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Organizing building capacity for NetZero renovation

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ABSTRACT

Dutch existing building stock has, according to Dutch governmental policy derived from the European goals, to be renovated towards NetZero in about 2050. However, this goal will not be reached without new digitalized tools, like BIM, 3D scanning and printing, automation and robotization of production processes. To make automation and robotization possible, standardization must be developed through the design, production and maintenance process. But there is already a standardization present in the current building stock, that can be put to use. For the professionals throughout building industry this means that new proficiency and new knowledge has to be achieved. 21st century skills have to be developed, but only after the 21st century skills for professionals have been researched and defined. This paper aims at explaining the interconnection between ICT innovation, recognizing patterns in the building stock and development of personal skills and proficiency for automation in Dutch NetZero building renovation.

Keywords: BIM, NetZero Renovation, 21st century skills

1. INTRODUCTION TO ORGANIZING BUILDING CAPACITY

The Dutch existing building stock is supposed to be NetZero in the year 2050, with an intermediate goal of 49% in 2030, according to Dutch governmental policy (Klimaatberaad, 2018). This means that about 6.7 million dwellings have to be upgraded to NetZero Energy. It is shown that the capacity of Dutch Building Industry is intended to grow, but not as fast as necessary for the upcoming tasks (Hoek et.al. 2018).

This complex technical challenge can be simplified by using a typology based approach for dwellings, representing the majority of Dutch building stock. However, it is already known that the necessary building capacity for performing such a gigantic task is not available nor

will it be realistically become available, unless automation is pushed to the limit (Van Nunen 2017). The goal of the paper is to show to what extend existing building capacity can be organized for NetZero renovation and to what extend building capacity has to be automated and robotized to achieve public policy. Finally the papers shows which personal skills and knowledge are needed to make professionals in the building industry fit for renovating towards NetZero energy renovation.

The rate of success for upscaling NetZero energy renovation lies within unlocking the data of the housing stock and showing opportunities based on data. When projects are still being based on the scale of a complex there is no room for expanding the market for renovation solutions. The overhead costs of a project put a burden that is too big. There is dire need to recognize repetition within the building stock. This repetition allows us to create solutions that are not only applicable for one complex, but for instance for 30 percent of all dwellings in the Netherlands. The overhead costs (sometimes up to 50 cents per invested euro in traditional projects) will diminish because of this repetition. With BIM we can gather, document and analyze data that visualizes the repetition. That way general features of the building are known, and can be used as a starting point for (deep) renovations, towards NetZero and beyond. It becomes the base for product development as well as concept development

Automation alone will not change the building industry. If every complex or every building at its own needs to be documented, it still is a lot of work, even if building industry can automize or robotize the task at hand. This paper will address a new view at the Dutch building stock which will allow automation for renovation solutions on a much larger scale. The repetition goes beyond the complex but searches for similar components, like roofs or facades in a neighborhood or town. All the knowledge of one roof can then be extrapolated to a similar roof in another street or even another city.

To facilitate upscaling based on repetition, this paper addresses the means in automation, like BIM, standardizing, industrialization, customization, 3D scanning and printing and robotizing, and their potential aid to enlarging building capacity. These means will be discussed in the perspective of knowledge transfer, innovation in building industry and the personal 21st century skills that professionals will have to develop differently from the skills that were present before in the 2000. The digitalization came through in building industry. There will be major changes in means and in skills handling the new means. This gives new input and new directions for institutes for higher education in architecture, building and construction.

1.1. Problem description

The renovation task is eminent. 90% of the existing stock remains but needs to be renovated towards NetZero. The Paris agreement points toward a 80-95% CO2 reduction. The building industry, which in The Netherlands accounts for 21,5% of the total CO2 exhaust, has an enormous task to full fill. On one hand a planned expansion of 1 million buildings and at the other hand all existing buildings that need to be renovated towards NetZero before 2050. The current rate of energy saving in non-profit housing for instance is too low (Filippidou

2018). The renovation task translates into 270.000 buildings a year, 5.200 per week, or simply 1.000 renovations a day (Nunen, 2017). This encounters several barriers:

- At this moment the availability of construction workers is low and the amount keeps decreasing (Economisch Insituut voor de Bouw (EIB), 2018) . There is need for 70.000 extra workers, just to fulfill the current building activities. The NetZero renovations need another 70.000 extra workers, if we work in the same way as we do now (Economisch Instituut voor de Bouw (EIB), 2017)
- In 2017, 63.000 new buildings were built per year (CBS, 2018) , but also 23.150 buildings were demolished (CBS, 2018), resulting in a net growth of approximately 40.000 buildings. This is barely enough for the needed expansion of the Dutch housing stock, which is forecasted to grow with 1 million in the next 25 years. Serious upscaling of new build production is, even according to contractors, not possible. This means that most of the current stock will remain. But also that the part that remains has a need for improvement.
- If building professionals accept the fact that 1.000 buildings a day are needed to be renovated this will have a huge impact at the rest of the building industry. For example 1.000 buildings a day, results in 1.000 permits, and 1.000 facades a day. Current timber workplaces can hardly produce 1.000 a week. So not only contractors are in need for a scale up, also the industry that provides the product needs to grow. (Huygen - BouwhulpGroep - Hogeschool Utrecht, 2017) (TKI-RVO rapport). Typical fail factors for NetZero renovation are widely spread amongst professionals in the building chain (Ravesloot, NetZero Housing Renovation, Fail factors for upscaling and market expansion,, 2016). The cost aspect is also holding back the upscaling. NetZero renovations of complete buildings vary between €70.000- 100.000, which is expensive, even with the quality added. The value added to the building is not in line with the costs. There is an efficiency gap. Notwithstanding this gap, the availability of money is for much households a barrier. The gap however can be closed soon with use of BIM and robotization 2016b (Ravesloot, Accelerating the Speed of NetZero Renovation with BIM, 2016)
- There is no base to come to a decision, especially in the consumers market. There are no examples. Professional parties like housing associations have some knowledge, but the owner-occupant generally lacks this knowledge. So there has to be a way to show the complete quality and cost of a (net zero) renovation. Decision making itself is a major issue in the professional Dutch building practice, there also innovation is needed (Ravesloot, Innovating process factors in improving sustainability of suburban building stock, 2012).

Digital information about buildings allows for all these aspects. Whether it is a maintenance task, a renovation task, or just a simulation of possibilities, the use of building information modelling seems unavoidable and necessary (Ravesloot, NetZero Housing Renovation, Fail factors for upscaling and market expansion,, 2016) (Ravesloot 2016a). With building information modelling many fail factors can be turned into success factors throughout the

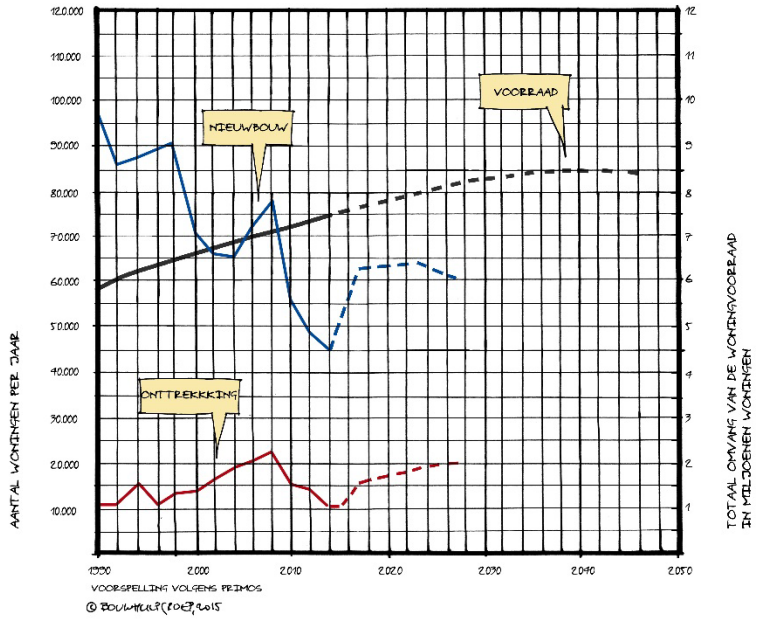

Figure 1: predicted net growth of Dutch building stock

design and supply chain. We see the following advantages using building information modelling:

A. communications through 3D models provides common base for collaboration, avoiding typical problems like different serial numbers in drawings, misinterpretation of 2D drawings, misinterpreted building knots from 2D drawings.

B. design alternatives from different technical and economical perspectives can be optimized. Parameters can be simulated in countless design alternatives, with reporting of effects on design and costs.

C. information of the construction phase can be used earlier in the design process.

D. co-creating partners can influence the design decisions earlier in the process.

Use of BIM is optimal in integrated contracts involving Life Cycle Costing and Total Cost of Ownership (TCO) calculations, prior to traditional procurement on lowest price. At this moment these kind of contracts are not common, and often be looked upon as complex.

1.2. Research methods and approach

The variable in this research paper is the extent to which the building industry professionals have the skills and knowledge (proficiency) to use digitalization to improve and enlarge the building capacity for Dutch NetZero renovation. Influencing failure and success factors are categorized from literature research. This categorization is done from the perspective of contemporary working methods opposed to new technologies as BIM, scanning and 3D printing.

The main research question is:

Which proficiency in digitalization is needed by Dutch building industry professionals to positively influence factors improving and enlarging building capacity in Dutch NetZero renovation?

Through interviews with experts in Dutch NetZero renovation best practices are listed. Typical technical and economical specifications are researched from documents in the projects In these projects the categorized factors are identified. In a comparison of projects on a linear timeline, the projects are compared. The question is to what extent available innovation in digitalization will improve the Dutch building capacity for NetZero renovation. Then the question is what this would mean for the knowledge and skills of Dutch building professionals?

2. 21st CENTURY SKILLS FOR NETZERO RENOVATION

Because the amount of buildings that have to be renovated, more expertise is needed in this field of building activity. At this moment literature depicts several trends going on with renovation:

- Need for energy efficient renovations (Nunen, 2017)
- Demand for circular renovations (Gemeente Rotterdam, 2017)
- Rising individualism (Projectgroep DEPW, 2012)
- Affordability of living (Ministerie van Binnelandse Zaken en Koninkrijksrelaties, 2018)
- For rental as well as privately owned market (VNG, 2018)

If we see this as a wish list, a different approach is needed, because the traditional renovation approach is too expensive, has no room for individual choices and is always based on the complex as one entity. Whereas the solutions are needed in a series of one, and based on a component. But dividing a building into components just adds the amount of data. If seven components are discerned, we are not discussing 7.5 million buildings, but over 50 million components. Digitalization with Building Information Modelling is needed to organize and facilitate this. Based on the research of typology, the basic information is already known, and design, preparation and implementation can be managed by BIM. It also allows for a market based on push, rather than pull (Ravesloot 2012, 2016).

BIM as standard

This means that BIM would become the standard in Dutch NetZero renovation, and Dutch building professionals would need the necessary knowledge and skills of BIM for in 21st century renovation. BIM is a software platform providing communication, exchange and interchange of building process related information, based on sharing of data. The use of BIM can provide a standard for automatization (Volk at.al. 2014). Less risk on human failure in processing data and information is proven by BIM. Less hours on labor and management can be presumably be achieved by using BIM. BIM does not start or stop when building activities are up hand, it is an ongoing way to manage al building related data. From design drawings, to construction calculations, but also the maintenance contracts, the revised drawings of prior renovations, and even the simulations of the upcoming plans.

BIM is part of the disruptive Information Communication Technology (ICT), so the question is not if, but when BIM will be the standard in building industry. Once it is, the production of NetZero renovation can be accelerated, hence leading to less cost.

Dividing the housing stock

The renovation task is huge. The current approach is a complex based approach, often applied by housing associations. But this is a tedious way of observing the complex, describing characteristics, designing plans and organizing the market. It is too work consuming and therefore not efficient. Similar buildings can be regarded as a variation on a type. It doesn't matter whether the building is 10 centimeters more wide or has an extra window. The principal details are what makes the building the building. So if we take another approach to look at buildings, perhaps other solutions and processes emerge.

A building consists of several parts that, combined together fulfil a function. In the past several researchers describes the division of a building into parts (Hermans, 1995), (Eekhout, 1997), (Oostra, 2001)) all from their own perspective. To understand the dynamics of different parts, or for the purpose of development. None of these divisions use the same name. Looking at these three studies and the dictionary, we will use the term component.

A component is a series of building products that, when combined fulfil a function. The reason to look at a part of a building and not the complete building has two advantages. First of all, the level of a component is to be overseen, or even S.M.A.R.T. It is more easy to discuss the performance of a roof than the performance of a complete building. Second the scale of repetition is much higher. A building has much more variables, so the chance a building with all the same variables, will occur is limited. However, when only a roof or façade is regarded much more repetition is possible.

At Rotterdam University of Applied sciences research started to discover the possibilities of a component based approach of the renovation market. This research starts with a cross section of the city of Rotterdam. That gives us a part of the city, which is divided in buildings with components that are similar. Based on this similarity solutions can be developed, but not aimed at a complex of 100, but with a potential repetition of millions.

Dividing the housing stock in a typology or archetype is nothing new, this has been done for years. But leaving the structure of a complex behind opens new opportunities. Industrialization on the component level, development of circular components are for example features based on the production level. But also financially there are new possibilities. Only a component instead of a complete building needs less money. Even financial instruments or lease constructions are more likely to succeed on a component level than for a complete building.

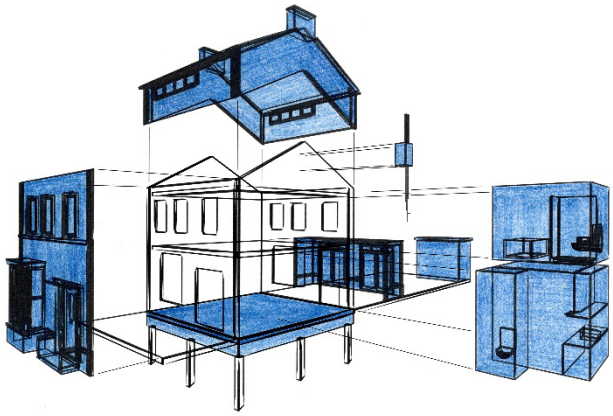

Figure 2: Component Renovation

But component based thinking increases the amount of data. Nowadays information is stored on the complex. So 100 buildings together. But if one building can be divided in 7 components, and each building needs to be documented it can no longer be done manually. The need for a data model is clear.

Renovation to the next level

With components as guiding entity, a new way of renovation can be introduced. First of all the pace of the renovation can follow the pace of the occupant or the pace of the building. For example when windows need to be replaced, the replacement of the component faced becomes an opportunity. With the component façade the energy consumption can drastically be reduced. But all the other components remain in place. That way no materials are wasted before their life span is over.

This adds to the second advantage of Component Renovation, the possibility to develop components with specific qualities. Based on the characteristics of a type of roof, a circular edition could be developed, or a luxurious edition, but also a low cost or an edition with a limited life span. The component level allows for component development instead of building development. This opens doors for small and medium enterprises (SME´s), to develop their own components. Key to component renovation is making sure that single components can be combined. Using BIM the different solutions can be interchanged.

And it is not only the development that can be realized part by part. The use of components allow people to choose form a range of options. Everyone can pick the component that suits his best interest. When a person wants to distinguish himself from the rest, a new façade can be chosen, whereas someone else chooses for the most sustainable façade. The component based approach allows for al these solutions. From a legislation point of view it can be asked whether everything is allowed, for example can every individual choose its own color, not regarding the results of the architecture? With BIM this can also be demonstrated. when all data is known images of buildings and simulations of new facades can be shown up front, and add to the decision making.

One of the main barriers of the upscaling of net zero renovation are the costs. A complete building renovation will cost about 80.000 euro or more. These kind of amounts are not readily available and specially not for individual owners. The current price of a component lies at 10.000-20.000, which could more easily be assembled then 80k. But because the scale of repletion is much larger, it is likely that the costs will diminish.

The previous advantage already mentioned the owner-occupant. In the Netherlands this accounts for about 5 million dwellings. With the component based approach the kind of ownership is no longer an issue. Housing association, owners, project developers and investors can all be targeted at their own specifics. This makes component renovation one of the few solutions that can make the complete housing stock sustainable. But to reach the individual owners, they have to get all the necessary information. This is where BIM comes to use again.

The professionals from building industry handling BIM need to become more mature in their organization and more proficient in their personal skills and competences. Stel (2015) shows from a survey amongst Dutch building industry professionals how very BIM proficient professionals differ from BMI newbie’s, The extend of:

- communication in the organization about BIM;

- sharing information about BIM;
- use of BIM for improvement of internal organizational collaboration;
- help from colleagues in the use of BIM;
- use of BIM for improvement of external organization collaboration;
- experience with BIM projects;
- enthusiasm to others to encourage to use BIM;
- communication about BIM Outside own organization;
- general actions to always improve BIM implementation.

It can be concluded easily that the above mentioned skills and competences are not only related to BIM. The skills and competences are not on the level of technical knowledge and technical proficiency, but more on the soft factors in human interaction during collaboration in engineering. This gives important information on curricula for building engineering education.

3. CONCLUSION

The NetZero renovation of 1.000 buildings a day is a task the building industry is not equipped for in 2018. Not in the decision forming process, not in the preparations and not in the production. The building industry lacks people to organize the process and do the building work, because most labor is done manually. Smart tools allow each individual to make smart choices for their NetZero home renovation. The consequences (cost, energy saving, maintenance, etc) can be seen in the perspective of finance and total cost of ownership.

Dividing the housing stock in components is a new way to look at the task that lies for us. We can chose which component to improve. With Building Information Models these choices can be transformed into plans, ready for permit process, and even for production. But the current employees are not equipped for this task and need another mindset. The goal of this research is to illustrate the need for automation of the renovation process and in the same time show possibilities to renovate step-by-step. The success of upscaling NetZero renovation depends on the availability of data and renovation opportunities. They are Decision forming tools for renovation. These tool have to be used by building industry professionals who can organize themselves with a high standard in maturity and with highly developed soft skills and competencies making them highly BIM proficient.

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