Creating state of the art? A passive house university hospital north of the polar circle

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Abstract. The recent Norwegian passive house legislation has raised concerns as to whether the building industry was able to build cost-efficient buildings, without overspending tax payers' money and having negative consequences for peripheral areas in particular in the very north part of the country. This paper aims at exploring and analyzing how these challenges created by the new legislation has been met during building of a new hospital block in Tromsø, the A-wing. Building on sustainable transition theory which identifies several recombinant dynamics, both public and private, we define the building of passive houses as a societal development encompassing dynamics like company development, personnel competences, as well as architectural, engineering and production methods. The empirical material draws on interviews, analysis of documents relative to the project and public media material. The case study revealed a mixture of recurrent, and specific cold climate challenges: some are directly related to passive house technologies, such as issues with the façade, others indirectly, such as Tromsø being a remote market for material and labour. The project encountered delays, shift in contracts and cost augmentations. Competences had to be developed and combined to achieve the standards of passive house building and the local workforce was complemented by adding workers from other regions and markets; the south and middle Norwegian, Nordic, Baltic and East European countries. Accordingly, the project was not isolated in the northern part of Norway and its challenges appeared to be rather organizational and managerial than technical.

Keywords: Passive House, Hospital, Sustainable transition.

1 Introduction

In the Norwegian process towards passive house legislation for new built, it has been claimed that the building industry was not technically ready for building according to such norms, and that passive houses standards would impose unduly high level of costs on society, that in turn would imply segregation and poorer living conditions for low resource inhabitants [1]. Most of this debate has also implicitly assumed that Norway building conditions were similar for the whole country disregarding challenges for specific geographic situations. However, climate differences 1000 km north of Oslo, do create special demands for sustainable buildings. Besides, the Norwegian state expects that public initiatives are to lead the transition towards climate change mitigation by first building show case examples, second by generally tighten the demands for public buildings. Similarly, there are political ambitions about a fair distribution of public infrastructure leading to the design and construction of hospitals north of the polar circle. In this specific context, the present paper aims at exploring how one of these hospital projects was realized, what were the actual challenges it faced during the design and production phases, and how were they overcome creating a state of the art university hospital north of the polar circle. To do so the contribution of the various players to meeting the passive house requirement is analyzed. The paper draws on transition and innovation theories as framework of understanding of sustainable building. The paper presents a case study of the A-wing (A-fløya) project at the university hospital north Norway (UNN) placed in Tromsø. It is located north of the polar circle, yet following the ASHRAE classification, in zone 7,"very cold", and not arctic [2].

2 Theoretical framework

The research questions demand a frame of understanding that can study challenges when creating a sustainable building, in this case a passive house building. And conceptualize the role of various players in this process. Sustainable transition theory provides a broad and sociological frame for understanding such innovation. The sustainable transition theory literature developed as a response to the societal challenges of climate change [3]. It encompasses looking at the drivers, emerging actor constellations, technologies and barriers in play. The arguments of "classical" transition theory, the Multi-Level Perspective [4, 5] and the Technological Innovation System [6] is in brief the following: The multi-level perspective views transition as a dynamic of an upcoming niche containing an innovation. The niche is challenging an incumbent regime and technological innovation system. The technological innovation system is defined as "a dynamic network of agents interacting in a specific economic/industrial area under a specific institutional infrastructure and involved in the generation, diffusion, and utilization of technology" [7] p 93. Further the multilevel perspective looks upon innovation in a sector as a socio-technical phenomenon and identify three levels of socio-technical interaction within which sectorial innovation can be explained [8]. The micro level is niches where innovations and new designs emerge protected from market mechanisms. The socio-technical regime forms the meso-level, which accounts for the dominating stabilized socio-technical regime which is reproduced by institutionalized learning processes. The macro-level is formed by the socio-technical landscape, an exogenous environment beyond direct influence of niche and regime actors. Niches are important as driver of innovation and can develop new socio-technical regimes towards a sustainable building sector and a sustainable society [4, 8]. The "classical" transition theories feature some important limits that need to be considered: (1) the use of levels to analyze the different dynamics. These levels risk producing illusions on separate worlds with different dynamics. (2) Conceptualization of many, if not too many, dynamics, which makes its explanatory power weaker (3) An unclear role of (human) agency implies that organized and managed change appear less appreciated among the dynamics. Here the two theories are adopted to provide a broad frame of reference around the building of sustainable buildings.

3 Method

The method answers to the main research questions by doing interviews, literature studies, document analysis, and presence at joint meetings. The literature search gathered material on Norwegian passive house development. The written documents used here encompassing the project's own documentation and project plans, scientific [9, 10, 11] and governmental [12], publications as well as public information. The latter sources are not referenced here. The hospital case was chosen for quite pragmatic reasons as the case was first developed for another study and therefore known by the authors. We followed two years of the development from October 2015, the early building phase to February 2017 where the construction was half way. We carried two rounds of interviews one in March 2016 and the second in February 2017. The design phase commencing in 2014 was documented by a desk study and the first round of interviews. In total, 13 semi-structured interviews were carried out mainly face to face but also as telephone interviews Interviewees were the client (the hospital) project manager, the architects, consulting engineers, the design built contractor, the technical installations contractor and representatives of the future facilities management. The players are identified in the text through their functional role as the interest here is in the building process of a passive house hospital and not their personal profile in line with the theoretical framework. The case material includes a case study published elsewhere (Koch 2017). It is a limitation that the research project has limited resources compared to the long high resource efforts of the A-wing project located in five main organisations in four quite spread geographical locations. It has been necessary to limit the data collection to a few occasions, relying a lot of "ex post" information, information that is built on how actors interpret something that happened in the past.

4 Case: Passive house university hospital in Tromsø

The A- Wing project is not the first passive house building to be erected in Tromsø. The first passive house was a small single-family house, I-BOX 120, finalized in 2005. This started a series of experiences of construction of passive houses in cold climate. The pioneer architect Steinsvik, who designed the first I-Box 120 house, commented on the national development of passive house in 2008: "An irresponsible low competence level of the technical consultants in Norway. That is the main problem of building passive houses in Norway" [13]. Nevertheless, passive competences and interest grew, also supported by national incentives and standards [14, 15, 16]. It was in this context that in 2008-9 a conceptual sketch for the A wing was contracted by UNN and developed by four companies, two Scandinavian players and two Trondheim based. Here the companies noted that the demands of energy performance were to create a passive house realizing high energy performance, a max net energy consumption of 160 kWh/m2 and energy label “A”. The issue of energy performance was integral, yet peripheral for the UNN strategy considerations in 2009. Location and costs dominated the strategy considerations. UNN decided to go for development of the A-wing and the Patient hotel on the existing site in the town of Tromsø. Upon the sketch project and the strategic decision, UNN initiated a concept project for the A-wing, that was conditioned again to an energy performance at label “A” and 160 kWh/m2, yet the demand for passive house level was not included. This was for a hospital building at contemporary Norwegian standard. The concept project was developed accordingly. In parallel to this a sketch project for the patient hotel was contracted in 2010 and continued with a design build contract in 2011. The main engineering consultants, a large national player, stated: ”The patient hotel should satisfy demands for passive house according to NS3701, something that put strict demands on energy design. [Our company] has contributed with consulting and simulation to reduce the need of cooling.... We ... also controlled the heat loss of the building through the building envelope (inclusive thermal bridges) is compliant with passive house demands and through collaboration with the architect contributed to making critical details moisture proof” (project presentation sheet). There thus appears to have been a slight difference in the energy performance demands for the two new buildings; the A-wing and the Patient hotel.

In 2012 a competition for the design of the A-wing was won by two Scandinavian companies an engineering company and an architectural company. The task was to do a functional specification project of the Awing. This involved specification of rooms. The building envelope stay largely as it was designed in the pre-project. In parallel the construction of the patient hotel commenced giving the design built contractor further experience building large scale passive houses. In 2012 the Norwegian government announced its future energy plan where passive house should become the legal demand for new built by 2016. In the same period, southern and mid Norway reached a considerable amount of realized passive house, SINTEF estimated a 1000, and a solid body of scientific documentation for selected projects [9, 10].

In 2014 the architectural and engineering design of the A-wing commenced. The latter was organized according to contracts for each technical specialism, preparing for a similar contractor structure. The client UNN shifted project manager and contract strategy however, to design build contracting, mainly to mitigate perceived risks in the project. At this time, the consulting engineer interpreted that the design was about 90% ready. At later stages tensions occurred on the degree of finalization. The client carried out a prequalification and tender and appointed of the later design build contractor and HVAC contractor that teamed up for offering the bid. Detailed design was ongoing in parallel at Architect and Engineering consultant. In 2015 Enova supported the A-wing as passive house at 6 mill kr (Enova is a body owned by the Norwegian Ministry of Petroleum and Energy and administer a series of incentives that contributes to reduced greenhouse gas emissions, development of energy and climate technology and a strengthened security of supply [17]). This assists in keeping the hospital at its goal of doing a passive house. In the summer, a design-built contract was signed at 683 million kroner, changing the concept to a double length and another facade. The costing estimations in this unusual contract, mostly reflect a risk management concern whereas passive house technologies were considered as known. In total 22.000 square meter, and a budget at 1,6 bill. Kroner, constituting a cost increase at around 400 million NOK compared to half a year earlier. The design-built contractor received a very detailed material from the architects and engineers and took over the risk on that basis, but also had to calculate material costs, that elevated the price. This was a general issue and not directly related to passive house elements. Yet the new approach to the building shell leads to roughly 9 months' design of the steel structure and a new prefabricated façade concept also involving the supplier. Part of this design was done by a sub supplier specialized in facades, which came up with a simpler and modular façade design than the one proposed by architects and engineering solving the insulation challenges. The building site activities commence in the autumn with demolition of the existing A-wing. While the construction continues in 2016, also auditing of work-drawings of HVAC involves negotiations between architects, engineers and the HVAC contractor. By august the contractors deliver a "tight building". Subsequently installation works and others worked downwards in the building commencing with the 10^{th} floor. The complex technical installation of the surgery theatres was carried out in parallel. An external HVAC expert was hired to audit the HVAC design. Many issues were found and corrected. In 2017 construction continue and the two main contractors and their sub-contractors hire construction workers from middle and southern Norway, Scandinavia,the Baltics and eastern europe. The lean based takt planning means that carpenters, plumbers, electricians, tile setter and painters follow each other. And the project was on schedule until October 2017. By May a gradual handover for operations began, planned to commence by January 2018. The performance at passive house standards is yet to be proved when electricity consuming equipment [18], employees and patient enters the building in 2018.

5 Discussion

The challenges of creating a state of the art university hospital at passive house standard north of the polar circle proved to be multiple and both of indirect and direct character. The encountered challenges that can be viewed as classical for public infrastructure projects. A prolonged time period, shift in contract form and cost augmentations. The shift in contract form meant that part of the knowledge with two Scandinavian operating consultancy companies was substituted with the design -built contractors competences and network. In terms of the specific creation of passive house performance, a series of actors' competences had to be developed and combined. The early architect competences of passive house technology and design approaches was transferred through documents to larger players, that focused on other aspects along with the client. But a foreign façade supplier also played a role through simplifying the building envelope design and offering a modularized solution. This supplier had competences on passive house techniques and Norwegian legislation from previous contracts in Norway. The HVAC and design built contractors craftsmen and building worker where a combination of mostly local, but also some migrant workers. There were clear signs of an impact of a local market of buildings, in particular a core of craftsmen only avaible at two or three companies. The hospital building required specific competences related to for example mounting of lead enforced gypsum walls and wall mounted toilets. Also, coordination issues occurred when basic electrical and ventilation installations were to be coordinated with major foreign equipment suppliers (such as surgery theatre suppliers). The competences mobilized were therefore quite a mixture of local, national (further south based), Scandinavian and Baltic origin. The A-wing project commenced and was conceptualized, while passive house technology was early days in Norway. Notably, the first passive house in Tromsø was made 2005- 2007. This is contemporary with the very first in Sweden [19] and earlier than the first in Denmark [20]. Moreover, even if Tromsø hosted an early mover in creating small passive house, most of the Norwegian trajectory preparing for the 2016 law enforcement have been carried out in southern regions of Norway [9, 10]. Clearly a demographic explanation would appreciate that most Norwegian people indeed live there. 35% thus lives in the largest six town in the south: Oslo, Bergen, Stavanger, Trondheim, Fredrikstad, and Drammen. In an international perspective, such a concentration is not unusual. And it also leads to concentration of passive house competences.

Enova, the national administrator of the incentive program for energy innovations supported the A-wing project and its passive house aspect. This support was instrumental for keeping the ambition. Not only industry experience, but also much of the documented research come from Trondheim and further south [9]. Even if single family houses were constructed early (2007), the transition from this niche to larger buildings took time. In multilevel perspective sustainable transition theory terms, the early single-family houses are the early niche experiments and subsequently the design become "dominant" and can move to larger buildings. The Patient hotel and the Alta fjord panorama were finished in 2013. The A-wing immediately after consolidated the innovation. Especially the patient hotel, at the hospital campus in central Tromsø developed competences by the actors. The possibilities of making sustainable innovation in public hospital projects is constrained by the long time span from conceptualization to finalized building. In this case the option of innovating to passive standard was adopted around 2009. Once construction began in late 2015, sustainable innovation of buildings in Norway focused on energy plus innovations [11] and the design built contractor found passive house technology a "walk in the park". The process emerged from very little knowledge in 2005 to the public energy plan of 2012 prescribing passive house as obligatory for new build by 2016. A relatively stiff push forward of passive house regulation thus risk hampering further steps of sustainable innovation, such as energy plus. There is a continual need for innovative steps with/ without public support, going beyond present legislation. The Norwegian state have indeed initiated further R&D, but also companies should advance their strategies.

6 Conclusion

This paper set out to scrutinize what special challenges has been met when creating a state of the art university hospital north of the polar circle? and how were they overcome? Also considering the contribution of the different players. The theoretical framework adopted understands sustainable transitions of building as occurring as result of a number of recombinant dynamics, two mains being important. First a niche development of sustainable buildings that come to challenge the incumbent regime of traditional building. Second a pressure of European and national law and regulation challenging the incumbent regime. There were many challenges of creating a state of the art university hospital at passive house standard in a cold climate. The hospital project encountered prolongation in time, shift in contract form and cost augmentations. The prolongation decoupled the design from further energy innovations. The shift in contract form created barriers for knowledge transfer between players, but at a time opened for another type of risk sharing, that was more expensive but also potentially safer. A series of actors' competences had to be developed and combined to create a building at passive house standard. For some passive house technology was well known, for others it was their first time using it. The early architect competences of passive house technology and design approaches was transferred through documents to larger players, that focused on other aspects along with the client. A foreign façade supplier, that was hired at a late stage change the building envelope design an assured the compliance with passive house standards. The HVAC and design built contractors craftsmen and building worker were a combination of mostly local, but also some migrant workers predominantly with little passive house skills. There were clear signs of local market impact, in particular of craftsmen. The competences mobilized, were thus quite a mixture of local, national (further south based), Scandinavian, Baltic and Eastern European origin. The development of the A-wing hospital project did not occur in a northern vacuum. As the sustainable transition theory posits, building passive houses is seen here to be a societal development. The project is embedded in societal dynamics like company development, personnel competence development, architectural, engineering and production methods and this is where the most challenges emerge from, rather than adopting and using passive house techniques in a narrow sense. And paradoxically, once finished, the hospital will be modern it is level of sustainability yet not state of art anymore as buildings in 2017 should contribute to energy production, be sustainable over a life cycle and be economically, environmentally and socially sustainable.

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