PERFORMANCE OF RETROFIT WITH ICT OF SOCIAL HOUSING - PROVING TECHNOLOGY OPTIMISTS WRONG?

Christian Koch [1] and Asmus Larsen[2]

[1] *Division of Construction Management, The Department of Architecture and Civil Engineering, Chalmers University of Technology, SE- 41296 Gothenburg, Sweden*

[2] *Ajour DK-5250 Odense, Denmark*

The costs of social housing retrofit are critical for social housing companies, for efforts to build sustainable cities, and for society. Compared to available resources, retrofits are deemed costly, and there is a need to improve productivity. One approach is to realise digital integration and (partial) automation processes, creating more performative digital practices. However what digitalisation should target and its scope is difficult to decide. Even standard concepts like Virtual Design and Construction (VDC) have many variants. To capture the performance gain of digitalisation requires measurement methods, while most methods are designed for new built and production, and does not appreciate the costs and values that characterize retrofit using digital practices. This paper aims at conceptualizing a method for understanding performance in digitalized retrofit of social housing. A review of approaches to productivity, efficiency and performance is done. Values produced are multidimensional and cannot be reduced to costs per m2. Performance is proposed conceptualized as values produced for clients, tenants and companies, and then compared to costs and effects of the digital practices. The context is two phases of a large Scandinavian retrofit project, followed by a longitudinal study using a mixed method approach. The social housing consists of 900 apartments in blocks and in row houses at 70.000 m2. The refurbishment encompasses new bath rooms, ventilation and parts of the building envelope. A gradual VDC implementation is carried out, avoiding an ambitious overall implementation. The performance is dependent of hybrid ICT and organizational practices, where the interaction with tenants is important. It is therefore a hybrid set of factors that lever performance, including intense coordination among contractors, continual communication, interaction with tenants and the craftsmen's learning during production. The impact of ICT is more indirect. Technology optimism or not, It is not technology alone that improves the performance.

Keywords: refurbishment, information technology, performance, stakeholder

INTRODUCTION

The benefits of renovating the European building stock are multiple and go beyond energy savings (Copenhagen Economics 2012, Mangold 2016, Wittchen and Kragh 2016), Yet renovations, refurbishment or retrofits come at serious costs, that should

[1] christian.koch@chalmers.se

Koch, C and Larsen, A (2018) Performance of Retrofit with ICT of Social Housing - Proving Technology Optimists Wrong? *In:* Gorse, C and Neilson, C J (Eds) *Proceeding of the 34th Annual ARCOM Conference,* 3-5 September 2018, Belfast, UK, Association of Researchers in Construction Management, 667-676.

energize a considerable interest in how the renovation can be done in an efficient and societally responsible manner. This includes a series of issues; efficient methods, processes, technology and financing are central. The choice of depth of the renovation is also important, and here the interest is in deep renovation, defined as a retrofit, refurbishment or renovation aimed for the deep refunctioning of the building envelope, heating, cooling, ventilation, hot water and /or the building's mechanical systems (GBPN 2013). Deep renovation could probably lead to improvements in the range of 30% - 50% of performance of the mentioned function areas (GBPN 2013). Through this definition, it is sought to overcome definitory overlaps between renovation, refurbishment and retrofit and to aim at a type of renovation that involves considerable investment.

Moreover, the focus in on the use of Virtual Design and Construction (VDC) as a means to make deep renovation more efficient. VDC is a concept for integrated use of ICT, organisation and management in design-build processes of new built (Kunz and Fischer 2012). However, it can be posited here that it can be accommodated also in the context of deep renovation. Especially, the research project appreciate that a medium-sized contractor has limited resources for "big bang" ICT implementations of VCD, yet at a time have an organisation ready for ongoing stepwise implementation of mundane ICT changes. On this background the questions of the paper are

-How can a VDC implementation be shaped that prepares for performance improvements of a refurbishment project?

-How can a performance improvement of such a VDC variant be measured?

In our response to the first main aim involve capturing characteristics of a particular variant of VDC suited for deep renovation. For the second main aim, a measurement concept is developed, but a guiding question has moreover been, would it make sense to measure price/ work hours per square meter in a refurbishment project? And it is posited that much more is needed to understand the value produced.

The contribution of the paper is first to commence conceptualising a comprehensive digitalization concept for refurbishment of social housing, framed as a VDC variant, technically involving integration of more information systems for supporting the building production process (rather than focusing on design) and a organisationally a VDC variant where tenants are very present and recurrent clients. Second to present a framework for measuring the performance of this renovation VDC variant through comparing two processes of deep renovation carried out on dwelling block with the same technical building features. The comparison consist of four main value/cost dimensions measured in four main steps and in 50 measures in total.

FRAMEWORK OF UNDERSTANDING

Below the framework of understanding is developed corresponding to the two main research questions; shaping of a VDC variant and matching performance measurement concept.

Understanding of VDC

VDC is a concept for integrated use of ICT, organisation and management in design-build processes. The concept has diffused in the industry for a decade and exist in several variants (Kunz and Fischer 2012, Eastman *et al*., 2011, Sen 2011, Andersson *et al*., 2016, Tjell 2016). Kunz and Fischer (2012)-s well-known definition combine visualization, integration, automation, and metrics. VDC would normally operate a

constellation of ICT-systems in what can be called and information infrastructure. Andersson *et al*., (2016) for example argue that VDC is beyond BIM, because BIM is merely information modelling in their view. They provide case examples where Revit, cloud-based collaboration software, Synchro scheduling, Excel, and more systems are brought together (Andersson *et al*., 2016).

An infrastructure understanding of VDC moreover lead to a further focus on the Kunz& Fischer (2012) dimension of integration. For long, systems used in VDC infrastructures has been poorly integrated, but over the years, data exchange standards, such as IFC and other means, have improved the interoperability, leading to lower transaction losses (Gallaher *et al*., 2004 compared to Svensk Byggtjänst 2016). Moreover, this leads to a VDC development where minor steps in the information infrastructure such as new software systems, plugins, more thorough use of functionality, developing object families etc., enters an emergent path of mundane steps only occasionally disrupted by major investments. Such paths are likely to be project and company specific leading to a host of variants (Gustafsson *et al*., 2015). A VDC variant is thus characterised by a particular constellation of information systems more or less integrated in an information infrastructure. This variant would in a deep renovation context probably involve technologies for (re)measuring the buildings and for involving and/or informing tenants in the process.

Importantly a VDC variant would have an organisational and collaborative side. And some VDC variants have indeed also been understood as mainly an issue about collaboration and coordination in co-located and/or virtual practices, such as big rooms (Tjell 2016).

From Productivity to Performance

Construction productivity is usually defined as an output/input ratio of a particular building processes. However, most authors continue immediately to add more concepts to qualify this (Bernold and AbouRizk 2010, Bröchner and Olofssson 2012, Josephson 2013). Josephson (2014) point to three types of definitions

1) Outputs/Inputs

2) A combination of efficiency (doing things right) and effectiveness (doing right things)

3) Includes any characteristics that makes the organization function better.

Performance function is defined as consisting of two factors productivity and effectiveness. The short-term focus on the output of the operation neglects the condition that the business consists of many other components. For example, the performance of the purchasing department might be critical to the success of the company (Bernold and AbouRizk 2010). This understanding has wide reaching consequences. ICT leads to involving a broader understanding of value creation for the stakeholders of the company, appreciating end-users' attribution of final value, the knowledge creation of the participating companies, but also their headquarters spend of resources as a cost.

Performance of VDC in Construction Projects

Counter to the above developed understanding of VDC variants, studies of performance and return of investment of VDC and BIM, in contrast, usually assume BIM and VDC are well described, unitary and relatively stable configurations (Azhar 2011, Giel 2013). They point to a series of aspects of VDC leading to improved

performance. Improved collision control, material take off, coordination reviews are examples (Azhar 2011, Giel 2013, Sen 2012). However, these are portrayed as related to VDC and/or BIM as such, in a non-differentiated manner. And typically, while recognizing the human element of the infrastructure in use, not conceptualising what impact the form of collaboration or organisation will have on performance. VDC-variants that appreciate the close intertwinement in performance of VDC and BIM between the social and the technical such as big room concepts (Tjell 2016) are not measured, even if Kunz and Fischer (2012) propose dimensions for such measurement.

Performance of Digital Practices

Davies and Harty (2013) and Whyte (2011) have studied the performance of digital practices. Davies and Harty (2013) focus on the building site and find emergent digital practices onsite involving building workers and managers related to the use of BIM models on a tablet computer. Similarly, Whyte (2011) in her study of design find examples of digital coordination of design. Engineers and architects develop different relationships with a shared digital model; different software packages and tools have become linked together into an integrated digital infrastructure, which create emerging hybrid practices. Such results call for a renewed understanding of cause-effects relations in use of VDC.

Summary of Theoretical Framework

Virtual design and construction is understood as an information infrastructure of ICT systems, interwoven with a set of collaborative practices. A particular variant of renovation is prevalent probably involving partial BIM-models, technologies for (re)measuring the buildings and organisational approaches for involving and/or informing tenants in the process. These two elements, technical and organisational, merge into digital practices. Rather than large one-off implementation, VDC is developed through adding to an existing ICT-infrastructure in a "puzzle brick" manner, where VDC come to consist of several software systems juxtaposed. Performance is conceptualised through types of values produced for the clients, the tenants and the companies, compared to the costs and the effects of the digital practices. The VDC variant are assumed to contribute to improved performance through digital practices on site and in design in a complex intertwined manner, extending into company knowledge creation and end-user value dimensions.

METHOD

This research adopts an overall interpretive sociology approach. Within this, the research design responding to the two main research questions is a mixed method set up combining qualitative and quantitative methods (Creswell and Clark 2011). This design is mainly due to the complex value pattern generated in the project both in processes and in the final result. It is an important positioning here, that data collected for performance measurement, that are quantitative, is rooted in a number of qualitative evaluations, such as for example decisions on where processes start and end. The research is a longitudinal study following briefing, design, production and commissioning enabling a capture of process cost and values created. The basic idea of the performance measurement is to compare two deep renovation processes carried out on comparable dwelling, one without VDC and one with use of VDC. The context analysed is two phases of a renovation project of entire apartment district consisting of 11 four floor dwelling blocks and 50 row house blocks in total a gross

area of dwelling of 71,000 m2, distributed over 1000 apartments and rowhouse units. These blocks were built at the same time and operated over a long period by the same housing association with similar maintenance across the blocks. The client and operator of this portfolio is a social housing company, with a central office/headquarter, a local association of tenants and the tenants themselves. The contract sum for the deep renovation is 77 million euro plus a design consultant fee of 2.2 million Euro. The timescale is approximately 5 years. The project can be considered as a deep renovation because bathrooms, ventilation, staircase facades, balconies, end facades, bottom back side, roofs are all to be renovated. However, side facades and building structure are major examples of elements not to be renovated. From March 2015, a series of meetings have been held with the project organisation and the participating companies on site. During 2016 most of the engineering and architectural design was carried out. This was followed through quarterly meetings and a round of interviews with representatives of the architects and engineers. In 2017 while the production has been emerging, a series of interviews and meeting observations have been carried out, following the construction processes. 13 days of presence on site including participation in Last Planner Scheduling meeting, informal dialogue, interviews, and round on site has been carried out. The field programme continues week by week the next year. Also in 2017 the contractor has been preparing the VDC variant. Solutions considered include use of drones, upgraded BIM models, improved location based scheduling, tenant's administration, tenant information. Over these meeting the researchers took part in discussing and prioritizing what to implement. It is a limitation of the project that even if ICT is carried out using early contractor involvement here, there has not been a strong ICT integration between architects, engineers and the general contractor. It is likely that learning will improve performance over time and correction for this competing effect to use of VDC has to be corrected.

The Measurement Concept

The project should document performance chances by introduction of a variant of VDC on a renovation project of social housing. This is done by comparing two phases of the renovation process. Four main measures are carried out: Measure 1 is of briefing and design (14 measures) focus on initial specifications, budget, ICT and knowledge resources invested, value expectation. Measure 2 is of the 1. Phase using existing ICT-approach and process. This period ran from start-up in late 2016 until 1 September 2017. Measuring phase 1 us done through a series of units that the renovation is targeting; roofs, bath rooms, ventilation, end facades, lower back side facades, balconies etc. 14 measures in total are put in place. Measure 3 is on the 2. Phase, where the focus is the process using the particular part of VDC. The period extending from the start-up in about September 2017 - late 2017. Measuring 2 shows how the project changes or improves. 13 measures in total. Measure 4 is on the result of phase 1 and 2 focusing on output, the refurbished dwellings. In total 9 measures.

Dimensions to Measure

Following the framework of understanding above, collection of data and qualitative field work is carried out. This covers the following four main dimensions: 1.Company knowledge, 2.customer perception, 3. productivity and 4. real estate economic value.

1. The knowledge in the involved companies is a performance dimension which involves a longer-term perspective. Here ICT will firstly be evaluated how personnel

competence and organisatoric embedded knowledge of ICT-platforms are developed. Second, knowledge is developed in the specific building project. Third knowledge is communicated and shared, i.e. are experiences captured and how are they communicated. Fourth, knowledge about the project material (input) is developed, for example does the actors of the project know, what is expected and what should be produced (output). And where do they seek information. Most of the measures in this knowledge dimension will be qualitative.

2. The customer perception dimension covers the perceived customer value created by the project. This includes satisfaction with the process, evaluation of how the housing association choose add-on optional solutions, a measure of perception of value before and after the renovation project, and finally an evaluation of the impact of renovation on tenants appreciation of quality of life. The measures in this dimension will be a combination of quantitative and qualitative.

3. The productivity measure will focus on the hours spent by building workers on site, foremen and site management distributed on the above-mentioned units. However also hours spent on design, project preparation, management and facility management preparations will be evaluated. The measurement of hours spent will be used to evaluate the units that the renovation is producing including roofs, bath rooms, end facades, staircase facades. In principle, all units valued more than 130,000 Euro will be measured. There is a measure of supply of material including manual work connected to receiving goods. And finally, the costs and investments in IT, software, websites, and infrastructure will be measured. The productivity measure is predominantly quantitative.

4. The real estate (economic) value involves the architectonic value. The value of the renovation for the area. The price augmentation of the estate (including its valuation for taxation purposes). The outdoor areas improvement, and the more symbolic change of a concrete housing district from the 60-ties changed into modern dwellings. The real estate value will amongst other things be evaluated by a real estate broker.

PRELIMINARY RESULTS

Present and Future ICT Infrastructure

19. Present ICT

The present ICT infrastructure comprises well known construction software systems (such as Revit, 2D Autodesk, project web), as well as more generic software (such as ERP used for accounting and material purchasing). The project uses a project web system, where all drawings and documents are stored and shared. The use of spreadsheets is widespread and include control of budgets and project economy. 2D based quality control (QC)-system and digital photos are used a lot, as well as normal email communication. Time planning of operations on site is being done location based on scheduling software used to coordinate and optimize the many different locations and teams to gain better workflows. A major challenge is the many warnings and option lists which is being corrected for the tenants and used by the contractors site management, it is time consuming and hard to grasp.

Future ICT

The future implementation is concerned with integration, i.e. easing the data flows between different actors, data repositories and systems. An essential ICT-optimization to gain better communication and planning between the actors, is the connection between; BIM data, locations, resident journals, options list and graphical

representation of i.e. bathroom types. Location based scheduling is surely a value-adding tool, but the use can be increased by connect time scheduling and the BIM-model. A future planned feature on the construction site is to embed BIM-models and time scheduling (4D). To face the challenge of many different bathroom types and resident options, the contractors are collaborating with the local retailer to optimize the ordering process. The target is to get small and specific units with the right materials and quantity for each bathroom type. Ordered by smartphone tablets.

The Design Processes

In the initial phases, pre- investigations, briefing and interaction with the clients, tenants and housing association representatives was carried out. The architect and engineer companies then elaborated a preliminary project, in compliance with sector agreements, and this project was used for tendering a contractor, which thus became involved in relatively early stage under the banner of early contractor involvement. In the subsequent phase, the main project, was elaborated. The architects chose to operate several partial Revit models of different parts of the building reflecting the areas adopted for deep renovation. For example, a large number of bathroom mock-ups was developed to document the many variants of bathrooms found in the building. The engineering company carried out design of installation, electricity and structural engineering. Revit was used for installation and electricity whereas 2D Autodesk was used for structural engineering. The internal organisation of the project in the engineering company involved a project manager, engineers and technicians that did most of the computer work in the design. The project manager carried out manual collision control, but the test block building revealed more collisions. Some of them due to dimension issues in the BIM models. The architects and engineers carried out design in parallel with the test block building process in 2016.

The Building Processes

From late fall 2015 small parts of the test blocks was made. However, the most of 2016 was spent awaiting final decisions from the client, which in turn waited for clearance for the publicly financed part of the building. By December 2016 is was possible to do the test blocks, which quickly revealed new issues to be solved. The whole building process was a bit delayed over the fall 2016 because of financial negotiations between the residents, the client and the entrepreneur. But still some of the contracts moved on at an increased speed.

Roofs

Especially the roofs, balconies, and the end façade worked out as a fast process. By June 2017 these contracts were about 6 months ahead of schedule. This is partly due to the skilled craftsmen, good management but also new and innovative scaffolding which is movable work platforms that create agility and lower assembly costs compared to traditional methods on the apartments blokes. Exactly the opposite has happened to the rowhouses, where the challenge is total cover of the roof, due to the replacement of the ventilations system. Both scenarios were unforeseen and undiscounted, and it came as a surprise to the management.

Bathrooms

The same issue is added to the bathrooms. The apartment blocks are quite easy to get to know for the craftsmen because the stairwells are equal to distributions to each side. But in the townhouses the types are very much unalike because of the lower heights and a bigger area with many different types and houses over all. A lot of pre-

investigation and registration is going on in the houses before the craftsmen are entering them. This might suggest VDC as a method to gain information in a new way, which could benefit orientation and communication before the craftsmen are entering the houses.

ANALYSIS

The case exhibits many of the specific features of renovation projects in social housing and also on contemporary use of a variant of VDC and BIM. The last aspect first, the project and the participating companies exhibit a fragmented, disintegrated use of ICT in a number of functions and processes. For example, data on the apartment units is maintained by the housing company, yet needed in the contractors planning. There is a non-integrated set of BIM models in play. There is little integration between design models and production planning software. Yet viewed separately many ICT supported elements are clearly in place in the project, such as an active use of location based scheduling. The interaction with tenants, the local housing association and the social housing company has been, what the building professionals experience as lengthy. Negotiations on different elements of the renovation, that should be included or not, continued not only in 2015, but also in 2016, making it hard to determine what the initial specification and budget was (i.e. the input of the performance measure, measure 1). Moreover, when building operations started running in the end of 2016 the interaction changed character into craftsmen directly entering the tenant's home leading to another set of interaction. The main contractor experiences difficulties in timing of demolition and moving of work platforms that made it difficult to comply with early warnings to the tenants. The site management carry out a series of coordination meetings every week, using last planner follow up and scheduling. This is done without ICT-support. Certain units in the building is presently ahead, the renovation of the roofs for example, while others, the renovation of tiles in the bathroom is catching up after a crew of bricklayers leaving the project for another more attractive employment. Finally, another recurrent aspect of renovation is the arrival of surprises during design and building. Here many variants of bathrooms and asbestos plates that has to be demounted in a particular way are examples. Moreover, also the economic capacity and willingness of tenants to invest in improvement of their own apartment came as a surprise.

DISCUSSION AND CONCLUSION

This paper set out to investigate how a VDC implementation can be shaped that prepares for performance improvements of a refurbishment project and how it can be measured? Performance of deep renovation can only cautiously be compared to new build or lighter renovation. It is a central value production for the client that interaction between building professionals and tenants is carried out in a smooth manner. This intervenes directly in the immediate daily building processes. Moreover, despite the active use of location based scheduling, the timing, rhythm of the different crews entering the tenants' apartment is very difficult to manage. During briefing and design the project went through quite some changes. Also, the architects developed experience and knowledge, digital practices on handling partial BIM models and a large number of bathroom variants. During production in phase 1 the contractors use a combination of ICT and meetings to coordinate and assure progress of their own employees and the sub-contractors. This is a digital practice relying a lot on face to face coordination. By June 2017 it is still left to recurrent planning how the

VDC variant will look in phase 2. A series of ICT-support proposals, laying more puzzle bricks into the VDC infrastructure is under consideration. This includes improving the BIM models for quantity take off, ICT-integration of the tenant's choices for the bathrooms, material purchasing alarms in location-based scheduling, 360-degree video filming of apartments, and tablets with building information. Concluding, the investigation of the VDC implementation appear to have improved performance of the refurbishment project and it has been measured what this improvement or change meant. The paper has proposed, first to measure the particular VDC variant in play and second a multidimensional framework for performance including knowledge production and end user valuation. A measurement program has been presented and the preliminary results discussed. In the first run, the existing VDC infrastructure is relatively fragmented, yet performs well on some islands, such as the location-based scheduling and architectural models of bathrooms. The performance challenges of this renovation project mirror many other projects of the same kind within social housing. Nevertheless, a particular performance in the studied context was found. And can in this exemplary manner provide learnings for future projects. It is a hybrid set of factors that lever performance, including intense coordination among contractors, continual communication, interaction with tenants and the craftsmen's learning during production. The impact of ICT is more indirect. It is not technology alone that improves the performance. A pure technological optimism is poorly grounded.

REFERENCES

Andersson, L, Farrell, K, Moshkovich, O, Cranbourne, C (2016) Implementing virtual design and construction using BIM. New York: Taylor and Francis.

Azhar (2011) Building Information Modelling (BIM) Trends, benefits, risks and challenges for the AEC industry. Leadership and Management in Engineering, 11(**3**).

Bassioni, H, Price, A and Hassan, T (2004) Performance Measurement in Construction, *Journal of Management in Engineering*, 20(**2**), 42-40.

Beatham, S, Anumba, C, Thorpe, T and Hedges, I (2004) KPIs: A critical appraisal of their use in construction. *Benchmarking: An International Journal*, 11(**1**) 93-117.

Bernold, L E and AbouRizk, S M (2010) *Managing Performance in Construction*. Hoboken, NJ: Wiley and Sons.

Bröchner, J and Olofsson, T (2012) Construction productivity measures for innovation projects. *Journal of Construction Engineering and Management*, 138(**5**) 670-677.

Copenhagen Economics (2012) *Multiple Benefits of Investing in Energy Efficient Renovation of Buildings*. Copenhagen: Renovate Europe.

Creswell, J W and Plano Clark, V L (2011) *Designing and Conducting Mixed Methods Research 2th Edition*. Los Angeles: SAGE Publications.

Eastman C, Teicholz P, Sacks R and Liston K (2011) *BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractors 2nd Editon*. Wiley and Sons. Hoboken.

Gallaher, M P, O'Connor, A C, Dettbarn, Jr. J L and Gilday, L T (2004) *Cost Analysis of Inadequate Interoperability in the U.S Capital Facilities Industry*. National Institute of Standards and Technology. Gaithersburg. Maryland.

GBPN (2013) *What is a Deep Renovation Definition*? Paris: Global Buildings Performance Network (GBPN).

Gustafsson, M, Gluch, P, Heinke, K, Gunnemark, S and Engström, D (2015) The role of VDC professionals in the construction industry. *Procedia Economics and Finance*, 21, 478-485.

Josephson, P E (2013) *Produktivitetsläget I Svenskt Byggande 2013, Nybyggnad Flerbostadshus Och Kontor*. Stockholm: Sveriges Byggindustrier.

Josephson, P E (2014) *Slide set for Course BOM025 Construction Processes and Management*. Chalmers University of Technology, Gothenburg.

Kunz, J and Fischer, M (2012) *Virtual Design and Construction: Themes, Case Studies and Implementation Suggestions*. CIFE Working Paper #097, Stanford University, CA.

Mangold, M (2016) *Challenges of Renovating the Gothenburg Multi-Family Building Stock*. PhD Thesis. Chalmers University of Technology, Department of Civil and Environmental Engineering, Gothenburg.

Sen, S (2012) The Impact of BIM/VDC on ROI: Developing a Financial Model for Savings and ROI Calculation of Construction Projects. MSc Thesis, KTH, Stockholm.

Svensk Byggtjänst (2016) *Besparingsmöjligheter Genom Effektivera Kommunikation I Förvaltningsprocesser*. Helsingborg: Industrifakta.

Tjell, J (2016) *The Constructed Space of a Construction Design Team*. Gothenburg, Sweden: Department of Civil and Environmental Engineering, Chalmers University of Technology.

Whyte, J (2011) Managing digital coordination of design: Emerging hybrid practices in an institutionalized project setting. *Engineering Project Organization Journal*, 1(**3**), 159-168.

Wittchen, K B and Kragh, J (2016) *Danish Building Typologies and Building Stock Analyses: Participation in the EPISCOPE Project*. København: SBi Forlag.