
REPORT

Review of implementation of fossil free building sites

CLIENT	The Climate Agency in Oslo
SUBJECT	Fossil free building sites
DATE/REVISION	20 th November 2018
DOCUMENT NUMBER	10206471-TVF-RAP-001



Multiconsult

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Report

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SUBJECT	Fossil free building sites	CONFIDENTIALITY LEVEL	Unrestricted
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Summary

It has been a requirement in Oslo for construction sites to be fossil free since 1st January 2017. On behalf of the Climate Agency in Oslo, Multiconsult has conducted a review detailing the experiences of meeting this requirement. The Climate Agency wanted to know which solutions are currently being implemented by contractors and suppliers, and to identify possible barriers and practical problems related to meeting the requirement.

The findings, conclusions and recommendations presented in this report are based upon a simplified survey and four interviews with developers and contractors for selected construction projects in the Oslo area. It is recommended to conduct a larger and more comprehensive investigation, using more respondents, interviewees and building site inspections to achieve more robust results.

The need for a standardised and clear formulation of the requirements

Responses from the survey and findings from the interviews highlight that the requirement to fossil free building sites has been implemented in very different ways and posed in different places of the tender documents. For some projects, the requirement has been clarified several places (in the requirement specification, the environmental follow-up plan etc.), while for others the requirement has been compiled in the collaborative phase. The execution and understanding of what is meant by fossil free building sites also varies from project to project. Findings from the interviews show that interpretation of the regulations has usually been carried out by the contractors and developers after contract award.

For future tenders, there is a need to clarify what is meant by the term “fossil free construction site”, and to what extent the measures will be implemented. A standardised system should be developed of how to fulfil the fossil free requirement.

Replacing fossil diesel with HVO biodiesel within the boundaries of a building site

The responses from the survey and findings from the interviews show that the requirement for fossil free construction sites largely has been achieved by replacing fossil diesel with HVO biodiesel for site machines within the site boundaries¹. Not many contractors have managed to implement emission free / electrical solutions for machines any larger than small handheld electrical tools. For a majority of the projects there has been no requirements for fossil free transport to and from the construction site or fossil free waste management.

Despite it being stated in tender documents for several of the projects, that the contractor shall provide emission free machines where possible, in practice, this has only been achieved to a limited extent. This is because battery powered machines with sufficient capacity are not readily available. Also, low battery capacity means that the

¹ In this context, site machines refers to machines that naturally belong to the building site and are not registered for use on public roads. This may include machines other than fixed cranes, eg, excavators, mobile cranes etc.

machines cannot be operated continuously throughout the day. In addition, emission free alternatives are a lot more costly than conventional technologies.

The need for a review of the energy and power requirements before the construction phase

Findings from the interviews indicate that there is a need for better planning of the construction power supply for building sites. Several of the projects indicated that they would have implemented more of the non-fossil solutions during construction phase if a sufficient construction power supply was established at the start of the project.

Certain machines are not certified for HVO biodiesel fuel

Some contractors pointed out that it can be challenging to procure machines that are approved to be operated with biofuels. The impression from the interviews is that thorough investigations are being conducted to find the right machines, but contractors are not prioritising fossil free alternatives if the project is at risk of delays. In certain cases, the contractors have experienced problems with machine suppliers in relation to the guarantees when using HVO biodiesel fuel.

Not as problematic as expected

Contractors indicated in the survey and interviews that they have had mostly positive experiences in relation to the requirement for fossil free solutions. The requirement has led to a demand for more administrative duties and an additional cost of the fuel, but many reported that they experienced fewer challenges than they were expecting. Some contractors also answered that in future projects they would implement fossil free solutions, even when it is not a formal requirement. These are encouraging results given the additional costs of fossil free building sites, mainly due to the higher price of biofuels.

Recommendations for further work

If the goal is to reduce greenhouse gas emissions from construction and building projects as much as possible, then it is necessary to evaluate more measures in addition to switching to sustainable fuels during the construction phase. Until now the building industry has been focusing on reducing energy consumption during the operational phase. As more energy-efficient buildings (during the operational-phase) are being built, the importance of energy use in the construction phase will increase, seen in the building's lifecycle perspective.

During the construction phase it is a clear recommendation to first look at the possibilities for reducing the total energy consumption for the project, and then focus on the fuel type. There are significant benefits both economically and for the climate with reducing fuel consumption. Requirements for sustainable fuel will provide further greenhouse gas savings. The requirements can be stated in the tender documents, where the contractor should be given the freedom to describe how this could be solved and to be rewarded for good measures in the field of greenhouse gas reduction.

Requirements should be measurable and made so that contractors are incentivised to implement change and have a target to aim for. If requirements are made for emission free solutions, these should be clear and well thought out. Further development is dependent upon ambitious developers who indicate early which requirements will be set. It is easier for the building industry to invest in emission free solutions if there is a certain predictability and long-term commitment. Investment in new machinery is expensive and a certain volume of this type of assignments is required if the investment is to be sustainable.

Looking beyond the requirements for fossil free or emission free construction sites, the use of methodology in BREEAM-NOR over several years has proved to provide good overall solutions for sustainable construction. CEEQUAL is an environmental certification system used in the construction industry in Norway, and is expected to be a tool for sustainability in construction projects. Both BREEAM-NOR and CEEQUAL make use of life cycle analyses and related measures for greenhouse gas reduction. Both systems provide good systematics, documentation and predictability in how environmental and sustainability requirements are set and desired by the both the building and construction industries.

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Concepts and abbreviations used in the report

Fossil free building sites are building sites that do not use fossil energy sources. This means that all construction machines on the construction site must use non-fossil fuels (e.g. biodiesel/electric). This applies, for example, to construction machinery, temporary heating, construction power supply and transportation to and from building sites. A fossil free building site is not the same as an emission free building site, however a fossil free building site may include the use of emission free machinery.

Emission free building sites is a more ambitious goal and means that all processes on the site are emission free. This involves the use of the energy sources that do not lead to local emissions of CO₂ or NO_x on the building site. For example, this will apply to electric, battery powered, or hydrogen-powered construction machinery, electricity or district heating for temporary heating and drying, zero discharge to, from, and at building sites (machinery, materials, waste and personnel).

HVO² (Hydrotreated Vegetable Oil) is a type of renewable diesel consisting of hydrotreated vegetable oils. HVO production utilises by-products, waste and residues from different production processes, such as offal, tall oil from the production of pulp (cellulose), frying oil from food production, or residues from palm oil production. HVO can be mixed into larger quantities of regular diesel (like HVO30) or used as a clean product (HVO100).

Biodiesel² is produced from vegetable fat or oils, such as rapeseed, soya or palm oil and is mixed into ordinary diesel. FAME (fatty acid methyl ester) with a basis of rapeseed, soya and palm is the most commonly used type of biodiesel used in Europe and Norway today. It is common to distinguish between conventional biofuels (1st generation) and advanced biofuels (2nd generation).

BREEAM-NOR is the Norwegian adaptation of BREEAM, Europe's leading environmental certification tool for buildings, originating from England. BREEAM-NOR is the industry's own tool for measuring environmental performance.

CEEQUAL is an environmental certification tool for construction and infrastructure projects, originating from England. CEEQUAL is on its way to becoming the construction industry's sustainability tool in Norway.

SUB Subcontractor
EFP Environmental follow-up plan
EPC Engineering, Procurement and Construction Contract

KID Kultur- og idrettsbygg Oslo KF (Municipal Undertaking for Culture and Sports Facilities Oslo)
OBY Omsorgsbygg Oslo KF (Municipal Undertaking for Social Service Buildings)
UBF Undervisningsbygg Oslo KF (Municipal Undertaking for Educational Buildings and Property)
BBY Boligbygg Oslo KF (Municipal Undertaking for Housing)
BYM Bymiljøetaten (Agency for Urban Environment)
VAV Vann- og avløpsetaten (Agency for Water and Sewage)

² <http://www.miljodirektoratet.no/no/Nyheter/Nyheter/2017/Februar-2017/Fakta-om-biodrivstoff1/>

1 Introduction

1.1 About the assignment

The Climate Agency in Oslo has engaged Multiconsult to conduct a review detailing the experiences related to implementing the requirement for fossil free building sites. The Climate Agency wanted to know which solutions are being used by contractors and suppliers, and to identify possible barriers or practical problems related to meeting the requirement.

1.2 Method

As a starting point for the assignment, the Climate Agency prepared a list of building projects in the Oslo area where there has been requirements for fossil free building sites since 1st January 2017. The list consisted of 19 building projects, shown in Table 1.1.

Table 1.1 Fossil free building sites in the Oslo area.

Fossil free building sites	Responsible developer	Replied to the questionnaire survey?	Interview conducted?
New Jordal Amphitheatre	KID	Developer and contractor	Developer, 15.10.2018
Lambertseter multi-purpose hall	KID	Contractor *	No
Restoration of the Ila staircase and Evald Ryghs staircase	BYM	Developer and contractor **	No
Olafiaplassen skate park in Grønland	BYM	Developer and contractor **	No
Skullerudbakken nursery	OBY	No	No
Lindeberg nursing home	OBY	Contractor	Contractor, 19.10.2018
Bogerud farm nursery	OBY	Contractor	Contractor, 10.10.2018
Gransletta nursery	OBY	No	No
Ryen health centre	OBY	Contractor	No
Grønland nursery	OBY	No	No
Marmorberget nursery	OBY	No	No
Prinsdalsbråten nursery	OBY	No	No
Lia nursery	OBY	Contractor	No
Lilleslottet nursery	OBY	No	No
Gustav Vigelands road 50-52	OBY	No	No
Rødtvet nursery	OBY	No	No
Vetland school	UBF	Contractor	Contractor, 11.10.2018
Prinsdal school	UBF	Contractor *	No
Slemdal school	UBF	No	No

* The same contractor responded to the survey on behalf of Lambertseter multi-purpose hall and Prinsdal school.

** The same developer (but different contractors) responded to the survey on behalf of restoration of the Ila staircase and Evald Ryghs staircase and the Olafiaplassen skate park in Grønland.

Based on this list, a simplified questionnaire was developed in Questback, which the Climate Agency distributed to contact persons among the responsible developers OBY, KID, UBF, BBY, as well as BYM and VAV. The aforementioned developers then forwarded the survey to the contractors of the fossil free building sites.

The target group for the survey was both developers and contractors of the fossil free building sites. Respondents who answered the survey are listed in Table 1.1.

The questionnaire used can be seen in Appendix 1.

Based on the answers from the survey, extensive interviews were carried out with appointed contact persons from each selected fossil free building site. The purpose of the interviews was to go into depth on what was considered to be particularly interesting answers from the survey. The questions from the survey were used as “conversation guides” for the interviews.

One interview was carried out per building site, either with the developer or the contractor. The interviews took place at the actual building site in question. Where permission was granted by the developers/contractors, the building sites were also inspected. The projects that were selected for interviews are listed in Table 1.1.

Attempts were also made to interview developers/contractors for two further building sites, but the contact persons did not find sufficient time for this. Despite this, Multiconsult considers that the four completed interviews provides sufficient evidence to be able to draw some conclusions.

Findings from the survey and interviews are summarised in this report. The report was handed over to the Climate Agency on 20th November 2018.

1.3 Premises and reservations

The findings, conclusions and recommendations in this report are presented on the basis of a simplified survey and four completed depth interviews. It is recommended to conduct a larger investigation based on more respondents, interviews and building site inspections in order to achieve more robust results.

Addressing the issue of sustainability and ethics regarding the use of biodiesel has not been included in Multiconsult’s scope of works. Nor has it been part of Multiconsult’s assignment to investigate any impacts that renewable diesel fuel could cause to machines or to give any recommendations on this matter.

2 Findings from the surveys and interviews

The survey was published on 10.09.2018 with a response deadline of 24.10.2018. There was a total of 11 responses to the survey, covering 10 fossil free building sites, as indicated in Table 1.1. Table 2.1 provides key information for each project that was contacted for an interview.

Table 2.1 Key information regarding the projects that were contacted for interviews.

	Bogerud farm nursery	Vetland school	New Jordal Amphitheatre	Lindeberg nursing home
Developer	OBY	UBF	KID	OBY
Contractor	HENT	A-bygg	NCC	Skanska
Contract type	EPC NS 8407 (collaboration)	EPC NS 8407	EPC NS 8407	EPC NS 8407 (collaboration)
Area	Unknown	Approx. 2 500 m ²	Approx. 11 550 m ²	Approx. 16 000 m ²
Budget	Contractors contract value approx. 88. mNOK.	Contractors contract value approx. 80 mNOK.	Original contract value 553 mNOK. Adjusted to approx. 694 mNOK.	Contractors contract value approx. 440 mNOK.
Environmental requirements (short version)	Fossil free building site, energy-positive buildings (with solar panels), BREEAM Very good.	Fossil free building site, passive buildings.	Fossil free building site.	Fossil free building site. Ambition level BREEAM Excellent, passive building, geothermal energy well, as well as NZEB-ambition (net zero energy).

In the following, main findings from the survey and interviews are presented.

2.1 Formulation of the requirements in the tender documents

Table 2.2 summarises the answers to the initial questions in the survey on the type of contract form and how the requirement for fossil free solutions was stated in the tender document. The information in the table is reproduced directly from the respondents.

Table 2.2 How was the requirement for fossil free solutions formulated in the tender documents / contract? What wording was used?

Building site	Developer	Type of contract form	How was the requirement for fossil free solutions formulated in the tender documents / contract? What wording was used?	Requirement for emission free solutions?
New Jordal Amphitheatre	KID	NS 8407	<i>Construction of New Jordal Amphitheatre shall take place fossil free. By this is meant; All construction machinery must be either electric or diesel based on standard EN 15940 (HVO/BTL).</i>	No
Lambertseter multi-purpose hall	KID	NS 8407	<i>The construction of the Lambertseter multi-purpose hall shall take place fossil free. By this is meant; All construction machinery must be either electric or diesel based on standard EN 15940 (HVO/BTL). Any use of construction machinery with other fuel must be clarified with the developer.</i>	No
Restoration of the Ila staircase and Evald Ryghs staircase	BYM	NS 8407	<i>From the requirement specification: "It is stated as a requirement in the contract that the construction area must be fossil free. All construction machinery that can be, shall be electrically connected, battery-electric or hydrogen-powered. Other machines will use sustainable biofuel with a standard reduction of greenhouse gas emissions of at least 35%."</i>	No

Olafiaplassen skate park in Grønland	BYM	NS 8406	<i>From the contract form and introductory in the priced bill of quantities: "It is stated as a requirement in the contract that the construction area must be fossil free. All construction machinery that can be, shall be electrically connected, battery-electric or hydrogen-powered. Other machines will use sustainable biofuel with a standard reduction of greenhouse gas emissions of at least 35%."</i>	No
Lindeberg nursing home	OBY	NS 8407	<i>OBY made a separate note describing the requirements for a fossil free building site.</i>	No
Bogerud farm nursery	OBY	NS 8407	<i>Was not asked. Was used in the collaborative phase.</i>	No
Ryen health centre	OBY	NS 8407	<i>It is stated that the project sets the requirements to have a fossil free building site under the contract's Appendix 1, General Requirements for the General Contractor; and environmental goals.</i>	No
Lia nursery	OBY	NS 8407	<i>Requirements for fossil free building site. Defined in EFP. All machines that can, must be powered by electricity/battery. Furthermore, there is a requirement for 2nd generation biodiesel. The requirements were further detailed together with the developer.</i>	<i>"All machines that can be, shall be operated by electricity or battery"</i>
Vetland school	UBF	NS 8407	<i>The building site must be fossil free. That is, all machines that can be operated electrically or by battery must be operated electrically or on battery. Any diesel-powered vehicles shall use second-generation biofuel, according to The Renewable Energy Directive.</i>	<i>"All machines that can be, shall be operated electrically or by battery"</i>
Prinsdal school	UBF	NS 8405	<i>Fossil free construction operations.</i>	No

Regarding the questions on contract form, 8 out of 10 respondents answered that an EPC NS 8407 (General conditions of contract for design and build contracts) was chosen. In the other two building projects NS 8405 (Norwegian building and civil engineering contract) and NS 8406 (the simplified Norwegian building and civil engineering contract) were chosen respectively.

From the table it appears that *the way* the requirement for a fossil free building site has been stated in the tender documents has varied from project to project. For some projects, the requirement has been stated in the requirements specifications, while for others the requirement has been stated in the contract form or in the project's EFP. There are also differences as to *when* the requirement for a fossil free building site has been introduced into the projects.

Points i) through to v) present some of the ways the requirement was specified for selected building projects.

i) Restoration of the Ila staircase and Evald Ryghs staircase

From the requirement specification:

The municipality of Oslo is working to ensure that all construction and building sites shall be emission free. In order to achieve the zero emission target, electrically connected, battery-electric or hydrogen-powered construction machines shall be used wherever possible. Other construction machinery shall use biofuels. This means: biogas, biodiesel, HVO or bioethanol. Biofuels used must be sustainable according to The Renewable Energy Directive.

It is stated as a requirement in the contract that the construction area must be fossil free. All construction machinery that can be, shall be electrically connected, battery-electric or hydrogen-powered. Other machines will use sustainable biofuel with a standard reduction of greenhouse gas emissions of at least 35%.

The tables in Appendix II A and B (Appendix to Chapter 3) of the Product Regulations x1, are used as the basis for assessment of biofuels, see https://lovdata.no/dokument/SF/forskrift/2004-06-01-922#KAPITTEL_4.

Vehicles used for carrying out the assignment shall comply with Euro VI/6. Any use of construction equipment that uses fossil fuels must be clarified with the client in advance.

The developer announced in an email that the same text was used for establishing of the Olafiaplassen skate park in Grønland, but it was included in the contract form.

ii) Lindeberg nursing home

From a separate note prepared by OBY (the requirement for a fossil free building site was originally not mentioned in the tender documents, but was prepared during the preliminary/collaborative phase):

Note – Fossil free building site Lindeberg nursing home:

System boundary: Built-in. This does not mean that we should not do anything outside the building site, but the focus is on what is going on within. We encourage suppliers to use trucks with efficient engines for delivery, avoid delivery in peak hours, and encourage all who are involved in the process to use public transport to and from work.

The following requirements apply to the project Lindeberg:

- *Where there are electrical alternatives with similar capacity for construction machinery, these shall be used.*
- *Machines that can not be driven electrically must be driven by certified biodiesel.*
- *Mass transport must be optimised. With focus on not moving masses more times than strictly necessary. The use of conveyor belts is considered. Establish collaborations with research projects conducted by Sintef. Skanska initiates this collaboration.*
- *Idle driving must be limited to 15%. Logging and reporting in construction meetings.*
- *Construction lights must be timed and must be LED lighting.*
- *Buildings must be sealed before heating.*
- *Geothermal energy wells must be established. If there is not enough power in heat pumps, it should be combined with electric heating.*

iii) Vetland school

From item B.2.3 *Contract provisions* in Part 2 of the tender documents:

Environmental requirements – fossil free building sites:

The building site must be fossil free. That is, all machines that can be operated electrically or on battery, must be operated electrically or on battery.

Any diesel-powered vehicles shall use second-generation biofuels, in accordance with EU renewal directive EN 15940. The contractor shall report to the developer/client about the amount of biodiesel and energy consumption on site. Environmental Product Declaration (EPD) is also required for any biofuel.

iv) New Jordal Amphitheatre

From the tender documents, the contract form, the project's EFP and Book 0:

Fossil free plant operations:

The construction of the New Jordal Amphitheatre shall be fossil free. By this is meant; All construction machinery must be either electric or diesel based on standard EN 15940 (HVO/BTL).

The developer states that this text was deliberately clarified and repeatedly communicated several places because this was one of the first fossil free building sites for KID.

v) Bogerud farm nursery

Bogerud farm nursery originally had no requirements to be a fossil free building site. However, this was established during the project's collaborative phase. The contractor is uncertain as to *how* the requirement became mandatory during the collaborative phase.

Table 2.2 shows that most respondents answered “no” when asked if requirements to provide emission free solutions were included in the tender documents (8 out of 10). The two respondents who answered “yes” refer to the text in the tender documents that stated: “All machines that can, shall be operated electrically or by battery”.

However, several of the respondents who answered “no” on the question have had the same type of requirement in their tender documents. It may therefore appear that there is uncertainty with regards to if the requirement was actually imposed and/or uncertainty about what is actually meant by emission free solutions. Several of the contractors responded in the interview that throughout the tender process they assumed that the developers would not expect unnecessary level of effort/investment to be made to obtain electrical machines.

2.2 Requirements that were set and solutions that were implemented

In the survey, the respondents were asked what requirements for fossil free solutions that were set and which solutions that were implemented, for the following parts of the building project:

- Demolition
- Transportation to/from building site (goods, masses and personnel)
- Installation of building materials
- Earthworks
- Energy consumption of temporary site buildings during construction (building heaters and power)
- Waste and welfare facilities

Requirements that were set

Most respondents refer to the fact that there was one overall requirement for fossil free building sites for all the phases. In other words, there have been no detailed and different requirements for fossil free solutions for each part of the building project as mentioned above. This was also confirmed in the interviews.

Most respondents answered that the requirement for fossil free solutions has not been applicable to the transportation to/from the building site (goods, masses and personnel). The same goes for waste.

From the interviews, the following was noted:

Transportation to/from building site: There seems to be consensus that the requirement for a fossil free building site only applies “within the fence” at the building site and only to site machines. In this context, site machines refers to machines that naturally belong to the building site and are not registered for use on public roads. This may include machines other than fixed cranes, e.g. excavators, mobile cranes etc.

For Bogerud farm nursery, it was required that all internal driving on the site should be fossil free, but the same requirements did not apply to deliveries to/from the construction site. According to the

contractor, this would have been very difficult to adhere to due to a high number of daily deliveries and many subcontractors, often with new drivers every day.

For Vetland school, the requirement for fossil free transportation in and out of the building site was considered unrealistic by the contractor and developer. A common understanding was therefore established that “external” transport could not be fossil free. The requirement for fossil free fuel was therefore only applicable to site machines on the building site.

Clarification of the requirement for fossil free solutions to apply only to site machines within the building site have mostly been obtained after contract award.

Waste: The feedback from the interview objects is that waste is usually handled by external companies (Norsk Gjenvinning, Franzefoss and others similar). Contractors, therefore, have no control over any fossil free waste management, other than that they encourage the waste companies to choose fossil free transport to/from construction site.

Site offices and welfare facilities: Several respondents and interviewees refer to the BREEAM requirements (for those with BREEAM certification) for the site offices and welfare facilities. This implies, inter alia, TEK10 requirements for the facilities. There has thus been no further requirements for fossil free solutions in relation to site offices and welfare facilities beyond this.

Solutions that were implemented

Table 2.3 summarises respondents' answers to which fossil free solutions that were implemented in various phases of the building project. Green cells indicate that an interview took place with the developer or contractor of the building site.

The following conclusions can be drawn from the table:

- The vast majority of respondents responded that the requirement for a fossil free building site has been solved by using biofuel in traditional construction machinery.
- However, some projects have taken an extra step:
 - Lindeberg nursing home has used electric tower cranes and an electric forklift. However, the lifting capacity of the electric forklift is only 1750 kg, so if required, it may occasionally be replaced by a diesel truck with a higher lift capacity of 3000 kg.
 - Bogerud farm nursery has used electric heating with a so-called “electric bear” – a machine for temporary heating that requires good power supply. The contractor highlights that the power demand could have been a problem in larger buildings where more activities were running concurrently. Power demand however, were not a problem during the construction of the nursery.
- As an added note, a few respondents refer to emission free/electrical solutions, in addition to smaller electrical handheld tools.

Table 2.3 Which fossil free solutions were used for the various phases of the building project? The green cells indicate that an interview took place with the developer or contractor of the building site.

Building site Phase	New Jordal Amphitheatre	Lambertseter multi-purpose hall	Ila staircase and Evald Ryghs staircase	Olafiaplassen skate park	Lindeberg nursing home	Bogerud farm nursery	Ryen health centre	Lia nursery	Vetland school	Prinsdal school
Demolition	Traditional machines using HVO100.	Construction machinery using biodiesel.	Electric pneumatic drill.	HVO100.	Traditional machines using HVO100. Some electric robots.	Smaller electrical tools. Motorsaw and excavator using biodiesel.	HVO-diesel.	-	Excavators using HVO100.	Construction machinery using biodiesel.
Transportation to/from building site (goods, masses and personnel)	No requirements. Electric vans used, but no requirements from developer.	No requirements.	Company bus, Euro 6 lorries.	-	No requirements.	No requirement. Transportation uses regular diesel.	No requirements.	Logistics biodiesel.	Got exemption from the requirement.	No requirements.
Installation of building materials	Traditional machines using HVO100. Smaller electrical machines.	Electrical tool.	Electrical tool.	HVO100 / electricity.	Electric tower cranes and electric truck. The latter must be replaced by diesel truck occasionally when extra lifting capacity is required.	Smaller electrical tools. Mobile crane on regular diesel.	HVO-diesel.	-	Lifts using power/battery. Unit for crane could not be operated on HVO100. Got permission for regular diesel.	Electrical tools.
Earthworks	Traditional machines using HVO100.	Construction machinery using biodiesel.	Construction machines using HVO.	HVO100.	Excavators using HVO100.	Two excavators using biodiesel.	HVO-diesel.	Solutions that create mass balance.	Excavators and drilling rig using HVO100.	Construction machinery using biodiesel.
Energy consumption of temporary site buildings during construction (building heaters and power)	Diesel aggregates using HVO100.	Biodiesel and district heating.	-	-	Use geothermal energy well and have dense construction before heating.	Electric heating with "electric bear".	Power, considering the possibility of using geothermal energy well.	Uses the building's floor heating system.	Pellets heating for concrete castings. Planning to use district heating for heating to internal works.	Biodiesel and remote heat.
Waste and site offices and welfare facilities	No waste requirements. Site offices and welfare facilities using electric power.	No requirements.	Electricity.	Electricity.	90% of the waste must be sorted according to EFP. BREEAM requirements for welfare facilities.	BREEAM requirements for welfare facilities (TEK10-standard).	Solutions that reduce waste. Focus on modular, prefabricated and precut.	Requirements set in EFP, as well as internal requirements.	Electric power for site offices and welfare facilities. No requirements for transportation of waste.	No requirements.

Other things of relevance that were mentioned during the interviews:

- Vetland school: The contractor is planning to use district heating for heating to internal works. The contractor has not started construction drying yet, as this is planned with district heating that is connected to the building. There are also heat pipes in the floor that can be used for heating, but it is uncertain if the contractor is planning to establish them. It is somewhat more expensive with pellets compared to diesel. Pellets require a lot of space, more than with a diesel solution. In some projects, there is planned for more construction power. For this project, due to difficult surroundings, it is limited what you get in terms of construction power.
- New Jordal Amphitheatre: Aggregates on biodiesel were used for drying the building. Pellets and reusing demolition material was considered, but local air quality requirements stopped this. There is a community close to building site, and the air quality in the area is monitored weekly. The project conducts dust measurements on site.
- Lindeberg nursing home: Geothermal energy wells must be used and must be well-ventilated before heating. The well park will be established early for liquid heating. If there is not enough power in the heat pumps, electric heating should be used as well. It has been Skanska's responsibility to project manage the construction power.

In the survey, the respondents were also asked what effects they expected from using the fossil free solutions. The answers from developers and contractors are reproduced below:

- *Better air and working environment. Increased costs. Improved climate globally.*
- *Reduced CO₂ emissions.*
- *We expect a lower noise level for our workers, that we help to the green house gas situation and we expect to be able to compete more easily for future tenders.*
- *Economically more expensive. Assumed less air pollution.*
- *HVO100 is more expensive than construction diesel. Fuel consumption seems to be greater.*
- *No financial benefit. Less air pollution is expected, and a reduction in noise level.*
- *Reduced climate emissions, more expensive fuel.*
- *Some suppliers have demanded an economic supplement for the use of biodiesel.*

2.3 Barriers and practical problems

Respondents from the survey were asked to describe any barriers or practical problems they have experienced in implementing fossil free solutions or trying to meet the requirement. Table 2.4 summarises the answers. The information in the table is reproduced directly from the respondents.

Table 2.4 Barriers and/or practical problems associated with implementing fossil free solutions/meeting the requirement.

Building site	Developer	Response
New Jordal Amphitheatre	KID	Developer: Some machines are not certified with the use of HVO. For the use of more emission free solutions, no transformers have enough capacity.
Lambertseter multi-purpose hall	KID	Contractor: Machine manufacturers for drilling rigs do not approve biodiesel.
Ila staircase and Evald Ryghs staircase	BYM	Contractor: Earlier there were problems with quality of biofuels, which meant we could not use the fuels on our machines. HVO diesel works very well. <i>The barriers are as follows. 1) Access to charging facilities on site. 2) Low battery capacity means that excavators can not be used on continuous basis throughout the day. Smaller wheeled loads that can not be operated continuously are the only full-electric solution that currently lasts a whole working day.</i>

		3) Major machinery has to be repaired and replaced over time. The shift will not take place within 1-2 years, but must happen gradually.
Olafiaplassen skate park	BYM	Contractor: Biofuels HVO100 is a scarce resource that also makes prices and deliveries somewhat unpredictable. In many cases, electrical equipment is not effective enough and has too low capacity/range. Developer: Mini-cranes with sufficient capacity to meet the needs require 400V which is not approved for biodiesel. It is challenging when the construction site can not be fenced completely and must be relocated due to access to the public. This makes planning of power supply with enough power difficult. Tower crane is not a real option for lifting the projects.
Lindeberg nursing home	OBY	Contractor: Access to large electrical machines is limited.
Bogerud farm nursery	OBY	Contractor: There is only one mobile crane in Oslo running on biodiesel. Bad selection of suppliers with good solutions to biodiesel. More expensive for the project. Some minor machines for basic work were applied for as there were no real alternatives.
Ryen health centre	OBY	Contractor: There is no supplier of mobile cranes today that offer cranes on HVO diesel. Nordic Crane is working on a solution. In today's market, it is not realistic to expect/require all transportation to and from the construction site to be running on 2nd generation biofuel.
Lia nursery	OBY	Contractor: It may be challenging to get hold of equipment. Not all suppliers have machines prepared for biodiesel/electricity. It may be challenging that there is not enough power capacity in the site. We experienced major changes in the industry only through this building process.
Vetland school	UBF	Contractor: It was not possible to obtain a building crane aggregate on biodiesel from the major rental companies (Ramirent, Cramo). In the project, the requirement for fossil free solutions has not been enforced for transport to/from the construction site. This would have been a major problem and difficult to follow up.
Prinsdal school	UBF	Contractor: Machine manufacturers for drilling rigs do not approve biodiesel. (NOTE: Same contractor as for Lambertseter multi-purpose hall)

Limited access to fossil free solutions

The contractor for Vetland school, A-bygg, claims that it was not possible to obtain a building crane aggregate on biodiesel from the major rental companies like Ramirent and Cramo. The project was therefore allowed to use regular diesel for this purpose. In an interview, the contractor explains that a mobile crane with a Mercedes engine running on biodiesel was used. Because the machine was running on biodiesel, the supplier demanded that the crane had to have additional service, and so it was out of order 1-2 days.

The contractor for Lia nursery points out that it is challenging to obtain fossil free equipment because not all suppliers have prepared their machines for biodiesel/electricity. However, the contractor claims to have experienced major changes in the industry through this building process.

The contractor for Bogerud farm nursery, HENT, explains that there is only one mobile crane in Oslo approved for biodiesel and that the selection of suppliers with good biodiesel solutions is poor. The contractor believes that the fossil free solutions made the project somewhat more expensive. HENT further emphasises that the project failed to find fossil free alternatives for some machines related to earthworks, among other things, for compaction of the ground with a roller and hopper. The project therefore sought discrepancies for these solutions. HENT points out in the interview that it will take time for suppliers to replace their machinery.

The contractor for Vetland school believes that it is only the largest contractors who will acquire electric machines and who will be able to participate in future tenders with ambitious requirements for emission free machines.

Some machines are not certified for HVO

A few respondents pointed out that some machines are not certified for HVO fuel. According to the contractor of Lambertseter multi-purpose hall and Prinsdal school, Asker Entreprenør, this applies particularly for drilling rigs where machine manufacturers do not approve the use of biodiesel. The developer for Lambertseter multi-purpose hall, KID, confirms that this was the case. For Lambertseter multi-purpose hall, the developer provided a guarantee to the contractor that they would pay for a new drilling rig if it was destroyed by HVO fuel.

KID also refers to the contractor of the New Jordal Amphitheatre, NCC, who applied for non-conformance as they could not find a suitable mobile crane certified for operation with biofuels. The contractor did not want to take the risk of using biodiesel on machines that were not certified for this, and so the developer ultimately granted a dispensation to use a mobile crane run by regular diesel.

Skanska, contractor for Lindeberg nursing home, indicates that some of their subcontractors have had problems with machine suppliers for guarantees. An excavator supplier (for demolition) stated that the warranty does not apply to HVO fuel, and that service has to be done more frequently compared to using diesel (500 hours vs. 300 hours) because the HVO fuel does not have the same lubricating effect as conventional fuel.

The contractor for Ryen health center explains that they do not know any mobile crane suppliers who offer cranes that use HVO diesel. The contractor indicates that Nordic Crane is working on a solution and they are closely following this development.

The contractor for restoration of Ila staircase and Evald Rygh's staircase, Skaaret Landskap, replied that problems were previously encountered in obtaining the right quality biofuels, but that today's HVO diesel works very well.

Emission free solutions do not have enough capacity/effect

The contractor for Olafiaplassen skate park, Braathen Landskapsentreprenør, points out that the current electrical equipment is not effective enough and has too low capacity/range.

The contractor for the restoration of Ila staircase and Evald Ryghs staircase, Skaaret Landskap, points out that smaller wheeled loads that are not operated continuously are the only full-electric solution that currently lasts a whole working day. Low battery capacity means that excavators can not be used on continuous basis throughout the day. The contractor also points out that access to charging facilities on site is a challenge.

Skanska, the contractor for Lindeberg nursing home, emphasises that access to large electrical machines with sufficient power is limited. The contractor knows that Hitachi is developing electric excavators with 15 tons capacity. Skanska however, has a need for machines up to 60 tons capacity, and thus there is a way to go until electric machines can compete with fossil fuelled excavators.

Lack of adequate construction power

Both contractors for Lia nursery and Bogerud farm nursery believe sufficient power capacity could prove to be challenging at the building site for the fossil free solutions.

In the interview with the contractor for Bogerud farm nursery, it is explained that electrical machines require a lot of power and good solutions for quick charging. The machines need to be operational all day, which is challenging for a building site with operating hours from 07:00 to 19:00 every day. The contractor questions how to solve this in terms of logistics and power requirements.

The contractor for Vetland school also points out that the power requirement on the building site is a problem, but that the contractors themselves could be better at planning for adequate power supply. For their project, more time could be spent on infrastructure development before building began, so that better use of non-fossil solutions such as district heating could be implemented during the construction phase.

2.4 More details on biofuels

Table 2.5 sums up questionnaire responses to questions about the type of biofuel used, if access was a problem, whether the biofuel satisfies the EU's sustainability criteria from 1st July 2017, and if there are any additional costs for using the biofuel in the projects.

Table 2.5 Type, access, documentation and additional costs of biofuels.

Construction site	Developer	Biofuel used?	Was availability a problem?	Did the biofuel satisfy the EU sustainability criteria from 1 July 2017?	Estimated additional costs due to the use of biofuels?
New Jordal Amphitheatre	KID	HVO100	No	Yes	2-3 NOK/liter. Approx. 100 000,- NOK extra in total.
Lambertseter multi-purpose hall	KID	HVO and 100% biodiesel	No	Yes	3 NOK/liter
Ila staircase og Evald Ryghs staircase	BYM	HVO	No	-	Unsure, but approx. 2-3 NOK/liter.
Olafiaplassen skate park	BYM	HVO100	Yes	-	-
Lindeberg nursing home	OBY	HVO100	No, but you must order in good time.	Do not know, it was arranged by our subcontractor.	This is included in the cost from the subcontractor, assume approx. 5 NOK/liter extra.
Bogerud farm nursery	OBY	HVO100	No	Yes	Yes, 113 000 NOK extra for the project. Total cost of the project is approx. 88. mNOK.
Ryen health centre	OBY	HVO	Yes. But it was mainly ok. It required good planning and close follow-up.	Yes	Not visible in the budget. Possibly taken into account in the form of unforeseen costs.
Lia nursery	OBY	HVO100	No	Yes	No
Vetland school	UBF	HVO100	No, our subcontractor arranged it.	No, only from 2009	No, not calculated. NOK 10.86 for regular construction diesel and NOK 14.47 for HVO100, from website of Circle K.
Prinsdal school	UBF	HVO og 100% biodiesel	No	Yes	3 NOK/liter

Most respondents (6 out of 10) stated that HVO100 has been used in their construction projects. Two respondents stated that HVO was used without specifying what type (cf. the terms and abbreviations used in the report are on p.6). Two other respondents stated that a combination of HVO and 100% biodiesel has been used. Because these were two possible pre-filled options in the questionnaire, we can not exclude the respondents having misunderstood, and actually meant HVO100 in response to the question.

A majority of respondents found that access to biofuels has not been a problem. From two respondents, it was pointed out that access is not a problem as long as you plan well and order the biofuel in good time. The contractor for Olafiaplasen skate park states that access is a problem and that the limited access makes prices and deliveries somewhat unpredictable.

6 out of 10 respondents confirmed that it is documented that the biofuels meet the EU's sustainability criteria from 1 July 2017. Missing responses from two respondents may indicate that they do not know this. The same applies to the contractor for Lindeberg nursing home which indicate that this is handled by their subcontractors.

Contractor for Vetland school, A-bygg, emphasised in the interview that the biofuel in their project meets the EU's sustainability criteria from 2009, referring to the following Circle K cutouts and their Sustainability Compliance Declaration for Biofuels:

The seller company Circle K Norway AS, for the product HVO100, declares as follows:

- *The biofuel product origin is: the Netherlands.*
- *The following components are used as feedstock to produce the product: UCO (100%).*
- *GHG savings: 90,95% actual value according to the DIRECTIVE 2009/28/EC of 23 April 2009, verified by certifying company SGS as part of ISCC-EU certification process.*
- *The feedstock used in the production of the product have the following origin: the Netherlands (100%).*
- *The land use on 1st January 2008 on which the feedstock was produced: NOT RELEVANT SINCE FEEDSTOCK HAS NOT GROWN ON LAND.*
- *The seller company CIRCLE K NORWAY AS, based on the sustainability declarations for the biofuel product delivered at Oslo Ekeberg with: cargo no. XXXYYYZZZZ "XXXXXXX" / 00.00.0000 confirms that the biofuel product is certified under the Red Bioenergy Sustainability Assurance (RBSA) scheme.*

Contractor for Bogerud farm nursery, HENT, points out that all products on site must be checked through Product Exchange, a system for collecting and checking construction products. When asked *how* it is documented that the biofuel satisfies the EU's sustainability criteria from July 1. 2017, the contractor refers to the suppliers' obligations that are available on the websites of, inter alia, UnoX and Circle K:

UnoX³

There are biofuels from different raw materials on the market. Uno-X, like the rest of the industry, has chosen to commit to the fact that all the biofuels we sell must be approved according to the EU's sustainability criteria.

In addition, we completely remove palm oil and residues from palm oil production. Therefore, you can safely use our pumps with good conscience, at the same cheap price as before. We encourage the whole industry to dispose of palm oil.

³ <https://unox.no/i/k/drivstoff/vart-biodrivstoff?backurl=https%3A%2F%2Funox.no%2F%23sc%3Ddrivstoff>

Circle K⁴

milesBIO HVO100 from Circle K is in line with the Norwegian and European standard for HVO diesel, NS-EN15940.

milesBIO HVO100 which is made up of waste has up to 90% CO2 reduction compared to CO2 emissions using fossil diesel. CO2 reduction using milesBIO HVO100 from vegetable oils will vary and depend on the type of feedstock. Circle K, however, guarantees that the CO2 reduction using milesBIO HVO100 will always be higher than 50% compared to fossil diesel, cf. the requirements set in The Renewable Energy Directive.

With regard to estimated additional costs of using biofuels, most respondents agree that this was approximately 2-3 NOK per liter compared with the standard construction diesel. The contractor for Vetland school points out that no additional costs have been calculated for this in the project, but refers to Circle K's website where the price difference between HVO100 and fossil construction diesel is just over 3 NOK per liter⁵.

2.5 Reduced energy consumption and/or efficiency measures

The respondents were questioned to what extent the focus on emission cuts (including requirements for fossil free solutions) has contributed to reduced energy consumption, if they had some examples of efficiency measures, and if efficiency measures have given some savings in their projects. The answers are summarised below:

- The contractor for Bogerud farm nursery claims that requirements for fossil free solutions have not led to reduced energy consumption or savings. However, the requirement has not led to any additional expenses either.
- The contractor for Vetland school believes that the requirement has not given any measurable effect and that no more or less fuel has been used on site.
- The developer of the New Jordal Amphitheatre (also the developer of Lambertseter multi-purpose hall) shows that different contractors have different experiences with the use of biofuels. For Lambertseter multi-purpose hall, the contractor claimed that the use of biofuels resulted in somewhat less fuel consumption. For the New Jordal Amphitheatre, the contractor claims that the use of biofuels has led to more fuel consumption. However, this is regarded as an opinion as no concrete numbers or measurements are available.
- The contractor for Lindeberg nursing home currently has no examples of reduced energy consumption or efficiency measures as a result of requirements for fossil free solutions.

⁴ http://m.circlek.no/no_NO/pg1334073735761/business/milesDrivstoffbedrift/Biodiesel.html

⁵ https://www.circlek.no/no_NO/pg1334073738687/business/milesDrivstoffbedrift/Priser.html

2.6 Case study from Lia nursery

Sintef has recently issued a *Guide to Innovative Procurement Processes – emission free construction sites*⁶ where Lia nursery has been used as a case study. The developer of the project is OBY, and the project was completed in November 2017. The EPC-contract project was required to be Norway's most environmentally friendly nursery, with an ambitious level of BREEAM Very Good and requirement of fossil free construction site.

When constructing Lia nursery, the use of biodiesel in building machines was used as an emission reduction measure. During the construction period, biodiesel was used in all machines except for the cranes. The results show that the use of biodiesel from the activities associated with the construction of Lia nursery, which replaced diesel for excavators, loaders, drilling rig and vibroplate machines, helped reduce greenhouse gas emissions from the construction site by 13%. Fuel emissions from the construction site would have been further reduced by 4% if biodiesel was also used for the cranes.

2.7 Details of power demand

On some building sites it can be challenging to get sufficient temporary power supply (construction power) to meet the electricity needs during the construction phase. If new machines are to be brought in performing tasks that are currently fulfilled by diesel-powered machines, this will add to the strain on the electricity demand, and potentially create further challenges and thus limit the possibility of using new types of electrical equipment.

Based on this, the respondents were asked whether power demand has been a problem during the construction period. Table 2.6 summarises the answers

Table 2.6 To what extent has power requirement been a problem?

Building site	Developer	To what extent has power requirement been a problem?
New Jordal Amphitheatre	KID	<i>This has been a challenge for building heating/drying. Thus, diesel aggregates have been used.</i>
Lambertseter multi-purpose hall	KID	<i>No issues.</i>
Ila staircase and Evald Ryghs staircase	BYM	<i>Not affected by this yet. But, as mentioned earlier, I think this will be one of the biggest challenges. The machines must generally be fast-charging in order to be ready for the following day. This means relatively many amps per machine.</i>
Olafiaplassen skate park	BYM	<i>Problematic to get enough power to execute the operation of a mini-crane.</i>
Lindeberg nursing home	OBY	<i>Our project is in a phase with little power requirements. In order to avoid problems with power supply, it is planned to use geothermal energy wells for heating and electrical only as backup.</i>
Bogerud farm nursery	OBY	<i>Can be problematic when power is used for heating as well. Will require more to electric machines as well.</i>
Ryen health centre	OBY	<i>It has not been, and most likely is not going to be a problem on this project. The project has taken into account this energy requirement when the provisional transformer/grid station was established.</i>
Lia nursery	OBY	<i>It has been solved as much is prefabricated.</i>
Vetland school	UBF	<i>This has been a problem at Vetland school. We had to use aggregate to operate the construction crane.</i>
Prinsdal school	UBF	<i>No issues. (NOTE: Same contractor as for Lambertseter multi-purpose hall)</i>

⁶ "Emission free building sites – State of the art – Guidance for innovative procurement processes". Subject 49, Sintef, 24.08.2018.

The interviewees mentioned the following:

- The contractor for Vetland school, A-bygg, points out that the supply of construction power has been adequate, but the supply nevertheless was unavailable for a couple of occasions. According to the contractor, this would have been an even bigger problem if full-electric excavators were used.
- Also the contractor for Bogerud farm nursery, HENT, states that the construction power short-circuited on a couple of occasions when multiple electrical machines were used at the same time. The main cause of the problem was the use of a so-called “electric bear” for electrical heating of the building. For larger projects, pellets heating would therefore be more appropriate.
- KID, the developer of the New Jordal Amphitheatre, explains that the lack of adequate construction power has been a challenge for the heating and drying of the building. Because there is not enough power, aggregates on biodiesel is used for drying the building. The developer states that a new transformer has been under construction since the autumn of 2018, but the project would have been in need for this since January 2017 if it was to be used on site.
- Skanska, the contractor for Lindeberg nursing home, emphasises that there is enough power on the site, especially at the moment when the project is in a phase with little power requirement. The contractor believe they have been lucky because there is enough capacity where they get their power from. Furthermore, the project is planning to use geothermal energy for heating, so the need for power supply is less compared to other construction sites.

2.8 Other information

The developer of the New Jordal Amphitheatre, KID, explains that they have recently announced three new tenders where requirements for fossil transport to/from construction sites will be enforced stricter than before. For example, for Ullern multi-purpose hall, it is required that the transport of materials and waste to/from construction site, within Norway's borders, shall be carried out with vehicles using fossil free fuel. In addition, the developer, in cooperation with the Norwegian Rental Association, has prepared a matrix with an overview of which emission free machines are possible to use.

From *Book 0, Ullern multi-purpose hall, EPC* (corresponding text is found in Book 0 for Frogner ice rink and Grorud multi-purpose hall):

The construction of the Ullern multi-purpose hall should be as environmentally friendly as possible. The developer has set the following minimum requirements for machinery and equipment used on site;

<i>Category: Construction</i>		
<i>Type of machine</i>	<i>Fossil free</i>	<i>Emission free</i>
<i>Excavator</i>	<i>X</i>	
<i>Loader > 4 tonn</i>	<i>X</i>	
<i>Loader ≤ 4 tonn</i>		<i>X</i>
<i>Rollers</i>	<i>X</i>	
<i>Compressors</i>		<i>X</i>
<i>Category: Heating and Drying</i>		
<i>Type machines/equipment</i>	<i>Fossil free</i>	<i>Emission free</i>
<i>Temporary construction heating and building heating</i>	<i>X</i>	
<i>Category: Lift and Construction Machinery</i>		
<i>Type of machines</i>	<i>Fossil free</i>	<i>Emission free</i>
<i>Crane</i>		<i>X</i>
<i>Mobile crane</i>	<i>X</i>	
<i>Scissor lift with a lifting height > 12 m</i>	<i>X</i>	
<i>Scissor lift with a lifting height ≤ 12 m</i>		<i>X</i>
<i>Boom with a lifting height > 12 m</i>	<i>X</i>	
<i>Boom with a lifting height ≤ 12 m</i>		<i>X</i>
<i>Cherry picker</i>		<i>X</i>

The list is not exhaustive. Machines/equipment not on the list should either be electric or use fossil free fuel. Transportation of material and waste to/from the building site, within Norway's borders, shall also be executed using fossil free fuel vehicles.

If there is a need for a machine or equipment types where the requirements for fossil fuel are not possible, this must be clarified with the developer in advance. In such cases, it is expected that the developer shall require that the machine/equipment is not older than 4 years without any additional compensation.

All fossil free fuel must comply with standard EN 15940 (HVO/BTL).

2.9 Summary

As a conclusion to the survey, the respondents were questioned about their overall experiences with requirements for fossil free solutions, and if in the future, without formal requirements for fossil free solutions, they would use fossil free solutions. Table 2.7 summarises the answers.

Table 2.7 Overall experiences with requirements for fossil free solutions.

Building site	Developer	What experiences have you made about requirements for fossil free solutions in construction projects?	Would you, in future projects, without formal requirements, implement fossil free solutions?	Anything further to add?
New Jordal Amphitheatre	KID	<i>Works well. It has a positive effect on the working environment. There have also been fewer challenges related to the requirement than expected.</i>	<i>Developer: Don't know Contractor: Yes</i>	<i>Developer: The question will be up to the contractor.</i>

Findings from the surveys and interviews

Lambertseter multi-purpose hall	KID	<i>Good experience, but there is a reduced number of contractors entering this market.</i>	<i>Contractor: Don't know</i>	Contractor: <i>The developer must consider the requirements for fossil free building sites. Overall, it is currently cost-driven for a contractor.</i>
Ila staircase and Evald Ryghs staircase	BYM	<i>We are open to it and are generally positive. Full-electrical machinery is coming, but right now it only works for tools and some machines.</i>	<i>Developer: No Contractor: Yes</i>	Contractor: <i>We are positive and like the initiative. Our workers are positive and want to contribute. As long as development is "relatively" fast forward, not by the method of incidence.</i>
Olafiaplassen skate park	BYM	<i>It is generally okay, but there are some situations where one should have the opportunity to express judgment and allow for fossil solutions.</i>	<i>Developer: No Contractor: No</i>	Developer: <i>Missing a standardised way of posting the requirements. Should be promoted equally in all contracts, e.g. in contract.</i>
Lindeberg nursing home	OBY	<i>Can be a challenge to get hold of HVO100. Rumors say that HVO100 means that fuel consumption will be higher and that more pollutants will be released when used. The environmental gain is when HVO100 is produced.</i>	<i>Contractor: Don't know</i>	-
Bogerud farm nursery	OBY	<i>Good air at building site. Few SUB/suppliers are aware of this.</i>	<i>Contractor: No</i>	<i>Contractor: When this becomes more common, the selection should be greater and cost reduced.</i>
Ryen health centre	OBY	<i>Requires good planning and close follow-up.</i>	<i>Contractor: Don't know</i>	-
Lia nursery	OBY	-	<i>Contractor: Don't know</i>	-
Vetland school	UBF	<i>There are alternatives to traditional diesel. Can mostly be handled internally on building site, but not on transport to and from building site.</i>	<i>Contractor: Yes</i>	-
Prinsdal school	UBF	<i>Good experience, but there is a reduced number of contractors entering this market.</i>	<i>Contractor: Don't know</i>	-

The table shows that the vast majority of respondents have had positive experiences related to requirements for fossil free solutions. One respondent emphasises that the selection of fossil free tools and machines is currently limited. Another points out that there may still be situations where one should allow for fossil solutions.

The developer of the New Jordal Amphitheatre emphasises that requirements for fossil free solutions have a positive impact on the working environment. The contractor for Bogerud farm nursery states that the fossil free solutions provide good air on the construction site, and that few subcontractors/suppliers are aware of this.

Despite the positive experiences, however, there are only a few respondents who answer "yes" to questions if they would use fossil free solutions in future projects without formal requirements for this. Considering the additional costs of building fossil free, cf. additional costs of using biofuel from Table 2.5, it is nevertheless encouraging that 3 out of 9 contractors say they would like to be fossil free in the future.

From the interviews, note the following:

- Several of the contractors emphasise the importance of a developer who has a realistic understanding of the requirements for fossil free solutions. In certain cases, it is difficult to procure fossil free alternatives, and this may not happen if there is a risk of delaying project progress.
- The contractor for Vetland school, A-bygg, points out that there is a competitive advantage of having experience with fossil free construction sites for future tenders. Experience with fossil free construction sites is actively used in their marketing.
- A-bygg also mentions that requirements for fossil free solutions have created awareness and discussion about environmental solutions among subcontractors and suppliers at the construction site.
- The contractor for Bogerud farm nursery, HENT, is positive to the requirement for fossil free solutions, but nevertheless answers “no” on the question of whether they would use fossil free solutions in future projects. HENT indicates that working days are already hectic as it is and that the requirement entails additional work that can make it challenging to maintain momentum.
- HENT prefers that the developers in future projects with requirements for fossil free construction sites are more specific about what is meant by fossil free solutions. This will make it easier to relay the requirements to subcontractors and suppliers. HENT believes that a SKOK (cf. a standard requirement specification developed by the municipality of Oslo) should have been prepared for fossil free building sites.
- The contractor for Lindeberg nursing home, Skanska, believes the selection of fossil free solutions must improve. Furthermore, it is emphasised that not all petrol stations have HVO fuel available.
- However, Skanska has not experienced that requirements for fossil free solutions are a major challenge. The requirement has led to more management and more expensive fuel, but the major contractors are usually good at adapting to such changes. The challenge is rather imposed for small contractors and suppliers who are not always aware of new requirements. Skanska indicates that they have had to reject some subcontractors on building sites that have not had suitable solutions.
- Skanska also states that they would like to see a complete account of what the actual environmental effect from biofuels is. Does it increase fuel consumption? Do the machines generate more emissions to the building site? Could it be more environmentally friendly to make sure all the machines are of the latest Stage class?

3 Conclusions

The need for a standardised and clear formulation of the requirements

Responses from the survey and findings from the interviews highlight that the requirement to fossil free building sites has been implemented in very different ways and posed in different places of the tender documents. For some projects, the requirement has been clarified several places (in the requirement specification, the EFP etc.), while for others the requirement has been compiled in the collaborative phase. The execution and understanding of what is meant by fossil free building sites also varies from project to project. Findings from the interviews show that interpretation of the regulations has usually been carried out by the contractor and owner after contract award.

It may seem as if there is a need to better define what is meant by a “fossil free building site”, and what ambition level and system limits should apply (if the requirement applies only to the building site, which building activities should the requirement apply to, should the requirement also include transportation and supplies outside the building site etc.). What each and every tender document puts in the terms “fossil free building site” and “emission free building site” must be well defined in future tenders. A standardised way of requiring fossil free solutions should be developed.

Replacing fossil diesel with HVO biodiesel within the boundaries of a building site

The responses from the survey and findings from the interviews show that the requirement for fossil free building sites largely has been achieved by replacing fossil diesel with HVO biodiesel for site machines within the site boundaries. Not many contractors have managed to implement emission free / electrical solutions for machines any larger than small handheld electrical tools. For a majority of the projects there has been no requirements for fossil free transport to and from the construction site or fossil free waste management.

Despite it being stated in tender documents for several of the projects, that the contractor shall provide emission free machines where possible, in practice, this has only been achieved to a limited extent. Reduction of requirements for emissions free machinery has been carried out in consultation with the contractor after award of contract. This is because battery powered machines with sufficient capacity are not readily available, in addition to the fact that it is very cost-effective. Access to battery-sized machines of the size required by these projects is also limited. Some machines can be supplied with an electric cable, but the range here is also limited.

The need for a review of the energy and power requirements before the construction phase

Findings from the interviews indicate that there is a need for better planning of the construction power supply for building sites. Several of the projects indicated that they would have implemented more of the non-fossil solutions during construction phase if a sufficient construction power supply was established at the start of the project.

It does not seem like the network capacity for the various projects has been investigated before awarding a contract. Some contractors communicated that they have been lucky with enough network capacity in the area. Others state that the power requirement has not been clarified before the announcement of the tender documents and that no sufficient time has been allocated to building a new transformer before construction starts.

Certain machines are not certified for HVO biodiesel fuel

Some contractors pointed out that it can be challenging to procure machines that are approved to be operated with biofuels. The impression from the interviews is that thorough investigations are being conducted to find the right machines, but contractors are not prioritising fossil free alternatives if the project is at risk of delays. In certain cases, the contractors have experienced problems with machine suppliers in relation to the guarantees when using HVO biodiesel fuel. Response from the survey and findings from the interviews shows that this applies to suppliers of drilling rigs, mobile cranes and excavators. Contractors do not want to risk using biofuels on machines that are not certified for this.

Not as problematic as expected

The contractors indicated in the survey and interviews that they have had mostly positive experiences in relation to the requirement for fossil free solutions. The requirement has led to a demand for more administrative duties and an additional cost of the fuel, but many reported that they experienced fewer challenges than they were expecting.

Some contractors also answered that in future projects they would implement fossil free solutions, even when it is not a formal requirement. These are encouraging results given the additional costs of operating fossil free building sites, mainly due to the higher price of biofuels.

Recommendations for further work

The findings described in this report show that requirements for fossil free construction site have been largely resolved by replacing fossil construction diesel with HVO fuel. If the goal is to reduce greenhouse gas emissions for construction and real estate projects as much as possible, it is necessary to evaluate more measures in addition to switching to sustainable fuels during construction phase.

Until now the building industry has been focusing on reducing energy consumption during the operational phase. For buildings environmentally certified after BREEAM-NOR, the energy theme (for operational phase) is weighted by a total of 19%. As more energy-efficient (operational-phase) buildings are being built, the importance of energy use in the construction phase will increase, seen in the building's lifecycle perspective.

During the construction phase it is a clear recommendation to first look at the possibilities for reducing the total energy consumption for the project, and then focus on the fuel type. There are significant benefits both economically and for the climate with reducing fuel consumption. Requirements for sustainable fuel will provide further greenhouse gas savings. The requirements can be stated in the tender documents, where the contractor should be given the freedom to describe how this could be solved and to be rewarded for good measures in the field of greenhouse gas reduction.

Requirements should be measurable and made so that contractors are incentivised to implement change and have a target to aim for. If requirements are made for emission free solutions, these should be clear and well thought out. Further development is dependent upon ambitious developers who indicate early which requirements will be set. It is easier for the building industry to invest in emission free solutions if there is a certain predictability and long-term commitment. Investment in new machinery is expensive and a certain volume of this type of assignments is required if the investment is to be sustainable.

DNV's supervisor for the organisation of fossil free and emission free solutions at the building site⁷ provides recommendations on how to proceed from the early stages of a project.

Looking beyond the requirements for fossil free or emission free construction sites, the use of methodology in BREEAM-NOR over several years has proved to provide good overall solutions for sustainable construction. CEEQUAL is expected to become an industry tool for sustainability in construction projects. CEEQUAL is already well established in England and throughout the world, where both private and public builders use this. Both BREEAM-NOR and CEEQUAL make use of life cycle analyses and related measures for greenhouse gas reduction. Both systems provide good systematics, documentation and predictability in how environmental and sustainability requirements are set and desired by the both the building and construction industries.

⁷ "Supervisor for the organisation of fossil free and emission free solutions at the building site". Report number 2018-0418, rev. 2. DNV-GL.

4 Sources

- “Emission free building sites – State of the art – Guidance for innovative procurement processes”. Subject 49, Sintef, 24.08.2018.
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Attachment 1: Questback - Study of fossil free building sites

- 1) Which type of entity do you represent?
 - Developer
 - Contractor
 - Supplier/Subcontractor
 - Other (please describe)

- 2) In which fossil free building sites have you as a developer/contractor/supplier/other been involved in?
 - Bogerud farm nursery
 - Establishment of the Olafiaplassen skate park in Grønland
 - Gransletta nursery
 - Grønland nursery
 - Gustav Vigelands road 50-52
 - Lambertseter multi-purpose hall
 - Lia nursery
 - Lilleslottet nursery
 - Lindeberg nursing home
 - Marmorberget nursery
 - New Jordal Amphitheatre
 - Prinsdal school
 - Prinsdalsbråten nursery
 - Restoration of the Ila staircase and Evald Ryghs staircase
 - Ryen health centre
 - Rødtvet nursery
 - Skullerudbakken nursery
 - Slemdal school
 - Vetland school
 - Other (please describe)

Information text 1

Fossil free building sites are building sites that do not use fossil energy sources. This means that all construction machines on the construction site must use non-fossil fuels (e.g. biodiesel/electric). This applies, for example, to construction machinery, temporary heating, construction power supply and transportation to and from building sites. A fossil free building site is not the same as an emission free building site, however a fossil free building site may include the use of emission free machinery.

Emission free building sites is a more ambitious goal and means that all processes on the site are emission free. This involves the use of the energy sources that do not lead to local emissions of CO₂ or NO_x on the building site. For example, this will apply to electric, battery powered, or hydrogen-powered construction machinery, electricity or district heating for temporary heating and drying, zero discharge to, from, and at building sites (machinery, materials, waste and personnel).

None of the following questions are mandatory.

3) What type of contract was used in the fossil free building project you were involved in?

4) How was the requirement for fossil free solutions formulated in the tender documents / contract? What wording was used?

5) Was there also a requirement for emission free solutions in the tender documents / contract? What wording was used?

6) What requirements for fossil free solutions were detailed and what solutions were implemented for the different phases of the building project?

	Requirements that were asked	Solutions that were implemented
Demolition		
Transportation to/from buildings site (goods, masses and personnel)		
Installation of building materials		
Earthworks		
Energy consumption of temporary site buildings during construction (building heaters and power)		
Waste and welfare facilities		

7) What are the expected effects (economic, health, air pollution, etc.) of using fossil free solutions?

8) Describe any barriers or practical problems related to implementing the solutions / meeting the requirement.

9) What type of biofuel was used in the fossil free building project?

10) Was biofuel access a problem in the fossil free building project?

11) Has it been documented that the biofuels meet the EU's sustainability criteria from 1st July 2017?

12) Has it been calculated on the fossil free building project that there are additional costs of using biofuels compared to fossil fuels?

Information text 2

On some building sites it can be challenging to get sufficient temporary power supply (construction power) to meet the electricity needs during the construction phase. If new machines are to be brought in which perform tasks that are currently fulfilled by diesel-powered machines, this will add to the strain on the electricity demand, and potentially create further challenges and thus limit the possibility of using new types of electrical equipment.

13) To what extent has the power demand been a issue on the fossil free building projects you have been involved in?

14) What is your experience regarding the requirements for fossil free solutions in building projects?

15) Would you, in future projects, without formal requirements, implement fossil free solutions?

- Yes
- No
- Not sure

16) Any other comments or suggestions?