Rethinking the Building Envelope as an Intelligent Community Hub for Renewable Energy Sharing

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Abstract The widespread use of electric vehicles is hampered by the lack of an adequate charging points network. Likewise, and depending on the use, there could be a lack of correspondence between energy use and production in buildings equipped with renewable energy production systems. For these reasons, a modular device, which could be fully integrated into the building envelope, has been developed. The aim of the project was both to regenerate the existing building envelope and to enhance the newest one, adding new functions. The main goal will be the support of the growth of an electric power-sharing attitude capable of promoting the widespread use of electric vehicles of electric vehicle (EV), supporting strategic actions to retrofit/convert a private building in shared spaces for EV mobility, ensuring enough coverage for charging devices and reducing costs for public administration.

Keywords Building envelope · EV · Sharing BiPV · Ventilated façade · Electric mobility

1 Introduction

The building sector, currently recovering from a recession that has affected it in recent years, is in the need to enter overwhelmingly into the circular and digital transformation. The development of interconnected buildings and micro-grid neighborhood, in terms of management and service provision, will soon take place for the benefits of all building users, vehicle users and pedestrians (related to what today has been identified as the great transition to the Internet of things (IoT) and smart city). This driving force is generating product innovation, contextualized within the sharing

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economy scheme, that is, the decision to share spaces in exchange for additional services that can be integrated and shared within locals and/or condominiums. This new paradigm is in fact, possible thanks to the introduction of newly available, scalable and modular technologies that meet the user demands (safety, security, monitoring and management).

The research project INCASe, funded by Regione Lombardia, makes part of this reference scenario. Its primary objective is to integrate modular shared charging points for light electric vehicles and within façades and/or enclosure systems in order to blend these systems into the urban fabric (see Fig. 1 for the set-up installation process and Fig. 2 for the device completeness detailing). The generated impact is the diffuse development of the neighborhood electrical vehicle (NEV) in urban areas and the creation of an interface to a scalable micro-smart grid by providing condominium recharging system. The project delivers, in addition to the development and integration of a charging device implemented within a building envelope system, the creation and application of a platform for managing and accounting the charging use by private individuals, through the use of a mobile app.

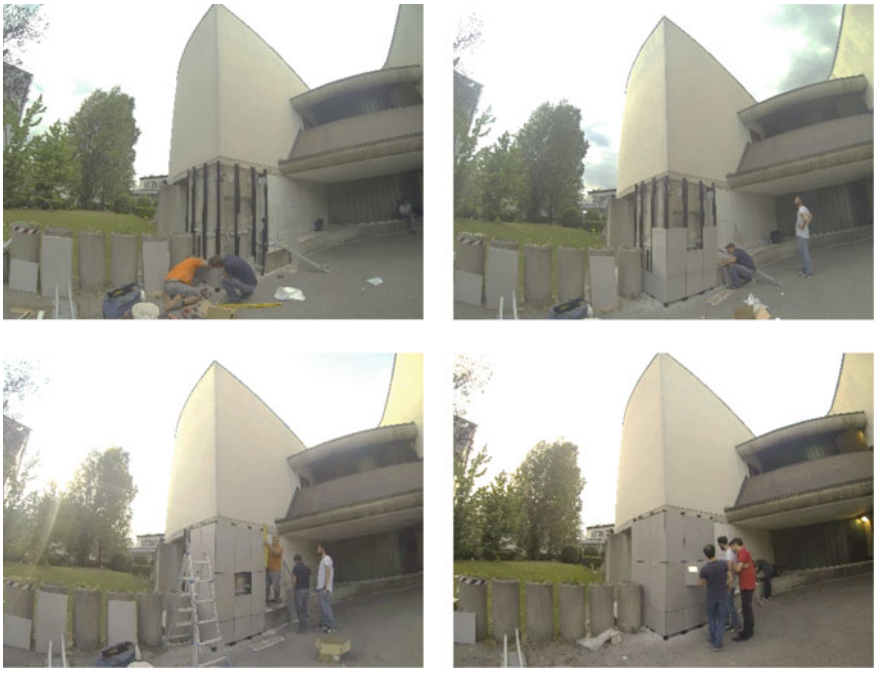

Fig. 1 Installation of the prototype module as a stand-alone device within the campus of Università degli studi di Milano

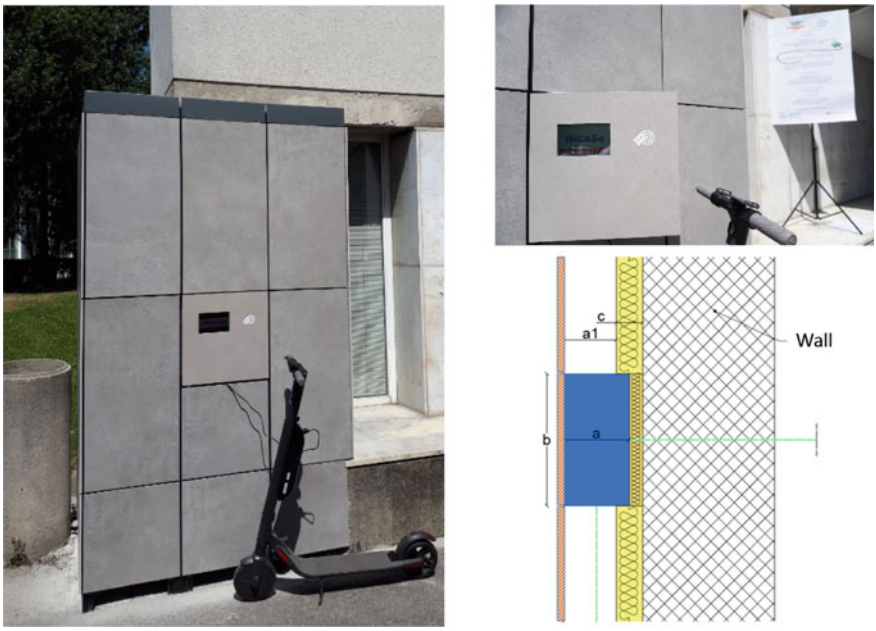

Fig. 2 Device completeness perspective, in situ demonstrator view (left and top right) and cross section (bottom right) where **a** and **b** are the dimension of the charging box, **a1** is the air gap dimension, **c** the insulation thickness

2 INCASe, Significance, Effect and Obtained Results

With the project INCASe (Integrated shared ChArge points for Smart buildings), software and hardware IoT have been developed, tested and perfectly immersed within a modular building element. This will enable the building to interface and communicate with the electrical grid, behaving then as a hub of the micro-grid acting as a shared sharing point for electrical vehicles. A scalable building component/device system prototype for electric mobility has been developed The proposed solution is the predisposed for intelligent electricity use and for the exploitation and enhancement of renewable resources used in the building aiming to reduce the need of use of the electricity grid for EV charging. Within the context of nearly zero energy buildings (NZEB), the device is able to:

Connect to both the electricity grid and to the private renewable energy sources produced in the building;
Recharge and manage electrical vehicles such as bicycles, scooters and mobility equipment for the disabled. The number of vehicles charged contemporarily will depend on the network availability; however, it will be optimized by power-sharing technologies;

Connect via open-communication protocols (i.e., Open Charge Point Protocol (OCPP) for additional app-based services).

The component is intended to be adaptable either to new buildings construction or to renovation interventions on existing buildings. In addition, it is suitable to be installed outdoors in parking areas, aside cycle paths, public access areas or can be installed as a stand-alone device. In this last solution, the system will be constructed using certified recycled material to maximize the reduction of ecological footprint. In Fig. 1, a series of photographs show the process of construction and integration of a portion of the new building envelope equipped with the INCASe module.

The system makes available and easily usable, by every individual user, fundamental information for the monitoring, optimization and enhancement of the electricity produced. Additional services that improve the building operation performance will be foreseen. Within these additional services, the following can be included: security control of the area, remote authorization for building access and the storage of orders placed with the courier. Likewise, the municipality would be able to have available shared charging spaces for the electrical mobility, guaranteeing the sufficient territory cover and reducing costs of implementation and management. In this way, the system is an alternative to the road infrastructure conversion and allows the efficient management of municipal spaces for free or paid parking otherwise necessary for recharging. The activities of sharing electrical vehicles or electricity provision will directly benefit the citizens by enhancing the use of these spaces, also due to the reduced costs of construction and maintenance.

3 Conclusions

The project is immersed within the context of the development of advanced sensor implementation for IoT devices, with the capabilities to be integrated for building automation at building scale through the installation of elements into a modular façade component enabling innovative interventions primarily on existing buildings.

The system will allow the acquisition of granular data coming either from the condominium's interior or from external affiliations of electrical vehicles that will be accessible for monitoring via the app-based environment and the cross-communication link with the device. Different techniques applied, would allow the real-time adaptation of the implemented functionalities for off-line analysis and profiling aimed at improving the service provided. Accordingly, it will be possible to allow the interaction of the device both with the electric vehicles plugged or with those registered for connection and with smart elements for building automation present in the condominium, primarily energy storage technologies (i.e., aside photovoltaics systems) and personal devices.

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