




BUILDINGS  
PERFORMANCE  
INSTITUTE  
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## DEEP RENOVATION USING PREFABRICATED COMPONENTS

The European construction industry, like many others, is confronted by an economy that is undergoing significant change, shaped by megatrends such as greater urbanisation, disruptive new technologies and digitalisation, globalised value chains and sustainability. At the same time, the European economy faces the profound challenge of meeting the ambitious climate mitigation goal set out in the Paris Agreement of keeping average global warming “well below 2°C” with an ambition of 1.5°C.

A key question for this industry is how to translate this challenge, in line with the other megatrends, into an opportunity for economic success and global leadership, while being aware of the environmental impact. Accelerating the pace of deep energy renovation in the construction value chain - extensive building improvement work that substantially increases energy efficiency and reduces energy consumption by 75% or more - has a vital role to play in ensuring economic success and can help achieve these public policy goals. Industrial and prefabricated renovation solutions will significantly contribute to achieving these goals. This factsheet highlights the work of four different Horizon 2020 projects in this area.



**Develops prefabrication of innovative, multifunctional building envelope elements for modular renovation solutions**

**Develops robust and reliable technology concepts and business models for triggering deep renovation of residential buildings in the EU**



**Develops plug-and-play solutions for deep renovation of the European building stock**

**Develops timber prefabricated modules and holistic methodologies for the renovation process**





## HOW CAN THESE SOLUTIONS REDUCE RENOVATION COSTS?

The high upfront cost of deep renovations is deterring investments in the sector. Industrial and prefabricated renovation is a concept with the potential to reduce the renovation cost. The four EU projects have shown that it is possible to achieve this through several means:

- The prefabricated and holistic renovation solutions developed by these projects take less time, are less disruptive for the occupants and are quick and easy to apply, while ensuring a high performance level.
- Considerable cost savings are achieved through shorter construction times:
  - ⇒ It is estimated that prefabrication in a factory can shorten construction time by 18% compared to state-of-the-art deep renovation practices. One prefabricated module of 20 m<sup>2</sup> takes on average just one hour to install by three workers on-site ([More Connect](#)).
  - ⇒ It is possible to reduce the on-site installation time for a detached house (with a façade surface of 380 m<sup>2</sup>) by 52% when applying a multifunctional prefabricated façade system, comprising integrated PV and HVAC components ([4RinEU](#)).
  - ⇒ A prefabrication approach decreases the duration of the overall renovation process by 25-44% ([P2Endure](#)).
- Fewer mistakes on-site can save an estimated 5-10% in costs ([P2Endure](#)).
- The standardisation of the renovation value chain through digitalisation and process optimisation can reduce the costs by up to 25% compared to a conventional renovation approach ([P2Endure](#)).

Industrial prefabrication  
can decrease the  
overall renovation process  
by **25-44%**



Digitalisation and  
process optimisation  
can reduce costs by  
**25%**



*Before and after photos of a 4RinEU pilot project in Oslo. Copyright: Ivan Brodey, Boligbygg*

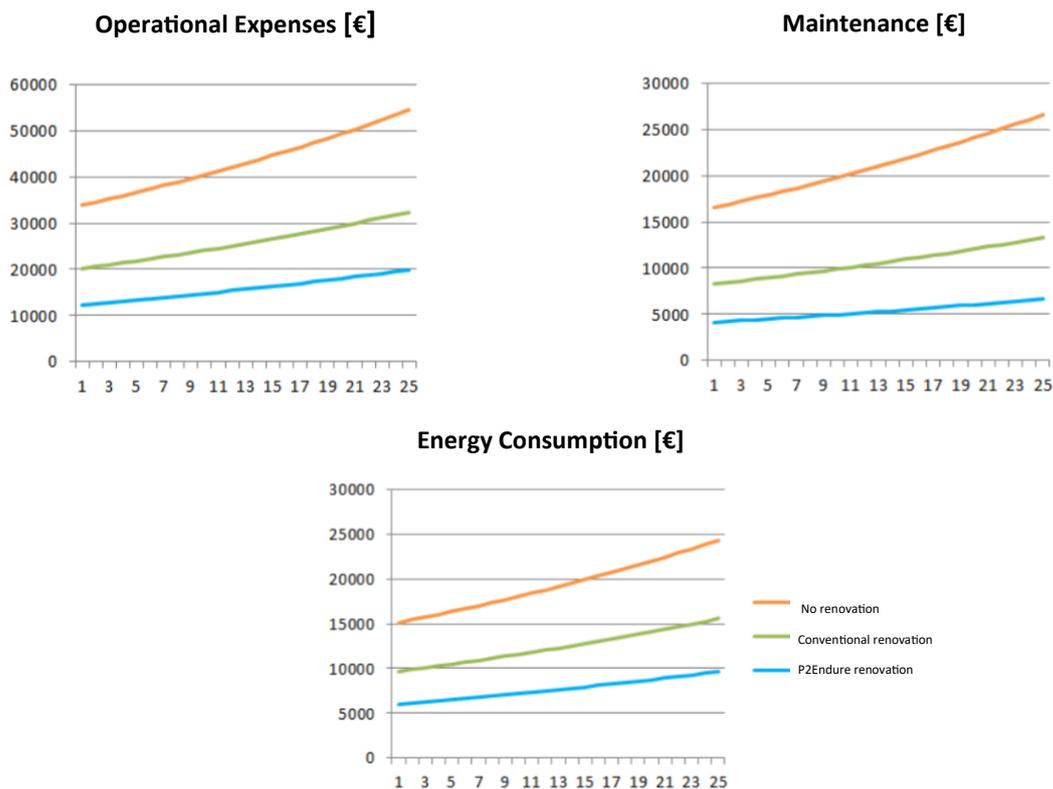
- With premanufactured components, the tenants in residential buildings don't have to leave the building during the installation works, while workers in non-residential buildings (hospitals, offices, schools etc.) are less affected by the works.
- The 4RinEU project is trying to facilitate the industrialisation of a number of "energy hub modules", known as the [Plug&Play Energy Hub](#). These modules, which are heat pump or solar based, should be able to manage an efficient heating and cooling system or domestic hot water supply, while being easy to install and use. The large-scale potential of this solution could drastically reduce the cost for these services.



- Evidence suggests that prefabricated renovation projects require less embodied energy.
- Prefabricated façade systems can increase the lifespan of a building, as the components are easier to replace and to repair, while multiple benefits are easier to monitor.
- Figure 1 illustrates the operational expenses over a 25-year period for (i) no renovation, (ii) conventional renovation, and (iii) P2Endure renovation.

Figure 1: P2Endure pilot case in Warsaw: Operational expenses in three renovation approaches.

Copyright: [P2Endure](#)



## HOW CAN PREFABRICATION STREAMLINE THE CONSTRUCTION VALUE CHAIN?

Building processes are becoming increasingly complex, which is why more interaction and collaboration between actors is needed. There are various opportunities to eliminate process and market barriers with organisational innovation leading to new business models focusing on collaboration between the different building actors, and/or new construction value chain-related ecosystems. Various types of loose or formal collaboration structures for achieving buildings with high levels of energy performance are appearing in all countries and the experiences connected to them are setting the scene for further development. The EU projects are trying to find solutions to this challenge:

- The RenoBIM software is an application developed by the [BERTIM](#) project. It is a cloud-based platform that sets out the best scenario based on the building design and requirements. The inputs and outputs of RenoBIM will be based on [Industry Foundation Classes \(IFC\)](#). The use of IFC formats allows a smoother collaboration between stakeholders, reduces waiting time, and minimises mistakes and the need to rework certain steps.
- The P2Endure project is developing an [eMarketplace](#) for innovative plug-and-play solutions such as facades, windows, or HVAC systems. The solution aims to integrate the services of architects, engineers and other building experts to create a holistic offer. The platform will also enable a more efficient management of the materials needed in the renovation process, including aspects of costs, time and quality issues. The optimisation of the manufacturing process, from working with individual craftspeople to systemic digitalised plug-and-play solutions, can generate a better service for the occupants ([P2Endure](#)).



*Final installation of a BERTIM demonstration case in La Charité, France. Copyright: BERTIM*

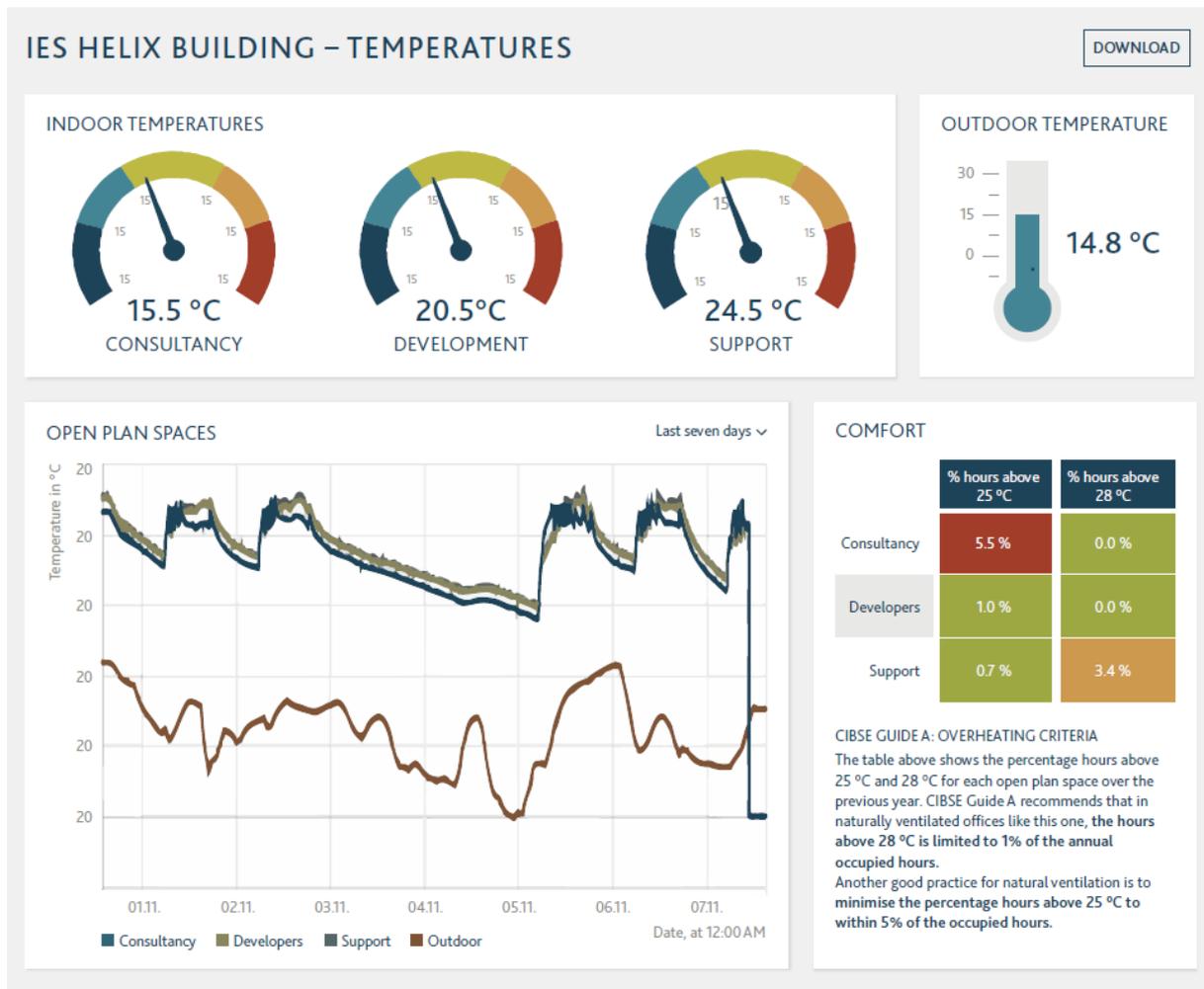
## HOW CAN THE APPROACH ENABLE HIGHER QUALITY RENOVATIONS?

The quality of energy renovations does not always meet the expected standards, due to inadequate products, faulty installations or user behaviour. This problem tends to undermine the demand for renovations. There is for example an embedded cost of failures during the construction on a traditional building site; this has been estimated to make up around 20% of global construction costs. The cost of failures is related to human error (54% of failures), material defects (12%), and errors during construction (34%) (D'Oca et al, 2018). The EU projects are showcasing how prefabrication solutions can facilitate a more reliable renovation process:

- A high quality assurance is easier with prefabricated solutions, as the production processes are not exposed to weather conditions and only the assembly is carried out on the building site. This also allows a reduction in the use of materials, waste, noise and dust pollution ([BERTIM](#)).
- Quality control of components is performed in the factory, where the use of standard products minimises design and production process faults. It also enhances the level of performance of the technologies installed as they are quality assured prior to installation ([More Connect](#)).
- Using building information modelling (BIM) during design and construction stages improves the precision of the technical detailing and accuracy of planning ([P2Endure](#)).
- The [4RinEU](#) project developed a [Sensible Building Data Handler](#) designed to gather, organise and prepare for analysis the large amount of data that is needed in the various phases of a deep renovation project. The app (developed by [IES](#)) allows users to create and manage multiple auditing projects, acting as a digital notebook for the auditor on-site.
- The [4RinEU](#) also introduced a tool named [EarlyReno](#), aimed at supporting the user in the early design of the renovation in order to maximise the exploitation of renewables on-site (e.g. ventilation and daylighting potential, as well as solar energy potential). It allows for the optimal integration of renewable energy.



Figure 2: Using the “Sensible Building Data Handler”, developers and project managers can handle different data and projects at the same time. Copyright: 4RinEU, Integrated Environmental Solutions Ltd. 2017



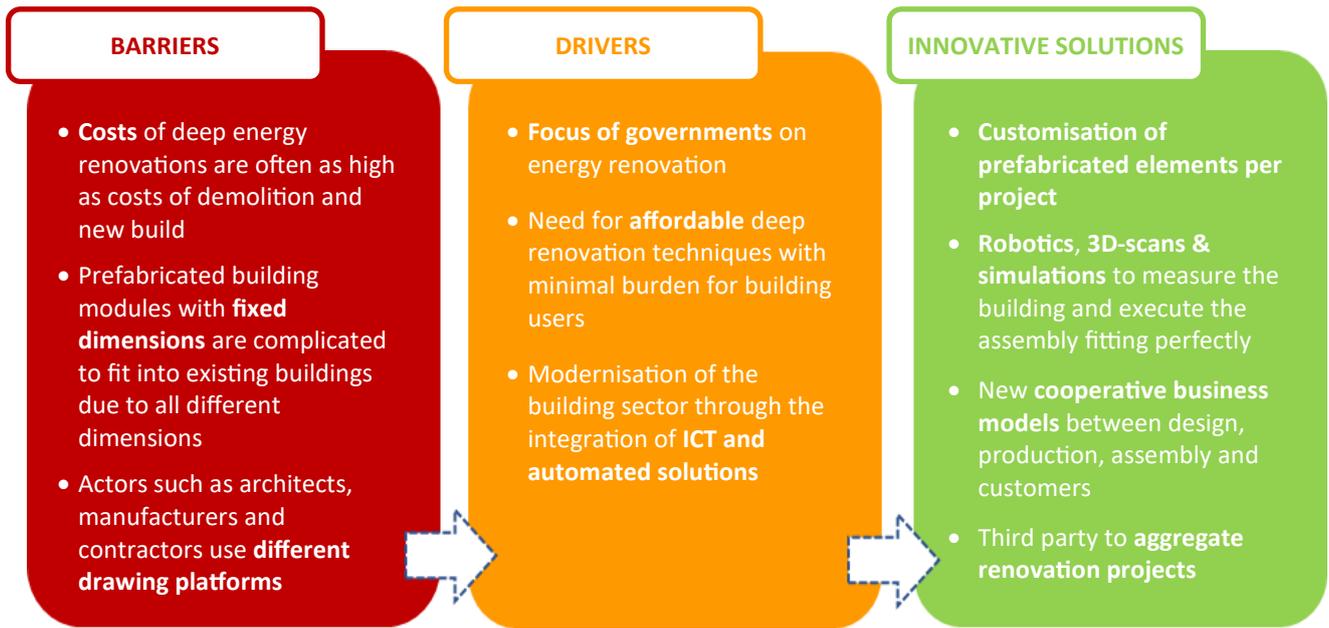
## WHAT IS THE POTENTIAL TO AGGREGATE DEMAND?

A large demand for deep renovation solutions is necessary to reduce the related costs. Manufacturing certain building components in factories comes with dedicated costs. While some solutions can be applied to both renovation projects and new buildings, a certain scale is required for the business model to become viable. The Dutch [Energiesprong](#) has been rather successful in aggregating demand for high-performing retrofits.

- The [RenobIM](#) is a web application developed by the [BERTIM](#) project, which utilises BIM technology. The tool allows automation of the data flow, starting from data gathering for the existing building, through the generation of a 3D model of the building and the design of the renovation project. It is a collaborative environment which enables architects, designers, manufacturers and building owners to configure a building renovation project and assess the feasibility and cost-effectiveness of various prefabricated modules. This innovative cooperation of actors makes processes more efficient and transparent.
- The [multicriteria-ranking tool](#) developed by 4RinEU can be used by building owners and investors in an early step in the renovation process. The instrument will outline a selection of suitable renovation packages for the specific building, considering financial aspects, energy, environment, construction management, as well as the comfort and health of the building's users ([4RinEU](#)).
- In the [More-Connect](#) project, a '[One-Stop-Shop](#)' concept is developed and offered to the end-user. In other words, the end-user deals with only one responsible party organising the design, production, installation, financing, performance contracting and aftercare.



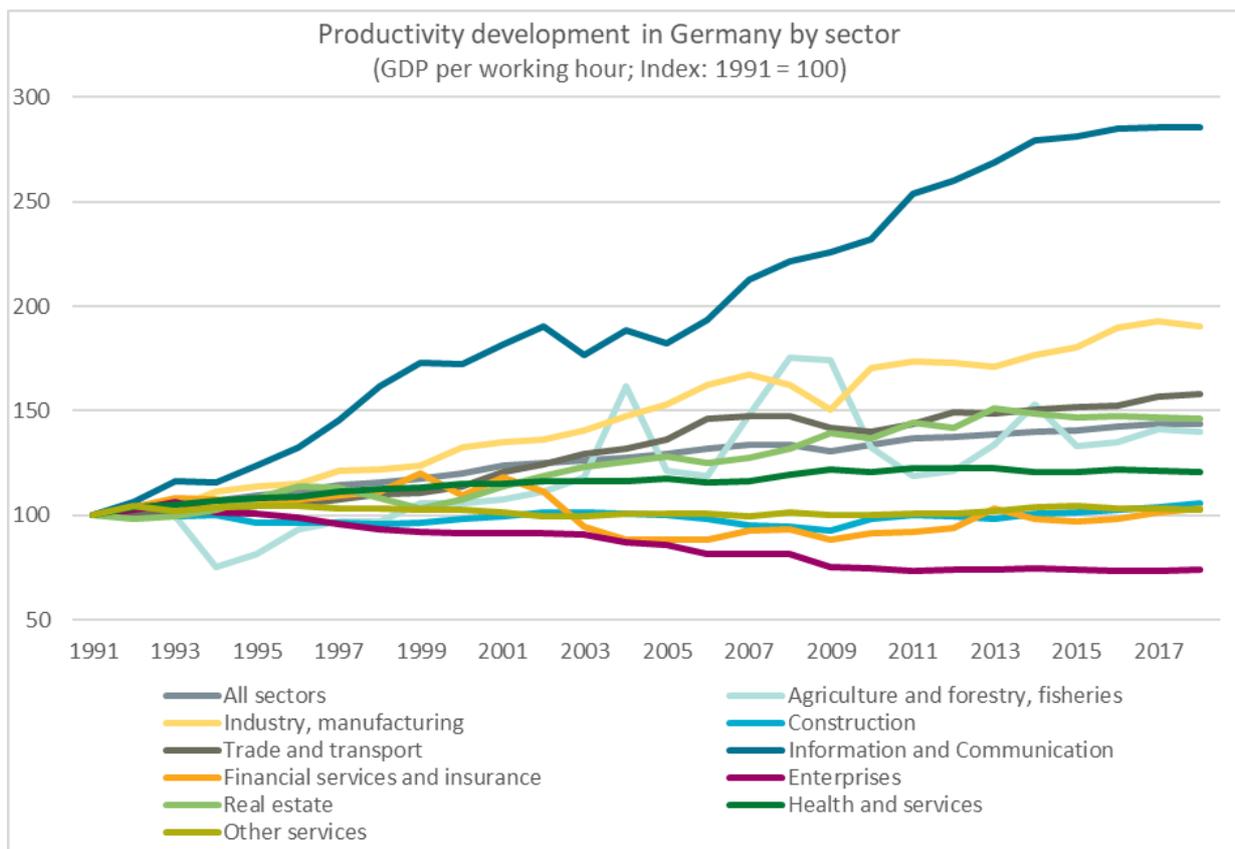
Figure 3: Outlining the innovation needed to increase demand for 'Prefabricated systems for deep energy retrofits of residential buildings' (BPIE, 2016)



## POTENTIAL FOR INNOVATIONS?

The importance of innovation to the European economy has never been greater. Globalisation, disruptive technologies, emerging business models and growing sustainability concerns are putting unprecedented pressure on European industries to adapt, and innovation might be the right response to them all. Innovation in the construction sector has so far been rather modest. Figure 4 illustrates the development of productivity in the construction sector compared to other sectors in Germany. The graph shows that productivity in the construction industry is low, one reason being the lack of innovation.

Figure 4: Development of productivity in Germany by sector (Own illustration based on Federal Statistical Office, 2018)





The four EU projects focus on innovation and try to use new technologies to increase the number of deep renovations.

- In the [BERTIM](#) project the Consortium is currently assessing innovative data-gathering solutions, including laser scanners, drones and tachymeters (electronic angle and distance measuring systems).
- Building information modelling (BIM) plays a key role in these models. BIM models can easily be exported to different software, such as Energy+ for energy calculation, which allows the pre-dimensioning of the modules and finally the export to CAD/CAM software ([BERTIM](#)).
- In the [P2Endure](#) project, the real innovation is the combination of the approaches – “plug-and-play” – and the coordinated, but individualised prefabrication process. Information and communication technology (ICT) solutions are developed based on enhanced BIM applications, integrating communication, development, prefabrication and monitoring.
- The [More-Connect](#) project focuses on innovation in products as well as in processes:
  - ⇒ Product innovation includes prefabricated, innovative, modular-composed building envelope elements, including the integration of multifunctional components for climate control, energy saving, building physics and aesthetics, with advanced plug-and-play connections.
  - ⇒ Process innovation includes a fully automated production process, starting with digital imaging using advanced geomatics, online configuration of the renovation concepts by end users, and a fully automated BIM-controlled production process. This process offers the possibility to produce ‘series of one’ in a mass production process.



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The Buildings Performance Institute Europe is a European not-for-profit think-tank with a focus on independent analysis and knowledge dissemination, supporting evidence-based policy making in the field of energy performance in buildings. It delivers policy analysis, policy advice and implementation support.

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