TU/e Technische Universiteit Eindhoven University of Technology /Department of the Built Environment
/Unit Building Physics and Services

7LY3M0 – Building performance and energy systems simulation

Week 5.Concept 1

Action: For many years, it has been said that building performance simulation has huge potential to assist decision-making in the early/conceptual building design phase. If this is indeed true, then why is it still not happening on a wide scale in the building industry? What are the two most important underlying causes and how can they be addressed?

Student A:
According to de Souza (2012), building designers regularly have issues with executing, and drawing conclusions from building performance simulations. This is due to two primary culprits. The first is a lack of knowledge about simulation in general and the physics behind the simulations. This prevents them from adequately understanding and analysing simulation results. This lack of understanding also makes it difficult for them to evaluate the effects specific decisions made in the design process have on simulation results. If they started to design something to be visually pleasing but had the insight in physics to know that what they are designing will be terribly inefficient, they might take steps to ameliorate this. The same happens with simulation. A designer that has a hard time using simulation tools will also be far less likely to even use them. Due to all this, issues with the conceptual design might only be found out at a later design stage when other engineers start simulating the building. Once issues are embedded in a design that has been presented to the client or won a design competition it can be terribly difficult to fix them.

The second issue mentioned by de Souza is with the building physicists and programmers designing the simulation tools. These tools come with interfaces that are often difficult to use. In an attempt to allow the user to determine every little detail of the structure they are simulating; they end up with overwhelming programs that can be intimidating. This is an issue that is common in the development of computer programs, especially when the same program is worked on for longer periods of time (sometimes decades). The constant addition of new features means programs end up being increasingly complicated.

Programs do not allow for the user to input vague design descriptions, which means that designers must put in a lot of detail that is undecided as of yet. This can increase the difficulty of determining the effects of certain factors on building performance. Programs need to be realized that help users in gaining an understanding of these relationships.

A large share of high-end architectural projects is awarded through competitions (Doeling, 2017). These are fast paced, and often followed by expedited concept design stages. Despite these clients will often expect performance statements that are made during these competitions to hold true during later parts of the design process. The issue that arises from this is that these competitions and hurried design stages don't allow the designers the time to properly evaluate their concepts. As a result, they might discover issues and efficiencies belatedly. At this point clients are expecting the designs to be pretty much set in stone, which in turn makes making changes difficult. Subsequently, buildings might be built where the designers realized, perhaps delayed but before it is built, that there are glaring inefficiencies in the design.

The first way to tackle this is by stopping the fast pace of engineering competitions. Hurrying architects like that can only hamper them in making buildings more efficient. When time is of the essence it becomes more difficult to incorporate costly simulations and elaborate calculations. Another important manner of addressing this is by increasing the amount of multidisciplinary collaboration in the early stages of building design. All relevant specialties should be involved as much as possible during the conceptual phases. Using their expertise ensures the creation of realistic, feasible concepts. Finally, the clients should change what they expect from the architects. Measurable and spatial deliverables should be determined upon and provided to the project owner. Uncertainties and assumptions should also be made clear.

Student B:

The use of building performance simulations has drastically increased in the past decade as it has posed itself as means to visualize various metrics such as air quality, ventilation, thermal health in addition to aiding engineers and architects in the design phase of the building to determine how can the environment function in an optimal and efficient way to ensure the comfort of its occupants and achieve energy conservation measures. BPS consist of representing the expected as well real-life characteristics of the building, and the control and energy systems encompassing the corresponding environment. However, adopting building performance simulations at large scales in early stages of the design phase of buildings has yet to become the norm or a standard procedure that is regularly integrated in the conceptual phase. With the abundance of simulation tools, it is evident that they all possess flaws in terms level of accuracy and platform simplicity (Zhou et al., 2014). In addition, it is worth noting that the designer needs to make sure that the appropriate tool is chosen to fit the purpose of his study/analysis to avoid modelling errors (Gaetani et al., 2016). Numerous challenges arise in the context of building performance simulations hindering their wide scale adoption in the building industry. In what follows, various challenges arising in the BPS application area are presented.

To begin with, the challenge of integrating human interaction in building design and operation still seems to be one of the obstacles in the degree of mirroring in BPS. In certain cases, occupants of a building make changes and variations to make the environment satisfactory for their personal preferences. These changes and variations range from adjusting different settings (light, thermostat, shades, clothing levels), modifying personal thermal devices for heating and cooling to drinking warm or cold beverages. All of these changes and interactions impact energy use and occupant comfort and is also bound to the accessibility of occupants to control systems to be able to do so. The issue lies in modelling human building interaction (HBI), as depicting the expected behaviours as well as their consequences on energy flow to in a robust way tom integrate in design strategies is a cumbersome task (Hong et al., 2018). Characterizing various occupant behaviours varies significantly between populations and even is specific in each building context. Large-scale sampling also does not pose itself a solution as it would generalize the behaviour model.

Furthermore, inconsistencies between simulated and real-life data discourages designers to rely on building performance simulations as it diminishes the confidence in the predictions and the reliance on such tools. Luckily, this obstacle can be resolved with a process known as calibration, where various inputs are changed/tuned to improve the model's predictions in a way that matches the actual measured data (Ohlsson et al., 2021). With the need of professional expertise and knowledge to be able to conduct calibration for BPS, novels methods that make this process systematic and efficient can pave the way towards increasing confidence in the predictions.

The microclimate of urban regions, labeled as Urban Heat Island (UHI), is characterized by its own characteristics that differ from the surrounding areas, hence traditional data cannot be applied in such cases as it will cause discrepancies in the findings, specifically in cooling and heat use. In the context of the design process, urban building energy modeling (UBEM) consist of performing simulations to visualize the interaction of building with the urban microclimate, providing valuable information for urban planning (Hong et al., 2018). The issue lies in precisely translating the urban microclimate, determined by various parameters such as local air velocity, solar reflections, buildings surface temperatures and many more, in the simulations. One solution might be to consider the whole urban area as one urban system rather than taking the buildings on an individual basis. With that being said, still a number of issues arise on the computing level of the tool (Hong et al., 2018). Large amounts of data, interdependencies between sectors within the urban area (including transportation), immense computing power and preliminary output results are all reasons that are standing in the way of relying on building performance simulations in a smooth workflow.

Lack of user knowledge and complex tools are considerably one of the major causes hindering the adoption of building performance simulations. Although providing manuals, clear instructions, and webinars to facilitate the use for inexperienced users, it does not present itself as a solution to be adopted on a large scale. However, simplification and creating a seamless user-interface can bypass the complexity issue designers face, providing them with a tool that is easy to navigate and understand to conduct the analysis.

Student A and B:

It has become clear that the primary reason for the insufficient integration of building simulation tools is due to a lack of collaboration and understanding between architects and building physicists. The solution should be to have the two groups find a common ground. Simulation tools need to become more suitable for use by architects with a different knowledge base than the physicists designing the tool. This can only be done by involving building designers in tool development. On the other hand, architects need to involve engineers at an earlier stage of building design. This should be enabled by changing the status quo of conceptual building design to ensure that there is enough time to properly do this.

The limitations of BPS also discourage use in early design stages. HBI is very difficult to model, often leading to simulation results that are wildly different from reality. Different (groups of) occupants will use buildings for different things and create these discrepancies between simulation and real life. Another limitation is the difficulty of implementing UHI. Even in early design stages decisions can be made that would've been different if UHI could have been taken into account. The issue is that UHI is incredibly dependent on the location a building will be built, which makes it difficult to properly design for in conceptual design phases. The computational issues make things even worse. All of this means that using simulation tools is a daunting task for any building designer.

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