Simulation of Cooling Strategies in Office Buildings: Load Shifting Potentials and DSM Strategies

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Overview

Cooling energy demand in buildings (residential and services sector) is expected to increase due to higher internal loads, rising comfort standards, or warmer climate [1]. Maximum cooling loads are often concentrated around the hottest hours of the day, correlating with peak electricity demand from other appliances. Thus, shifting cooling loads by demand side management (DSM) to off-peak hours is beneficial for electric utilities and reduces the strain on the electric grid. Moreover, electricity consumers can benefit from lower energy prices at off-peak [2]. The utilization of renewables such as wind or solar is limited by their variable and intermittent character [3]. Since highest photovoltaic electricity production is at noon just before cooling load peaks, DSM could also prove as a solution to compensate for the peak generation of renewables [2]. Therefore, the aim of this study is to evaluate several (pre)cooling strategies and compare them to the electrical load of conventional cooling during peak hours.

Indoor temperature and load profiles of office buildings (light and heavy mass buildings) will be simulated for different DSM strategies by means of the building simulation software IDA-ICE. Simulations for the location of Buenos Aires will demonstrate the potential of photovoltaic electricity generation to cover cooling loads and highlight DSM potentials and cooling strategies for this climate region.

Methods

Several studies looked at the cooling demand in office buildings especially in hot climate regions of European countries, the US or Asia. Usually one building type in a specific climate zone is defined and simulated over a short period of time [4],[5],[6]. However, in this study, simulations with the building simulation model IDA-ICE for different types of office buildings are conducted. Therefore, office spaces with different orientation towards the sun and different building parameters are defined and used to calculate specific cooling demand and respective load profiles. This approach first provides insight into building specific prospects (e.g. the impact of the thermal mass) to shift cooling loads. Second, it enables a comparison of the DSM potential between different strategies to meet reasonable indoor climate comfort conditions.

Results

Preliminary results show the potential to integrate large shares of photovoltaic generation and to partially shift demand to hours with a dedicated price level. Different operating strategies of cooling units are tested, always with an emphasis on the perpetuation of indoor climate comfort at predefined levels between 23°C and 26°C (see Figure 1). As can be seen, by adjusting the cooling load to the availability of photovoltaic generation, indoor temperatures rise to max. levels of 26°C during the night but temperatures are lowered during the day, when PV-generation is available. During the night or over weekends, when cooling demand is low, electricity demand is kept at a minimum to guarantee predefined temperature levels.

Especially, DSM strategies to better use solar PV or wind supply are prospective options to increase the deployment of renewables for cooling. Depending on the seasonal variation, varying cooling strategies during the year offers additional DSM potentials. Additionally, preliminary results show, that the effectiveness of the DSM strategies is highly dependent on the building type, i.e. the structure of the building which is able to buffer certain cooling needs.

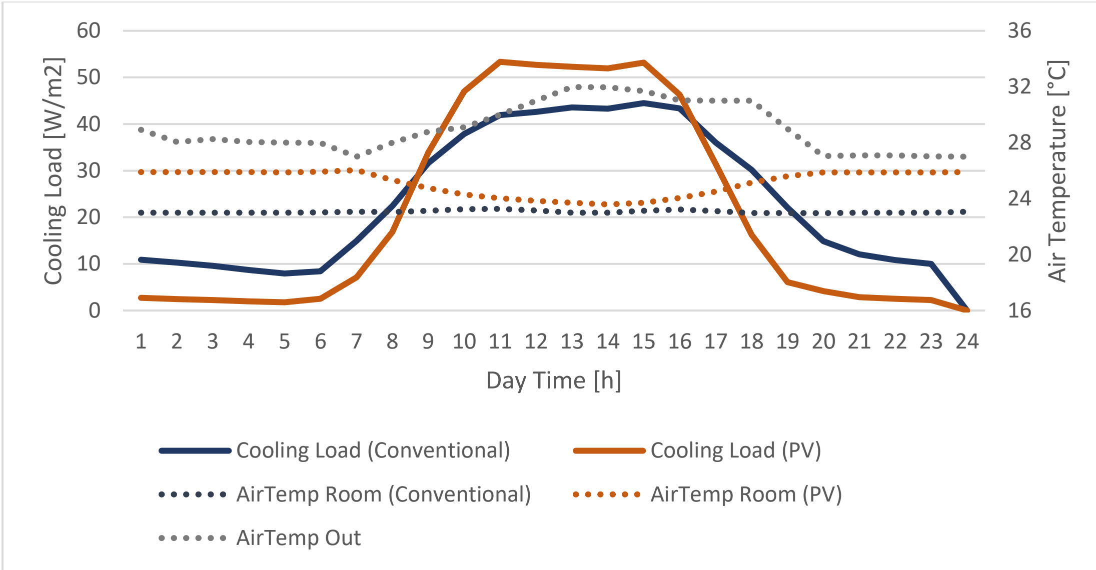

Figure 1 Exemplary cooling load and indoor / outdoor temperatures for a new office building with high shares of window glazing (light mass). Depicted is the profile for a Friday, late summer day.

Conclusions

This study will be particularly relevant due to the expected increase of cooling energy demand in buildings correlating with shortcomings of electricity generation in Argentina during summers. The results for single office building electricity load simulation as from this study can be further integrated into energy system models to assess the overall impact of cooling demand from different sectors (e.g. residential or services sector). Especially in the cooling sector, coupling of building simulation results to energy system models and the evaluation of the overall potential for DSM options are scarce.

To conclude, cooling energy demand in buildings is expected to increase due to a variety of factors. DSM is a proposed option to shift electricity loads to dedicated hours, which is beneficial for both, electricity producers and consumers. Consequently, different operating strategies should be tested in practice to appraise the DSM potential of cooling loads in services sector buildings.

References

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