Urban Layers: Towards an Integrated Urban Analysis and Design

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While space in cities is becoming a scarce resource, the importance of the quality of the physical urban environment is more and more evident. Vibrant and inclusive districts have been associated with higher quality of living and innovation potential. Districts that promote outdoor activities with good outdoor comfort, air quality and green spaces can boost the health and productivity of the inhabitants. Areas where special attention is given to an efficient use of energy and water and to a reduction of urban heat island effect are proven to be more resilient and future-proof. However, given the extreme complexity of the urban system and its metabolism, all the above mentioned aspects are intertwined with each other, therefore an integrated approach is required. When it comes to process management, the communication with stakeholders plays a key role to achieve a high quality urban development and it has been always a challenge. Last but not least, sparse and often inconsistent norms and policies largely lack a holistic vision about the urban environment, not stimulating and often preventing urban innovation.

In early 2020, ABT elaborated the idea that having a tool able to quantify the quality of an urban project with facts and evidence, without complex engineering calculations could facilitate this process and the communication among stakeholders. Oosterhoff Group (the holding ABT is part of) started the project Urban Layers as part of the Quake innovation center. The aim of the project was to tackle the above-mentioned issues by developing a computational tool that will assist decision makers and design teams with an integrated analysis and evidence-based evaluation of the physical urban space. The tool was envisioned in the form of an online platform, where urban designers, engineers, developers, investors and municipalities will be able to generate virtual scenarios of districts and cities and to assess the quality of an urban project in different aspects and reveal a deeper correlation between different aspects or disciplines of the urban design.

Urban Layers was designed as multicriteria, modular and agile. *Multicriteria:* it addresses several technical aspects of the urban space at once, like energy networks, urban water management, connection with physical, environmental and anthropological context, comfort of outdoor spaces, mobility, costs and value of land, data strategies, etc.: these were mainly technical aspects (which can be based on science and evidence), but the idea was to keep Urban Layers open to be extended also to issues in the social realm. *Modular,* because composed by several independent calculation engines, each of which addresses one of the above-mentioned aspects (e.g. the energy module calculates the total energy consumption of a district, while the comfort module simulates the local microclimate). Each module has separate inputs and separate outputs from the others; however, some modules can be interconnected, i.e. the outputs of a module are the input of another. *Agile,* because Urban Layers provides analysis results in real time and is based on a light calculation method. Instead of deterministic calculations and simulation algorithms, it makes use of available data and machine learning.

In 2020, the project started with a goal to create the first module (the Energy Module for aggregated district energy calculation) and to integrate it into an online framework in which other modules would be integrated as well later on. However, both due to some technical difficulties and because of the urgent need to test the tool in the market, we shifted our strategy to working with prototypes of modules in different offline platforms (e.g. Power BI and Grasshopper) and test these in the market with workshops with clients and by applying them in commercial projects. The development of the integrated tool (including the GUI and a middleware to exchange data among modules and with the GUI) is reserved for later and will start no earlier than 2022 depending on the results of the module prototype implementation phase. Currently, the Urban Layers consists of the Energy module, the Site-Scan module, the Urban Comfort module, the Mobility module and the Water Management module. These modules are also schematically visualized in Figure 1.

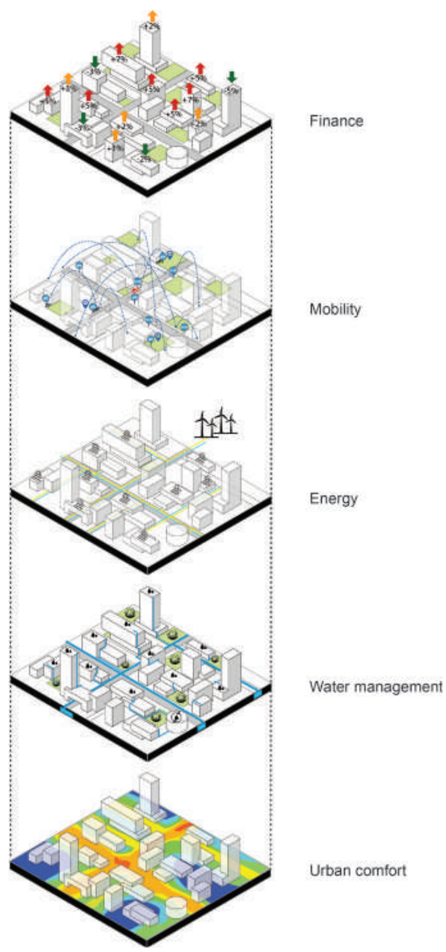

Figure 1: Schematics of some of the "layers" calculated in the software.

ENERGY MODULE

It can calculate the aggregated, hourly energy demand and consumption for a year of different groups of buildings (clusters) after defining the building functions (offices, retail, houses, etc.) and the energy systems (mixes of energy technologies like boilers, ATES, heat pumps, etc.). The tool shows results with several graphs in real time while the user changes the input. The Energy Module does not perform any simulation, but is connected to a large database of average, normalized hourly energy profiles per each building function: the aggregated energy demand is calculated based on such database in real time. The Energy Module is currently in its beta version and entirely developed in Java Script.

SITE-SCAN MODULE

Developed in PowerBI and MapBox and currently in its beta version, the Site-Scan Module visualizes and processes a series of geolocalized data (currently only in the Netherlands). The tool makes quick scans of the existing situation of project sites and provides necessary inputs to the user. An overview of the data stored in the Site-Scan module can be found in Figure 2.

In the future, the tool will be used to directly provide data to all the other modules. At the moment, the module can collect information about the year of construction, building height and ground-floor area, energy labels and function of all buildings in a selected area. By elaborating this data and using the same algorithm of the Energy Module, the Site-Scan Module estimates the aggregated energy demand profile of the selected buildings. The module will be expanded for working with more geolocalized datasets, for instance local mobility, recorded urban heat island effect, noise levels, etc. The tool is already being used in commercial projects, specifically in collaboration with Gemeente Zwolle for the development of a large district heating grid.

URBAN COMFORT MODULE

The objective is to create a tool that is able to calculate in real time the distribution of wind speed, heat stress risk, solar access and noise levels in the public spaces. In order to achieve real-time speed, any form of simulation is avoided. For this reason the tool uses machine learning. A first experiment has been successfully completed, in which a Machine Learning algorithm has been trained with the results of Computational Fluid Dynamics (CFD) simulations: the algorithm calculates in a fraction of a second the wind speed at pedestrian level around a simple group of buildings. The plan is to run a much larger number of CFD, noise and sun simulations on a larger number of urban geometries and train the algorithm with the results. A tool able to generate infinite variations of urban geometry has already been developed and it works.

Figure 2: Site-Scan module: collection of information from the existing building.

MOBILITY MODULE

The prototype is developed in Grasshopper. A 3D map of an area can be directly downloaded from the open data platform, which includes layers of both buildings and infrastructure together with their functional data. By simulating the 10min walking range from essential amenities (shops, restaurants, schools, post offices, pharmacies, parks, etc.) the tool calculates the "walkability" score of a particular neighborhood, as visualized in Figure 3. Similarly, the Mobility Module can also calculate the risk of car traffic congestions in specific locations. In this way, the tool can be used to anticipate the consequences of adding a new amenity or a new pathway in a neighborhood or to give suggestions to improve the distribution of certain amenities.

Figure 3: Mobility module: calculation of the street network within 15 min walk from a specific amenity.

WATER MANAGEMENT MODULE

It calculates the water run-off from a groups of buildings and the adjacent surfaces. It analyses differences between the current and planned situation in the development area. The increase of hard surface of the built area increases the water runoff in case of rain event, leading to higher load on the sewage infrastructure. A local water management strategy is needed. The tool calculates the required local water storage capacity according to LEED, BREEAM and local Planuitwerkingskader (PUK). It evaluates different low-impact measures such as gutters, infiltrations strips, bioswales as strategies for reducing the required local water storage capacity. It evaluates the impact of design choices such as surface cover, roof-types on water run off capacity.

The final goal remains to create a platform that would allow not only Oosterhoff Group, but also third parties to easily connect, collaborate and share knowledge and data. With Urban Layers we plan to smoothen the communication between different stakeholders and the decision making process, offering an integrated, evidence-based view on several aspects of urban projects. By avoiding extensive and costly engineering studies, Urban Layers will allow science-based decisions already in the very early stage of the urban design. Municipalities and designers will be able to elaborate urban visions based on data which normally are too complex to elaborate in early design. In turn, this will allow a more effective urban design and more certainty in meeting sustainable development goals. Urban Layers is still under development: therefore Oosterhoff Group and ABT are actively looking for bright minds willing to contribute to the project and, of course, concrete urban case studies to show its potential. ■