Zukunft Bau

SUMMARY REPORT

Title
LUX – Light, Valuable Resource for City and Building

Long Title: „Auswertung und Vergleich bestehender und neu zu planender Gebäude hinsichtlich des Energieeintrags. Bilanzierung der Verbrauchsenergie mit dem Fokus auf den Lichtanteil der solaren Strahlung. Erstellung eines Energieeffizienz (Licht) Planungstools mit Musterkatalog.“

Research Motive

The lack of affordable housing in european cities calls for increasing building density. Under these circumstances, daylight becomes a precious good. This research project focuses on daylight optimization in densely built areas. How much daylight does a Human Being need? Which geometries are most suitable for maximizing daylight exposure at high densities? When Buildings become more compact, floor plans with higher depths – ergo less daylight inside the building - are the result. How can this aspect be taken into consideration?

Research Objective

Goal and Structure:

The goal is to integrate the daylight aspect into the development process of architectural and urban design. In order to reach that goal, a fundamental understanding of the geometrical dependencies between building and natural source of light is needed, as well as a simple benchmark. The LUX project is focused on developing such a benchmark method.

A variety of well tested daylight simulation tools is available today. However, most of them require experts to operate them, and they are only applicable to already developed geometries in an advanced state of the design process. They do not provide a more general understanding of geometrical dependencies – specifically in an urban scale.

Our approach is to develop that general understanding, based on parameters like Building Height and Distance, Roof Shape (which are already part of building code regulations) but also Building Depth, Orientation, Floor Plan Geometry - which are currently not taken into account, but have a strong impact on daylight efficiency.

The project’s core element is the creation of a database which correlates daylight parameters (time, geographical position, light, heat…) with geometrical parameters important for urban planning (density, building depth, height, distances, orientation, typology…).

The data collected from simulations will then be analyzed for regularities and dependencies, in order to develop simple ‘rules-of-thumb’ that can be easily integrated in the architectural and urban design process. Additionally, the database will be transformed into an online tool permitting intuitive (visual) public access to the collected data.

The research result is meant to enable Planners to make more founded decisions regarding daylight and energy efficiency in early design stages, even before consulting specialists, and to have better judgment on their design decisions’ impact on daylight related issues.

Methods:

In order for the results to be relevant in the design development process, it is important for the geometrical parameter values to relate to real-life dimensions. Value ranges for our analysis are therefore based on building code limits and practical experience. Simulations are based on solar data for Germany, subsequently geometries are also based on German building code. The parameter values need to be limited in order to maintain a manageable database size without overly limiting possible results.

It is also essential, how the amount and quality of daylight is measured. Which criteria are important specifically for residential buildings? How can these qualities be measured and judged?

Typical available methods, which are in use for office buildings, focus on daylight autonomy, i.e. minimizing the need of artificial lighting in order to reach 300lux on a tabletop height during common business hours. In this scenario, the main criteria is a reduction in cost and energy consumption. The goal is to spread the available daylight as evenly as possible, due to the homogenous programmatic demands of an office building. This method will not necessarily provide optimal results for residential buildings with their heterogeneous spatial and programmatic arrangements.

In our setup, we use daylight simulations based on a virtual sky with local weather data, which takes into account sunny and cloudy days alike. We measure the solar impact on the façade in kWh.

This method only covers the amount of daylight available on the building envelope. A second step is necessary in order to assess daylight quality inside the building.

In this step, the daylight factor (DF) is determined for every point on a floor plane. This is done geometrically, with a far smaller computational effort than interior lighting simulations. Combining the simulation result on the façade with the daylight factor inside the building allows for a quick assessment of interior daylight availability on a very large range of geometrical variations.

It is also suitable to show the impact of glazing size and position within the façade.

Conclusion

The simulation data suggests, that the ratio of solar impact on façade to building floor area is a reliable indicator for interior daylight availability. It was not possible to verify the reliability of that indicator in depth, but we suggest this should be considered in future research.

In order to assure direct access to the results of this research and applicability in practical work (regardless of possible future research based on the data), an online tool was developed. Additionally to an intuitive and visual access to the simulation database, a 3d-Tool for interior lighting quality analysis based on urban parameters is accessible under the following web address: http://www.citylux.de

The results show, that parameters on an urban scale, like orientation or building depth, have a strong impact on interior lighting conditions and show regularities in correlation with other geometrical parameters. It was not possible to develop reliable ‘rules of thumb’ based on the existing data, but it seems promising and worth further investigation. We believe, a further in-depth analysis of the collected data could be the foundation for reliable rules assuring an acceptable minimum of available daylight in dense neighborhoods, which could be implemented into norms or building code.

Given the size of our database, machine learning could be an interesting field for future research based on our data. The database itself can be used for the development of more advanced machine learning routines, but at the same time, this method could advance our understanding of the relationship between daylight and building geometry beyond the means of common analysis tools.

Basic Information

Short title: LUX _ Licht, natürliche Ressource für Stadt und Gebäude

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