Development of Advanced Computational Support for Responsive Building Elements

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Introduction

Responsive building elements (RBEs) have the ability to react to transient outdoor environmental conditions and occupant comfort requirements through changes in their own shape or properties. Switchable windows, phase change materials, dynamic daylight concepts and adaptable thermal insulation systems are some of the well known examples of RBEs. Introduction of such RBEs into building design has the potential to offer reduced energy bills, lower CO_2 emissions and increased thermal comfort over conventional methods that employ static property elements. Lack of information regarding expected effects of RBEs on whole-building performance and their associated risks have been prime impediments in their adoption in real buildings.

Figure 1: A few examples of Responsive Building Elements

Aims and Objectives

The main objective of this project is to develop and test a computational performance framework that can be used to analyse the direct (e.g. energy, emissions, comfort) as well as indirect performance benefits (e.g. renewable energy integration and multivariate indoor environmental quality) of buildings with RBE systems. The application potential of this framework will be demonstrated using a series of case studies. Apart from this, in this project, concepts such as uncertainty and risk mitigation will also be analysed to explore the potential of RBEs as viable building components.

Methodology

The three main elements of this research will be simulation and optimization, probabilistic risk analysis and post-optimization analysis.

Simulation and optimization	• Development of co-simulation for integrated daylight and thermal performance of RBE • Integration of simulation with dynamic optimization algorithms
Probabilistic risk analysis	• Sensitivity analysis and uncertainty propagation based on occupant influence and weather conditions will be used to investigate if RBEs lead to robust buildings
Post-optimization analysis	• Mapping between design and performance aspects will be done using data mining and advanced data visualization techniques

This project will use different case studies to cover the broad range of physical adaptation mechanisms (thermal, visual, photovoltaics and air flow), various renewable energy integration opportunities and development states (low, medium and high TRL).

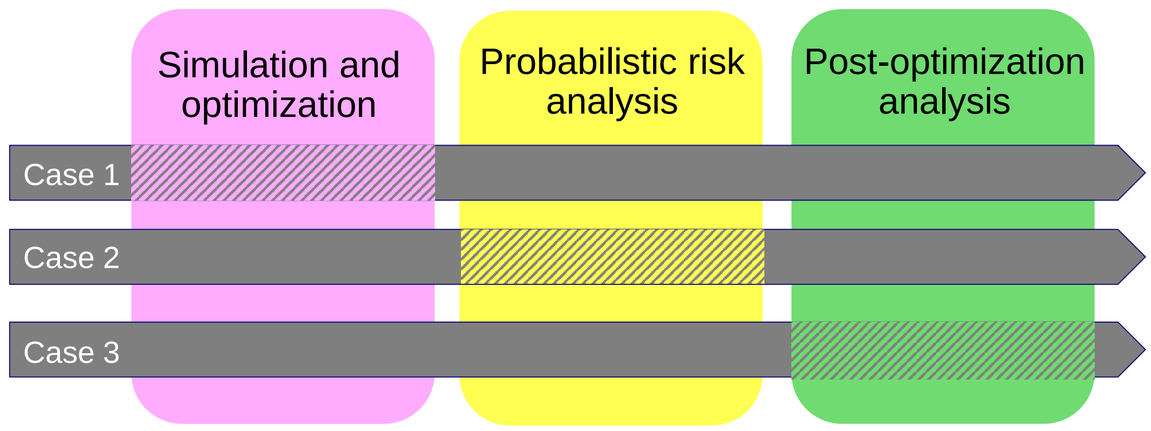

Figure 2: Overview of the research methodology. Each of the case studies will deal with the three elements, but each of them puts special emphasis on one of the topics.

Expected Results

- Material scientists and product developers will be able to use simulation-based feedback to drive research and development process of their innovative project.
- Façade designers will be able to make better informed decisions about the potential of RBE systems. The uncertainty based approach will enable them to communicate with building owners the risk vs opportunity of these systems.