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No or low emissions from construction logistics – Just a dream or future reality?

Christoffer Venås^a, Cecilie Flyen^a, Selamawit Mamo Fufa^a, Mats Janné^b, Anna Fredriksson^b, Nicolas Brusselaers^c, Koen Mommens^c Cathy Macharis^c SINTEF Community, Oslo, Norway^a; Department of Science and Technology (ITN), Norrköping, Sweden^b; MOBI research centre, VUB, Brussels, Belgium^c.

christoffer.venas@sintef.no

Abstract. *Introduction:* Construction sites are among the major sources of greenhouse gas emissions (GHG) in the construction industry. Large quantities of construction materials and other resources need to be transported to, within, and from construction sites. Implementation of different construction logistics solutions can reduce the impact from construction. The objectives of this article are to map the status and present the current practice of construction logistics in Norway, and to discuss how different no or low emission construction logistics solutions can be promoted. *Methods:* Methods applied are a literature review including findings from the recent development of emission free construction sites and qualitative case study with interviews carried out in Norway. *Results:* Findings indicate that lack of regulations, specific requirements and awareness, and use of traditional methods to avoid risks are some of the challenges for minimizing impact from construction logistics. However, opportunities are also present; mainly driven by political ambitions, improved environmental requirements in public procurement tenders and market demands and ambitions for reductions in emissions and costs. Preliminary results from interviews in Norway support these findings. *Conclusions:* The study show that the goal of achieving no or low emission from construction site is possible through setting ambitious requirements, good planning and a close and open collaboration between involved stakeholders. *Grant support:* This work is part of the Joint Programming Initiative (JPI) Urban Europe project "Minimizing impact of construction material flows in cities: Innovative Co-Creation", supported by the national research councils of the participating countries (Sweden, Norway, Austria, Belgium).

1. Introduction

Increased construction activities in the dense urban built environment affects both inhabitants and local environments. Construction causes disturbances through vibration, noise and emissions and increases traffic, while road capacity decreases due to road closures and redirections. Construction traffic compose 20% (ton km) of the goods traffic in Sweden [1], and while the need to minimize the impact is not new, authors have reported difficulties in implementing successful solutions. Reasons are several, for example: the fragmented and temporary nature of construction projects with the continuously change of teams and involved parties, conflicts of actors' interest, lack of knowledge transfer between projects and a low innovation rate [2]. It is now time to pass these implementation hurdles as the on-site GHG emissions from construction sites represent around 5-10 % of the total emissions from cities [3]. However, emissions levels from construction sites depend on many factors



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including the site itself, its size and location, time of the year and size of the project. To fulfil the Paris Agreement and reduce GHG emissions, the City of Oslo aims to be the world's first emission free city by 2030, rewarding solutions for emission free transport and construction sites in all public procurement. This paper aims to map the status, and present both current practice of construction logistics and lessons from new developments of emission free construction site activities in Norway. Further, the implementation of no or low emission logistic solutions and how the construction process can be improved to realize sustainable construction logistics, is discussed.

2. Method

The methodology used in this study is twofold: first to provide background information and present the findings from literature review on lessons from the Norwegian emission free construction site activities, secondly to discuss the findings from two qualitative interviews performed in an on-going project in Oslo. The on-going project used as a case study is a nursing home for elderly (Tåsenhjemmet) with a total floor area of 14 500 m². The project is currently in the planning phase to be constructed in 2020-2022. The building is going to satisfy passive and energy-plus house standards, as well as being certified as BREEAM-NOR Outstanding. The procurement model used in the project is a turnkey contract with partnering agreements that emphasizes collaboration and coordination. The ongoing qualitative study aims to map the status of construction logistics (CL) in Norway starting with two in-depth interviews with the main actors in the construction management, the building owner/client and the contractor from the case study. The first interviewee (building owner's representative) works for a large public building agency, as project leader for the construction of the new case study building. The second interviewee is the project manager for the responsible contractor for the case project.

3. Lessons from Norwegian emission free construction site

MIMIC project builds on a collaborative construction logistic concept (Smart Governance Concept/SGC) developed in the former JPI project CIVIC ("Construction In Vicinities: Innovative Cocreation"). The main research scope of CIVIC was urban construction logistics. MIMIC expands the scope of the work in the previous project to include construction management and construction process. This paper is one output of MIMIC project with focus on connecting the SGC knowledge from the CIVIC project to the current state of sustainable construction process and management in Norway.

In planning of development areas and the related construction logistic activities, the local planning authorities cannot set ambitions that implies requirements that are stricter than legal requirements. Thus, Norwegian legal requirements constrain the environmental ambition levels locally for sustainable construction. Possibilities for regulative measures are at hand but are limited. The developers, including public building owners through public procurement procedures, can however set ambitious and specific requirements in their civil conditions of tenders. Studies show the importance of setting specific, achievable requirements in the early phase of the procurement, to enable sustainable and innovative construction [5, 6, 7]. The larger, ongoing development of fossil free, emission free, and waste free construction sites in Oslo demonstrate how the public building owners are imperative drivers to change through their requirements in the tender. They determine the pace of change from the current, to a more sustainable construction practice [8]. By setting achievable ambitious requirements in competitive tenders, the City of Oslo has prompted a rapid development of new market-oriented fossil and emission free solutions. Market dialogue has been used as a tool in pre-commercial procurement of emission-free construction sites, enabling the setting of specific, but realistic requirements in tenders, and strategically addressing the market for upcoming demands. This will give the suppliers needed incentives to develop new solutions. The market-dialogue has initiated several innovative research projects, to supply electrical machinery and logistics solutions, including a zero-emission digger, and a zero-emission solution for concrete delivery [9]. Another effective measure has been to reduce risks for contractors in pilot projects. In the first emission free

construction site in Norway, in Olav Vs street in Oslo [9], the building owner procured electrical machinery directly from the machinery rental market. The building owner also took responsibility for on-site supply and costs for electricity, to make the project tender attractive for pro-active contractors. The lessons from Olav Vs street project demonstrates measures which enable to solve the challenges of CL governance, and how, if implemented in further public procurement projects, this can affect the market, city planning and public legal regulations.

The current Norwegian emission free construction site activities limited to transportation for off-site activities is not part of the Olav V's street project. Political ambitions and ongoing initiatives support the realization of new solutions. The City of Oslo aims at piloting emission free, heavy-duty transportation and delivery of goods. A building material distributor aims at offering fossil free delivery of goods by electric crane for loading and unloading materials [10].

4. Results from qualitative interviews

The interviews form the case study in Norway provided insight to how construction logistics is an underestimated topic for the on-site operational part in the Norwegian construction industry. The contractor interviewee believes that there is little awareness of the importance of high quality in on-site logistic operations to accomplish successful construction projects. The contractor has the specific responsibility for planning the logistics. To avoid risks the building owner have paid the contractor to take hand of all construction operations, in turnkey contracts. However, they are eager to contribute to solve occurring challenges and obtain the best solutions in cooperation with the contractor. Positive dialogue is seen as a preventive measure towards low quality and errors. Both the interviewees see good communication between the on-site actors as a key element for successful operations. Morning meetings with the workers at site are described as key elements for successful operational planning of logistics. The building owner experience that actors lack the ability to see the full picture of a project, and that they need strategies to involve all actors on the site.

New types of requirements, like BREEAM or fossil free construction sites, were highlighted as main drivers for increasing consideration of better planning. In addition, both interviewees mention the importance of material selection from the experience in the past projects where prefabricated cross-laminated timber elements, led to increased efficiency of operations and better planning. Innovative construction methods and requirements are ways of developing and integrating better planning and innovative logistic solutions. Even higher environmental requirements are expected, strengthening the trend over the last years. Both interviewees think such requirements will be the most important driver for changing the current trend in the Norwegian construction industry. The contractor interviewee argued that the public building owners are and will be leading this change through their procurement strategies. He believes that advanced planning systems will become more important, resulting in better logistic solutions and fewer operations on electrified sites in the future.

5. Discussion

The results show the need for strategic planning construction logistics to achieve no or low emission from construction logistics. Present demands in tenders for logistic solutions are too vague. Willingness of increased cooperation to solve challenges is however present. Unfortunately, there is a lack of awareness of the challenges and lack of stakeholder involvement to enable implementation of better CL solutions.

The lessons from emission-free construction sites projects show how political will and active market-dialogue can help overcoming barriers and improve environmental requirements in tenders to implement emission free logistics solutions. To genuinely obtain no or low emissions from construction logistics, off-site transports to and from the construction site must be included, and new solutions must be developed. The ambitions for investing in emission free transportation in Norway [9,10], indicates a potential for future realisation of truly emission free construction logistics. The findings further highlight that solving the challenges related to CL is more than only implementing electric vehicles to reduce emissions. Raised awareness of the necessity of planning logistics, through

the development of emission free construction sites, might initiate a needed shift towards sustainable and efficient logistic operations. Further, a market-driven push may act as a driver for authorities to discuss the ambitions of the legal framework. Increased complexity and limited flexibility of emission-free machinery and equipment require a professionalization of the logistics planning in the construction process. Thus, more efficient CL solutions are required.

The results from the interviews indicate that the traditional turnkey contract may act as a limitation for collaboration in the building process. By facilitating CL solutions, the building owner may make them more attractive to employ. This also ensures a more active involvement of the building owner in the logistics planning. Olav Vs street is an example of how the building owner takes more responsibility by facilitating the electrical logistic and supply. In addition, the use of third-party logistic(service) providers (TPLs) as a separate contract partner, as promoted by Janné & Fredriksson [11] and Ekeskär [12], could also have a potential for the building owner to more actively ensure good logistics.

The authors acknowledge that the qualitative study is an ongoing work, and the sample selection so far is too limited to make conclusions solely based on the qualitative data. However, the case study project is innovative and environmentally ambitious. Both interviewees are representatives for dynamic and modern enterprises who are seemingly open to cooperation. In that sense, they represent the innovation front of the Norwegian construction industry.

6. Conclusions

The study shows that the goal of achieving low or no emissions from construction sites is possible through smart public procurement that drives development of innovative logistic solutions. Implementation of no or low emission solutions at construction sites require better planning and closer collaboration between involved stakeholders. Thus, the sense-of-urgency of climate change can give the needed push towards sustainable construction logistics, yielding reduced impacts on society. The study also highlights considerable scope for further analysis.

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