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Development of advanced multifunctional façade systems: Thermo-acoustic modelling and performance

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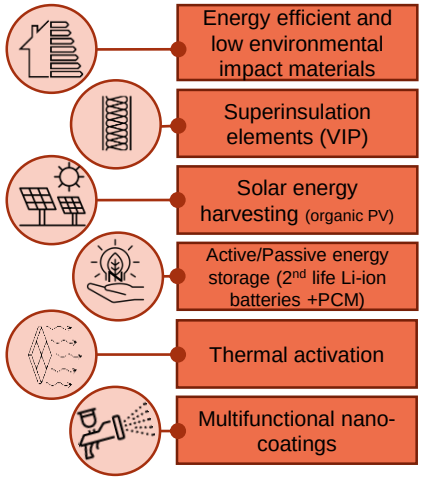
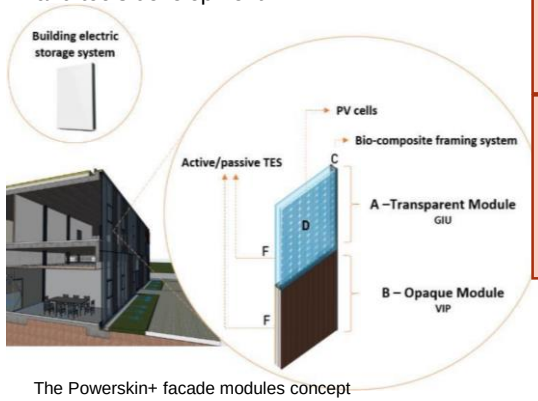
Abstract
The development of lightweight and multifunctional curtain wall systems, which integrate different technological solutions, is aimed at achieving increasingly higher requirements related to energy efficiency as well as indoor environmental quality in non-residential buildings. On one hand lightweight and thin façade elements present several advantages (such as construction time, space, and transportation savings, less weight on primary structure etc.), while facing the challenge of guaranteeing the required thermal and acoustic performance and achieving legislative compliance on the other. In the framework of the Horizon 2020 Project Powerskin+ (PS+) a new concept of multifunctional façade, which combines high performance insulation, energy harvesting, heating system, and latent heat storage capabilities is under development. Within the design process of the different sub-modules (opaque and transparent), performance calculations are carried out by means of existing simulation tools, or ad-hoc developed models for more complex systems. In this study, the authors present the main steps required to accelerate the simulation-based design process and the future thermal and acoustic optimization of the novel lightweight and multifunctional façade element.

Introduction
In the framework of the EU H2020 POWERSKIN PLUS project, the development of an advanced façade system, which can integrate different technological solutions, aims to achieve increasingly higher requirements related to energy efficiency and indoor environmental quality in non-residential buildings. An extensive simulation campaign had to be carried out, assisting in developing a new concept of opaque and transparent façade modules that combine several high technological solutions.



The different solutions integrated in the PS+ facade module

The development of complex façade systems embedding several technologies required a holistic approach hereafter presented. The three main working steps are summarized:
1.Collection of material properties
2.Framework on commercially available tools
3.Preliminary simulations, methodologies and tools development



The Powerskin+ facade modules concept

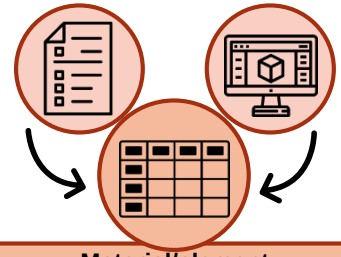
Collection of material properties
A common information dataset about materials type and properties represent an essential tool to facilitate the comparability and the reliability of the results collected. A database was created to quickly select the properties of each material that will be potentially implemented in the façade modules.

Framework on commercially available tools
The module configuration are constituted by different materials and components each characterized by own features, the identification of the most suitable simulation tool could represent a complex task. To simplify this process, a summary table which collects all the commercially available simulation software for thermal/energy and acoustic performance simulation was created. The main information reported are showed below.

Scale	Subcategory	Scope
Component	Time-domain, spatial domain, Calculation method, Envelope type acoustic simulation, co-simulation capabilities.	Heat stress, Thermal bridging, Heat balance, Mass transport, Optical properties, component acoustic
Whole building		Heating/cooling demand, Heating/cooling load, Indoor thermal comfort index, Natural lighting, Indoor Air quality, Façade acoustic

The tools database structure

Preliminary simulations, methodologies and tools development
The information collected from the previous steps were merged in a final matrix, an instrument created to identify the suitable tools or ad hoc methodology accordingly to the specific simulation purposes. The main structure was classified into 3 main scale, and for each one a set of different information were eported as showed below.



Material/element Component Whole building
PS+ target values, Additional target values, Evaluated KPI, Risk, How to, suitable software

The final matrix structure

Conclusion
The preliminary steps to approach the simulation activities needed for the development of the PS+ advanced façade modules are presented. The Material Database has facilitated and harmonized the input data selection to be used in the ongoing simulation activities. The material database is intended to be continuously implemented. The framework on commercial tools was used to select the most suitable software to perform thermal and acoustic simulation. The preliminary simulation, methodologies and tool development have provided useful support for the start-up of the façade module simulation and development.

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