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PILOT FOR A ZERO- EMISSION INFRASTRUCTURE WORKSITE IN HELSINKI: TURNING KULOSAAREN PUISTOTIE INTO A CYCLING STREET

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How can an infrastructure project reduce emissions at worksites?

Construction sites cause both significant carbon dioxide emissions and harmful local emissions. In Helsinki, the Kulosaaren puistotie project was one of the pilot locations for the City's zero-emission infrastructure worksites, with the aim of reducing emissions from worksites by promoting the use of alternative driving power in machinery. The Kulosaari worksite used four fully electric machines, while the rest of the equipment used renewable HVO diesel.



Fully electronic wheel loader and mini-excavator being charged. Photo: Tim Karike.

In this publication, we describe the pilot project on Kulosaaren puistotie in more detail and illustrate other work done by the City of Helsinki to reduce the climate impact of infrastructure construction and promote circular economy. The Kulosaari pilot and other low-emission infrastructure worksites complement the City's actions to achieve carbon neutrality.

Carbon-neutral Helsinki requires that emissions from worksites are reduced

The emissions from worksite machinery and heavy transport in construction constitute a significant portion of the carbon dioxide emissions of cities and municipalities. They also produce local emissions, dust, and noise, which degrade air quality and are harmful for health. In a densely built urban environment, the harmful effects of worksites are emphasised.

However, the climate and health impacts of worksites have not been sufficiently reduced by current legislation, and the CO₂ emissions caused by machinery are not regulated. This problem has been identified in Helsinki, and one of the goals of the *Carbon-neutral Helsinki 2035* action plan is to reduce carbon dioxide emissions from worksites, e.g. by piloting the use of zero-emission machinery in the City's infrastructure projects.

“Zero-emission construction sites will be piloted in the City's own construction projects, and a model and criteria for all sites will be adopted based on the experiences from the pilot. The model and the criteria will be included in the environmental document for infrastructure and housing construction projects, as well as in the environmental plan of the site. Operators with construction projects within the City will be steered to use the model and the criteria.”

Action 46. Zero-emission worksite machinery, Carbon-neutral Helsinki 2035 action plan (you can follow the progress for the action via *Helsinki Climate Watch* (in Finnish))

A voluntary Green Deal to promote zero-emission worksites

The City of Helsinki signed a *Green Deal on reducing emissions from worksites* with the Ministry of the Environment in September 2020. The Cities of Espoo, Vantaa and Turku; Senate Properties; and Helsinki Region Environmental Services Authority have also signed the deal. The Green Deal on zero-emission worksites encompasses all construction and maintenance purchased and implemented by the City of Helsinki and its municipal enterprises.

The deal aims to reduce emissions gradually, e.g. by setting emission standard requirements for machinery and heavy vehicles and increasing the amount of machinery using electricity or other alternative driving power. The goal of the deal is that worksites give up fossil fuels completely by 2025. Additionally, at least 50% of the machinery used at worksites and worksite transport vehicles should be powered by electricity, biogas or hydrogen by 2030. The deal also puts in place requirements regarding worksite electricity and heating.

International exchange of experiences

Oslo is seen as a pioneer in zero-emission worksites, the lessons from which other cities follow with great interest. Cities are at very different stages of development: some are only just starting discussions on the topic, while others have gained strong political support for reducing worksite emissions, and pilot projects have already started. However, many of the challenges are common to all, and cities exchanging information and experiences has been proven useful. Concrete cooperation is seen in development projects, for example. The City of Helsinki also actively participates in this international work for zero-emission worksites. In 2020, Helsinki participated in the E-ZEMCONS project funded by EIT Climate-KIC, which promoted zero-emission worksites through market dialogue.

Furthermore, the *Big Buyers for Climate and Environment* initiative funded by the European Commission is one of the cooperation channels. The Big Buyers initiative aims to promote collaboration between significant public sector buyers. The members of the Zero Emission Construction Sites working group under the initiative aim to

set shared requirements for zero-emission worksites at EU level and increase pilots on procurement criteria for zero-emission worksites. The discussions held are related to the availability of electric machinery, use of biofuels and cost effects of zero-emission requirements. In the Big Buyers Initiative prior to the current stage, the *Zero-Emission Construction Sites* working group produced the following materials to support zero-emission worksites:

- The *Lessons learned report* on the most important things learned from the collaboration between cities in the working group.
- Factsheets aimed at *policymakers, businesses* and *citizens* that provide arguments for moving to zero-emission worksites for different target groups.

More sustainable public procurements through cooperation

When public operators work together and combine their purchasing power, they have better chances of impacting the market. Zero-emission machinery is already available on the European market, but the low-emission qualities of larger machinery, in particular, still require innovation.

It is key for companies that the demand for zero-emission solutions is not only based on individual pilots, but a systematic way of operating – companies want to see predictability and certainty of the investments' profitability. In this, public buyers, such as cities, can show the way and promote the development of the market and sustainable solutions through their procurements. The impact of public procurements is gaining increased attention, and both the Finnish Green Deal for zero-emission worksites and the European Big Buyers initiative are examples of public operators working together to shape the market.

The Kulosaaren puistotie worksite as a testing field for zero-emission operations

The project of turning the Kulosaaren puistotie boulevard in Kulosaari into a cycling street, which started in Helsinki in July 2020, was a pilot project in which the volumes of carbon dioxide emissions and harmful local emissions from the worksites were reduced through concrete action. The goal of the pilot was also to create demand for low-emission and zero-emission machinery. This was the first infrastructure project in Helsinki to use fully electric machinery.

Turning Kulosaaren puistotie into a cycling street – background on the procurement

The goal of the procurement was to renovate Kulosaaren puistotie into a cycling street, as a part of Itäbaana, which is one of the main cycling routes to the city centre. On a cycling street, traffic moves on cyclists' terms, meaning that cars adjust their driving style and speed to the cyclists'. Vehicles move one after the other, avoid overtaking and keep their speed at 30 km/h, at the maximum. A cycling street also improves the safety of pedestrians as the pavements are reserved for walking only.

The project contributed to the implementation of Helsinki's new Bicycle Action Plan, the goal of which is that Helsinki become a cycling city where cycling is possible year-round and for all ages, and the share of cycling of all modes of transport be at least 20 per cent by 2035. The Bicycle Action Plan primarily focuses on ways of improving the different areas of the cycling infrastructure. The most important measure highlighted in the plan is more rapid implementation of the target cycling network.

The Construction Contracting Services of the Urban Environment Division was in charge of the procurement and acted as the client in the project. The participants of the procurement preparations and the market dialogue that preceded them included the head of construction contracting, the development manager, the procurement specialist and the project director from the Construction Contracting Services, and the environmental inspector, environmental planner and project staff from the City's Environmental Services. The contractor selected was VM Suomalainen Oy.

Market dialogue ensured successful tendering

In December 2019, the Urban Environment Division of Helsinki held a market dialogue event aimed at infrastructure contractors interested in submitting tenders for the zero-emission infrastructure worksites of the City of Helsinki. The invitation to the event was published in the Hilma system, in addition to which the contractors received invitations by e-mail. At the event, the Helsinki's carbon neutrality goals for 2035 were presented, and participants received information about what zero-emission worksites are and what role they play in achieving the goals. In addition to this, a draft of the environmental criteria for machinery and the opportunity to use electric machinery at worksites were presented. After the event, City representatives talked to the contractors one-on-one.

The market dialogue event was attended by eight contractors who mostly agreed that the sector is indeed developing towards zero-emission worksites. The topics discussed included the current availability and prices of electric machinery. The market dialogue provided certainty of the previously suggested minimum criteria for low-emission worksites. It also added the finishing touches to the scoring system for electric machinery.

One of the challenges was setting criteria that are sufficiently ambitious for achieving emissions reductions while also keeping them at a realistic level. It was important that competition would not be too restricted and small companies could still participate in the tendering. Since the availability of large electric excavators is still very limited, delivery times are long and prices are several times the prices of machinery using combustion engines, it was determined that demanding such machinery is not feasible. At the same time, we still wanted to encourage the use of electric machinery as far as it was available. It is to be expected that the increasing demand will also increase the supply in the future.

Based on the market dialogue, the criteria for tendering for both the zero-emission worksite pilot and for more extensive use at low-emission infrastructure worksites were finished in spring 2020. The call for tenders for the zero-emission worksite at Kulosaaren puistotie was published in May 2020. The development of the contract documents was carried out in parallel with the preparation of the Green Deal on zero-emission worksites. However, the requirements used for Helsinki's infrastructure projects are more ambitious than the Green Deal currently requires. The Green Deal only defines the minimum level, and cities may use stricter criteria at a more rapid pace, if they so wish.

Criteria used in the procurement of the Kulosaaren puistotie project

The following minimum criteria for zero-emission worksites were used in the procurement:

1. The contractor must have a valid and certified environmental management plan (e.g. RALA Certification or similar) verified by a third party in order to reduce the environmental impact of the operations and improve the energy efficiency of heavy transport equipment, as well as routines for monitoring and reporting on these issues.
2. Worksite machinery must meet the requirements of STAGE IV emission standards, at the minimum. Worksite machinery refers to the following:
 - wheel loaders
 - excavator loaders
 - skid steer loaders
 - wheel excavators
 - crawler excavators
 - telescopic handler
 - tractors
 - smooth rollers
 - road graders
 - multi-function machines
 - cranes
 - forklift trucks.
3. The heavy transport equipment used by the contractor must meet the emissions requirements of EURO VI standard, at the minimum.
4. All machinery must be either electric, or the fuel used by the machinery and the heavy transport equipment of the contractor must be non-fossil. Acceptable (non-fossil) fuels include biogas, hydrogen, ethanol (e.g. ED95) and renewable HVO diesel or fuel oil in accordance with the EN 19540 standard.
5. The electricity used on the site must be produced using renewable energy sources and a certificate of the origin of the electricity must be presented.
6. The heating of the worksite must be implemented with district heating, fossil-free biofuels or electricity from renewable sources.
7. All the small machinery on the site (power ≤ 4 kW) must be electric.

In addition to this, rocks must be loosened either through wedging or using a rock fracturing chemical ('snail dynamite').

The contractor must draft an environmental plan for the site and have it approved by the developer before signing the contract. The environmental plan of the worksite must specify operating methods to prevent negative environmental impacts and guide the measures on the site towards a more environmentally friendly direction.

Environmental plan monitoring reviews must be held during the project to oversee the actual consumption and compliance with the regulations set. In addition to this, the contractor must prepare reports on how the low-emission worksite has affected the implementation and costs of the work and present them at the follow-up inspections.

In addition to the minimum criteria, the number of electric machines was used for comparison:

The contractor with the most economically advantageous tender will be selected. The most economically advantageous tender is the one with the best price-quality ratio out of the tenders that meet the developer's criteria. Price accounts for 70% of the comparison, and quality for 30%.

Quality points for overall economy are awarded for electric machinery. The contractor may enter up to five electric machines in the scoring.

The quality score is calculated in the following way:

- five electric machines, 100 p
- four electric machines, 80 p
- three electric machines, 60 p
- two electric machines, 40 p
- one electric machine, 20 p
- No electric machines, 0 p

As an appendix to their tender, the contractor must upload a report on the electric machinery submitted for scoring. This report must include proof that the machinery submitted fulfils the requirements for electric machinery.

Practices in Kulosaari as a result of the tendering

As a result of the tendering, four fully electric machines were used at the Kulosaari worksite (three 4.2-tonne wheel excavators and one mini-excavator), and the rest of the equipment used renewable HVO diesel, apart from a few exceptions. The machinery proved even cleaner than expected in terms of emissions levels: for example, most of the asphalt pavers not included in the requirements were at STAGE IV level, and one of the drill carriages was at STAGE V level. The pilot project provided both the contractor and the client with lessons on the practical challenges posed by electric machinery: in the future, the limitations of the battery duration and charging times can be better taken into consideration in the project and work stage planning.

The list of machinery and equipment used in the project was updated as new machinery was brought onto the worksite. The fuel and electricity consumed at the worksite was reported monthly at the worksite meetings. One of the goals of the pilot project was testing the collection of new kinds of data to assess emissions impact. In their current form, there is no systematically collected data available on the emissions of construction sites or the fuel volumes used there, for example. In Kulosaari, monitoring and reporting was developed in cooperation between the client and the contractor.

Positive experiences encourage to continue the work

Verifying emissions impact

When most of the machine work of the Kulosaari pilot was completed, the co-implementers of the HENRY project, VTT Technical Research Centre of Finland and the City Of Helsinki, prepared rough calculations of the project's emissions compared to a hypothetical 'conventionally implemented' project based on the data provided by the contractor regarding fuel and electricity consumption and operating hours of the machinery. The emissions calculations were also considered important by the contractor, since when new requirements or

targets are set, assessing their results must be possible in order to verify the impact and profitability of the investments. According to the calculations below, the project's emissions equated to about 42% of the emissions of a conventional project, and the emissions saved amounted to over 106 tonnes of CO_{2e}, which is equal to the annual carbon footprint of around a dozen Finnish people.

Comparison of lifecycle emissions (tCO _{2eq})	Kulosaari pilot for zero-emission worksites	Hypothetical conventionally implemented project	Difference / emissions savings
Machinery and transport vehicles (renewable HVO diesel / fossil diesel)	76,92	182,48	105,56
Electricity (renewable green electricity / average Finnish electricity production)	0,00	1,04	1,04
(production)	0,16	0,00	-0,16
Total emissions	77,08	183,53	106,44

It is worth noticing that the emissions calculations for infrastructure projects involve many uncertainties, and that there is no common calculation method available (cf. the method for the whole life carbon assessment of buildings prepared by the Ministry of the Environment of Finland). To complete the calculations, several choices need to be made, such as the emission factor used for renewable diesel and the exclusions applied: for example, if only direct emissions created inside the worksite fences are applicable, or if lifecycle emissions from the production of the machinery are included, too. Different choices yield different results that are not comparable, which is why it is important to make the basis of the calculations transparent.

As a part of the work on the green deal for zero-emission worksites, a shared tool for emissions calculations will be developed to monitor and verify worksite emissions. By using a shared system, we can produce the necessary data on worksite emissions and compare the results, but also better assess the impact of the actions taken.

Dialogue supports successful procurements

Even though environmental criteria for machinery and transport equipment have been tested in the past, the entity of zero-emission worksites is still new for both procurement clients and contractors. Market dialogue is a key tool for sharing information, since it provides clients with opportunities to share their plans and chart the market, and also for companies to share their information and views.

It was also key to have market dialogue with the contractors to support the preparation of the Kulosaari contract. The market dialogue was used to carefully chart the companies' capability to meet the requirements planned by the client. This allowed contractors to ask questions and provide comments on the plans, which also reduced the risk of any misunderstandings. The Kulosaaren puistotie project was a new kind of a pilot for a zero-emission worksite where both the developer and the contractor wanted to learn things for the future. Based on the data and experiences collected of this pilot, we can further develop the criteria for zero-emission worksites and the reporting procedures of worksites, for example.

The City of Helsinki has also arranged zero-emission worksite-related market dialogue with the contractors of its housing production and participated in *the shared market dialogue of Green Deal operators* held by the Network-based Competence Centre for Sustainable and Innovative Public Procurement (KEINO), in which the goals of the commitment were discussed from the perspectives of both building and infrastructure construction. In addition to this, Helsinki has carried out market surveys where elements such as the level of the machinery and transport equipment of operators in the paving and housing production sectors were studied.

Market dialogue will also continue in the future since both technology and companies' readiness to reduce worksite emissions are constantly developing. To achieve the carbon neutrality goals, various solutions must be

studied, and all future options must be kept open. Even though renewable bio-based fuels are currently one of the easiest ways of reducing direct emissions from machinery, the availability, production sustainability, and calculated emission impact of biofuels involve challenges, and their status may yet change. Many companies are currently investing in the development of electric equipment, but in the future, the use of hydrogen may also offer opportunities at worksites, not forgetting biogas.

Low emissions and circular economy in the City's infrastructure construction

It was decided that all infrastructure worksites of the City of Helsinki subject to tendering will be implemented in a low-emission fashion from summer 2020 onwards. In addition to the zero-emission worksite at Kulosaaren puistotie and *the low-emission worksite of Ilmala tramway* pilots, fossil-free and low-emission worksites have also been implemented in Helsinki in several infrastructure construction projects. The projects have mainly been successful, and it seems the low-emission requirements have not impacted contractors' willingness to submit tenders or the tendering prices. In 2021, Helsinki aims to apply its low-emission worksite policies to all new infrastructure, housing and maintenance projects, in accordance with the Green Deal.

Low-emission infrastructure worksites and the pilot project at Kulosaaren puistotie complement the City's actions to achieve carbon neutrality. The City of Helsinki is doing long-term work to reduce the climate impact of infrastructure construction and promote circular economy. Construction is one of the themes of *Helsinki's Roadmap for Circular and Sharing Economy*, published in 2020, and the progress of the actions is monitored via the *Circular Economy Watch*. In recent years, Helsinki has become a pioneer in recycling land masses, and significant development work is being done in *earthworks and mass coordination*. The purpose of mass coordination is to look for new purposes of use for the excavated soil, aggregates and building materials generated through the City's own construction projects. When these materials are utilised in areas nearby, the amount of waste taken to landfill, the demand for new soil and the emissions caused by transport all decrease. *By utilising materials produced during construction, the City of Helsinki saved about 55 million euros, 8.2 million litres of fuel and 20,200 tonnes of carbon dioxide emissions in total during 2014–2020.*

Minimising lifecycle emissions of construction projects and identifying the climate emissions of procurements

To make sustainable and low-emission choices, information is required both on the lifecycle emissions and climate impact of the project. The City of Helsinki aims to *minimise the lifecycle emissions of the City's construction and infrastructure projects and identify procurements that are significant in terms of climate emissions and circular economy, for which emissions calculations, lifecycle models and climate impact assessment will be developed.*

In Helsinki, carbon footprint calculations have been carried out at the end of projects such as the renovation of Iso Roobertinkatu and the construction of Kivikko multi-level junction. *In the planning of the Arabia section of Hämeentie renovation*, climate-wise reviews steered the work, and resource-wise design choices were made based on emissions calculations. In the reviews, conventional construction practices were compared to resource-wise alternatives connected to the development work done by the City regarding landmass coordination, recycling of paving stones and using recycled substrates. The use of renewable fuels in accordance with the Green Deal on zero-emission worksites was also taken into consideration. In addition to this, new data was produced about the environmental impact of rainwater separation and traffic arrangements during construction, as well as the impact of planning on future maintenance emissions.

Planning, technical solutions and choices of material have a substantial impact on the level of emissions and costs incurred, and the chance to influence the entire project's emissions is at its highest during the planning phase. Based on *the results of the CO₂ calculations and climate-wise review of the Hämeentie renovation*, it

was shown that climate-wise planning can reduce the emissions of a project by almost as much as a third. By following the recommendations of the resource-smart solutions for the Hämeentie street renovations, the City of Helsinki can save an estimated 308,000 kg of CO₂e. This option cuts the emissions by about 27% compared to the total emissions of regular building sites. The cost savings are also significant: 910,000 euros, equalling more than a third of the implementation price. Savings are achieved particularly by recycling materials.