Nordic Innovation

Guidelines for Emission-free Construction Sites

Contents

This publication is also available online in a web-accessible version at:
https://pub.norden.org/us2024-437

Preface

This project is part of the Nordic Sustainable Construction programme initiated by the Nordic ministers for construction and housing and funded by Nordic Innovation. The programme contributes to the Nordic Council of Ministers' Vision 2030 by supporting the Nordics in becoming the leading region in sustainable and competitive construction and housing with minimal impact on the environment and climate.

The programme supports the green transition of the Nordic construction sector by creating and sharing new knowledge, initiating debates in the sector, creating networks, workshops, and best practice cases, and helping to harmonise Nordic regulations on the climate impact of buildings.

The programme runs from 2021 to 2024 and consists of the following focus areas:

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Work package 1 – Nordic Harmonisation of Life Cycle Assessment

Work package 2 – Circular Business Models and Procurement

Work package 3 – Sustainable Construction Materials and Architecture

Work package 4 – Emission-free Construction Sites

Work package 5 – Programme Secretariat and Capacity-Building Activities for Increased Reuse of Construction Materials

This report is one of the WP4 deliverables.

The work has been conducted by a multidisciplinary working group with participants from the Green Building Council in Iceland, the Icelandic Ministry of Infrastructure, the Housing and Construction Authority of Iceland, and the University of Iceland. The Icelandic Ministry of Infrastructure is the responsible party.

Nordic Sustainable Construction

For more information on Nordic Sustainable Construction, visit our website here: www.Nordicsustainableconstruction.com

Glossary

CDW (Construction and demolition waste) – the debris generated during the construction, renovation, and demolition of buildings, roads, and other structures.

Climate declaration – in the context of the Nordic countries' efforts to reduce emissions from the construction industry, this is a mandatory report detailing the greenhouse gas emissions associated with a building's entire lifecycle. The aim of this initiative, whether planned or already implemented, is to standardise how the environmental impact of buildings is measured and reported.

CO_2e – carbon dioxide equivalent, a unit often used to standardise the global warming effect of different gases.

kg CO_2e/m^2 – unit for greenhouse gas emissions per square metre of construction. Useful for new construction.

kg CO_2e/m^2yr – unit for greenhouse gas emissions per square metre and year. Useful for emissions during a building's lifetime.

EFCS (Emission-free construction site) – a site where all activities are carried out without producing greenhouse gas emissions, typically by using electric or renewable energy-powered machinery and implementing sustainable practices to eliminate the carbon footprint from waste and other parts of the construction site.

LCA (life cycle assessment) – a systematic method for assessing the environmental impact of a physical construct throughout its lifecycle.

Limit value – the maximum allowable emissions for new construction, often required alongside an LCA to ensure that its environmental impact remains below regulatory thresholds.

NRMM (Non-road mobile machinery) – machinery that is not intended for use on public roads. This includes equipment such as construction machinery (e.g., excavators, loaders), agricultural and forestry equipment (e.g., tractors, harvesters), and industrial machinery (e.g., generators, compressors).

On-site energy – energy generated and used at the construction site itself, often from renewable sources, to minimise carbon emissions.

Executive summary

This report provides comprehensive guidelines for stakeholders who are aiming to reduce emissions from construction sites, primarily by applying the concept of emission-free construction.

The target audience includes urban planners, designers, project owners, contractors, and all other stakeholders within the construction industry who have an influence on emissions from construction activities.
The key findings are that emission reductions are feasible at all stages of construction, with significant opportunities before construction even begins. Achieving emission-free construction requires a collaborative effort, with active participation from all stakeholders. While notable progress has been made in the Nordics, further efforts are essential to meet emission-reduction targets.

In addition to this document, four posters with key information are included in the appendix to further support the implementation of these guidelines.

1. Introduction

Sustainable construction must respect planetary boundaries in terms of material extraction and geochemical cycles. Excessive greenhouse gas emissions from industrial processes and unsustainable land use come at a great cost to current and future generations. The construction industry is one of the largest emitters of greenhouse gases and must implement drastic emissions reductions in all phases of a building's lifecycle. At present, a considerable proportion of emissions can be attributed to the transport of building materials and activities on the construction site. Measures to reduce these emissions are encompassed in the EFCS concept.

The concept of reducing and eventually eliminating carbon emissions from construction sites has gained significant momentum in recent years. As the construction industry continues to expand its knowledge and expertise in this area, the need for comprehensive guidelines has become clear.

These guidelines are designed to promote EFCS and assist stakeholders in implementing effective emission-reduction strategies. The report is structured around four main sections. The first section (chapter 2), planning and design, offers strategies for designers, architects, and urban planners to incorporate emission-free principles from the outset. The second section (chapter 3) focuses on procurement, providing guidance for project owners when tendering. The third section (chapter 4) covers implementation, detailing best practices for contractors and subcontractors during the construction phase to achieve emission-free operations. The final section (chapter 5), evaluation, presents methods for all stakeholders to assess and ensure compliance with emission-free objectives throughout the project lifecycle.

In conclusion, key points from each topic are summarised in the appendix, provided as printable sheets for easy reference. Stakeholders are encouraged to print the relevant sections and keep them to hand to reinforce their commitment to emission-free construction practices.

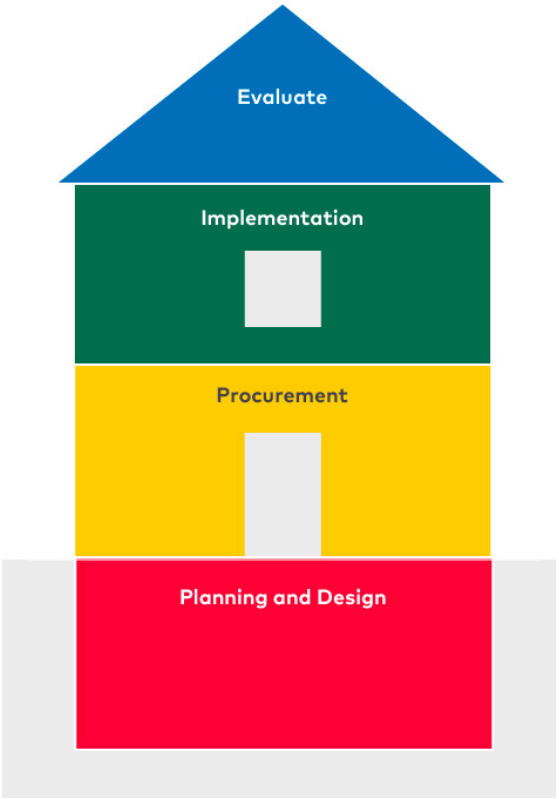
The guidelines build on the foundation laid by the earlier work of WP4, including the first report Emission-free construction sites: definitions, boundaries and terminology – current status in the Nordic countries[1] and the second report Emission-free Construction Sites: Knowledge Gaps and Research Needs.[2] These guidelines serve as a valuable resource for anyone committed to reducing construction site emissions.

1. 'Emission-free construction sites: definitions, boundaries and terminology - current status in the Nordic countries', 2023. [Online]. Available: https://www.nordicsustainableconstruction.com/knowledge/2023/march/report-on-emission-free-construction-sites
2. 'Emission-free Construction Sites: Knowledge Gaps and Research Needs', 2024. [Online]. Available: https://www.nordicsustainableconstruction.com/knowledge/2024/january/emission-free-construction-sites-

The four sections of the guidelines are interconnected. Nothing substantial will happen without a plan and design. In large projects, procurement is a critical element, with tendering being a key stage in this process, especially in public-sector projects. Once a construction project has been planned, designed, and procurement has occurred, the construction process begins. It is at this stage that EFCS methods should be implemented.

Emissions during construction are evaluated during and after the process, which influences the entire construction process. The data gathered through this evaluation can be used in various ways to improve environmental performance, ensure regulatory compliance, and enhance sustainability practices. Maintaining dialogue between stakeholders is crucial for the effective sharing of information and use of data. A non-exhaustive list of stakeholders can be found below, along with a graphical representation of the division of the sections.

Figure 1.1 The four sections and stakeholders



Evaluate

Research
Academia
Everyone
else

**Imple-
mentation**

Contractors
Sub-
contractors
Workers
Suppliers

Industry groups
Utility providers
Grid operators

Procurement

Owners
Clients
Procurement
managers

**Planning
and Design**

Designers
Urban
planners
Govern-
ment
Municipalities

1.1. Scope of the guidelines

The focus of these guidelines is on climate change measured by the level of carbon emissions during the construction phase of buildings and other structures. Although building construction is the main theme, the methods can be applied to other structures, such as roads, railways, and utility systems. It specifically addresses embodied carbon emissions or, more specifically, the life cycle assessment (LCA) phases A4 – Transportation of materials, and A5 – Construction installation process. The definition of the activities included is based on the EN 15978 standard, which is widely used to define system boundaries for LCAs in the construction industry.

Phase A4 covers the transportation of building materials and equipment to the site.

A4 Transportation (EN 15978)

Transport of materials and products from the factory gate to the building site, including any transport, intermediate storage and distribution

Transport of construction equipment (cranes, scaffolding, etc.) to and from the site

All impacts and aspects related to losses due to transportation

The construction and installation process, A5, includes all activities required to complete the building or part of the building during the assessment (EN 15978).

A5 Construction (EN 15978)

Activities related to site emissions:

Groundworks and landscaping

Transport of materials, products, waste and equipment within the site

Onsite production and transformation of a product

Provision of heating, cooling, ventilation, humidity control etc.

Installation of the products into the building including ancillary materials

Waste management processes of other wastes generated on the construction site, including transportation from the building site

Production, transportation and waste management of products and materials lost during A5

In the expected update of the EN 15978 standard, the A5 module is divided into four sub-modules: pre-construction activities (A5.1), construction activities (A5.2), waste and waste management (A5.3), and transport of construction workers (A5.4).

Work package 1 (WP1) of Nordic Sustainable Construction has published a report on impact assessment methods – **Recommendations for a Common Nordic Approach to Combat New Buildings' Life Cycle Climate Impact,**[3] with A5.1 recommended to be mandatory only if there is an existing building on the site, A5.2 and A5.3 suggested to be mandatory, and A5.4 suggested to be non-mandatory.

In other contexts, module A5 has also been divided into two parts: A5.2 energy, and A5.3 waste. In this report, the energy component will be referred to as A5.E and the waste component as A5.W. These guidelines can also be used during deconstruction, with the elements of module A5.1 divided into A5.E and A5.W.

Table 1.1 Categories of emissions from the construction site.

		Equipment and activities	Sources of emissions
A4	**Transportation**	Vehicles	Fossil fuels Renewable energy
A5.E	**Energy**	Construction machinery Vehicles on site Power generation	Fossil fuels Renewable energy
		Heating and drying Lighting and appliances Electric tools and machines	Fossil fuels Renewable energy District heating
A5.W	**Waste**	Production of waste materials Transport of waste materials Recycling Landfill	Raw materials and production Fossil fuels Renewable energy Waste processing Landfill emissions

3. 'Nordic view on data needs and scenario settings for full life cycle building environmental assessment', Nordic Innovation, 2024. [Online]. Available: https://www.nordicsustainableconstruction.com/knowledge/2024/june/recommendations-for-a-common-nordic-lca-approach

1.2 Legal framework for LCAs in the Nordics

The introduction of a legal framework for disclosing lifecycle greenhouse gas emissions, with or without limit values, in all the Nordic countries is planned by early 2025. Denmark was the first to issue limit values in 2023, with Sweden, Iceland, and Finland expected to follow in 2025. In June 2021, Norway proposed a comprehensive LCA scope and limit values for buildings, but these were rejected in January 2022. There are no plans for new limits. The current primary focus of the Norwegian government is to establish a climate partnership with the construction industry to cut emissions.

The Nordic countries are preparing to take the next step in exploiting the climate protection potential of the building sector and to drive innovation. Carbon emissions during the product stage (A1-A3) and construction stage (A4-A5) are often grouped and referred to as upfront embodied carbon emissions, as they are released before the building starts operating. Upfront emissions are the part of the lifecycle that can be confirmed with real values upon delivery of the building and calculated without making assumptions about the future. A focus on upfront embodied carbon emissions is about reducing emissions today, rather than in the distant future. Additionally, the ongoing transition of energy systems and industry towards low emissions suggests that future emissions will likely be comparatively low.

As of January 2024, Finland and Iceland include both A4 and A5 in the proposed limit value scope, and Iceland includes both in the proposed climate declaration scope. Norway includes A4 and the waste component of A5 in the climate declaration scope. Sweden includes both in the climate declaration scope from 2022 as well as in the proposal for limit value for 2025 and the proposed climate declaration for 2027.

From July 2025 climate impacts from A4 and A5 are included in the requirement of limit values in Denmark.[4]

1.3 Baseline emissions

Knowledge about actual emissions from construction sites is gradually increasing. Current emissions from phases A4 and A5 are being estimated across the Nordic region in preparation for the upcoming regulation of limit values. The activities included in the system boundary differ, and the definition of area and units is not standard. The harmonisation of standards and methods for the estimation and

4. 'Ny aftale stiller ambitiøse klimakrav til nyt byggeri'. Accessed: Jun. 26, 2024. [Online]. Available: https://www.sm.dk/nyheder/nyhedsarkiv/2024/maj/ny-aftale-stiller-ambitioese-klimakrav-til-nyt-byggeri

regulation of emissions is an important goal. Emissions from energy use are typically included as this is a well-known factor. Emerging research shows that waste is just as important when considering construction emissions.[5][6]

In this chapter, estimated emissions values for A4 and A5 have been collated from the Nordic countries. Although these numbers are intended to indicate current emissions levels, they are expected to change and improve as more accurate data becomes available.

Iceland

In March 2024, a harmonised methodology for the preparation of LCAs for buildings in Iceland was officially published. This also marked the beginning of an 18-month transition period for the introduction of LCAs. At the same time, generic values for the Icelandic market were published. These state A4 as 19.79 kg CO_2e/m^2 and A5 as 42.50 kg CO_2e/m^2.[7]

Norway

Norwegian building regulations require an LCA pursuant to EN 15978 with the full inclusion of module A4, and only waste for module A5. Real values or indicative values for the amount of waste (cut and loss) provided in guidelines can be used. The emission values from the environmental product declaration (EPD) data should be used or trusted third-party databases, with 25% added on top of these values. With regard to transport, EPD data, standard values for transport distances, a transport calculator, or real transport distances and modes of transport can be used.[8]

Sweden

In Sweden, KTH Royal Institute of Technology and the Swedish National Board of Housing, Building and Planning (Boverket) conducted a large study, which was updated in 2023. The average emissions for A4 and A5 was 44 kg CO_2e/m^2. Private homes had the least impact at 24 kg CO_2e/m^2, while office buildings and schools had an impact of 53 kg CO_2e/m^2. Although the balance between A4 and A5 was not specified, it appeared to be roughly equal. Although the system boundary included waste in module A5, not all groundwork activities were

5. K. Kanafani, J. Magnes, S. M. Lindhard, and M. Balouktsi, 'Carbon Emissions during the Building Construction Phase: A Comprehensive Case Study of Construction Sites in Denmark', *Sustainability*, vol. 15, no. 14, p. 10992, Jul. 2023, doi: 10.3390/su151410992.
6. K. Kanafani, J. Magnes, A. Garnow, S. M. Lindhard, and M. Balouktsi, 'Ressourceforbrug på byggepladsen: Klimapåvirkning af bygningers udførelsesfase.', Aalborg Universitet, Aalborg, 2023:14, 2023. [Online]. Available: https://vbn.aau.dk/ws/portalfiles/portal/611626468/BUILD-rapport_2023_14_Ressourceforbrug_p_byggepladsen.pdf
7. 'Íslensk meðaltalsgildi | Húsnæðis- og mannvirkjastofnun'. Accessed: Jun. 27, 2024. [Online]. Available: https://hms.is/mannvirki/lifsferilsgreining/islensk-me%C3%B0altalsgildi-lca
8. 'Byggteknisk forskrift (TEK17) med veiledning', Direktoratet for byggkvalitet. Accessed: Jun. 30, 2024. [Online]. Available: https://www.dibk.no/regelverk/byggteknisk-forskrift-tek17

included.[9] The proposed limit values in Sweden are defined for modules A1 to A5, while the values for A4 and A5 are not specified separately.

Denmark

In 2021, Denmark adopted a National Strategy for Sustainable Construction, which introduced limit values for construction emissions. Initially set at 12 kg CO_2e/m²yr, these values will be gradually reined in. Ahead of the 2025 review, the Danish construction industry called for stricter CO_2e regulations, asserting their readiness for ambitious changes. A separate limit of 1.5 kg CO_2e/m²yr for the construction process will be implemented, which corresponds to lifetime emissions of 75 kg CO_2e/m^2 for a 50-year lifespan.[4]

That is above the value from the recent comprehensive case study of construction sites in Denmark that looked at 52 + 9 Danish construction sites in respect of their carbon emissions from transport in module A4 and the construction-installation process in module A5. The median result was 0.28 kg CO_2e/m^2yr for A4, and 1.00 kg CO_2e/m^2yr for A5. This translates to 14.00 kg CO_2e/m^2 and 50.00 kg CO_2e/m^2 over the standard 50-year lifespan.[5]

The new limit also lies above the values from the recent report that seeks to develop quantitative key figures and reporting criteria for the implementation of the building process stage in the whole-life carbon requirements of the Danish building regulations. Here, the resulting median is 0.4 kg CO_2e/m^2yr for module A4, and 1.0 kg CO_2e/m^2yr for module A5.[6]

However, it is likely that this report has influenced decision-making regarding the update of the LCA regulations and the accompanying limit values by providing a benchmark for allowable emissions, guiding policymakers in establishing more stringent and precise criteria.

Finland

The Ministry of the Environment in Finland has published a generic LCA database for construction [10]. This database is based on average values from various studies. Emissions in module A5 are set at 43 kg CO_2e/m^2 for residential buildings and 52 kg CO_2e/m^2 for other building types. Only energy use is considered and waste is omitted. Emissions for groundwork are set separately at 7 kg CO_2e/m^2. For module A4 the database has a generic value of 20.4 kg CO_2e/m^2.

9. T. Malmqvist, S. Borgström, J. Brismark, and M. Erlandsson, 'Referensvärden för klimatpåverkan vid uppförande av byggnader Version 3', KTH Royal Institute of Technology, Stockholm, 2023.

Table 1.2. Estimated emissions values for A4 and A5 in the Nordic countries.

	A4 (kg CO_2e/m^2)	**A5** (kg CO_2e/m^2)	
Iceland	19.79	42.50	Generic values for LCAs [7]
Norway	LCA databases +25%		Byggeteknisk forskrift TEK17 [8]
Denmark	20.50	50.00	BUILD Report [6]
Denmark	75.00		National strategy [4]
Sweden	44.00		KTH and Boverket [9]
Finland	20.40	50.00-59.00	Generic values for LCAs[10]

Finland: Generic values for LCAs[10]

10. 'Emissions database for construction', Emissions database for construction. Accessed: Jun. 30, 2024. [Online]. Available: https://co2data.fi/rakentaminen/#en

1.4. Action hierarchy

Activities and methods aimed at lesser environmental impacts can be categorised and ranked by their effectiveness.

Avoid, shift, improve

A commonly used hierarchy is "avoid, shift, improve". Although this originally related to transport, it can be applied to A4 – transportation and A5.E – energy on site.[11][12]

Avoid: Avoiding unnecessary transportation can be achieved by consolidating deliveries and sourcing materials locally. Avoiding new construction and thereby reducing energy use prevents significant emissions. This can be done through planning and design by opting to use existing buildings instead of demolishing and building new ones, as well as by sharing spaces and employing other innovative methods.

Shift: Shifting to more sustainable transport options, such as electric vehicles, can significantly reduce emissions. Shifting towards low-carbon fuel sources for machinery and equipment on site also reduces emissions.

Improve: Improving the efficiency of current transportation methods through the use of fuel-efficient vehicles and optimised logistics helps to lower environmental impacts. Enhancing the energy efficiency of on-site machinery further reduces emissions.

Applying this hierarchy helps to deliver EFCS by systematically reducing transportation-related emissions.

11. 'Sustainable Urban Transport: Avoid-Shift-Improve (A-S-I)', SUTP. Accessed: Jun. 30, 2024. [Online]. Available: https://sutp.org/publications/sustainable-urban-transport-avoid-shift-improve-a-s-i/
12. K. Dhawan, J. E. Tookey, A. GhaffarianHoseini, and A. GhaffarianHoseini, 'Greening Construction Transport as a Sustainability Enabler for New Zealand: A Research Framework', *Front. Built Environ.*, vol. 8, May 2022, doi: 10.3389/fbuil.2022.871958.

Table 1.3. The hierarchy of A4 and A5.E: avoid, shift, improve

		A4 Transport	A5 Energy
Avoid	System-wide	Avoid trips – reduce distance	Avoid new construction and the use of energy
Shift	Individual mobility	Shift towards low-carbon modes of transport and fuel sources	Shift towards low-carbon fuel sources
Improve	Vehicle efficiency	Improve fuel efficiency and load capacity of modes of transport	Improve energy efficiency of on-site machinery

The 3Rs

In relation to the circular economy and waste, there are similar three principles – reduce, reuse, and recycle – also known as the 3Rs of waste management. More nuanced frameworks are proposed that describe each item in more detail. These are naturally termed 5R, 7R, and 10R.[13]

Table 1.4. The hierarchy of A5.W: reduce, reuse, and recycle

3R		A5 Waste
Reduce	Use less building material	Avoid unnecessary material use Reduce size Design for less waste
Reuse	Keep original function of material	Repurpose building Refurbish and repair building Reuse and repurpose materials in new construction
Recycle	Raw materials from used components	Salvage high-value material streams Mine waste for materials Convert waste to energy

Material use in the construction industry is depleting natural resources and is clearly not sustainable. The most effective way to reduce the environmental and economic burden is to build using less material. This directly translates into less waste.

When a building or a construction reaches the end of its useful life, its materials and components can be used in new construction. The building should preferably be reused without needing to dismantle it, or even be moved to a new location.

Finally, if reuse is not possible, the materials from a construction should be recycled with highest level of efficiency achievable. Incineration for energy recovery should be the last resort. Landfill is not considered to be an option.

13. Krzysztof Pikoń, Magdalena Bogacka, Marcin Landrat, and Katarzyna Piecha–Sobota, 'A guide to circularity in construction', Polish Green Building Council, 2023. [Online]. Available: https://circon.plgbc.org.pl/

2. Planning and Design

In this chapter, we will discuss how building designers and urban planners make a significant contribution in the delivery of EFCS by incorporating new methods into their practices. This involves prioritising the reduction of waste and energy consumption through conscious material choices, efficient design strategies, and stakeholder collaboration.[14]

Early-stage decision-making

Decisions made in the early stages often have the greatest impact on the final overall performance of the building. As a construction project evolves from an idea to planning and design, decisions are made that dictate the majority of embedded carbon in a building. Carbon emissions throughout the lifetime of the planned construction need to be taken into account. Consider how the decisions made will affect emissions at each stage of construction. Some actions to lower carbon emissions at the construction site are limited by design factors such as the choice of materials.

Main actors

The state and municipal administrations take the first steps in construction and infrastructure planning and therefore have immense potential to reduce emissions from construction sites. Authorities also have the opportunity to impose restrictions on emissions in general as well as to provide incentives.

Investors, property developers, and project owners play an important role. Decisions regarding low-impact construction are made at this level and these stakeholders set the course for designers.

The process

The process can roughly be divided into planning and design phases, starting with a conceptual stage and urban planning. At the conceptual stage, broad decisions are made regarding site selection, land use, and initial design concepts. This sets the framework for carbon reduction at a later stage. Urban planning involves integrating these projects into the broader context of a city, considering factors such as transportation, energy use, and earthworks.

14. WSP, 'Net Zero Carbon Construction'. 2021. Accessed: Jan. 25, 2023. [Online]. Available: https://www.wsp.com/en-au/insights/net-zero-carbon-construction

Design, in this context, is considered as the development of individual structures and buildings. It involves detailed decisions about building materials, construction techniques, and systems that significantly influence a construction's emissions. By prioritising the reduction of waste and material and energy consumption in design, significant reductions in emissions can be achieved.

Collaboration

Fostering collaboration among urban planners, developers, policymakers, and local communities to implement these guidelines effectively. By embracing these guidelines, urban planners can steer development initiatives towards EFCS.

2.1 Urban planning and infrastructure

Needs assessment

In the world of urban planning and infrastructure, every choice matters. Authorities must decide whether to build new or preserve what is already there. With sustainability in mind, it is worth considering that sometimes the best way to reduce emissions is simply not to build. So, before diving into new projects, it's crucial to ask: Is it really necessary? If construction is unavoidable, let's prioritise small, efficient designs. But let's not forget what's already available. Repurposing existing buildings can be a smart move. And let's think about relocating businesses and homes to areas with empty buildings, breathing new life into forgotten spaces.

Location

The strategic selection of project locations is crucial, particularly with transportation efficiency in mind. Opt for locations where the transportation of earth/soil, building materials, machinery, and waste is over shorter distances. Moreover, choose areas where minimal earthworks are required due to favourable soil conditions and topography.

Infrastructure

If there are plans for using clean energy machinery during construction, ensuring the availability of clean energy sources from the outset of a construction project is necessary since time is valuable. Strategic location selection also involves prioritising accessibility to existing road infrastructure, electricity grids, water supply networks, and other essential utilities in order to minimise emissions from construction sites.

Urban planners should plan the order of infrastructure construction with this in mind. With an electricity grid and water supply network already in place, there is more

potential to reduce energy consumption during construction, and temporary pipework can be avoided.

The power needed for charging electric machinery during construction can easily surpass the rating of the utility supply for the building. Electrical distribution and construction in the area can be scheduled so that power peaks are distributed evenly over time. This makes it necessary to find out the requirements related to the charging infrastructure of the construction sites.

Timing

Whenever feasible, construction activities should be scheduled to coincide with seasons that require minimal heating/cooling and lighting in order to reduce energy consumption, lower emissions, and enhance overall construction efficiency. This can save time, money, and emissions.

Waste management

Integrate waste management systems within urban planning frameworks. Allocate designated areas within project sites for sorting and storing construction and demolition waste (CDW) as well as for building material that is being stored on-site, facilitating the efficient separation and recycling of materials. By promoting circular economy principles, urban planners can minimise emissions from waste disposal and resource extraction.

Key points

- Consider the necessity of the project and explore alternatives to a new building.
- Select project locations strategically to minimise transportation distances and earthworks.
- Ensure the availability of clean energy sources from the outset.
- Plan the order of new infrastructure to ensure that essential utilities are in place from an early stage.
- Schedule construction activities to coincide with the seasons to minimise the need for heating/cooling and lighting.
- Allocate designated areas for sorting and storing building materials and waste.

2.2 Building materials

Prefabricated

Select building materials that result in minimal CDW, such as prefabricated elements, which can minimise on-site cutting and reduce reliance on large machinery. Prefabrication not only reduces material waste but also speeds up construction timelines and reduces energy consumption. Fewer machine hours mean fewer emissions. Prefabricated material that facilitates disassembly can also reduce emissions from machinery during demolition when the time comes. This also reduces waste during demolition since materials that are designed for disassembly are more likely to be reused.

Excess material and packaging

CDW can also be minimised by specifying exact material requirements when purchasing so as to minimise over-ordering and reduce packaging. Consult with suppliers to explore packaging alternatives that minimise waste without compromising product quality or safety. Additionally, negotiate with suppliers to establish protocols for the return of packaging, pallets, and excess materials, promoting a closed-loop system and further reducing waste generation.

Local material and communication

When selecting materials, prioritise local options to minimise transportation distances and associated emissions. This also reduces reliance on long-distance supply chains. Maintaining good communication with those responsible for construction is crucial. A detailed set of project specifications is important in ensuring that the right materials are utilised as planned. Deviation from the specified materials can result in higher emissions and negate efforts to achieve emission-free objectives.[13]

Key points

- Select building materials that result in minimal waste and reduce energy consumption.
- Use prefabricated components designed for disassembly in mind.
- Specify exact material requirements.
- Prioritise local materials.
- Write a detailed project specification to ensure proper material use.

2.3 Excavated material

Construction and civil engineering projects often involve moving large amounts of excavated material in the form of soils and rocks. This process is both costly and energy-intensive, resulting in considerable emissions. Early-stage design and planning to avoid large-scale excavation and long-distance transportation of these materials are crucial for reducing emissions.

Mass disposal plan

A key strategy for minimising emissions is to incorporate a mass disposal plan early on in the project. The aim of such a plan should be to reduce the occurrence of excavation and the need for new raw materials and landfill usage. It should also focus on minimising the transportation of bulk materials. By planning how to reuse and recycle materials locally, emissions associated with transportation can be significantly reduced.[15]

Avoid soil disturbance

Optimal sustainability in construction is achieved by maintaining existing natural ecosystem functions. At an early stage of project planning, consider how earthworks and construction can be adapted to avoid or reduce soil disturbance, excavation, and relocation. These practices help to minimise environmental impact and emissions.

15. 'Hållbarhetskriterier för Schaktning och masshantering | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/schaktning-och-masshantering/

CityLoops project

The CityLoops project, funded by the EU, provides guidelines for sustainable soil management and soil reuse assessment.[16] Recommendations include evaluating alternative project locations and building designs to reduce soil excavation. Architectural considerations can also help minimise excavation needs. Exploring on-site or local reuse options for excavated soil – such as landscaping, noise reduction, biodiversity enhancement, climate mitigation, infrastructure, or recreational uses – can reduce transportation needs and associated emissions substantially.

Maximising on-site soil reuse should be a priority. Efforts should be focused on avoiding the transportation of soil to distant locations by identifying local reuse opportunities. Minimising excavation and utilising excess soil locally are effective strategies for reducing transportation emissions.

Key points

- Develop and implement a mass disposal plan early on in the project.
- Prioritise the local reuse and recycling of excavated materials.
- Minimise the transportation of bulk materials through optimised design and planning.
- Follow sustainable soil management guidelines to reduce environmental impact and emissions.

16. Cityloops, 'Guidelines for Sustainable Soil Management and Assessment of Soil Reuse Potential of Excavated Soils', Cityloops. Accessed: Jul. 01, 2024. [Online]. Available: cityloops.eu

3. Procurement

The start of this chapter summarises recommendations on the preparation of procurement using new priorities such as EFCS. The chapter also includes examples of how procurement criteria have been utilised to reduce emissions from construction sites, citing the Green Deal in Finland, Oslo City, and the Swedish Criteria Bank. Subsequently, the chapter introduces a suggested method that outlines how minimum requirements, award criteria, and bonuses can be applied in procurement to promote emission reductions at construction sites. Finally, the chapter discusses follow-up methods to ensure the ongoing effectiveness of these procurement strategies.

Procurement for EFCS should be predictable, harmonised, and preferably simple to implement. In order for EFCS goals to be realised, ambition levels should match political mandates. Since LCA demands and limit values will be standard in all the Nordic countries within a few years, one method is to use criteria based on those requirements to build upon existing legal obligations.

Procurement takes place at different stages in the construction process. It is commonplace to go to tender once the design is finished and before construction; this is typically referred to as the Design-Bid-Build (DBB) method. This chapter primarily discusses this form of tender.

Contracting authorities may fear a lack of valid tenders when stipulating emission reductions in the tender. Flexibility within the criteria is therefore preferred, which makes the suggested method below useful. In this method, LCA criteria allow bidders to choose which parts of the construction site, or modules A4 and A5, the emission reductions will come from. However, if during the planning phase the procurer identifies significant potential for reducing emissions from certain parts of the construction site, then focusing the criteria in that direction can be successful.

3.1 Preparation

As mentioned in the previous section, a good plan is an important foundation that can make a big difference. This also applies when it comes to procurement.

Time

When incorporating EFCS in procurement, extra time should be factored in, as should extra costs. Due to the complexity of the contract, there might be a need for additional time from when the project is tendered until the bidding period ends as it

can take longer to bid on a project with new requirements. A longer lead time at the outset facilitates a smoother transition for the market as it adapts to new requirements, fostering greater participation and innovation. In addition, extra time might be needed during construction due to a new emphasis on reduced emissions and difficulties in implementing new methods. Although more time means more cost, it mitigates defects that could be costly later on.

Cost

The ability to implement the goals of EFCS can depend on funding, especially when the first steps are taken, as there is an increased need for green machinery, better organisation, and more time. Nevertheless, in Norway where there is a decent level of experience, there are promising examples of bids that feature a plan for reduced emissions at the worksite and a lower price.[17]

Goal setting

Establish ambitious goals from the outset that align with the organisation's strategies. One such goal is included in the environmental conditions set forth by Ríkiskaup, which state that the generation of waste in construction must be minimised, regulations on noise must be respected, and better energy efficiency must be ensured. This aligns well with the aims of EFCS[18]. LCA demands and limit values are expected to become standard in all the Nordic countries within a few years. As knowledge of the environmental impact of modules A4 and A5 improves, and with the inclusion of these modules in international standards such as the European standard EN 15804, it is likely that A4 and A5 will soon be incorporated into LCA requirements across all the Nordic countries. To build upon existing legal obligations, one approach is to use criteria based on these LCA and limit value requirements.

Dialogue

With the market expected to evolve and diverge rapidly across the Nordics in the next few years, engaging with potential contractors early in the procurement process can be beneficial. This provides a mutual understanding of expectations and an opportunity for the buyer to clearly communicate their objectives or ambitions for the purchase to potential bidders and learn what possibilities exist[19]. During stakeholder dialogue, it is important to remember that the contractor's business and performance goals can influence their attitude towards emissions reductions. Performance goals often conflict with efforts to reduce emissions at construction sites. However, there

17. E. A. Fossland, 'Veinor AS var mest miljøvennlig og vant anbud i Bodø', NRK. Accessed: Jul. 01, 2024. [Online]. Available: https://www.nrk.no/nordland/veinor-as-var-mest-miljovennlig-og-vant-anbud-i-bodo-1.16151182
18. Ríkiskaup, 'Umhverfisskilyrði fyrir byggingaframkvæmdir - Grunnviðmið', Ríkiskaup. Accessed: Jul. 01, 2024. [Online]. Available: https://www.rikiskaup.is/is/innkaup_og_utbod/samfelagslega-abyrg-innkaup/vistvaen-innkaup/umhverfisskilyrdi-i-utbodum
19. 'The Concept for the Green Deal for Zero-Emission Construction Sites | Hankintakeino.fi'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.hankintakeino.fi/en/materialbank/concept-green-deal-zero-emission-construction-sites

are also instances where the market goes further than the regulations require, with stakeholders demanding more stringent requirements than those currently mandated. They seek such regulations because they provide stability and enable contractors to know what to expect, which helps in planning and meeting market demands effectively. For the same reason, procurement methods should be predictable and consistent. An example of the market going further than the regulations require is the Reduction Roadmap in Denmark.[20]

Key points

- Expect extra time and cost.
- Establish goals that align with the organisation's strategies.
- Engage with potential contractors.

3.2 Procurement methods

Different procurement methods and forms of criteria can produce varying results. Examples of criteria used in the Nordics to reduce emissions on construction sites include those adopted by the City of Oslo and the criteria included in the EFCS component of the Green Deal agreement Finland. The Swedish Criteria Bank provides many good examples of EFCS criteria. Below is a non-exhaustive list of procurement methods and criteria that have been used.

Minimum requirements

Minimum (mandatory) requirements in tenders describe the properties required in the service to be produced. These are used when market engagement indicates sufficient maturity, which is when multiple suppliers can cater for a demand. In the case of technologies that are already widely available, such as small electric NRMM and subsequently bigger machinery, requirements can be set without issue. Heating and drying processes, such as those involved in concrete foundation work, can also be mandated to have zero emissions. When formulating these mandates, it's crucial to emphasise the desired outcome, such as eliminating the use of fossil fuels, rather than to prescribe specific solutions.[21]

20. 'Reduction Roadmap', Reduction Roadmap. Accessed: Jul. 01, 2024. [Online]. Available: https://reductionroadmap.dk
21. Big Buyers Initiative, 'Public Procurement of Zero-Emission Construction Sites', Big Buyers Initiative, 2022. Accessed: Jan. 19, 2023. [Online]. Available: https://bigbuyers.eu/fileadmin/user_upload/Materials/BBI-ZEMCONS-lessons-learned.pdf

Award criteria

Award criteria (evaluation) are used to determine which tender will be awarded the contract when the basis of "the economically most advantageous tender" is applied. These criteria can, for example, give preference to tenders that use a greater proportion of emission-free machinery on site. The weighting of the award criteria should be significant enough to influence the bids. As technology advances, these criteria can gradually be adopted as minimum requirements.[21]

Contractual requirements

Contractual requirements are placed on the supplier or the service and are conditions that must be met during the execution of the contract. These requirements ensure that suppliers adhere to specific environmental and performance standards throughout the project. For instance, contractors could be required to report regularly on their emissions, use only specified types of low-emission machinery, or adhere to strict waste management protocols.

Application of bonuses

Bonuses can be applied to incentivise contractors' ambitions to go beyond the minimum requirements. Bonuses can be awarded for delivering additional environmental benefits, such as surpassing emissions reduction targets, implementing innovative green technologies, or completing projects ahead of schedule with reduced environmental impact. Financial incentives can motivate contractors to strive for excellence in sustainability, pursuing continuous improvement and the adoption of best practices. These bonuses are generally awarded after the project is complete to allow for a comprehensive evaluation of performance. However, the exact timing can depend on the specific provisions of the contract and the structure of the project.

3.3 Examples from The Green Deal

The aim of the Green Deal Agreement for Public Procurement, a voluntary commitment, is to promote zero-emission construction sites. Procurement units and government parties in Finland collaborated on its development. While the private construction sector is not mandated to adopt it, procurement units can choose to require full or partial compliance with it.

An example of *award criteria* is quality scoring, where price accounts for 70% of the evaluation and quality for 30%. Quality points for the budget as a whole are awarded for the use of electric machinery. The contractor may enter up to five electric machines for scoring (e.g., 100 points for five electric machines, 80 points for four, 60 points for three, and so on).

Procurement criteria for machinery and energy consumption in the Green Deal concept for zero-emission construction sites include *minimum requirements* such as: At least 30% of the machinery used for the project being powered by electricity, hydrogen, or biogas. The remaining machinery at the construction site must use non-fossil fuels. Acceptable non-fossil fuels include ethanol (e.g. ED95) and renewable HVO diesel or fuel oil in accordance with the EN 15940 standard.

Other methods that seek to reduce emissions should be considered in proportion to the scope of the procurement in order to avoid unnecessary restrictions on the market. Within the Green Deal, most contractual requirements will be applied to contracts worth more than EUR 1 million and may also be applied to smaller contracts. Such requirements include the requirement of an emissions-reduction-related environmental plan, an environmental management system that adheres to a standard or that is verified by a third party, and that all small machinery (power of less than 4 kW) used at the site needs to be electric.

The application of bonuses includes: EUR 25 per hour for the use of electric or biogas machinery weighing more than 1.5 tonnes at the construction site, based on the operating hours of the machine in question. EUR 0.25 per kilometre for using biogas transport vehicles. EUR 15 per hour for STAGE V machinery in active use at the construction site, based on its operating hours. The maximum bonus payable is EUR 30,000.[19]

Minimum requirement	Award criteria	Contractual requirement	Application of bonus
30% electric, hydrogen, or biogas. The rest non-fossil fuel.	Quality points are awarded for electric machinery, where quality accounts for 30%.	Environmental plan, environmental management system, small machinery = electric.	- EUR 25 per hour for >1.5 tonne electric/ biogas machinery. - EUR 0.25 per kilometre for biogas-fuelled transport vehicles.

3.4 Examples from the City of Oslo

As part of the City of Oslo's ambitions to have fossil-free and, in time, zero-emission construction sites, the city has standard climate and environmental requirements.[22]

22. Klimaoslo, 'Climate and environmental requirements for the City of Oslo's construction sites', Klimaoslo, Oslo, 2019. [Online]. Available: https://www.klimaoslo.no/rapport/climate-requirements-construction-sites/

Contractual requirements are mandatory for all procurements valued at NOK 500,000 and above. When the estimated value of a procurement exceeds NOK 5 million, both the contractual requirements and award criteria come into play. However, for procurements with an estimated value of less than NOK 5 million, while the contractual requirements apply, the use of award criteria is optional.

Furthermore, for procurements valued at more than NOK 51 million, the minimum requirements must be adhered to in addition to the contractual requirements and award criteria. This tiered approach ensures that procurement processes are appropriately tailored based on the scale and complexity of the project, balancing regulatory compliance with operational efficiency.

The minimum requirements require that all energy consumed for heating purposes shall be zero-emissions. This applies throughout the construction period. This can be achieved by using electricity, district heating, or other zero-emission technology. This requires that the infrastructure owner be contacted during the planning stage in order to ensure that the infrastructure is ready in time.

As standard, environment-related *award criteria* account for 30% (with a minimum of 20%) of the total weighting. At least 50% of this environmental weighting pertains to construction machinery and transport to/from the site. If no additional environmental requirements are planned, the weighting of these criteria may be increased. Points are awarded to the contractor based on the ratio of zero-emission and/or biogas-based machinery and vehicles. The contractor is also awarded points for the reduced transport of material and for their ability to reduce the use of fossil-fuel vehicles for the transport of waste, equipment, personnel, etc.

The contractual requirements state that all machinery used on the site shall be fossil-free and zero-emission by 2025. All vehicles used for transporting bulk materials and waste shall comply with Euro 6/VI emission standards as a minimum, make use of fossil-free fuel, and be zero-emission by 2025. In addition, running on idle is not permitted for any machinery or vehicle.

Minimum requirement	Award criteria	Contractual requirement	Application of bonus
Heating and drying must have zero emissions.	Minimum 20% weighting, half of which is attributed to machinery and transport.	All machinery used on the building/-construction site shall be fossil-free.	-

3.5 Examples from the Swedish Criteria Bank

The procurement criteria used in Oslo and the Green Deal are focused primarily on energy use and machinery. Below are some examples of criteria from the Swedish Criteria Bank covering other areas of the construction site. Most are technical specifications, which are a type of contractual requirement in tenders.

Reducing climate impact from mass handling

Using procurement criteria to reduce the climate impact from mass handling can be effective. Although designers can have a significant influence on emissions related to these factors, there are also various requirements that can be imposed on contractors.

One approach is to mandate the **development of a mass disposal plan**. The governing priorities of such a plan should include minimising transport, reducing the climate impact of fuel use, avoiding the use of new raw materials, pursuing the reuse and recycling of materials as locally as possible, and minimising landfill. Additionally, when selecting locations for bulk handling, those with the least impact on the natural environment should be chosen.[23]

The contractor can also be required to work according to the **client's mass disposal plan**. The mass disposal plan must be updated and adjusted before excavation begins, with the goal of reducing total transportation and idling, and ensuring that as much material as possible is reused and recycled, and as locally as possible.[24]

Protection and management of materials

It is logical to minimise waste during construction in order to reduce emissions. The effective management and protection of materials during construction is essential for minimising waste.

Mandating that building materials must be stored in such a way that they are not damaged or do not attract moisture or dirt is one way of ensuring the protection of the material through the technical specification. Instructions must be given in a

23. Upphandlingsmyndigheten, 'Hållbarhetskrav för Masshantering för minskad klimat- och naturpåverkan – totalentreprenad | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/schaktning-och-masshantering/upphandling-av-totalentreprenad-masshantering/masshantering-for-minskad-klimat--och-naturpaverkan--totalentreprenad/basniva/
24. Upphandlingsmyndigheten, 'Hållbarhetskrav för Masshantering för minskad klimat- och naturpåverkan - utförandeentreprenad | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/schaktning-och-masshantering/upphandling-av-utforandeentreprenader-masshantering/masshantering-for-minskad-klimat--och-naturpaverkan---utforandeentreprenad/basniva/

language that those who handle the material can understand.[25]

A technical specification that mandates that construction waste must not exceed a certain weight per square metre can also be used. The contractor is required to report on the project's strategy for achieving the waste targets and their integration in planning and purchasing.[26]

To insist that the contractor must systematically sort leftover materials, resources, and construction waste throughout the implementation of the project is another technical specification that can be used. The aim of such a requirement is to increase the degree of reuse and recycling, reduce the amount of waste, and contribute to the increased circularity of resources.[27]

Another possibility is to require the contractor to draft a **material and waste management plan** with the aim of achieving the resource-efficient management of resources, materials, spills, and waste, and reducing the impact on the environment and climate during the various phases of the project.

Such a plan should include instructions, routines, measures, and means of documentation. It should also mention the quantity that is planned to be reused, recycled, etc., and include information on where the sorting containers should be placed at the construction site, how many containers are needed, and if they are needed the whole time or just for a period of time.[28]

Avoiding energy and material consumption

In procurement, there should be a focus on avoiding energy and material consumption during construction. An easy way to achieve this is to reduce errors, deficiencies, and damages in the project by developing a good project culture.

The Swedish Criteria Bank offers a description of how to use "Good project culture" as a procurement criterion (special contract conditions), where there is the possibility of adding weight to environmental issues.[29]

It states that the person who discovers or is informed about errors, deficiencies, and damages is to correct these if doing so falls within their role and capacity Examples

25. Upphandlingsmyndigheten, 'Hållbarhetskrav för Skydd av materialet | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/flerbostadshus-nybyggnad/totalentreprenad/skydd-av-materialet/basniva/
26. Upphandlingsmyndigheten, 'Hållbarhetskrav för Avfallsmängder, nybyggnad | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/flerbostadshus-nybyggnad/totalentreprenad/avfallsmangder-nybyggnad/basniva/
27. Upphandlingsmyndigheten, 'Hållbarhetskrav för Resurser och avfall - Sortering i fraktioner och statistik | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/flerbostadshus-nybyggnad/totalentreprenad/resurser-och-avfall---sortering-i-fraktioner-och-statistik/basniva/
28. Upphandlingsmyndigheten, 'Hållbarhetskrav för Material- och avfallshanteringsplan | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/flerbostadshus-nybyggnad/totalentreprenad/material--och-avfallshanteringsplan/basniva/
29. Upphandlingsmyndigheten, 'Hållbarhetskrav för God projektkultur | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/flerbostadshus-nybyggnad/upphandling-vid-projektering/god-projektkultur/avancerad-niva/

include seeing building material wrongly stored and therefore being damaged, or witnessing unnecessary idling of machinery. Naming those responsible increases the weight of responsibility and gives the client the opportunity for better visibility into the contract. Qualification requirements for a quality, environment, and security manager can be useful.[30]

Renewable energy requirements

When there is a requirement for using electricity over fossil fuels, the source of the electricity needs to be taken into account. A technical specification could be that the electricity for charging vehicles (and machinery) must come from renewable sources. [31] This is similar to the requirement that biodiesel must be produced using renewable raw materials and bio-waste.

3.6 Suggested method

With LCA demands and limit values set to become standard across all the Nordic countries within a few years, it is logical to use criteria based on these requirements to build upon existing legal obligations. Contracting authorities may worry about receiving too few valid tenders if the criteria are too strict. Consequently, flexibility within the criteria is essential.

Setting criteria for lowering emissions from A4 (transport of products to the construction site) and A5 (construction and installation processes) as a whole can be more effective than specifically asking for green energy machinery. This approach gives bidders the flexibility to choose how they will achieve the required emissions reductions, fostering innovation and cost-effective solutions.

LCA criteria

Various approaches for contractors to reduce emissions from A4 and A5 are suggested in the chapter on "Implementation" in this report. The reference amounts can be derived from generic numbers (see Table 1.2) which can be expected to be frequently updated in the near future as data collection improves. As regulatory limit values are established, the goal should be to set the criteria lower than these legal thresholds (if the limit value for A4 and A5 is specified). The criteria for emissions can be set as a percentage of the limit values, depending on the environmental aspirations of the project. This should ensure that emissions reductions at construction sites do not

30. Upphandlingsmyndigheten, 'Hållbarhetskrav för Kvalitets-, miljö- och arbetsmiljöansvar | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/bygg-och-fastighet/flerbostadshus-nybyggnad/totalentreprenad/kvalitets--miljo--och-arbetsmiljoansvar/basniva/
31. Upphandlingsmyndigheten, 'Hållbarhetskrav för El från förnybara energikällor | Upphandlingsmyndigheten'. Accessed: Jul. 01, 2024. [Online]. Available: https://www.upphandlingsmyndigheten.se/kriterier/fordon-och-transport/drivmedel/stationstankning/el-fran-fornybara-energikallor/basniva/

come at the expense of other parts of the LCA but rather encourage targets for even lower emissions and in more areas.

Application of bonuses

LCA-related criteria can be used in different procurement methods. An easy starting point is to use this as a bonus application criterion, whereby a bonus is calculated and paid for a reduced amount of emissions from A4 and A5 (based on estimated emissions) once the construction process is complete. The bonus amount can be connected to a calculated carbon price. Where more data is needed, a softer start can be to pay a bonus for every sub-module (A4, A5.E and A5.W) whereby specific data is gathered along with verification.

Award criteria

The use of LCA criteria as an award criterion where quality points are awarded for planned emissions reductions from A4 and A5 would be a more ambitious approach. One quality point would be awarded for each 10% reduction from the estimated emissions, up to 10 points for a 100% reduction. The estimated emissions might stem from an LCA calculation if there is a requirement to calculate the LCA at the design stage or if the project owner has it calculated for the procurement process. Although the calculation could also be based on generic figures (see Table 1.2), it is recommended to be more precise for this method. When award criteria are used, it is recommended that the percentage attributed to price does not exceed 60%. This approach increases the likelihood that environmental factors will have an impact and reduces the probability that an ambitious bid will be undercut by a cheaper one. The remaining 40% can be allocated to quality points and environmental points, or entirely to environmental criteria.

Minimum requirements

In the most ambitious projects, LCA criteria would be used as minimum requirements or a mix of minimum requirements and award criteria. As a minimum criterion, emissions from A4 and A5 would need to be a certain amount below the estimated emissions where the amount would need to be well-considered based on market capacity and ambition.

Additionally, a combination of award criteria and minimum requirements can help ensure that environmental priorities are not compromised. The minimum requirements keep bidders aligned with mandatory standards, while the award criteria encourage a higher level of ambition.

Key points

Application of bonuses:

- A bonus is awarded for every sub-module that is evaluated (where generic figures are not used).
- A bonus is awarded for reducing emissions from A4 and A5 by XX%. The bonus amount can be connected to a calculated carbon price.

Award criteria:

- Quality points are awarded for reducing emissions from A4 and A5, with the percentage attributed to price not exceeding 60%. One quality point is awarded for each 10% reduction, up to 10 points for a 100% reduction in emissions from A4 and A5.

Minimum requirements:

- Emissions from A4 and A5 need to be XX% under the stated estimated emissions.

With this procurement method, it is important to state clearly that carbon balancing is not allowed and will not be counted as emissions reduction.

Dialogue

The contractor should engage in dialogue with the designers or those responsible for the LCA calculations. There is a possibility that an LCA has already been conducted during the design phase (if national regulations mandate LCA calculations before construction). Data collected to verify that procurement promises have been met can be valuable when processing the LCA after construction.

3.7 Follow-up

To ensure the contractor's fulfilment of the conditions, the procuring organisation should explain its follow-up plan or strategy for monitoring compliance in the procurement documents. The follow-up approach should always be adapted to the content, size, and duration of the contract. Regular follow-up meetings, involving both the contractor and the client (or their representatives), should be scheduled. These meetings can be integrated into construction and/or environmental meetings attended by the client. Additionally, random checks can be conducted, during which the contractor demonstrates and explains how the conditions are being met.

Action plan

An action plan for how the contractor will reduce the emissions from A4 and A5 (except for the first suggested method of the application of bonuses) should be a requirement in the follow-up of suggested procurement methods. This action plan should include information on which sub-modules the reduction stems from. At follow-up meetings, it should be checked that accounts are being produced for the sub-modules for which emission reductions had been proposed (Table 4.1 in the evaluation chapter can be used). When the contract includes the use of clean energy machinery, an up-to-date equipment list should be reviewed along with the machines used on site.

Sanctions

Included in the climate and environmental requirements for the City of Oslo's construction sites is a provision regarding breach of contract. The provision states that if the supplier is unable to meet one or more of the environmental requirements or does not deliver in accordance with the tender, the project owner is entitled to levy a proportionate daily fine for the period of time during which the breach lasts. In the event of repeated or severe breaches of the environmental provisions, the project owner is entitled to terminate the contract with immediate effect.[32]

32. Klimaoslo, 'Climate and environmental requirements for the City of Oslo's construction sites', Oslo, 2019. [Online]. Available: https://www.klimaoslo.no/wp-content/uploads/sites/88/2019/11/Climate-and-enviromental-requirements.pdf

Key points

- Follow-up meetings, review action plan.
- Propose a step-by-step plan if promises are not kept.

4. Implementation

This chapter will first focus on reducing emissions from energy and transportation in phase A4 followed by A5E. This is achieved by utilising the *Avoid, Shift, Improve* hierarchical framework, where types of actions are listed in order of impact:

1. Avoid energy use
2. Shift to clean energy
3. Improve energy efficiency

The focus will subsequently be on waste from phase A5W, guided by the 3R framework:

1. Reduce – produce less waste
2. Reuse – use the product again
3. Recycle – use the material to make new products

When it comes to the actual work on the construction site, there are numerous ways to reduce emissions from transport, minimise fossil fuel use, and minimise waste. The most straightforward and effective actions involve reducing energy consumption through improved transportation planning, reducing idling time, and minimising waste through better storage and planning. Many of the current barriers to emission-free construction can be overcome with careful planning, optimisation, and adaptation of current work practices. Planning ahead with key stakeholders is critical for the implementation of emission-free practices at construction sites, whether driven by one's own ambition or external requirements such as tender conditions. In the earliest stages of construction planning, it is essential for contractors to create a plan that accounts for energy needs and power peaks, optimises transport logistics, and minimises waste.

4.1 Reducing emissions from transportation – A4

Avoid unnecessary emissions from transport

Optimising the transport of materials, equipment, and waste disposal through planning and collaboration with key stakeholders can help reduce emissions. Source building materials from local suppliers and prioritise the use of locally available resources to minimise transportation distances. Avoid materials produced in remote locations as long-distance transport always requires considerable energy use. Limit the transportation of excavated mass by reusing and recycling materials as close to the site as possible. Engage with stakeholders, including suppliers and subcontractors, at an early stage in the project to plan for material availability and reduce transportation needs. Additionally, co-ordinate with other nearby construction projects to share resources and materials effectively.

Shift to low-carbon modes of transportation

When considering which modes of transport to use for the project's transport needs, prioritise the use of available vehicles and transport modes that will minimise emissions. For example, use electric vehicles when available. If unavailable, use biofuel vehicles. Further discussion about low-carbon energy use can be found in Chapter 4.2. Early planning is essential for ensuring that the proper infrastructure exists for charging transport vehicles. If biofuels or hydrogen is used, ensure that an adequate supply will be available for the duration of the project. Consider the transport methods that other stakeholders (material hauliers, waste hauliers, others involved in construction site transport) are using, and engage in dialogue with them about using the lowest emission transportation modes available. When it comes to long-distance transportation, bear in mind that transportation by sea results in the least amount of emissions per unit of distance travelled, followed by rail.

Improve efficiency

Emissions reductions can also be achieved through driver training and the use of energy-efficient vehicles. Drivers can be trained to avoid idling and drive smoothly and efficiently, and to report when vehicles need maintenance. If fossil fuels are used, the most energy-efficient vehicles should be used. Optimising delivery routes and schedules can minimise travel distances and avoid traffic. This can also facilitate the use of smaller vehicles with a higher utilisation rate. Working with suppliers to optimise delivery times of equipment and materials can ensure that vehicles are loaded efficiently to reduce the number of trips to and from the construction site. There are many types of logistic software available that can help with transport optimisation.

Example: Material production and transport are the key to the most substantial emissions reductions. Lukutori Square was built using Finnish paving stones instead of stones imported from China, where the stones are usually sourced from. Had stones from China been used in the pilot project, its total emissions would have been more than three times higher. Although building using local materials requires more resources in terms of planning and contracting tenders, in the long run, carbon-neutral and sustainable construction is not more expensive, but actually helps to save money.[33]

Key points:

Avoid ↓	• Source building material from local suppliers and priorities the use of locally available resource. • Keep transportation of masses down by reusing and recycling materials as close to the site as possible. • Include suppliers and subcontractors early to plan for material availability and minimize transportation.
Shift ↓	• Use vehicles with the lowest emissions available (e.g., electric or biofuel). • Plan early for charging infrastructure or biofuel supply. • Discuss low-emission transport options with stakeholders. • Prefer sea or rail transport for long distances to minimize emissions
Improve ↓	• Train drivers to minimize idling, drive efficiently, and report vehicle maintenance needs promptly. • Optimize delivery routes and schedules to minimize travel distances and avoid traffic. • Coordinate with suppliers to optimize delivery times and load vehicles efficiently to reduce trips. • Utilize logistics software for transport optimization where available.

33. HNRY, 'Emission-free construction site: green public procurement'. Accessed: Jul. 01, 2024. [Online]. Available: https://hnry.fi/en/emission-free-construction-site-green-public-procurement/

4.2 Reducing emissions from energy use – A5.E

Avoid energy use

Although avoiding energy use on construction sites can be difficult, there are factors worth considering. To start with, it can be effective to look at all expected energy consumption on the site and identify ways to eliminate what is not strictly necessary and optimise energy use where possible. Construction sites vary in shape and size, so there are no ready-made solutions. Energy is typically used for machinery, on-site transport, heating, lighting, and various small tools and equipment.

The site layout should be planned and optimised to minimise energy use, especially considering earthworks and the transport of mass, where fossil fuels are often used. Energy for heating and drying can often be limited by preventing heat loss and not heating unused spaces. If possible, work should be planned to prevent the need to heat uninsulated spaces during the winter months.

If an electricity grid connection is not available and electricity is produced on site, special care should be taken to save electricity.

Shift to clean energy

The use of fossil fuels on site is a major emitter of greenhouse gases. Diesel is traditionally used for heavy equipment and fossil-based gas is often used as a heat source. Electricity that is supplied to construction sites may also be produced from fossil fuels. Replacing this fossil fuel use with clean energy is one of the most important goals for EFCS.

Electricity supply to the site should be from renewable sources when possible. This depends on availability in each country or market area and is not within control of the construction industry.

Emission-free energy options for heating and drying include district heating, biofuels, and electricity. Using an emission-free district heating system is often the most efficient and economical choice. Biofuels are highly efficient when used as a heat source and can therefore be a better option for heating than electricity. Bio-methane is a clean burning gas that is widely available. Wood burners are commonly used in most of the Nordic countries. Although these are excellent heat sources, care must be taken to only use modern clean burning variants. Electricity can also be used for heating, especially in countries with ample supply at moderate prices. Heat pumps are also becoming popular where electricity is used for heating. Heat pumps can reduce the cost of heating with electricity considerably.

There are several energy options to replace fossil diesel in heavy machinery and trucks on site. Biofuels such as bio-methane, biodiesel, and HVO are commonly used and typically provide an 80% reduction in emissions compared to fossil diesel. These fuels can be used with current machine fleets and readily available equipment. The drawbacks are the poor efficiency of the combustion engines and local air pollution. It is also important to only select sustainably produced biofuels.

Battery electric machinery and heavy trucks are now becoming available. Although the upfront investment is high and availability is somewhat limited, the cost of operation is lower than comparable diesel equipment. On-site operations are completely emission-free, so there is no local air pollution and limited noise pollution. The main drawback is their short range, so the machines often need to be charged during the working day. Contractors should assess the availability of suitable machinery early on in the project and engage in discussions with subcontractors about accessing green energy equipment. When it comes to electric machinery, collaborate with power suppliers and grid operators before and during the project to understand potential constraints on the power supply, as the use of battery electric machinery can strain existing utility systems. Consider using battery containers to manage charging capacity issues. Combining battery-powered and cable-powered machinery can alleviate charging challenges. Designate an on-site charging and logistics co-ordinator to optimise charging schedules and manage any adaptation of procedures.

Hydrogen equipment is slowly coming to the market and hydrogen from renewable sources is available in some of the Nordic countries. Fuel cells convert hydrogen into electricity for use in machinery and vehicles. This is the optimal way of using hydrogen as there is a high level of efficiency and no emissions. Nevertheless, fuel cells are expensive and the production of large units is still limited. A fuel cell combined with a battery pack is an excellent choice for replacing diesel generators for on-site electricity production in cases where a grid connection is not available. Some larger construction machinery and trucks are available with hydrogen combustion engines. Although the burning of green hydrogen results in no carbon emissions, there are still some emissions of nitrogen oxide locally.

The availability of biofuels, hydrogen, or other clean energy fuels varies by location, underscoring the importance of early engagement with suppliers to secure a reliable, sustainable supply. Additionally, consider transport logistics and distances required for these fuels. The same goes for district heating and electricity connections. Arranging a district heating connection to the site can take considerable time and should be arranged as soon as possible, preferably as part of the project planning phase. When battery electric heavy equipment is used, a powerful grid connection is needed. This must be arranged at an early stage, preferably as part of the project planning process.

Table 4.1 below outlines the benefits, barriers, and best practices associated with the clean energy sources currently suitable for construction site use.

	Benefits	Barriers	Best practices
Electric	-Zero on-site emissions -Reduced noise -No local air pollution -Energy security	-Limited supply of electric construction machinery and vehicles -Limitations in grid capacity -Charging infrastructure often inadequate	Involve the power provider and grid operator early on -Adapt work procedures to accommodate charging needs -Plan machine fleet according to available charging capacity -Use peak shaving equipment
Biodiesel **HVO** **Biogas**	Vehicles and machines widely available -For large machines that have a long range	Local emissions -Poor energy efficiency -Sustainability issues	Use where energy infrastructure is lacking -Choose fuel from local sources -Only use certified sustainable fuels
Hydrogen Combustion	Low local air pollution -For large machines that have a long range	Poor energy efficiency -Limited availability of vehicles and machines	Interim solution while fuel cell machinery is developed -Use sustainably sourced hydrogen
Hydrogen fuel cells	No local pollution -High level of energy efficiency -Reduced noise	-Limited availability of vehicles and machines	Use sustainably sourced hydrogen

Improve energy efficiency

To optimise energy efficiency, consider the versatility of machines in fleet selection and task planning. Use the most efficient machinery and vehicles available. Efficient machinery usage can be achieved through worker training in optimal operation techniques. Look at all equipment that uses energy and assess the energy efficiency of the equipment itself and how it is used. One example of energy-efficient equipment is LED lighting, while efficiency in-use includes reducing the idling time of diesel-powered machinery. An overall improvement in efficiency requires trained personnel and the use of energy-saving standards.

Key points:

Avoid ↓	• Avoid unnecessary energy use by reviewing all expected energy consumption. • Prevent heat loss and avoid heating unused spaces.
Shift ↓	• Use electric machinery when possible; opt for biofuels or other clean energy instead of diesel to cut emissions. • Assess machinery availability early; discuss with subcontractors about accessing green energy equipment. • Coordinate with power suppliers and grid operators to manage constraints on battery and electric machinery. • Explore battery or plug-in machinery; use battery containers and appoint a charging coordinator to optimize schedules. • Consider district heating systems for heating and drying, and arrange early connections to central heating systems if applicable.
Improve ↓	• Pair machinery and equipment with digital controls to improve logistic. • Provide training for workers in efficient machine operation. • Implement strategic work planning logistics like reducing idling to enhance energy efficiency.

4.3 Reducing emissions from waste – A5.W

It is essential to establish a comprehensive waste management plan before construction starts. A waste management plan assists in the identification and implementation of strategies to minimise the amount of waste generated.

The waste management plan should include instructions, routines, measures, and documentation methods. It should specify the amount of material that is planned to

be reused and recycled, detail where the sorting containers should be placed and how many containers are needed, and whether these containers are required throughout the project or just for certain periods. The waste management plan should then be used to identify improvements that can reduce emissions from waste on site. Appointing someone to oversee and manage the waste management plan will help to ensure that waste is reduced, reused, or recycled properly.

Reduce

Effective planning can help contractors better estimate material needs, optimise usage, and prevent excess waste, thereby reducing the overall emissions associated with waste production and disposal. When a material takeoff is conducted, the materials needed should be estimated as precisely as possible to avoid excess. The sizes to be purchased should also be considered to minimise off-cuts. Proper storage of materials and the optimisation of delivery times can reduce waste from product damage. Software such as BIM or other programs can be used to organise the storage of building materials and waste on site.

Reuse

Although the reuse of building materials hinges on the designer, there are steps that contractors can take after the design is finalised. Reusing as much mass as possible is ideal, not only to reduce energy consumption from transportation as mentioned above, but also to minimise resource use and unnecessary landfill. One way is to reuse crushed concrete, bricks, or other aggregates for backfilling or non-critical applications. Additionally, when a large amount of excavated material needs to be removed, it is advisable to consider using it on site (such as in landscape designs in consultation with a landscape architect) or at nearby construction sites.

The waste management plan should look at opportunities for reusing existing materials on site. This applies to excavated materials and structures that will be deconstructed. Workers should be trained in deconstruction for the purpose of reuse and to prevent damage to reusable building materials.

Recycle

It is essential to collaborate with waste management companies to ensure the recycling of waste materials. Maintaining ongoing dialogue with waste management companies throughout the construction project in order to communicate the goals of waste reduction and recycling of materials will help to optimise this process and inform waste management companies about the needs of EFCS. Dialogue should also be maintained with workers on site, who should not only be trained to use the waste sorting system, but also be informed about work practices that reduce waste generation.

Key points:

Waste management plan ↓	• Set up a comprehensive waste management plan • Estimate material needs, optimize usage, and prevent excess waste • Specify the amount of material planned for reuse and recycling • Details on where the sorting containers will be placed and how many are needed • Appoint an employ to oversee and manage the plan.
Reduce ↓	• Precisely estimate materials in a material takeoff to avoid excess. • Considere the purchased sizes to minimize cutoffs. • Properly store materials and optimis delivery times to reduce waste from product damage. • Use a software such as BIM to organize the storage of building materials and waste on-site.
Reuse ↓	• Precisely estimate materials in a material takeoff to avoid excess. • Considere the purchased sizes to minimize cutoffs. • Properly store materials and optimis delivery times to reduce waste from product damage. • Use a software such as BIM to organize the storage of building materials and waste on-site.
Recycle ↓	• Have an early dialogue with waste management companies to optimise the process and communicate needs. • Have a dialogue with workers on site and train them to use the waste sorting system and reduce waste generation.

5. Evaluate

This chapter provides recommendations for the evaluation of emission-free construction projects. It includes suggestions for data collection which aligns with LCA methodology and proposes that key stakeholders share feedback to improve and advance progress in respect of EFCS.

In order to determine if a construction site is emission-free, it is vital to collect data during the construction phase on on-site energy use, transportation energy use, and waste. As clients increasingly demand demonstrability of emission reductions, accurate data collection becomes indispensable. For green transport and machinery, for example, tracking actual energy consumption and comparing it to conventional emission-producing machinery can provide valuable insights. These measurements not only help in validating emission reductions, but also in learning how to minimise and further reduce emissions effectively. Collecting this data is also a way of identifying whether demands made in the procurement are being met.

LCA data

The report "Nordic view on data needs and scenario settings for full life cycle building environmental assessment" [3], from WP1 of the Nordic Sustainable Construction project provides in-depth guidance on data collection for conducting LCAs on buildings in the Nordic countries. The report suggests using generic figures for transport and waste since this can be time-consuming and difficult to measure and validate. However, metered data can replace these estimates, which is particularly necessary for energy use. With the increased focus on using LCA methodology for measuring emissions from buildings, software, and other tools to support data collection during the construction phase are continuing to be developed to ease and improve the accuracy of the data collection process.

Contractors need to provide information on kilowatt-hours (kWh) and electricity sources, fuel usage, and the amounts of waste generated. To facilitate this, it is recommended to assign someone to collect data using automated or digital methods that are compatible with LCA methodologies. This system should be established early on in the construction process, be designed for simplicity, and be easy to share among stakeholders. Verification documents or third-party assessments are recommended to validate the measurements.

Feedback

Establishing a system at the construction site for regular evaluation and feedback on emission-free construction practices allows for the identification and amplification of

success while addressing any issues that arise. Creating a process early on for sharing feedback with key stakeholders such as those involved with planning, material and service providers, and external stakeholders can accelerate the progress of the industry towards EFCS.

Key points

- Establish a data collection system.
- Use LCA methodology for guidance.
- Create a process for evaluation and feedback to share with all stakeholders.
- Consider using automated or digital processes.

5.1 LCA data collection recommendations

Evaluation is crucial for achieving the goal of EFCS. The industry is in the early stages of developing emissions-free construction practices, so it is important to thoroughly evaluate the measures taken in each project to assess the effectiveness of these measures. Every phase of the project including the design, planning, procurement, and implementation should evaluate the actions taken to reduce emissions at the construction site. Sharing information is vital for improvement, increasing engagement, and creating benchmarks for the industry. In this section we will go through the A4 and A5 modules and sub-modules and how they are or should be evaluated.

A4

A4 includes the transport of materials, products, equipment, and services to site. This includes all transport from the factory gate to the construction site including return journeys, intermediate storage, and distribution. It also includes impacts and aspects related to losses due to transport. Different methods have been used to calculate this and specific data is often used for A4.

To gather specific data, information about the distance travelled and energy source is needed by way of verification and travel logs. This is approached in partnership with waste hauliers, suppliers, material hauliers, and equipment hauliers.

A5

A5 includes groundworks and landscaping, transportation of products, waste and equipment within the site, construction processes and installation, temporary works, and waste management.

A5.E primarily includes emissions from machinery use and heating and cooling. These emissions are evaluated by gathering data on all machinery used on site, their energy sources, and the amount of energy used. It is recommended to keep verifications of energy sources and record the hours worked on the machinery. For heating and cooling, information is needed on the energy source and amount of energy, which can be obtained from automatic or manual meter readings or verifications of energy sources provided by utility services and contractors.

A5.W includes emissions from waste and waste management. In order to use measured data, gather information from waste hauliers about the volume or weight of the waste and its type. For waste management, data on distance and energy sources can be collected by obtaining verifications and travel logs.

On-site data collection

As with the implementation of any new process, although data collection at the construction site can be complicated initially, it can be adapted quickly with the right techniques. It is a good idea to consider a data collection plan before work starts, and assign the proper resources and employee(s) to this task. Data collection methods could be as simple as a data collection sheet or an automated or digital process through logistics software or other platforms that can manage data collection.

Table 5.1 Recommended data to collect for measuring emissions from transportation, energy use, and waste during the construction phase.

LCA module	Activity	What to consider	Values	How to measure	Stakeholders
A4	**Transportation**	Transport of materials, products, and equipment to the construction site from: -Manufacturer -Storage/warehouse -Retailer	-Distance -Energy source	-Verification (of energy source) -Travel logs	Suppliers Material, product, and equipment hauliers
A5.E	**Energy use**	Emissions from: machinery	Type of machinery Energy source Amount	Verification (of energy source and worked hours)	Suppliers Subcontractors
		Heating and cooling: -district heating -power station sources (for temporary works or other processes)	Energy source Amount	Automatic or manual meter reading Verification	Utility providers
A5.W	**Waste**	Construction waste:	-Volume -Weight -Type	-Waste management company reports or verification	Waste hauliers
		Transport of waste from construction site	-Distance -Energy source	-Verification	Waste hauliers

Review

Data can be validated by way of third-party audits, utility providers, or from invoices and verifications. Monitoring of the site to ensure that electric machinery or other emission-reduction measures are being implemented can be done by way of electronic monitoring systems or site visits by supervisors, owners, or other key stakeholders. Having a data collection system that can be checked by different stakeholders at different stages of the construction process can facilitate better data quality and transparency.

Key points

- Establish a plan for data collection early on and dedicate time and resources to it.
- Share the data gathered for improvement, increasing engagement, and creating benchmarks for the industry.
- Thoroughly evaluate the measures taken in each project to assess their effectiveness.

5.2 Feedback

On the construction site, it is important to collect regular feedback from workers, supervisors, subcontractors, and any other team members involved in the implementation of the project. Setting up regular meetings and recording the pertinent feedback to deliver to the appropriate stakeholders will help to improve both the current project and future projects.

The stakeholders involved in the planning process will need feedback from the construction team in order to evaluate whether the decisions made during the planning and procurement processes resulted in fewer emissions on the construction site.

Communicating feedback to material and service providers throughout the project can help to improve logistics, alleviate operational issues, and inform these providers about the growing demand for the types of products and services that are necessary for emission-free construction.

External stakeholders such as government and regulators, research and academia, and industry groups can utilise the information provided from the construction team

and planners to create baselines to determine best practices and influence the market to promote the development of the products and services necessary to achieve emission-free construction.

Key points

- Sharing feedback with stakeholders is crucial to reaching the goal of emission-free construction.

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Appendix

This appendix provides a printable summary of the guidelines for reducing emissions from construction sites. The intention with this appendix is to provide a quick reference for the key points outlined in the main document.

The summary has been designed for easy printing and distribution among team members and stakeholders. It can be used during planning, training, and operational activities to ensure that all personnel are informed about the critical aspects of the guidelines.

Guidelines for EFCS planning and design

Here are the key points to keep in mind in EFCS planning and design.

Urban planning and infrastructure

- Consider the necessity of the project and explore alternatives to a new building
  - Repurpose existing buildings
- Strategic selection of project locations
  - Minimise transportation distances and earthworks
  - Prioritise accessibility to existing road infrastructure, electricity grid, water supply network, etc.
- Ensure the availability of clean energy sources from the outset
- Plan the order of new infrastructure to ensure that essential utilities are in place from an early stage
- Schedule construction activities to coincide with the seasons
- Allocate designated areas for sorting and storing building materials and waste

Building materials

- Select building materials that result in minimal waste
- Select building materials that reduce energy consumption
- Use prefabricated components designed for disassembly in mind
- Specify exact material requirements
- Prioritise local materials
- Write a detailed project specification to ensure proper material use

Excavated material

- Develop and implement a mass disposal plan early on in the project
- Prioritise the local reuse and recycling of excavated materials
- Minimise the transportation of bulk materials through optimised design and planning
- Follow sustainable soil management guidelines to reduce environmental impact and emissions

For more information on procurement for emission-free construction projects, see Chapter 3 of the Guidelines for Emission-free Construction Sites.
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Guidelines for EFCS procurement

Here are the key points to keep in mind during EFCS procurement.

Plan

- Expect extra time and cost
- Establish goals that align with the organisation's strategies
- Engage with potential contractors

Suggested criteria

Application of bonuses:

- A bonus is awarded for every sub-module that is evaluated (where generic figures are not used).
- A bonus is awarded for reducing emissions from A4 and A5 by XX%. The bonus amount can be connected to a calculated carbon price.

Award criteria:

- Quality points are awarded for reducing emissions from A4 and A5, with the percentage attributed to price not exceeding 60%. One quality point is awarded for each 10% reduction, up to 10 points for a 100% reduction in emissions from A4 and A5.

Minimum requirements:

- Emissions from A4 and A5 need to be XX% under the stated estimated emissions.

Keep in mind

- A combination of award criteria and minimum requirements can be used
- An action plan should be required
- State clearly that carbon balancing is not allowed and will not be counted as emissions reduction

Follow-up

- Regular follow-up meetings (integrated in construction/environment meetings)
- Verify that accounts are being produced as planned (monitoring of waste and resources)
- Up-to-date equipment list and machines used on site

For more information on procurement for emission-free construction projects, see Chapter 3 of the Guidelines for Emission-free Construction Sites.
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Guidelines for EFCS implementation

Here are the key points to keep in mind in the implementation of EFCS.

A4 Transportation

Reducing emissions from transportation means reducing energy use. The "avoid, shift, improve" hierarchy can be used to reduce energy use.

Avoid ↓	• Source building material from local suppliers and priorities the use of locally available resource. • Keep transportation of masses down by reusing and recycling materials as close to the site as possible. • Include suppliers and subcontractors early to plan for material availability and minimize transportation.
Shift ↓	• Use vehicles with the lowest emissions available (e.g., electric or biofuel). • Plan early for charging infrastructure or biofuel supply. • Discuss low-emission transport options with stakeholders. • Prefer sea or rail transport for long distances to minimize emissions
Improve ↓	• Train drivers to minimize idling, drive efficiently, and report vehicle maintenance needs promptly. • Optimize delivery routes and schedules to minimize travel distances and avoid traffic. • Coordinate with suppliers to optimize delivery times and load vehicles efficiently to reduce trips. • Utilize logistics software for transport optimization where available.

A5.E Energy use

Reducing emissions from energy use on site. The "avoid, shift, improve" hierarchy can be used to reduce energy use.

Avoid ↓	• Avoid unnecessary energy use by reviewing all expected energy consumption. • Prevent heat loss and avoid heating unused spaces.
Shift ↓	• Use electric machinery when possible; opt for biofuels or other clean energy instead of diesel to cut emissions. • Assess machinery availability early; discuss with subcontractors about accessing green energy equipment. • Coordinate with power suppliers and grid operators to manage constraints on battery and electric machinery. • Explore battery or plug-in machinery; use battery containers and appoint a charging coordinator to optimize schedules. • Consider district heating systems for heating and drying, and arrange early connections to central heating systems if applicable.
Improve ↓	• Pair machinery and equipment with digital controls to improve logistic. • Provide training for workers in efficient machine operation. • Implement strategic work planning logistics like reducing idling to enhance energy efficiency.

A5.W Waste

The "reduce, reuse, recycle" hierarchy can be used to reduce emissions from waste.

Waste management plan ↓	• Set up a comprehensive waste management plan • Estimate material needs, optimize usage, and prevent excess waste • Specify the amount of material planned for reuse and recycling • Details on where the sorting containers will be placed and how many are needed • Appoint an employ to oversee and manage the plan.
Reduce ↓	• Precisely estimate materials in a material takeoff to avoid excess. • Considere the purchased sizes to minimize cutoffs. • Properly store materials and optimis delivery times to reduce waste from product damage. • Use a software such as BIM to organize the storage of building materials and waste on-site.
Reuse ↓	• Precisely estimate materials in a material takeoff to avoid excess. • Considere the purchased sizes to minimize cutoffs. • Properly store materials and optimis delivery times to reduce waste from product damage. • Use a software such as BIM to organize the storage of building materials and waste on-site.
Recycle ↓	• Have an early dialogue with waste management companies to optimise the process and communicate needs. • Have a dialogue with workers on site and train them to use the waste sorting system and reduce waste generation.

For more information on procurement for emission-free construction projects, see Chapter 3 of the Guidelines for Emission-free Construction Sites. Nordic Sustainable Construction 2024

Guidelines for the evaluation of EFCS

Here are the key points and recommendations for the evaluation of EFCS.

Data collection

- It is vital to collect data during the construction phase to estimate emissions from transportation, energy use, and waste.
- Establish a data collection system before the project begins and dedicate the necessary resources and personnel for data collection.
- Use LCA methodology for guidance.
- Consider using automated or digital processes.

LCA module	Activity	What to consider	Values	How to measure	Stakeholders
A4	**Transportation**	Transport of materials, products, and equipment to the construction site from: -Manufacturer -Storage/warehouse -Retailer	-Distance -Energy source	-Verification (of energy source) -Travel logs	Suppliers Material, product, and equipment hauliers
A5.E	**Energy use**	Emissions from: machinery	Type of machinery Energy source Amount	Verification (of energy source and worked hours)	Suppliers Subcontractors
		Heating and cooling: -district heating -power station sources (for temporary works or other processes)	Energy source Amount	Automatic or manual meter reading Verification	Utility providers
A5.W	**Waste**	Construction waste:	-Volume -Weight -Type	-Waste management company reports or verification	Waste hauliers
		Transport of waste from construction site	-Distance -Energy source	-Verification	Waste hauliers

Sharing feedback

- Prior to the project, establish a process for sharing feedback with key stakeholders throughout the project and once the project is complete.
- Key stakeholders include planners, material and service providers, construction teams, and external stakeholders (industry groups, government and regulators, researchers etc.) to accelerate the progress of the industry towards EFCS.

For more information on the evaluation of emission-free construction projects, see Chapter 5 of the Guidelines for Emission-free Construction Sites. Nordic Sustainable Construction 2024

About this publication

Guidelines for Emission-free Construction Sites

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US2024-437
Published: 23.09.2024
Cover photo: Róbert Magnússon

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