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Smart Cities for Smarter Citizens: Participatory Planning in Housing Renovation using 3D BIM Tools: the Case of Eckart Vaartbroek

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1 ABSTRACT

The Triangulum Project is one of the first Smart Cities and Communities (SCC1) Lighthouse projects under the European Commission's Horizon 2020 programme for research and innovation, developing urban laboratories in Eindhoven (NL), Manchester (UK) and Stavanger (NO). These labs serve as testbeds where new technologies and innovative approaches integrating energy, transport and ICTs[1] solutions are tested so that successful cases can be replicated in other areas of the city and beyond. In Eindhoven, one of the objectives is to change the concept of the Eckart-Vaartbroek neighbourhood from a low-priced housing area to a modern, energy-efficient one (approx. 15,000 m2 of living area). With an ICT-based 3D BIM tool (WoonConnect) the tenants can customise energy-retrofit packages for their dwellings. Within the combinations, the residents can choose between options that include insulation, improved glazing, solar panels and increased use of renewable energy. Furthermore, the co-creative approach aims at raising awareness of the opportunities for reducing the energy bill, including recommendations such as changing human behaviour. Thus, it allows all parties to identify appropriate measures to be taken to achieve maximum energy savings. At the same time, the tool intends to empower the user through the architectural design process and to enhance citizen engagement. During the project lifetime, this neighbourhood is turning towards a renovated and sustainable district. The experience of Eindhoven in implementing this solution provides a starting point for initiating replication of similar projects in any city willing to invest and promote smart participation and citizen participation in planning and implementation.

This paper explores Eckart Vaartbroek's dwelling refurbishment use-case as a reference for a co-creative process of architecture and urbanism using ICT and 3D BIM-based solutions.

Keywords: Netherlands, energy saving, digital tools, co-creation, Smart Cities

2 INTRODUCTION

2.1 The Triangulum project

The Triangulum project was one of the first three projects chosen to receive funding within the Smart Cities and Communities Lighthouse projects under the EU's Horizon 2020 framework programme for research and innovation. The Lighthouse Cities Manchester (UK), Eindhoven (NL) and Stavanger (NO) serve as a testbed for innovative smart city solutions focusing on energy, mobility, ICT and business opportunities. In parallel, the three so-called Follower Cities of Leipzig (DE), Prague (CZ) and Sabadell (ES) are developing a strategical plan to become a smart city based on the experience, challenges, and lessons learned observed from the Lighthouse Cities. This deployment of solutions shows their potential beyond the technology to create positive energy districts, reduce greenhouse gas emissions and energy consumption, improve the public transport and quality of life as well as to promote the innovation ecosystem and citizen engagement.

2.2 Lighthouse City of Eindhoven

Eindhoven is the centre of the so-called "Brainport" Region, which has the vision to become the largest Dutch and European leading innovation and technology hub until 2030. Today, the city is one of the three most economically prosperous areas of the Netherlands, delivering about 14 % of the national gross domestic product (GDP) (Garrido-Marijuan et al., 2017). Within Triangulum, two districts - Strijp-S (former Philips headquarters) and Eckart Vaartbroek – are being transformed into sustainable living environments. Eckart Vaartbroek is a residential area in Eindhoven, where energy-efficiency renovations were carried out on the social housing stock that predominates in this area.

[1] ICT: Information and communications technology

ISBN 978-3-9504173-8-8 (CD), 978-3-9504173-9-5 (print)
Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI, Clemens BEYER, Judith RYSER, Christa REICHER, Canan ÇELIK

3 REFURBISHING SOCIAL HOUSES IN ECKART VAARTBROEK WITH WOONCONNECT

Within Triangulum, the neighbourhood Eckart Vaartbroek is being transformed from social housing from 1960 into a smart social housing district, aiming to become Eindhoven's leading innovative low energy district.

3.1 Eckart Vaartbroek

Located in the north of the city, the neighbourhood contains around 5.000 housing units that are either privately owned or owned by housing associations. An example of the latter is the social housing company Woonbedrijf[2] that owns 1.900 units, of which 70 were refurbished within the Triangulum project. The building typology is quite homogeneous in the area, as many lower-price European districts. However, the current population diversity, where senior and retired citizens are cohabiting with young lower-middle-class families, needs an upgrade of the public and social environment.

3.2 WoonConnect: an ICT-based use-case and 3D BIM-based solution

WoonConnect, a software developed by the dutch company De Twee Snoeken (Fig. 1), was developed outside the Triangulum scope. It was chosen for testing co-creational housing refurbishment by the housing association Woonbedrijf in Eckart Vaartbroek. The tool was designed to enable an interactive renovation process by providing tenants or homeowners with the opportunity to manage their energy consumption through renovation measures and behaviour insights (Gemeente Eindhoven et al., 2018). This is possible since the digital 3D-tool allows the housing association and apartment owners to improve their dwellings and see the impact of their actions in terms of energy consumption (i.e. showering, heating), contrasted with the expected results of a renovation. In the case of Woonbedrijf tenants, the set of measures was predetermined. The measures chosen can be visualized along with the respective rent/cost implications of each dwelling, allowing the inhabitants to make a more informed decision regarding the refurbishment of their buildings.

This use case aims to involve tenants in the process of renovating and maintaining the homes that are owned by the social housing association Woonbedrijf. Tenants can initiate their home refurbishment, as they have the chance to customize and plan the renovation start at a time that is most convenient for them. The tool enables tenants to make informed decisions on what pre-defined renovation options they want to realize. To use it, each tenant gets an own login code to the platform. The tool provides direct feedback on the web-application what the influence of renovation is. Thus, the tenant can directly receive an offer for a renovation option.

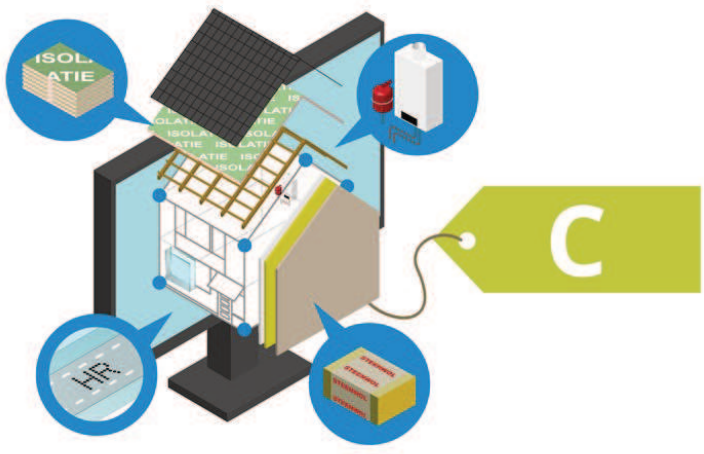

Fig. 1: Illustration of the WoonConnect tool with an energy label C. Source: De Tween Snoken.

More than 50% of the tenants have used WoonConnect by themselves or with the assistance of friends or family after a short demonstration of the program. The latter was facilitated by the tenant-guidance-worker of Woonbedrijf (Wijngaard, 2020). The hands-on experience with the tool creates a new sense of influencing power and was accompanied by several direct interactions to capture the preferences of the tenants. Besides,

[2] Also known as Stichting Woonbedrijf SWS.Hhvl

the renovation allows the housing association to directly interact with the tenants, working together on improving the living conditions in an individual household level. Conversations face to face with them at their kitchen tables was part of Woonbedrijf´s unique approach, which opted for the individual renovation of houses according to the tenant wishes as opposed to what housing associations usually do. A total of 225 out of the 254 homes that were part of the Triangulum project used WoonConnect for renovations. The missing 29 houses did not use the tool due to initial technical challenges of the instrument and also difficulties to carry on with a renovation process at that time. The latter tend to renovate whole housing blocks at the same time and in the same way (Gemeente Eindhoven et al., 2018).

The WoonConnect tool offers several renovation options. A basic renovation package with a selection of measures is paid by the company with funds from the European project. The selected measures available in this package are new insulated roof, exchange of single-glazing to double-glazing, new ventilation system based on a CO2 sensor, new layout of homes (i.e. bigger bathroom), among the most relevant ones. Installing a new or larger skylight, solar panels on the roof, and specific toilet, shower and kitchen artefacts are considered additional measures and therefore paid by the tenants by an increase of their rent. (Woonbedrijf, 2018). In the area, according to the information collected and monitored within the project, 7918 m2 social housing buildings have been renovated, reducing GHG emissions by 20.43%. The estimated energy bill reduction is 61%. For the digital renovation platform of Woonconnect, 284 people (28.6%) used it (74 houses were refurbished within the project scope), and 174 made a plan (scenario) for the renovation of their home (Evans et al., 2020).

The payback period varies from 18 years for the houses installing solar panels and upgrading the mechanical ventilation of their home to between 35-50 years for the rest of the basic renovation measures. The payback for the basis renovation for Woonbedrijf comes in the future when increasing the rent and reducing their budget for regular maintenance. In the case of the tenants, they have a lower energy bill and therefore, an overall decrease in their living costs (Wijngaard, 2020). In terms of energy savings, an improvement of the energy label[3] for each renovated house is foreseen. As a result of this demonstration in Eckart-Vaartbroek, 20% of the homes are at energy label A, and 51 of the 74 tenants from the houses funded by EU-funding chose as an extra measure to improve the energy label.

Furthermore, the Eindhoven partners have conducted three tenant surveys with an above-average tenant satisfaction rate of 7.5. The first survey took place two weeks before the start, the second during and the third one five weeks after the renovation. Moreover, more than 50% of the tenants are making use of the digital tool by themselves.

After each renovation, an increment in the energy and resource efficiency is expected. The implementation also builds a database of possible solutions and measures adapted to a specific type of housing. Thus, a live 3D BIM[4] record of the housing stock is created to be used for later maintenance, and it will support the renovation process by producing the necessary documents and tracking decisions (Gemeente Eindhoven et al., 2018).

The co-creative approach was based on an active participation model. The use of this tool is called co-creative design process as the tools enables tenants to customize and make their own choices for the renovation of their home, especially compared to a standard renovation process of social housing. The participation model started with direct kitchen-table interviews in 200 homes and followed with the preparation of the renovation plans based on the outcome. All renovation measures and upgrades were designed and developed based on these participative sessions with the tenants. To prepare the tool for the tenant, the plans were entered into the Woonconnect tool, and a guided process to familiarise them with the platform accompanied this phase (See Fig. 2). This enabled tenants to make informed decisions on the renovation options. In total, the development of the 3D tool took between 2-5 years, whereas the implementation time of the renovation is less than half a year (Lämmel & Stöffler, 2020). According to Woonbedrijf, the development time took longer because of the innovative nature of the tool. In future implementations, this time is expected to be reduced to 1-2 years (Wijngaard, 2020).

[3] According to the Dutch regulations, houses and other buildings must have an energy label that measures the energy performance certificate of the edification (Business.gov.nl, 2020).
[4] BIM: Building information modeling

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Fig. 2: Explanation of how to start the renovation process. Source: Woonbedrijf.

Apart from the refurbishment scenarios and the savings calculations in the energy bill, WoonConnect also features an online survey which collects input provided by the household. The survey collects qualitative information that provided the Municipality of Eindhoven and Woonbedrijf with an idea of the resident´s involvement in sustainability projects as well as an overall view of the satisfaction with the neighbourhood (Gemeente Eindhoven et al., 2018).

Also, to measure the energy savings, smart meters have been installed in all the houses. The main idea of having these devices was also to create a visual tool to make users aware of the behavioural changes they can pursue to reduce their energy consumption. Therefore the data is being used by the network operator to develop other tools that might help users to translate the energy consumption of the user into a user-friendly platform for the user to understand their behaviour based on their energy consumption. The energy network operator pays instalment and maintenance of the smart meters and is also in charge of feeding back the excess of energy generated into the grid.

Moving to the implementation of the use-case, supporting factors framed in legal, infrastructural, and social areas were crucial. In legal terms, the housing association is bound by law to maintain and improve the houses (Government of the Netherlands, 2019). In terms of infrastructure, the type of homes where the digital tool and the renovation were executed is present in the Netherlands in high proportions, approximately one million times (Lämmel & Stöffler, 2020). This represents the opportunities for scaling-up the ICT solution in the country. The last supporting factor is the social one, which proved to be a base element but at the same time a challenge. In general terms, there is a high usage of new technology; however, it is not always common in several relevant tenant groups.

4 DISCUSSION

This section addresses the challenges and lessons learnt throughout the Triangulum project and hand by hand with the implementations. Furthermore, it reflects on the importance of ICT in urban development.

4.1 Lessons learnt

In the specific case of this 3D-ICT tool WoonConnect, these were highly related to the users' engagement. As part of the lessons learned the direct and personal interaction at kitchen-tables was highly crucial for the success of the project. To get to know the customer was identified as a key to reach the implementations trying to foresee if the digital tool was right for the user. Before starting, the design of a customer journey is crucial. From this, two things were identified. First, the user needs some help to get started; and second, a 100% self-service tool is not entirely realistic. The user's engagement is vital but needs to be promoted from the neighbourhood level through social groups, etc.

4.2 Challenges

In terms of challenges, the privacy issues were very relevant for the tenants, which at first were not keen to share their data. It was necessary to create enough trust to collect the data. The involvement of many partners and their interest in different types of data made the households feel afraid about the questions and uses of the information, for instance, the energy data collection was only possible through the energy provider company and the consent of the tenants. The scepticism affected baseline construction and monitoring. Another challenge was the digital-friendly level of tenants. In some cases, older people were not able to use the tool by themselves but only sometimes with the help of the family. Moreover, the high maintenance costs and some technical problems were an issue.

4.3 The importance of ICT in urban development

The smart city infrastructure includes the physical and ICT aspects of the city. The physical infrastructure consists of the actual structural elements of the city, including buildings, streets, railways, electricity and water supply facilities. In contrast, ICT infrastructure refers to any communication infrastructure such as fibre optics, Wi-Fi networks and wireless access points, along with service-oriented information systems. ICT is considered a vital component of the smart city concept, supporting the integration of different urban systems and their operational processes to improve the quality, performance and interactivity of urban services. The use of information and communication technology and real-time data processing enabled the development of safer, faster and reliable smart city infrastructure systems (e.g. energy, transport, governance) (Mohanty et al., 2016). ICT also seeks to reduce costs and consumption of resources and encourages citizen participation. Some of the most widespread ICT solutions are energy management systems, traffic control systems, intelligent networks, urban data platforms, mobile applications, etc. In terms of the benefits experienced with the implementation of the use-case in Eckart Vaartbroek, ICT proves to benefit stakeholders in different levels and sectors (Fernandez et al., 2019). The revenues of the implementation were visible in the civil society by reducing the energy bill for tenants; in the private sector, by providing new business opportunities to contractors; and in the public sector, where the initiative was started (Lämmel & Stöffler, 2020).

Although in this case, the main actor was not the municipality or the local authority –Woonbedrijf is a non-profit private company– this solution might be interesting to stimulate a more inclusive real state sector that responds with more sustainable solutions to the citizens' needs. Moreover, this kind of projects are for the public sector attractive as it brings technology closer to their citizens, as well as raising awareness and comply with the city's commitment and goals to tackle climate change. Enabling the weakest, most excluded and powerless citizens to gain or regain power over their lives is what empowerment is all about so under a bottom-up approach, empowerment can be reflected through people' s involvement in the development and decision-making process (Chambers, 1997; Fors et al., 2002). Thus, this case study not only includes the residents but empowers and makes them owners of the renovation process.

Besides the impacts identified and measured within the Triangulum project, external studies about WoonConnect have been executed. The independent consulting organisation Fakton, which works for the Government of the Netherlands, calculated the impact of the ICT tool and 3D BIM solution WoonConnect for municipalities and households. By giving some examples, the results of the study demonstrate substantial

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costs savings on permits, demolition, renovation, and home improvements. For instance, in the category, smarter home improvements the costs and benefits of the refurbishment are instantly evident, providing a transparent process, clear client communication and the facility of working with KPIs. The savings in this field are calculated around €200 to €1200 per home annually with and 8% of savings on home improvement costs. In terms of more efficient sustainability, Fakton found that the insight into the construction of houses, the possible recycling of materials and building elements and the possibility to identify the presence of harmful substances represents savings of €2,400 per home, meaning and 8% of the sustainability costs (WoonConnect, 2018).

ICT, therefore, plays an essential role in helping cities reduce their carbon footprint and make them a better place to live.

5 CONCLUSIONS

The tool has proven to be a good practice within the project, as it fulfils the mission of reducing greenhouse gas emissions and energy costs, as well as involving residents in a co-creative process. Despite the technological barriers, this case study successfully demonstrates the integration of users into the decision-making process of a co-creative design process. Moreover, it stresses the importance of not only involving citizens in such processes but also educating and raising awareness of several opportunities available to reduce their energy consumption.

Furthermore, a city vision where all efforts strive for the same goal must also be taken into account. In the case of Eindhoven, this is the Brainport vision, which rediscovers and highlights the importance of the ICT sector in stimulating further urban development in the city. These city visions must be accompanied by the political will of the city's leader and governments to ensure acceptance and adequate resources. While much effort is focused on other sectors (energy, mobility), ICT has great potential due to its role in unified communications, becoming an integral and fundamental sector for the cities of today and tomorrow. Investing in such solutions should, therefore, be a priority to tackle climate change and foster urban transformations.

The process of becoming a smart city can be seen as a tool that helps to improve the quality of urban life and makes cities more sustainable and resilient. The only way to improve people's quality of life in this context is to involve them in the city planning process and giving them the necessary role for actively shaping this transformation process. In the end, this transformation affects themselves.

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