Computational Assessment of the Energy Flexibility of BAM Office Building using Building Thermal Mass as Storage

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Background

Renewable energy penetration is transforming the energy market. Consumers are no more solely energy users but also energy producers ('Prosumers'). Moreover, onsite renewable energy generation is increasingly becoming an economic way for households/building owners to meet the energy needs of their dwellings considering the falling price of solar photovoltaic panels. While society strives for energy autonomy, many challenges stand in its way.

The main challenge is maintaining the stability of the grid. While earlier electricity generation was centralized and predictable, now it is not the case. A high share of renewable energy resources in the energy mix can destabilize the grid if the electricity generation is not matched with the electricity consumption. While storage can be an option to store the excess energy produced on-site or relieve the grid from the pressure of excessive demand during peak hours, it is still not a holistic solution as it cannot counteract any unpredictable rise or fall in generation or demand. It is in this context that energy flexibility is being explored as a feasible solution.

As heating and cooling loads constitute a high percentage (nearly 30-40%) of the final energy consumption, shifting of these loads can offer a major contribution to achieving this flexibility. While external storage systems like heat storage tanks can be used to store/conserve this heat, it is more interesting to analyse the storage potential of the building thermal mass as it is considered as a cost-effective solution[1] since the investment is minimal.

Problem statement

Currently, there is a lack of understanding about the amount of energy flexibility that can be provided by buildings by using their building thermal mass and about the benefits that accrue to building owners by investing in measures to exploit energy flexibility.

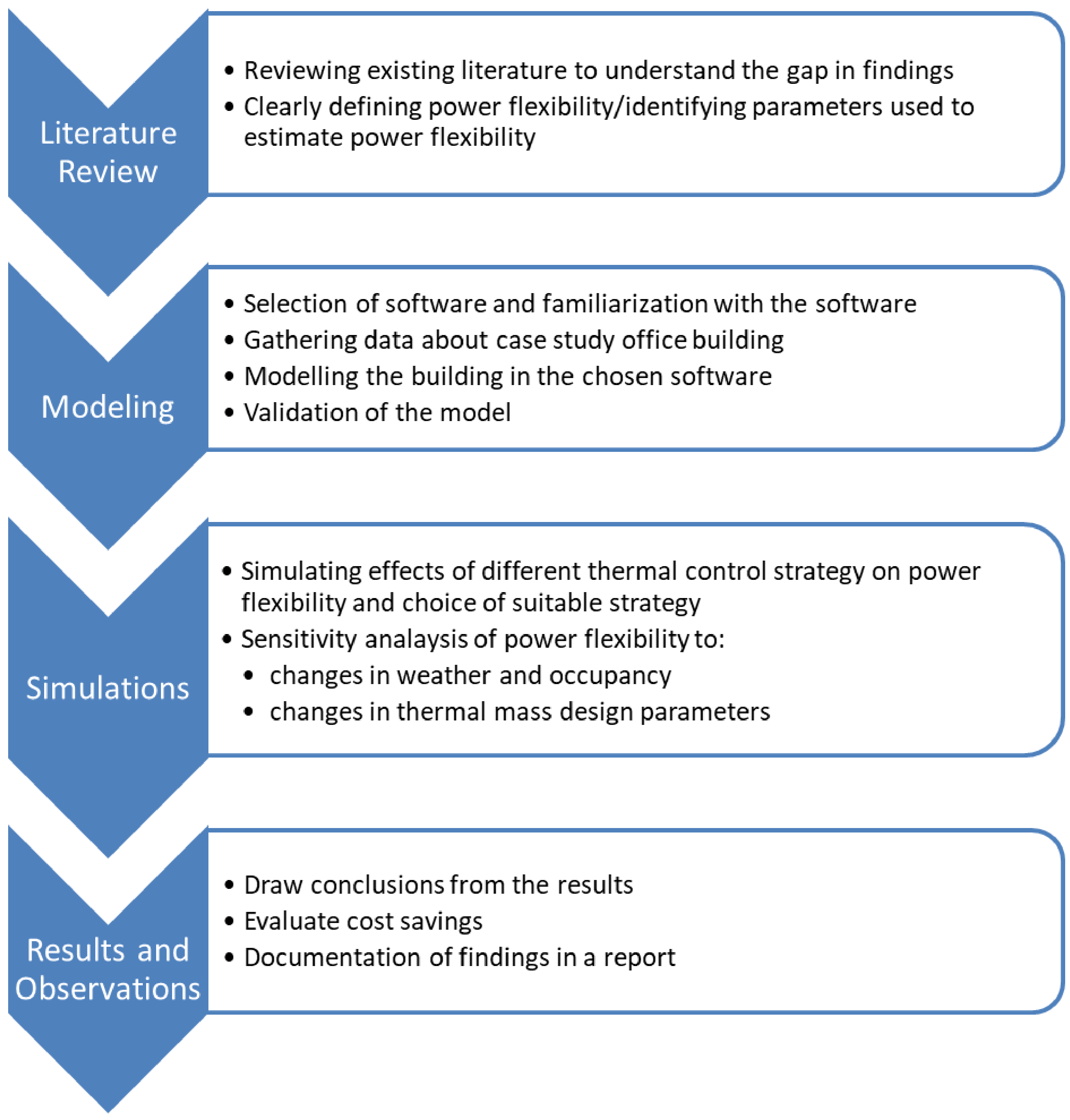
Research question

How much cost savings can BAM achieve by shifting heating and cooling loads in its office building using the building's thermal mass for heat storage/conservation while complying with the occupant thermal comfort control strategies identified in Project iCare[2]?

Sub-questions:

1. How do different aspects of control strategy like the duration of pre-heating or pre-cooling and the time of day of application of such strategy impact energy flexibility?
2. How sensitive is the energy flexibility provided by the thermal mass to weather and occupancy changes?
3. What is the effect of building design parameters like insulation and construction materials on the storage potential and energy flexibility provided by the building thermal mass?
4. How much cost savings can be derived from load shifting using the thermal mass as storage considering the following scenarios: a) Increase in self consumption and decreased reliance on the grid, b) Decrease in overall energy required for heating/cooling, c) Shifting of the heating and cooling loads to off-peak hours considering a time-of-use electricity pricing scheme or other DSM incentives from the grid operators.

Methodology



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