M4.2 User-friendly tool for the calculation of the coupled performance

WP4. Modeling, T4.1

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Table of Contents

1 Introduction

Coupled daylight and thermal simulations are more and more needed in the building concept design phase to support the definition and implementation of comfortable and energy efficient buildings. Managing such coupled simulations is an easy task neither for building envelope practitioners nor for researchers.

Thanks to a series of dedicated projects, University of Innsbruck, Bartenbach and Zumtobel Lighting have developed a simplified tool called DALEC.

This report aims to summarize the main DALEC features and underlining the usability to support the design of envelopes for comfortable and energy efficient buildings.

2 DALEC: what's behind?

The webtool DALEC – "Day- and Artificial Light with Energy Calculation" (www.dalec.net), enables an easy and fast evaluation of different façade solutions. With DALEC, an online concept evaluation tool for lighting designers, architects, building engineers and building owners has been developed in the consortium of Bartenbach, Zumtobel Lighting and the University of Innsbruck. Although easy to use, the software accounts for the complex thermal and lighting processes in buildings and allows a simple evaluation of heating, cooling and electric lighting loads. Not only energy, but also user behaviour is considered, and visual and thermal comfort is evaluated (glare, overheating frequency).

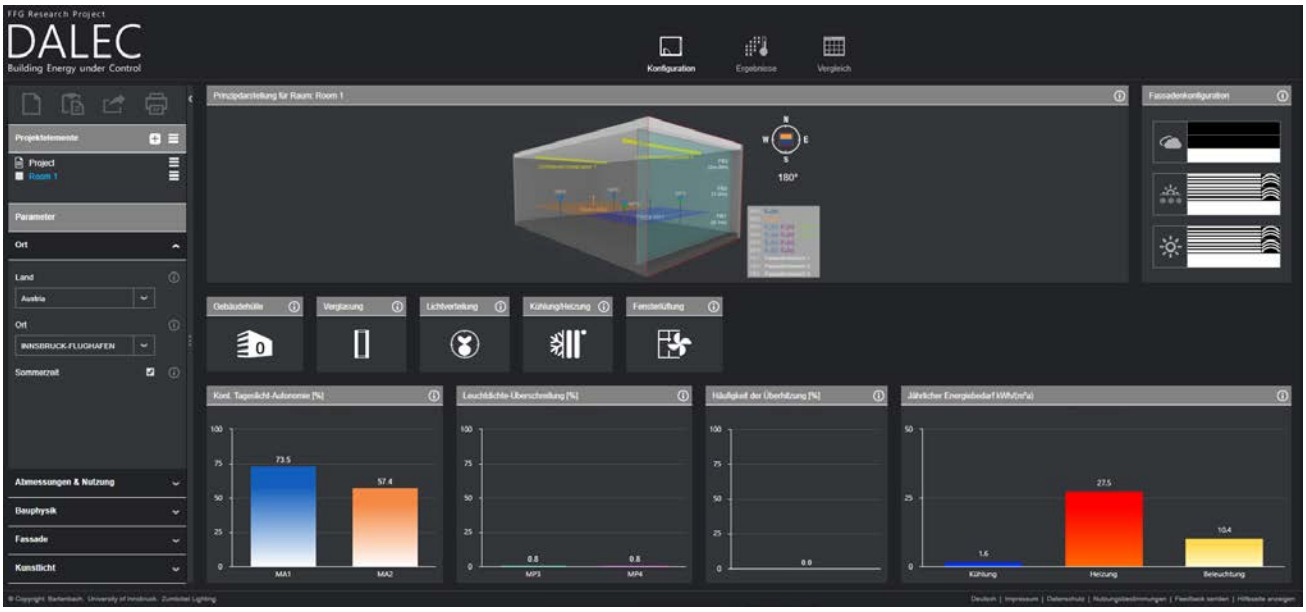

Figure 1: The DALEC web interface – www.dalec.net

3 DALEC: main features

The main purpose of DALEC is to compare different façade systems and artificial light systems for a specified room, representative for all rooms with the same façade orientation in a larger building. The focus lays on office buildings. The following quantities addressing visual and thermal comfort and energy performance can be compared.

- Glare: percentage (hours per total annual occupied hours) of luminance exceedance
- Overheating frequency (hours per total annual occupied hours) (if an active cooling system is not available)

- Continuous daylight autonomy
- Heating demand
- Cooling demand (if an active cooling system is available)
- Artificial lighting energy demand

Since DALEC employs the Radiance three phase method, the daylight illuminance on the work plane is calculated accurately for both direct and diffuse irradiance. The gap to the normative required values on the working planes (500lx) and traffic areas (300lx) needs to be added by artificial light. Employing the light distribution curve of the luminairs from the chosen artificial lighting system, allows an accurate calculation of the artificial lighting energy demand. Dissipated heat is then considered as an internal gain in the energy balance of the room, which is calculated in a standardized manner (EN13790).

The simulation is done for a whole year in the specific location of the building and the defined façade orientation. To fit best to a specific user project the room geometry can be adopted. The rooms width, height and depth can be adjusted within certain boundaries as well as the window to wall ratio independently in three horizontally divided façade parts. However, in the present version of DALEC, the geometry is limited to cuboid rooms with one façade, but generalizations for rooms with more facades and other geometries are work in progress.

To achieve an accurate comparison in terms of energy, building physics parameter such as SHGC- and transmissions values of the window and the U-values of glazed and opaque façade parts can also be specified. Since the specified room is thought to be surrounded by similar rooms, the heat flux through internal walls is assumed to be close to zero (adiabatic boundary conditions), and not considered in the energy balance. For each façade part, a different façade system consisting of glazing and shading resp. light guiding devices can be specified.

For realistic assessment of such systems control strategies must also be considered. In DALEC rule-based control strategies can be applied, by specification of thresholds. Upper limits can be defined for the global vertical irradiation on the façade and for the observed luminance by the hypothetic user inside the room, above which the façade system closes. What exactly happens when the façade closes can be defined for the heating and the cooling period independently.

While the normative thermal simulation does not require large computing power, the lighting calculation is way more time consuming, since ray tracing algorithms are required. The high speed of the DALEC online calculation can only be reached by employing precalculated data, which is stored in a data base. For the simulation of a user project, a sophisticated interpolation algorithm is employed to fit the precalculated data to the input freely specified by the user.

During FACEcamp, DALEC was validated and compared against some other simulation tools. Several results of such comparisons are activities done collaborating within in the IEA SHC Task 56 on Solar Envelopes and will be published in the Deliverable Report of Subtask C (http://task56.iea-shc.org/). Bartenbach, University of Innsbruck as well as EURAC as Task coordinator have been involved intensively in those activities and a fruitful knowledge transfer from the FACEamp activities have been made within the task consortium.

Moreover, first proof-of-concepts have been made by coupling DALEC with Rhino as a geometry platform. While the official DALEC version is applicable via the web-interface, an integration into the BIM-environment via IFC will be established soon. Therefore, a plug-in for Revit is in development in order to specify the needed data in a Revit model to run a DALEC-calculation.

4 Useful links

Further information to the methodology of DALEC can be found in the following documents:

→ http://dalec.net/#help

→ Werner, M.; Geisler-Moroder, D.; Junghans, B.; Ebert O. and Feist W. (2016). DALEC – A Novel Web-Tool for Integrated Day- and Artificial Light & Energy Calculation. Submitted in: Journal of Building Performance Simulation.

→ Matthias Werner; Gekoppelte lichttechnische und thermische Methoden zur Ganzjahresbewertung von Fassadensystemen für die Planungspraxis; Dissertation; University of Innsbruck; 2017

A worldwide guidance of appropriate parameter values of façade systems depending on the location and façade orientation can be found in the following paper:

→ M. Werner, et. al.; Analysis of Worldwide Performance of Façade Systems; 15th IBPSA Conference, San Francisco, CA, USA, Aug. 7-9, 2017

The results of the comparison of DALEC with other building energy simulation tools have been published within the work done in within the IEA Task 56:

- Magni, M. et.al (2019), Comparison Of Simulation Results For A Reference Office Building – Analysis Of Deviations For Different BES Tools, IBPSA Building Simulation Conference 2019, Rome

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