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FOSSIL- AND EMISSION-FREE BUILDING SITES

Guide to arranging fossil- and emission-free solutions on building sites

Energy Norway, the Norwegian District Heating Organization, ENOVA, the Federation of Norwegian Construction Industries (BNL), the Norwegian Contractors Association Oslo, Akershus and Østfold (EBAO), Climate Agency, City of Oslo and Nelfo

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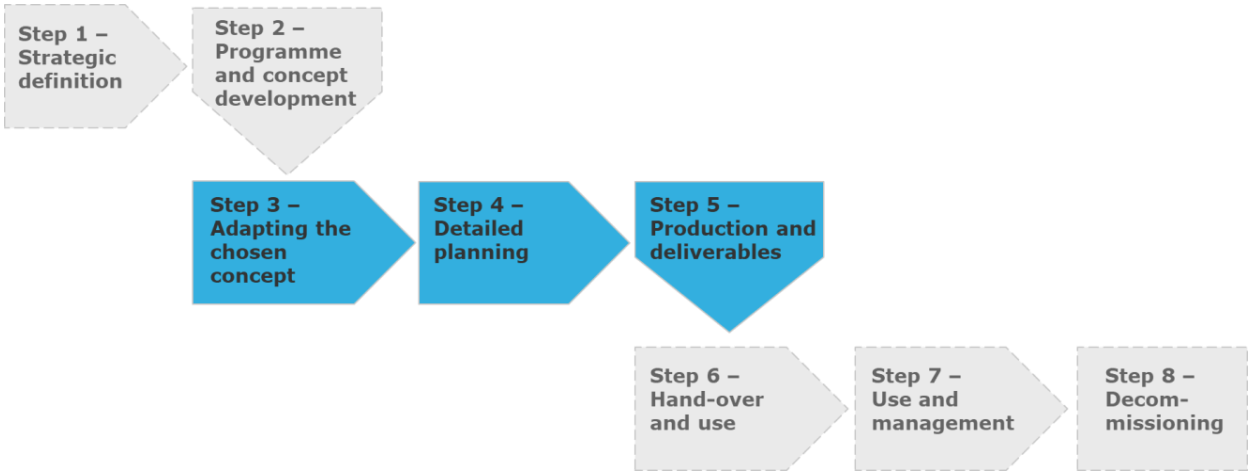
Contents

SUMMARY

Currently, building sites in Norway mainly use fossil energy sources. In the past few years, this has received increased attention due to a desire to reduce greenhouse gas emissions and local air pollution. DNV GL has prepared a guide to arranging for the use of fossil- and emission-free alternatives on building sites on behalf of Energy Norway, the Norwegian District Heating Organization, ENOVA, the Federation of Norwegian Construction Industries (BNL), the Norwegian Contractors Association Oslo, Akershus and Østfold (EBAO), Climate Agency, City of Oslo and Nelfo.

The guide focuses on what should be done differently in the building process when using fossil-free and/or emission-free alternatives compared to when using conventional technology. It is designed as a checklist and points out the action points where the building process is different from that on a traditional building site. The action points shed light on what is required to arrange for the use of fossil-free and emission-free heating solutions, construction machinery and equipment on building sites.

The structure of the guide agrees with the steps in the general outline of the building process, which consists of eight steps. This guide only deals with steps 3 to 5.



General outline of the building process according to the "Next Step" phase standard /D09) – this guide deals with steps 3 to 5

In Step 3, the chosen concept is adapted and this is the first time there is sufficient information on the project (for example, where the new building is to be located) for it to be relevant to plan for a fossil-free or emission-free building site. In Step 6, the building is put into operation, and the building site is thus closed down.

For steps 3 to 5 in the building process, there are specified action points that it is important to take into consideration when working towards a fossil-free or emission-free building site. Each action point has an ID according to the step to which it belongs: "A" for *step 3: adapting the chosen concept*, "D" for *step 4: detailed planning* and "P" for *step 5: production and deliveries*. More detailed sub-points are specified under each action point on level 1 (for example, A1 or P2). The relevant parties are listed on the right in the guide: developer, contractor, subcontractor, DSO[1], district heating company and fuel supplier. The parties' roles are specified here for each action point.

[1] Distribution System Operator

r - responsible
e - executes
c - to be consulted
i - to be informed
d - decides

		Developer	Contractor	Subcontractor	DSO	District heating co.	Fuel supplier
Step 3: ADAPTING THE CHOSEN CONCEPT	**A1. Estimate the building's electric power and heat demand when in operation**	r					
	A2 Find out what fossil-free and emission-free alternatives are available at the building site in question	r		c	c	c	c
	A3. Find out the existing alternatives for reducing the building site's energy demand	r			c		c
Step 4: DETAILED PLANNING	**D1. In the invitation to tender, stipulate realistic requirements for the use of fossil-free and emission-free alternatives at the building site**	r	c	c			
	D2. Map the energy and power demand	i	r	c			
	D3. Plan the creation of infrastructure up to the building site	i	r	c	c	c	i
	D4. Ensure that the logistics at the building site are adapted to the use of fossil-free and emission-free alternatives	i	r	i	c	c	c
Step 5: PRODUCTION AND DELIVERIES	**P1. Logistics and execution plan**		r	e			
	P2. Measuring and reporting energy usage for continuous learning	r	e	i	c	c	c

This report is intended to provide more detailed background information and a framework for the guide. Chapter 1 provides an introduction in which the method as well as limitations and definitions are described. Chapter 2 describes fossil-free and emission-free alternatives during the building period, chapter 3 provides in-depth information on the guide's structure and contents, chapter 4 provides perspectives on developments in the area in the short and long term, while chapter 5 describes the road ahead in the work to achieve emission-free building sites in Norway.

1 INTRODUCTION

DNV GL has prepared a guide for arranging for the use of fossil-free and emission-free alternatives at building sites on behalf of Energy Norway, the Norwegian District Heating Organization, ENOVA, the Federation of Norwegian Construction Industries (BNL), the Norwegian Contractors Association Oslo, Akershus and Østfold (EBAO), Climate Agency, City of Oslo and Nelfo.

Currently, Norwegian building sites mainly use fossil energy sources. In the past few years, this has attracted more attention due to a desire to lessen greenhouse gas emissions and local air pollution. We would like this guide to help reduce emissions on building sites by facilitating the increased use of energy solutions based on electricity, district heating and other non-fossil solutions as well as the implementation of energy efficiency improvement measures.

The goal has been to establish a practical and usable guide. The guide's focus is therefore on what should be done differently during the building process when using fossil-free and/or emission-free alternatives compared to when using conventional technology. It is formed as a checklist and points out the action points where the building process is different from that on a traditional building site. The action points shed light on what is required in order to arrange for the use of fossil-free and emission-free heating solutions, construction machinery and equipment on building sites.

This report is intended to provide more detailed background information and a framework around the guide. The method, limitations and definitions are described further on in this chapter. Chapter 2 describes fossil-free and emission-free alternatives during the building period, chapter 3 provides in-depth information on the guide's structure and contents, chapter 4 provides perspectives on developments in this area in the short and long term, while chapter 5 discusses the road ahead in the work of achieving emission-free building sites in Norway.

1.1 Method

The guide has been prepared in close contact with relevant parties. During the project, interviews/talks have been held with 25 parties representing developers, contractors, suppliers, district heating companies and DSOs. An open workshop with representatives of the above interested parties and affected organizations has also been held. An overview of the interviews held and workshop participants is included in annexes 2 and 3.

Through the interviews and workshop, several action points and subpoints have been identified and these are linked to steps in the building process. For a general outline of the building process, the steps in the phase standard "*Neste Steg*" (Next Step) /D09/ have been used, illustrated in Figure 1. The resulting checklist, with action points and subpoints linked to the steps to which they belong, makes up the actual guide.

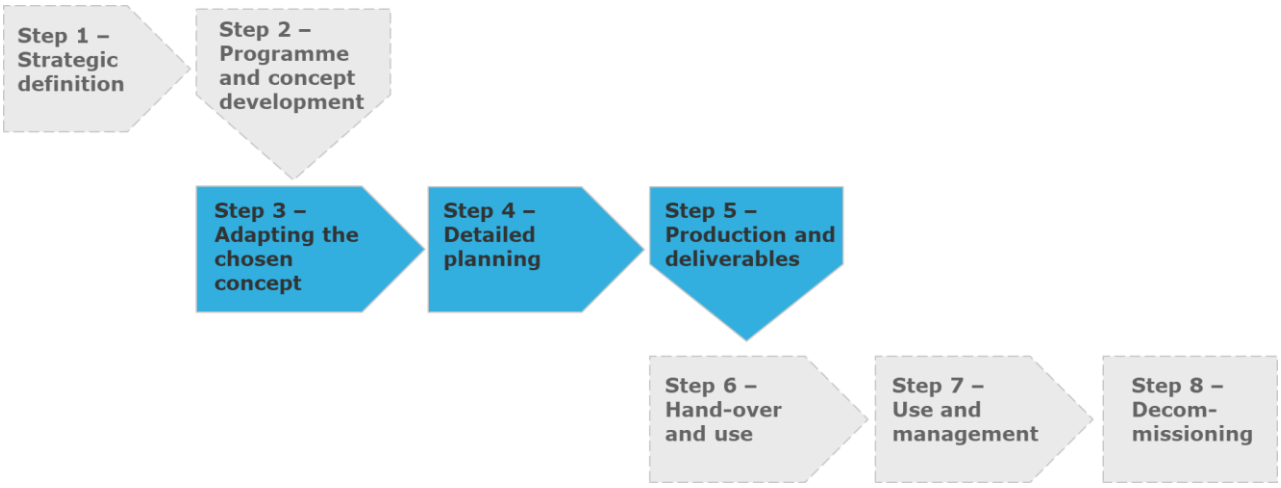


Figure 1. General outline of the building process according to the phase standard "*Neste Steg*" (Next Step) /D09/ - this guide deals with steps 3 to 5

This guide only deals with steps 3 to 5, see Figure 1. In Step 3, the chosen concept is adapted and this is the first time there is sufficient information on the project (for example, where the new building is to be located) for it to be relevant to plan for a fossil-free or emission-free building site. In step 6, the building is put into operation and the building site is therefore wound up.

Below is a brief description of the steps in the building process according to the "Next Step" phase standard – for a more detailed description, refer to the *Veileder for fasenormen «Neste Steg» (Guide to the "Next Step" phase standard)* /D09/.

Step 1 – Strategic definition: identify the reason, general goals and frameworks for the measure (i.e. new building). The typical output of this step is recognition of the user's need for a measure and a justified assessment of whether it is commercially sensible to examine the measure with a view to implementing it.

Step 2 – Programme and concept development: ascertain whether the measure is feasible and decide which solution in principle is most expedient. The typical output is a conclusion of if the measure is feasible, an assessment of which concept (solution in principle) best satisfies the owner's business plan and the users' needs, and a decision on whether to go further and which concept is to be developed.

Step 3 – Adapting the chosen concept: develop the principles for a technical solution, realistic strategies and plans for the measure so that a final decision on implementation can be made on the correct basis. The typical output of this step is the final scope for the solution (functions and areas), a specific execution plan and a cost estimate (acctual budget), including a final decision to finance and carry out the project.

Step 4 – Detailed planning: develop a sufficiently detailed and quality assured work basis so that safe and proper execution is possible. The typical output of this step is a correct, agreed-on basis for producing the measure to the right quality and according to schedule, as well as a sufficiently detailed execution plan. In a construction subcontract, the tender documents are created as a description and drawings that the contractors assign a price to. In a Engineering, Procurement and Construction (EPC) contract, the responsibility for this is assigned to the turnkey contractor.

Step 5 – Production and deliveries: complete the delivery (the building) in accordance with plans and intentions, safely and with the correct workmanship/design. The project execution is to be built on the basis created by advisors – subject to either the developer or the contractor.

Step 6 – Hand-over and use: hand over a flawless project and ensure that all the systems are correctly adjusted for their intended use.

Step 7 – Use and management: ensure technically good and economical operations that meet the needs of the project's user and provide the intended effect.

Step 8 – Decommissioning: the sale of the building, or termination of the building's period of use (demolition).

1.2 Scope

The guide and report focus on activities that lead to energy usage and emissions *at the building site.* This includes the use of heating, construction machinery and any other equipment. In addition, there is a focus on the infrastructure necessary for arranging the use of emission- and fossil-free heating solutions and machinery.

The transport of masses, materials, machinery, persons, etc, to and from the building site and the energy usage and emissions linked to the production of materials and other activities outside the actual building site are not covered by this project. Figure 2 illustrates the guide's focus area, i.e. the activities linked to the building site on which the guide focuses.

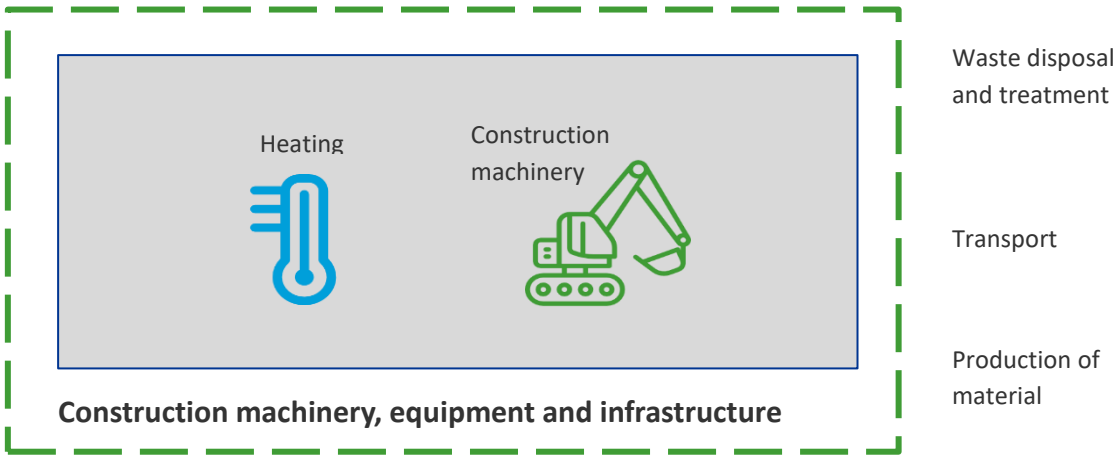


Figure 2. Illustration of the guide's focus area – within the area marked in green.

The report does not discuss or consider emission factors linked to the use of various energy carriers. A more detailed discussion relating to the environmental and ethical aspects of using biodiesel is mentioned by several parties. However, it is not within the scope of this assignment to discuss this in any further detail.

The guide is practically oriented, with an overview of what should be implemented in order to make conditions suitable for fossil- and emission-free alternatives. Cost/benefit assessments or other assessments linked to the use of emission-free alternatives or introduction of emission requirements on building sites are not covered by this project.

1.3 Definition of emission-free and fossil-free alternatives

The concepts of emission-free and fossil-free have to some extent been used interchangeably when talking about emissions from building sites. A definition of the meaning of these concepts in this context is therefore provided here:

- An emission-free building site entails the use of energy sources that do not lead to local emissions of CO_2e or NOx *at the building* site. Emission-free heating alternatives include heating based on

electricity, district heating and other energy carriers that do not lead to local emissions of CO_2e or NOx at the building site. Emission-free alternatives when using construction machinery include battery-electric machinery and electric machinery connected directly to the power grid (electric-cable construction machinery). In the longer term, other emission-free alternatives may be developed to replace or supplement the emission-free alternatives mentioned above.

- A fossil-free building site entails the use of emission-free machinery and solutions, and in addition allows the use of sustainable bioenergy and biofuels.

2 FOSSIL-FREE AND EMISSION-FREE ALTERNATIVES DURING THE CONSTRUCTION PERIOD

This chapter discusses the existing alternatives to the use of fossil energy at the building site. Table 1 provides an overview of fossil-free and emission-free heating and construction-machinery alternatives. The various fuel alternatives listed in the table below can also be combined.

Table 1. Fossil-free and emission-free alternatives at the building site

Alternative	Fuel / energy source	Heating	Construction machinery
Fossil-free	Pellets	x	
	Biofuel	x	x
Emission-free	District heating	x	
	Electricity	x	x
	Geothermal heating	x	
	Hydrogen*		
Other	Energy efficiency	x	x

**Not commercially available today*

With the exception of hydrogen, the alternatives are commercially available technologies already used in building projects today. Some of the alternatives, such as district heating, are only available in areas where a district-heating infrastructure has been built or there are plans to establish district heating, while for example electricity, pellets and biodiesel are solutions that are available nationwide. Given the accessibility of sustainable biofuels, it should be possible to meet a requirement of a fossil-free building site throughout Norway.

The alternatives are described in more detail below.

2.1 Heating and drying out

Temporary heating and drying out at the building site is often called building heat. Building heat is used to heat up interiors and dry out moisture, to set concrete, to heat up facades and for defrosting/frost protection. At present, diesel and propane are the two energy sources mainly used for heating. In connection with heating of interiors, electricity and district heating are also used to a considerable extent, while pellets and biofuel are used to some extent.

Heating and drying out at the building site can be divided into three activities: 1) heating when laying a concrete deck at the building site (concrete hardening), 2) facade heating and 3) interior heating. Heating at the building site is used to dry out materials and to achieve a satisfactory temperature when it is too cold outside to carry out necessary work. The need for heating is thus highly dependent on the outdoor temperature. In general, it can be said that the need for heating is restricted to the period from November until the end of March. At other times of the year, the need for heating is limited or non-existent.

2.1.1 Fossil-free heating

Fossil-free heating alternatives include bio-based energy sources such as pellets and biofuels (e.g. bioethanol, biodiesel, HVO100 or biogas).

Pellets

Pellets can be used to heat and dry out a building, but is also very suitable for point heating for defrosting/frost-protection purposes, for example. A pellet-based heating solution is in theory available

throughout Norway. Due to the limited capacity, it is an advantage to order in advance as there may be a waiting period for deliveries.

The flexibility of pellet-based heating solutions is very similar to that of current hot-air heating systems. Interviews have shown that pellets are a cheaper solution than a hot-air heating system (using diesel without road tax). The cost linked to equipment (cost of capital) is higher, but the actual operating costs are lower. Due to the relatively high cost of capital, pellets are a solution that is from a cost perspective most suitable for heating over longer periods (2-3 months or more).

A pellet-based heating solution is a relatively small system that does not require much space. However, there is a need to plan the location of pellet containers for filling purposes. It is important that the container is located close to the filling site.

Biofuel

Biofuel (bioethanol, biodiesel, HVO100 or biogas) may be used as alternatives to fossil fuels for heating and drying out at building sites. Biofuel, in the form of HVO100, is available throughout Norway but there may be availability problems due to the high demand. When using a biofuel, it is important that it is sustainable, i.e. meets the EU sustainability criteria, and that biofuel made from palm oil and bi-products of the palm oil industry are avoided.

In 2017, the world's largest liquefied biogas (LBG) facility was established at Skogn in Levanger, Norway. Biogas is thus available in Norway and can potentially replace the use of propane at building sites. So far, no technical solutions for this are available on the market /D10/.

2.1.2 Emission-free heating

Alternative energy carriers to ensure emission-free heating and drying out at the building site include district heating, geothermal heating and electricity.

District heating

A district heating facility is in practice a central heating facility that supplies a city district or several buildings with energy for hot water and heating. The facility uses various energy sources, ranging from industrial waste heat to waste heat from the incineration of refuse, heat pumps, bioenergy, etc, to heat water. In Norway today, district heating has been built or is being built in 92% of all towns with more than 10,000 inhabitants. /D02/ Municipalities can stipulate a duty for new buildings to be connected to the local district heating network. Whether or not there is a duty to connect and the floor spaces that apply therefore vary from municipality to municipality.

District heating may be used for heating and drying out at the building site. However, it is normal for new buildings to be connected to the district heating network after they have been built. If the building is instead connected at the beginning of the building process, the district heating can be used at that time too. Heating and drying out can be carried out either by using the building's future permanent facility or by connecting mobile units directly to the district heating intake in the building /D03/.

In order to use district heating during the building period, it is important that contact between the contractor and the district heating company is established at an early stage, as to clarify the required power and potential need for new infrastructure. Experience has shown that the contractor and district heating company can find solutions together if they have a good dialogue. The contractor may be cautious about doing this if it has not used district heating before and has no experience of it. Interviews have shown that contractors which have used district heating before often want to use it again.

Interviews also show that, in most cases, it is not a problem for the district heating company to deliver the power required. District heating is more efficient than hot-air heating systems and experience shows

that the power used is less than what is available. If there is a need for point heating at some location, there may be a need for extra power/heating.

Planning is essential, for example technical rooms should be located as close to the heating pipes as possible and pipes and hoses should be located such that any unwanted stoppage due to damage/a leak or a necessary move is prevented. It is important to clarify whether a permanent heating plant or mobile units are to be used. If district heating is used during the construction period, there is a risk that dirt/sediments will enter the permanent solution, so it is important to use a filter on the heat exchanger. It is important to be aware that the use of a permanent heat exchanger may in some cases affect the equipment's guarantee period, so that this is to be considered and evaluated before implementing the solution.

Geothermal heating and heat pumps

Geothermal heating is obtained by utilizing heat stored in rocks, earth or ground water. A heating plant extracts the heat stored in the ground via energy wells. An energy well is usually a borehole with a diameter of around 14cm and a depth of 80-200m. Anti-freeze liquid circulates in plastic tubing in the borehole and brings up energy which is extracted in a heat pump. /D04/

The parties we interviewed have little experience of geothermal heating, but this is regarded as an alternative that can also be used during the construction period. If geothermal heating is to be used during the construction period, the energy wells' location must be given careful consideration. In the same way as for district heating, it is important that technical rooms are located as close to the heating pipes as possible and that pipes and hoses are situated such that an unwanted stoppage due to damage/a leak or a necessary move is prevented.

Heat pump alternatives, such as air-to-air heat pumps or air-to-water heat pumps, can also be considered for heating during the construction period - especially if use of these energy solutions is planned once the building is in operation.

Electricity

Electricity can be used as an energy source for heating and drying out at the building site. The building site is connected to the power grid via a temporary facility, such as a temporary substation, that allows electricity to be obtained from the grid owner during the construction period.

If electricity is to be used at the building site, it is important that contact with the local DSO is established as early as possible, so that arrangements can be made for power and infrastructure to be available at the building site.

The opportunity to use electricity may be restricted by the power available, i.e. the volume of electricity that can be delivered without the electricity grid having to be upgraded, leading to high costs being incurred (construction contribution). Interviews and experience of using electricity at building sites indicate that, in the vast majority of cases, the building's power demand when in operation is sufficient to cover the building site's power demand for both heating and the operation of electrical construction machinery. Ambitions for a more energy-efficient building may increase the risk of the building's power demand when in operation not meeting the building site's power demand.

If there are restrictions on the available power, or there is a desire to avoid overdimensioning a system that is to be used when the building is in operation, then mobile batteries may be a solution. In the longer term, several parties point to electricity storage using hydrogen as an energy carrier being a possibility.

2.2 Construction machinery

The use of construction machinery varies widely from building project to building project – from projects with simple ground conditions that only require a couple of excavators for a few months to projects that also require machinery to move earth, piling, etc. A project's level of complexity considerably affects the energy usage and emissions of construction machinery at the building site. Today, diesel is the main energy source used as fuel for construction machinery. Below, available fossil-free and emission-free alternatives are described.

2.2.1 Fossil-free construction machinery

Fossil-free construction machinery includes construction machinery that uses biofuels such as bioethanol, biodiesel, HVO100 or biogas.

Experience of fossil-free building sites obtained from interviews shows that almost all types of machinery are available for the use of HVO100. Mobile cranes appear to be the only machinery not approved for the use of biodiesel (HVO100). Table 2 provides an overview of available types of machinery that can use HVO100.

Table 2. Overview of available types of machinery that can use HVO

Machine types	Producer	Availability in Norway	Supplier
All machines newer than 20 years	Caterpillar	Yes	Pon Equipment
All machines	Volvo	Yes	Volvo Maskin AS
Limited	Hitachi	Yes	Nasta

Technologically, it is therefore not difficult to use fossil-free construction machinery. Other challenges may be the availability of biofuels that meet EU sustainability criteria (with requirements as to climate benefit and area usage). To control the use of fuels, it is possible to establish a biofuel tank at the building site that all parties must fill from. Another alternative may be for subcontractors to document their usage by, for example, filling receipts.

2.2.2 Emission-free construction machinery

Electric construction machinery is emission-free construction machinery. In the future, there may also be construction machinery that uses hydrogen as an energy carrier. Interviews and experience of using electricity at building sites indicate that, in the vast majority of cases, the building's power requirement when in operation is sufficient to meet the building site's power requirement for both heating and the operation of electric construction machinery.

Currently, electric-cable construction machinery is available in all machine categories, while hybrid and battery-electric solutions are only available for small machinery categories. In Norway, the number of available electric construction machines is limited. There is a need to plan and order these at an early stage to ensure access to the electric machines that are on offer, and it may even be necessary to hire for a few extra months to ensure access to this machinery. If demand increases, then the supply will also increase.

Table 3 and Table 4 show an overview of the available hybrid and battery-electric construction machinery. The overview does not give a complete list of electric-cable construction machinery, if asked for, they are already available in all machine categories. Electric-cable construction machinery is used in, for instance, mines, mountain facilities and when building tunnels.

Table 3. Overview of hybrid construction machinery

Machine category	Model	Battery/ cable	Producer	Lifting capacity (tonn)	Oper-ating time	Availability in Norway	Supplier /rental firm
Excavator < 75 kW	803 dual power	Battery	Wacker Neuson	1		Yes	Utleiersenteret
Excavator < 75 kW	803 dual power	Battery	Wacker Neuson	1		Yes	Cramo
Excavator < 75 kW	803 dual power	Battery	Wacker Neuson	1		Yes	Wacker Neuson AS
Excavator > 75 kW	HB215LC-2 Hybrid	Battery	Komatsu	23		Yes	Hesselberg
Excavator > 75 kW	HB365LC/NLC-3 Hybrid	Battery	Komatsu	37		Yes	Hesselberg

Table 4. Overview of battery-electric construction machinery

Machine category	Model	Battery/ cable	Producer	Lifting capacity (tonn)	Oper-ating time	Availability in Norway	Supplier /rental firm
Mining loader	Scooptram ST14 Battery	Battery	Epiroc/Atlas Copco	14		No	Epiroc Norge AS/Atlas Copco Norge AS
Loader	Avant e6	Battery	Avant	< 1.4	2-6 h	Yes	Felleskjøpet Maskin BA
Loader	Kramer 5055e	Battery	Wacker Neuson	< 2.5	5 h	Yes	Wacker Neuson AS
Excavator < 75 kW	TB216E	Battery	Suncar HK	2	"One workday"	No	Huppenkothen
Excavator < 75 kW	TB1140E	Battery	Suncar HK	16	"One workday"	No	Huppenkothen
Dumper	DT10e	Battery	Wacker Neuson	<0.9	8 h	Yes	Wacker Neuson AS
Dumper	TCH-R800 FED	Battery	Messersi	0.8	4.5 h	Yes	Thor Heldal AS
Dumper	600WS	Battery	Fort	0.6	6 h	Yes	Maskin Importøren AS
Dumper	BendI E 450	Battery	TUFFTRUK	0.45	4 h	Yes	Limaco AS
Dumper	ED1500	Battery	Ecovolve	< 1.5	"One workday"	Yes	Dia Proff Norge AS
Dumper	Komatsu 605-7	Battery	Komatsu	110		Yes	Hesselberg
Mobile crane	ECO-095/ECO-295	Battery	Unic	< 3		Yes	Knutsen Maskin AS
Excavator> 75 kW	ZX160LC-6	Battery/ cabel	Hitachi	17		Yes	Nasta
Excavator> 75 kW	Sennebogen 818RE	Cable	Sennebogen	20		Yes	Volvo Maskin AS
Mining loader	Scooptram ST1030	Cable	Epiroc/Atlas Copco	10		No	Epiroc Norge AS/Atlas Copco Norge AS
Excavator> 75 kW	323F Z-line	Battery	Caterpillar	25	5-7 h	Yes	Pon Equipment
Loader	WL20e	Battery	Wacker Neuson	2		Yes	Utleiersenteret
Loader	1160 eHoftrac	Battery	Weidemann	5		Yes	Utleiersenteret
Excavator < 75kW	Brokk 100		Brokk	1		Yes	Utleiersenteret
Excavator < 75kW	323F Z-line	Battery	Catepillar	25		No, will be available in 2018	Utleiersenteret
Excavator < 75kW			Volvo	3		No, but ordered	Utleiersenteret

Machine category	Model	Battery/ cable	Producer	Lifting capacity (tonn)	Oper-ating time	Availability in Norway	Supplier /rental firm
Loader	Kramer 5055e	Battery	Wacker Neuson	2		Yes	Cramo

The use of electric construction machinery must be planned for at an early stage in the construction process. The necessary infrastructure, such as charging points and the logistics around them, must be well thought out. It is important that the locations of charging points and/or connection points do not lead to cables lying on the ground at inappropriate spots.

3 THE GUIDE

The guide is structured according to the steps in the general outline of the building process. For a general outline of the building process, the steps in the phase standard "*Neste Steg*" (Next Step) /D09/ have been used, see Figure 1 with an associated description of the steps in chapter 1.1.

For steps 3 to 5 in the building process, action points that are important to take into consideration in order to work towards a fossil-free or emission-free building site have been specified. Each action point has an ID according to the step to which it belongs: "A" for *step 3: adapting the chosen concept*, "D" for *step 4: detailed planning* and "P" for *step 5: production and deliveries*. Under each action point on level 1 (for example, A1 or P2), more detailed sub-points are specified.

The relevant parties are listed on the right in the table: the developer, contractor, subcontractor, DSO, district heating company and fuel supplier. The parties' roles are specified here for each action point.

Each action point and its sub-points are described below.

	r - responsible e - executes c - to be consulted i - to be informed d - decides	Developer	Contractor	Subcontractor	DSO	District heating co.	Fuel supplier
Step 3: ADAPTING THE CHOSEN CONCEPT	**A1. Estimate the building's electric power and heat demand when in operation**	r					
	A2 Find out what fossil-free and emission-free alternatives are available at the building site in question	r		c	c	c	c
	A3. Find out the existing alternatives for reducing the building site's energy demand	r			c		c
Step 4: DETAILED PLANNING	**D1. In the invitation to tender, stipulate realistic requirements for the use of fossil-free and emission-free alternatives at the building site**	r	c	c			
	D2. Map the energy and power demands	i	r	c			
	D3. Plan the creation of infrastructure up to the building site	i	r	c	c	c	i
	D4. Ensure that the logistics at the building site are adapted to the use of fossil-free and emission-free alternatives	i	r	i	c	c	c
Step 5: PRODUCTION AND DELIVERIES	**P1. Logistics and execution plan**		r	e			
	P2. Measuring and reporting energy usage for continuous learning	r	e	i	c	c	c

3.1 Action points in step 3: adapting the chosen concept

In order to arrange for a fossil-free or emission-free building site, it is necessary to start as early as possible in the building process. Interviews show that one success factor is if the developer has enough information on the possibilities so that realistic requirements can be stipulated. The developer should know something about the building's power demand when in operation, the fossil-free and emission-free alternatives that are available in the area and whether there are opportunities to reduce the power demand at the building site. This is summarized and detailed further in action points A1 to A3.

r - responsible e - executes c - to be consulted i - to be informed d - decides		Developer	Contractor	Subcontractor	DSO	District heating co.	Fuel supplier
Step 3: ADAPTING THE CHOSEN CONCEPT	**A1. Estimate the building's electric power and heat demand when in operation**	r					
	A2 Find out what fossil-free and emission-free alternatives are available at the building site in question	r		c	c	c	c
	A3. Find out the existing alternatives for reducing the building site's energy demand	r			c		c

A1. Estimate the building's power demand when in operation

A1a. When estimating, consider both the total demand and just the heating demand

An important basis for being able to arrange for a fossil-free or emission-free building site is to have a good estimate of the power demand at an early stage in the project planning. Among other things, this will help make conditions suitable for having an electrical infrastructure in place early on in the project. Ideally, the building site's energy and power demands are to be estimated during this stage. Information from interviews and the workshop indicate that it may be difficult for the developer to estimate this so early in the building process. So a first step may be to estimate the building's power demand when in operation, as this provides an indication of the need for available grid capacity. The power demand when in operation is usually sufficient to meet the need during the building period. It is important that the heating demand is looked at individually, as this can be met by technologies other than electricity, such as district heating or geothermal heating. The building's estimated power demand when in operation is an important basis for the initial dialogue with suppliers of fossil- and emission-free alternatives, refer to A2.

A2 Find out what fossil-free and emission-free alternatives are available at the building site in question

Once a developer has prepared an estimate of the building's power demand when in operation, there is a basis for finding out what fossil-free and emission-free alternatives can meet this demand. During this phase, the availability of district heating and the grid capacity in the area are investigated. In addition, the availability of biodiesel, biogas, pellets and hydrogen is investigated, and the availability of energy resources at the building site is assessed. Finally, it is important to know something about when relevant solutions may be in place.

A2a. Is district heating available in the area? (Refer to the detailed zoning plan for the area/zoning plan)

In *Step 3: adapting the chosen concept*, the developermust obtain information on whether district heating is available. The developermust also obtain information on whether the property is subject to a duty to connect to a district heating plant. Such information is found in the detailed zoning plan for the area. A duty to connect means that when a building is to be erected within a district heating licensing area and the building's duty to connect is determined in the plan, the building is to be connected to the district heating plant. It is up to the individual municipality to determine the rules that are to apply to connection, since it can grant full or partial exemptions from the duty to connect if it can be documented that the use of alternative solutions will be better for the environment than such a connection. It is important to have a good dialogue with the district heating company. In *Step 4: detailed planning*, the contractor will contact the local district heating company to clarify the necessary measures and the timeframe.

A2b. Check the available grid capacity in the area (contact the local DSO)

The developer should establish contact with a local DSO as early as in *Step 3: adapting the chosen concept* in order to initiate a dialogue on the available grid capacity. DSOs will at an early stage be able to provide information about whether it will be difficult or easy to deliver the power demand envisaged by the developer. Later, in *Step 4: detailed planning,* the contractor and local DSO will exchange more detailed information and prepare a more detailed plan. This is described in item D3a.

There are several reasons for it being important to contact a local DSO at an early stage to clarify necessary measures. One of these is that the available grid infrastructure is not always very good. In most cases, grid access is not a problem, but it can be more difficult in some places, such as in older districts of Oslo. If there is a lack of capacity in the local grid, there may be a need to dig trenches to the nearest transformer station, which can be expensive and time-consuming. The time horizon for being able to deliver 2-3 MW may be anything from 2-3 months to several years. If this will take a long time, it is important to be aware of this early on so that a compound technology solution which is not entirely based on the supply of electricity can be found. In cases where there are restrictions relating to the available grid capacity, alternative solutions such as mobile battery stations may be evaluated.

A2c. Consider whether energy resources available on the building site, or planned energy solutions in the building itself, can be utilized during the building phase

Examples may be the utilization of thermal solar power, solar cells or various heat pump solutions. These solutions should be seen together with the energy solution in the finished building.

A2d. Check the availability of biodiesel, biogas, pellets and battery solutions/hydrogen with suppliers in the area

The developer must make sure to find out from fuel suppliers what the availability of biodiesel, biogas, pellets and hydrogen is like in the area. The distribution infrastructure should also be assessed – if infrastructure is lacking, external tanks or containers at the building site may be a possibility.

A2e. Evaluate whether there are other activities at the building site in addition to heating and construction machinery that can be replaced by fossil-free or emission-free solutions

There may be other activities at the building site that currently use fossil energy sources. An example of this is concrete pumping, an activity that can be electrified if planned well. Another example is choice of rooftop solution, where choice of material can have an effect on emissions.

A2f. How long will it take before relevant solutions can be used?

Once the various fossil-free and emission-free alternatives that are available have been mapped, it must be assessed how long it will take before the relevant solutions can be used. This varies from building site to building site, and in some places certain alternatives may have a long lead time, which means it may take a long time until the alternative can be used. It is important to form a picture early on of when available alternatives can be used at the building site in question.

A3. Find out the existing alternatives for reducing the building site's energy demand

The building site's energy demand can be reduced through energy efficiency improvement measures (A3a) or by optimizing such things as the logistics at the building site (B3b). Do not allow the alternatives mentioned here to limit the possible measures that can be implemented to reduce the building site's energy demand.

A3a. Examine opportunities for implementing energy efficiency improvement measures

Possible energy efficiency improvement measures are:

- Reduce idling
- Improve sealing of the building before heating and drying out
- Install a temperature sensor to control the heating and drying out according to an indoor temperature, for example 16°C
- Use construction machinery with a more modern engine class
- Use more effective alternatives to hot-air heating systems
- Use prefabricated concrete elements instead of cast-in-situ concrete. It is important to note that this measure moves the emissions from the building site to where the prefabricated concrete elements are made.

A3b. Consider opportunities for optimizing logistics at the building site

The interviews clearly show that planning and logistics are extra important when using alternative solutions since the empirical base is small. In addition, it can be mentioned that generally, for all types of building sites, there is a great potential for improving the logistics by reducing the volume of short transport at the building site. Short transport may be reduced by, for example, the correct equipment and material arriving at the building site at the right time.

3.2 Action points in Step 4: detailed planning

During this stage, the developer prepares tender material and invites tenders for the project. In the case of a design and build contract, a contractor is then awarded the project. The contractor plans the work, especially for fossil- and emission-free building sites; maps the energy and power demands, plans for the creation of infrastructure up to the building site and ensures that the logistics at the building site are adapted to the use of fossil-free and emission-free alternatives. This is summed up and detailed further in action points D1 to D4.

r - responsible
e - executes
c - to be consulted
i - to be informed
d - decides

		Developer	Contractor	Subcontractor	DSO	District heating co.	Fuel supplier
Step 4: DETAILED	**D1. In the invitation to tender, stipulate realistic requirements for the use of fossil-free and emission-free alternatives at the building site**	**r**	**c**	**c**			

PLANNING	D2. Map the energy and power demands	i	r	c			
	D3. Plan the creation of infrastructure up to the building site	i	r	c	c	c	i
	D4. Ensure that the logistics at the building site are adapted to the use of fossil-free and emission-free alternatives	i	r	i	c	c	c

D1. In the invitation to tender, stipulate realistic requirements for the use of fossil-free and emission-free alternatives at the building site

D1a. Take into account the opportunities and restrictions that become apparent in *Step 3: adapting the chosen concept*

This means that information on available alternatives or any restrictions that become apparent in *Step 3: adapting the chosen concept* should be passed on during the acquisition process, for example if a technology is not available in the area in question.

D1b. Consider having a dialogue with the supplier market to obtain information (for example via a written request for information)

A dialogue with the market on an acquisition can be established via dialogue meetings, one-to-one meetings or a written request for information (RFI). Information obtained through a dialogue with the market may be, for example: the availability and experience of using fossil- and emission-free alternatives, or whether suppliers have experience of using fossil- or emission-free solutions for activities at the building site other than heating and construction machinery (ref. A2e.)

D1c. Check the public procurement pages of the Agency for Public Management and eGovernment (Difi) for ideas on how to formulate a requirement of emission-free and fossil-free building sites.

Difi has gathered information on stipulating requirements for fossil- and emission-free building sites and provides examples of requirements and award criteria.

D1d. Consider using incentive schemes to ensure fossil- and emission-free solutions

Incentive schemes may be stipulated in the contractual terms and conditions. For example, the developer may pay the energy costs if emission-free solutions are used or there may be incentives to reduce the scope of transport, for example by ensuring good capacity utilization and coordination. It is a good idea to link incentive schemes to the building project's goals and KPI[2]s.

D1e. Consider weighting tenders by using tender-pack award criteria that promote energy efficiency improvement measures, low-emission solutions and zero-emission solutions

An award criterion must be measurable and be understood in the same way by suppliers. The criteria must reflect the need for and/or goals of the acquisition. Difi's website contains information on the wording of award criteria and evaluation models. Difi has also gathered examples of award criteria that are relevant for fossil- and emission-free building sites (ref. D1c).

D1f. Stipulate a requirement that energy consumption must be reported (try to have a simple, unified reporting format that does not take a lot of time to fill in)

[2] Key Performance Indicator

D2. Map the energy and power demands

D2a. Calculate the energy and power demands at the building site - calculate both the total demand and the demand for only heating and drying out

It is important to calculate the energy and power demands at the building site so that relevant solutions can be dimensioned. It is a good idea to use empirical figures from previous projects to ensure that nothing is omitted.

D2b. Calculate the building's energy and power demands when in operation - calculate both the total demand and the demand for only heating

It is important to know whether the building site's power demand is less than that of the finished building, so that reinforcements do not have to be implemented afterwards. If the demand at the building site exceeds the demand of the building in operation, combinations of solutions may be implemented to avoid over-dimensioning.

D2c. Consider infrastructure requirements and measures to optimize the logistics, power demand and energy demand

If it is planned to use electric construction machinery at the building site, it is important to ensure there are the necessary charging facilities at/near to the building site.

- Are there any electric car charging points near to the building site that can be used? If so, are the sockets the right type so that these charging points can be used to charge the construction machinery?
- If there is no available infrastructure nearby, the charging station's location on the building site must be planned.

Consider ways of implementing energy efficiency improvement measures (ref. A3a) and optimizing logistics (ref. A3b) and/or the power demand. The power demand may, for example, be optimized by planning when electric construction machinery is to be charged.

D3. Plan the building of infrastructure up to the building site

In order to use emission-free solutions based on district heating and electricity, there must be a connection to the local district heating/power grid. Depending on the power demand (mapped in D2), it may also be necessary to upgrade existing infrastructure elsewhere in the grid and this may be time-consuming. It is therefore important to obtain an overview of the necessary measures as early on as possible. Since the infrastructure may be used during the building's operational phase, it is also important to compare the building's power demand when in operation with the power demand during the building period.

D3a. Contact a local DSO and clarify the necessary measures and the timeframe for these based on D2

As mentioned under A2b, the developer should contact the DSO as early as in *Step 3: adapting the chosen concept* in order to start a dialogue regarding available grid capacity. At this stage, the DSO will most probably be able to provide information on whether it will be difficult or easy to deliver the power demand envisaged by the developer. Since it will be challenging to estimate the power demand during the building phase and other detailed information at such an early stage, the contractor will have to give the DSO new information when this has been obtained in D2. The information that it is important to obtain before talks with the relevant DSO is as follows:

- Information on the power demand in the building phase and operations phase obtained in D2. It is important to have information on the power demand in the finished building so that reinforcements do not have to be implemented afterwards.

- It is important for the DSOs to know where it is relevant to locate the temporary substation so that they know where it will be optimal to create a connection.

D3b. Clarify the opportunity to use the same grid facility as is to be used during the building's operations period, or alternatively to rent a provisional facility or use battery solutions/hydrogen

If the power demand during the building period is less than or the same as that of the building in operation, it may be possible to use the substation that must be in place during the operations phase as early as in the building period. In such case, the party that is to be the DSO's customer must be clarified. However, factors other than the power demand may make it difficult to use the permanent solution during the building period, such as the location of a substation on the building site. Subcontractors may also take responsibility for connecting both permanent and provisional facilities.

D3c. Contact a local district heating company/supplier of other energy solutions and clarify the necessary measures and the timeframe for these based on D2

If district heating is used, the items discussed for power grids in D3a will also be relevant here.

D3d. Clarify the opportunity for using the same heat exchanger that is to be used during the building's operations period or for renting a heat plant

Refer to D3c. However, it is worth noting that it is only the power required for heating and drying out that is relevant.

D3e. Create progress plans with milestones that show when solutions must be in place

Progress plans that include project milestones are important in order for the grid and district heating companies to obtain a good overview of when the supply should be in place. Create progress plans based on the information obtained and share them with all involved parties.

D4. Ensure that the logistics at the building site are adapted to the use of fossil-free and emission-free alternatives

The use of fossil- and emission-free alternatives may lead to changes in how the logistics at the building site must be planned and carried out.

D4a. Consider how the planned permanent energy solutions can be used during the building period

One of the main principles for keeping costs low is to consider whether solutions that are to be used in the building in operation can also be used during the building period. Examples of such solutions are electric-car charging stations that can also be used by construction machinery, or starting to use permanent interior heating solutions during the building period.

D4b. Plan the location of energy operations centres and any tanks/containers on the building site

The use of district heating and electricity will require there to be energy/grid operations centres on the building site and it may be relevant to erect biodiesel tanks, etc, if biodiesel is used. Can these be located at their permanent site? Their location will affect the logistics on the rest of the building site, so it is important to consider where they are to be located before *Step 5: production and deliveries.*

D4c. Plan the location of pipes/hoses/cables to minimize the movement of these during the work (*Step 5: production and deliveries*)

If electric construction machinery is used, there may be a need for cables to charging stations or the construction machinery, for example. With water-borne heating systems, it may, for instance,

be a good idea to plan for building heat and develop the interior main network at an early stage. The ventilation system or rising mains that have been established early on may be used, for example.

D4d. Create a map and plan of the area showing where the relevant technologies are to be connected

Good maps and plans of the area provide an overview of all the items in D3 and D4. This facilitates the work of both external infrastructure suppliers and subcontractors.

3.3 Action points in Step 5: production and deliveries

In *Step 5: production and deliveries,* the building site is established and everything that has been planned has been implemented. The contractor follows up the subcontractors and reports to the developer as agreed. The action points in P1 and P2 describe in general what it is important to think about in this phase at fossil- and emission-free building sites. For conventional building sites, it is just as important to measure and report the energy usage and emissions.

r - responsible
e - executes
c - to be consulted
i - to be informed
d - decides

		Developer	Contractor	Subcontractor	DSO	District heating co.	Fuel supplier
Step 5: PRODUCTION AND DELIVERIES	**P1. Logistics and execution plan**		r	e			
	P2. Measuring and reporting energy usage for continuous learning	r	e	i	c	c	c

P1. Logistics and execution plan

P1a. Evaluate the realism of the planned solutions early on in *Step 5: production and deliveries* in order to identify and minimize risk

If new technologies and new solutions are used, it is extra important that the contractor at an early stage and thereafter continuously evaluates the logistics and execution plan and updates this as required. This allows any problems to be discovered early on and minimizes the likelihood or consequences of them arising.

P2. Measuring and reporting energy usage for continuous learning

There is little information on the energy usage at building sites. There is a reporting requirement and a requirement of concluding meetings with the main parties in the building process. Summarizing experiences creates a basis for more knowledge in this area. These are important points for ensuring learning from experience and enabling documentation of the effects of using fossil- and emission-free solutions. Experience and empirical data should be reported to an experience database for emission- and fossil-free building sites if any such is available (ref. Chapter 5).

P2a. The contractor measures and reports energy usage as agreed

P2b. The developer ensures that the contractor's reporting is as agreed and that the necessary information is obtained to ensure high-quality data on energy usage (ref: D1f)

P2c. Hold a concluding meeting with a final evaluation and summarize the experiences linked to the use of fossil-free and emission-free alternatives at the building site

4 PERSPECTIVES GOING FORWARD

This part deals with the parties' expectations for the future linked to the availability of emission-free alternatives for heating and for construction machinery, in both the short (until 2020) and long term (until 2030).

Fossil-free building sites are currently easily available and are regarded as a step towards emission-free solutions. Interviews show people believe fossil-free building sites will have a role to play in the longer term too, for example in more rural areas where air quality is not a problem. This is based on the use of sustainable biofuels that at least meet the EU sustainability criteria and on the avoidance of biofuel from palm oil and by-products of the palm oil industry.

Interviews clearly show the parties believe that the requirements stipulated by developers leading up to 2020 and 2030 will determine developments. If developers stipulate requirements and are willing to pay any additional costs, developments will take place quickly. There is also a belief that the availability of fossil-free and emission-free alternatives will increase if financial incentive schemes, like the subsidies for electric cars, are introduced. The largest municipalities and towns in Norway are expected to lead the way – to stipulate requirements first and, together with the largest parties, to be the first movers.

4.1 Emission-free heating up to 2020 and 2030

Emission-free alternatives for heating and drying-out at building sites are already commercially available. The use of these is in some cases limited by either the capacity of the electricity grid or the availability of district heating in the area in question.

Within the area of heating and drying out at the building site, developments up to 2020 and 2030 are therefore more related to other heating alternatives that can be used in those cases where the opportunity to use current alternatives is limited. Examples of such new solutions may be the use of large mobile battery banks or hydrogen. Large mobile battery banks are expected to develop in line with batteries in general, with some time lag. For a description of battery developments, refer to part 4.2.

Several parties have in interviews said they expect hydrogen to be available as a heating alternative by around 2020. Hydrogen is likely to become an alternative within the transport sector first, and several hydrogen cars and trucks are already being developed and are planned to be launched between 2018 and 2020. Hydrogen cars cannot normally use traditional fuels, and this may make it challenging to establish a new hydrogen infrastructure /D08/. It is difficult to establish an infrastructure for selling hydrogen as a fuel until there are enough cars on the roads, while the public will not buy hydrogen cars until there are enough filling stations. In December 2017, Norway had nine hydrogen stations in operation. Three new ones are being built between 2018 and 2019, and from 2020 there are also expected to be maritime hydrogen stations /D06/.

However, emission-free heating based on hydrogen may develop quickly. It is namely the case that hydrogen can replace natural gas as an energy carrier where natural gas is currently used to heat buildings /D07/. The road from this to replace natural gas with hydrogen for heating and drying out at building sites is probably not long. Given further developments in the hydrogen infrastructure in Norway, the parties' expectations regarding the availability of hydrogen as a heating alternative by around 2020 may be realistic.

4.2 Emission-free construction machinery up to 2020 and 2030

A key to the increased availability of large electric construction machinery is batteries with a larger capacity combined with reduced costs. The interest in battery technology and electricity storage has increased considerably in the past few years. This is due, among other things, to the increased use of

variable renewables, such as wind and solar power, as well as to the growth in the number of electric cars and a desire to stop using fossil alternatives in various markets, such as at building sites. This increased demand is driving battery developments in a positive direction.

The Norwegian Water Resources and Energy Directorate (NVE) has analysed the total battery capacity of Norway's electric cars up to 2030. The growth in the use of batteries is primarily expected to be in connection with electric cars and buildings with solar panels. The NVE report's calculations show that the total battery capacity of Norway's electric cars is expected to grow from around 2.5 GWh in June 2016 to almost 100 GWh in 2030. Literature studies conducted by the NVE show that the size of electric car batteries is predicted to increase from the current average of around 30 kWh to 80-100 kWh by 2030. /D05/

These battery-size developments mean it is likely that all types of construction machinery may be electrified by 2030. This is also in line with the parties' expectations expressed in interviews. Interviews show a general expectation that large electric construction machinery will be available in the future and that contractors are ready to start using these as soon as they are available. The parties expect emission-free construction machinery to be widely available in 2030 – either electric or hydrogen-based alternatives.

5 THE ROAD AHEAD

In order to arrange for the use of fossil-free and emission-free technologies, further work can be carried out on several topics. Below is a description of four areas that have become apparent while creating the guide and within which further work can be considered.

The creation of an experience-sharing database

There is little information and statistics on energy usage at conventional, fossil-free and emission-free building sites. Knowledge has also been identified as one of the main barriers to the increased use of fossil- and emission-free technology /D01/. In order to efficiently adapt to emission-free technology and make its positive effects visible, there is a need to share experience. If developers start to stipulate uniform requirements for the reporting of energy usage (ref. D1f) and/or contractors hold concluding meetings with a final evaluation, then experience and empirical data can be logged in an experience database. It is important that any reporting requirements are based on a uniform format and are perceived by the parties as beneficial and not very time-consuming.

ENOVA already has a searchable list of the technology projects it supported between 2012 and 2017. In addition, it is currently establishing a new solution for sharing knowledge from all the projects it has supported over the years. Any future development of a database for sharing experience of conventional, fossil-free and emission-free building sites should therefore be seen in connection with ENOVA's work in this area.

Platform with an overview of available emission-free construction machinery and equipment

There is no overview of the existing emission-free construction machinery and equipment alternatives. It may therefore be a good idea to establish a platform with an overview of available construction machinery and equipment. Such an overview may be based on the overview started on in this project, where the availability of machinery has been mapped. It is important for all parties to have an opportunity to report their available alternatives, so that the platform does not lead to the preferential treatment of some parties. Bellona is currently mapping available electric equipment and should be involved in any further work on a platform to provide an overview of available emission-free construction machinery and equipment.

Emission calculator

A need for a tool for calculating emissions from a building site – an emission calculator – has been identified. The Norwegian Environment Agency is already working on this and is about to launch such a tool for municipalities. Any further work in this area must be seen in connection with the Norwegian Environment Agency's work.

Focus on transport

This guide focuses on activities at the building site, excluding transport. The transport of materials, machinery and personnel accounts for considerable emissions. The next step may therefore be to continue working on mapping all the transport linked to a building site, the associated emissions and ways to reduce these. Campus Evenstad has worked on this and managed to log activity data via transport logs. The further work focusing on transport should take Campus Evenstad's experience into account.

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For an interview list, see annex 2

For a list of workshop participants, see annex 3

ANNEX 1: GUIDE FOR FOSSIL- AND EMISSION-FREE BUILDING SITES

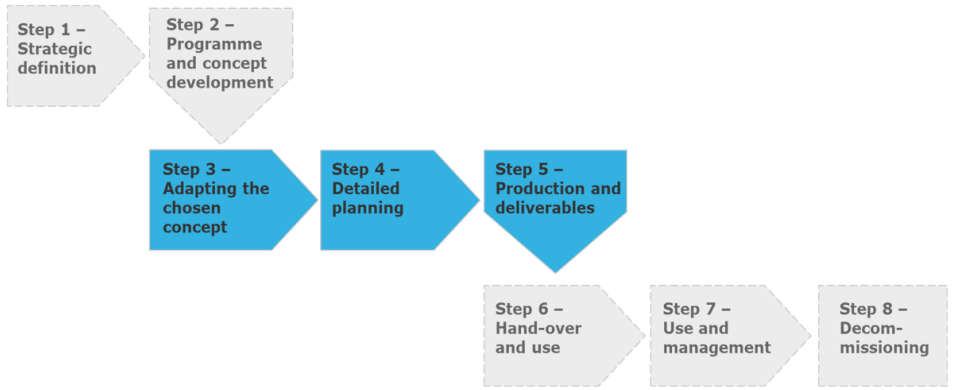
Guide to arranging fossil- and emission-free solutions on building sites

The guide is structured according to the steps in the general outline of the building process. For a general outline of the building process, the steps in the phase standard "*Neste Steg*" (Next Step) /D09/ have been used, see figure to the right for an illustration of the steps.

For steps 3 to 5 in the building process, action points that are important to take into consideration in order to work towards a fossil-free or emission-free building site have been specified. Each action point has an ID according to the step to which it belongs: "A" for *step 3: adapting the chosen concept*, "D" for *step 4: detailed planning* and "P" for *step 5: production and deliveries*. Under each action point on level 1 (for example, A1 or P2), more detailed sub-points are specified.

The relevant parties are listed on the top-right in the table: the developer, contractor, subcontractor, DSO, district heating company and fuel supplier. The parties' roles are specified here for each action point.

For further details on the guide, refer to DNV GL Report No. 2018-0418, Guide to arranging fossil- and emission-free solutions on building sites.



Overordnet skisse av byggeprosessen etter fasenormen «Neste Steg».

r - responsible
e - executes
c - to be consulted
i - to be informed
d - decides

		Developer	Contractor	Subcontractor	DSO	District heating co.	Fuel supplier
Step 3: ADAPTING THE CHOSEN CONCEPT	**A1. Estimate the building's electric power and heat demand when in operation**	**r**					
	A1a. When estimating, consider both the total demand and just the heating demand	r					
	A2 Find out what fossil-free and emission-free alternatives are available at the building site in question	**r**		**c**	**c**	**c**	**c**
	A2a. Is district heating available in the area? (Refer to the detailed zoning plan for the area/zoning plan)	r				c	
	A2b. Check the available grid capacity in the area (contact the local DSO)	r			c		
	A2c. Consider whether energy resources available on the building site, or planned energy solutions in the building itself, can be utilized during the building phase	r		c			c
	A2d. Check the availability of biodiesel, biogas, pellets and battery solutions/hydrogen with suppliers in the area	r					c
	A2e. Evaluate whether there are other activities at the building site in addition to heating and construction machinery that can be replaced by fossil-free or emission-free solutions	r					
	A2f. How long will it take before relevant solutions can be used	r			c	c	c
	A3. Find out the existing alternatives for reducing the building site's energy demand	**r**			**c**		**c**
	A3a. Examine opportunities for implementing energy efficiency improvement measures	r					
	A3b. Consider opportunities for optimizing logistics at the building site	r					
Step 4: DETAILED PLANNING	**D1. In the invitation to tender, stipulate realistic requirements for the use of fossil-free and emission-free alternatives at the building site**	**r**	**c**	**c**			
	D1a. Take into account the opportunities and restrictions that become apparent in Step 3: adapting the chosen concept	r					
	D1b. Consider having a dialogue with the supplier market to obtain information (for example via a written request for information)	r	c	c			
	D1c. Check the public procurement pages of the Agency for Public Management and eGovernment (Difi) for ideas on how to formulate a requirement of emission-free and fossil-free building sites.	r					
	D1d. Consider using incentive schemes to ensure fossil- and emission-free solutions	r					
	D1e. Consider weighting tenders by using tender-pack award criteria that promote energy efficiency improvement measures, low-emission solutions and zero-emission solutions	r					
	D1f. Stipulate a requirement that energy consumption must be reported (try to have a simple, unified reporting format that does not take a lot of time to fill in)	r					
	D2. Map the energy and power demands	**i**	**r**	**c**			
	D2a. Calculate the energy and power demands at the building site - calculate both the total demand and the demand for only heating and drying out	i	r	c			
	D2b. Calculate the building's energy and power demand when in operation - calculate both the total demand and the demand for only heating	i	r	c			
	D2c. Consider infrastructure requirements and measures to optimize the logistics, power demand and energy demand	i	r	c			
	D3. Plan the building of infrastructure up to the building site	**i**	**r**	**c**	**c**	**c**	**i**
	D3a. Contact a local DSO and clarify the necessary measures and the timeframe for these based on D2		r		c		
	D3b. Clarify the opportunity to use the same grid facility as is to be used during the building's operations period, or alternatively to rent a provisional facility or use battery solutions/hydrogen		r	c	c		
	D3c. Contact a local district heating company/supplier of other energy solutions and clarify the necessary measures and the timeframe for these based on D2		r			c	
	D3d. Clarify the opportunity for using the same heat exchanger that is to be used during the building's operations period or for renting a heat plant		r	c		c	
	D3e. Create progress plans with milestones that show when solutions must be in place	i	r	i	i	i	i
	D4. Ensure that the logistics at the building site are adapted to the use of fossil-free and emission-free alternatives	**i**	**r**	**i**	**c**	**c**	**c**
	D4a. Consider how the planned permanent energy solutions can be used during the building period		r	c			
	D4b. Plan the location of energy operations centres and any tanks/containers on the building site		r	c	c	c	c
	D4c. Plan the location of pipes/hoses/cables to minimize the movement of these during the work (Step 5: production and deliveries)		r	c			
	D4d. Create a map and plan of the area showing where the relevant technologies are to be connected	i	r	i	i	i	i
Step 5: PRODUCTION AND DELIVERIES	**P1. Logistics and execution plan**		**r**	**e**			
	P1a. Evaluate the realism of the planned solutions early on in Step 5: production and deliveries in order to identify and minimize risk		r	e			
	P2. Measuring and reporting energy usage for continuous learning	**r**	**e**	**i**	**c**	**c**	**c**
	P2a. The contractor measures and reports energy usage as agreed	r	e				
	P2b. The developer ensures that the contractor's reporting is as agreed and that the necessary information is obtained to ensure high-quality data on energy usage (ref: D1f)	r	c	c	c	c	c
	P2c. Hold a concluding meeting with a final evaluation and summarize the experiences linked to the use of fossil-free and emission-free alternatives at the building site	r	c	c	c	c	c

ANNEX 2: INTERVIEW LIST

No.	Company/organization	Date of interview
1	Akershus Energi Varme AS	19.01.2018
2	Cramo	17.01.2018
3	Eidsiva Nett AS	31.01.2018
4	EL-Bjørn	02.02.2018
5	Epiroc Norge AS	12.01.2018
6	Georg Andresen & Sønner A.S	06.02.2018
7	Hafslund	20.02.2018
8	Heat Work	01.02.2018
9	Johnson Controls	21.02.2018
10	Laugstol	26.02.2018
11	Limaco	16.01.2018
12	NASTA	18.01.2018
13	NCC	05.01.2018
14	Nettpartner	20.02.2018
15	NorBetong AS	08.02.2018
16	Norsk Bio	06.02.2018
17	Pon Equipment AS	24.01.2018
18	Ramirent	16.01.2018
19	Saint Gobain Norge	06.02.2018
20	SINTEF Byggforsk	23.01.2018
21	Skanska	12.02.2018
22	Tafjord Kraftvarme AS	08.02.2018
23	Unicon	31.01.2018
24	Utleiesenteret	16.01.2018
25	Veidekke	08.02.2018

ANNEX 3: PARTICIPANTS AT THE WORKSHOP ON 28.02.2018

	Name	Company/organization
1	Jonathan Agersborg	Fortum
2	Jan Peter Amundal	Enova
3	Morten Andresen	El-Bjørn AS
4	Ole Ivar Barkenæs	Haflsund Nett AS
5	Torfinn Belbo	Zero
6	Oddvin Breiteig	Nelfo
7	Geir Magnar Brekke	Statkraft
8	Kristina Bødal	Kultur- og idrettsbygg
9	Pablo Gonzalez Castrillo	Skanska Norge AS
10	Ole Johan Dahl	DNV GL
11	Sophie Davidsson	DNV GL
12	Thea Hellenes Ekre	Miljødirektoratet
13	Kristian Emhjellen	NTNU Gjøvik
14	Torild Engh	EBA
15	Tron Egil Grov	Boligbygg
16	Geir Gule	CS Stillas
17	Trond A Haga	El-Bjørn AS
18	Jan Henrik Hassel	NTNU Gjøvik
19	Marit Hepsø	Miljødirektoratet
20	Bengt Herlitz	Østfold fylkeskommune
21	Magnus Hjelmfoss	Universitetet i Agder
22	Stein Hov	NorBetong AS
23	Kjetil Hundekilen	Unicon
24	Christina Ianssen	Bellona
25	David Ingvarsson	SWEP International AB
26	Jørn-Ove Jespersen	Hafslund Nett AS
27	Thomas Heiberg Johansen	BAS Maskinutleie AS
28	Magnus Johansen	Nettpartner AS
29	Nina Skeime Kostøl	Contiga
30	Randi Lekanger	Skanska Norge AS
31	Arne Øvrebø Lie	DNV GL
32	Eric Mazzocchi	Statkraft
33	Trygve Mellvang-Berg	Norsk Fjernvarme
34	Philip Mortensen	Climate Agency/Oslo Municipality
35	Rabin Junior Osuma	Universitetet i Agder
36	Trine Dystad Pettersen	Byggevareindustriens Forening
37	Lars-Morten Rostad	Ramirent
38	Ingvild Kilen Rørholt	ZERO
39	Odd Olaf Schei	Difi
40	Reidar J. Schille	HeatWork
41	Tore Selfors	Ramirent
42	Sondre Kvalem Seljelid	Tafjord Kraftvarme AS
43	Kjell Petter Småge	Grønn Byggallianse
44	Jonas Vevatne	Statsbygg
45	Kjetil Vikan	BAS Maskinutleie AS
46	Rune Vilhelmsen	UCO
47	Andreas Walnum	Pon Equipment AS
48	Ingunn Irene Wang	Unicon
49	Marianne Kjendseth Wiik	SINTEF Byggforsk

ANNEX 4: AGENDA FOR THE WORKSHOP ON 28.02.2018

Workshop – Guide to arranging fossil-free and emission-free building sites
Date: 28 February, 9am – 1pm
Place: Næringslivets Hus (Energy Norway)

Agenda

8.30am – 9am: Registration and simple breakfast

9am – 9.10am: Welcome and a brief introduction to the reason for the guide
Trygve Mellvang-Berg, Norwegian District Heating Organization, on behalf of the project group

9.10am – 9.20am: About the workshop and the agenda for the day

9.20am – 10am: Professional updates

The Pilot-E project and guide on emission-free building sites for kindergartens
Marianne Wiig, SINTEF Building and Infrastructure

Emission-free construction machinery
Andreas Walnum, Pon Equipment

Report on the use of mineral oil for building heat at building and civil engineering sites
Marit Hepsø, the Norwegian Environment Agency

10am – 10.10am: Coffee break

10.10am – 11.30am: "Group work"
Ideas for the guide and proposed measures to arrange for fossil-free and emission-free building sites

11.30 – 12 noon: Simple lunch

12 noon – 12.50pm: A review of the group work and a discussion

12.50pm – 1pm: Conclusion and the road ahead
Trygve Mellvang-Berg, the Norwegian District Heating Organization, on behalf of the project group

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