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/Department of the Built Environment

**/Unit Building Physics and Services**

7LY3M0 – Building performance and energy systems simulation

**Week 3.Concept 1**

*Action: Imagine that you are involved in the design process of a new high performance office building that uses ventilative cooling (natural ventilation) and a large building-integrated PV system, in the city of London. The design brief asks for a future-proof building, and the idea is to analyze both the influence of (i) the local microclimate including urban heat island effect, and (ii) future climate change scenarios. Unfortunately, time is very limited, and you have to choose for one of the two options. Which of the two analyses approaches would you pick, because it could have the largest impact on the design of the building? Why?*

***Student A***:

The major concerns and studies emphasizing the implications climate change could have on humans in the absence of serious actions, have prompted researchers to consider and adopt future-oriented agendas and policies in their designs (Georgiadou, 2014). However, such statement covers a wide range of topics and given the importance of carefully conducting such studies due to high uncertainty and inability to precisely predict the future, the designer is left in some situations where time (or financial) constraints limit him within a specific scope of analysis. In our case, we are subjected to determine which aspect, the local microclimate or future climate change scenarios, is most fit to analyze and makes a significant impact, as it will influence the decision-making body responsible of designing the office building.

The growing rate of urbanization across the globe has drastically affected the microclimate of urban regions, creating a so-called Urban Heat Island (UHI), where the temperature is warmer than that in its surrounding rural areas (Sun et al., 2014). Hence, traditional weather data cannot be used when conducting a study in those areas as it may lead to significant discrepancies in the findings, especially in the heating and cooling energy use. On a broader aspect, “future-proofing” a building against climate change scenarios mainly tackles the influence of climate change on the thermal performance of buildings (Wilde et al., 2012).

The local microclimate appears to be the critical aspect to analyse over future climate change scenarios. To begin with, the higher temperatures in urban areas imply the need and use of additional cooling in buildings compared to rural areas (Oxizidis et al., 2008). In addition, it was also found that the urban heat island is a major influencer on energy consumption for heating and cooling purposes. Given that the building under investigation adopts ventilative cooling, which depends on outside temperature and humidity, it is then crucial for the designer to look further into this aspect as it has major implications on cooling practices. The photovoltaic system is also affected, where its various uses, for heating (PVT) and power generation, are dependent on various parameters found in the analysis of the local microclimate.

On the other hand, analysis of future climate change scenarios in the context of building performance has proved to be a complex process that requires utmost accuracy in terms of parameters and data (Wilde et al.,2012). Furthermore, Wilde et al. demonstrated the unreliability of the predictions underlining the effect of climate change on building performance due to the high uncertainty and assumptions made during the process. With that being said, in addition to the margin of error in predicting future climate parameters, the designer has to modify the predictions to take into account the UHI effect, which in turn increases the rate of error. If future climate change scenarios were to be solely considered, the impact that it would have on the design process of the building would be shadowed by that of the local microclimate, due to the latter being a more ‘local’ analysis, where the former gives generalized insights.

***Student B***:

To try to figure out which of these issues will have the larger effect on building design it is wise to first consider what their predicted effects will be in the long term. UHI is a relatively well understood phenomenon. Its consequences are apparent, and with proposed mitigation concepts being researched by many different researchers it is possible to lessen the effects in the future through smarter city planning and implementation of different strategies that have been discussed at length in literature (Mohajerani et al., 2017; Onishi et al., 2010). Examples of these strategies are use of highly reflective materials to lower radiative heat absorption, cool pavements and roofs and inclusion of far more urban greenery (Akbari, 2015). This means that future effects of UHI are mainly dependent on the choices made by city planners and building designers, and as a result it should be possible to plan for the future.

Research on UHI in London by Kolokotroni et al. from 2006 and 2007 showed that annual urban cooling loads are up to 25% higher than the rural load, and annual heating load is reduced by 22%. Their research from 2006 investigated the effects of UHI on ventilative cooling in London specifically. Their findings state that a properly optimized rural office building, making use of ventilative cooling and night ventilation strategies, would not need any artificial cooling and need 42% of the cooling required for an urban optimized office. This shows a large difference in ventilative cooing effectiveness between urban and rural environments, attributable to UHI, which means building design should also change drastically to account for these effects.

The effects of climate change are a less well-defined topic. The global mean temperature will increase, but this does not mean that it will simply be warmer by this amount all over the world. Chances of extreme weather events occurring will become far higher, especially the global average chance of heatwaves (Arnell, 2019). Planning for this would mean requiring far more cooling headroom, with minimized ventilative cooling since the outside air would be far too hot during these periods. PV panels become far less efficient when exposed to excessive heat, which means that engineering these for extreme heat waves requires implementation of extra cooling capacity, so they keep functioning efficiently in these times (Popovici, 2016).

The real difficulty starts with the unpredictability of climate change. Excessive heat is not the only possible effect, with extreme weather events of all types increasing spells of extreme cold are also possible. There are also the more complicated effects like the potential collapse of the gulf stream (Boers, 2021). This would cause warm water from other parts of the planet to no longer be transported to Europe, which could in turn cause a large drop in average temperatures in western Europe. Collapse of major ocean circulations would affect many other parts of the world, with local average cooling effects of up to 8 degrees (Vellinga; Wood, 2002). The larger effects of the melting of polar and Greenland ice are also difficult to predict. Extreme rainfall events will be far more likely in many parts of the world as well. What makes all of this even more difficult is that it is virtually impossible to predict what type of climate change effects will affect a specific part of the world to any acceptable degree of certainty.

All of this means that implementing future proofing related to climate change in building design entails planning for both extreme heat and extreme cold, large amounts of rainfall and water saving measures in case of drought. Ventilative cooling becomes less effective at these extreme temperatures and PV panels require cooling during heat spells. To make matters worse it is virtually impossible to plan for the future use a building might serve. As a result, designing a future proof building that is built to stand the test of climate change is prohibitively expensive. UHI meanwhile has far more obvious effects, and design that takes these into account and tries to mitigate them is doable and previous research shows clear actions that can be taken for this.

***Student A and B***:

All in all it has become clear that concentrating on design that focuses on climate change related phenomena is not the way to go. The unpredictability of the effects means that it is prohibitively expensive and difficult. UHI is also a growing problem, but its effects and potential mitigation strategies are far more clearly defined. As a result it is much easier to predict what will happen related to it in the future, and take this into account when designing a building. Ventilative cooling design that does not take UHI into account will be significantly less effective than when it is, which would make the system virtually useless. Climate change could potentially render ventilative cooling ineffective as well, but this is far from certain, so it is better to design a system that at least works right now.

Taking UHI into account in PV panel integration starts with cooling design, something that would also help if temperatures rise due to climate change related heat increases. Climate change induced extreme cold just makes the panels more efficient, so not much has to be done there. Further extreme weather events like severe flooding should have smaller effects on PV panels and ventilation systems. Therefore the focus will be on the urban heat island effect.

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