LAYMAN'S REPORT

CONIPHER

CONcrete Insulating PHotovoltaic Envelope for deep Retrofitting

www.life-conipher.eu

LIFE14/CCM/FR/000954

THE PROJECT IN A WORD

The LIFE CONIPHER project successfully developed an innovative "plug-and-play" insulation photovoltaic envelope for deep building retrofitting. This innovative system, designed by VICAT and partners, offers a comprehensive solution for enhancing energy efficiency, reducing greenhouse gas emissions and increasing renewable energy production.

The CONIPHER panel, which combines photovoltaic modules, concrete façade, insulation, and connections, provides a rapid and efficient retrofitting process. A pilot project in France showcased its technical feasibility and environmental benefits, demonstrating its adaptability to a wide range of buildings. While final savings were slightly lower than anticipated, the module's ability to reduce energy consumption and carbon footprint is significant.

The project's innovative design, featuring a modular and easy-to-install system, contributes to its potential for widespread adoption. Additionally, the CONIPHER envelope's ability to optimize energy use, especially during hot seasons, addresses the challenges posed by climate change and improves overall sustainability.

Despite facing technical delays and the impact of the COVID-19 pandemic, the LIFE CONIPHER project successfully achieved its objectives and completed all foreseen tasks. The consortium, consisting of VICAT, ARAYMOND, and CEA, played a crucial role in the project's success.

The LIFE CONIPHER project has paved the way for more sustainable and efficient deep building renovations. The CONIPHER module represents a promising solution for addressing climate change and improving energy performance in existing buildings.

THE PROJECT PARTNERS

COORDINATING BENEFICIARY

Vicat, at the origin of the invention of artificial cement more than 200 years ago, is a leading industrial player in the field of mineral and bio-sourced construction materials. Committed to a carbon neutrality trajectory across its value chain by 2050, the family business (listed on the stock exchange) today operates 3 main businesses: Cement, Ready-Mixed Concrete (BPE) and Aggregates, as well as activities complementary to these basic professions. The cement group employs 9,900 people and achieved a consolidated turnover of 3.642 billion euros in 2022. Present in 12 countries – France, Switzerland, Italy, United States, Turkey, Egypt, Senegal, Mali, Mauritania, Kazakhstan, India and Brazil – Vicat generates more than 60% of its turnover internationally.

ASSOCIATED BENEFICIARIES

With more than 8 000 employees in 25 countries around the world, the ARaymond Network designs, manufactures and markets assembly and fastening systems. Founded in 1865, this family business based in Grenoble, France, and the inventor of the press stud, has always put human values at the heart of its success. ARaymond, is based on the conviction that the well-being and empowerment of its collaborators are essential to its continued success. Guided by innovation and sustainable value creation, the ARaymond Network is today one of the global leaders in fastening and assembly solutions. Initially focused on serving the automotive market, it now also serves the energy, agriculture, healthcare and construction markets.

A major player in research, development and innovation, the CEA is active in major sectors such as defense and national security, nuclear and renewable energies, biotechnological and medical research, and technological research for industry. Since 2005, the CEA has been leading the research, development and innovation activities of INES, the French National Institute for Solar Energy, where it concentrates its activities related to solar energy and the management of energy networks and systems. It is also the holder of the Institute for Energy Transition INES.2S.

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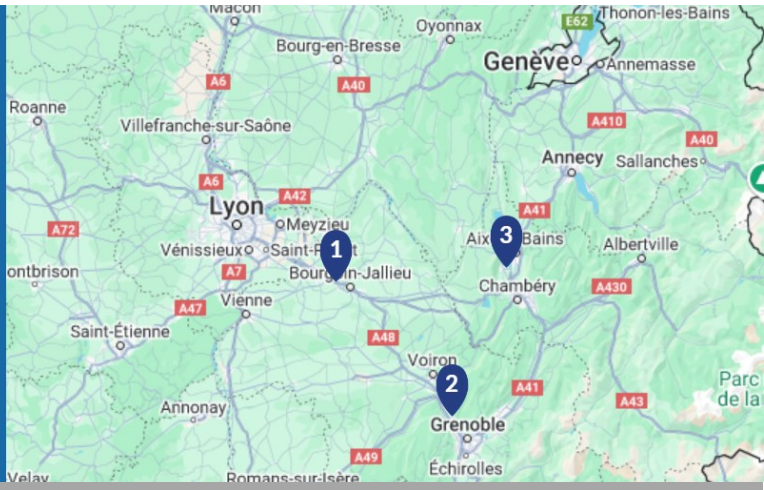
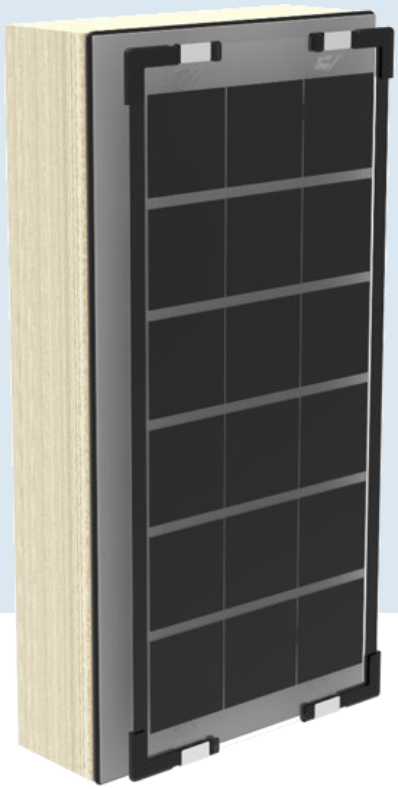


THE PROJECT MAIN OBJECTIVES AND RESULTS

FAST INSTALLATION	Design a durable cladding panel for an easy and quick deep renovation, including solar panels, concrete façade, insulation and connections (mechanical and electrical) and prove the ease of installation of the CONIPHER deep renovation panel: only one or two trades and 50% less time for installation.	A 38% installation time has been measured, but identified, simple and realistic improvements could allow the system to reach a 80% installation time reduction.
HIGH THERMAL PERFORMANCES	Prove the technical feasibility and environmental benefits of the CONIPHER envelope on a renovated and occupied collective building showing a 60% reduction in primary energy consumption and 75% in greenhouse gas (GHG) emissions, thanks to a high thermal resistivity (R=5 m².K/W).	A reduction in primary energy consumption of 68% and in GHG emission of 71% was measured, thanks to a thermal resistivity of 4.5 m2.K/W.
DURABLE MATERIALS	Select materials whose high performances are maintained over time thanks to their intrinsic qualities (incombustibility, low porosity, stainless steel, impact resistance) and their integration (protection against bad weather and heat), thus ensuring a longer lifespan.	The lifespan of the fasteners is determined by that of the insulation because they are integrated into the latter, itself determined by the lifespan of the concrete facing, of over 100 years.
FIRE RESISTANCE	Design a fire-resistant panel thanks to the choice of non-combustible materials and long-lasting integration in the event of a fire.	Rock wool insulation and concrete facing are non-combustible. The sensitive part of the fixing is protected by a large thickness of insulation, ensuring excellent fire resistance to the system.
INDUSTRIALIZED SOLUTION	Define an economical and easy prefabrication process for qualitative industrial manufacturing of CONIPHER panels, and enable obtaining an energy performance of the envelope corresponding to forecasts (less than 7% difference) thanks to a reduction in human errors during of the installation.	An easy and economical prefabrication process has been set up for the demonstration, and is ready for replication.10% difference with forecast have been explained and solutions found.
RENEWABLE ENERGY PRODUCTION	Ensure the production of renewable electricity through intelligent integration of photovoltaic panels on the east, west and south facades, ensuring a return on investment (ROI) of less than 10 years and self-consumption of electricity of 60% over one year (compared to 30% on average for typical PV solar panel installations).	PV integration on south façades of the demonstrator was not possible, yielding a ROI of 11 years. If so, a ROI of 5 years is expected thanks to a 76% of self-consumption.
RECYCLABLE COMPONENTS	Adopt a life cycle approach including easy upgrade of technology and recyclability of components in existing industries thanks to its modular and prefabricated approach: 85% of the mass of components must be recyclable and waste on site must not not exceed 5% by mass.	100% of the components are separable and recyclable in existing recycling sectors. Uncorrectly managed demonstrator wastes reached 9% but should be reduced to 1% in future.
MODULABLE FACADE	Ensuring applicability to a wide range of buildings across Europe with a multi-support, independent anchoring system, streamlined dimensions, and versatile aesthetics and functionalization.	CONIPHER system can be accomodated on solid or hollow brick and concrete supports. Insulation and facing can be easily modified. Fixations foster 5 functionalisation types on demo site.

THE SYSTEM CONCEPTION

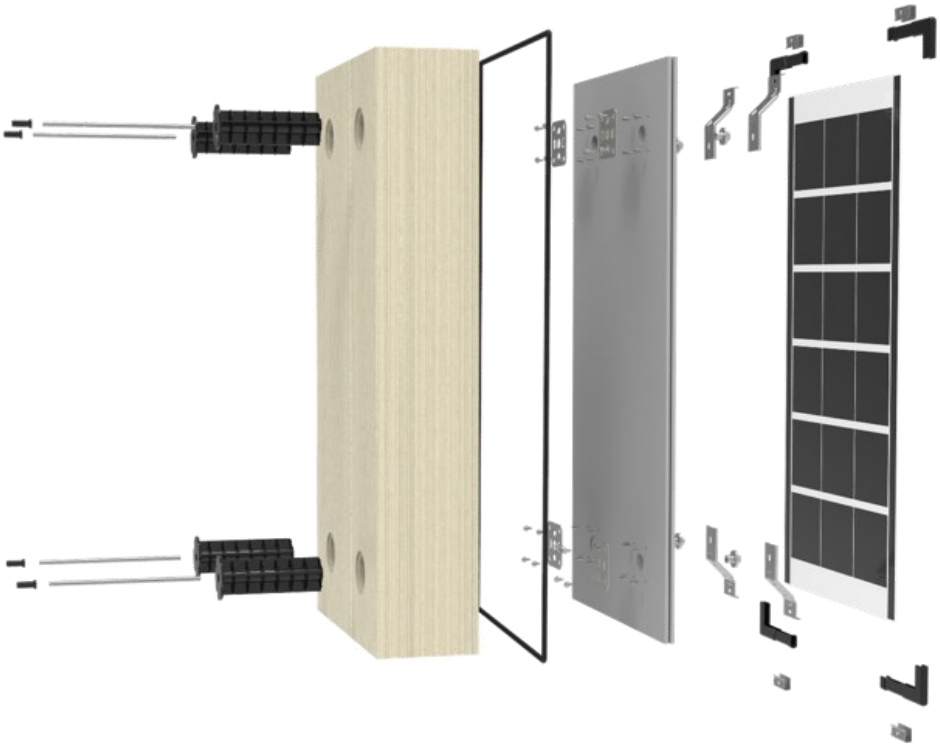
The development of the CONIPHER system involved an in-depth study of 4 concepts, leading to the creation of 12 designs and 3 prototypes. The standardization of dimensions, the simplification of components, and the optimization of manufacturing and installation processes enabled the development of an innovative system, offering high thermal performance and exceptional durability, while remaining competitive in the market.



The CONIPHER panel is composed of:

- an ultra-high performance Smart-UP fiber-reinforced concrete plate, with a lifespan of over 100 years
- a 200mm EcoRock Duo rock wool insulation block (Rockwool) ensuring thermal resistance to the system of 5 m2.K/W
- a ventilated bifacial photovoltaic panel allowing an increase in electricity production by 22%
- a fixing system to meet the mechanical requirements defined by certifications entities (earthquakes, shocks, wind), thermal (reduction of thermal bridges) and the objectives of rapid installation of the various components during the factory assembly phases and fixing on site

EXPLODED VIEW



THE PROOF-OF-CONCEPT

The installation of 8 CONIPHER panels (6 m2) on an instrumented facade on the CEA INES FACT tool made it possible to validate the manufacturing, integration and installation concepts. Thermal monitoring showed a 92% reduction in heating thanks to a thermal resistance of the façade close to 5 m2.K/W. Electrical monitoring showed higher winter and intermediate season production than the integration of photovoltaic panels on the roof, and a 22% gain in output thanks to bifacial technology.

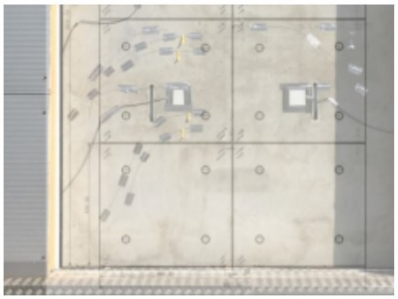
Manufacturing of UHPC facing

Preparing the insulation

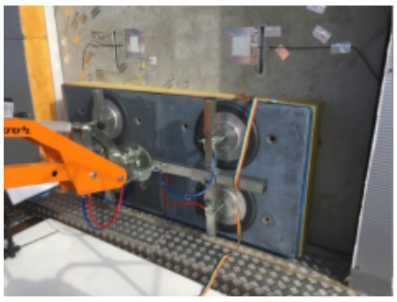
Assembling the components

Panel storage

Installation of concrete walls



Preparation of the facade (positioning of sensors according to the layout)



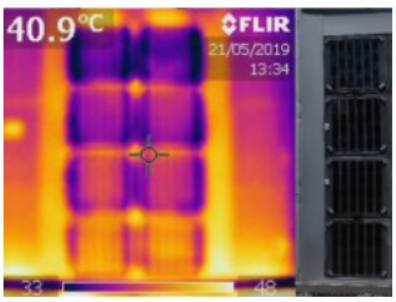
Lifting the panels

Drilling of the support

Fixing the panels

Installation of PV modules

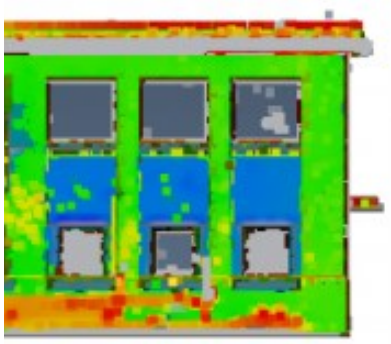
Wiring and finalization of the facade

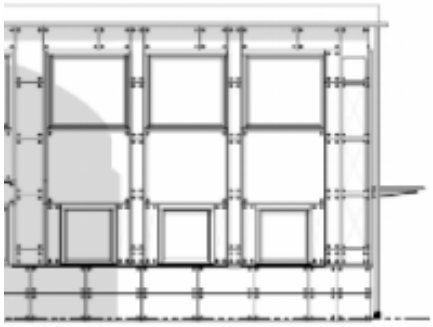


System energy monitoring

THE SYSTEM DEMONSTRATION

The CONIPHER demonstrator was installed on the northeastern wing of the Vicat cement factory administrative building in Montalieu-Vercieu, a sensitive building in a heavy industrial site, with particularly demanding characteristics: 24/7 occupancy, a busy production environment, high safety requirements, complex architectural detailing and non-optimal orientation. These challenges were successfully overcome by Workspaces-A architecture agency, which selected and coordinated specialized companies capable of adapting to the specific requirements of the project and the demands of an innovative system like CONIPHER.





The successful realisation of the CONIPHER demonstrator involved several key steps:

- **3D Laser Scanning:** A laser survey captured detailed dimensions and shapes of the building, enabling accurate planning and production of prefabricated elements.
- **Building Layout:** Careful planning optimized the arrangement of construction elements, minimizing material waste and ensuring aesthetic harmony.
- **Facade Preparation:** The northeastern wing of the building underwent extensive preparation, including removal of organic coatings, treatment of the base and parapet, and installation of metal profiles.
- **CONIPHER Panel Installation:** The panels were installed in July 2023, with an installation rate of 20m²/day. Training, optimized lifting tools, and drilling techniques could further improve efficiency.
- **Photovoltaic Panel Installation:** ARaymond's innovative fixing system enabled rapid installation of the photovoltaic panels, with 24 panels installed in a single day.

The Vicat cement plant in Montalieu-Vercieu

The Vicat cement plant in Montalieu-Vercieu, located in France, was built in 1922 and has benefited from significant investments to increase its production capacity, optimize its cost price, reduce emissions and improve safety. The cement plant has also implemented several innovative projects to reduce its carbon footprint, notably the Meteor project which aims to increase the proportion of alternative fuels to fossil fuels. By 2030, the objective is to use 100% alternative fuels.

ENVIRONMENTAL BENEFITS

WASTE GENERATION

The CONIPHER system, comprising pre-assembled insulation and cladding panels, offers a more sustainable alternative to traditional deep renovation methods. Unlike lightweight materials like expanded polyurethane and aluminum composites, which are often non-recyclable, CONIPHER uses durable, mechanically assembled materials that are easily recyclable. This factory-based assembly process allows for better control and optimization of waste quantities, minimizing unsorted waste on renovation sites.

During the prototype installation, waste generation was closely monitored. While initial measurements showed a higher-than-target waste quantity, this was partially attributed to factors like rain collection and the deconstruction of the roof and cap. With improvements in layout and handling methods, waste generation is expected to be significantly reduced, especially during larger-scale renovations.

Key waste reduction strategies include:

- **Preventing rock wool waste:** Custom cutting in the factory reduces offcuts, minimizing waste.
- **Reusing extra panels:** Proper planning and storage will limit the need for additional panels, reducing waste. Unused panels can be used for other projects.
- **Recycling broken or removed panels:** The components of CONIPHER panels are easily dismantled and recyclable, ensuring efficient treatment and recovery of deconstruction waste.

ENERGY

The CONIPHER system demonstrated significant energy efficiency improvements in a controlled environment at the FACT tool. Key findings include:

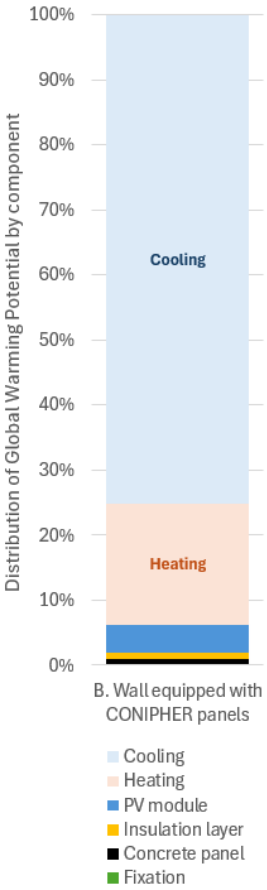
- **Enhanced thermal insulation:** The system achieved a measured thermal resistance of 4.5 m²K/W, close to the calculated value, indicating excellent insulation properties.
- **Reduced energy consumption:** The system reduced primary energy consumption by 68%, significantly exceeding the initial target of 60%.
- **Increased electrical production:** Bifacial cell technology contributed to a 22% increase in electrical production compared to standard cells. Vertical installation of photovoltaic modules on the façade is complementary to roof-mounted systems due to higher winter and intermediate season production
- **Optimized self-consumption:** The system achieved 76% self-consumption, exceeding the target of 60% and further reducing primary energy consumption.

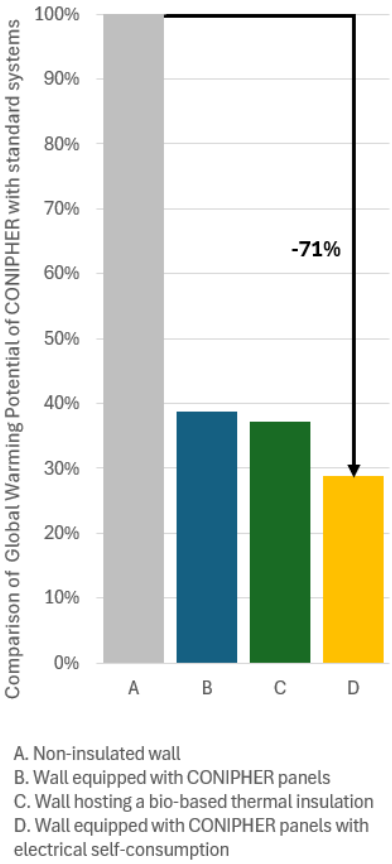
GREENHOUSE GAS EMISSION

A life cycle analysis revealed that the CONIPHER system significantly reduces greenhouse gas emissions compared to traditional renovation methods. Key findings include:

- **Reduced emissions:** The system reduced greenhouse gas emissions by 71%, primarily due to reduced energy consumption from heating and cooling.
- **Sustainable materials:** The use of recyclable materials and efficient manufacturing processes contributed to the overall environmental benefits.
- **Self-consumption benefits:** The high self-consumption rate further decreased emissions by reducing consumption of grid-supplied electricity for highly impacting cooling.

Overall, the LIFE CONIPHER project successfully demonstrated the potential of its innovative insulation photovoltaic envelope to drive sustainable and efficient deep renovations. The system's environmental benefits, including reduced waste generation, enhanced energy efficiency, and decreased greenhouse gas emissions, make it a promising solution for addressing climate change and improving building performance.





SOCIO-ECONOMIC BENEFITS

COST ANALYSIS

The CONIPHER system offers a competitive cost solution within the market for deep renovations. While initial costs may exceed conventional systems, long-term savings and benefits can justify the investment.

A technical-economic study, based on the demonstrator, indicated a higher-than-market production and installation cost. However, factors like project scale and maturity explain this discrepancy. Simple and realistic optimizations will reduce costs, but still 10% higher than conventional solutions using similar materials.

Despite this, the short payback period of photovoltaics (less than 10 years) significantly reduces the overall cost. In a building with 30% south-facing photovoltaic coverage, the payback period is 5 years, generating profits for 20 years. This reduces the effective installation cost to a level aligned with the market sweet spot.

While CONIPHER offers equivalent thermal performance but is more durable and qualitative, its higher initial cost may pose a challenge for certain market segments. However, the long-term benefits and positive image associated with photovoltaics can be appealing to social housing landlords and large companies seeking sustainable solutions.

LONG-TERM SAVINGS

Beyond photovoltaic income, long-term savings include reduced energy bills and maintenance costs. The prefabricated nature of CONIPHER ensures quality control and limits installation errors, leading to more efficient insulation and reduced energy consumption.

The system's durability, thanks to high-performance materials and innovative fasteners, minimizes maintenance needs and extends its lifespan. This reduces the need for frequent repairs or replacements, resulting in significant cost savings over time.

JOB CREATION

The CONIPHER system has the potential to create jobs and stimulate the local economy. While the demonstrator project involved a small number of temporary workers, future projects will benefit from the system's ease of assembly and installation.

The system can be installed by unskilled workers with minimal training, making it accessible to a wider workforce. Off-site construction also offers better working conditions and can reduce installation time, further enhancing its economic benefits.

Some of the the next related project explore the possibility of robotic installation, potentially directing workers towards more skilled and higher-paying roles, contributing to the long-term sustainability of the thermal retrofitting industry.

SOCIAL BENEFITS

The thermal renovation of the Montalieu cement plant's administrative building significantly enhanced occupant comfort, particularly in terms of acoustics. Multiple occupants reported improved noise reduction, which is especially valuable in a factory environment. This is particularly beneficial for employees in areas requiring concentration and reflection, such as the laboratory and the control room hosted in the demonstrator.

While thermal comfort improvements were not very sensed in a regulated industrial environment, this is less likely to be an issue in residential settings, especially poorly heated or air-conditioned social housing. The CONIPHER system's excellent insulation can significantly improve winter and summer comfort for social housing residents.

SAFETY AND FIRE RESISTANCE

The CONIPHER system offers enhanced safety and fire resistance. Its incombustible components and high potential fire resistance make it an ideal choice for buildings with photovoltaic installations. This is especially crucial in light of the Grenfell Tower disaster, which highlighted the serious safety risks associated with unsuitable construction materials. The CONIPHER system's design incorporates safety measures that can help prevent such tragedies.

2017 Grenfell tower fire in London

INNOVATION & MARKET ACCEPTANCE

INNOVATION AND DEMONSTRATION VALUE

The CONIPHER system introduced several innovative features, demonstrated through prototypes on FACT and the Montalieu cement plant's administrative building.

- **Bifacial Photovoltaic Cells:** The use of bifacial cells increased electricity production by 22% by capturing light from both sides of the module. This was enhanced by integrating an air gap between the concrete facing and module, improving cooling and sunlight reflection.
- **Vertical PV Integration:** Installing modules vertically increased production during winter and intermediate seasons when sunlight is lower, complementing summer-efficient roof-mounted panels. This also maximizes module installation on buildings with limited roof space.
- **Functionalizable Facade:** The system allows for the integration of additional functions like demo awnings, communication panels, mechanical ventilation extraction, and rainwater downpipes without affecting insulation.
- **Modular Design:** The modular nature of the CONIPHER system enables easy panel removal and replacement, facilitating maintenance and future modifications.
- **Speed and Ease of Installation:** The system's modular design and innovative fixing system significantly reduce installation time, making it suitable for time-sensitive projects and reducing labor costs.
- **Off-Site Manufacturing:** The system's prefabricated components offer quality control, reduced waste, and shorter construction times.
- **Durability and Sustainability:** The system's high-quality materials and construction ensure long-term durability, reducing maintenance costs and improving sustainability.

REPLICABILITY AND TRANSFERABILITY

To minimize costs, the CONIPHER system was designed with efficient manufacturing processes and material usage. The system's components are designed for easy replication, with the exception of the concrete slab, which may require local manufacturing due to its weight.

Dissemination efforts have generated interest and created links with potential partners, including major players in the construction industry. However, several barriers may hinder direct replication:

- **Design Adjustments:** Ensuring a perfect seal between the cladding and the building may require design modifications.
- **Initial Cost:** The higher initial cost compared to conventional systems may limit market penetration.
- **Aesthetics:** The concrete cladding and visible fixings may not be aesthetically appealing to all customers.
- **Installation Constraints:** The system requires a flat support surface, which may not be available in all buildings.

To address these challenges, future projects, such as ADEME funded ByWall-C project, will benefit from the lessons learned from CONIPHER. The system's alignment with the Energiesprong approach will enhance market acceptance and simplify certification processes.

By addressing these barriers, the CONIPHER system will contribute to a wider adoption of sustainable and efficient deep renovation solutions.

CONIPHER descendant prototype installation by ARaymond in the frame of ADEME funded ByWall-C project