European Commission

# High energy performing buildings:

## Support for innovation and market uptake under Horizon 2020 Energy Efficiency

*Energy*

Publications of the European Union
Project number 2018.4202



More information on the European Union is available on the internet (http://europa.eu).

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PDF : ISBN 978-92-9202-376-8 DOI 10.2826/495211 EA-04-18-658-EN-N

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Publication prepared by the European Commission's Executive Agency for Small and Medium-sized Enterprises

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The EU's buildings sector needs to develop and deploy more innovative solutions in order to enhance the building stock's energy efficiency and help meet energy and climate policy targets. The European Union is therefore supporting projects that address design and construction processes as well as new technologies, with funding from the Horizon 2020 programme. The results developed by these projects address key challenges at each stage of the value chain for new nearly zero-energy buildings, deep renovation of existing buildings, and energy-smart buildings.

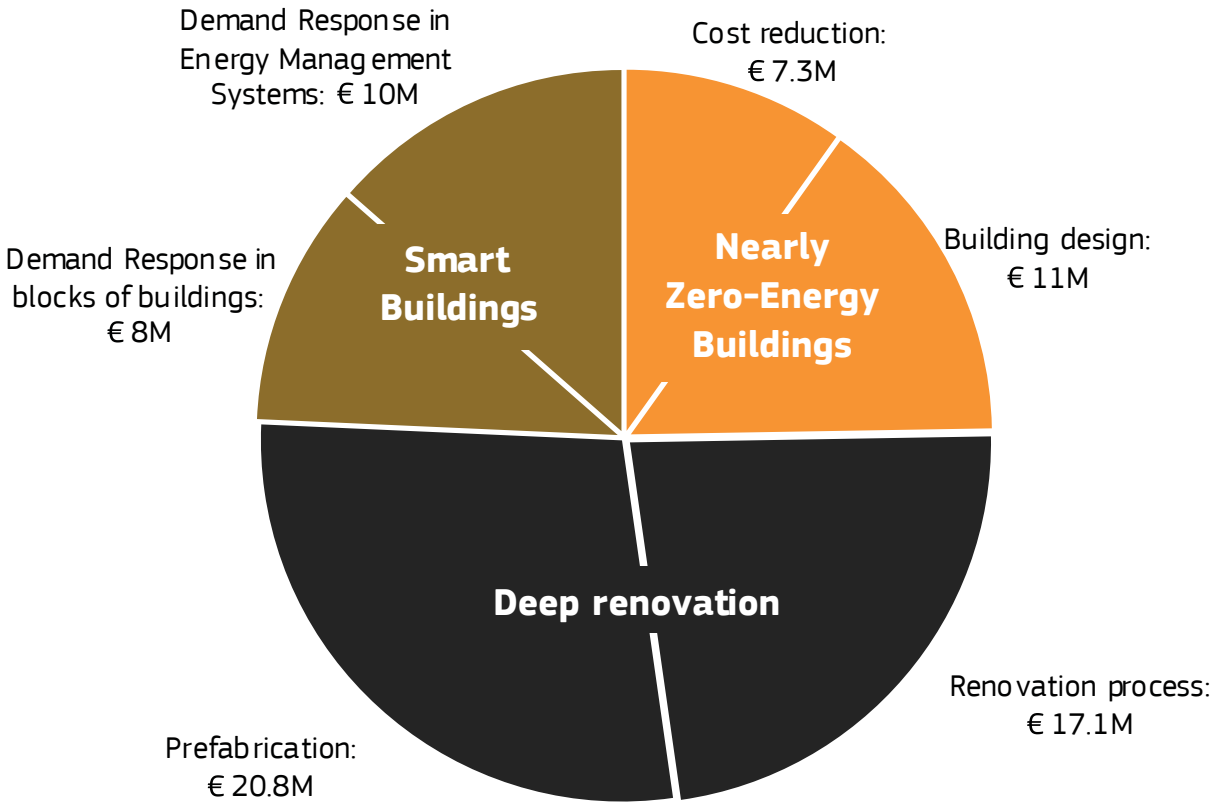



**Figure 1:** Distribution of EASME's Horizon 2020 spending for the 24 projects studied.

# EU support for high energy performing buildings

By ensuring that new and renovated buildings are energy efficient, Europe can realise a number of benefits including lower energy bills and reduced greenhouse gas emissions. The **Energy Performance of Buildings Directive** (EPBD) requires every new building across the EU to be a **Nearly Zero-Energy Building** (NZEB) by the end of 2020. Member States have also devised long-term strategies to reduce energy consumption in existing buildings by promoting cost-effective renovations under the **Energy Efficiency Directive**. The European Commission's **Executive Agency for SMEs** (EASME) is helping the buildings sector to meet these goals by supporting innovation in high energy performance buildings, through the Horizon 2020 programme for research and innovation.

Since 2014, EASME has supported 24 projects working to promote the uptake of deep renovations, cost-effective NZEBs, and smart building technologies with over €74 million from the Horizon 2020 programme[1].

Accelerating deep renovation has been the focus of 12 projects. These can be divided into two categories: those looking to improve the renovation process, for example by providing holistic renovation packages through **one-stop shops**, and those looking to reduce costs and installation time, by developing **prefabricated components** based on an industrial manufacturing process. Saving costs is also a key priority of the 7 projects that have been dealing with new NZEBs. While some projects such as **A-ZEB**, **CoNZEBs** or **ZERO-PLUS** seek to identify the most cost-effective combination of technologies, others like **InDeWaG** strive to develop entirely new components that would offer designers new options. Other projects are preparing the ground for aggregating the demand of blocks of buildings with a view to integrate them in Demand Response schemes, in some cases by using **adaptive modelling and big data analytics** to assess the reliability of available flexibility. Ensuring interoperability and engaging with the users remain some of the key challenges in this regard.

[1] Average EU funding for these projects amounted to about 3.1 million Euros per project.

**Figure 1**: Installation of a prefabricated façade panel in Oslo, 4RinEU project.

# Deep renovation: Process innovations and prefabrication

The decarbonisation of the EU's building sector requires a huge effort to renovate the existing stock, which already accounts for a large proportion of the buildings that will be standing in 2050. Despite the challenge, such retrofits are not taking place in sufficient numbers, and too many of them fall short of tapping the full savings potential. The limited appetite for energy renovation among building owners and tenants is a complex problem that often suffers from lengthy processes, high costs, split incentives between landlords and tenants, uncertainties about prospective savings and returns as well as a lack of integrated solutions due to the fragmentation of service providers. Addressing several of these issues, the creation of **one-stop shops** for deep renovation has proved to be an effective way to encourage owners to optimise the energy performance of their buildings. For example, market development teams have been set up in the Netherlands to activate mass demand for deep renovation. Building on the success of the Dutch Energiesprong initiative that has already renovated over 100,000 homes, **TRANSITION ZERO** is exporting that system to the UK and France by developing the necessary regulato-

ry and economic environment. TRANSITION ZERO is concluding initial agreements for 5,000 houses in a solution that brings together social housing organisations, government bodies and financiers in a single package. The renovations with pre-fabricated façade and roof modules are financed by the energy savings engendered, offering a 30-year performance guarantee. The accelerated offsite construction process increases built quality whilst at the same time decreasing the time spent on site, which minimises disruption for building occupants.

Several other projects are also developing holistic renovation packages that make use of industrialised manufacturing and assembly processes. **MORE-CONNECT** is demonstrating deep retrofits that can be carried out in six days, offering a return on investment with a short payback time. A performance guarantee for both energy consumption and indoor environmental quality will serve as an incentive for building owners to undertake deep retrofits. MORE-CONNECT is developing a range of **modular building components** on a plug-and-play basis, which in theory should reduce installation time. In the **P2Endure** project, plug-and-play components are being demonstrated for both building envelopes and technical systems, together with **other recent innovations** such as augmented reality and 3D printing on the building site. Prefabricated façade panels for retrofit are also being **developed by 4RinEU**, incorporating insulation, new windows and renewable energy systems.

A solution that brings together the offsite construction process with Building Information Modelling (BIM) is being developed by **BERTIM**. Scanned data from an existing building is imported into a new **RenoBIM** tool to design prefabricated timber façade systems, which can then be exported to industrial CAD-CAM machinery for prefabrication. Innovations using BIM are also central to the **IMPRESS** project. It brings together reconfigurable moulding (RM) techniques, 3D laser scanning and 3D printing technology and embeds them in a cloud-based BIM model that incorporates all stages of the building process from design, construction and installation through to operation. Its new **Online Management Platform** allows all team members to collaborate and plan the project based on a shared BIM model. In tandem with the BIM approach, IMPRESS is also developing three kinds of easy-to-install prefabricated panels, suitable both for over- and re-cladding of the building envelope. The panels feature enhanced thermal and acoustic insulation properties, reduced thickness and weight. Some of the panels also incorporate phase change materials, which can help passive heating and cooling. In addition, all panels have embedded sensors to assess their performance once installed.

Alongside technological and process improvements, energy efficient renovation can also be encouraged by providing transparent information about the performance and commercial viability of such retrofits. In rented dwellings, this can help to combat the split incentive between landlord and tenant, which discourages investment. For example, the **RentalCal benchmarking tool** helps landlords and housing managers to compare options for renovation investments and assesses projected energy savings and financial returns. A **map-based application** developed by **ENERFUND** allows people to view buildings based on their Energy Performance Certificate and rate them according to their suitability for renovation.

Planning for energy renovations in a stepped arrangement over the longer term can be made more effective by devising individual building renovation roadmaps. **iBRoad** is developing **customised "iBRoad-Plan" roadmaps** combined with building logbooks or "passports" that keep a record of energy-related interventions. iBRoad has found that homeowners and buyers **need more user-friendly and trustworthy advice** on the best steps to follow when performing energy renovations. **ALDREN** also proposes to develop building passports for step-by-step renovation, whilst at the same time providing harmonised energy performance ratings via a common European Voluntary Certification scheme.

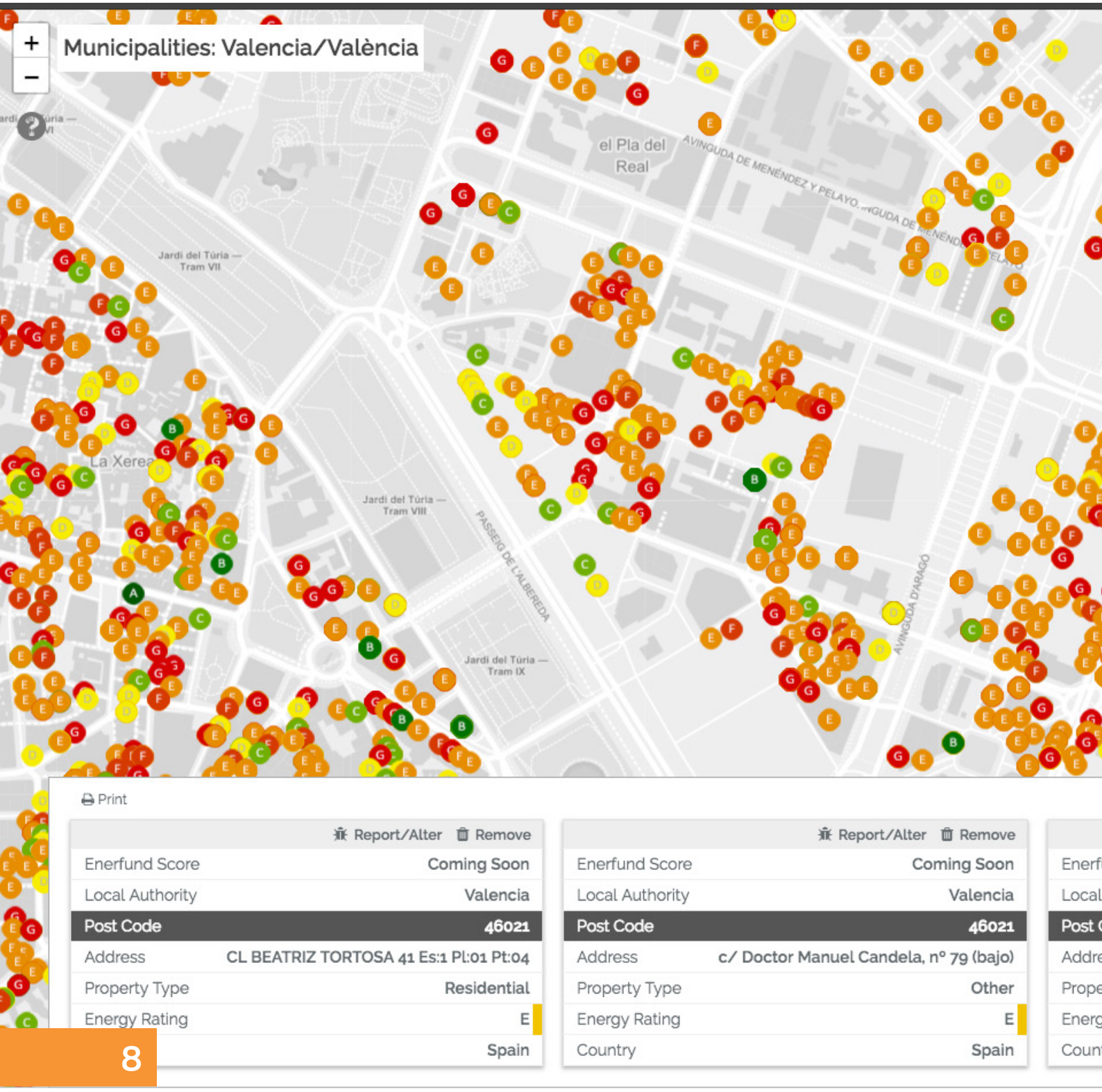


**Figure 2**: Screenshot of ENERFUND's mapping app.

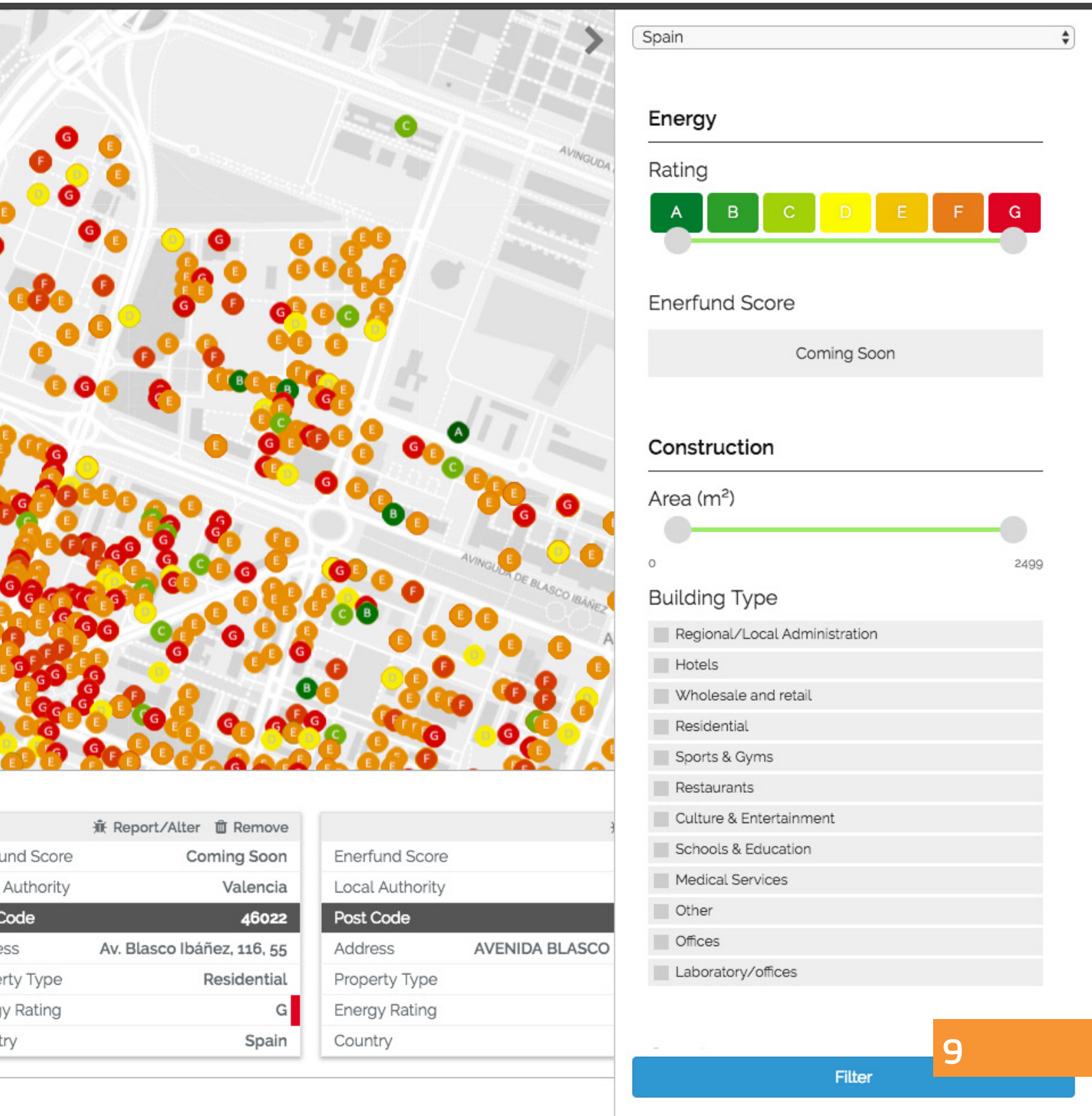
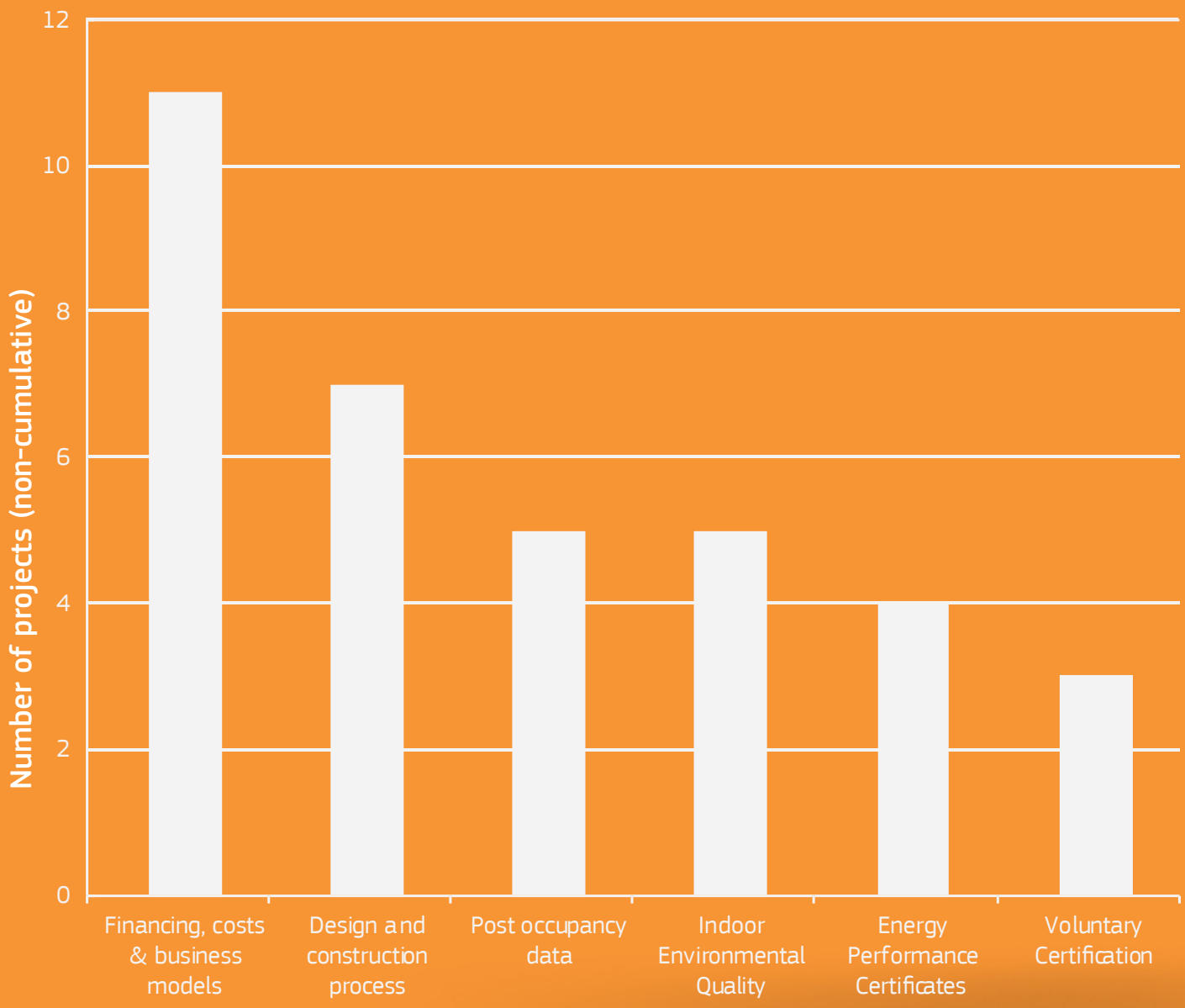


**Figure 3**: Aspects of the building process targeted by deep renovation projects



# Design and cost reduction of New Nearly Zero-Energy Buildings

Apart from the need to renovate the existing building stock, it is also imperative that design and construction processes are able to deliver Nearly Zero-Energy Buildings in the market. In practice, the mainstreaming of NZEBs is hampered by a performance gap between designed and measured energy consumption. This is partly due to occupant behaviour not being sufficiently taken into account at the design stage[1].

Additionally, the **extra over cost for NZEBs** remains too high compared with conventional buildings. It is therefore crucial to identify potential cost savings in both planning and construction processes to spur the rollout of high energy performing buildings. Significant cost reductions could potentially be achieved using the right combination of technologies, faster construction processes including prefabrication, and appropriate renewable energy sources or local low temperature district heating systems. **CoNZEBs** is exploring such **NZEB solution sets**, including life cycle assessments, for multi-family housing in close cooperation with housing associations. The project is also investigating end users' experiences and expectations whilst also providing tenants with guidance on energy efficient behaviour consistent with a high performing building. Another potential way to reduce the extra over cost of new NZEBs is to shift the focus from individual buildings to entire settlements. In this way economies of scale can come into play, together with a sharing and management of energy loads between individual buildings. **ZERO-PLUS** is constructing four pilot demonstration settlements that will each save at least 16 percent of the normally expected building costs by using mass-produced technologies and integrating them into a system that is optimally designed according to the local climate.

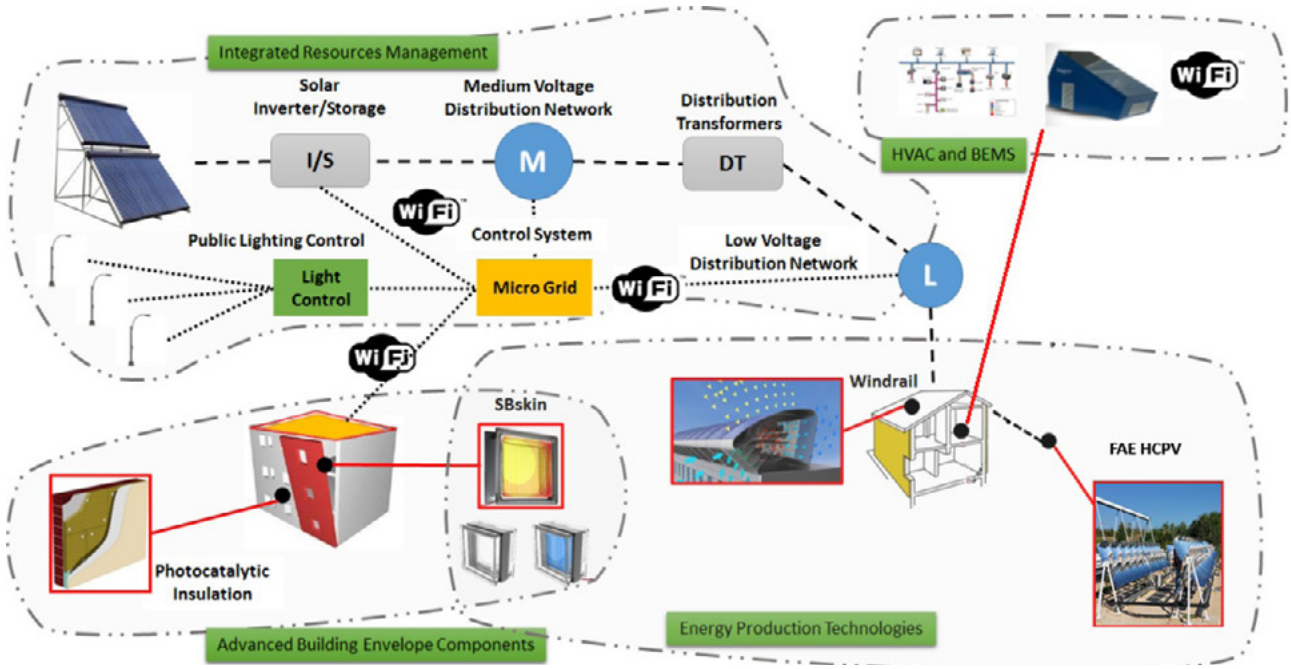



**Figure 4**: Synoptic diagram of the system in ZERO-PLUS.

[2] See for instance E. Delzendeh et al.: **The impact of occupants' behaviours on building energy analysis: A research review.** Renewable and Sustainable Energy Reviews 80 (2017), 1061-1071.

**Figure 5**: 3D model of an InDeWaG demonstration site.

Innovative building components are also needed to improve the energy performance of new NZEBs in a cost-effective manner and to facilitate the integration of renewable energy generated on-site or nearby.

One promising solution is the **InDeWaG** fluid glazing system that maximises the use of daylight while harvesting solar energy. The technology integrates solar thermal absorbers Building Integrated Photovoltaics (BIPV) into glazing elements that help to temper the indoor climate. Following initial demonstrations, the project is integrating water flow into a glazed façade system that would satisfy the cooling and hot water demand of an entire building. By reducing the need for traditional heating and cooling equipment, the system aims to reduce overall building costs for NZEBs by at least 15 percent, and would especially suit highly glazed buildings such as offices. The integration of a series of solar thermal absorbers of varying opacity enables the system to operate at different temperatures, for example 30°C for heating and seasonal energy storage, 60°C for sanitary hot water supply and 90°C for cooling through absorption chillers.

# Smart buildings

In addition to improving construction processes and building components, energy efficiency can also be enhanced by optimising energy management. This can for instance be achieved through improved controls linked to smart meters, sensors and appliances. Digital tools can also help to make the case for deep renovation by analysing and customising information on existing building systems for building users and investors. **4RinEU** is developing a tablet application enabling users to make better decisions based on real-time information. It will help users to identify and locate installed systems such as sensors, meters, lighting and room heating controls, and to use this information to improve the operation of the building.

Using building energy management to balance energy networks also contributes to the energy efficiency of the wider energy system beyond the individual building, either by consuming less at peak demand hours or by consuming more when demand is low. Increasing the flexibility of energy demand in this way is key to tackling the growing need to balance consumption and generation that comes with the rising share of variable renewables in the EU energy mix. Buildings have the potential to provide such flexibility, through on-site energy storage, power-to-heat or activation of smart appliances. Aggregating the demand from multiple buildings offers the possibility to manage the large amount of energy that is needed to balance electricity markets. To this end, several local energy management solutions from individual buildings can be integrated into a Demand Response management system for a block of several buildings. This is the aim of **DR-BOB**

which is demonstrating the benefits of this approach at university and hospital campuses and a technology park. Before an aggregator can use the flexibility potential of communities, however, one first needs to assess how reliably this potential could be activated. Adaptive modelling and big data analytics offer ways to determine the capacity for flexible demand of building blocks, as is being carried out by **Sim4Blocks**. Moreover, digital smart technologies play an increasing role in optimising energy consumption, integrating distributed generation and storage, reacting to requests from energy networks and adapting to the needs of building occupants. All of these functionalities need to be integrated into building automation and control systems. A key challenge in this regard is to ensure interoperability between building energy management systems, energy networks and the appliances inside the building.

There is also a need to **engage more effectively with building users** to change their consumption behaviour, for example by providing user-friendly interfaces or financial rewards. While automation reduces the need for human intervention, consumers do not deem financial incentives alone to be sufficient reason to engage in active energy management. The ability of market actors to offer such schemes depends on the **varying regulatory conditions in Member States**, i.e. the readiness of electricity markets for Demand Response, the price levels of these markets and consumers' access to flexible energy tariffs. Addressing the technical challenges related to the integration of buildings in Demand Response schemes, and involving building users are thus two of the main challenges that are taken on by **HOLISDER**, **RESPOND**, and **TABEDE**, to create new business opportunities for innovative energy services based on energy savings and flexible consumption.

**Figure 6:** Schneider Electric's T11 building, an industrial campus and test site of the **TABEDE** project.

# Further opportunities for EU support

Horizon 2020 projects have since 2014 been working to increase the energy efficiency of the buildings sector across several parts of the value chain, including design and construction processes, building components and energy management systems. With support from the Executive Agency for SME's, Horizon 2020 projects are contributing to EU policy objectives of accelerating deep renovation and ensuring that new buildings comply with nearly zero-energy standards. The three thematic areas of smart buildings, deep renovation and new NZEB together represent 24 projects that benefit from some €74 million of EU funding.

Although many of these projects have already developed promising solutions, more effort is needed if we are to decarbonise the EU's building stock. Rates of renovation remain too low across most of Europe, new NZEBs too often use more energy than was expected and frequently cost too much to build, while the integration of buildings in Demand Response schemes has yet to become a market reality in many parts of the EU. Consequently, the European Commission is continuing to offer support for innovation and market uptake of high energy performing buildings via the Horizon 2020 Work Programme for secure, clean and efficient energy. For 2018 and 2019, the total budget for the Energy Efficiency Calls amounts to approximately €212 million. In the buildings sector, four funding topics focus on the themes outlined in this article:

- Decarbonisation of the EU building stock: innovative approaches and affordable solutions changing the market for buildings renovation (topic **LC-SC3-EE-1-2018-2019-2020)**:
- Integrated home renovation services (topic **LC-SC3-EE-2-2018-2019**);
- Upgrading smartness of existing buildings through innovations for legacy equipment (topic **LC-SC3-EE-4-2019-2020**);
- Next-generation of Energy Performance Assessment and Certification (topic **LC-SC3-EE-5-2018-2019-2020**).

EA-04-18-658-EN-N

Publications Office

ISBN 978-92-9202-376-8
DOI 10.2826/495211