

Three stories describing the impact of research on the development of Norwegian Construction industry

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Abstract

Increasing focus on energy and climate performance is challenging the construction industry. At the same time globalization of the economy is a driving force for improving competitive advantages. Involving research and developing new technology are among the strategies to meet these challenges. This paper presents three role model projects with goal-breaking performances. The history of these projects illustrates how R&D is involved in the ongoing processes of change and improvements within the construction industry. The cases includes Vennesla library illustrating innovative use of wood, Powerhouse #1 illustrating innovative energy solutions, and Brøset neighborhood illustrating plans for ambitious sustainable urban living. Using an innovation system approach we focus on the institutional framework supporting the development processes. Four elements are found to be of special importance in the development history of the three case projects: a) collaboration via research centers with industry partners, b) support from funding institutions combining financial and expertise support, c) industrial development programs triggering competition, and d) a tradition for government / industry collaboration in policy development. Professional networks are crucial for R&D processes, both regional, national and internationally. Finally the paper discusses whether the findings are specific for a Norwegian or Nordic context. Our findings support previous studies in that the Nordic countries have developed a variety of the knowledge based economy strategy that emphasize learning, knowledge transfer and collaboration in R&D processes.

Keywords: Low energy use, Wood, Construction process, Innovation, R&D involvement.

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1. Introduction

1.1 Background

Increasing focus on climate performance in buildings and demands for higher energy efficiency are drivers for a changing construction industry in Norway. Industry partners, researchers and public enterprises cooperate to reach higher performance levels involving new technology and new collaboration methods. The last couple of decades represent a period of high activity level within the industry, challenges from a global market and also new technological opportunities.

The Norwegian construction industry is the third largest industries in Norway regarding occupation and turnover. However, the relative share invested in research and development (R&D), is low compared to other industries (Espelin and Reve 2007). In the increasingly more knowledge-based economy collaboration between industry and researchers is crucial to upkeep Norwegian and European competitiveness (European Commission 2007).

In this paper we present three role model projects in order to explore how the impacts of R&D are bringing the construction industry forward.

We are especially interested in exchange and uptake of knowledge during the development process.

1.2 Theoretical approach

For this purpose we apply a system approach to R&D in industrial development and innovation. This theoretical perspective acknowledges that progress is carried out through a network of various actors underpinned by an institutional framework (Asheim and Coenen 2005). The innovation system involves the various actors in the value chain of the construction industry. The framework includes institutions and measures constituting the current research and innovation policy. In Norway this framework includes universities and research institutes, centres for research-based innovation, funding for research and industrial innovation, and various development programs (Norwegian Ministry of knowledge 2008-2009). This policy model is in accordance with theories describing the dynamics of innovation as a Triple Helix of university – industry – government relations (Etzkowitz and Leydesdorff 2000).

The system perspective is also useful to enlighten how the production system interacts with and responds to changes in its surroundings (Luhmann 1996). Of special relevance in this paper is how the construction industry responds to incentives for improving environmental performance.

1.3 Research questions

Purpose of this paper is to enlighten how R&D ideas are translated into industry outcomes. The analysis will address the question of what institutional framework are involved in successful R&D processes.

The case presentations will focus on what actors and networks that are involved, what research contributions role model projects draws upon, and what challenges triggered the industrial innovations.

Finally the paper discusses the relevance of the Norwegian (or Nordic) context for R&D uptake in the construction industry.

2. Material and methods

The case projects are selected among recent and on-going projects with goal breaking ambitions and results.

The material on which we base our analysis is partly published in project reports and partly in form of news and reports published at various industrial magazine's and web pages. The Brøset and Powerhouse cases also include interviews with the project partners.

2.1 Case presentations

Vennesla library illustrate the development of using wood as a design and construction material. *Powerhouse #1* is a concept project for a building design optimized for sun energy production in Nordic climate and *The Brøset district* is planned to become a sustainable neighborhood that motivates for a extremely low climate gas emission life style.

2.1.1 Case 1: Vennesla library – wood as a design and construction material

Wood has a long tradition as construction material in Norway and is considered environmental friendly and a natural building material among Norwegians⁴. Back in the Viking age wood was a natural building. As experts of their time the Vikings used the huge forest resources to build Long houses of timber logs and Long ships of oak. The tradition of building houses with timber logs lasted until the beginning of the 19th century before steel and other materials as concrete took over as construction materials.

Its use has a long tradition, including mountain villages of log houses, urban neighbour houses that is internationally recognized on the UNESCO World Heritage list as Bryggene i Bergen (Hansiotic wharfs houses) the wooden mining city of Røros and the stave churches. In general Nordic people like the idea of being surrounded with healthy and natural materials in a modern community with increasing focus on technology.

⁴ 94 per cent (Norsk Monitor 2005)

In the 90'ties there was an upswing of using wood as a construction material as new technology made it possible to develop new products that could handle larger span and larger dimension and stronger wooden beams of glulam and massive wood elements. This story tells the impact of the R&D investment between research organizations and actual stakeholders on wood as a construction material.

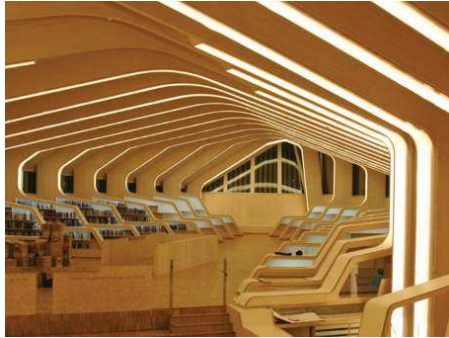


Figure 1: Vennesla library and culture centre (Photo: Moelven)

Vennesla library is a project exploring the characteristics of wood as construction material both from engineering and an architectonic point of view. Figure 1 show the wooden ribs that not only are carrying the load of the building, but also integrate the interior in a spectacular way. The architect⁵ company Helen & Hard has specialized on wood constructions combining environment ambitions and outstanding design, and has become internationally recognized also for the Norwegian pavilion at Expo Shanghai (2010) and the Pulpit Rock Mountain Lodge (Preikestolen, 2008). Vennesla library has been awarded a number of prizes for innovative architecture and use of wood as construction material.

The Vennesla library illustrates a history where new design, technology and research are combined with a traditional material and cultural recognition. Vennesla library represents a continuation of development of wood constructions in Norway and the Nordic countries, and draws upon a number of R&D inputs, among others on load-carrying capacity in various shapes of massive wood.

Development of glulam came as a result of an industrial network around the Moelven timber mill in the Hedmark region. Existing practical knowledge on wood were combined with research at the Norwegian Wood Technology Institute⁶ resulting in innovative glue techniques. The leap into this new product were triggered by a national political initiative to invite the national construction industry to promote Norwegian culture and values in the new facilities to be built for the Olympic Games at Lillehammer (1992) and the new Oslo airport (1994). The crucial challenge of fire protection was solved via collaboration with a chemical industry partner within the same region.

2.1.2 Case 2: Brøset - Development of urban green living

In general, settlements in Norwegian cities are densely built. In these times of urban growth there is a challenge to develop environmental sustainable neighbourhoods in urban areas. This example presents the plans for Brøset in Trondheim and show how experiences and research contributions is included in the front end phase.

⁶ www.treteknisk.no

Traditional urban settlement and industrial buildings in the 1000 years history of Trondheim are built on wood. Major parts of the central city still have the characteristics from this tradition. Recently the Trondheim municipality has decided that wood will be a preferred material for new public buildings. This came as a result of major R&D impacts. Among these are new experiences on the potentials of multi-storey buildings in wood, and new knowledge on greenhouse gas emission qualities of wood and forestry as alternative to other construction materials.

Trondheim municipality presented the plans for the first environmental friendly neighbourhood in 2003. The plan for Rosenborg Park included ambitions for reducing energy consumption to 50 %, improving waste handling and recycling, reducing the number of private cars and including landscape architecture as part of the plan for 500 new dwellings. The project was one of six projects in a national initiative for urban environmental pioneering, supported by the Norwegian Housing Bank, Enova and SINTEF Building and Infrastructure as a research partner. There was also international comparative research on the initiative⁷. The project succeeded in improving environmental performance, and provided valuable experience for further urban development. However, the fact that a very high number of dwellings were accepted to be built in this area got a lot of negative attention in the media.



Figure 2: The area planned for the new Brøset neighbourhood. Experimental garden and outdoor shed with information (Photo: Trondheim municipality)

When the Ministry of environment initiated the development program *Cities of the future* in 2008, Trondheim applied as partner, and introduced the plans for a new carbon neutral neighbourhood, Brøset. Cities of the future is an initiative to meet the national ambitions for improved environmental sustainability, and is a cooperation between Norwegian municipalities and the State. The program will provide valuable know-how for future urban planning. Especially there will be intensified exchange of experience among the three municipalities aiming to develop similar green urban livelihoods; Kristiansand, Bærum and Trondheim.

The ambition for Brøset is to be a carbon neutral neighbourhood, using little energy and "healthy" materials and being a socially sustainable living environment. There are ambitious plans for reducing traffic and energy use and at the same time uphold living comforts.⁸

⁷ The international research initiative included participation from 14 countries in Europa (Husbanken, 2003).

⁸ <http://www.regjeringen.no/en/sub/framtidensbyer/the-participating-cities-/trondheim/a-new-city-of-the-future.html?id=548223>

The Brøset project has accomplished an architectural competition with four parallel contributors. This material is used to develop a zoning plan in 2012. All throughout the process citizens of Trondheim have been invited to participate at open workshops of the architectural competition and then through the public hearing of the zoning plan. The hearing in itself is experimental, as citizens were invited to visit the area throughout the summer 2012, and to meet planners in an outdoor shed close to the experimental garden (see figure 2) where people could rent a bed to grow vegetables and useful plants. In addition the plans received a lot of attention in media.

The Norwegian University of Science and Technology (NTNU) and the research institute SINTEF follow the process (Gansmo et al 2011). The research team includes a broad span of disciplines in order to match the many aspects of the planned neighbourhood, in particular designing settlements that enable people to lower their total “carbon footprint”. Preliminary calculations on carbon neutral living arrangements are among the inputs.

Throughout the process there is built a special relation with the city Freiburg in Breisgau in Germany⁹. This Green City Freiburg has approximately the same number of inhabitants and similar goals for environment friendly living, housing and transport. In contrast to Trondheim, however, Freiburg has nearly thirty years of experience, being a result of strong local engagement in the Green Alternative Movement since the 1980ies. Inspired by Freiburg a *Climate Centre* will be located at Brøset, for the purpose of demonstration and documentation for the industry during the development, and for inhabitants and visitors.

In this case we find that planners and politicians are the primary partners in R&D activities. Due to the global challenge of improve climate performance, national policy has provided financial support for local initiatives, and institutional support via research programs and international exchange of knowledge. R&D uptake is most active in relations between the public representatives, local community planners, universities and expertise within the Housing bank and Enova. Municipalities are exchanging experiences while at the same time competing about the most innovative green project. Meanwhile the construction industry is expectant and awaits convincing market opportunities.

2.1.3 Case 3: Powerhouse #1 – development of energy efficient and energy producing commercial buildings

The Powerhouse alliance was established in 2010 by a property and developing company, an entrepreneur, an architect, an aluminium producing company and an environmental organization.

The alliance wants to demonstrate that it is possible to build energy-positive buildings not only in warm climates, but also in colder climates such as that in Norway. The first project, Powerhouse #1, is planned as a new office building for business tenders. The intended location is at the city harbour of Trondheim. The project includes energy saving

⁹ http://www.fwtm.freiburg.de/servlet/PB/show/1199617_l2/GreenCity.pdf

measurements, integrated ventilation, heating/cooling solutions, and electricity production integrated in the building's construction (see figure 3). The ambition is to develop Norway's first – and the world's northernmost – energy-positive office building.

While Powerhouse #1 is still in the concept phase the Powerhouse alliance is now designing its first rehabilitation project. New façade solutions, new technology for energy production and control systems are among the planned measurements. The ambition is to transform the existing building from the 1980ies into net energy producing buildings – “plus buildings”.



Figure 3: Powerhouse #1 at Brattøra port, Trondheim (Photo: www.powerhouse.no)

The Powerhouse Alliance¹⁰ draws upon experience from the various partners. The environmental organization Zero took the initiative by challenging the Norwegian construction industry to increase the investments of research for renewable energy. Among those responding is the aluminium company Hydro. Hydro has during its more than hundred year's history been active in research and development activities. The current priorities are building systems and façade solutions with integrated energy production. The property and developer company Entra joined the alliance due to its environmental friendly business concept¹¹. Entra contributes with experience from a major energy efficient rehabilitation project and later the completion of Norway's largest office building with passive house standard¹². Similarly the construction company Skanska and the architects Snøhetta joined the alliance with international experience and high ambitions regarding energy efficiency and environment performance.

¹⁰ <http://powerhouse.no/en/>

¹¹ <http://www.entra.no/en/>

¹² Papirbredden II, Drammen. Completed 2012. Low carbon concrete and geothermal energy wells.

The Research Centre for Zero Emission Building (ZEB)¹³ is part of a national program for environmental friendly energy research, involving NTNU, SINTEF and a group of industry partners and international research partners. ZEB has become an associated partner in the Powerhouse #1 project. ZEB is responsible for the challenge of calculating embodied energy in the building material¹⁴ and comparing various alternatives.

The story of Powerhouse exemplifies the behaviour of industrial actors seeing a potential market for innovative solutions. Similar to the Vennesla story, a group of individual enterprises saw an opportunity to collaborate due to supplementary expertise. The alliance draws partly on internal R&D capacity and partly on the newly established ZEB centre. Both include relations to international R&D networks. Special in this case is that a non-governmental organization triggered the initiative, that R&D investments are basically financed by the industrial partners, and that the ambition is to prove that the innovative building concept can be realized on a commercial basis (as a business rental building).

3. Findings

The institutional framework for R&D in Norwegian construction industry has some characteristics that are illustrated by the three case stories in this paper.

Firstly it is the funding institutions. The national housing bank (Husbanken) has a long tradition to be a financial instrument to implement national policy regarding housing in Norway. As for environmental and energy ambitions, Husbanken share this role with the more recently founded institution Enova. They both provide support from highly qualified experts. They also honor initiatives with goal-breaking results status as Role model projects. The three case stories illustrate how R&D activity in the construction industry is encouraged by an institutional framework that combines promotion with expertise and financial support. This finding is supported by previous studies revealing that R&D uptake in a market dependent industry depends on the potential economic value of new knowledge (Saviotti 1998, Schartinger et al 2002).

Secondly there are the centres for research-based innovation. Examples illustrated by the cases are The wooden centre, TreSenteret at the technical university NTNU and the Zero Emission Building research centre (ZEB). They both have industry and research partners and operate on long term conditions. Previous studies have explored how research centres operate as a source for learning for their industrial supplier companies (Bozeman 2000), and the three case stories illustrates this mechanism.

Thirdly there are the development programs. The case stories illustrate how ambitious clients and visionary politicians have succeeded to trigger the industry with programs such as Cities of the Future, Future Built and Norwegian Wood. Award-winning buildings and Role

¹³ <http://www.zeb.no/index.php/about-zeb>

¹⁴ Embodied energy covers energy consumed in obtaining, processing and transporting the building materials for the construction, maintenance during operation life span and final disposal of the materials.

model projects receive a lot of publicity and interest from the market. Previous studies have revealed the dynamic of regional innovative systems (Cooke & Leydesdorff 2006, Asheim & Coenen 2005), and how competition can be a driving force in innovation processes.

Fourthly there is the tradition for government/ industry collaboration. Involvement of industrial actors has proved to be a key to success in development processes. Organizations within the construction industry are involved in formulating new building regulations, and only research-based knowledge is considered legitimate to underlie new regulations. Such involvement contributes to implement R&D investments into practice, and is in accordance to recent theories including the element of democracy into innovation systems of the twenty-first-century (Carayannis & Campbell 2012).

4. Discussion and conclusion

The institutional framework identified in this paper may have some characteristics that are specific for the Norwegian or Nordic countries. Variations in the political economy between the Nordic countries and others may provide an explanation for the specific institutional framework for R&D based innovation. In “coordinated market economies” the state and its government plays an active regulative role in the construction market and are also active in supporting R&D activities together with industrial bodies. In such economies strategic interactions between firms and public actors are important for innovation and environmental improvements, compared to liberal market economies. There are discussions among scholars what implications this has for translating R&D into industry outcomes. According to Hall and Soskice’s theory (2001) actors within the Nordic countries have a strong developed knowledge absorptive capacity. The focus is on incremental innovation while the capacity for creating radical innovations is weaker than for liberal market economies. Empirical studies however have not proved this distinction, and rather suggest to focus on the productivity of R&D processes independent of economic and political systems (Akkermans et al 2007)

Norway and other Nordic countries have applied a variety of the knowledge based economy strategy that might be characterised as “learning economy” (Asheim and Coenen 2005). In a learning economy innovation is understood as an interactive process which is socially and territorially embedded and culturally and institutionally contextualized (Lundvall 1992). The learning perspective implies a dynamic notion of innovation, drawing the attention to knowledge transfer and collaboration in R&D processes. The three case stories presented enlighten how innovation and development progress step by step and who are the driving actors.

The three case stories illustrate some mechanisms and processes of the innovative development within the Norwegian construction industry. The system approach has revealed the relevance of networks and roles of various actors involved. The examples indicate that “the learning economy” has proved as a striking institutional framework for translating R&D into environmental ambitious projects.

In addition to national collaboration also international exchange of R&D is most relevant. Norway has great advantages from learning from European countries¹⁵ regarding the use of wood, energy efficiency and green urban living. Similarly Norwegian experiences are conveyed to other countries. The Moelven glue laminated wood has been developed further and the production of massive wood element is now transferred to the Holtz 100 massive wood technology. Research and product development performed by Hydro for a European market is about to become recognized in Hydro's home country. The Scandinavian Architecture is internationally recognized due to several status projects done by architects with international education and background. They are among the driving forces for new and green urban settlements in Norway.

R&D investment impacts should be considered at a long time-frame. Research investments on massive wood has a long history in Norway. Research on energy efficiency has a shorter history than wood. However existing research institutes and universities are mobilized by extensive research programs during the last few years. Green urban living, on the other hand, is a new research area, and so far there exist no research investments dedicated for this purpose.

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¹⁵ <http://www.regjeringen.no/en/dep/lmd/whats-new/Speeches-and-articles/speeches-and-articles-by-the-minister/speeches-and-articles-/2012/speech-at-a-seminar-on-wood-and-wood-den.html?id=670145#>

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