performance** are analysed thanks to several mathematical models with different level of fidelity. All analysis models use the unique parametric synthesis urban model so that any **morphological, topological** or data change will influence the whole data.



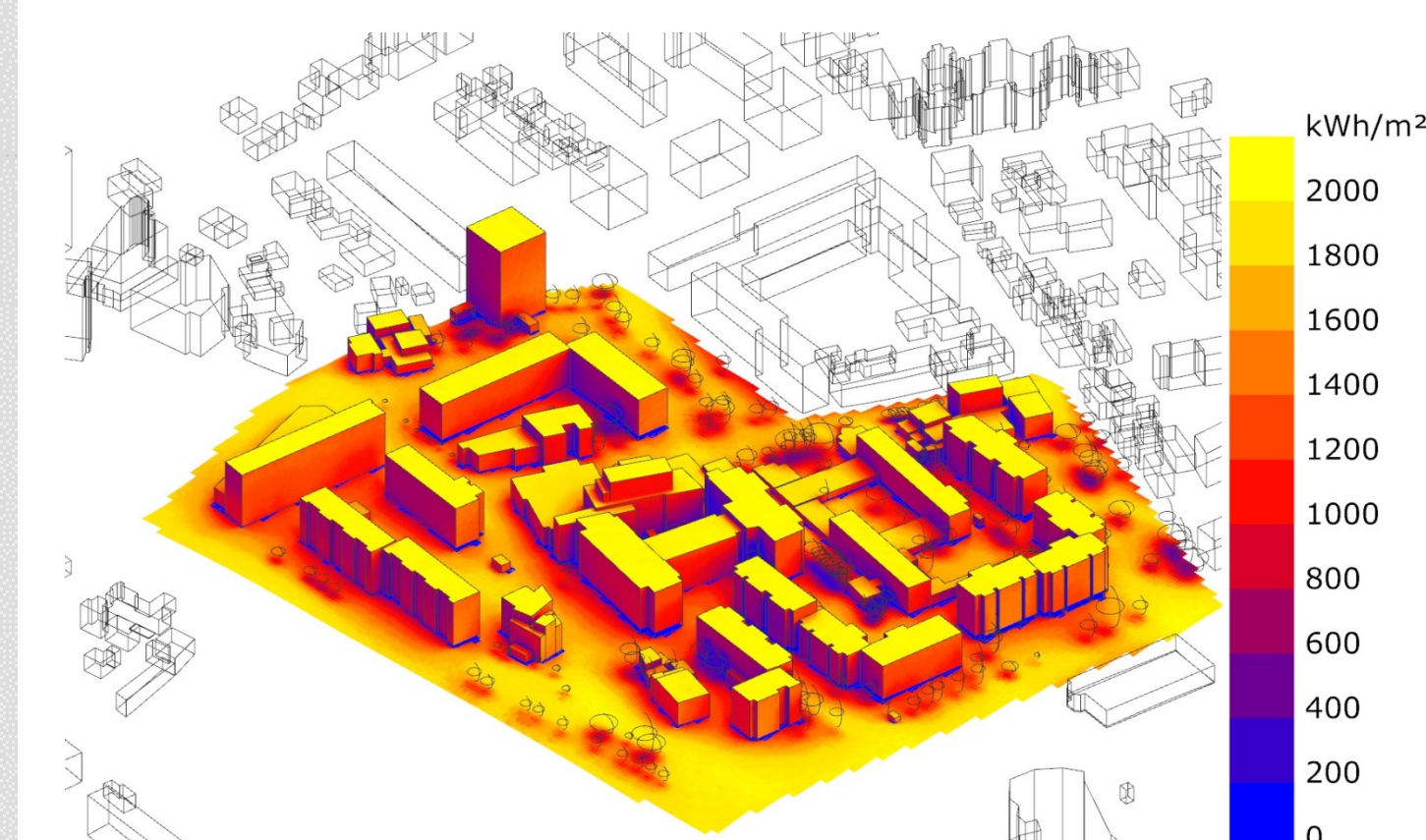
The **dynamics of the urban microclimate** and its effects on outdoor and indoor conditions is captured by using **specific simulation tools** (UrbaWind for the CFD airflow, Radiance for solar irradiation, EnergyPlus for indoor and outdoor thermal conditions)



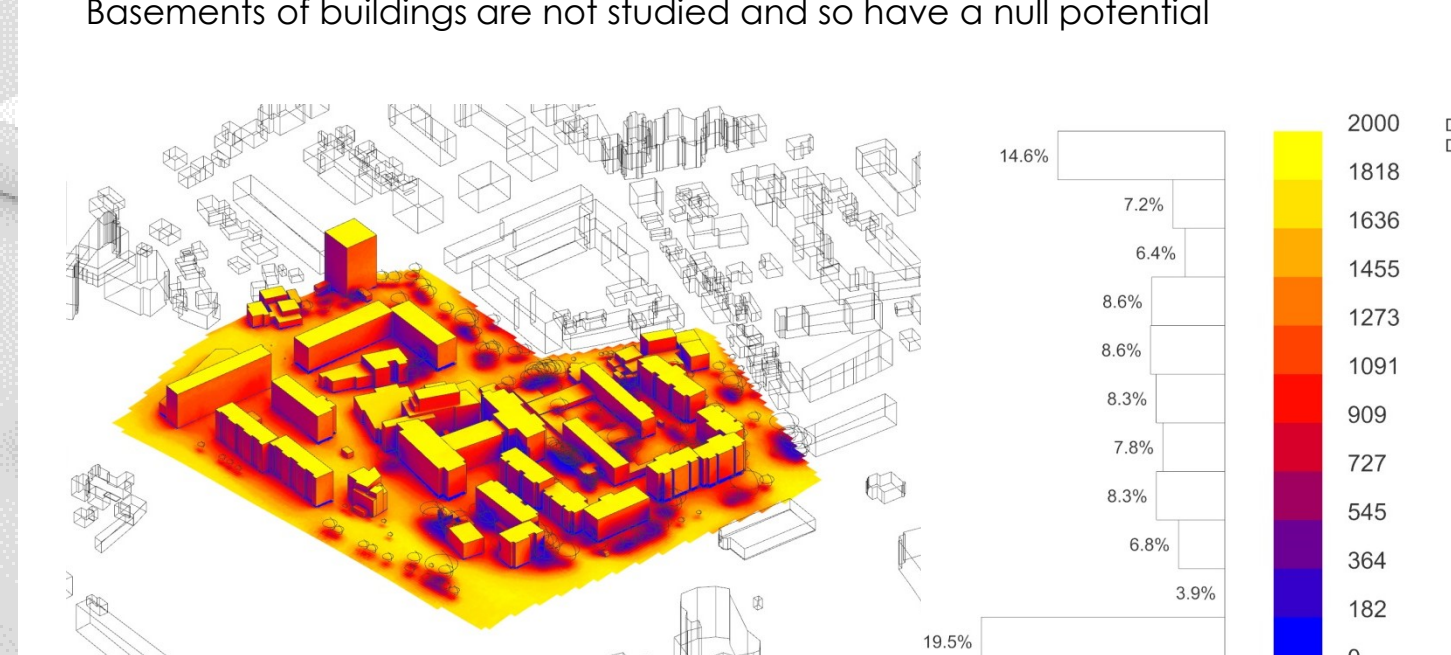
PARAMETRIC STUDY

Impact of modelling simplification on solar potential

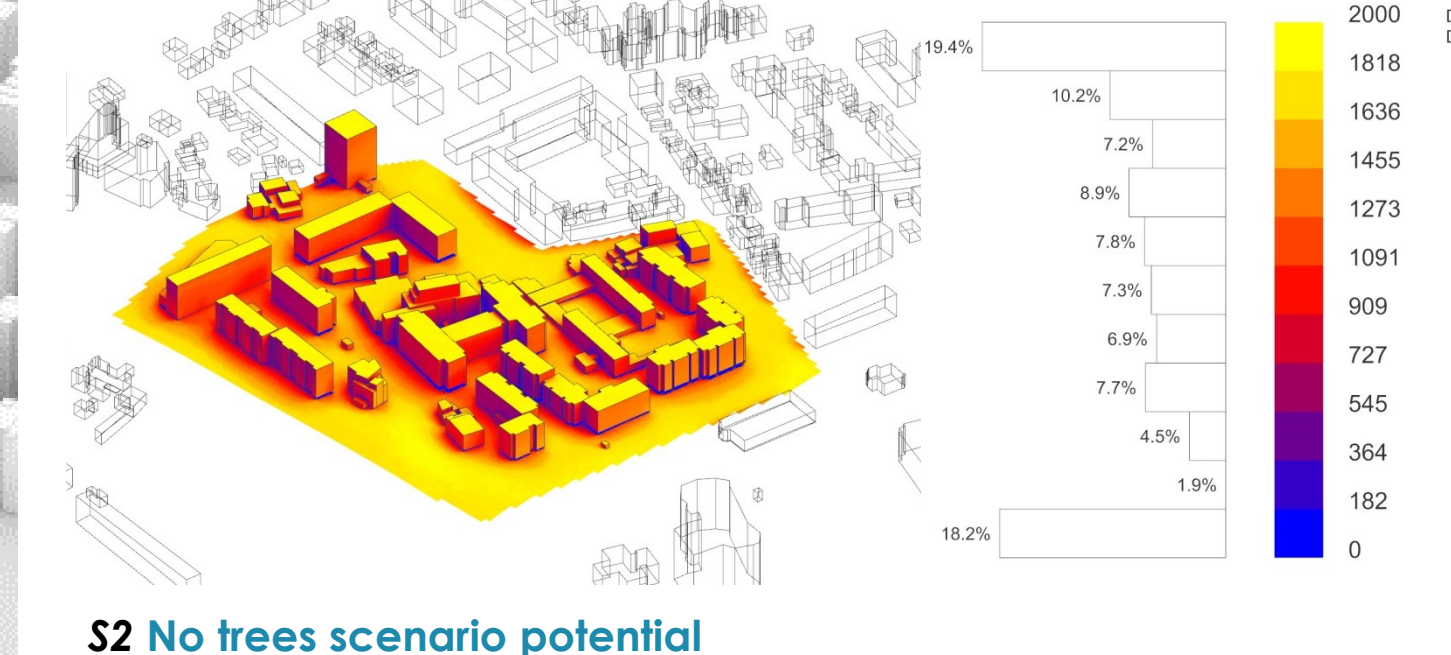
The **parametric generation** of the urban environment and its constitutive elements allows running similar simulation with various scenarios. Here the most detailed 3D model is simplified gradually to assess the **impact of each modelling scenario on the solar potential of more detailed ones**.



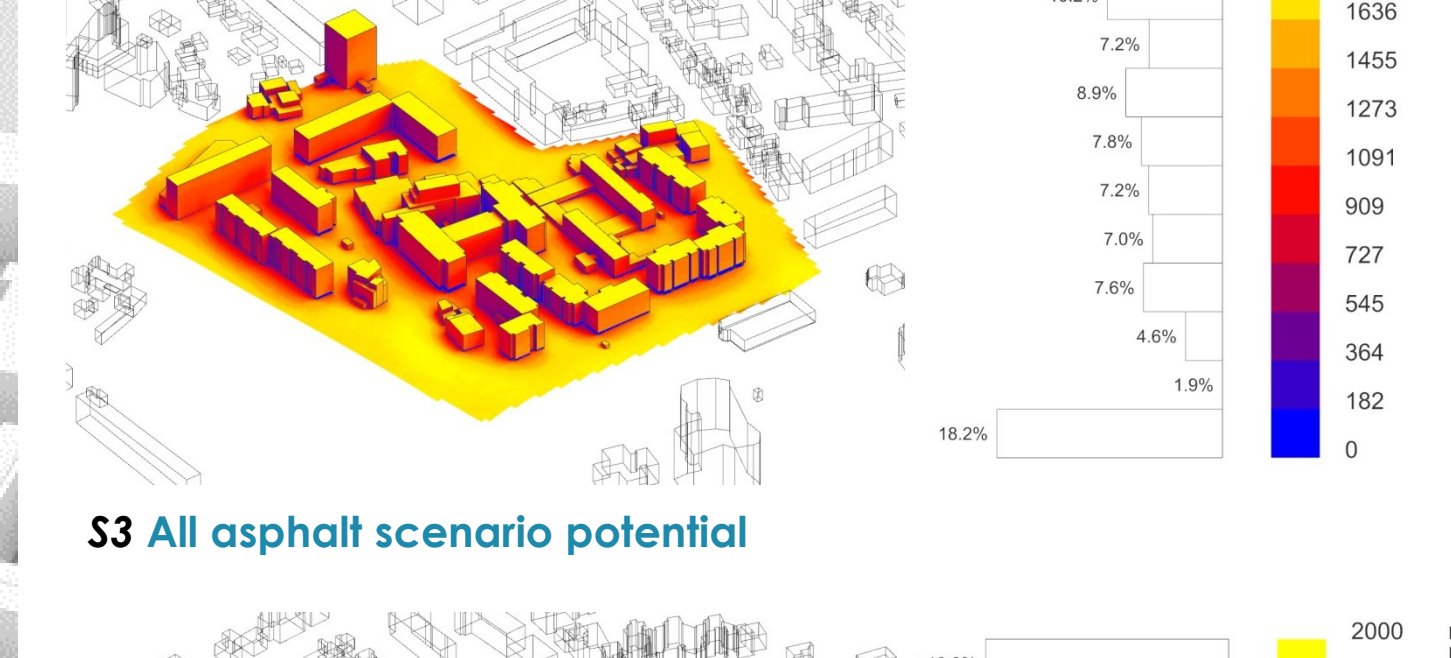
DS Detailed scenario solar potential
 Basements of buildings are not studied and so have a null potential



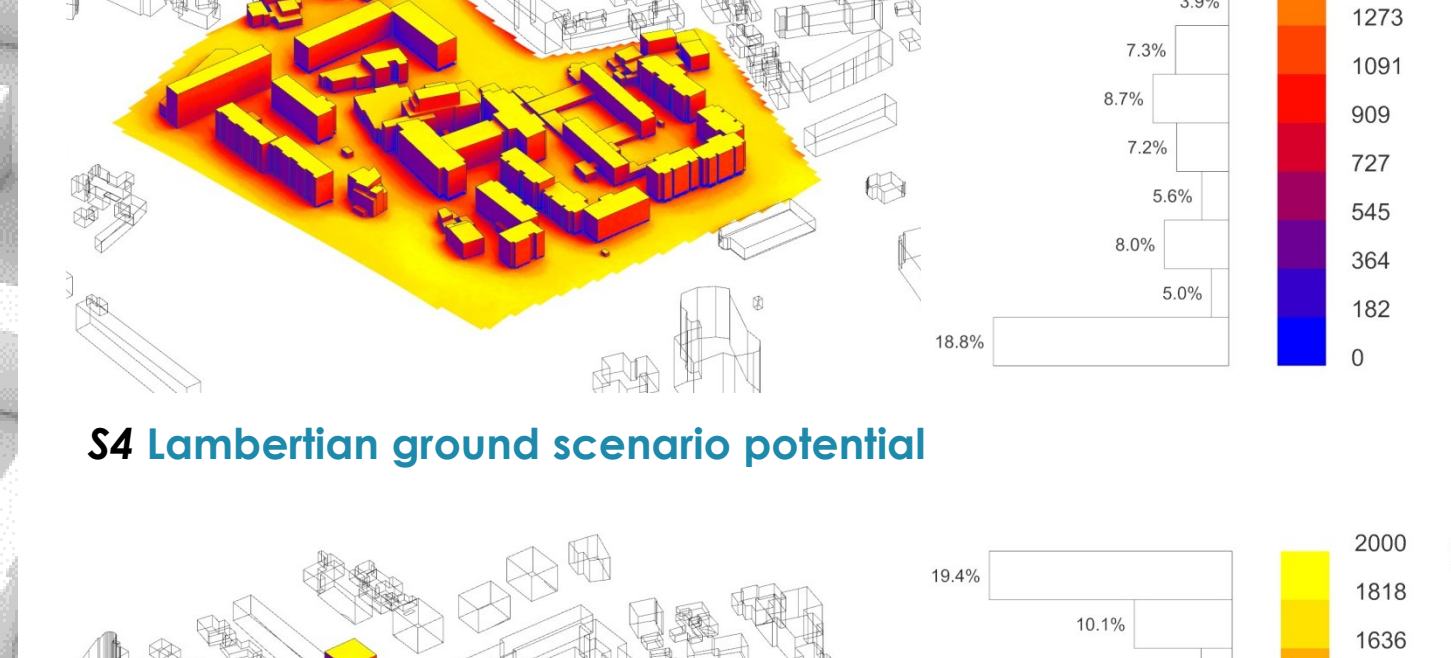
S1 Spherical trees scenario potential



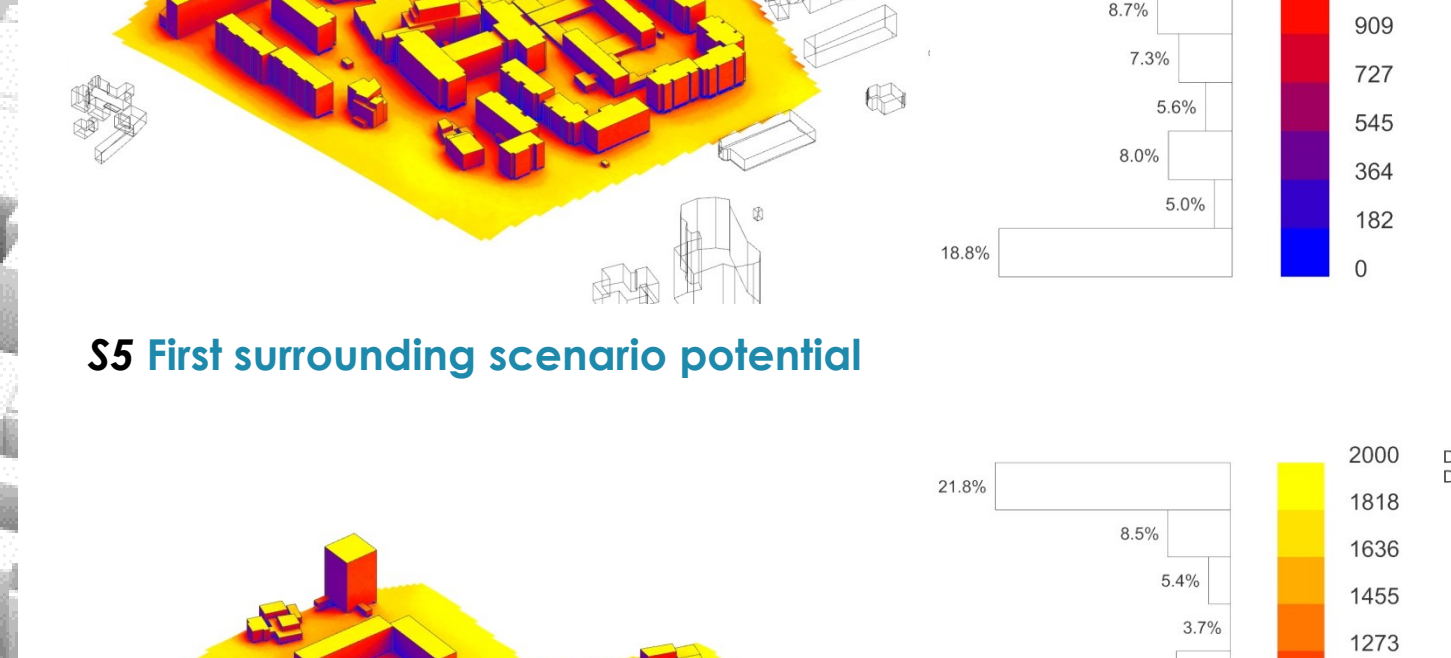
S2 No trees scenario potential



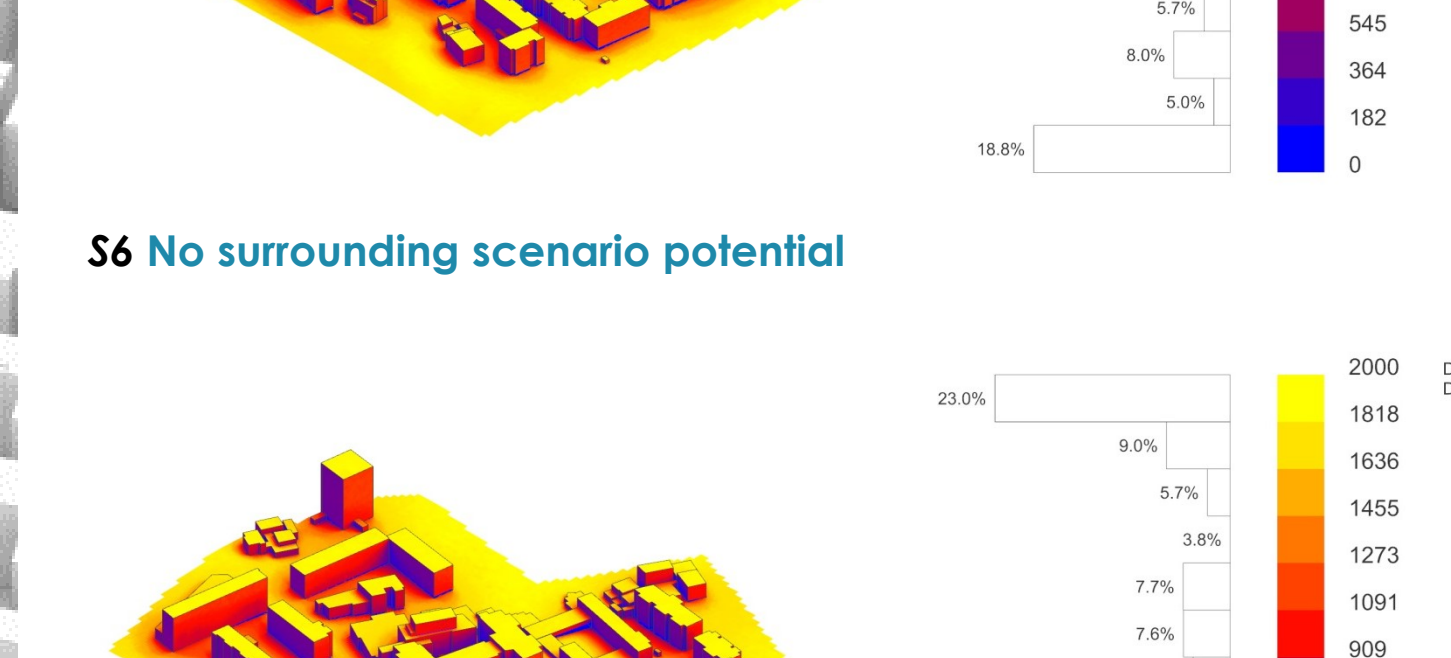
S3 All asphalt scenario potential



S4 Lambertian ground scenario potential



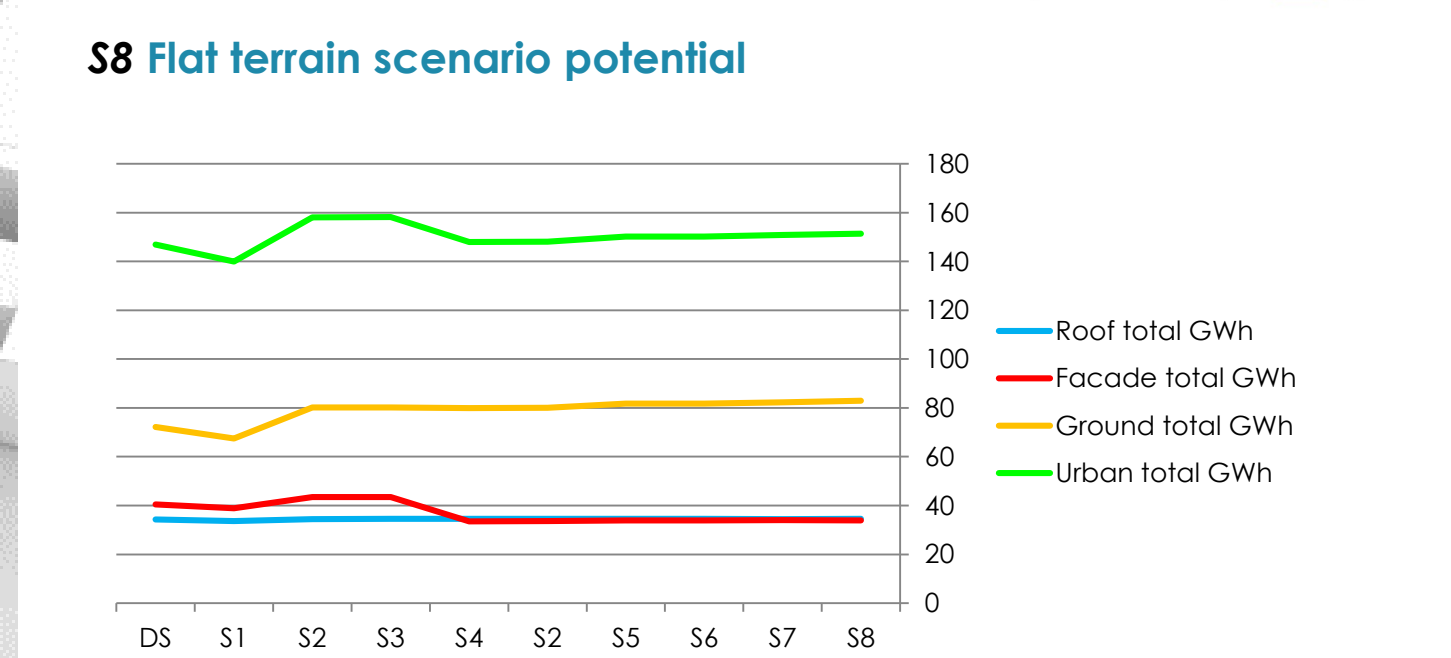
S5 First surrounding scenario potential



S6 No surrounding scenario potential



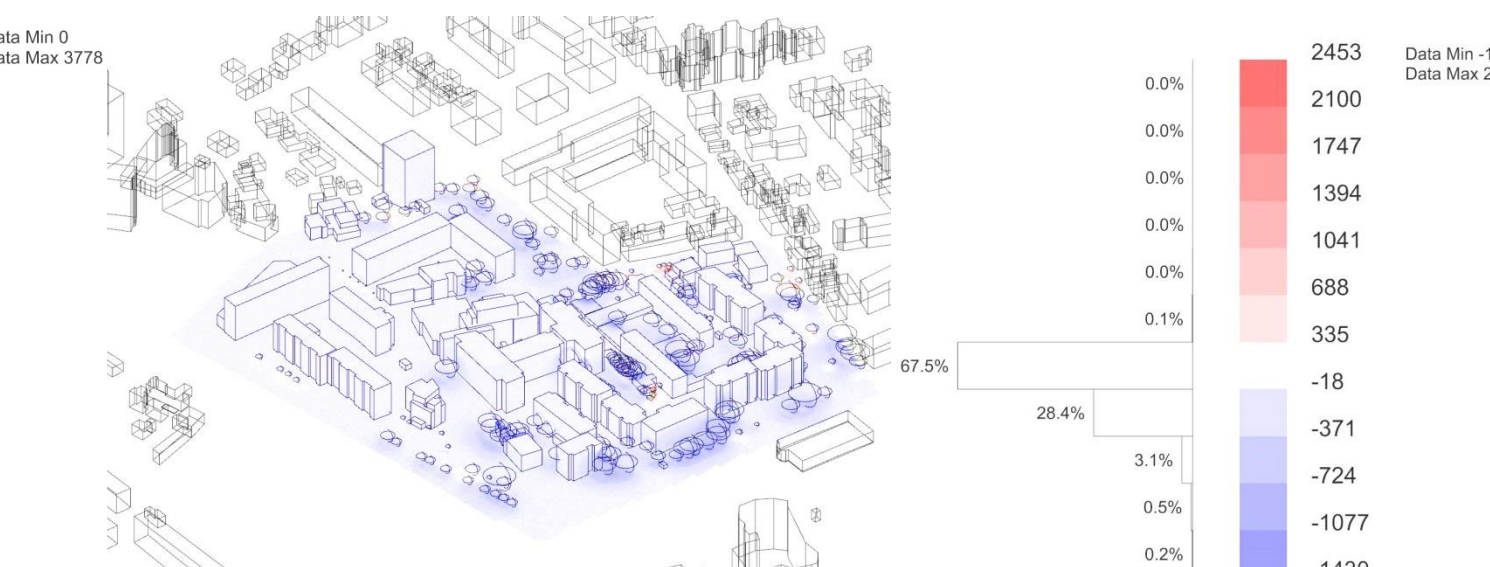
S7 Unsampled terrain scenario potential



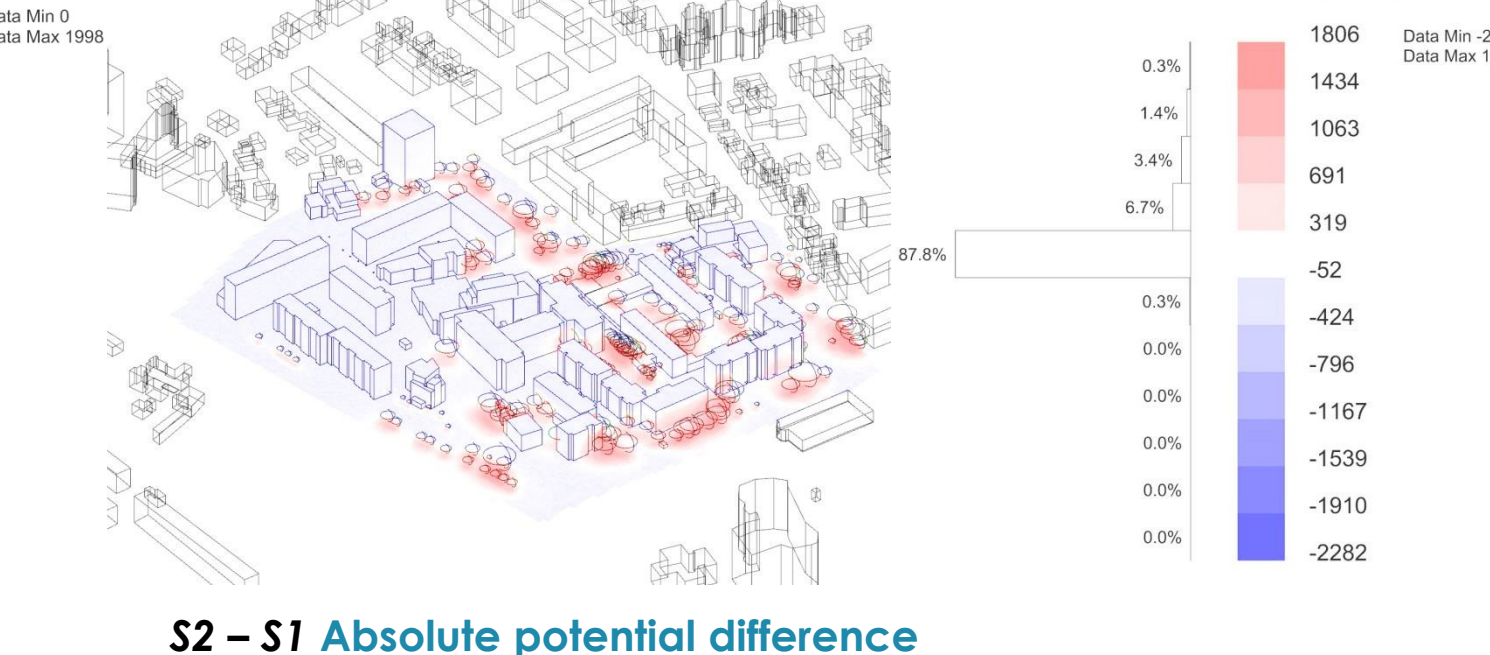
S8 Flat terrain scenario potential

| Radiance parameters | ab=2, ad=1000, as=16, ar=98, grid size=1m |
|----------------------|---|
| DS Detailed scenario | Ovoid trees, detailed ground materials distribution (asphalt/grass), extended surrounding, sampled topography |
| S1 Spherical trees | DS with simple trees instead of ovoid trees |
| S2 No trees | S1 with trees removed |
| S3 All asphalt | S2 with all asphalt ground instead of the asphalt/grass distribution |
| S4 Lambertian ground | S3 with 20% reflective lambertian ground instead of all asphalt |
| S5 First surrounding | S4 with extended surrounding removed, only first radius of surrounding buildings kept |
| S6 No surrounding | S5 with no surrounding buildings |
| S7 Unsampled terrain | S6 with SRTM (30m precision) terrain instead of 3m sampled terrain |
| S8 Flat terrain | S7 with flat terrain instead of SRTM terrain |

Radiance and geometric parameters of the simulated scenarios



S1 - DS Absolute potential difference



S2 - S1 Absolute potential difference



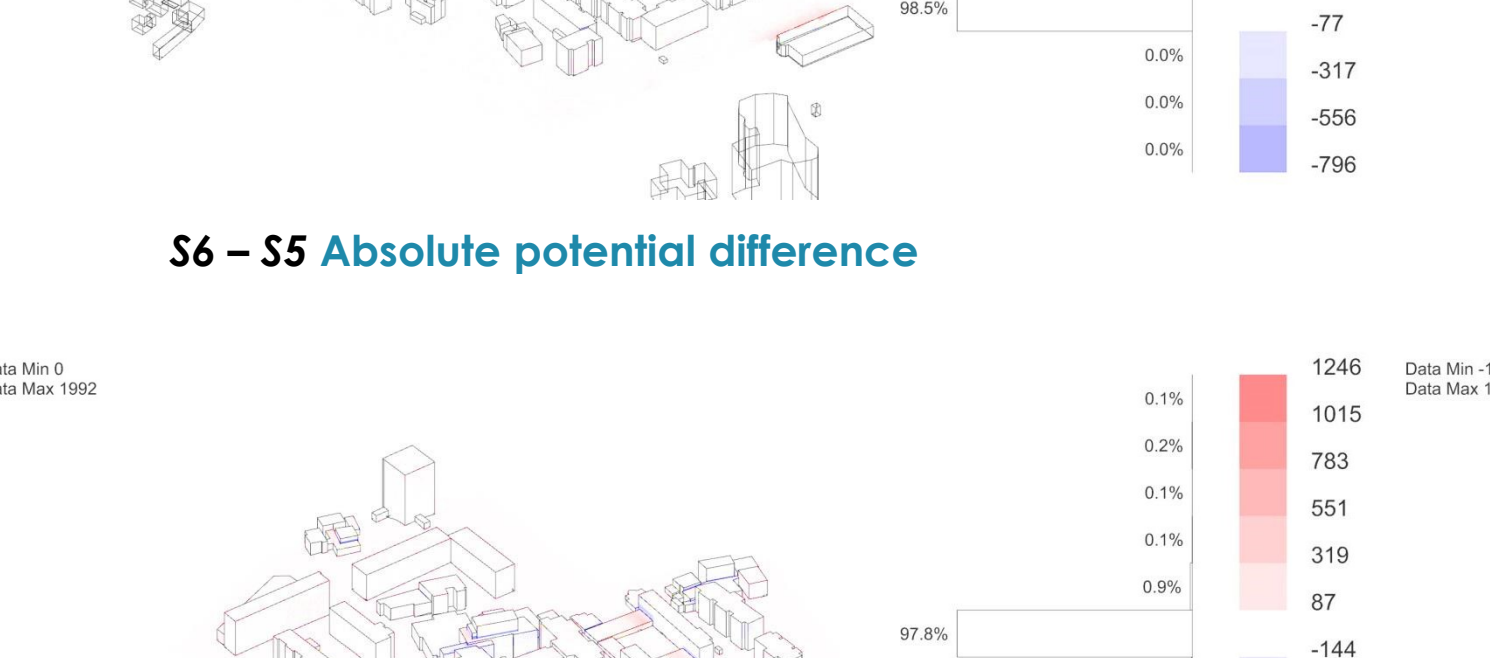
S3 - S2 Absolute potential difference



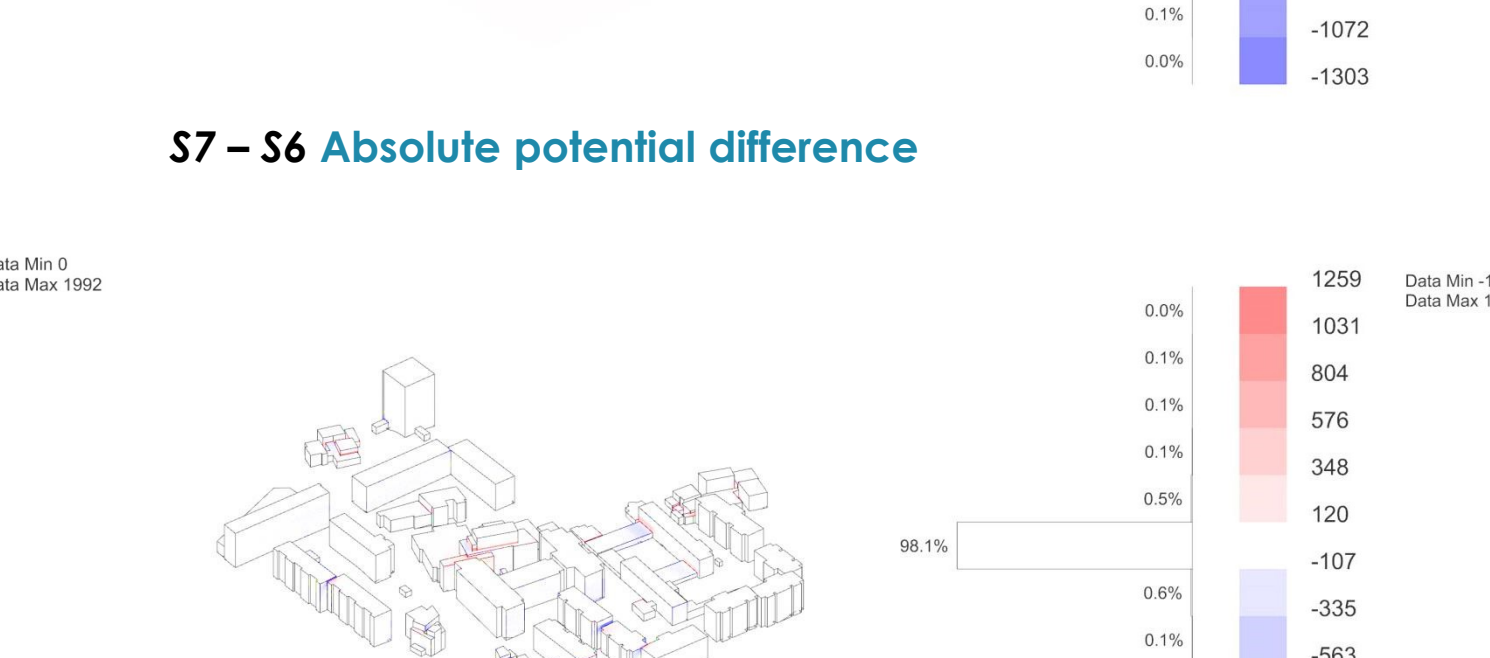
S4 - S3 Absolute potential difference



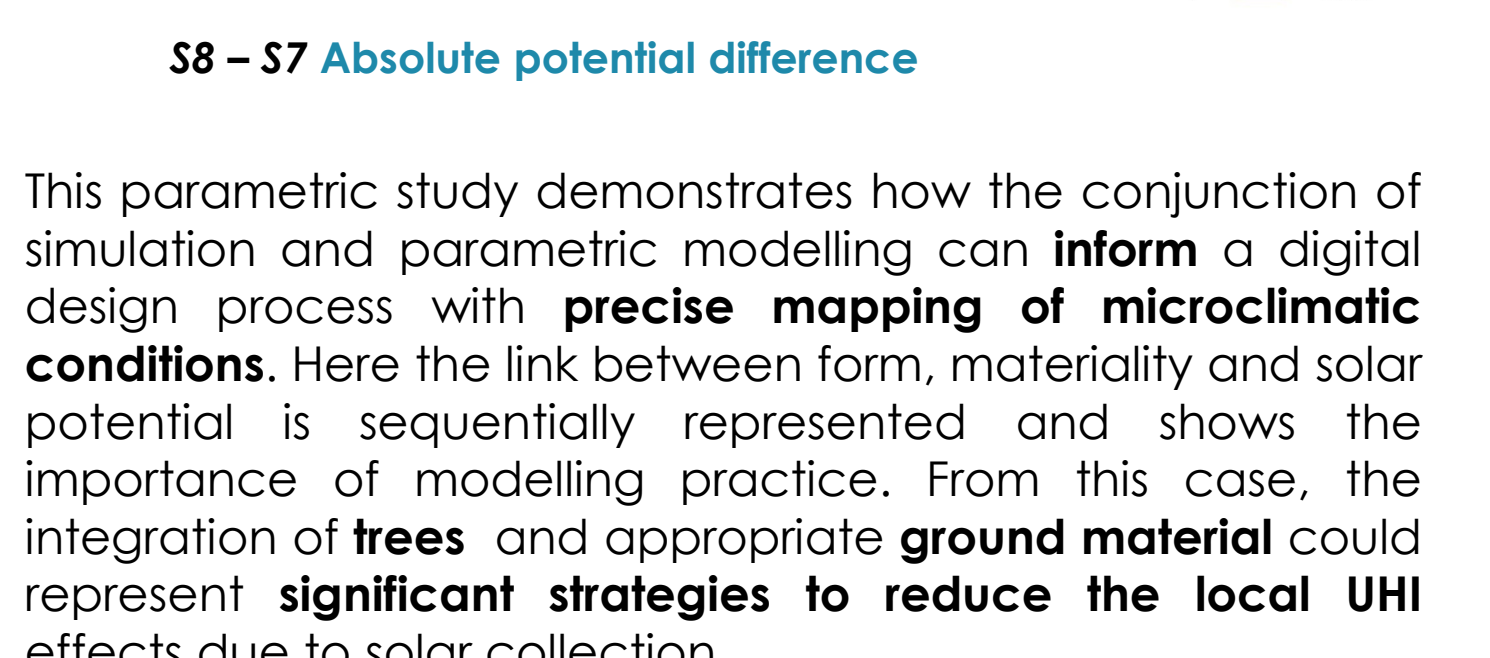
S5 - S4 Absolute potential difference



S6 - S5 Absolute potential difference



S7 - S6 Absolute potential difference



S8 - S7 Absolute potential difference

This parametric study demonstrates how the conjunction of simulation and parametric modelling can **inform** a digital design process with **precise mapping of microclimatic conditions**. Here the link between form, materiality and solar potential is sequentially represented and shows the importance of modelling practice. From this case, the integration of **trees** and appropriate **ground material** could represent **significant strategies to reduce the local UHI effects** due to solar collection.

DS to S8 Total solar potential evolution