ADAPTIWALL

Multi-functional light-weight wall panel based on ADAPTIVE Insulation and nanomaterials for energy efficient buildings

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PARADIGM SHIFT TOWARDS CLIMATE ADAPTIVE BUILDINGS

Achieving EU's energy-efficiency targets (2050 goals) depends on the right measures to retrofit the existing building stock, which is dominated by residential buildings. Approximately 85% of the existing dwellings were built before 1990 with poor façade and roof insulation. Current retrofitting solutions focus on airtight (thick) insulated envelopes, needing auxiliary heating, ventilation and cooling (HVAC) systems to compensate for shortcomings of airtightness and high insulation (poor indoor air quality and over-heating). Also, by fully disconnecting outdoor from indoor, potential energy savings by using outdoor thermal energy for indoor heating/cooling are lost. Therefore, a paradigm shift is needed from a rigid insulated envelope to a fully responsive, climate adaptive envelope in order to drastically reduce auxiliary systems and as such accelerate installation and create extra energy savings with respect to current retrofitting solutions.

ADAPTIWALL BREAKTHROUGH

The ambition of the ADAPTIWALL project is to reduce heating and cooling demands by more than 50% compared to current retrofitting solutions. To reach this ambition, the chosen principle is to use an adaptive insulation to regulate incoming heat or cold and to temporarily store this outdoor heat (or cold) in a lightweight concrete buffer until it is needed indoor for heating or cooling purpose. Furthermore, a drastic reduction in auxiliary heat recovery and ventilation installations is foreseen by including a total heat exchanger system within the wall. By integrating these three components (adaptive insulation, lightweight concrete buffer and total heat exchanger), the result of this project will be a climate adaptive, multi-functional lightweight prefab panel suitable for rapid, cost-efficient and energy efficient retrofitting of façades, with a reduced envelope thickness of 30% and reduced weight of 50%.

ADAPTIWALL PROJECT APPROACH

In order to reach the above ambition, ADAPTIWALL has chosen a combined approach of material development (adaptive insulation, lightweight concrete buffer and total heat exchanger), integrated panel design and building energy simulations. While the panel in itself is adaptive, also the design and switching protocol will be adapted to regional climate conditions and local building practice so that ADAPTIWALL facades can be built throughout Europe. Material development, panel design will mainly take place in the first half of the project, while panel prototype testing and an ADAPTIWALL façade demonstrator will take place in the second half of the project.

ADAPTIWALL CONSORTIUM

Because ADAPTIWALL integrates several functions and materials, different European players from the chain are gathered in the consortium: one large construction company (Acciona [ES]), one specialized prefab façade construction company (Fasada [PL]), three material component manufacturers (Sioen (insulation) [BE], Isodal (prefab concrete) [BE], Prochimir (membrane heat exchanger) [FR], one consultant engineer for prefab industry (Snijders [NL]) and two research organizations (TNO [NL], CEA [FR]). TNO is coordinator of the project.

Siska Valcke and Wietske van Kanten [TNO]

Demonstration

The demonstration will take place on two PASSYS test cells situated at the CEA-INES experimental platform at Le Bourget du Lac in France. The original facades of the test cells have a very high insulation level and are quasi adiabatic. On the removable test façade the ADAPTIWALL panel(s) will be mounted with a test area of 3.3 x 3.6 m^2. The two test cells are next to each other, south oriented and are subject of outside weather conditions, while they have hydrothermal control on the inside.

INCAS experimental platform (CEA-INES)

ADAPTIWALL PROGRESS

Lightweight concrete buffer

Within the ADAPTIWALL façade panel, the core component will be lightweight and based on concrete. This component will support the whole façade system, and act as a thermal reservoir (buffer) for storing or releasing heat/cold coming from indoor/outdoor, which will be regulated by the surrounding adaptive insulation.

The currently proposed and investigated technology to achieve a lightweight thermal buffer is based on increasing the ability to store heat (thermal inertia) of lightweight concrete, such that thermal properties of a normal to high density concrete are reached. For this, "phase change materials" are being incorporated into the hollow structure of lightweight aggregates, such that latent heat can be stored or released following temperature gradients within the buffer. The phase change materials are fixed within the lightweight aggregate by modified vacuum impregnation technology and stabilizing the aggregate by thermal treatments. Furthermore, the cement based binder is being adjusted for optimal heat exchange to and from the lightweight aggregates.

Araceli Galvez Moreno [Acciona Infrastructures]

Adaptive insulation

Material development for the adaptive insulation component focusses on enabling switchable thermal properties of the insulation, including a state-of-the-art regulation system linked to an integrated sensor and monitoring system. Following a climate related protocol, heat transfer will be allowed or not through the adaptive system. Within the ADAPTIWALL panel two separate adaptive insulation systems will be integrated that regulate heat transfer between the adjacent parts: one system will be placed between the cladding and the lightweight loadbearing buffer (e.g. high thermal conduction on a sunny winter day to guide thermal energy into the buffer), and one between the buffer and the indoor interior.

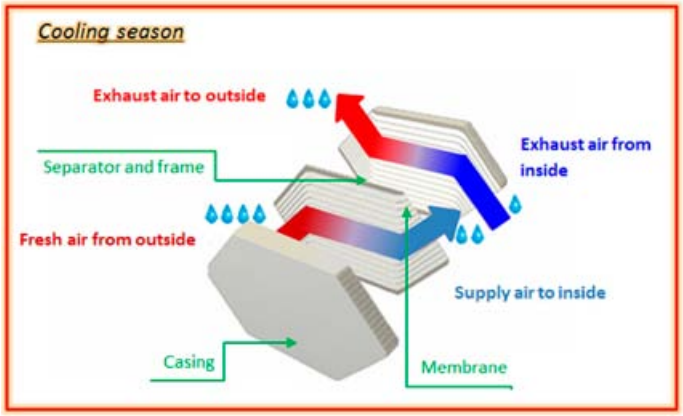
During the first two years of the project, several adaptive insulation concepts are studied, held against application requirements (e.g. lifetime, thickness and weight limitations, ease to assemble and installation, cost, etc.) and are being simulated in terms of their contribution to energy reduction. For the chosen concept, the most appropriate materials are being selected and tested on the component level in a hotbox system.

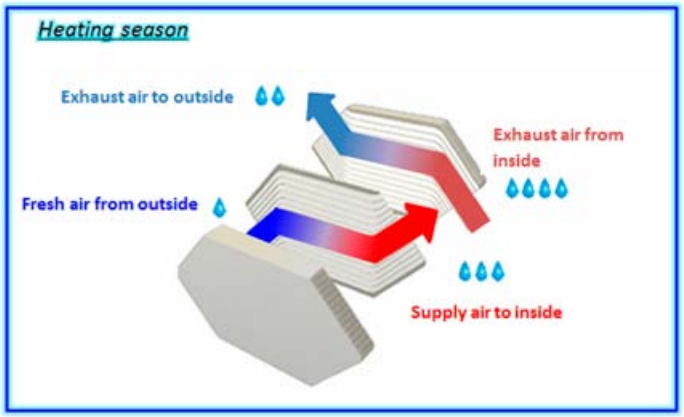
Bert Groenendaal [Sioen Industries NV]

Total Heat Exchanger

The total heat exchanger component (THEX) allows energy recovery from exhaust air into fresh air. Thanks to an optimized breathable membrane, (permeable to moisture but liquid water- and air- tight), a THEX is more efficient than traditional recovery systems as it transfers both sensible and latent energy. Furthermore, thermal comfort in the building is directly targeted in terms of temperature and hygrometry. Global system modeling is performed for estimating energy gains by the THEX, for different climate types and ADAPTIWALL configurations. At component level, optimal design and manufacturing of the THEX and its membrane (including post-treatment) are being investigated using a theoretical modeling as well as experimental approach. A functional prototype will be manufactured and integrated in the ADAPTIWALL panel.

Mathieu Mariotto [CEA/LITEN-Building and Thermal Systems].





Stacking of Membranes and Separators + Distributor and Casing

Simulation and design integrated ADAPTIWALL panel

The potential of the integrated ADAPTIWALL panel is being investigated by performing simulations in TRNSYS software. The first simulations have been performed using a one-room model in a Dutch climate. This provides boundary conditions and minimally required material properties for the development of the different materials and components by the partners in the project. In turn, the partners

provide properties of possible (beyond) state of the art materials that can be used in ADAPTIWALL simulations. The simulations performed thus far have demonstrated the potential of ADAPTIWALL to cut energy demand significantly (>50%) by effectively storing solar heat. The simulations have shown that ADAPTIWALL can outperforms static insulation of the same thickness in terms of energy performance. The next steps consist of optimizing ADAPTIWALL and its control strategy, scaling up to a full building model and integrating the different components.

Tim Dijkmans [TNO]

Summary progress and planning

Two general assemblies with the full consortium have taken place, one in Delft (NL) at TNO and one in Chambéry (FR) at CEA, where the PASSYScells were visited and progress was discussed with an internal advisory board.
The ADAPTIWALL project is now in its ninth month and first simulations have confirmed the promising potential of the ADAPTIWALL approach. First materials have been selected and are being optimized. Their properties are being fed back into the simulations so that more accurate estimations of energy consumption reduction can be made. In the coming six months, final decisions on materials and component design will be made so that the separate components can be tested by the end of 2014 after which integrated panel prototypes can be assembled to be tested in the lab in 2015.

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PROJECT INFORMATION

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PROJECT PARTNERS

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