Policy insights and recommendations:

Cleaner Construction Machines in Europe

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Index

List of Acronyms

AFIR, Alternative Fuels Infrastructure Regulation

CO, Carbon Monoxide

CO2, Carbon Dioxide

CO_2e, Carbon Dioxide Equivalent

GHG, Greenhouse Gas

ETS 2, EU Emissions Trading System 2

LCA, Life Cycle Assessment

NOx, Nitrogen Oxides

OEM, Original Equipment Manufacturer

NRMM, Non-Road Mobile Machinery

TCO, Total Cost of Ownership

TEN-T, Trans-European Transport Network

PM, Particulate Matter

ZE, Zero-Emission

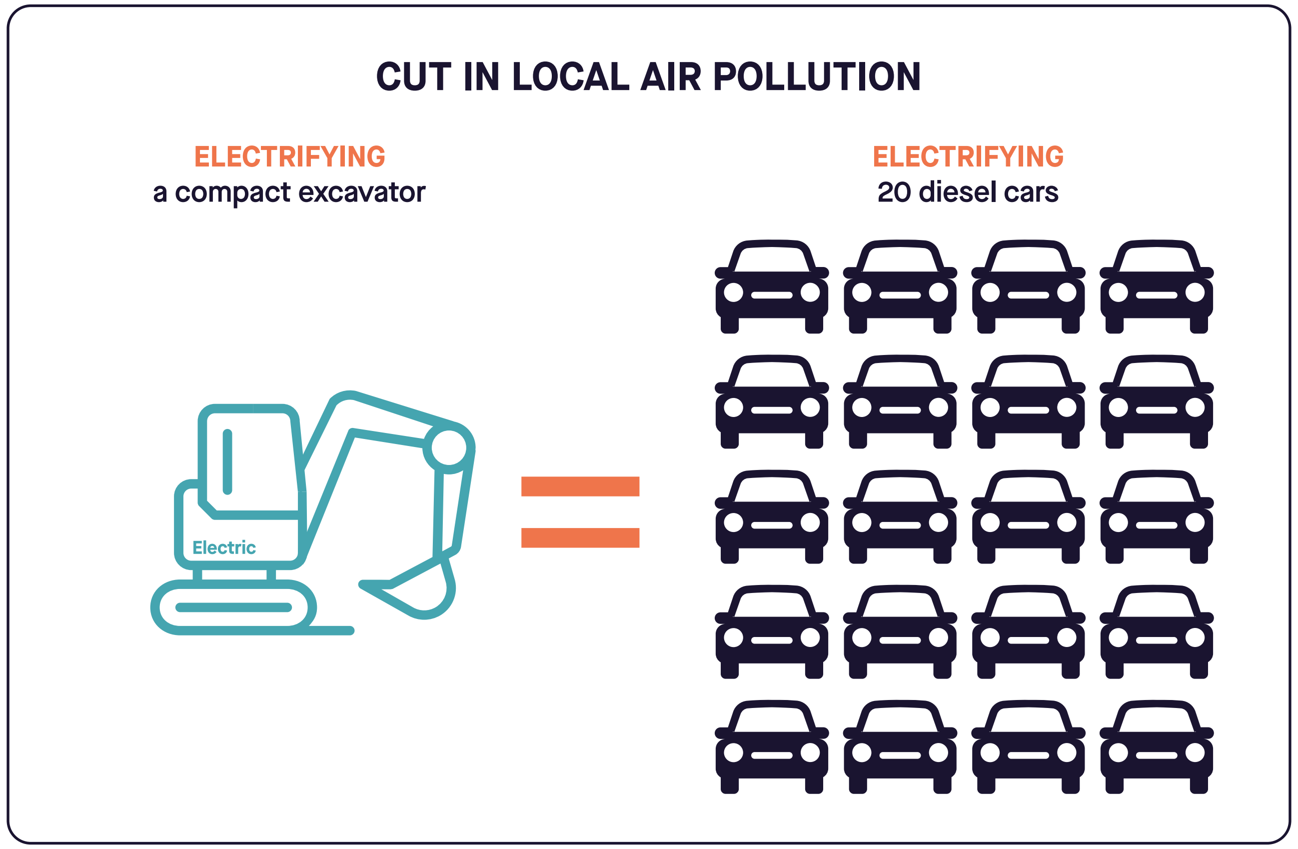
ZECS, Zero-Emission Construction Sites

ZEM, Zero-Emission Machines

1. Introduction

Across Europe, construction activities remain a significant source of greenhouse gas emissions, local air and noise pollution. Although many industries are undergoing rapid decarbonisations, the shift towards zero emission construction machinery is still in its early stages. While some countries, such as Norway and the Netherlands, have made notable progress, zero emission machinery only accounts for a fraction of the overall fleet in Europe. Off-road equipment emits 108 Mt CO_2e per year, accounting for 3.1% of the EU's total climate emissions — equivalent to nearly 55 million cars.[1] Without decisive action, fossil-fuelled machines will continue to dominate the construction sites for many years, delaying European climate ambitions.

The European Union has set a target of becoming net zero by 2050. Assuming an average lifespan of construction machinery is roughly a decade, achieving this goal implies that all new construction machines must be zero emission before 2040.



1 https://www.transportenvironment.org/articles/reducing-emissions-from-non-road-mobile-machinery

Unlike other vehicle categories, the path towards zero emissions remains unclear for construction machinery. While cars, vans, buses and trucks all have defined transition timelines and heavy regulatory instruments to support these timelines, non-road mobile machinery (NRMM) such as construction machines, currently fall into a regulatory gap in EU climate policy.

Benefits of zero emission construction machinery extend beyond lower carbon emissions. Construction activity and machines is a major and underreported source of local air pollution. In 2022 over 280.000 premature deaths have been attributed to exposure to pollution levels of PM2.5 and NO2 above WHO guidelines.[2] In the Netherlands, 253.000 mobile machines produce the same magnitude of emissions as 11,3 million road vehicles (in NOx & PM).[3] Transitioning from diesel-driven to electric construction machines has the potential to drastically reduce air pollution in European cities. Replacing just 5000 compact diesel excavators in London with electric excavators would have a similar impact as removing 100.000 diesel cars.[4]

There is a widespread perception that zero-emission construction machinery represents an untested and immature technology. This is proved wrong by a growing number of zero emission machines, and a rapid growth in the number of projects being completed with only electric power-trains. Norway and the Netherlands are examples of two countries where the transition to zero emission construction machinery has already started and is progressing well. Multiple projects have already been completed entirely emission-free. Evaluations of these projects show that despite some minor transitional issues, emission-free construction sites generally work very well.[5]

Decisive action towards zero-emission machinery also presents a strategic and economic opportunity for Europe. European machine producers have a strong position globally today, with an estimated production value of €76 billion per year, comprising agriculture, forestry, mining, quarrying and construction machines.[6] In the long run, zero emission machine technology is expected to be the preferred option, due to efficiency and low cost.[7] European producers are offering a wide variety of zero emission machines, but in most categories the demand is too low for mass production, and the purchase prices remain high. At the same time, Chinese manufacturers, experienced in electrifying the on-road transport, are gearing up and taking ever increasing market shares in Europe. To prevent European machine producers from facing similar difficulties as the European auto industry, the EU must take immediate leadership and help create a viable market for zero-emission construction machines.

Although non-road mobile machinery also includes agricultural and other equipment, this report will mainly focus on construction machinery, based on technological maturity, share of emissions and tested policy solutions. Agricultural machinery and relevant policies should also be investigated more closely in later reports. This policy paper analyses barriers and explores successful policies implemented to introduce and roll out zero emission construction machinery in both Norway and the Netherlands. Finally, this paper provides concrete policy recommendations for the European Union, national governments and local authorities to accelerate the transition to zero-emission construction machinery. Only through a decisive, coordinated action can Europe ensure that its construction sector contributes to a sustainable, competitive and climate-neutral future.

2 https://www.eea.europa.eu/en/analysis/publications/harm-to-human-health-from-air-pollution-2024
3 https://www.emissieregistratie.nl/
4 https://www.volvoce.com/global/en/news-and-events/news-and-stories/2025/pioneering-a-uk-first-mobile-charging-trial-with-transport-for-london/
5 https://www.nyeveier.no/media/ovrdbyg5/kunnskapsprogram-pilotprosjekter-for-utslippsfrie-anleggsplasser-i-transportsektoren-1.pdf
6 https://cris.vtt.fi/files/99622455/Pathways_for_CO2_regulation_in_NRMM.pdf
7 https://www.energimyndigheten.se/energisystem-och-analys/framtidens-energisystem/langsiktiga-scenarier/

2. Summary

The transition to zero-emission construction equipment offers clear environmental and long-term economic benefits, but remains slow due to high investment costs, limited energy infrastructure, restricted machine availability, and lack of knowledge. These are barriers that are expected to diminish as technology matures, production scales up, and supportive policies drive market growth.

Both Norway and the Netherlands demonstrate that a successful transition to zero-emission construction depends on dedicated long-term policy frameworks, strong public procurement requirements, and predictable financial support. While Norway's success is driven by climate goals, the Netherlands has combined strict nitrogen-emission regulations with a structured national roadmap that mobilizes public and private actors despite severe grid constraints. This shows that transparent targets, coordinated governance, and innovation-friendly incentives are key to accelerating market transformation across different national contexts. Accelerating the transition to zero-emission construction machinery requires coordinated policy action at local, national, and EU levels — combining pilot projects, financial support, public procurement, regulation, and long-term roadmaps to stimulate demand and reduce costs. This is summarized in the Table with policy recommendations below.

POLICY RECOMMENDATIONS

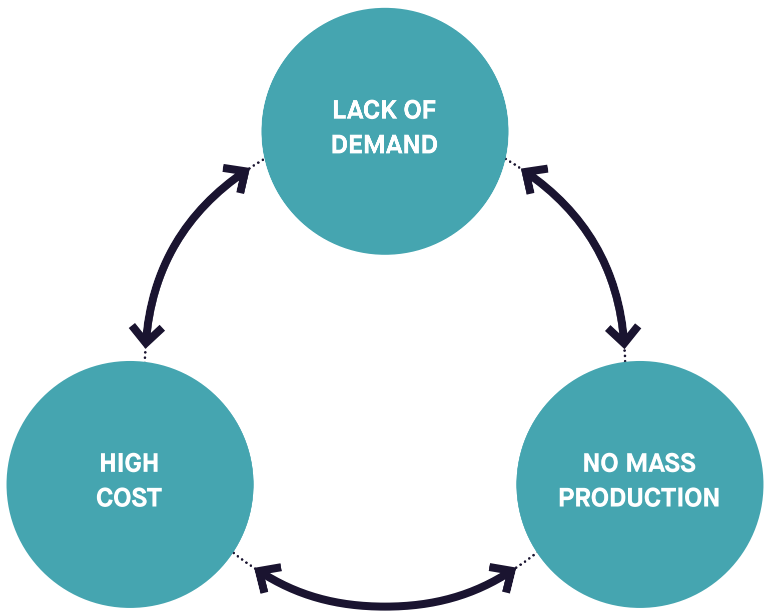
Barriers	Policy tool	EU	National	Local
Lack of market and knowledge	Pilot schemes	1. Set up pilots in EU financed infrastructure projects (DG MOVE) 2. Upcoming Connecting Europe Facility Fund	3. Public Infrastructure Companies with pilots in portfolio 4. Pilot projects when building national/EU charging infrastructure for transport (AFIR)	1. Start with smaller, controlled ZECS pilots 2. Use results to inform guidelines and standardise requirements
Lack of demand	Public procurement	1. Add ZE machinery as new category in revised Clean Vehicles Directive 2027 (10%-100% ZEM 2030-2040) 2. Revised Public Procurement Directive: Mandatory, increased use of ZEM	1. Binding National Road Map 2. National Road Authorities: I. Set a clear target and strategy II. Make a committing internal plan III. Follow up in tenders, demanding increasing % of ZE 3. Demand an increasing % of ZE in all public construction sites	1. Enable early market dialogue 2. Set a clear future procurement target 3. Demand increasing % of ZEM in tenders 4. Coordinate energy planning
Lack of supply, high cost	Regulation	1. Regulate CO2-emissions from NRMM through OEMs. 2. Similar to light duty vehicles regulation: Gradual tightening, until 100% sold ZEM in the EU by 2040. Several models: I. A percentage of all produced machines must be ZE (measured in kWh) II. A percentage of all produced machines must be ZE (measured in tons) III. A percentage of all produced machines must be ZE (measured in number of machines)	1. Provide legal framework for cities to impose local regulation 2. Notify upcoming building regulations with increased share of ZE machinery 3. National ban on fossil fuels on all construction sites from (investigated and announced well in advance)	1. Require gradually increasing % of ZE in all major construction sites 2. Building permits regulation 3. Zero Emission Zone
High investment cost, poor grid	Financial support	1. Define NRMM as a critical industry 2. Support build-up of a ZE European NRMM value chain throuh upcoming European Competitiveness Fund	1. National funding to public procurers, covering a portion of extra cost of ZE in tenders 2. National support to buyers of ZE machinery and charging equipment/energy systems for site	In absense of national financial support, consider local, targeted support schemes (grid, power solutions, machinery etc.)

3. Barriers

Developers and contractors are increasingly recognizing the environmental and eventual economic benefits of adopting zero-emission construction equipment. Despite this, the transition away from fossil-fuelled equipment remains slow. Several challenges, such as high costs of investment, lack of energy infrastructure and limitations in machine selection must be resolved. There is also a widespread perception of zero-emission construction equipment as a far less mature technology than it actually is, which further contributes to hesitation and delay in adoption. These barriers are in large symptoms of an early-stage market, with costs expected to fall and technology to mature as production volumes increase.

ADDITIONAL COSTS

A major barrier to the transition from conventional to zero-emission construction sites is the additional costs that zero-emission machinery present. The transition from fossil-fuelled to zero-emission construction equipment requires a significant amount of investment, both in machinery and energy systems on site.



The relationship between production costs and market demand resembles a classic 'chicken and egg' dilemma: high market demand is needed to trigger serial production, which in turn enables economies of scale and lowers production costs. On the other hand, market demand is highly dependent on price, and prices must likely decrease for market demand to increase[8].

8 https://prod.ucwe.capgemini.com/no-no/wp-content/uploads/sites/23/2023/10/How-to-succeed-with-zero-emission-construction-sites-Learnings-from-Norway-version-2.0.pdf

The investment costs associated with zero-emission machines are greater than conventional, fossil-fuelled machines. Depending on the type and size of the machine, the additional cost of investment in a zero-emission machine ranges between 0%-220%.[9] Electric light wheel loaders have the lowest additional cost of investment at 0-20%, and electric medium and heavy excavators have the highest additional cost of investment at 100-200%. In general, smaller machines have less additional costs of investment associated with zero-emission than larger ones.

The higher investment costs of zero-emission equipment originate from three main sources:

1. **Firstly, batteries produced for zero-emission construction machines are significantly more expensive than other batteries.** A survey of the Norwegian market shows that batteries for zero-emission construction cost around 400-500€/kWh.[10] This is significantly more than batteries intended for other purposes, with the prices of lithium-ion batteries now falling to approximately 100€/kWh.[11] Stricter safety requirements for batteries used in heavy construction environments contributes to the higher costs, as these batteries must withstand rough handling, vibration and more extreme operating conditions. The biggest price-drives is however that batteries built for other purposes (mainly electric cars) are produced in far larger volumes, allowing producers to cut costs.

2. **Secondly, zero-emission construction equipment is subject to larger investment costs, due to the absence of serial production.** The market for zero-emission machines is only large enough to sustain mass production of a few selected excavators, wheelloaders and other emission-free machines. Currently, many emission-free machines are produced without a driveline entirely, and have an electric engine installed at the location of demand. This production method leads to increased costs compared to mass production. However, the amount of mass-produced zero-emission machines is gradually increasing, and prices are expected to fall as market matures and production lines increase[12].

3. **Thirdly, the transition to zero-emission construction equipment often requires significant upgrades to energy infrastructure, which further contributes to the overall costs.** Unlike diesel machinery, electric construction machines depend on high capacity charging facilities and robust grid connections or battery storage availability, especially on large or remote worksites. Establishing sufficient power supply, installing transformers, and setting up fast chargers can involve substantial capital expenditure. Moreover, in areas where the local grid capacity is limited, contractors may need to invest in temporary energy solutions such as battery containers or mobile substations, further increasing the total cost of adopting zero-emission machinery. These infrastructure-related expenses are an important part of the overall investment calculation for contractors considering the transition.

Despite the additional costs of investment, zero-emission machines also offer significantly reduced operating costs when compared to fossil-fuelled construction machines. This is mainly due to higher energy efficiency and lower energy-costs[13], the

9 https://vista-analyse.no/no/publikasjoner/utslippsfri-bygge-og-anleggsvirksomhet/
10 https://vista-analyse.no/no/publikasjoner/utslippsfri-bygge-og-anleggsvirksomhet/
11 https://about.bnef.com/blog/lithium-ion-battery-pack-prices-see-largest-drop-since-2017-falling-to-115-per-kilowatt-hour-bloombergnef/
12 https://www.enova.no/nb/bedrift/bygg-og-eiendom/tema-utslippsfrie-anleggsplasser
13 https://prod.ucwe.capgemini.com/no-no/wp-content/uploads/sites/23/2023/10/How-to-succeed-with-zero-emission-construction-sites-Learnings-from-Norway-version-2.0.pdf

latter depending on country and affordability of electricity. Calculations from Sweden, comparing a road project built with diesel-powered machines to the same road project built using electric machines, finds that the operating costs of using electric machines were 55% lower than for diesel-powered machines.[14]

Due to high investments, and low operating costs, zero emission construction machines are more competitive when considering total costs of operation. Depending on electricity prices, several types of machines are already competitive (like smaller excavators), and zero-emission machines are expected to become increasingly competitive as the market grows and prices fall. Better planning of energy use and charging times can also significantly reduce the need for grid capacity and lower investment costs.

Despite a positive outlook on the competitiveness of zero-emission construction machines, a substantial, up-front investment cost is still considered the main barrier to achieve a transition from fossil-fuelled to zero-emission equipment. Many contractors either lack capital or are unwilling to take financial risks by investing in zero-emission solutions without lower investment costs or government support. Lack of predictability and consistence between tenders, are also lowering the willingness to take risks and invest.

Looking ahead, the prospects are promising. Manufacturers and contractors predict a growing market. As demand increases and production scales up, unit costs are expected to fall. Volvo has previously predicted the prices of zero-emission construction machines to level out against diesel machines before 2030.[15] In order to secure market growth and kick-start the transition from fossil-fueled to zero-emission machines, policy, defined goals, predictability and financial support schemes are essential.

ENERGY AND INFRASTRUCTURE AVAILABILITY

Another significant barrier to the transition from fossil-fuelled to zero-emission machines is access to renewable energy. Zero-emission construction sites require reliable and high-capacity electricity to charge and supply heavy construction machinery. In most cases, this requires more planning and investment in power and grid access, as well as more focus and knowledge in planning and overseeing charging times, battery use and energy management systems.

A transition from fossil-fuelled to zero-emission machinery will result in a significant increase in electricity consumption on construction sites. Although access to sufficient power may be a challenge, experience so far suggests that it is grid access which is the biggest barrier for developers.[16]

Zero-emission construction sites result in significant power peaks, especially if all machines are to be charged during a lunch break or at the end of the day. The required power demand may exceed the grid capacity in the area and require grid investments and also developing charging infrastructure before construction work can begin. An additional challenge is presented by construction sites in areas where there is no permanent demand for grid access. Such infrastructure and energy needs increase complexity and costs of zero-emission construction sites.

More flexible solutions such as mobile charging, battery containers and load balancing systems offer effective responses to many of the challenges associated with zero-emission equipment. Although these technologies are still under development, they provide practical means of reducing power peaks and enhancing on-site flexibility. Careful planning to reduce power peaks is essential. For instance, dividing lunch breaks into two groups can halve the peak energy demand. In markets where l zero-emission construction sites have been successfully implemented, energy service providers have emerged as key players. In mature markets, these providers offer flexible solutions to bring down power peaks and improve efficiency through energy plans and digitalisation. However, this requires cooperation and knowledge sharing between actors involved in zero-emission construction sites.

TECHNOLOGICAL CHALLENGES

The technology behind zero-emission construction sites has made remarkable progress in recent years. Technical solutions for many types of machinery are not only available, but have proven highly capable in real-life projects, demonstrating good performance, reliability and durability even under demanding conditions. Despite this, there are still some machine types that do not have fully satisfactory electrical alternatives.

There are still some limitations in the range of zero-emission machinery available. While most machine types have zero-emission alternatives, and smaller machines are increasingly being mass-produced, certain larger machines remain difficult to acquire. This is especially the case for heavy, specialized and energy-intensive machines, such as those associated with asphalt laying, drilling and tunneling[17]. Whilst development for hydrogen fuelled alternatives are entering the market, this currently limits contractors' ability to offer entirely emission-free projects across all construction phases.

As was the case in the initial phases of EV charging, some projects report recurring communication issues between construction machines and the chargers. This could be addressed through enhanced standardisation and cooperation between the manufacturers of charging equipment and machine producers.

LACK OF KNOWLEDGE AND EXPERIENCE

Another significant barrier in the transition towards zero-emission construction sites is the lack of knowledge and experience on how to plan and implement an electrically powered construction site. This includes limited understanding of available technologies and the performance of electric machinery. These knowledge gaps can result in project delays, which are costly.

Zero-emission construction machinery requires new ways of organizing and executing construction work. The most obvious difference is that contractors must account for charging times, battery capacity, and potential power peaks which can interrupt operations. Operators who are accustomed to diesel-machinery may view charging times as a constraint, until they gain knowledge on how to manage battery use efficiently to avoid downtime. There is also limited experience available in the market to help contractors in navigating challenges such as choosing appropriate charging infrastructure or managing energy logistics.

Even as the technology for zero-emission construction becomes increasingly robust and competitive, human factors such as knowledge, experience and willingness to adopt new ways of working remain a crucial barrier. Without focused efforts on training, experience-sharing and industry-wide guidance, many contractors and operators will view the transition to zero emission as too uncertain or complex to pursue.

IN SUMMARY

In summary, the transition to zero-emission construction machinery still has several obstacles to overcome in order to fully replace fossil-fuelled machinery in the construction industry. With greater demand, production volumes will increase, technology will mature, and costs of the machines and supporting infrastructure will become more available and affordable. With the right policy support, financial support schemes, support for pilots, public procurement requirements and industry collaboration, policymakers can increase demand to the point where it will be profitable for the rest of the market to undergo the same transition.

14 https://www.me.se/globalassets/medlemskap-media/om-oss/mes-elektrifieringsrapport-2023-10-31.pdf
15 https://www.volvoce.com/global/en/news-and-events/news-and-stories/2021/infographic-electromobility-milestones/
16 https://vista-analyse.no/no/publikasjoner/utslippsfri-bygge-og-anleggsvirksomhet/
17 https://www.enova.no/nb/bedrift/bygg-og-eiendom/tema-utslippsfrie-anleggsplasser

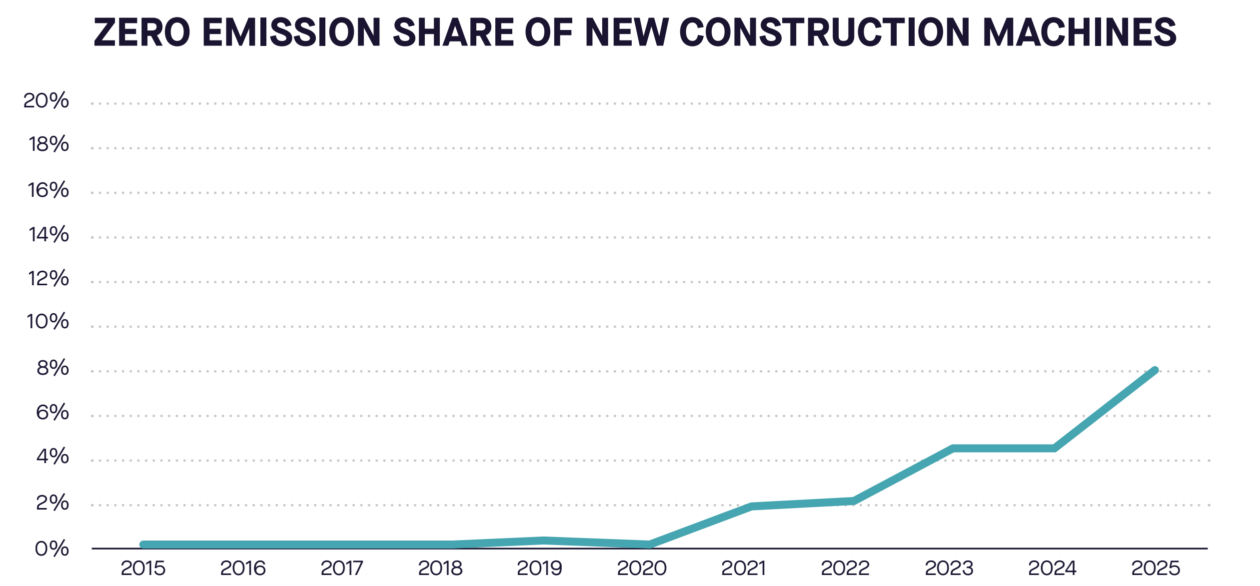
4. Successful policy in Norway

STATUS IN NORWAY

Norway has established itself as a global leader in the transition to zero-emission construction sites. Cutting direct emissions of CO2 has been the main driver. A combination of local and national goals and regulation, along with financial support schemes, has made Norway one of the first countries in the world where emission-free machines are rapidly gaining ground. In the first quarter of 2025, 8% of all new construction machines, and 13,8% of new excavators were zero-emission machines.[18] The Norwegian Environmental Agency has estimated that it is feasible for all construction machinery in Norway to be zero-emission by the first half of 2040.[19]

PUBLIC PROCUREMENT

Public procurement requirements have been one of the most influential instruments used in support of the transition from fossil-fuelled to zero-emission construction machinery. Public procurement has been used strategically to cut emissions and transition the industry from fossil to renewable alternatives. Over the years, more requirements have been gradually and predictably introduced for public procurement, and they have gradually become stricter. In Norway, such public procurement policies have originated both from local and national authorities.



Source: The Norwegian Machinery Wholesalers Association

18 https://mgf.no/q1-25-statistikk-anleggsmaskin/
19 https://www.miljodirektoratet.no/publikasjoner/2025/januar-2025/klimatiltak-i-norge-kunnskapsgrunnlag-2025/

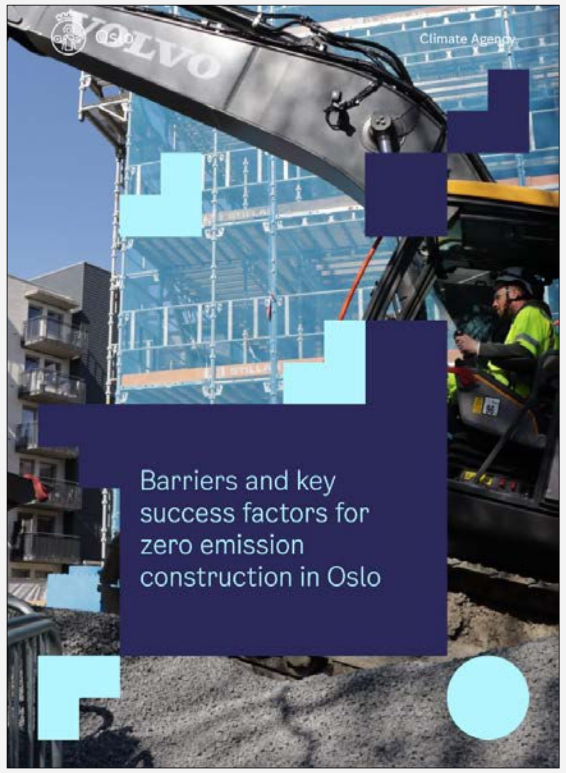
Local Level
Many of the contractors who have acquired zero-emission machines, have done so because of the public procurement requirements introduced by major Norwegian cites. In 2021, seven of the largest Norwegian cites signed a joint declaration with ambitious targets on zero-emission construction. Together, Norway's seven major cities committed to achieving zero-emission construction activities in all projects acquired by the municipality by 2025 and a complete transition, including private sector construction, by 2030.[20]

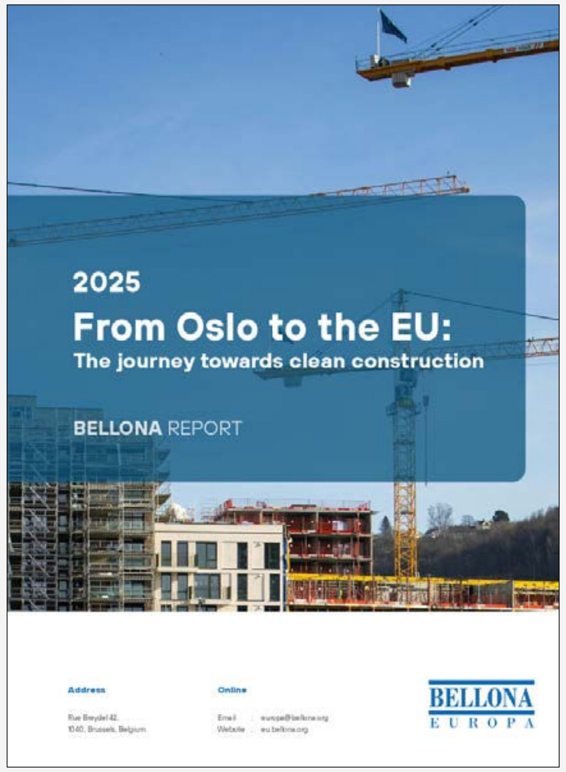
Oslo, one of the signatories of the joint declaration, stands out. Oslo's ambitious policies on reducing emissions from construction sites began in 2017, when the city mandated all municipal construction sites to be fossil free. Ever since, the city has had different mechanisms to award contractors who prioritised zero-emission technologies. In 2019 and 2020, Oslo committed itself through its new climate strategy to require zero-emission construction on municipal sites in 2025, and all citywide construction sites in 2030.[21]

Lack of knowledge, both about the energy system on site, the technology and the site management, was a barrier initially. As a result, Oslo started up with single machines, followed by a pilot on a fully electric site, to solve the energy related barriers and gain knowledge for further procurement. The pilot was carried out in Olav V St. in 2019, using primarily electric construction machinery, demonstrating the feasibility of zero-emission construction and paving the way for future projects. Wide market dialogue with the sector, the whole value chain, the energy sector and the procurer has been crucial to the transition to zero-emission construction machinery.

This approach has been incredibly successful. In 2024, 85% of the work conducted at municipal construction sites was with a clean, zero-

The City of Oslo offers guidelines to inform contractors, a useful, practical example to other European cities.





Source: https://www.klimaoslo.no/rapport/barriers-success-factors-for-zero-emission-construction-in-oslo/ and https://eu.bellona.org/publication/from-oslo-to-the-eu-the-journey-towards-clean-construction/

20 https://www.capgemini.com/no-no/insights/research-library/how-to-succeed-with-zero-emission-construction-sites-emlearnings-from-norwayem/

21 https://www.klimaoslo.no/rapport/barriers-success-factors-for-zero-emission-construction-in-oslo/

SIX KEY LESSONS

Six key lessons from Oslo
for succeeding with public procurement
as a strategic tool:

1. Long-term vision and political leadership were essential to steer the market towards zero emission technologies.

2. Strategic use of public procurement — embedding environmental criteria into tenders, not just lowest price — created strong demand signals.

3. Early and continuous market dialogue with contractors, suppliers, and grid operators helped overcome technological and logistical barriers.

4. Energy systems planning and collaboration with grid operators were critical to ensure adequate power supply for ZECS operations.

5. Pilot projects such as Olav Vs St. allowed the city to de-risk innovation, build contractor confidence, and refine technical specifications.

6. Data-driven approaches using life cycle assessments and emissions reporting helped measure progress and improve future project designs.

Source: Bellona Europa (2025). From Oslo to the EU: The journey towards clean construction. https://eu.bellona.org/publication/from-oslo-to-the-eu-the-journey-towards-clean-construction/

A POOL OF EMISSION-FREE MACHINERY

The county of Østfold has provided a pool of emission-free machinery that municipalities or other projects can borrow to test zero-emission machines. This has helped reduce knowledge barriers and lowered the risk of trying out new technology. The project has increased use of zero emission machines on municipality level.

The Norwegian Roads Administrations Action plan for cutting 55% of direct emissions from road construction by 2030. Revised in 2025.[25]

emission energy source. From 2025, all municipal construction sites are using zero-emission energy sources. Oslo has also reached and taken a leading role through European and international networks such as Eurocities Big Buyers Working Together[22] and C40[23] to share their experience and accelerate the development towards zero-emission construction sites.[24]

Strategic use of public procurement, by clearly communicating future requirements well in advance and gradually increasing them, has yielded significant benefits. It has made the city's requirements more predictable and manageable for machine suppliers, contractors and other market actors, and ensured they have had sufficient time to plan for the transition.

Norway's other large cities, including Bergen and Trondheim, are shaping their policy to transition to clean construction sites in similar ways as Oslo. In both cities there will be a minimum requirement of zero-emission for all contractors. Through the joint declaration and coordinated policies, zero-emission construction is increasingly becoming the norm for contractors wishing to compete for public tenders, with zero-emission construction projects being completed as far north as Bodø, a city well north of the Arctic Circle.

National level

In addition to local public procurement policies, national policy has consistently supported the transition. One of the most impactful measures has been the introduction of mandatory weighting of climate and environmental criteria in public tenders.

As of January 2024, 30% of evaluation criteria in public tenders must be based on climate and environmental assessments. Thus, public buyers not only will choose who wins a given tender based on price or quality, but also based on who can deliver the most climate-efficient project. It is also allowed to set absolute demands (such as using electric machinery), if documented that the effect will be better for the climate. This gives contracting authorities a strong legal and procedural basis to require reduced emissions, including the use of electric construction machinery. It also enables contractors to compete based on emission reductions, rather than solely on price.

Weighting climate criteria in public procurements not only introduced climate solutions, but also gives providers greater flexibility in how they choose to make their projects more climate-friendly. It allows

22 https://public-buyers-community.ec.europa.eu/communities/zero-emission-construction-sites
23 https://www.c40.org/news/future-of-clean-construction-oslo/
24 https://www.c40.org/news/future-of-clean-construction-oslo/

25 https://www.vegvesen.no/om-oss/presse/aktuelt/2025/04/utslippsfri-massetransport-blir-hovedregel-i-alle-utbyggingsprosjekter/

bidders to propose a wide range of environmental measures, not necessarily including zero-emission machinery. It may mean that some tenders prioritise other environmental actions over zero-emission construction equipment. This makes the outcome somewhat dependent on how the procurement is framed. Therefore, other additional measures has been important to ensure the reliably demand for zero-emission machines.

The Public Roads Administration has been a frontrunner in the adoption of clean construction machinery. The administration has set a target of reducing direct GHG emissions from its own construction activities by 55% between 2020 and 2030. To achieve this, it has made an action plan where zero-emission construction machinery will be the standard requirement in all new contracts from 2027. Until 2027, the requirements are gradually tightened for different segments of machinery, already resulting in a rise in tenders where use of zero-emission construction machines is mandatory.[26] This provides greater predictability for the industry.

To improve performance against minimum criteria in tenders, a bonus has been applied where a certain prize has been given for each tonne CO_2 reduced beyond the minimum. This price has then been deducted from the total tender, allowing more expensive bids to remain competitive if they offer lower emissions A similar bonus system is to be applied in Sweden and Denmark. This approach makes it possible to invest in zero emission equipment while still remaining price competitive.

A crucial aspect of the Public Roads Administration's procurement policy is addressing the availability of sufficient electrical power at construction sites, which is essential for the operating of electric construction machinery. Power assessments are now integrated into project planning from early stages, ensuring that zero-emission construction sites are used where available. A pilot site has also been operating fully electric through a cold winter to test the energy system and performance.

FINANCIAL SUPPORT SCHEMES

As mentioned in Chapter 3, the transition to zero-emission construction machinery still faces economic and market barriers. The procurement cost of zero-emission machines remains at a significantly higher level than for conventional machines. Despite notably lower operating costs, and an expected cost reduction, targeted financial support schemes have been necessary to sufficiently stimulate the transition in Norway.

Since 2017, Norwegian authorities launched and managed several financial support schemes aimed at the transition within the construction sector. The support programs have been designed to stimulate market maturity, boost demand and reduce investment risk, thereby encouraging market actors to adopt new zero-emission construction solutions. The support has primarily taken the form of investment grants, which cover a portion of the additional cost incurred when acquiring zero-emission machines. A program has also been designed for supporting energy infrastructure on site, especially systems for energy storage and charging. The financial support within these programmes has amounted to 140 million EUR (as of 2024).

The current support scheme offers an investment support of up to 40% (capped at 5 million NOK) of the additional cost of purchasing emission-free, when compared to conventional machines. The grant is available to all private and public enterprises, including municipalities, government agencies, contractors, leasing and rental companies.

In the Norwegian approach, the support schemes are designed to be technology-neutral, allowing for battery-electric, cable-electric and hydrogen-powered solutions. Although the support scheme thus far predominantly has been deployed towards battery-electric machines, this approach allows the market to decide which technology is preferable.

A report from Vista Analyse (2024), commissioned to evaluate Enova's support programs, concludes

26 https://vegvesen.brage.unit.no/vegvesen-xmlui/handle/11250/3115828

that the support schemes have been cost-effective, well-targeted and well designed for their intended purpose.[27] Yet according to business organisations, rapid changes and uncertainty of continuation of support programs have at times given an unnecessary lack of predictability, resulting in uncertainty, possibly slowing down the sales of ZEM in 2023-2024.[28] An important lesson is that predictable support schemes, as with other policy tools, is necessary to lower the risk of investing in new technology.

In addition to the investment support program, national authorities have also supported the transition by providing financial support to local authorities wanting to test zero-emission construction machinery, through the program called "Klimasats".

While this program is not exclusively targeting construction, it has become an important enabler of local innovation by funding early-phase projects, feasibility studies and pilots aimed at furthering the technology and knowledge of zero emission construction sites.

Many local authorities, such as Oslo, Bergen, Trondheim and Østfold have used this program to finance local projects using zero-emission construction equipment. The program has financed 131 projects, at a cost of approximately 20 million EUR[29]. It has been used by many local authorities to realise tests and get first-hand experience in how to plan for and implement emission-free construction.

Government pilots

Since 2022, Norwegian authorities have annually selected a set of projects in which they finance and test various new emission-free solutions. It has played a pivotal role in supporting innovation, market learning and competence gathering. Through this program, the Norwegian government has spent 218 million NOK on 39 different projects ranging from conversions of diesel-powered vehicles to testing electric machines in arctic climates.

27 https://vista-analyse.no/no/publikasjoner/utslippsfri-bygge-og-anleggsvirksomhet/
28 https://www.tungt.no/article/view/1041829/bransjens_dom_er_at_enova_forsinker_nullutslipp_i_bygg_og_anlegg
29 https://www.miljodirektoratet.no/ansvarsomrader/klima/for-myndigheter/kutte-utslipp-av-klimagasser/klimasats/klimasatsprosjekter/?so=desc&sc=updated&type=63893#&canceled=true

Through these pilots, government agencies responsible for the development and maintenance of the Norwegian road and rail networks, implemented a series of pilot projects aimed at developing and testing solutions for zero-emission construction sites in the transport sector.

The purpose of these pilots has been to accelerate the use of new technologies and build operational experience for all actors involved. An evaluation of the pilot-scheme concludes that it has been highly effective in driving knowledge development and market expertise in construction site energy planning, charging logistics, and machine selection.[30]

LOOKING FORWARD

Looking forward, Norway is already considering the next steps in the development of emission-free construction. The ministry of Climate and Environment has opened up for regulating emissions from all construction sites at the municipal level through the Pollution Act. Based on this, Oslo proposes a new local regulation requiring large construction and infrastructure projects to use zero-emission or biogas-powered machinery. The plan introduces a phased approach: from January 1st 2027, at least 30% of a site's total energy use must be zero-emission or biogas-based, increasing to 90% by 2030. The regulation would apply only to major projects (not small buildings under 200 m^2) and allow exceptions where compliance is disproportionately costly or technically unfeasible. This is important for Oslo in order to reduce emissions from both private and state construction sites.[31]

The Norwegian Environment Agency and Norwegian Agency for Public and Financial Management (DFØ) have drafted a legal proposal where all public procurers will be obliged to demand that a minimum amount of the work (measured in energy) within a construction site has to be done with zero-emission technology. The proposal is to demand 5-10% renewable energy use in all public construction sites[32], and 20-40% in 2030. The proposal is currently on hold at political level (Q4 2025).

Norway's progress in developing a market for zero-emission construction is the result of deliberate action across multiple levels of government. The use of public procurement, especially by cities such as Oslo, Bergen and Trondheim, as an instrument to incentivise transition, has been essential in shaping market demand. Combined with national public procurement regulations, predictable financial support schemes and state-run pilots, this has further driven the transition.

30 https://www.nyeveier.no/media/ovrdbyg5/kunnskapsprogram-pilotprosjekter-for-utslippsfrie-anleggsplasser-i-transportsektoren-1.pdf
31 https://aktuelt.oslo.kommune.no/byradet-vil-stille-krav-til-utslippsfrie-byggeplasser
32 https://www.miljodirektoratet.no/publikasjoner/2025/mai-2025/klimakrav-til-bygge--og-anleggsplasser-i-offentlige-anskaffelser-utredning-del-2/

Case

Zero-emission construction machines in large-scale rehabilitation projects

The Municipality of Oslo has long had strict public procurement requirements, mandating that all public construction projects must be 100% emission-free from 2025. This policy has been a huge success, with 75% of all machines being used in municipal construction projects being zero emission as early as 2023.

The rehabilitation of Sophies Minde is currently one of the largest fully electric building sites in the world, with more than 20.000 square metres and multiple years of construction. The project is driven exclusively on electrically powered construction machines, including cranes, drills, wheel loaders and excavators. These measures are estimated to reduce the emissions of the building project by 93%[33].

To power these machines, the building site has two permanent and a temporary power station installed, ready to fast-charge machines as needed. Additionally, the use of zero-emission construction equipment has drastically reduced the noise-pollution usually associated with building projects in dense, urban neighbourhoods.

This project proves that the use of zero-emission construction machinery is not only feasible, but provides significant emission reductions as well as better conditions for employees, neighbours, and local businesses.

33 https://www.klimaoslo.no/lyden-av-lave-klimagassutslipp/

5. Successful policy in the Netherlands

STATUS IN THE NETHERLANDS
The Netherlands is a country at the forefront of the transition from fossil-fuelled to zero-emission machinery. Through the **Routekaart Schoon en Emissieloos Bouwen (SEB)**, the Dutch government provides a detailed and structured pathway for the construction sector to transition away from fossil fuels. The clarity and long-term nature of this policy make it easier for stakeholders in the construction market to adapt. The nature permits, restricting nitrogen emission and requiring zero-emission construction machines in and around nature sites, has been a driving force.

Comparing to Norway, the Dutch projects are generally bigger and involves heavier machinery. Another significant difference between the two countries, is that the Norwegian energy system is more robust and flexible, with a grid coping better with electrification. The Dutch electricity grid is stretched to the limit, facing severe congestion and capacity constraints, as rapid growth in renewable energy generation and electrification of industry and transport outpaces infrastructure upgrades. Dutch entrepreneurs have responded creatively to this challenge, developing a range of solutions — from direct charging with renewable energy that bypasses the grid, to mobile wind turbines.

A distinguishing feature of the Dutch approach is that the motive for transitioning to zero-emission construction equipment is related to a significant nitrogen problem, mainly caused by intensive farming and human activity. Reducing nitrogen emissions from the construction sector has been central to the shift from fossil powertrains to more sustainable solutions. The Clean Air Agreement, targeting the local air pollution, has also been a motivation.

Nature permits
In 2019, the supreme court in the Netherlands stated that construction machinery should not be allowed to emit nitrogen in vicinity of nature conservation areas (Natura 2000 areas). The restrictions on nitrogen emissions requires special permits for building in these areas, as the fossil fuel construction machinery is emitting substantial amounts of nitrogen[34]. Since then, several large projects have conducted with zero-emission machinery.

EMISSION REQUIREMENTS
Increasingly ambitious emission requirements constitute the main framework of the Dutch mission to transition the construction sector. In 2023, the government initiated an agreement with several stakeholders, including state authorities, provinces, municipalities, state infrastructure companies and several industry organizations.[35] The agreement, though not legally binding, commits all parties to a long-term, binding plan for stricter emission regulation on construction sites. In addition to introducing a minimum level of emission requirements, all signatories committed to exceeding these minimums requirements, either by

34 https://www.government.nl/topics/nature-and-biodiversity/natura-2000
35 https://www.opwegnaarseb.nl/wat-is-seb/convenant-seb

committing to a basis or ambitious level. The clean and zero-emission building roadmap (SEB) is a voluntary agreement of signatories, and thus not yet legally binding for all projects, but includes projects commissioned by the signatories.

Utrecht, as the first city, has bound the requirements in SEB to its building permits. Anyone wishing to qualify for construction in Utrecht must adhere to the roadmap.

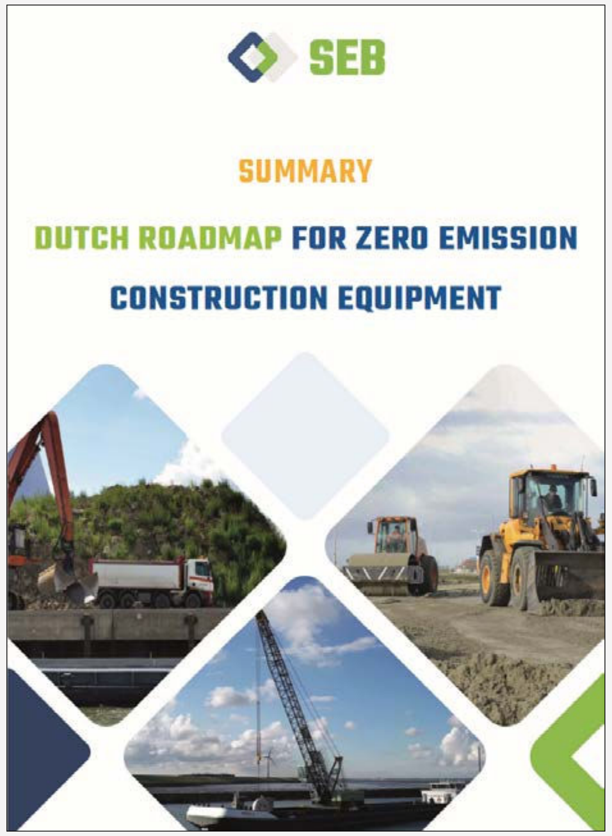
Together with the agreement, the government also composed a road map detailing the exact emissions requirements for the different sizes of machines, and the different ambition[36] levels in the coming years.[37]

The voluntary agreement allows signatories to pledge their commitment to one of three levels of ambition; minimum, basis, or the ambitious level.

Minimum requirements

The road map establishes minimum emission requirements for mobile machinery to drive the transition towards emission-free building practices across the Netherlands. These minimum requirements form the foundation of the national strategy and are intended to create a level playing field across the country.

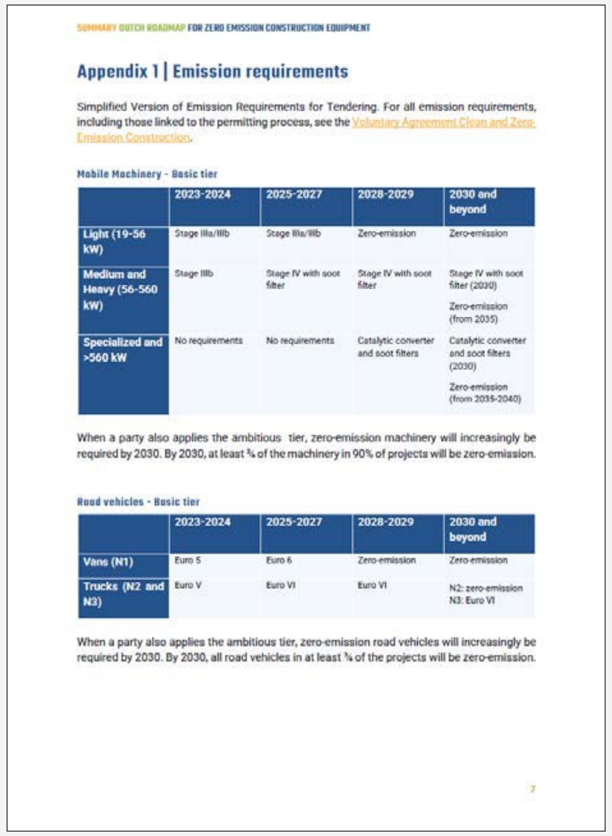
These requirements are gradually phased in, firstly raising the emission standards, and secondly introducing dates within which 100% of the machine fleet must be zero-emission. The lightest machine



SEB

SUMMARY

DUTCH ROADMAP FOR ZERO EMISSION CONSTRUCTION EQUIPMENT



SUMMARY DUTCH ROADMAP FOR ZERO EMISSION CONSTRUCTION EQUIPMENT

Appendix 1 | Emission requirements

Simplified Version of Emission Requirements for Tendering. For all emission requirements, including those linked to the permitting process, see the Voluntary Agreement Clean and Zero-Emission Construction.

Mobile Machinery - Basic tier

	2023-2024	2025-2027	2028-2029	2030 and beyond
Light (19-56 kW)	Stage IIIa/IIIb	Stage IIIa/IIIb	Zero-emission	Zero-emission
Medium and Heavy (56-560 kW)	Stage IIIb	Stage IV with soot filter	Stage IV with soot filter	Stage IV with soot filter (2030) Zero-emission (from 2035)
Specialized and >560 kW	No requirements	No requirements	Catalytic converter and soot filters	Catalytic converter and soot filters (2030) Zero-emission (from 2035-2040)

When a party also applies the ambitious tier, zero-emission machinery will increasingly be required by 2030. By 2030, at least ¾ of the machinery in 90% of projects will be zero-emission.

Road vehicles - Basic tier

	2023-2024	2025-2027	2028-2029	2030 and beyond
Vans (N1)	Euro 5	Euro 6	Zero-emission	Zero-emission
Trucks (N2 and N3)	Euro V	Euro VI	Euro VI	N2: zero-emission N3: Euro VI

When a party also applies the ambitious tier, zero-emission road vehicles will increasingly be required by 2030. By 2030, all road vehicles in at least ¾ of the projects will be zero-emission.

7

Source: https://www.opwegnaarseb.nl/documenten/2024/11/04/routekaart-seb-engels[38]

36 https://cdn.opwegnaarseb.nl/media/Routekaart%20SEB%20-%20definitief.pdf
37 https://www.opwegnaarseb.nl/wat-is-seb/convenant-seb
38 https://www.opwegnaarseb.nl/documenten/2024/11/04/routekaart-seb-engels

categories must be fully emission-free by 2028, followed by all machine categories. The requirement for the complete emission-free operation for the heaviest machines will be introduced in 2035.

Basis requirements

At the basis level, the road map establishes a framework for voluntarily exceeding the minimum requirements. All stakeholders who have committed to the basis level, mostly state and local actors, commit to actively incorporating zero-emission machinery standards into their procurement and project execution.

Ambitious level

The ambitious level applies to all public and private buyers who have committed to this level through the agreement. Organisations committed to this level seek to lead the market transformation and drive innovation in zero-emission construction.

Participants at the ambitious level commit to systematically plan and carry out frontrunner projects, on top of the basis requirements. This approach stimulate early demand and accelerate the learning curve for the entire sector.

All participants at the ambitious level have a given portion of their project portfolio dedicated to frontrunner projects. Over time, stricter requirements will be imposed on how big a portion, and the criteria for what qualifies as a frontrunner project.

Participants of the ambitious level include some of the largest purchasers in the Netherlands, such as the Directorate-General for Public Works and Water Management (Rijkswaterstaat), the rail infrastructure company, Rotterdam port, Schiphol airport and some of the largest municipalities in the country (such as Amsterdam, Rotterdam and The Hague).

AMBITIOUS LEVEL	2023	2025	2028	2030
Frontrunner projects (% of total project portfolio)	5-25%	25-50%	50-80%	75-95%
ZE performed work (% of total performed work)	10-30%	30-70%	70-90%	90-100%

The current commitments to the ambitious level are expected to result in a large number of projects building with an increasing proportion of zero-emission machines. As with the Norwegian front runners, the Dutch have concluded that a greater effort is needed in Europe to accelerate the use of zero-emission machinery, reaching out to other governments, cities, and the EU level. Among other initiatives, Rijkswaterstaat has created the network “Leap to Zero” to accelerate the European transition to zero emission construction sites[39].

FINANCIAL SUPPORT SCHEMES

As previously mentioned, the additional cost of zero-emission machinery is one of the biggest barriers facing the transition to zero emission construction. The acquisition cost of zero-emission machines is significantly higher than conventional machines, and despite notably lower operating costs, financial support schemes have in the Netherlands been necessary to stimulate the transition.

The Dutch government has towards 2030, pledged 1 billion EUR to financial incentives for cleaner construction. Financial support schemes have been designed to boost demand, increase market maturity and stimulate innovation.

The biggest part of the pledge will go to investment grants to acquire emission-free machines, either through new acquisitions or through retrofitting existing equipment. The scheme offers investment support of up to 40% (50% for smaller companies) of the additional cost of acquiring an emission-free machine.

By providing direct financial incentives to buyers of zero emission construction machinery, the hope is that the currently higher prices will be partly offset, and thereby contain some of the investment risks.

In addition to supporting contractors in equipment acquisitions, several financial support programs are designed to assist municipalities, provinces, water authorities and other public agencies to set stricter climate requirements. Targeted financial support is provided to enable them to integrate zero-emission requirements into their procurement practices and to help adopt zero-emission construction standards. This includes funding for pilot projects, feasibility studies, charging infrastructure and a coverage of some of the additional costs of requiring emission-free machinery. **This support has been important for municipalities and other public byers to be willing to take the risk of new zero-emission technology.**

Zero-emission machinery has also been supported indirectly by two broad tax programs, targeted at reducing the investment cost of sustainable equipment. The programs work together using tax deductions (MIA) and a depreciation scheme (VAMIL) for the companies acquiring the machines[40].

39 https://www.rijkswaterstaat.nl/nieuws/archief/2024/03/leap-to-zero-eerste-internationale-conferentie-over-de-gezamenlijke-transitie-naar-een-emissieloze-bouwplaats
40 https://business.gov.nl/subsidy/mia-vamil/

Case

Using zero emission

In the Netherlands, zero-emission construction machines are increasingly making their way into Dutch construction sites. An ongoing dike reinforcement project along the River Waal is among the first major infrastructure projects in Europe to be constructed entirely using emission-free machinery. The Tiel-Waardenburg dike reinforcement project is one of the Netherlands largest flood protection initiatives. The project aim to reinforce and strengthen more than 19 kilometres of the Waal dike. To reduce emissions as far as possible, a cornerstone of this project is the exclusive use of fully emission-free construction machinery. More than 40 electric machines, including excavators, trucks, piling rigs, cranes and compactors, are being used in the project.

One of Europe’s first large fast-charging hubs has been built in conjunction with the project. Watthub is a charging hub for heavy machinery and can provide 10 MW of power to a total of 42 charging points. Watthub has been used as an efficient charging location for heavy machinery, trucks and other mobile charging solutions.

Shifting to zero-emission construction machines has led to significant environmental benefits. A study from the Dutch research organisation TNO (2025) estimates that the use of such equipment on this project has eliminated around 1000 tonnes of CO annually[41].

41 https://www.dijkversterkingtielwaardenburg.nl/wp-content/uploads/sites/52/2025/03/Onderzoeksrapport-TNO-Assessment-of-sustainalble-charging-operations-of-Mekante-Dieks-construction-equipment.pdf

6. Policy recommendations

As addressed in Chapter 3, the main barrier for increased adoption of zero-emission construction machines is the lack of demand. As demand for zero-emission construction machinery remains insufficient to support large-scale serial production, the acquisition costs of such equipment are currently too high to enable a rapid transition. Although emission-free machines offers significantly lower operating costs, the initial acquisition costs remain so high that, from a purely economic view, a full transition is not yet feasible. However, as demand increases, it is likely that acquisition costs will fall to a level where switching to zero-emission solutions will be economically advantageous.

There is also a range of efficient solutions available to address challenges related to energy infrastructure on zero-emission construction sites. Battery containers in various sizes, fast charging with different capacities, and increasingly sophisticated energy planning systems, all contribute to lowering the barriers that energy infrastructure has previously posed for electric construction machinery. Despite such solutions being technologically viable, due to a lack of demand for clean construction, they have not yet made their mark on the European market. The grid situation is also varying across European countries.

The main barrier to overcome is therefore the lack of demand for zero-emission construction machinery. To arrange for a quick and decisive transition, Europe requires a coordinated effort between the European Union, national governments and local governments to stimulate demand for emission-free solutions.

The table below summarises the policy recommended in this report.

A Europe-wide policy is necessary to incentivise the adoption of zero-emission machinery. Currently, Non-Road Mobile Machinery (NRMM) is one of the few vehicle types not regulated by the EU for greenhouse gas reductions. NRMM is subject only to general climate policy and is not specifically targeted like aviation, maritime transport, trucks, vans, and cars, despite the availability of largely mature technology. This regulatory gap poses a significant barrier for the European Union's 2050 climate targets.

To reduce emissions from the construction sector and support the electrification of mobile machinery, ZERO recommends that the European Union funds zero-emission pilot projects and passes legislation to regulate emissions from

POLICY RECOMMENDATIONS

Barriers	Policy tool	EU	National	Local
Lack of market and knowledge	Pilot schemes	1. Set up pilots in EU financed infrastructure projects (DG MOVE) 2. Upcoming Connecting Europe Facility Fund	3. Public Infrastructure Companies with pilots in portfolio 4. Pilot projects when building national/EU charging infrastructure for transport (AFIR)	1. Start with smaller, controlled ZECS pilots 2. Use results to inform guidelines and standardise requirements
Lack of demand	Public procurement	1. Add ZE machinery as new category in revised Clean Vehicles Directive 2027 (10%-100% ZEM 2030-2040) 2. Revised Public Procurement Directive: Mandatory, increased use of ZEM	1. Binding National Road Map 2. National Road Authorities: I. Set a clear target and strategy II. Make a committing internal plan III. Follow up in tenders, demanding increasing % of ZE 3. Demand an increasing % of ZE in all public construction sites	1. Enable early market dialogue 2. Set a clear future procurement target 3. Demand increasing % of ZEM in tenders 4. Coordinate energy planning
Lack of supply, high cost	Regulation	1. Regulate CO2-emissions from NRMM through OEMs. 2. Similar to light duty vehicles regulation: Gradual tightening, until 100% sold ZEM in the EU by 2040. Several models: I. A percentage of all produced machines must be ZE (measured in kWh) II. A percentage of all produced machines must be ZE (measured in tons) III. A percentage of all produced machines must be ZE (measured in number of machines)	1. Provide legal framework for cities to impose local regulation 2. Notify upcoming building regulations with increased share of ZE machinery 3. National ban on fossil fuels on all construction sites from (investigated and announced well in advance)	1. Require gradually increasing % of ZE in all major construction sites 2. Building permits regulation 3. Zero Emission Zone
High investment cost, poor grid	Financial support	1. Define NRMM as a critical industry 2. Support build-up of a ZE European NRMM value chain through upcoming European Competitiveness Fund	1. National funding to public procurers, covering a portion of extra cost of ZE in tenders 2. National support to buyers of ZE machinery and charging equipment/energy systems for construction sites	In absense of national financial support, consider local, targeted support schemes (grid, power solutions, machinery etc.)

construction machinery. In addition, the EU should enable the inclusion of stricter climate requirements in public procurement policies.

ZERO believe that Europe must take steps to protect its lead as a technological innovator within zero-emission construction. To ensure a successful and resilient transition for European industry, it is essential to regulate both the supply and demand sides of the market. Accelerating the shift to zero-emission construction is key to safe-guarding jobs in Europe, reducing dependence on non-European industries, and cutting greenhouse gas emissions

As emissions from the construction sector fall under the Effort Sharing Regulation (ESR), reducing emissions from construction machinery is primarily a national responsibility. As many European countries are struggling to meet their ESR commitments, it is crucial that action is taken to cut emissions from the construction sector**. ZERO recommends that countries implement a variety of policies, starting with pilot projects and financial support schemes, followed by public procurement and necessary national regulation.**

Yet, the transition to cleaner construction machines cannot happen without involving European cities. In most cases where electrification of machinery has advanced significantly, it is urban areas that have led the way. Many cities are grappling with air pollution, and construction activities are often a major contributor to local emissions. In London, emissions from construction is estimated to make up 4% of NOX, 8% of $PM_{2.5}$ and 30% of all PM_{10}-emissions[42]. **To address air and noise pollution, reduce GHG-emission and improve working conditions on construction sites, ZERO recommends that local governments adopt stringent public procurement requirements and implement either building permit requirements or zero-emission zones**.

In the following sections, policy recommendations are described, starting with local level, moving onto national and finally EU level.

LOCAL POLICY

For a rapid transition to zero-emission machinery, coordinated policies at the European, national, and local levels must be implemented in a way that complements and reinforces one another.

So far, local governments have played a crucial role in the transition to zero-emission construction sites. Cities are uniquely positioned because they often are large public purchasers, there is a pressing need to address local air quality, and cities usually have better access to power grids - allowing for a smoother use of electric construction machinery.

Experience from cities who have come far, show that local authorities are crucial to electrifying the machine fleet. In Norway, the city of Oslo has gone miles ahead, **mandating that all public construction project must be 100% emission-free from 2025. This regulation is set to be tightened, and from 2030 the city will require zero-emission construction on all construction sites within its boundaries, both private and public.**

For local authorities, the benefits in terms of air quality should be particularly compelling. Zero-emission machinery eliminates emissions of NOx and particulate matter (PM), both of which are major contributors to urban air pollution. This not only improves working conditions for construction workers, but also protects the health of city residents. The resulting health and environmental benefits clearly demonstrate why cities should lead the way in phasing in zero-emission machinery to create healthier, more liveable urban environments.

Pilot schemes:

Pilot projects have proven to be an important first step in cities as diverse as Oslo, Barcelona, and Copenhagen. Launching pilot projects enable public buyers to test zero-emission construction site (ZECS) requirements in a controlled environment before scaling up. Oslo's first pilot at Olav V St. provided key insights into technical, logistical, and regulatory challenges, while building capacity and supplier confidence. Pilots generate valuable data on energy use,

42 https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory--laei--2019/

LOCAL POLICY RECOMMENDATIONS

Barriers	Policy tool	Local
Lack of market and knowledge	Pilot schemes	1. Start with smaller, controlled ZECS pilots 2. Use results to inform guidelines and standardise requirements
Lack of demand	Public procurement	1. Enable early market dialogue 2. Set a clear future procurement target 3. Demand increasing % of ZEM in tenders 4. Coordinate energy planning
Lack of supply, high cost	Regulation	1. Require gradually increasing % of ZE in all major construction sites 2. Building permits regulation 3. Zero Emission Zone
High investment cost, poor grid	Financial support	In absense of national financial support, consider local, targeted support schemes (grid, power solutions, machinery etc.)

emissions, and equipment performance, and help de-risk innovation through flexible contract terms — such as public authorities covering energy costs or extending timelines. This lowers the barrier of market entry for suppliers, as well as fosters collaboration, and strengthens political and stakeholder support for future large-scale implementation.[43]

Public procurement:
Successful stories always start with a pilot to test technology and overcome the barrier of knowledge and scepticism. But to scale up the use of zero-emission machines, one of the most powerful tools at local governments disposal, is public procurement.

Local governments, especially in urban areas, should establish their own procurement requirements that promote the use of clean construction practices. These requirements should be introduced early in the planning process and follow a long-term, gradual trajectory towards 100% zero-emission to allow industry actors to adapt. An effective model for city governments is mandating that a certain amount of the machine-hours, or energy use, on construction sites must be zero emission.

Furthermore, clearly defined procurement targets, such as requiring 50% of energy used on-site to be zero-emission by a specific year, can provide the industry with the time and certainty needed to make strategic investments in clean technology. If more cities in a country or area join forces, this will create a bigger market and provide more incentive for the industry to adapt.

Suggested further reading:
Bellona (2025). From Oslo to the EU: The journey towards clean construction. https://eu.bellona.org/publication/from-oslo-to-the-eu-the-journey-towards-clean-construction/

Regulation:
As zero-emission construction becomes widespread, local authorities can use regulations to secure clean construction. Unlike public procurement rules, which only apply to public-sector projects, building permit conditions apply universally, also including private and state developers. As such, it serves as a strong incentive for the entire industry to invest in zero-emission machines. Three alternatives for regulations is proposed below.

1. Gradually increase ZE percentage requirements on all major construction sites
Oslo plans to set percentage-based energy use requirements for construction sites, using the Norwegian Pollution Act as the regulatory framework. If paired with long-term clarity and a predictable phase-in schedule, such rules can provide the market with confidence to scale up production and reduce costs. However, it is essential that the public sector continues to lead by example; procurement standards should remain more ambitious than permitting requirements to drive ongoing innovation.

2. Regulation of Building Permits
Another solution is to require environmental standards as a prerequisite of getting a building permit. This approach allows cities and municipalities to expand the reach of climate policy beyond public procurement, influencing both public and private developers. An effective model, used in Utrecht in the Netherlands, is regulating which types of machines must be zero-emission. This targets machinery itself, allowing policymakers to initiate smaller categories like mini excavators, with phased targets for larger machines.[44] After a while, municipalities can set a definitive date after which all construction machines must be emission-free.

3. Zero-emission zones
A third regulatory solution is to allow for zero-emission zones to include machinery. A zero-emission zone is a designated area within a city where only vehicles and machinery that meet strict emission standards, eventually being zero emission, are allowed to operate. This solution primarily applies to cities that have or plan to introduce some form of low or zero-emission zone.

While many European cities have already implemented low-emission zones, few have committed to fully zero-emission zones — and even fewer include construction machinery within their regulatory scope. This could be done gradually and announced well in advance, for example starting with small excavators, expanding to other machine categories as the market is maturing. Notably, London has announced plans to introduce a city-wide zero-emission zone for construction machinery by 2040, making it one of the first major cities to take this step. The advantage of this approach is that many cities are already familiar with the concept and have regulatory frameworks in place to support low-emission zones. This makes the transition to zero-emission zones relatively straightforward from a governance perspective.

Financial support
In absence of, or with insufficient, national financial support, local governments should consider providing local financial support to help kickstart the initial market for zero-emission machines. This could be a vital supplement to the other local policy tools, offering similar impact to national support, but on a smaller scale and with easier implementation.

NATIONAL POLICY
Certain European countries, such as Norway and the Netherlands, are leading the way in the adaptation of zero-emission construction machines. However, for the transition to be both widespread and successful, greater attention and stronger political instruments are needed from European countries.

Because emissions from construction machines fall under the effort-sharing regulation, national governments hold the primary responsibility for reducing them. To achieve this, they have considerable freedom to shape national rules and regulations in ways that promote cleaner construction practices.

Make a binding National road map
Through the Energy Performance of Buildings Directive, the European Union will require life cycle CO_2-emissions to be calculated for all new buildings. Member states must set limits for lifetime emissions in new buildings. To be successful in enforcing those limits, national authorities must have roadmaps detailing how to reduce emissions from construction machinery during the construction phase.

The Dutch Roadmap for Zero-Emission Construction Equipment (see Chapter 5) is a strong example of a national plan focused specifically on construction machinery. It brings together national government agencies, all provinces, around 38 municipalities — including the five largest — as well as key business networks and industry organisations.[45] Denmark has a similar, national agreement between public buyers, with the intention of increasing demand for zero-emission machines.[46] For such a national road map to reach its full potential, it must be binding, providing the market a predictable signal to invest in zero-emission machinery.

Pilot schemes
An important first step in addition to, or while waiting for, a European pilot scheme is to establish national pilot projects.

Pilot schemes are crucial for advancing the adoption of zero-emission construction machinery in Europe, as they provide practical, full scale, real-life demonstrations of the technological readiness and help build vital expertise among contractors and public buyers.

Pilot schemes have already yielded significant insights into energy planning, charging logistics and machine selection, making such schemes a stepping stone towards large-scale, emission-free construction projects.

43 https://eu.bellona.org/publication/from-oslo-to-the-eu-the-journey-towards-clean-construction/
44 https://www.utrecht.nl/wonen-en-leven/gezonde-leefomgeving/luchtkwaliteit/emissieloos-bouwen?utm_source=chatgpt.com
45 https://www.opwegnaarseb.nl/documenten/2024/11/04/routekaart-seb-engels
46 https://co-pi.dk/sammen-om-emissionsfrie-arbejdsmaskiner/?utm_source=chatgpt.com

NATIONAL POLICY RECOMMENDATIONS

Barriers	Policy tool	National
Lack of market and knowledge	Pilot schemes	1. Public Infrastructure Companies with pilots in portfolio 2. Pilot projects when building national/EU charging infrastructure for transport (AFIR)
Lack of demand	Public procurement	1. Binding National Road Map 2. National Road Authorities: I. Set a clear target and strategy II. Make a committing internal plan III. Follow up in tenders, demanding increasing % of ZE 3. Demand an increasing % of ZE in all public construction sites
Lack of supply, high cost	Regulation	1. Provide legal framework for cities to impose local regulation 2. Notify upcoming building regulations with increased share of ZE machinery 3. National ban on fossil fuels on all construction sites from (investigated and announced well in advance)
High investment cost, poor grid	Financial support	1. National funding to public procurers, covering a portion of extra cost of ZE in tenders 2. National support to buyers of ZE machinery and charging equipment/energy systems for construction sites

Moreover, they help uncover and address location-specific or national obstacles that could hinder broader adoption of zero-emission construction practices. The first try and introduction of new technology is also essential. Based on the experience from the Norwegian Road Authorities, and the opportunity of synergies from charging infrastructure construction, we recommend the following two approaches:

1. Public infrastructure companies testing pilots

In most European countries, road authorities and other public infrastructure companies constitute a significant share of the construction sector. Such companies should therefore take responsibility for implementing pilot projects and testing zero-emission solutions within their own development portfolios.

In all cases where emission-free construction has come far, it has been driven by companies or organisations willing to take the lead and test new zero-emission solutions.

2. Use ZEM pilots when building charging infrastructure

Another good opportunity to pilot and deploy zero-emission construction machinery lies in the large-scale rollout of new charging infrastructure required by the EU, regulated by the Alternative Fuels Infrastructure Regulation (AFIR) and the Trans-European Transport Network (TEN-T). As thousands of new charging points will be built across Europe, authorities should seize this momentum to demand zero-emission construction machinery in construction. Piloting electric machinery in such projects is likely to be more cost-effective than in other sites, since these sites already require substantial grid connections and power infrastructure.

Financial support

Financial support is necessary in the early phase of transitioning to zero-emission construction equipment. As discussed in chapter 3, the main barrier to adoption is the increased investment cost of buying zero-emission construction machines, compared to conventional diesel equipment. **State-funded investment support that covers a portion of the documented additional cost would also be highly effective.** By addressing the most critical obstacle directly, such a scheme would incentivise contractors to choose zero-emission machinery earlier and at a larger scale than market forces can achieve alone.

Such a support scheme would help reduce costs, not just for contractors, but also for public authorities and private developers requiring emission-free construction services. When combined with strong public procurement requirements, investment support forms the backbone of the "middle-phase" of the transition, where the technology is available but not yet fully cost competitive.

Whilst public procurement and pilot projects largely increase public-driven demand for zero-emission machinery, a financial support scheme lowers the threshold for private companies to choose cleaner construction practice.

Multiple European countries already have financial schemes to support emission-free machines. In both Norway and The Netherlands, schemes have been set up quite similarly, and according to EU state aid regulation. The Norwegian scheme is designed as investment support, covering up to 40% of the documented additional cost of purchasing zero-emission machinery compared to conventional diesel-powered equipment.

Two main setups (that may be combined):

1. Supporting the buyer of the machines with up to 40% (50% for small companies) of the documented additional costs of purchasing emission-free compared to conventional diesel-powered machinery, as in the Netherlands and Norway. There could also be schemes for supporting mobile energy storage and charging.

2. Using national funding to support the public authorities (municipalities, cities, regions or national infrastructure companies) with coverage of some of the additional costs for tenders of zero-emission sites. This allows for extra cost on machines and energy systems in the tender (as in the Netherlands).

Public procurement
Public procurement makes up a significant share of the European economy, being valued at a total of 2 trillion EUR, or 14% of the EU´s GDP.[47] In addition, aligning with EU-set regulations, national authorities can make a significant impact by amending their own purchasing practices.

National governments oversee agencies that are major buyers of road, rail, and infrastructure construction services. Such agencies are in a unique position to lead by example. In both the Netherlands and Norway, public road authorities have set ambitious targets. In Norway, the Norwegian Public Roads Administration requires zero-emission machinery in several tenders, and from 2028, this will become the general rule for all new contracts. In the Netherlands, Rijkswaterstaat has committed to using 90–100% zero-emission machinery on at least 75% of projects by 2030.

ZERO's next recommended national approach is to introduce a requirement where a certain percentage of machine hours of public construction projects must be performed with zero-emission machines. This requirement can gradually be increased until a complete requirement for emission-free construction sites is reached.[48]

It is crucial that public procurement requirements are communicated well in advance. By clearly stating that a certain percentage of machine hours must be zero-emission by a coming date, governments give contractors the time and incentive to invest in clean machinery before

EXAMPLE FOR A ROAD AUTHORITY COMPANY

1. Set a clear target and strategy.

2. Make a committing internal plan.

3. Follow up in tenders, demanding an increasing percentage of zero-emission machinery.

a mandatory requirement is introduced. This long-term visibility is essential to de-risk investment and stimulate market readiness.

We recommend combining this with pilot projects in the initial phase, alongside a support scheme to cover the additional costs in public procurement.

Regulation
Following pilot projects, financial support schemes and public procurement requirements, the next steps should be national regulation.

Building regulations can require that a minimum share of energy comes from zero-emission machinery as a condition for obtaining a building permit. Alternatively, requirements may target specific categories of equipment, gradually mandating that an increasing share of machines used, differentiated by weight class, must be zero-emission. For example, regulations could initially require 100% of mini excavators to be emission-free, while allowing a longer transition period for heavier equipment. To provide direction, a national deadline should be set for when all construction machinery must be emission-free.

Requiring 100% emission-free construction machines to obtain a building permit is one possible final step towards achieving emission-free construction sites.[49]

This approach extends beyond public procurement and creates strong incentives for private developers to adopt zero-emission solutions. These thresholds will gradually increase between 2028 and 2040, providing both ambition and predictability. Importantly, public procurement requirements should always be more ambitious than those linked to building permits, ensuring that the public sector continues to drive innovation.

EUROPEAN UNION POLICY
European policy is essential for a successful transition to cleaner construction. While countries like Norway and the Netherlands are currently setting the pace, meeting our climate goals requires a collective effort. To cut emissions swiftly and effectively, the European Union and all its member states must commit to promoting cleaner construction practices.

The European Union has ambitious climate policy and a goal of net zero by 2050. This target will be difficult to achieve if direct emissions from the construction industry still exist in 2050. Assuming an average lifespan of ten years for construction machinery, 100% of new construction machines must be emission-free in 2040 if the European Union is to meet its climate ambitions.

EUROPEAN UNION POLICY RECOMMENDATIONS

Barriers	Policy tool	EU
Lack of market and knowledge	Pilot schemes	1. Set up pilots in EU financed infrastructure projects (DG MOVE) 2. Upcoming Connecting Europe Facility Fund
Lack of demand	Public procurement	1. Add ZE machinery as new category in revised Clean Vehicles Directive 2027 (10%-100% ZEM 2030-2040) 2. Revised Public Procurement Directive: Mandatory, increased use of ZEM
Lack of supply, high cost	Regulation	1. Regulate CO2-emissions from NRMM through OEMs. 2. Similar to light duty vehicles regulation: Gradual tightening, until 100% sold ZEM in the EU by 2040. Several models: I. A percentage of all produced machines must be ZE (measured in kWh) II. A percentage of all produced machines must be ZE (measured in tons) III. A percentage of all produced machines must be ZE (measured in number of machines)
High investment cost, poor grid	Financial support	1. Define NRMM as a critical industry 2. Support build-up of a ZE European NRMM value chain through upcoming European Competitiveness Fund

47 https://www.eca.europa.eu/en/publications/SR-2023-28
48 https://www.miljodirektoratet.no/publikasjoner/2025/mai-2025/klimakrav-til-bygge--og-anleggsplasser-i-offentlige-anskaffelser-utredning-del-2/
49 https://www.miljodirektoratet.no/publikasjoner/2025/juni-2025/utredning-av-virkemidler-for-en-omstilling-til-utslippsfrie-byggeog-anleggsplasser-utredning-del-1/

Currently, NRMM is primarily regulated to reduce local emissions such as PM and NOx. Existing Europe-wide policies that impact climate emissions from construction machinery are largely embedded in broader legislative packages which do not have electrification of construction equipment as their main objective or effect. Examples of such legislation is the upcoming ETS 2 framework, which through pricing of emissions will make zero-emission solutions more competitive, or the Energy Performance Building Directive which has clear ambitions to reduce lifecycle building emissions. Due to the lack of specific, targeted legislation aimed at reducing GHG-emissions from construction machines, non-road mobile machinery is still subject to a **regulatory gap** in European climate policy.

The responsibility for cutting emissions from this area falls on the individual member states, under the effort-sharing regulation. However, Europe-wide policy is needed to decarbonise an entire sector; this cannot be left to individual countries alone. The upcoming introduction of ETS 2 will contribute to the transition by raising the operating costs of fossil-fuelled construction machines. It is, however, likely to be far from enough to stimulate the required transition.

In addition to climate targets, there are strategic reasons to pursue strong policies for transitioning construction machinery to zero-emission alternatives. If Europe manages the transition poorly, it risks falling behind and surrendering a growing market segment to foreign manufacturers. By positioning the European market at the fore-front of developing zero emission construction solutions, Europe has an opportunity to protect its industrial strength and secure a leading position in a global market that is set to move away from fossil fuels.

Pilot schemes
The European Union could accelerate the adaptation of zero-emission machinery by establishing a European pilot project scheme, for example based on the Norwegian pilot scheme described in Chapter 4.

1. **The very first step to test zero-emission construction machinery should be to finance an EU pilot project for testing out such machines and solutions on already planned, EU-funded construction projects.**

The European Union is expected to invest heavily in infrastructure in the coming years. In the upcoming long-term budget, the Commission has proposed spending 82 billion EUR on developing infrastructure through the Connecting Europe Facility (CEF). This represents a unique opportunity to develop competence in large-scale, comprehensive zero-emission construction projects.

2. **By mandating that a handful of projects receive funding from the CEF, the Commission can ensure that all or large parts of a selected few major infra-structure projects are built with zero-emissions construction equipment.**

It should be a goal to carry out zero-emission construction pilots with the lowest possible emission, ideally using only electric machinery throughout the entire projects. This approach enables contractors and public entities to test and familiarise themselves with the equipment, charging infrastructure, energy systems, and to build competence in addressing potential energy-related challenges. EU-funded pilot projects could also serve as a strategic way to introduce zero-emission machinery in member states that might otherwise delay the transition.

Public procurement
Greener public procurement policies are essential if Europe is to make clean construction sites the norm. Public procurement has already proven to be a valuable tool, and in most cases where cleaner construction machines is gaining traction, ambitious and strategic procurement practices have been a major driving force, as demonstrated by the examples from Norway and The Netherlands.

The use of public procurement to incentivise green acquisitions is currently insufficient. Over the past three years, only 20% of procurement contracts

in Europe have employed strategic procurement to reduce environmental impacts.[50] This highlights the immense potential of green public procurement as a driver for the transition to cleaner construction. European policymakers should seize the upcoming revision of the Public Procurement Directive as a unique opportunity to gain a powerful new tool in the effort to reduce greenhouse gas emissions from construction.

1. Through the EU Green Public Procurement (GPP) initiative, the European Commission has developed multiple sets of criteria aimed at reducing the environmental impact of public purchasing. Although the Commission encourages authorities to follow these guidelines, they remain voluntary, and member states are free to decide whether to adopt them. The current guidelines for construction works do not include information on the feasibility and practicality of zero-emission machinery. **In the upcoming revision of the Public Procurement Directive, specific guidelines for requiring zero-emission machinery should be developed and made mandatory, in order to increase the national share of public construction projects.** This approach is already in place in Oslo and is under consideration by the Norwegian government at the national level[51, 52]. To promote European leadership in clean technology, the Commission is to propose a "Made in Europe" criterion for public procurement.[53] Transport & Environment (2024) suggests "defining mobile machinery as a strategic industrial sector through the upcoming revision of the EU public procurement framework(…), and to put in place preferential procurement rules in the form of a 'buy green and European' clause for zero-emission equipment."[54]

2. Another solution is to adopt sector-specific legislation targeting construction machinery directly. **By mandating that a certain percentage of machinery used on public construction sites must be emission-free, both production and uptake of such equipment would increase significantly. These requirements should be phased in gradually, rising from 10% to 100% over a ten-year period.**

   The upcoming revision of the Clean Vehicles Directive in 2027 presents a valuable opportunity to implement such measures. The Directive requires public authorities to include minimum targets for low- and zero-emission vehicles in their public procurement of transport services. **The scope of the directive would have to be increased to include vehicles and machines used by private contractors on public construction sites. Introducing a requirement that 10% of machinery used in public contracts must be zero-emission by 2030, increasing to 100% by 2040, would provide contractors with predictability and sufficient time to prepare and invest in clean technologies.** This solution also allows the member states flexibility in how to meet these requirements.

While such requirements may lead to increased initial costs, the additional costs of zero emission projects are often more moderate than commonly assumed. A review by Oslo Economics (2025) found that construction projects using exclusively zero-emission machinery incurred estimated additional costs ranging from 3-37%. The highest costs were observed in small projects with limited energy infrastructure, while most projects fell within a range of 3-8%.[55] Prices for zero-emission machinery are expected to decline, and many anticipate that zero-emission projects will become cost-competitive by 2030[56].

50 https://api.public-procurement-data-space.europa.eu/superset/dashboard/strategicprocurement/
51 https://www.miljodirektoratet.no/publikasjoner/2025/mai-2025/klimakrav-til-bygge--og-anleggsplasser-i-offentlige-anskaffelser-utredning-del-2/
52 https://aktuelt.oslo.kommune.no/byradet-vil-stille-krav-til-utslippsfrie-byggeplasser
53 https://cdn.newsletter.mfa.no/p/r/0QvTk2_p51SrXt08SVZX6Vx2LNbpHnM7J40PfZA_-x4=
54 https://www.transportenvironment.org/articles/reducing-emissions-from-non-road-mobile-machinery
55 https://www.miljodirektoratet.no/publikasjoner/2025/januar-2025/kostnader-ved-omstilling-til-nullutslipp-pa-bygg--og-anleggsplasser/
56 https://www.enova.no/nb/bedrift/bygg-og-eiendom/tema-utslippsfrie-anleggsplasser

Actively leveraging public procurement policies can effectively stimulate market adoption and encourage the use of zero-emission machinery. Over time, this will lead to substantial health, environmental and economic gains.

Regulation

Achieving this goal will require targeted regulation of construction machinery. So far, European emission Stage standards for NRMM have been effective in reducing NO_x and $PM_{2.5}$ emissions. Between 1997 to 2016, these emissions fell by 70-95%, with emissions starting to flat out after 2016.[57]

The next step for European emission regulations is reducing the remaining part of NO_x and PM-emissions, as well as finally addressing greenhouse gas emissions from construction machinery. Faced with the choice between tightening existing Stage regulations or accelerating the shift to zero-emission machinery, ZERO propose the latter. Rather than developing entirely new emission standards, focusing efforts and R&D investment on zero-emission technologies will yield greater long-term benefits. Developing a new set of Stage VI emission standards might focus R&D-funds into extending the age of fossil drivetrains within the construction sector.

A regulation should be introduced once there is steady demand for zero-emission machinery, driven by stricter public procurement standards that ensure the machines are actually purchased. However, by initiating dialogue and announcing an upcoming regulation, the EU would send a strong signal to European OEMs to start a gradual production shift from fossil-fuelled to zero-emission machinery. Supported by rising demand, a regulation would help secure a competitive European NRMM industry capable of meeting the demand, rather than being outpaced by international competitors.

Therefore, European policy should be designed to actively promote the shift to zero-emission technology. A tentative proposal from ZERO is that coming machine regulations should, as far as possible, be modelled on existing light-duty vehicle regulations. This would help reduce the administrative burden for both manufacturers and authorities.

CO2-emission standards for cars and commercial vehicles have been in force for several years and represent a proven regulatory method for a supply-driven approach to zero-emission vehicles.

This would suggest that a production regulation of European construction machines should consist of a combination of zero emission per unit of power produced, as well as certain goals of percentage of produced machines that must be zero emission. It is important to recognise that construction machinery differs significantly from road vehicles, and therefore requires a tailored regulatory approach. Any new regulation must avoid placing excessive reporting burdens on manufacturers, while still driving meaningful change. **Regulating emissions from construction machinery could follow a similar structure to existing EU rules for light duty vehicles, although with different measures. One approach could be to introduce a system in which manufacturers for example would be obliged to ensure that their yearly production of construction machines meets an average number of units, energy output or tonnage for the machines sold to the European market. This fleet-wide emissions cap would be progressively tightened over time, with interim targets to drive market adaptation.**

Ultimately, the regulation would ensure that all new construction machinery sold in the European market must be zero-emission by a target year. This could for example be set to align with a goal of 100% new zero-emission machines by 2040, supporting the European Union's climate ambitions of being net-zero by 2050. As a "phase -out" policy for fossil-powered machines, this measure directly targets the supply-side of machines, ensuring a steady, predictable transition for both the industry and end-users.

57 https://www.sciencedirect.com/science/article/pii/S2352186423001839#b20

Such a regulation can be designed in several ways.

1. **A percentage of all produced machines must be zero emission (measured in kWh)**

2. **A percentage of all produced machines must be zero emission (measured in tons)**

3. **A percentage of all produced machines must be zero emission (measured in machines)**

The first alternative, mandating that a minimum percentage of produced kWh must be zero emission is probably the most precise regulation. Using kWh as the unit of measurement allows us to compare emissions across different machine types- and sizes, which is a way of regulation that does not distort competition between producers of various construction machines. However, a challenge with this solution is the lack of an European-wide standard on measuring energy use. Currently manufacturers measure energy-use in different ways, potentially allowing manufacturers to measure energy-use in advantageous ways. For a regulation based on kWh to work, the European union must, in close cooperation with the manufacturers, first develop a European standard for measuring energy-use in construction machines. Once such a standard is established, it could serve as the foundation for future regulations. **Alternatives 2 and 3 are less precise but could enable the implementation of a simple regulation with minimal administrative burden.** Measuring the number of machines placed on the market or the total tonnage would be straight-forward. A regulation based on weight or amount may distort competition between manufacturers, favouring producers of smaller construction machines as they are easier to electrify. A measurement based on tons could give tunnel machine producers an advantage, as they already have a large proportion of ZE equipment. At the same time, one can argue that it is not problematic that some of the OEMs overfulfill the regulation, as long as the rest are able to meet the regulation requirements and there is a sufficient demand for their ZE products in the market. At the other hand, such a solution would make an uneven playing field.

ZERO recommends a further consideration to inquire which alternative would allow for the most efficient transition to zero-emission machinery, whilst minimizing downsides for manufacturers.

This represents the final and most impactful step towards fully decarbonizing construction machines, with a goal of triggering serial production of ZE machines, lowering the costs and increasing the availability. While likely to face political resistance, an early announcement and clear timeline would provide the necessary lead time for industry adaptation and innovation. The proposed regulation would prevent a repeat of past pitfalls seen in other sectors, such as the heavy reliance on non-European suppliers for electric buses, trucks, and cars, by making sure European manufacturers lead the technological race for zero-emission construction machinery. This will help safeguard the competitiveness of the European industrial base in a market which probably will move towards zero emission technology in the long run due to lower costs and energy efficiency.

Financial support

To transition to ZE machines for member states, and enable all regions and countries to take part in the transition, the European Union could support the introduction of ZE machinery in these markets financially.

The European NRMM industry is a major industry and exporter with an estimated production value of 76 billion Euros[58, 59] its higher efficiency and lower operating costs. European manufacturers already offer a range of zero-emission models, but limited demand prevents large-scale production and keeps prices high. Meanwhile, Chinese producers, drawing on their experience in electrifying the on-road transport sector, are rapidly expanding their presence in the European market. To prevent Europe's machinery industry from facing challenges like those seen in the automotive sector, the EU must take decisive action to foster a strong and competitive market for zero-emission construction equipment. One way of doing so could be by explicitly defining ZE NRMM as a critical industry under "clean industry / decarbonization" in the upcoming European Competitiveness Fund (ECF). This could make it easier for the NRMM industry to gain financial support for the transition to ZE machinery ahead.

Regardless of the exact regulatory approach chosen, investing in the competitiveness of the European NRMM industry would boost innovation, create jobs, reduce emissions, and strengthen Europe's ability to face growing international competition — all at the same time.

58 https://cris.vtt.fi/files/99622455/Pathways_for_CO2_regulation_in_NRMM.pdf
59 https://www.enova.no/nb/bedrift/bygg-og-eiendom/tema-utslippsfrie-anleggsplasser

7. The promising future of zero-emission construction machinery

THE COST OF DOING NOTHING

The figure on the bottom is showing a scenario of diesel costs. The scenarios have been developed by the Swedish Energy Agency, and are based on implemented policies (the lower part of the outcome) and announced policies (the upper part of the outcome). For the Swedish Transport Administration, this means that contractors' fuel costs increase from SEK 2.1 billion per year in 2025 to SEK 3.4 billion per year in 2037 (under the assumption that annual diesel consumption corresponds to 150 million litres of diesel). The figure on the top shows that a positive TCO on ZEM compared to diesel is possible in Sweden today (2025) and that the TCO is positive in most in scenarios by 2030. Source: Trafikverket (2025) and Energimyndigheten (2025)

Although many challenges remain, the transition from fossil-fuelled to zero-emission construction machinery is demonstrated in multiple pilot projects, in several cities and early markets. Pilot projects have been started in major European cities such as Barcelona and Paris, and several Nordic capitals. Also, Dutch cities are increasingly setting ambitious zero-emission construction machinery-targets. As projects are demonstrated, regions are requiring increasing share of ZE construction projects, and local air pollution and GHG emissions area reduced, the benefits of ZE construction is increasingly visible.

A transition to zero-emission machines will lead to significant savings in construction projects. Despite currently being more expensive, projections show the costs of zero-emission construction machines will continue to fall, especially as battery technology and prices improve, and as a growing demand for electric machines allows for mass production to occur. For certain types of machines, operational costs are lower for zero-emission machines. If investment costs continue to fall, we will approach a situation where zero-emission machines will allow construction companies to cut costs.

Zero-emission machines have the potential to increase the efficiency of construction sites. Firstly, electric construction machines are significantly more energy efficient than fossil-fuelled machines. Secondly, the transition to electric machines also helps facilitate research and development of autonomous machines, possibly allowing for great efficiency benefits. Already now, electric machines gather more data than fossil variants, which can be used by construction companies to optimize operations.

Another major advantage of a successful transition to zero-emission construction machines is the improvements it brings to the environment for workers and neighbours. Electric construction machines have the advantage that they produce less noise, fumes and vibrations than their fossil-fueled counterparts. This leads to quality of life-improvements for people who spend a lot of time near machines, such as workers and people who happen to live or work near a construction site.

Finally, a future where zero-emission machinery is the norm will cut emissions, both of GHG and other harmful gases such as NOx and PM. This leads to cleaner air, a healthier environment, and contributes to making it possible to meet European climate ambitions.

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Artificial intelligence (ChatGPT) has been used to gather, analyze and compare information as well as to create an outline-structure for this paper. All results of AI-use have been processed, reviewed and approved.

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