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AN APPROACH TO CIRCULAR BUILDING RENOVATION USING PRODUCT SERVICE CONCEPTS

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Abstract:

Accelerating the rate and depth of energy renovations in buildings is one of the biggest challenges currently facing the construction industry. The increasing range and complexity of building technologies make product selection challenging. At the same time, we need to embrace new circular building strategies in which material waste is eliminated. In an ongoing process materials and components are reused or remanufactured and can constantly be replaced with new and more efficient ones. The paper describes the first pilot project for a facade leasing at the Delft Technical University that explores ways of implementing circular construction methods. It acts as collaboration catalyst to further develop the complex system of contracts, financing structures, and operational services required to turn the facade leasing project into a feasible proposition. First general conclusions are drawn concerning supply, demand side, financial and legal aspects.

Keywords: circular building, facade renovation, leasing, product service concepts

PRISTUP KRUŽNOM OBNAVLJANJU ZGRADA KORISTEĆI SERVIS PROIZVODNIH USLUGA

Apstrakt:

Povećanje stope i opsega obnavljanja energije u zgradama je jedan od najvećih izazova sa kojim se građevinska industrija suočava. Povećani obim i složenost građevinskih tehnologija otežavaju odabir proizvoda. U isto vrijeme, trebamo da uključimo nove kružne strategije građenja u kojima se eliminišu otpadni materijali. U toku procesa materijali i komponente se ponovno koriste ili su ponovno proizvedeni i uvijek se mogu zamijeniti novim i efikasnijim. Ovaj rad opisuje prvi pilot projekat za fasade na lizing (facade leasing) na Tehničkom univerzitetu u Delftu, koji istražuje načine primjene kružne metode izgradnje. Projekat je podsticaj za saradnju u cilju daljeg razvoja složenog sistema ugovora, finansijskih struktura i operativnih usluga potrebnih da bi se projekat za fasade na lizing pretvorio u izvodljiv poduhvat. Doneseni su prvi opšti zaključci u pogledu snabdijevanja, potražnje, finansijskih i pravnih aspekata.

Ključne riječi: kružno građenje, obnavljanje fasade, lizing, koncept proizvodnih usluga

1. INTRODUCTION: THE GROWING NEED FOR FASTER AND MORE FLEXIBLE BUIDING RENOVATIONS

Accelerating the rate and depth of energy renovations in buildings is one of the biggest challenges currently facing the construction industry. Across Europe, a large number of buildings constructed during the post-war boom of the 1950's to 1970's are quickly reaching the end of their original service life [1]. Their façades and building systems are far below current standards, their energy consumption is unsustainably high, their spaces are in many cases uncomfortable and dysfunctional, and, as if this wasn't enough, they are also very expensive to maintain.

1.1. THE EXISTING DUTCH UNIVERSITY BUILDING PORTFOLIO

In the case of Dutch universities alone, almost 60% of the building portfolio of 14 universities studied dates back to before the 1980'[2]. This represents hundreds of thousands of square meters of façades which need to be substantially improved in the coming decades if we are to meet emission reduction goals set by the European Union and the Paris Agreement. And yet, it is but a small sample of millions of square meters of commercial, residential, and public space across the continent which require similar and immediate action.

The paper describes a pilot project in the context of the building portfolio of the Delft Technical University and here buildings with approximately 180.000m2 GFA are in need of renovation. At the same time there is a request for new and flexible use space, since the institutional landscape is constantly changing and the universities need to accommodate modern education and research concepts. This asks for renovation concepts that allow for different uses such as offices, teaching studios, laboratories and even student housing. For the renovation of facades it means that, to a certain extend, different qualities in terms of daylight management and ventilation must be possible.

1.2. BOTTLENECKS IN THE CURRENT RENOVATION PROCESS

Today's process for retrofitting an existing building, or to improve the planned energy performance of a new construction, is difficult and involves a sensitive collaboration between a number of parties with, in many cases, conflicting financial incentives and commercial interests [3]. The increasing range and complexity of building technologies makes product selection challenging. Knowledge transfer barriers between the parties manufacturing these components, and those responsible for their maintenance and operation, can result in a suboptimal selection and operation of these systems. The companies responsible for developing and supplying these technologies are in most cases marginalized to a secondary role, and keep no direct interest in the long-term performance of their products, which regularly end up being disposed of by the client at the end of their service life, resulting in an unnecessary production of waste and the loss of valuable products and materials. For all these reasons, it becomes difficult to evaluate and monitor the ongoing benefits of a performance improvement project in terms of energy use, carbon footprint, resource consumption, or economic gains.

2. A CIRCULAR APPROACH TO NEW BUILDING ENGINEERING

The Ellen MacArthur Foundation (EMF), established in 2010, defines the Circular Economy the following [4]: "A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles." Contrary to the linear model of make-take-dispose, in which goods are manufactured from raw materials, then sold on the market, used and finally disposed as waste, the circular model is regenerative, which means using waste as a resource for the manufacturing of new goods [5]. To be able to function well in the closed, circular system of the earth, the economy and the environment should also be balanced in inputs and outputs [6].

For the approach to renovation, the building is not seen as a cradle-to-grave project, in which materials come in at the start, are used for a limited amount of time, and are turned into waste or recycled into raw elements at the end, but as an ongoing process in which building components are constantly replaced with new and more efficient ones, while the old ones are broken down into spare parts which can be reused to produce the following technological generation.

2.1. IMPLEMENTING CIRCULARITY WITH NEW BUSINESS MODELS

The transition towards this new way for working, however, requires an extensive reorganization of incentives and responsibilities across all stakeholders in the construction value chain. Performance contracts, in other words the shift from an economic system based on the sale of products to one based on the provision of services, can play a determinant role in the economic and environmental feasibility of both future new constructions and renovations. By outsourcing the management and upgrade of technological systems to the suppliers responsible for developing them, we can achieve a faster market uptake of new and more efficient systems, while reducing the initial investment requirements of developers and building owners. Circular industrial loops are also facilitated, as suppliers who retain the ownership of their products have a significant incentive to extract maximum value from them as they reach the end of their service-life.

2.2. FACADE LEASING AS PRODUCT AND PROCESS INNOVATION

Façade leasing as a combined strategy relies on recent innovation on two fields: On one hand, technological innovation in the form of multifunctional façades results in building envelopes which have the potential of delivering an ongoing indoor comfort service. This can be done through the use of decentralized, façade-integrated building support systems which replace the traditional installations running through the ceilings and hallways of traditional constructions. The current range of such decentralized technologies has expanded to include a wide spectrum of energy generating technologies, air-handling systems, electric and communication infrastructure, and even advanced profit-generating elements such as media screens, or air-filtering solutions such as green façades. The placement of all these components on the exterior layer of the building does not only facilitate their maintenance and replacement, it also enhances the capacity of the façade to not simply protect the indoor spaces from the weather, but actively generate the energy required to control and monitor the indoor comfort conditions which it also provides.

On the other hand façade leasing relies on innovation in business and management practices, which includes new methods of financing, contracting, and operating these new and highly complex building systems, could facilitate the complicated transition required throughout the entire building process: First, it would support the initial design and engineering of components which can be more easily maintained and replaced. Second, it would promote high-quality production, based on durability and performance rather than lowest initial cost. Last and foremost, it would enhance the operation and reprocessing of components, incentivizing a long-term, ongoing collaboration between the suppliers of building technologies and the clients and users whose spaces are conditioned by the formers' systems.

3. THE TUDELFT PILOT PROJECT - A LIVING LAB

More than many other users and operators of commercial real estate, universities tend to have a long-term commitment and attachment to their locations and their campuses. The size of such campuses also provides an economy of scale which is difficult to replicate. More significant still, they have a social responsibility to lead the way towards better and more efficient practices, particularly those that involve a more efficient and responsible management of energetic and material resources. These and many other factors makes them the ideal testing ground for new methods of construction, organization, and collaboration.

In September 2016 a consortium of companies, ranging from component suppliers to façade fabricators, installed a pilot project temporarily replacing a section of the façade on the low-rise building of the Faculty of Electrical Engineering, Mathematics and Computer Sciences at TU Delft, commonly known as the EWI building (Fig. 1). The aim of this pilot project is to research ways of implementing circular construction methods. It demonstrates the state-of-the-art in façade-integrated technologies, and acts as anchor point and collaboration catalyst to further develop the complex system of contracts, financing structures, and operational services required to turn the Façade Leasing research project into a feasible and implementable proposition.

This solution does not seek to address the particular problems of the EWI building's future, but instead uses the building's representative quality as an icon of modernist architecture. Building such as the EWI, which are quickly reaching technical obsolescence, also display a degree of standardization and modularity that can make them the ideal target for deep energy retrofitting action, and hence for the implementation of new business model such as the one proposed by this project.

Four different façade panels were installed. The first one as the 'low-end' version with basic minimal u-value, and interior sun shades. The second panel (Fig. 2) has integrated PV cells and decentral ventilation system with heating, cooling and heat recovery, which is especially interesting for renovation purposes. Panel 3 and 4 have different configurations of in-glass or external sunshades, electrical or manual operable windows.

The panel configurations were analyzed according to their predicted energy performance by calculating savings through level of insulation, ventilation concept (with or without heat recovery), cooling and artificial lighting demand (depending on daylight managing system), or even potential energy gain through integrated PV panels. Building users evaluated the panels in terms of interior view and predicted visual and thermal comfort.

A total cost of ownership calculation (TCO) has been executed, including initial investment costs, energy costs, and maintenance effort.
It needs to be mentioned that the comparison is partly theoretical because all panels are installed at a single meeting room. Nevertheless, the comparison lead to interesting conclusions. For example that the owner preferred expensive external sun shades with a wind-resistance of up to 11 Beaufort, according to the requirements of the rough and windy Dutch coastal climate. Those proved to be most energy efficient and, due to their sturdiness, relatively cheap in terms of maintenance costs. Also interesting to mention is that the cheap panel No1, is one of the most expensive in terms of TCO. This demonstrates that a new product service oriented business model will lead to different solution, which potentially higher quality.

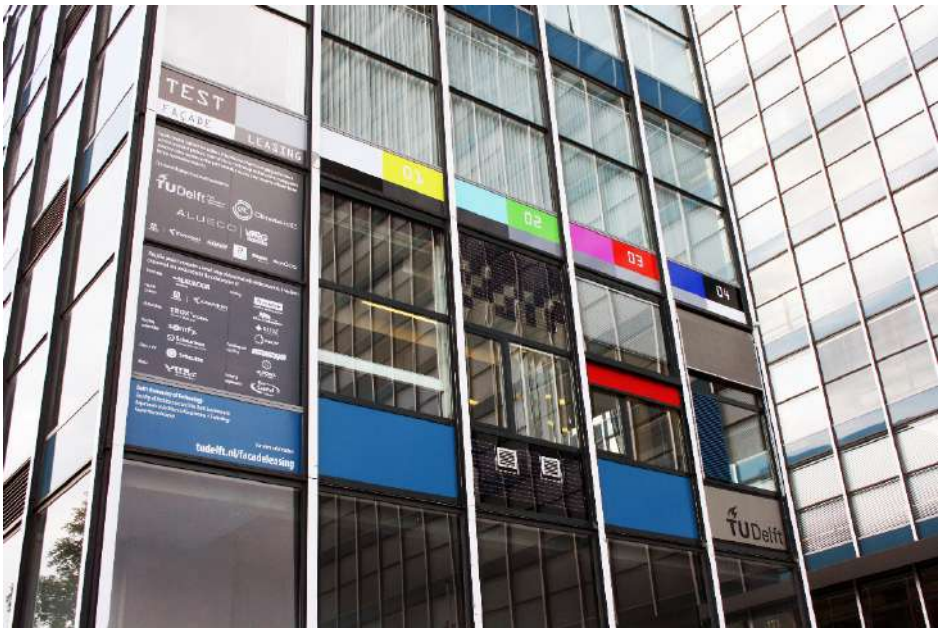

Figure 1. The Façade mock-up at the TUDelft, showcasing 4 different façade configurations

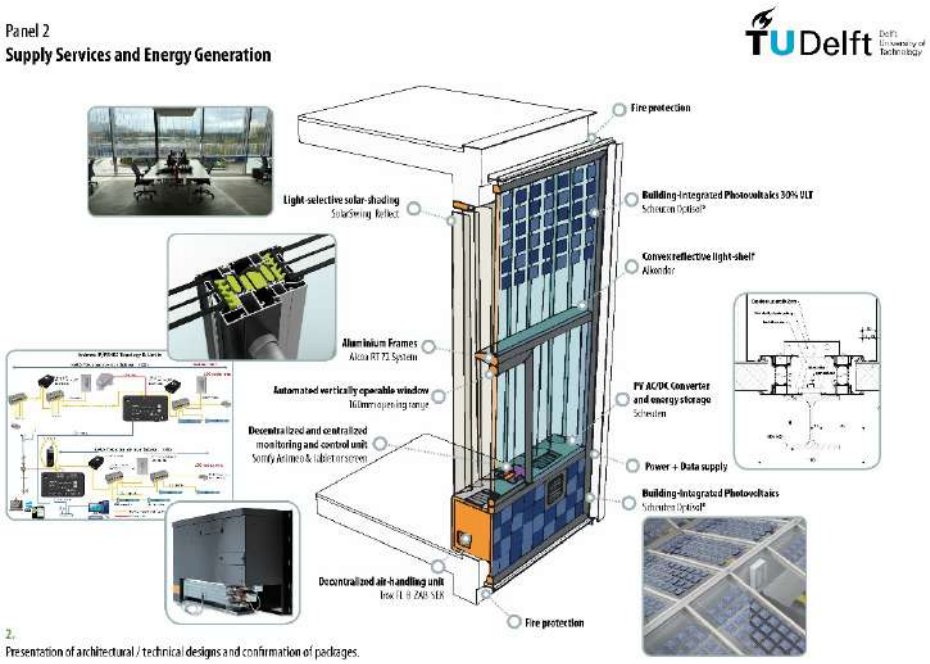

Figure 2. Technological breakdown of Panel 2 of the TU Delft pilot project, showing decentralized building support services. It is the most complex and expensive test unit. The other three panels are constructed with different product configurations of ventilation and shading systems.

4. CONCLUSION

The aim of the pilot project is to research ways of implementing circular construction methods, through product service concepts. It is a fist approach towards a highly complex and new territory and acts as anchor point and collaboration catalyst to further develop the complex system of contracts, financing structures and operational services required to turn the Façade Leasing research project into a feasible and implementable proposition.
In this paper first general conclusion can be drawn:

4.1. SUPPLY SIDE PERSPECTIVE

The project demonstrates the state-of-the-art in façade-integrated technologies. Especially the integration of building services and façade construction components is very challenging for the industry partners. It needs new project consortiums that bridge the traditional crafts. Generally, the façade industry is very mature and able to manage complex processes, oriented towards the whole life-cycle of facades. But it needs a considerable change in their management structures. The shift from a product delivery towards a service oriented industry can open new business fields and higher profit margins.

4.2. DEMAND SIDE PERSPECTIVE

The TU Delft has just formulated the goal to achieve higher circular standard throughout the whole organization. The concept of leasing facades generally offers a potential for a more flexible building stock management. The high initial investment can be translated into a monthly leasing fee, freeing investment capital. The main hurdles to overcome are reforming traditional decision making and managing structures. The whole procurement and facility management strategy needs to be reformed, potentially freeing personnel by outsourcing services.

4.3. LEGAL AND FINANCIAL ASPECTS

Building financing today is based on asset related values. Leasing concepts are challenging these financial models, since the ownership of building components, such as facades, would be held by external parties. That also raises legal questions. At the moment we are looking at lease in perpetuity concepts. Experts involved in this project agree that also legal and financial models will have to get innovated to accommodate new circular building models. Banks such as the ABNAMRO are working with us to develop new approaches.

4.4. A NEW APPROACH TO CIRCULAR BUILING

Generally, the concept allows a whole life-cycle view on the performance of the façade. Builders and system suppliers stay involved during the whole time and have the incentive to choose construction methods to optimize the performance and minimized maintenance costs. Possible changes and upgrades, desired by the client, can be accommodated and technical provisions can be made. A maximized residual value at the end of the life-time can have a considerable effect on the cost of the façade. In opposition to the current linear approach, this concept would certainly support circular building methods. However, the mock-up was build using traditional construction methods. These are very limited in its disassembly potential and thus allowing for a reuse of components to a higher level than simple recycling. With the need for circular building methods, we can expect a positive impact on the development of new building products as well at the development of a market for the 2nd life of building components.

5. THE FOLLOWING STEP

In early 2018 the project consortium has received further funding from the EIT Climate-KIC for the upscaling of this research pilot project to a large scale practical demonstrator case-study. Targeted is the renovation of the East Façade of the Civil Engineering building at the TU Delft. Final methodology, and objectives of this new project stage are currently being discussed, and will be made public as soon as they have been agreed upon by all parties involved.

While the 2016 EWI pilot project focused on the showcasing of available decentralized façade technologies, this demonstrator case-study brings together architects, builders, developers, and managers of buildings, as well as lawyers, financiers, scientists, and business developers, to produce the first practical example of a Façade-as-a-Service performance contract.

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