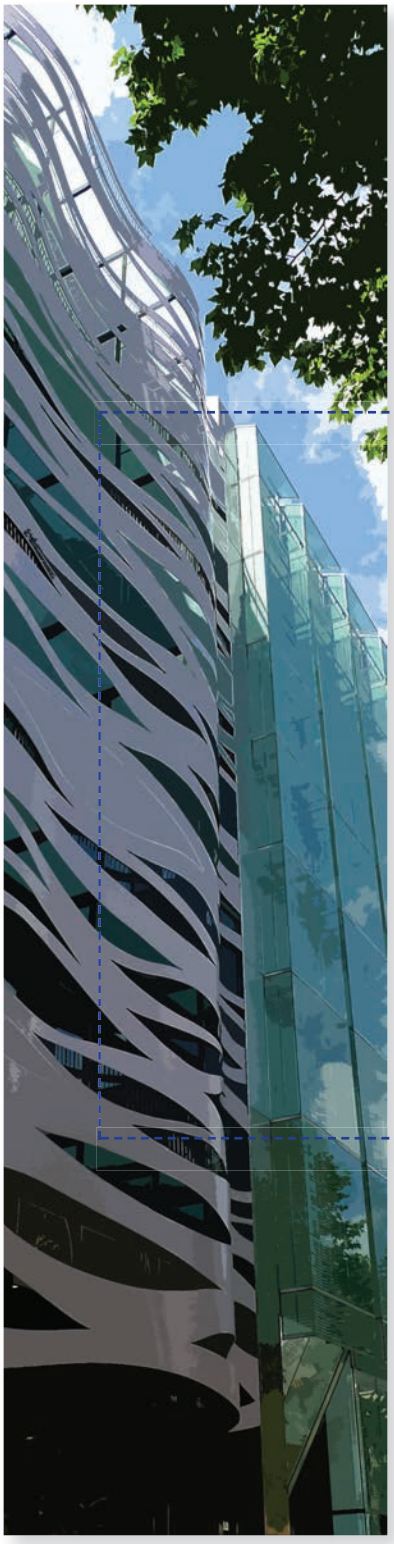

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(editors)

PROCEEDINGS FROM
7TH NORDIC CONFERENCE ON

CONSTRUCTION ECONOMICS AND ORGANISATION 2013

GREEN URBANISATION – IMPLICATIONS FOR VALUE CREATION

TRONDHEIM
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7th Nordic Conference on Construction Economics and Organisation, Trondheim 12.-14. June 2013

FOREWORD

The first Nordic Conference on Construction Economics and Organisation was held in Gothenburg at Chalmers University of Technology back in 1999. Since then, the conference has been held biannually (with the exception of 2005) in Sweden (4 times), on Iceland and in Denmark. Now it is Norway's turn to host the conference, and Finland is scheduled to take over the baton next time. We are very pleased to be carrying on the tradition, and we hope to live up to the expectations created by previous conferences.

In 2011 in Copenhagen an initiative was taken that marked a shift in the organization of this series of Nordic conferences: CREON was founded. The first general assembly was held during the 6th Nordic conference. The CREON network is a voluntary, non-profit association for people who study, work, teach and do research about all aspects of management and construction. The CREON network aims to promote collaboration across Nordic knowledge institutions and this series of conferences is an important activity for CREON. NTNU and SINTEF, as local organizers, are proud to present the 7th Nordic conference on behalf of CREON.

We, the organizers, had two specific ambitions when we started preparing for this conference: Firstly, we wanted this conference to be acknowledged as a high quality academic conference. We have therefore put a lot of effort in the review process. Three rounds of blind reviews is a lot of work, but now when we see the result – it was worth it. The close collaboration with Akademika Publishing makes sure publication points can be awarded to the authors. The papers are presented in two parallel sessions over three days here at the NTNU Gløshaugen campus.

Secondly, we wanted to establish a closer connection with the construction industry. We therefore put together a very strong Program Committee, comprising of prominent representatives from the Norwegian Construction Industry, who identified the main topic: Green Urbanization – Implications for Value Creation. We realized that it was not realistic to turn an academic conference into a popular construction industry event, so we have chosen to collaborate with NTNU in marking their new initiative for improving knowledge about the building process. Thus the idea for the Building Process Day was born – we will spend half a conference day together with distinguished guests from the Norwegian construction industry. The building process day will also be the scene for another conference innovation: Statsbygg awards for best paper and best young researcher. Enjoy!

Ole Jonny Klakegg, Kari Hovin Kjølle, Cecilie G. Mehaug , Nils O.E. Olsson, Asmamaw T. Shiferaw, Ruth Woods (Editors).

INTRODUCTION, CONTEXT AND SUMMARY

The construction industry plays an important role in society. Construction forms our physical surroundings and creates the infrastructure we need to develop society. Physical infrastructure and buildings represent approximately 70 per cent of Norway's Real Capital. Public investments in infrastructure constitute half of all infrastructure investments in Norway. It is also a major factor in the society's economy, representing a substantial share of the GNP, and, for example, it represents approximately 30% of the employment in Norway. According to Statistics Norway the construction sector is the third largest industry in Norway, employing 350,000 workers in more than 75,000 enterprises, and has a high turnover; over NOK 308 billion in 2011, approximately the same level as 2008 which was a top year. The Confederation of Norwegian Enterprise (NHO) states that the construction industry in Norway provides 10% of the total value creation. The construction industry is truly a cornerstone of our society.

On the other hand the dwellings and construction industry is also mentioned as "the 40% industry" by the Ministry of Local Government and Regional Development. This is a reminder that the construction industry uses approximately 40% of the total energy in our society, 40% of the materials, and produces about 40% of the waste that goes into landfills. This indicates the industry's importance in relation to climate and other environmental challenges. If there is one industry that really can make a difference, it is probably construction.

Furthermore, the construction industry has a reputation of being conservative, having a low degree of innovation, and low productivity. It is not known to be the first industry to implement sustainable solutions. The construction industry does use low-tech solutions and employ low skilled workers, but it does also include highly advanced New Tech solutions to technical problems and engage some of the most qualified engineers in our society. The truth about this industry is as complex as the problems it is trying to solve on behalf of society.

In the next ten years, growing globalization will promote an already increasing trend of competition among international construction companies according to The Federation of Norwegian Construction Industries (BNL). Additionally, Norway has the following challenges ahead:

- Growing population, expected to surpass 7 million by 2060, up from today's 5 million
- Increasing trend towards centralisation
- Growing elderly population with needs for health care and housing
- More pressure on transport infrastructure
- An ever increasing immigrant workforce

- Long cold winters and harsh climate, worsened by climate change which may lead to more floods, landslides and frequent winter storms

All these challenges will lead to:

- High demand for new dwellings
- Need for higher investment in low energy buildings
- Need for more robust buildings and infrastructure
- Need for more investment in transport infrastructure
- Need for a larger workforce and recruitment in all sectors
- Need for good integration programmes, development of expertise and training in relevant areas for new migrants and unskilled labour.

These are the sort of challenges that the Program Committee saw when they discussed the profile for this event back at the beginning of 2011. They called it Green Urbanization. The situation calls for new solutions, new knowledge, new thinking. Both small steps and huge leaps help as long as they lead in the right direction. Is the construction industry ready for it?

The sector is fragmented and contains many small enterprises. Thus, large companies account for a smaller share of the construction output in Norway than in most other countries. Small companies with highly specialized competence indicate a fragmented industry. The typical construction project is also said to be one-of-a-kind at a hectic pace. It is obviously hard to optimize process and solutions in such an environment.

Although to a lesser degree than other countries, the Norwegian construction industry is currently facing the challenges that have followed the 2009 financial crisis; small enterprises lost competence due to temporary redundancy and the investments were at a minimum level. Therefore, the diffusion of new knowledge and investments was also at a minimum. To what degree is the construction industry equipped to meet challenges ahead? And to what degree is the academic community able to help this industry overcome its challenges? These are questions that deserve to be asked, and perhaps some answers or indications may be found among the contributions to this conference? Are the academic resources ready for it?

This introduction, its examples and identified challenges are chosen from the Norwegian context, in full awareness of the current peculiarities of the Norwegian situation. We do have a special and advantageous position, but Norway is still clearly a distinct part of the Nordic context. We are also deeply embedded in the bigger international economy and global community. Therefore, the conference profile and the Nordic conference setting feel highly relevant in 2013.

The contributions span a wide range of issues, organized in three tracks with three major themes in each:

Sustainable Development of the Urban Environment	**Organizing for Execution**	**Efficiency in Construction**
The Sustainability Perspective	Governance and Strategy Implementation	The Human Aspect in Construction
Sustainable Design	Decision Making and Relations	Productivity and Quality
Sustainability and People	Learning from Construction Projects	Supply Chains and Planning

The first track; **Sustainable Development of the Urban Environment** is the signature track of this conference. It relates directly to the challenges addressed by the program committee back in 2011. The invitation to authors included contributions on sustainability in a wide sense – the concept of sustainability, the framework conditions defined by government and international agreements, the built environment, both the upgrading of existing buildings and finding solutions for future built environments. As the papers of this track shows, the authors cover these issues from several perspectives and cover a wide range of issues as intended. The track provides a varied and thought provoking approach to the term "sustainable"; one of the most oft-used terms in the construction industry today, but which also continues to be one of the most important issues.

Key issues addressed by the papers are; different challenges in combining urbanization and environment respect, the role and use of green certification systems, the role of sustainability in project management, passive house building, renovation and retrofitting from a sustainable perspective and the development of new technology to the deal with climate and age related problems in building materials. Green has become an important issue and two papers look at the role of green certification and policy in stimulating company activity. It can on the one hand, as one paper suggests, become a catalyst, stimulating more green certified buildings. On the other hand, green may mean, as the second example shows, following the market rather than focusing on policies which benefit clients and society. Encouraging a sustainable build is a theme which may be understood as central in this track; it is present in the aforementioned papers and also plays a role in the papers which focus on retrofitting, project management and the building of passive houses. Further issues are exploring the difference between project management success and project success; analyzing collaborative working and experienced effects on the energy performance of a building project; an analysis of existing Norwegian retail development and their impact on local energy consumption; and the effects of user involvement in the briefing and design of a workplace. Scandinavian and particularly Norwegian examples

dominate the papers, but there are also case stories from USA and China and contributions from the Netherlands and the UK.

The second track; **Organizing for Execution** represents a combination of new and classic issues around governance, decision making and learning. It covers issues with a wide perspective and long-ranging consequences for the organisations involved. Key issues are governance mechanisms, strategy implementation, decision making, relations and learning. Several papers discuss aspects of governance and how organisations may implement processes and structures in order to improve their value creation and value for money in investments. Examples presented here are the governments in the Netherlands and Norway, as well as several anonymous companies associated with the construction industry. This has a lot to do with designing purposeful decision making processes and using the right criteria for prioritizing and choice of projects. Other perspectives are how to implement necessary transformations of the organization in a changing environment. This is an important issue in a world of increasing globalization, competition and new technologies.

One major topic in several papers is the clarity and better understanding of roles and responsibilities in project organisations and between the project and its mother organization, as well as other stakeholders. These relational issues include communication, motivation, emotions and trust, just to mention some important aspects. The most fundamental topic in these papers is perhaps learning. Learning from cases and accumulating experiences in organisations in construction has been argued a particularly challenging thing to do. Several papers look into these challenges.

The types of organisations represented in these papers range from large public agencies, via industrial companies down to facilities management companies. The projects range accordingly from large infrastructure investments via large building design and development processes down to small and medium sized renovation and upgrading projects in existing buildings. All in all, this track comprises discussions on some of the major issues engaging the research community on construction projects in recent years. The picture is clearly Nordic in the sense that most of the cases reported are documented in the Nordic region, but extended to include Poland, France and the UK.

The third track; **Efficiency in construction** is the original core area of construction economics and organisation, internationally perhaps better known as construction management. It covers both qualitative and quantitative aspects of efficiency in construction. The majority of the papers address the human aspect in construction, but in different ways. Innovation, learning, daily life, scheduling, BIM, productivity, quality, procurement, contracts and supply chains are addressed, among other issues. Roles and interfaces between different stakeholders in a construction project are addressed in several papers.

Innovation is a key topic. It is addressed both explicitly in some papers, and implicitly in many more papers. Innovation in the construction sector is an important topic. It is mainly

illustrated through cases. The construction sector is characterised by cooperation between many stakeholders. Design, planning and execution are typically carried out by project-oriented organizations. Deliveries of building components and materials are carried out by manufacturing companies. Interestingly, we also have comparisons between the construction sector and other sectors, as well as the use of analytical models used in other industries but here applied in a construction context.

Contracts and supply chain are addressed in several papers. The contractual relationships in the construction industry are illustrated, with special focus on incentives and stakeholder relations. Planning is addressed in a quantitative way, but from different perspectives. We also have a terminology overview related to planning.

The track includes examples of technology advancement in the construction industry, including Building Information Modelling (BIM).The track includes BIM approaches in a life cycle perspective.

Cases and data come from a wide array of countries, and are not limited to the Nordic region.

The research approaches represent an interesting mix of theoretical work in the form of literature reviews and conceptual papers, development of decision models and understanding of observed performance in real situations, as well as documenting learning from cases and demonstration projects. The empirical side is not surprisingly dominated by document studies and interviews. Several papers are based on case studies. Some papers have a more theoretical approach, while others are very empirical and data driven. In total these proceedings represent a good cross section of contemporary research in the field of construction economics and organization in 2013.

TABLE OF CONTENTS

Track 1: Sustainable Development of the Urban Environment

The Sustainability Perspective

Sustainable Design

Sustainability and People

Track 2: Organizing for Execution

Governance and Strategy Implementation

Decision Making and Relationships

Learning from Projects

Track 3: Efficiency in Construction

The human aspect in construction

Productivity and quality

Supply chains and planning

PARTNERING FOR THE DEVELOPMENT OF AN ENERGY-POSITIVE BUILDING. CASE STUDY OF POWERHOUSE #1

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Abstract. *Powerhouse #1 is planned to become the first and northernmost energy-positive office building. An alliance of companies within the Norwegian construction industry has been established to reach this ambition. Partnering has been suggested as a means to improve performance in general within the construction industry. Studies reveal that the industry is yet to yield the positive effects that have occurred in other industries. Strategic alliances such as Powerhouse are an exception within Norwegian construction industry. The paper analyses the case of Powerhouse #1 regarding collaborative working and experienced effects to the energy performance of the project. The material consists of interviews with participants in workshops during concept phase of the project, in addition to written and oral presentations. Our findings indicate that Powerhouse are aiming to combine long-term and project business objectives. Industrial Energy Design methodology has resulted in an energy concept for a building with outstanding energy performance. During the process shared understanding and respect has developed between the participants. If the project is able to realize the ambition on commercial conditions it will represent a turning point regarding energy efficient construction.*

KEYWORDS: energy-positive building, partnering, construction industry, collaboration

1 INTRODUCTION

There is a global challenge to reduce energy consumption in man built environments, and the construction industry is expected to improve energy efficiency. However there is a concern over general under-performance in the industry and analyses indicate that improvements are slow. In this situation there are a few construction projects with outstanding aspirations regarding energy performance. In Norway for the time being Powerhouse #1 is the most extreme, with ambitions to be a net energy producer.

1.1 The project background

In 2010 the Norwegian non-governmental organization ZERO hosted a national conference on reduction of greenhouse gas emissions. The conference was addressing challenges and opportunities for the construction industry and gathered representatives from leading companies within the value chain in addition to politicians, regulation authorities and universities. ZERO especially challenged the industry on how to build energy-producing buildings in the near future. More than one of the speakers argued that this ambition is possible to reach in Norway within the near future. One of the participating companies, Hydro, suggested to establish an alliance to explore how such a building can become reality, and from this stage invited partners to join in. This was the starting point for the Powerhouse alliance.

Industrial partners establishing an alliance for a construction project is an exception to the traditionally fragmented practise within the industry. The Powerhouse #1 is a project of special interest due to the combination of business collaboration and high energy ambitions.

1.2 Literature review

The work method of the first project of the alliance, Powerhouse #1, differs from the traditional process within the industry. Usually work tasks are performed separately by each specialist. Since the tradition of serial working within the value chain is identified as a major hindrance for improvement of environmental performance within the construction industry (Egan, 2002, Bishop et al, 2009, Norwegian Government, 2004), the working method of Powerhouse is of strategically interest for improving performance within the industry in general.

The Construction Industry Institute's definition of partnership can be said to cover the main aspects of industrial collaboration in general, namely to best achieve the business objectives of all parties involved (CII, 1991). There are two distinct types of collaborative relations. One is the strategic, long-term commitment. The purpose is to achieve specific business objectives by maximizing the effectiveness of each participant's resources. The other is the project specific commitment, with the purpose to achieve specific project objectives.

Within international construction industry partnering has got special attention and has been gradually developed and tested in practice. A literature review reveals a tendency to focus on project partnering (Bygballe et al, 2010). The relationships are found mainly to include clients and main contractors, while sub-contractors and suppliers rarely are included (Dainty et al, 2001, Miller et al, 2002). These findings are among the explanations for the limited effects of collaborative work experienced so far within the construction industry (Winch, 2000).

Studies also reveal that tools and techniques to design relationships are emphasized at the expense of the social aspects, such as development of shared understanding and trust for the benefit of improving construction (Bygballe et al, 2010). According to Bresnen and Marchall (2002) this can be characterized as an engineering approach to relation development. Engineering processes focus on formal and systematic tools and techniques, including contracts and financial incentive systems, dispute resolution procedures and use of workshops and facilitators for teambuilding. The alternative according to Bresnen and Marchall are evolutionary processes, which focus on the dynamic, social and informal aspects of collaboration, including the acknowledgement of the complexities of relations between individuals and organizations with varying structural and cultural backgrounds.

Collaborative work forms are found to be of special interest in complex projects, in international projects and for innovative purposes (Aarseth, 2012). Research and development on project management within the construction industry has led to a number of methodologies for these purposes. Of special relevance for our case study is Integrated Energy Design (IED). The method focus especially on the design process, and emphasize multi-disciplinary teams, participants skilled and motivated in energy issues, use of workshops and facilitating close cooperation between architect, engineers and relevant experts through the process (KS architects, 2009). The purpose of IED is to obtain a high level of integration and synergy of systems to reach very low energy use over the whole life cycle of the building. The idea is that the best gains of performance are achieved from the beginning of the project. Therefore the design process requires a high level of general skills and of communication within the team (KS Architects, 2009, Andresen, 2012).

The case study presented in this paper will explore what characteristics from the literature that can be recognised in Powerhouse #1.

1.3 Purpose

This paper analyse the first Powerhouse project, Powerhouse #1. Focus is on the partnership and the collaborative work methods being used during the concept stage in order to reach the energy ambition.

The purpose is to explore partly what collaborative work methods that are being used. And partly what implications the partnership has had for the development of the building concept.

2 MATERIALS AND METHODS

This case project is selected due to its strategic interest. Compared to other construction projects the energy ambitions are outstanding. Related to case study theory the Powerhouse project can be considered a "critical case" (Flyvbjerg, 2004) based on the following argument: If collaborative work models are found to benefit the result of this project, then such working models can be beneficial to improve energy performance also in other construction projects.

Data is provided partly via interviews with participating informants, and partly from written and oral presentations.

Interviews with nine representatives at the workshops were carried out on behalf of the ZEB program. Each interview was performed according to an interview guide prepared specifically for the purpose. They were performed in face to face meetings, by telephone or via Skype and lasted about one hour. Interviews were carried out during a three month period after the Design concept report were completed in June 2012.

Oral and written presentations have been given by various alliance partners during 2012. A concept report on Powerhouse #1 is published by architects (Snøhetta, 2012), and has been available for this analysis. Also articles in newspapers and industrial magazines are analysed.

3 PRESENTATION OF THE CASE PROJECT

3.1 The alliance

The Powerhouse alliance consists of developers Entra Eiendom, construction group Skanska, architects Snøhetta, environmental group ZERO and aluminium company Hydro Powerhouse, 2012).

The Powerhouse alliance is part of a shared strategy to improve use of energy efficient and energy producing solutions in construction projects. The Powerhouse projects intend to renew the way of working in construction projects and also to be innovative regarding technological solutions and visual design.

During the process of developing the concept for Powerhouse #1 additional stakeholders have been involved. Among these are scientists within the Research Centre on Zero Emission Buildings (ZEB), which draws upon the expertise at the Norwegian University of Science and Technology (NTNU), SINTEF and their national and international associates. Also Siemens and Multiconsult have contributed with experts on automation and photovoltaic (PV) energy production, respectively.

3.2 The ambition

The Powerhouse alliance aims to prove by an example that it is possible to build energy-positive buildings in Norway. The ambition is to build Norway's first energy-positive commercial building, Powerhouse #1. The chosen location is Trondheim, north of 62nd latitude, implies that it will also be the world's northern-most building of its kind.

The building shall be energy-positive over its total life time. By this it is meant that it has

to generate more renewable energy over the operational life than is required by the manufacturing of all materials, the erection, operation and disposal of the building. Calculations are based upon expected operational life time of 60 years. Produced energy is required to be of equally high quality as consumed energy. This in effect implies that the building must produce electricity, not only heat or other types of energy, at a quantity larger than its own consumption. And production of electricity must be on the building itself.

In addition, the project shall be economically sustainable, implying to be realized at commercial conditions. Potential tenders are enterprises with a focus on energy and the natural environment.

The alliance plans to build more than one energy-positive building. Already while Powerhouse #1 is at the concept stage, the construction work of Powerhouse #2, - a refurbishment project further south in Norway - has started.

3.3 The concept

The building is prepared mainly for offices, approximately 750 workstations over 10 floors. In addition it will include public space on ground floor, meant for cultural activities, and parking space at the basement floor.

To reach a positive net energy production, the building combines a set of measurements: Energy efficient building shape, demand control, hybrid ventilation, optimized daylight, sea water heat exchange, local photovoltaic production of electricity and reduction in embodied energy in building materials. The building is planned according to passive house standard and to reach the BREEAM category “outstanding”.

The extensive use of solar energy is the most innovative element in Powerhouse #1. To create ideal conditions for photovoltaic electricity production, the building has got a shape where the roof is made out of one surface facing south and with an ideal gradient of the slope. Instead of the traditional cubic shape of office buildings Powerhouse #1 consists of inclined planes with its volume stretched in height. An elliptical outdoor room admits daylight into the building (See figure 1 and 2). To summarize the non-conventional design Powerhouse use the slogan “Design follows environment”.

The concept for Powerhouse #1 is reflected in sustainability in a broad sense. It aims to be climate neutral in a life cycle perspective. The building will produce local and renewable energy. It also intends to be energy producing in the sense that it provides added activity and creativity for people who will be working in and visiting the facilities.

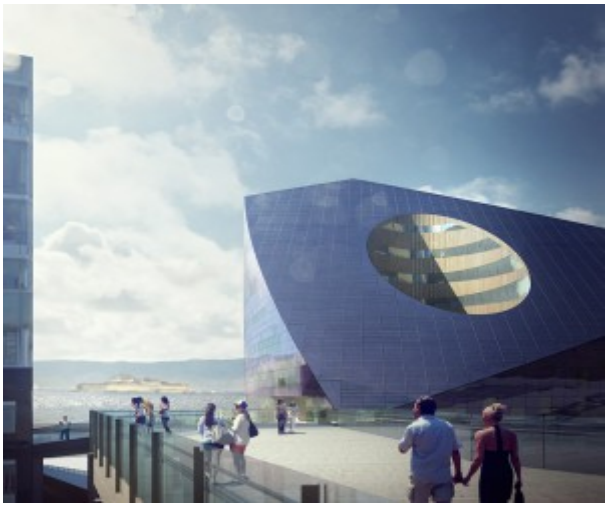

Figure 1: Powerhouse #1 concept project with integrated photovoltaic energy production (Illustration: Snøhetta / MIR)

Figure 2: Powerhouse #1 concept project at the location at Brattøra (Illustration: Hydro)

3.4 The work methods

The Powerhouse alliance has made extraordinary efforts for collaboration during the process of developing Powerhouse #1. This includes interdisciplinary work methods during concept stage, and also cooperation with local authorities and neighbour enterprises regarding development of the Brattøra area.

The Powerhouse #1 concept has been developed during serial workshops with a process leader (facilitator). Up to fifty persons have contributed with theories and experience, suggestions and questions in an open and multi-professional dialogue. In this early process the combination of key competence has been emphasized. Participants as well as project leader are reporting that the workshops has been necessary to handle the complexity of the task, namely to consider all energy implications of the construction.

Collaboration with the local authorities has been according to traditional role models. There is a local zoning plan for the Brattøra area, which regulates the building plot for industrial activities and sets physical limitations for the buildings. For the time being there are on-going negotiations regarding the height of the planned Powerhouse #1 which exceeds the height restrictions.

Very low or zero energy buildings require that energy supply, thermal storage and day lighting systems, are viewed in integration with the architectural design. Cooperation between the client, architects and the various specialized engineers early in the design phases offer opportunities for large impacts on performance to the lowest cost and disruption (Andresen 2012).

4 FINDINGS

The case study reveals that collaborative working has been crucial for the development of Powerhouse #1. The powerhouse alliance chose to establish a multi-disciplinary team to develop the building concept, and used workshops to explore alternative solutions for the ambition of an energy-producing office building at Brattøra in Trondheim. Six findings will be presented here.

4.1 Developing shared understanding

During the concept phase members of the project team have developed a shared understanding of the task. Workshop participants and the project leader report that this is unique for the chosen work method, and would not have been achieved with traditional work methods. The shared understanding has been developed through exchange of knowledge and ideas within the team. Participants report to have learned how professionals within other

disciplines reflect. The team members have improved mutual respect for the needs and expertise of other professions, implying that traditional boundaries between disciplines were demounted. The mutual understanding and respect have proven crucial for the positive outcome of the challenging concept discussions.

Workshop as a collaborative work method has been a new experience to most participants. Especially for the engineers close collaboration with the architects has been a challenge and inspired to explore innovative concepts and new combinations of solutions.

In fact, members of the project team report how their basic idea of an office building has been challenged during the process. The energy ambition has forced the project team to handle a set of very differing comprehensions of energy. One of them is the idea of a building as a power station. Another is the idea that a building should provide creative energy to the people using them. In addition there is the vision of buildings as part of a circular flow of ecological energy.

4.2 Exploring optional solutions

The workshop model has proved valuable for presenting alternative energy solutions. The various theoretical possibilities were tested through exchange of questions and arguments among the participants at the workshops. Photovoltaic energy production was compared to wind energy and heat pumps, and a broad spectre of building designs and materials were explored regarding energy performance.

Shared understanding of the task and mutual respect for each other's expertise has also been vital for the necessary decision making. During the workshops, as alternatives were discussed and one solution stood out to give the best performance, there was a consensus decision on the chosen solution.

Participants experience that close cooperation has affected the project concept positively. The process has exposed the complexity of the project and in particular how decisions are intertwined.

4.3 Intensifying energy ambitions

One of the underlying discussions in the workshops has been on how to operationalize the ambition of "an energy-positive building". Together the team has specified to include embodied energy in the energy accounting, and to include a greenhouse gas emission account for the total life time. These two criteria are set in accordance to requirements of the ZEB research centre.

Further there was a discussion on quality of the energy. The project team agreed that electricity is of higher quality than heat. Implication of this is that the overall energy accounting cannot be fulfilled by exporting heat and importing electricity. The team also discussed where the energy can be produced. To ensure that the building in itself is energy-positive, the team specified that production of electricity shall be physically located on the construction.

All in all, the criteria specified by the project team have raised the energy ambitions for the project. The alliance has thereby created a definition of plus buildings, different from existing buildings in other parts of Europe, without succumbing to the temptation of reducing the ambition due to localization of the project.

4.4 Early involvement of contractors

Previously ambitious construction projects have faced the challenge of finding experienced and willing entrepreneurs and sub-contractors. Implications have been that parts

of the concept were left later on during the process. Either in negotiations with the entrepreneur or due to materials not fulfilling the specifications. Or that the project has incurred extra costs due to lack of experience. The Powerhouse alliance already includes a construction group and a supplier of energy producing building surfaces. If these partners continue the collaboration during the next project stages, the shared understanding that has been developed during the concept stage may ensure successful completion of the project.

4.5 Commercial success?

Powerhouse #1 is to be built within commercial conditions and restrictions. In contrast to traditional project planning this part of the ambition has so far gained little attention According to the project group this is done by purpose, to be able to focus on the energy ambition. The intention of the alliance is to consider the costs of alternatives in the coming design stage, and also to upkeep the energy qualities. However, this may prove to be more conflicting than at the previous project stage.

Traditionally, entrepreneurs will calculate additional costs for risk implied by new building concepts. However, after being part of the concept development an entrepreneur within the Powerhouse alliance can be expected to minimize the extra risk cost.

All in all, there is uncertainty regarding the market value for energy-positive office facilities. The prestige of being the first and northernmost building of its kind might turn out to become the conclusive aspect when the final decision has to be made with respect to actually build Powerhouse #1 at Brattøra or not.

4.6 Socially acceptable?

Environmental sustainability is the major aspect of Powerhouse #1, as illustrated in the project slogan. However, after the energy concept has been developed the next challenge is to meet the criteria of social sustainability, both regarding formal regulations and acceptance among the public in general.

The design of Powerhouse #1 is developed to optimize the production of electricity via photovoltaic systems on the roof and surface of the building. To reach the office area criteria for the project the total volume is erected to a shape that can be associated with ancient pyramids. As a result the height of the building exceeds the limitations in the regulations for the Brattøra area. This experience raises the question if traditional regulation plans take considerations for environmental innovative constructions. To find a solution for how to combine regulation criteria with innovative design is crucial for this project to be realized.

Dialogue with the public has proved more challenging than expected. The innovative design is a contrast to building traditions in Trondheim, and has triggered loud arguments in regional media. The impression is that even to people who appreciate the idea of environmental friendly constructions, the design of Powerhouse #1 is highly challenging.

The Powerhouse alliance organized a working group for community contact. However, this group has not been active so far. How the challenges of social acceptance are solved is another conclusive aspect regarding realization of Powerhouse #1.

5 DISCUSSION

Our analysis reveals that Powerhouse #1 to a high degree is in accordance with the definition of partnership suggested by the Construction Industry Institute (CCI, 1991). First of all it is both a strategic and a project partnership. The alliance was first established for strategically purposes, and has developed from one project to the next. Secondly the results so far indicate that the partnership has succeeded in achieving both business and project objectives due to shared contributions of the partners involved. The Powerhouse #1 concept

and the refurbishment project Powerhouse #2 are both intended to break records regarding energy performance among Norwegian buildings. These characteristics make the Powerhouse alliance an exception within Norwegian construction industry today. The strategic partnership have similarities with other industries, e g the petroleum industry, where partnering has been crucial for stimulating performance gains and innovation (Barlow, 2000). Our material gives no explanation to why the alliance partners have chosen this untraditional strategy, and further studies are needed to explore this issue.

The findings indicate that Powerhouse #1 has been able to combine an engineering approach to partnering with an evolutionary process (Bresnen & Marshall, 2002). There exist a contract formalizing the alliance, stating the ambitions and conditions for when a project is considered part of the strategic alliance. Similarly for each project there are partnering contracts formalizing ambitions and financial aspects among others. Workshops and process facilitation is used as suggested by the Integrated Energy Design methodology. According to Bresnen and Marshall these methods are considered part of an engineering approach to partnership. However our informants are enthusiastic about the relational experiences that have come as results of the process. The shared understanding and mutual trust that has developed within the team is considered as valuable for the final result as the energy and design concept. However the process has been challenging. Informants report that they have had times when they could not see the relevance or participating in discussions that were outside their own area of expertise. Consensus decisions during workshops were a new experience for the participants, and as distinct from strong traditions within all partner organizations. However, to develop a shared understanding of the complexity of the energy issue is reported to be a key success factor to conclude on a concept for the energy positive office building at Brattøra. Again Powerhouse is found to differ from the majority of partnership projects within the construction industry, which invites for further studies.

The IED methodology emphasizes to establish multi-disciplinary teams from the start of the project. While partnering theory emphasize involving the whole value chain in partnering relationships. Powerhouse #1 has managed to combine this. Partly by including a contractor, an architect, a property developer and one key supplier in the alliance. And partly by inviting external participants to participate in the workshops. According to the literature these are characteristics that might contribute to Powerhouse achieving full benefit from partnering.

The definite success criteria for a partnership among industrial enterprises is whether the business objectives are achieved. For the time being Powerhouse #1 stands on hold, while Powerhouse #2 is already in construction stage. This might indicate that the concept developed during the project #1 is considered as a business success worth using in the refurbishment project, project #2. Documenting the commercial success will be the final test for Powerhouse. Making the Powerhouse projects into reality, and prove economic and environmental sustainability might be the turning point for the Norwegian construction industry, both regarding energy performance and partnering.

6 CONCLUSIONS

As a conclusion the concept project of Powerhouse #1 is found to be an illustrative example on the relevance of collaboration in early planning of constructions with high energy ambitions.

Collaborative working methods being used are multi-professional teams and workshops during early planning stage. Also other means of Integrated Energy Design are recognised in this case project. Establishing the alliance of industrial partners is the method used at the strategic level. The methods represent an extensive form of collaboration.

Major effect of this partnership is a concept for an energy positive office building at a

location north of 62th latitude. Workshops have proved to be a creative and efficient work method to solve the challenges of complex integrated design. The multi-professional team has developed a consensus on the final concept project for Powerhouse #1.

This case study illuminates the relevance of partnering and collaborative working methods for developing the energy design concept of Powerhouse. For the time being this case is an exception within Norwegian construction industry. Powerhouse already represents a turning point regarding energy efficient construction at northerly latitudes, which would not happen without partnering.

Whilst our study is limited to a one case study, it appears hardly conceivably to arrive at the high energy performance obtained in this project without some kind of collaboration or industrial partnership.

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