FORSCHUNGSINITIATIVE Zukunft BAU

Short Version

Title

Long title: “Development of a method for the simulation of building life cycle costs – LZK-SIM [BAU]”

Starting position

Life cycle costs (LCC) are an important factor regarding the design, planning, construction and operation of buildings. Still, the ability to influence costs is largest in the planning phase. Therefore, this research project aims to develop a tool, LZK-SIM [BAU], to predict and analyze LCC during the planning phase of buildings.

Subject of the research project

The main benefit of LZK-SIM [BAU] is a publicly accessible, easy-to-use tool for LCC optimization of buildings. The user receives an LCC-optimized configuration for a building by entering key information available in the planning phase. The method can be combined with empirical data to simulate LCC of a building. From a mathematical point of view, the optimized planning of building components, considering lifetimes, leads to so-called knapsack problems with interdependence relationships and uncertainties in a cost-benefit analysis. For this purpose, criteria, target systems and restrictions have to be defined. Target systems and restrictions can be represented in the simulation program, while criteria and their weightings are defined by the user.

The LZK tool was originally to be developed on the basis of empirical building data. Because of severe difficulties in collecting such data, the model was finally developed on the basis of synthetic data. For this purpose, a comprehensive literature search was carried out and cost and building parameters were taken from relevant publications and standards. At the same time, attempts were made to receive empirical data from building owners and operators.

A standard office building was defined for the model development, which represents a common distribution of areas as a percentage. No fixed room arrangement was specified. The building elements used in office buildings are defined on the basis of standard room types ("functional areas"). The quantities and masses of the building components result from the user-defined cubature and usual characteristic values. These form the basis for predicting construction and usage costs.

A client-server architecture was selected for the tool. The backend on the server side encapsulates the largest range of functions. Communication with the frontend is established via PHP, the database (DB) is updated, the optimization module (python) is started and the data from the optimization are prepared for visualization. The web-based fontend is used for interaction with

the user and visualization of the results. Communication with the backend takes place via PHP (AJAX), the interface is based on CSS (Bootstrap Framework).

Static data, e.g. on cost groups, execution types and their properties, are stored in a MySQL database. Cost characteristic values are stored for the essential usage costs, with which cost trends can be predicted for each building configuration. The DB allows simple maintenance of the LZK-SIM [BAU] data and ensures that new or updated data can be quickly integrated.

The core of the optimization module was implemented in the programming language Python, which provides a comfortable interface to the solver gurobi. Gurobi is a state-of-the-art tool for solving mixed integer linear programs (MIP) and is freely available for academic purposes. In Python the static data are drawn from the DB and after a preprocessing together with the input data of the user (from the PHP module) the variables and constraints of the optimization model are generated. The optimization of the model is then triggered by gurobi and the result is prepared from the optimal variable assignments. JSON (JavaScript Object Notation) was chosen as the data exchange format (similar to XML).

The user interacts with the tool via web interface in his or her web browser. After entering some data, the optimization process is started. The period under consideration is 5, 10, 20 or 50 years. The optimization target is the cumulated cash values of the LCC. For each of the selected periods $T \in \{5,10,20,50\}$ the optimization module calculates a cost-optimal configuration of execution types.

At the end of the calculation, the user is forwarded to a diagram page that shows the cost curves of the individual optimum solutions OPTT. In addition to the cash value of the LCC (optimization target), the cumulated/periodic actual costs are displayed.

After completion of the optimization, the cost trend over the years is calculated for each of the optimal solutions. The presentation of the cost trends provides information on how sensitive the different solutions are with regard to the time horizon.

Conclusion

Client, planner and architect can use the LZK-SIM [BAU] tool to obtain crucial information about the expected LCC already during the planning phase. In this way, conflicting objectives or optimization potentials can be identified early on and the planning adapted accordingly. In addition, the tool allows the optimization of the configuration of components and technical systems in relation to the entire life cycle. The various functions of the LZK-SIM [BAU] tool can be further optimized and supplemented. The basic prerequisite for this is the extension of the empirical data basis.

Basic information

Short title: LZK-SIM [BAU]

Project management/ researches: Prof. Dr.-Ing. Karsten Körkemeyer, Prof. Dr. Björn-Martin Kurzrock, Prof. Dr. Sven O. Krumke, Dipl.-Ing. Kristina Heim, Nils-Magnus Wasser, M.Sc., Dennis Aldenhoff, M.Sc., Dr. Michael Holzhauser, Ingo Besenbruch, B.Sc.,

Total cost: 200,000 €

Federal subsidy: 130,000 €

Project duration: 26 months