Concept Script week 3

Imagine that you are involved in the design process of a new high performance office building that uses ventilative cooling (Links to an external site.) (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?

Management of thermal performance risks in buildings subject to climate change

**Abstract**

*This article reports on the use of building performance simulation to quantify the risks that climate change poses to the thermal performance of buildings, and to their critical functions. Through a number of case studies the article demonstrates that any prediction of the probable thermal building performance on the long timeframes inherent in climate change comes with very large uncertainties. The same cases are used to illustrate that assessing the consequences of predicted change is problematic, since the functions that the building provides in themselves often are a moving target. The article concludes that quantification of the risks posed by climate change is possible, but only with many restrictions. Further research that is needed to move to more effective discussion about risk acceptance and risk abatement for specific buildings is identified.*

* Very large uncertainties when predicting long term thermal performance changes related to climate change
* Assessing the consequences of the predicted change also problematic, since building functions change over time
* Quantifying changes of climate change risk possible, but only with many restrictions

Urban heat island effect on energy application studies of office

Buildings

**Abstract**

*Because of the urban heat island (UHI) effect a metropolitan area is typically warmer than its surrounding rural area. This has led to a growing concern that the use of standard (mostly rural) weather data leads to inadequate decision-making with regard to the energy efficiency of buildings in metropolitan areas. This paper conducts a series of computational studies that explore the UHI effect on two routine applications of building energy simulation: (1) predicting the magnitude of energy use and (2) predicting energy savings. We present the results based on case studies of office buildings in 15 representative cities across different climate zones in the U.S. The results show that the UHI considerably modifies the urban climate measured by cooling and heating degree days. As a consequence, ignorance of the UHI effect remarkably underestimates building total energy use in hot climate zones where cooling energy use is dominant, yet causes overestimation in cold climate zones where heating energy use is prevalent. In mild climate zones, the UHI effect only has a moderate effect because the effects on cooling and heating mostly average out. When building simulation is used to assess energy savings that is measured as the ratio to the corresponding baseline such as in a comparative analysis of retrofit measures, the UHI effect is less of a factor*

* UHI causes standard weather data to be insufficient due to the higher temperatures in metropolitan areas compared to rural areas where this data is usually gathered.
* UHI has large effect on amount of cooling and heating degree days
* Consequence: total energy use far higher in hot climate zones, lower in cold climate zones
* Neglecting the UHI effect has smaller effect when comparing different retrofit measures vs the same baseline

Which has larger effect building design through integrated PV system and ventilative cooling?

* UHI
* Ventilative cooling

Will be far less effective during cooler periods of the day, since UHI causes the area to cool down a lot less than it would without heatsoak.

* PV panels

Should have very little effect on PV panel power output, the only issue is the higher temperatures causing the PV panels to have a lower efficiency, since they work best at lower temperatures.

* Climate change
* Ventilative cooling

Climate change should make temperature extremes larger, meaning more heating necessary during winters and more cooling during summers. This is however not completely sure, the slowing or stopping of the gulfstream could permanently lower temperatures in western Europe, which would require buildings to be build for heat retention and easy/efficient heating, lowering cooling requirements. Similarly there are many more potential effects of climate changes, some that are being forecast but probably many more that are unanticipated.

* PV panels

Again, very dependent on what actually happens with climate change. If it’s just an overall increase in temperature extremes the effects of extreme heat and cold on PV panels needs to be looked at.

All in all climate change is going to have a bigger impact on the effectiveness of ventilative cooling and especially PV panels, the thing is that the effects which it will have are much more difficult to anticipate and properly take into account due to the massive uncertainties involved.

UHI will have smaller effects but there are far more clear steps to take UHI into account, so looking at UHI and changing the design based on that has a much higher expected return.

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 optimised 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 optimised 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 effect 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.

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