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Marianne Kjendseth Wiik[a], Cecilie Flyen[a], Selamawit Mamo Fufa[a], Christoffer Venås[a]

SINTEF Community, Børrestuveien 3, 0373 Oslo

marianne.wiik@sintef.no

Abstract. **Introduction.** Over the next 5 years, Norway shall construct roads, rail tracks and buildings for up to 300 bNOK. Statens vegvesen (SVV), the Norwegian road authority, has calculated that construction, operation and maintenance of Norwegian roads are responsible for 1.5-2m tCO_{2eq}/yr. SVV also found a correlation between cost and emissions and found that every 1MNOK invested leads to ca. 35tCO_{2eq}. When considering the national transport plan (NTP), this equates to 10% of Norway's climate budget. In order to reach climate mitigation goals, public developers have initiated environmental measures in public procurement to reduce GHG emissions. **Methods.** This paper collects, compares and reviews environmental criteria written into Norwegian public procurement to see which measures are being implemented, how they are being implemented, and to discuss how effective these measures are in cutting GHG emissions. Contracts are sampled from major public developers in the Norwegian construction sector. **Results.** The results show that public procurers use a range of tools to facilitate for emission reductions. **Conclusions.** This paper reviews environmental measures in public procurement of Norwegian construction. Lessons learnt may be spread to other countries and the private sector. **Grant support.** None.

1. Introduction and Background

The United Nation's sustainable development goals (UN SDG) highlight important issues to be addressed by society; including sustainable cities and communities (SDG 11), responsible consumption (SDG 12) and climate action (SDG 13), which are some of the focus areas of this paper [1]. As a response to the Paris agreement [2], Norway is committed to reducing greenhouse gas (GHG) emissions by 50 percent by 2030 compared to 1990 levels, this commitment is extended to the Norwegian national transport plan (NTP) and Oslo municipality. Over the next 5 years, Norway shall construct roads, rail tracks and buildings for up to 300 bNOK [3, 4]. Statens vevesen (SVV) – the Norwegian road authority - have calculated that construction, operation and maintenance of Norwegian roads are responsible for 1.5-2m tCO_{2eq} annually [3]. SVV also found a correlation between cost and emissions and found that every 1MNOK invested leads to ca. 35tCO_{2eq}. When considering the NTP, this equates to 10% of Norway's climate budget, and highlights an area for significant improvement. In return, Oslo participates in the C40 programme, and received the European Green Capital Award in 2019 [5, 6]. This is partly because Oslo has an ambition that all construction sites shall be emission free by 2025, and all public transport by 2030. BaneNor is committed to reducing CO_2 emissions by 40% from buildings by 2030, and plan for a 50% reduction in emissions from operation and maintenance. In order to reach climate mitigation goals, Norwegian public developers have initiated environmental measures (i.e. actions,

policies, strategies) in public procurement procedures to reduce GHG emissions from the Norwegian construction industry.

Furthermore, high levels of local pollution (e.g. NOx, SOx and particulate matter) in many European cities has led to emergency measures such as slashing speed limits, banning wood burning and the operation of fossil fuel construction machinery to reduce emissions. If these pollution peaks persist, more rigorous restrictions may be implemented, such as banning fossil fuel vehicles which would result in cities grinding to a halt [7]. However, Norway is in a unique situation compared to other European cities, since electricity generation is largely based on hydropower with relatively low emissions (ca. 15gCO_{2eq}/kWh [8]). Implementing electric construction sites would avoid a cease of operations and facilitate for almost emission free construction.

The recent Norwegian parliamentary white paper on smarter purchasing - efficient and professional public procurement - allows public developers to ask for environmental measures as either a requirement specification, qualification requirement, allocation criteria or contractual requirement [9]. This is the first time Norwegian procurers have legally been able to set environmental criteria in public procurement and as such, the white paper has quickly been adopted [10]. As a result, Oslo municipality's climate strategy [11] focuses on direct and indirect GHG emissions from i.a. material use and requires emission accounting for the whole life cycle, for at least two environmental product declarations (EPDs) to be documented for the ten largest construction materials and for all buildings to be BREEAM certified. However, slightly different approaches are required for building and infrastructure. Buildings are typically more complicated since they consist of more products with smaller dimensions. For buildings a Norwegian standard for calculating GHG emissions has been developed [8] and emission free construction machinery is available. However, infrastructure have fewer materials of larger dimensions with typically high embodied emissions (e.g. concrete, steel and asphalt), and the standardisation work has only just begun. Large emission free machines are not available, and biodiesel is deemed expensive.

2. Method

This paper collects, compares and reviews environmental criteria written into Norwegian public procurement contracts to provide a state of the art and see which measures are being implemented, how they are being implemented, and to discuss how effective these measures are at cutting GHG emissions from public procurement of buildings and infrastructure. Contracts are randomly sampled from major public Norwegian developers in the construction sector, such as Statsbygg – state building developer, Oslo municipality, SVV, BaneNor – state rail network and Nye Veier – state road developer and cover projects like Olav Vs road, E18 Dørdal-Grimstad, Tåsen and Lindeberg nursing homes, Oslo City accident and emergency (A&E), Lia, Munkerud, Vollebekk and Fossum nursery schools. The scope of this paper is turnkey contracts announced on Doffin, the Norwegian database for announcement of public procurements administered by the Directorate for Management and ICT (DIFI).

3. Results and Discussion

Requirement specifications may include i.a. requests for EPDs or other environmental labelling. For example, SVV have set requirements for CO_2 accounting, documentation of diesel use, project specific EPDs, and facilitate for this through deductions or bonuses for deviations compared to averaged EPD emission factors e.g. ±2 kroners / kgCO_{2eq}. In addition, the contractor shall use vehicles and machinery of the latest technology (e.g. EURO6 or Stage IV). Clauses for zero emission construction machinery have also been introduced including a performance bonus of 400kr/hour for up to 2000 hours for excavators over 16t and 700kr/hour for excavators over 25t. In contrast, Statsbygg have a requirement specification on EPDs, whereby contracts stipulate a minimum of 20 EPDs documented for major building components. The German EPD foundation, IBU, has observed that selecting products with EPDs has a positive impact on the ecological footprint of a building [12]. Oslo municipality has set requirements for fossil and emission free building sites at Lia, Munkerud, Vollebekk and Fossum nurseries, Tåsen and Lindeberg nursing homes and Oslo City A&E. Similarly, BaneNor also includes requirement specifications for fossil free construction and is focusing on electric ventilation, drilling,

concrete spraying, injection, drying, heating and on-site vehicles, excluding personal and tunnel vehicles. BaneNor also requires 10 EPDs for materials with the largest contributions to GHG emissions. In addition, electric detonators shall be used to reduce the amount of plastic waste from blasting rock, steel fibres shall replace plastic fibres in concrete and 80% of waste shall be sorted.

Qualification requirements may include i.a. compliance with EN14000 or using best value procurement (BVP). Oslo municipality has two pilots (Munkerud and Vollebekk nurseries) and Nye Veier has E18 Dørdal-Grimstad that use BVP. In BVP, the contractor is evaluated on criteria such as competency and performance, whereby price only accounts for 25% of the assessment criteria. Another 25% of the evaluation criteria is based on interviews with key personnel from the contractor's project team. The procurement phase is less comprehensive, with detailed planning being a part of the contractor's responsibility after procurement. The tender consists mostly of project goals, with an emphasis on reaching project ambitions. At Vollebekk, establishing a collaboration based on trust was identified as a key benefit to the procurement process. In Munkerud, the contractor stated that the procurement process gave contractors the opportunity to optimise solutions and innovate. The environmental goal of the project was to include Oslo municipality's environmental strategy within budget. The project resulted in a timber building with fossil free construction and low operational energy use. In E18 Dørdal-Grimstad, an emphasis was placed on trust-based collaboration with many stakeholders, however the process highlighted a need for third party quality assurance. Project execution models are also trending in turnkey contracts, which includes several elements from integrated project delivery and early contractor involvement. Here, the procurement process is completed before detailed planning is completed. At Olav Vs road a new model for a two-step concession agreement was tested. Here, Oslo facilitates the production of construction machinery for contractors and then the contractors have a right to hire them. However, feedback from tenderers foresee sub-contracting machinery in this manner is not practical in larger projects. There are also other considerations with regards to long manufacturing lead times, managing energy onsite and having qualified personnel on-site. BVP has highlighted the importance of early contractor involvement for innovative and complex green projects, whereby better planning and collaboration is essential to lower the risk for the client.

Allocation criteria involves weighting environmental performance by a minimum of 30%. Many of the contracts sampled weighted it between 40-60%. At Olav Vs road, construction machinery was weighted 50% within the environmental performance criterion, whilst Statsbygg require a 40% reduction in GHG emissions from materials, energy and construction compared to Norwegian building codes. First-hand experiences from Lia nursery has enabled Oslo municipality to raise the quality and environmental criteria in future procurement processes from 60% to 75% [13-15] as well as set GHG emission reductions as award criterion. In contrast, Nye Veier require a minimum 10% reduction in GHG emissions in all projects, and request LCA calculations for all project phases.

Table 1 provides an overview of the contractual requirements for material use, certification scheme and tools specified by Statsbygg, SVV and BaneNor. Equivalent information for Oslo municipality and Nye Veier was not available at the time. These requirements are identified as drivers for innovation, for reducing national GHG emissions, and for encouraging private actors to follow suit.

Table 1: Contractual requirements for material use, certification schemes and tools.

	Statsbygg	**SVV**	**BaneNor**
Concrete	low carbon class A max. 240 $kgCO_{2eq}/m^3$	Low carbon class B/C	low carbon class A
Insulation	max. $6kgCO_{2eq}/m^2$	-	-
IHULT steel beams	min. 70% recycled max. 1.5 $kgCO_{2eq}$/FU	min. 80% recycled	min. 85% recycled
Cold formed steel	-	min. 10% recycled	min. 15% recycled
Steel piling	-	1 $kgCO_{2eq}/kg$	max. 1100 $kgCO_{2eq}/t$
Reinforcement steel	max. 0.53 $kgCO_{2eq}$/FU	max.600 $kgCO_{2eq}/t$	max. $600kgCO_{2eq}/t$
Asphalt	-	max. 60 $kgCO_{2eq}/t$	

Aluminium	min 80% recycled		min. 80% recycled
Certification	BREEAM Excellent		
Tools	CoBuilder, klimagassregnskap.no, OneClickLCA	EFFEKT 6.6, vegLCA.	Excel

Changes in public procurement are often implemented by public developers' purchasing power and through market analyses, information to and from suppliers, dialogue conferences and interviews which facilitate for market predictability. However, none of these changes can take place without the legal framework in place. It is difficult to measure the effectiveness of Norwegian green public procurement, since changes are recent, and the ripple effect is difficult to quantify. However, increasing the allocation criteria of environmental performance to a minimum of 30% and following it up with GHG emission reduction targets and documentation requirements are important for contractors. Through the dialogue conferences it was acknowledged that the most environmentally friendly project is not necessarily the cheapest, and that public procurers needed to facilitate for this transition. This has been met through BVP. It is important to manage GHG emissions early in the project, when there is the greatest influence on the design of the building or infrastructure to achieve the greatest emission reduction.

4. Conclusion

This paper reviews environmental measures in public procurement of Norwegian buildings and infrastructure. Lessons learnt may be spread to other countries and the private sector.

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