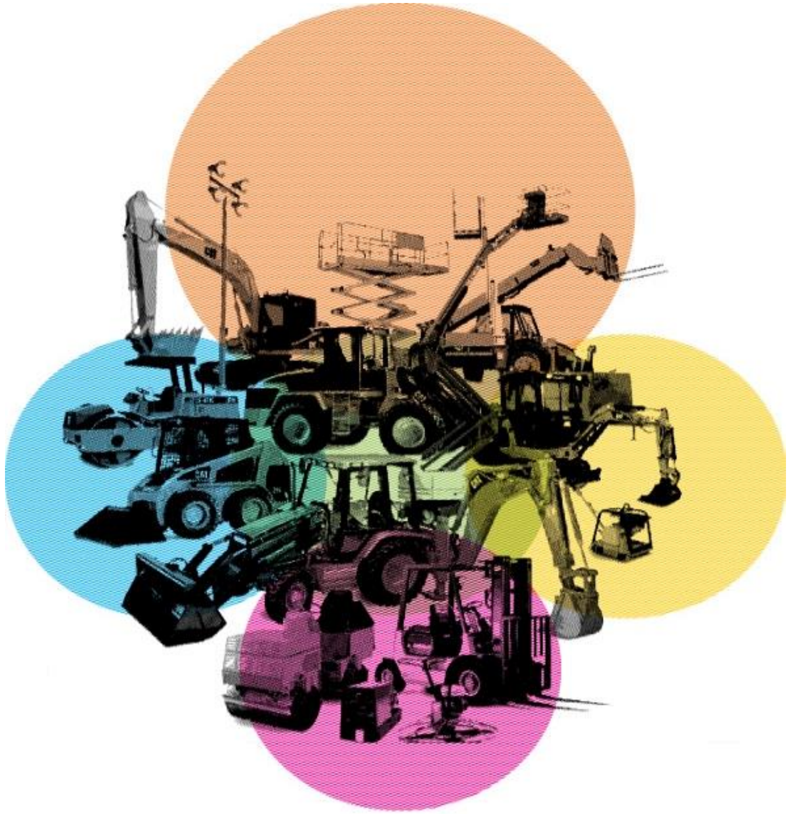
Prepared in
collaboration with EY

Energy Transition in Rental

Full report
June 2025



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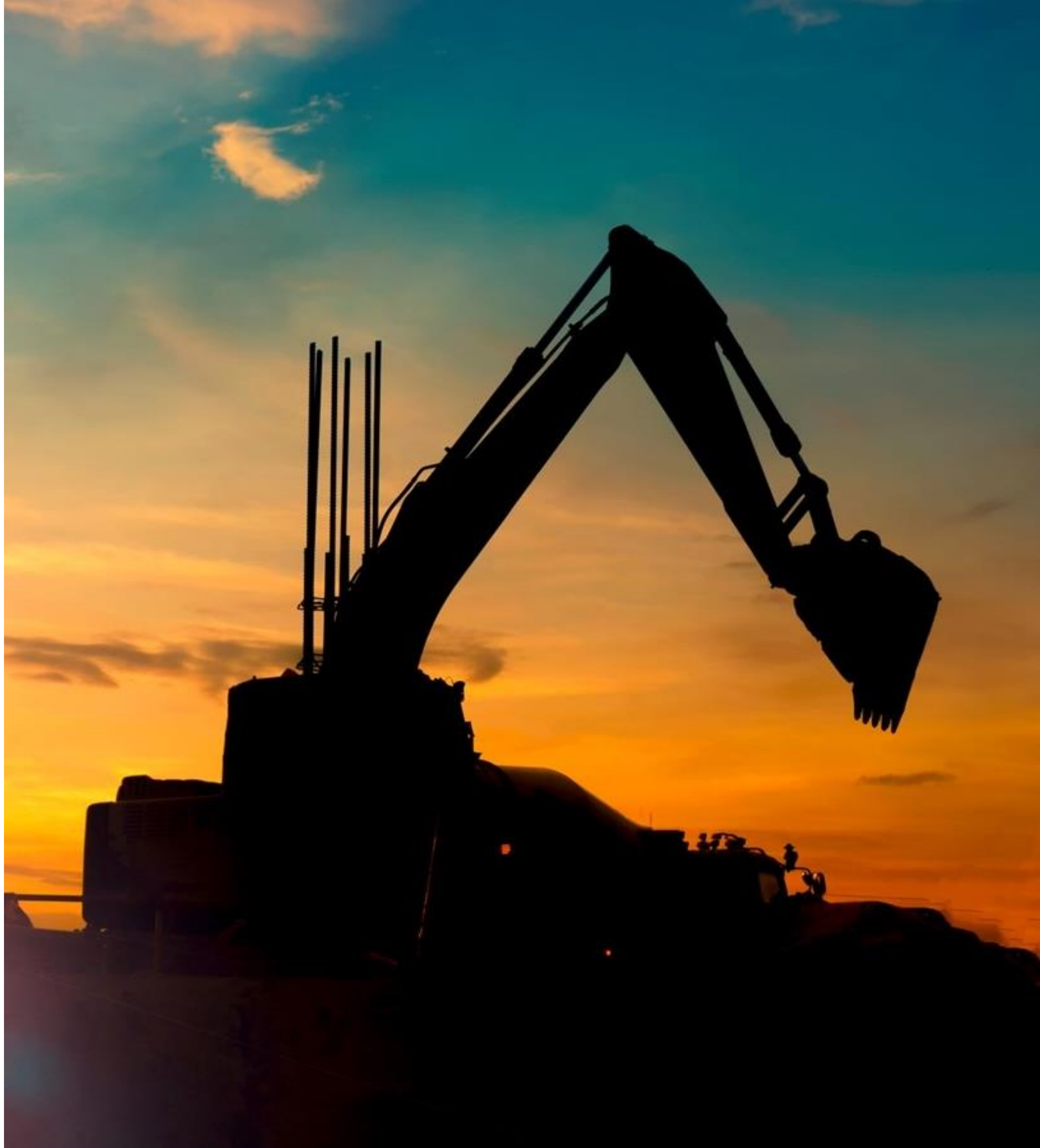
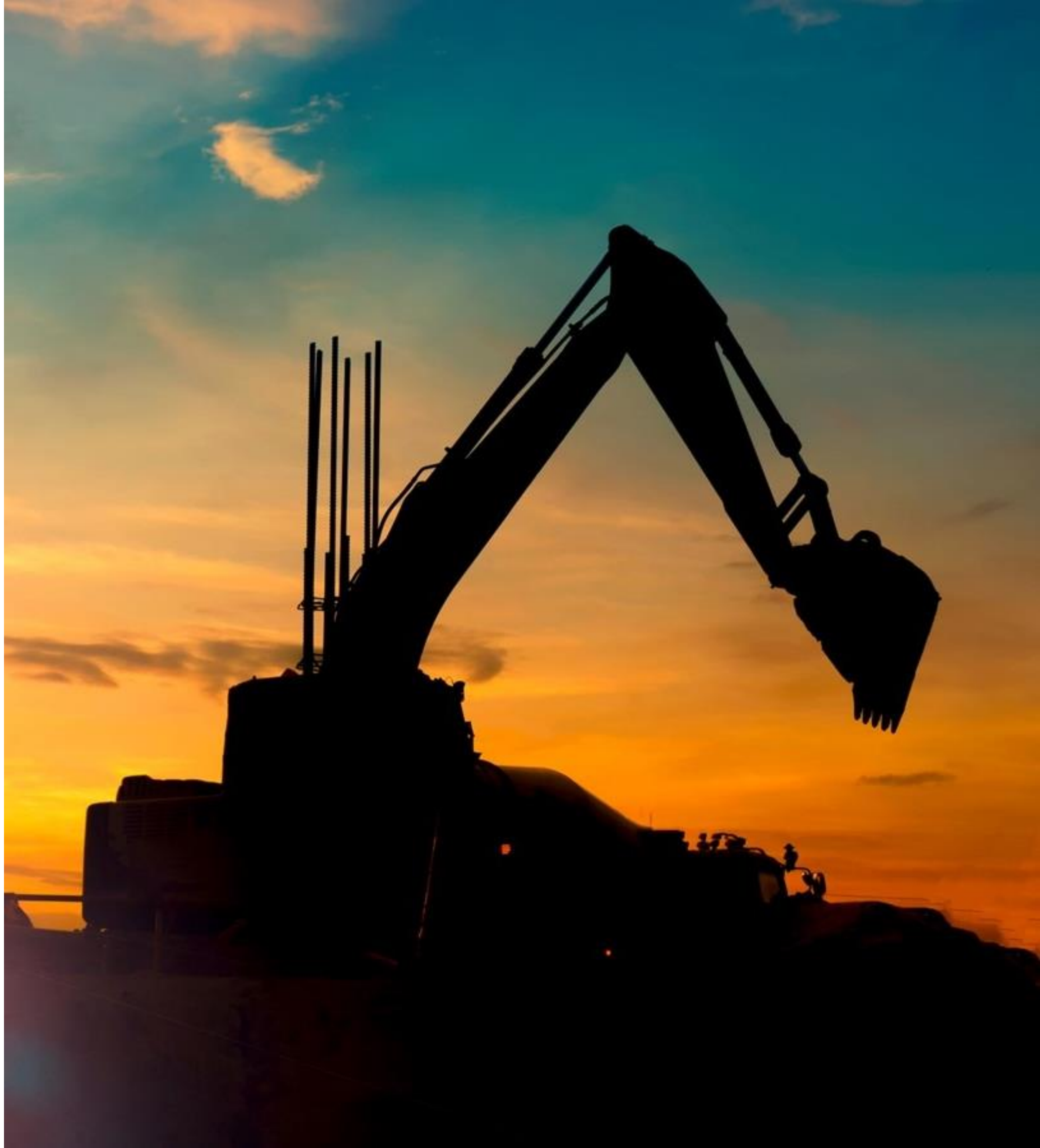


Objectives, scope of work and methodology



The ERA energy transition project aims at facilitating the energy transition in the rental industry and ultimately contributing to achieving European decarbonization targets

The energy transition is necessary to achieve the European Union's reduction targets set out in the "Fit for 55" package, defined under the Paris Agreement. It is defined as the shift from using fossil fuels to cleaner, renewable energy sources, aiming for a more sustainable and environmentally friendly energy system.

Non-road mobile machinery impact on climate

Non-road mobile machineries, or off-road equipment*, is responsible for 108 Mt CO2e per year, which **represents 3.1% of the EU's Greenhouse Gas (GHG) emissions.**

EU GHG emissions' reduction objectives

The EU "Fit for 55" package sets greenhouse gas reduction objectives of **-55% by 2030 and aims to achieve net-zero by 2050** (1990 baseline).

The Non-Road Mobile Machinery sector falls under this objective through the Effort Sharing Regulation (ESR), with a global objective of reducing **CO2e emissions by 40% by 2030** (2005 baseline)**.**

The energy transition supports four key objectives:

- **Decarbonize rental activities**
- **Comply with local, national and European regulations**
- **Meet customers' expectations**
- **Strengthen European energy independence**

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*Non-road mobile machines included are those used in industry and construction, and ones used for mining and airport operations, machines used in commercial, agriculture and forestry, fishing, residential, inland waterways, rail and military sector. Sources: [1] T&E - Reducing emissions from non-road mobile machinery ; [2] Fit for 55 – Consilium, Effort sharing 2021-2030: targets and flexibilities - European Commission

Objectives of this report

1 | Low-carbon solutions options and adoption barriers

- Identify the most appropriate type of energy depending on equipment types
- Determine the barriers to the alternative types of energy adoption

2 | Customer requirements and value proposition

- Detail the challenges and opportunities of the energy transition from the customers' point of view
- Identify new product and services offering

3 |Standards and training for battery-electric solutions

- Summarize current trends in batteries and infrastructure to articulate the rental industry standards needs
- Identity training needs

4 | Revision of the rental TCO model

- Provide recommendations to update the TCO model based on the conclusions of the first three phases

6 low-carbon solutions have been analyzed to identify the solutions with the highest potential to replace fossil fuel equipment

6 low-carbon alternatives to fossil fuels have been considered during this project. This analysis was conducted through:

- A comprehensive **literature review**
- **28 interviews** with 9 rental companies, 13 OEMs, 5 rental customers and 2 associations
- **Analysis of 7 responses provided by rentals to an online survey** sent in the context of this study
- **Analysis of 17 responses provided by OEMs to a second online survey** sent in the context of this study

Low-carbon solutions analyzed

Battery electric		Machines powered on electric batteries (either 100% battery or hybrid), with different charging solutions to be explored (e.g. charging standards, fast charge, swappable batteries). Although it is not the core of the analysis, cable connected solutions may also be assessed for specific use cases.
Biofuels	**HVO**	Hydrotreated Vegetable Oil. A diesel fuel produced by hydro processing renewable feedstocks, like fats and oils, defined as a renewable diesel, that meets the European Renewable Energy Directive II criteria for biofuels.
	Biodiesel	Diesel fuel produced by transesterification of renewable feedstocks, like fats and oils, that meets the European Renewable Energy Directive II criteria for biofuels. Using biodiesel blends higher than B7 (i.e. 7%) requires modifications on engine fuel injection systems and filters.
Hydrogen	**Fuel cells**	Hydrogen used in fuel cells or internal combustion engines, that meets the European Renewable Energy Directive II criteria for low carbon hydrogen.
	ICE	
Synthetic fuel (e-fuel)		Liquid synthetic fuels meeting the European Renewable Energy Directive II requirements of **RFNBOs** (Renewable Fuels from Non-Biological Origin), also called **e-fuels** (e.g. e-ammonia, e-methanol).

| Sources: [1]Renewable Energy – Recast to 2030 (RED II) - European Commission & Renewable Energy Directive

This work draws on the participation of >35 industry stakeholders

Countries where interview and survey respondents’ HQ are located

Countries where interview and survey respondents declared having main activities

Rentals and representatives

- 9 rentals were interviewed and 7 of them also completed the survey
- Headquarters are based in 6 different European countries
- The panel of companies approached includes companies of all sizes: 3 with revenues of less than 500 million euros, 2 with revenues of between 500 million and 2,000 million euros, and 4 with revenues exceeding 2,000 millions.*

OEMs

- 13 OEMs were interviewed and 9 of them also completed the survey
- 8 other OEMs (not interviewed) also responded to the survey
- Headquarters are based in 9 different European countries and 3 from outside of Europe
- The panel of companies approached includes companies of all sizes: 7 with revenues of less than 500 million euros, 5 with revenues of between 500 million and 2,000 million euros, and 3 with revenues exceeding 2,000 millions. *

Customers and associations

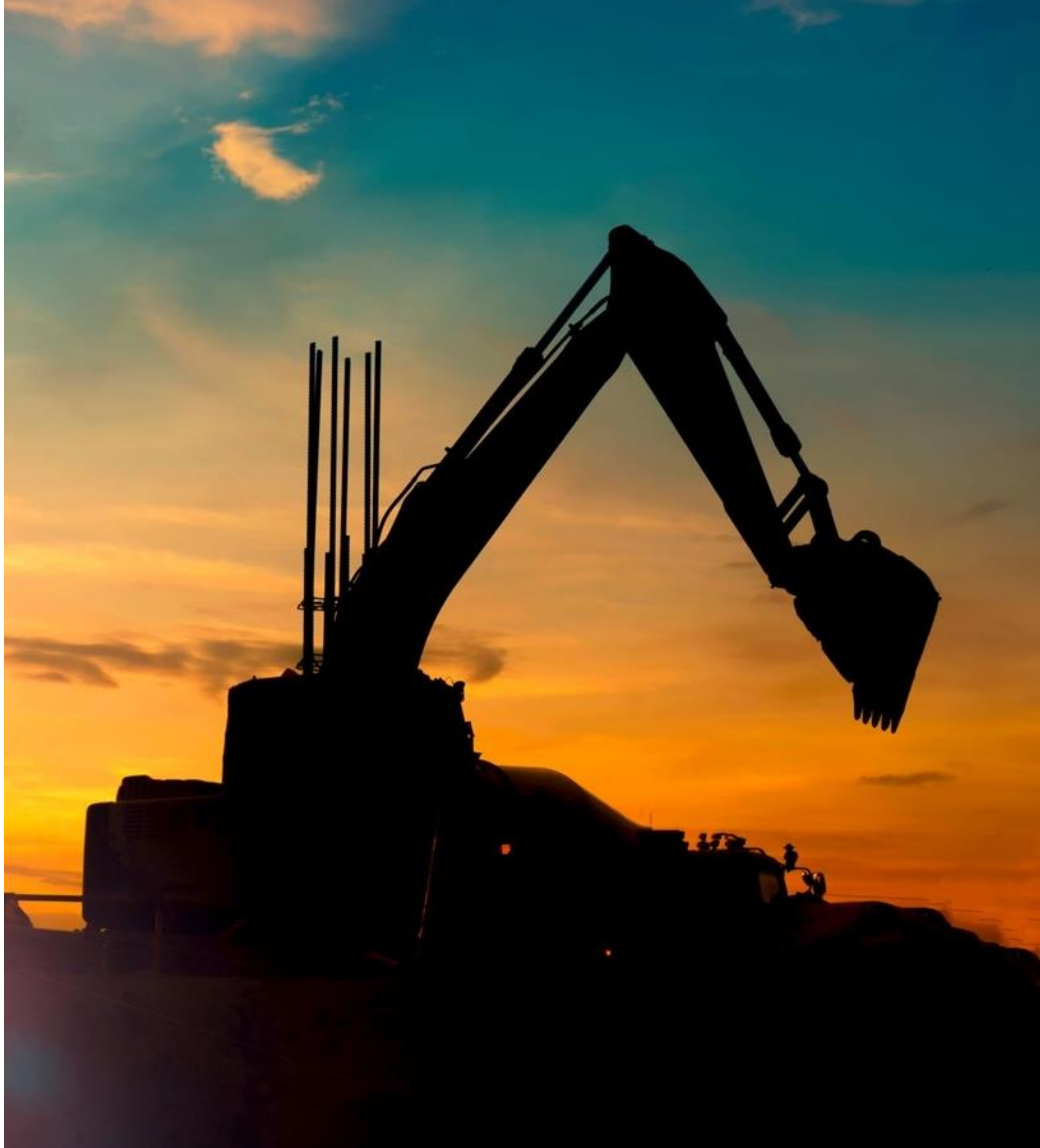
- 5 customers in construction sector were interviewed
- 2 associations and public authorities were interviewed

**2023 revenues*

CAPTION: Data collected through interviews and/or survey

ERA Energy Transition in Rental | Sources: EY analysis on data collected through OEM and rentals interviews, survey and on companies' annual reports.

1. Landscape of low carbon alternatives



TCO considerations and operational practicality are the main priorities for low-carbon solutions adoption, while environmental impact is key for regulatory compliance

The low-carbon solutions analysis has been performed based on 24 sub-criteria, grouped in 5 macro analysis criteria

Analysis criteria definitions

TCO	CAPEX	Initial investment required to purchase equipment, infrastructure or technology need to deploy the low-carbon solution
	OPEX	Ongoing operational costs, such as fuel, energy consumption, maintenance, trainings, and other recurring expenses over the technology's lifespan, resale price not included
Operational practicality	Operational performance	Efficiency and suitability of the solution for selected applications (e.g., power and torque delivered, refueling or charging needs impacts on operations)
	Infrastructure and energy supply	Availability and compatibility of necessary refueling or recharging infrastructure (especially for remote sites) and energy sources to support the solution's deployment
Environmental impact	GHG emissions and other pollutions	The solution's effect on greenhouse gas (GHG) emissions and air pollution (incl. PM, Sox, Nox)

Electric batteries and HVO are the two solutions with the highest potential to replace fossil fuel in the equipment sector

The potential of each of the 6 low-carbon technologies to fossil fuel consumption reductions was assessed as part of this project:

		Fossil fuels	Battery electricity	Biofuels		Hydrogen		Synthetic fuels (e-fuels)
				HVO	Biodiesel	Fuel-cell	ICE	
TCO	**CAPEX**	●	◐	●	●	○	◐	●
	OPEX	◐	●	◐	◐	○	○	○
Operational challenges	**Operational performance**	●	◐	●	◐	◐	●	●
	Infrastructure and energy supply	●	◐	◐	◐	○	○	○
Environmental impact	**GHG and other pollutions**	○	●	◐	◐	●	◐	◐
CURRENT POTENTIAL FOR FOSSIL FUEL CONSUMPTION REDUCTIONS		-	●	●	◐	◐	◐	◐
TREND (5 – 10 years outlook)			↗ *Progress on battery tech (performance, cost and GHG)*	↘ *Shortage risks due to high demand growth*		~ *Uncertainty on infrastructure and costs, progress on technology*		
ACTIONS* to be taken by rental companies			*Installation of charging infrastructure, safety provisions*	*Installation of HVO fuel tanks in branches*				

- **We will focus on HVO and battery electric**, the two low-carbon solutions with the greatest potential to replace fossil fuels.
- Given the variability of data on **electric batteries** across different equipment types, **we will provide illustrative examples** to support our analysis.

● Favorable ◐ Mixed ○ Unfavorable ↗ Upward ↘ Downward

ERA Energy Transition in Rental | * more details further in the report | Sources: EY analysis from literature research, OEMs data, interviews

Note: The assessment made can vary across countries (e.g. some countries have a strong hydrogen development policy and thus faster infrastructure development and cost reduction)

Biofuels are so far the most widely used low carbon solution among non-electrified equipment* but present environmental and long-term sourcing challenges

8 out of the 9 respondents to the rental companies’ survey declare that they rent equipment that is compatible with biofuels.

Biofuels are widely adopted due to the low required CAPEX and their lower direct environmental impact

Environmental impact

- Direct GHG emissions (users’ scope 1, tailpipe emissions) from biofuels are considered by convention “neutral” as combustion emissions are compensated by CO2 absorption during biomass growth.
- The use of HVO and of B100 (biodiesel) is associated with reductions in Sox (sulfur oxides), PM (particulate matter), and HC (hydrocarbon). The use of HVO also leads to a reduction in NOx of between 10 and 15%.

Operational practicality

- Biofuels, such as biodiesel and HVO, are easy-to-use solutions that require minimal or no engine modifications. HVO can either be blended with diesel or used at 100% in the tank.
- In addition, no additional infrastructure, engineering, maintenance or training are required.
- HVO and biodiesel blends up to B7 (7% biodiesel) can be used on equipment subject to the Non-Road Mobile Machinery (NRMM) regulation on Stage V engines, although they require the fitment of exhaust aftertreatment technologies.

Nonetheless, they are not to be considered as an ideal solution due to the challenges they face

Environmental impact

- Upstream GHG emissions (indirect emissions due to fuel production) are higher for biofuel than for diesel (+50% for biodiesel, +30% for HVO).
- Competition with forestry and human food production gives rise to major controversies.
- For biodiesel, NOx emissions tend to increase compared to diesel (between +4% and +13%).

Operational practicality

- Using biodiesel blends higher than B7 requires:
    - modifications on engine fuel injection systems and filters;
    - further type-approval tests by OEMs to ensure compliance with the Stage V regulation.
- Biofuels can be used in Low-Emission and Fossil-Free Zones but not in Emission-Free Zones (see section on climate regulations).

Long-term sourcing challenges

- According to the IEA, biofuel use in the road, aviation, and maritime sectors is likely to fall short of the IEA Net Zero by 2050 Scenario trajectory by 1.6 to 1.4 times.

ERA Energy Transition in Rental | * this statement excludes equipment that were already widely electrified (e.g. portative tools, some indoor access) | **Indirect Land Use Change | ***Used Cooking Oil

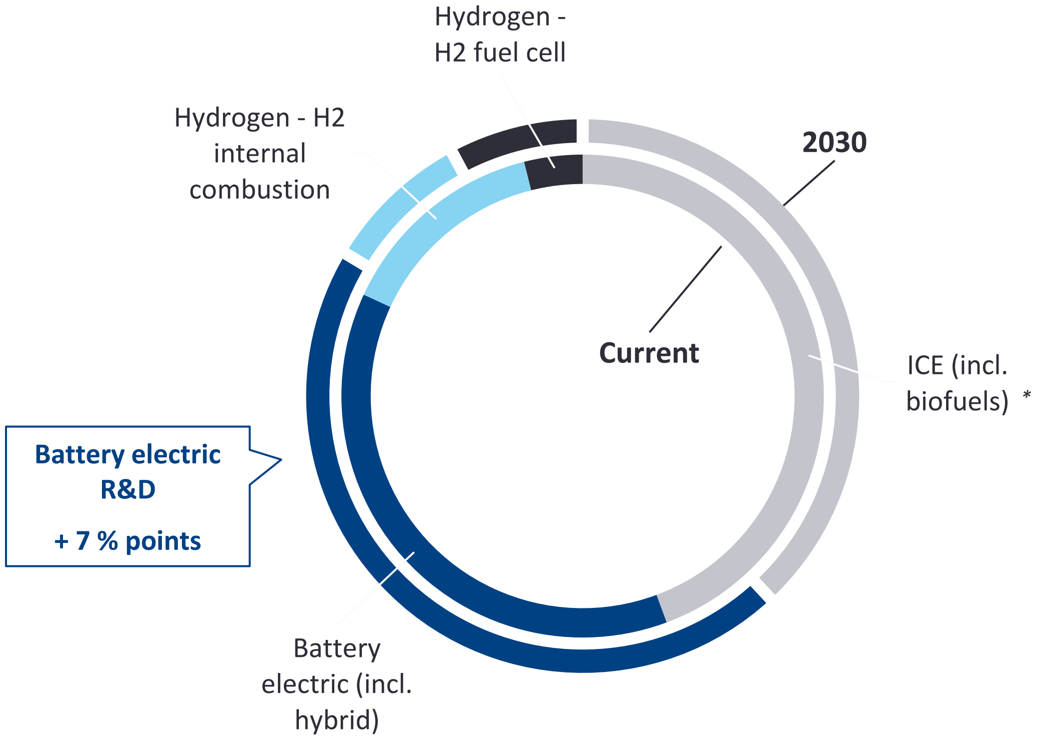
Sources: Interviews; OEM Survey; IDTechEx , the Electric Future of Construction: EV Machines On The Rise, Comparative Study of Combustion, Performance and Emission Characteristics; Report to USDA, Directive - EU - 2023/2413 - EN - Renewable Energy Directive - EUR-Lex, How Oslo is driving a transition to clean construction; International Energy Agency, The Role of E-fuels in Decarbonising Transport

Projected R&D shares per technology among OEMs suggest that electric batteries will be the top priority technology, closely followed by ICE (including biofuels)

Among the survey responses, the most prevalent technologies in equipment are currently internal combustion engines (ICE), including fossil fuels and biofuels, as well as electric batteries.

According to the survey conducted as part of this study, OEMs are planning to increase R&D share dedicated to low-carbon solutions (2030 horizon) – especially for electric batteries.

Average projected R&D share (%) per technology (current vs. 2030)



*ICE as Internal Combustion Engines includes fossil fuel and biofuels.

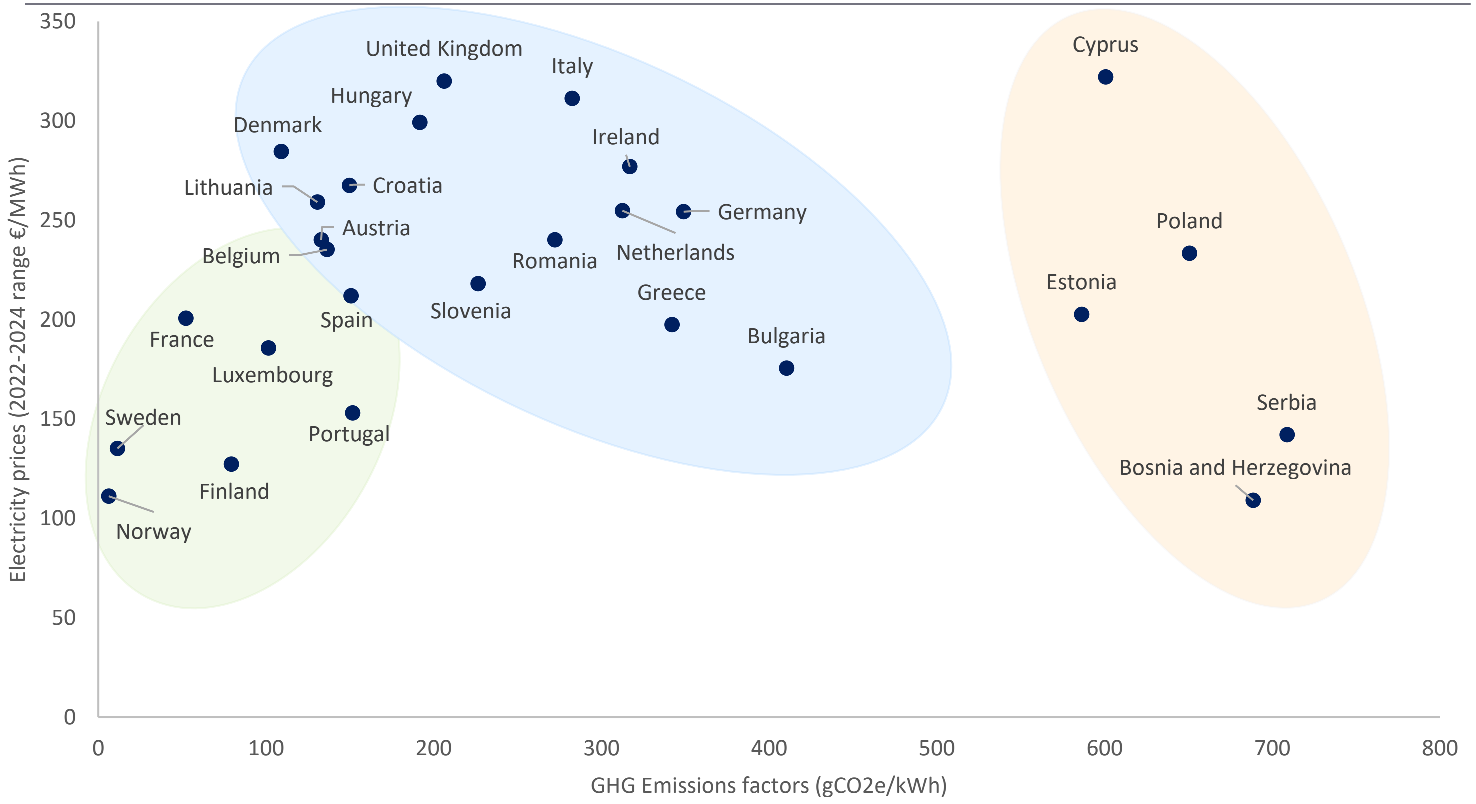
Key take-aways

- R&D related to ICE, including biofuels, currently receives a higher share (44%) than electric batteries (38%).
- However, while R&D dedicated to ICE is expected to decrease by 13% by 2030, R&D for electric batteries is projected to increase by 7%.
- **By 2030, R&D for electric batteries is expected to reach 46%, compared to 38% for ICE.**
- Other low-carbon technologies, such as hydrogen, are prioritized by a lower number of OEMs *(caution is advised when interpreting hydrogen-related figures, as only 6 respondents provided data on this topic)*.

Electric batteries’ TCO and environmental impact may greatly vary according to national specificities (electricity price and carbon intensity of the electricity mix)

While electricity carbon intensities in Europe vary by more than a factor of 100, electricity prices may “only” differ by a factor of 3.

Electricity prices and carbon intensity in Europe [1,2,3]



Competitiveness level for electric batteries deployment:

- 🟧 Least competitive countries (high elec. prices and/or carbon intensity)
- 🟦 Average level of competitiveness
- 🟩 Most competitive countries (low elec. prices and carbon intensity)

Additional information

- Due to European decarbonization objectives, electricity carbon intensities are decreasing in Europe. **Generating one kilowatt hour is estimated to have emitted, on average, 19% less CO2 in 2023 than in 2022 and 35% less than a decade ago.[4]**

Data from ERA carbon reporting project

-84%[5]

average energy GHG emissions reduction

achieved by battery electric machines vs. diesel ICE

Sample: Boom lifts, Compressors, Dumpers, Forklifts, Min & mid excavators, Pumps, Scissor lifts, Sked steers, Wheel loaders, Telehandlers
European average power grid GHG intensity

ERA Energy Transition in Rental | Sources: [1] Eurostat, Electricity prices for non-household consumers, including taxes and levies, Average price between 2022 and 2024; [2] IEA Emissions database, 2021; [3] For UK : UK: non-domestic prices for electricity 2023 | Statista; [4] European Environment Agency; [5] EY Analysis

Illustration for a 2.5 tons excavator – Battery electric equipment offer substantial savings in operational expenses, but the rental fee remains a barrier to adoption for the customers

Electric batteries benefit from strong OPEX savings

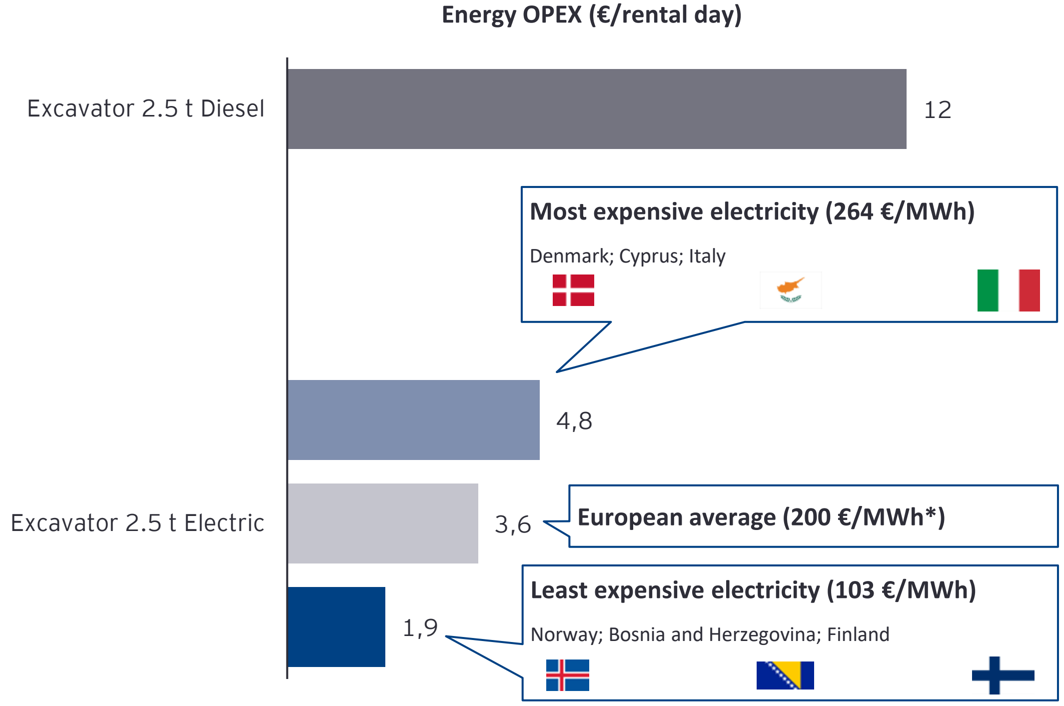
Higher CAPEX but lower OPEX compared to ICE

- The CAPEX premium of commonly rented battery electric compact equipment is in a **[x1.3 – x2.5] range compared to ICE versions.**
- The higher CAPEX of electric equipment is mainly due to battery cost, rapidly decreasing (-4% per year by 2030 for Nickel-Manganese-Cobalt (NMC) and Lithium Ferro Phosphate (LFP), according to EY forecasts).
- Economies of scale are critical to battery electric solutions production cost decline (see battery section).
- The lower energy price and maintenance savings considerably reduce the share of OPEX in TCO.

The higher rental fees remain a challenge for battery electric equipment deployment

- The adoption of battery electric machines remains challenging, as customers often focus solely on upfront rental costs and overlook OPEX savings. Only a few are willing to pay the premium price.
- Time and intensity of use (utilization rate) are critical to leverage on OPEX savings.

Illustration
Energy OPEX savings for a 2.5 tons excavator



Battery electric 2.5t excavators offer approximately **70% savings in euros in energy OPEX** compared to diesel 2.5t excavators, based on average power price in Europe.

However, offsetting the **[x1.3 – x2.5] typical CAPEX** premium (and thus rental fee premium) requires a very high utilization rate, which is rarely observed in most use cases.

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* The average price for Europe has been calculated for the period spanning 2023 to 2024. Sources: Interviews; OEM & Rental Survey; ERA carbon reporting project data on equipment consumption; Eurostat's non household power prices (2024) ; EY Analysis

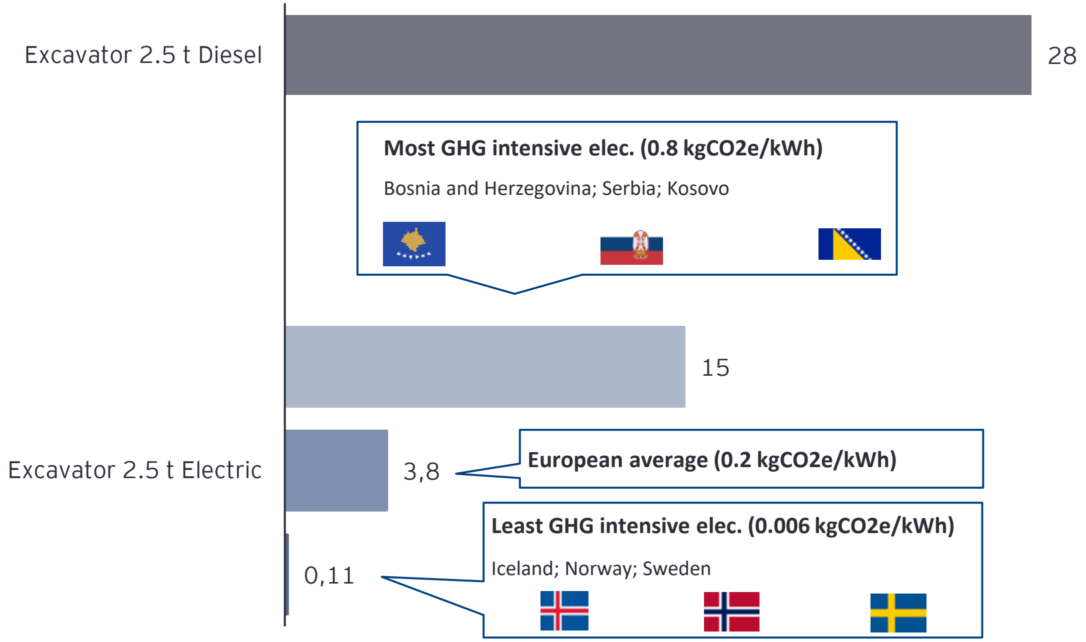
Data collected through interviews and/or survey

Illustration for a 2.5 tons excavator – Electrification provides GHG emission reductions compared to fossil fuels during use phase, even considering emissions associated with battery manufacturing

2.5-ton **electric excavators allow for approximately an 85% reduction in direct GHG emissions compared to diesel excavators**, due to both the lower carbon intensity of electricity compared to diesel and the higher energy efficiency of electric engines.

When calculating in **Life Cycle Assessment (LCA)**, which evaluates environmental impact throughout the entire lifecycle—from raw material extraction to disposal—**the average GHG abatement is around 62%** (European power grid average).

Direct GHG emissions (Scope 1 & 2) – kgCO2eq per rental day*

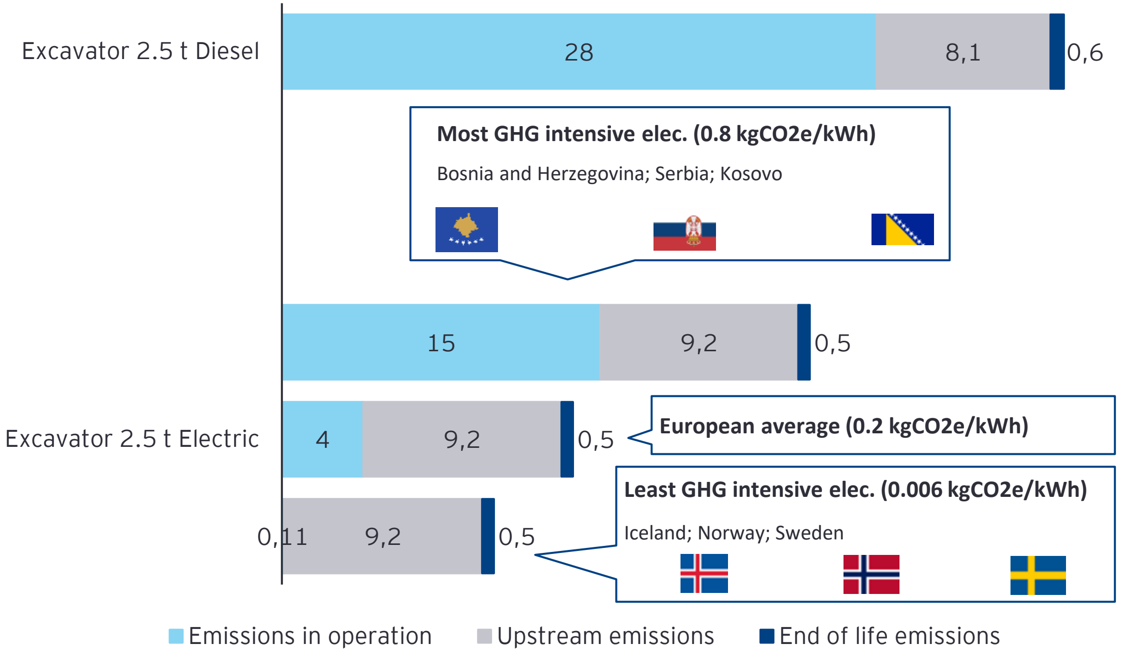


Most GHG intensive elec. (0.8 kgCO2e/kWh)
Bosnia and Herzegovina; Serbia; Kosovo

European average (0.2 kgCO2e/kWh)

Least GHG intensive elec. (0.006 kgCO2e/kWh)
Iceland; Norway; Sweden

GHG emissions in Life Cycle Analysis – kgCO2eq per rental day*



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European average (0.2 kgCO2e/kWh)

Least GHG intensive elec. (0.006 kgCO2e/kWh)
Iceland; Norway; Sweden

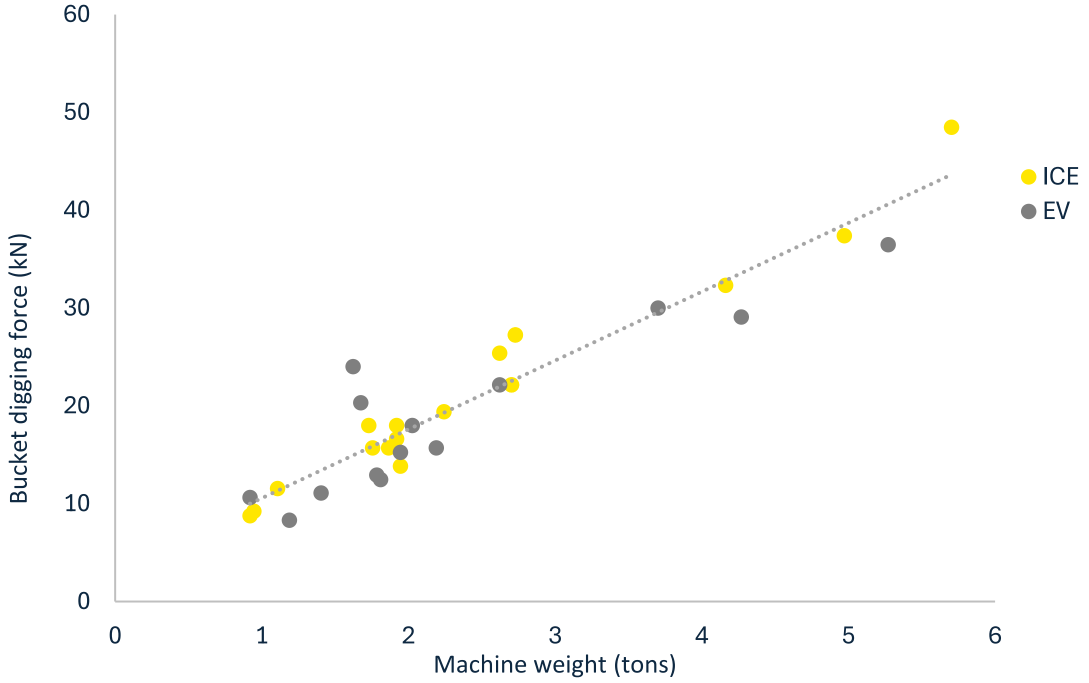
ERA Energy Transition in Rental | *excluding transportation: device manufacturing, emissions in operation (energy), end-of-life emissions | Sources: ERA carbon reporting project; IEA Emissions database, 2021; Equipment manufacturers emissions reporting; EY analysis

Battery electric excavators’ digging power and battery range align with most common usage, offering an operationally viable low-carbon solution

Electric excavators can provide the same digging power as ICE versions.

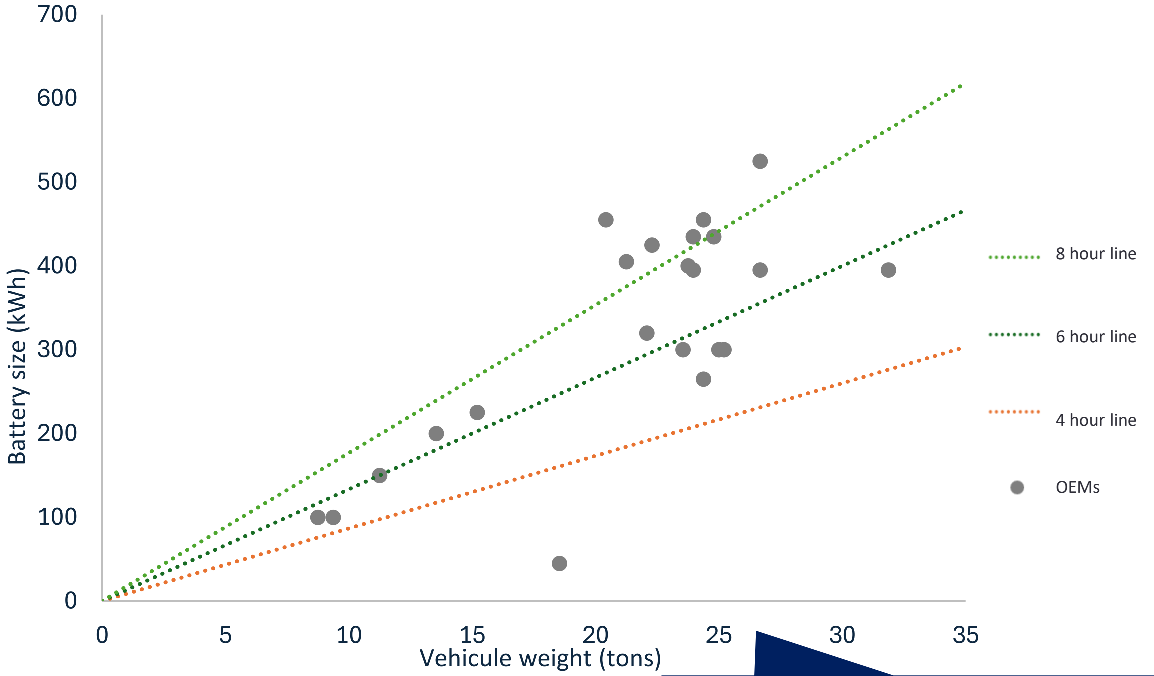
The autonomy of battery electric excavators is not a barrier to adoption for a majority of use cases. Sectoral data shows that most rental excavators (<10t) are used for up to 5 hours per day, aligning with the runtime of existing electric solutions (> 5h).

Electric digging machines up to 6t provide equivalent performance compared to ICE*



**Analysis based on engines’ publics technical information*

Runtime is up to 8hours for excavators up to 25t*

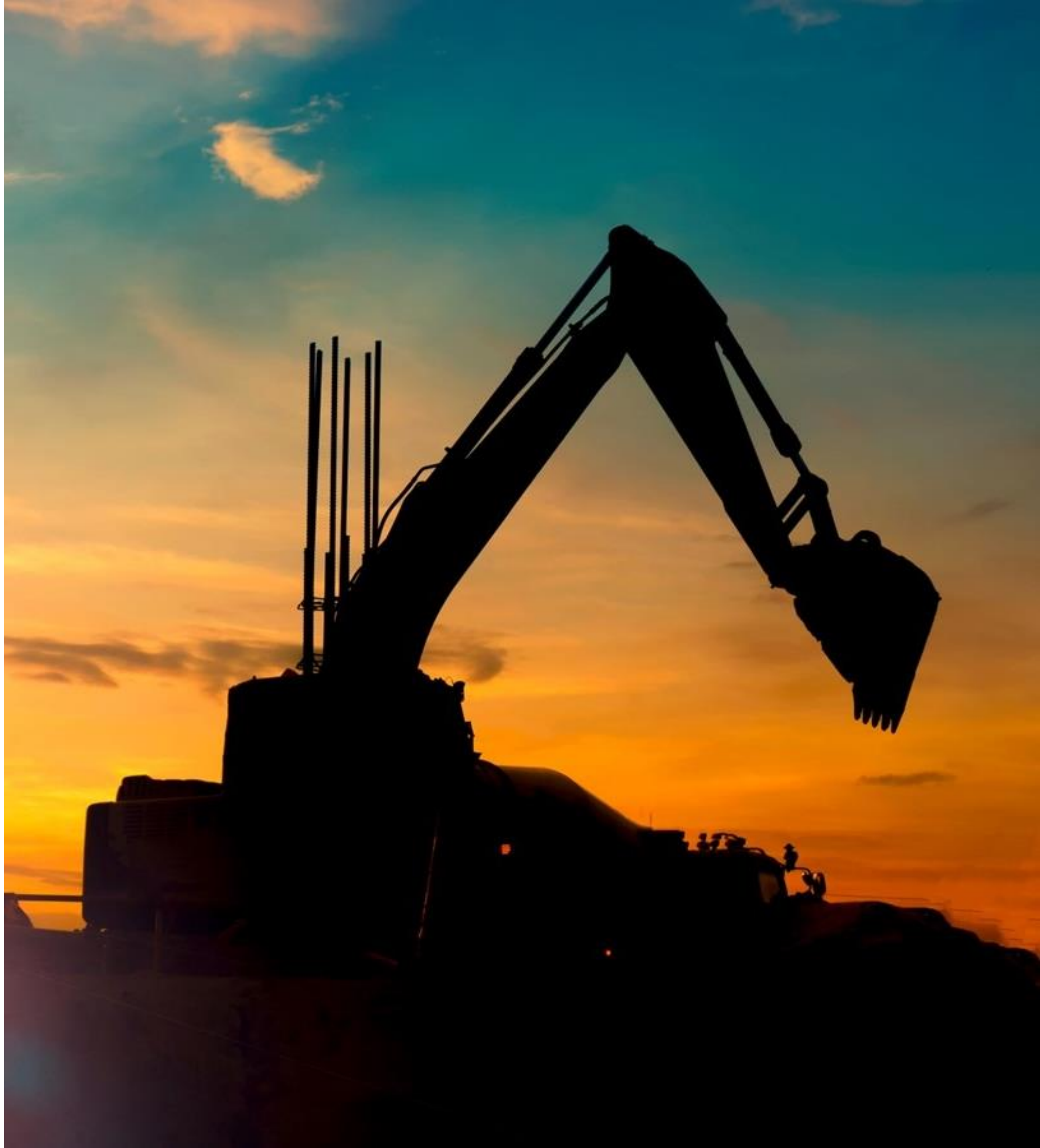


ERA Carbon reporting project data reveals that **excavators are commonly used 3-5 hours/day**

Interviewees declared that **most rental excavators in Europe are <10 t**

Sources: The Electric Future of Construction: EV Machines On The Rise, IDTechEx, 2024

2. Customer value proposition



The customer value proposition is based on the assessment of drivers and challenges for low-carbon solutions adoption, including 3 specific case studies *(construction sector)*

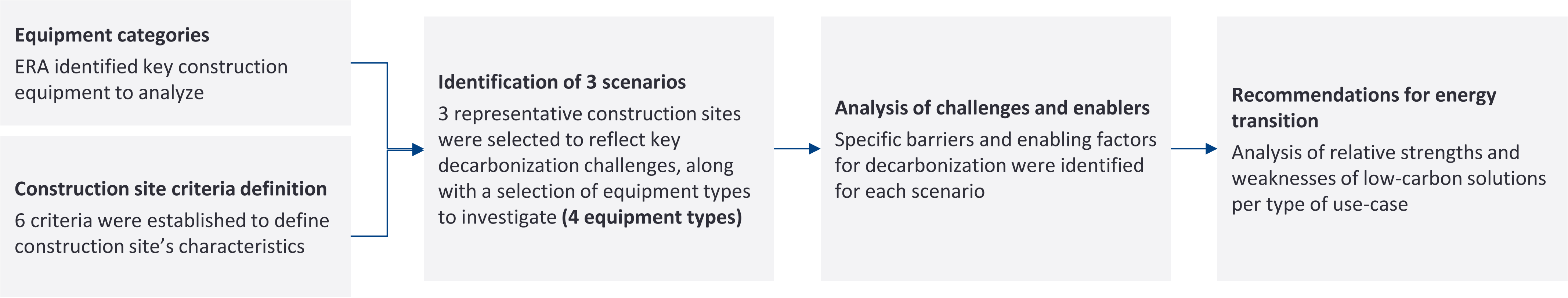
This section aims to explore the energy transition's value for customers through the analysis of the following elements:

1 Drivers and challenges for low-carbon solutions

- Climate and "emission free" regulations were analyzed, as the main enabling factors for low-carbon solutions adoption.
- Top barriers to adoption were assessed per low-carbon solution based on interviews conducted with OEMs (13), rentals (9) and customers (2), as well as rentals and OEMs' answers to the project's online survey.

2 Use case analysis

- The analysis of 3 use cases in the construction sector* aimed at assessing specific challenges and enablers for a low-carbon transition on construction site, as well as providing recommendations to foster such low-carbon transition.
- This analysis has been conducted thanks to the above-mentioned interviews as well as literature review.



Equipment categories
ERA identified key construction equipment to analyze

Construction site criteria definition
6 criteria were established to define construction site's characteristics

Identification of 3 scenarios
3 representative construction sites were selected to reflect key decarbonization challenges, along with a selection of equipment types to investigate **(4 equipment types)**

Analysis of challenges and enablers
Specific barriers and enabling factors for decarbonization were identified for each scenario

Recommendations for energy transition
Analysis of relative strengths and weaknesses of low-carbon solutions per type of use-case

3 Analysis of impacts on rental companies' business models

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* the analysis also applies to other industries (e.g. event)

Top energy transition challenges relate to CAPEX premium, access to energy infrastructure, standardization and practicality of use, clear enablers have been identified to overcome them

	1	2	3
	CAPEX premium	**Energy infrastructure**	**Standardization & practicality of use**
challenges	*Battery electric and hydrogen powered (fuel cells) machines' investment premium is in a 30% - 100% price premium range*	*Electricity supply in operations is a challenge, with grid connection times ranging between several months and a year in urban areas and being rare in remote locations – some locations will never have access to grid connection*	*This category encompasses both charging protocols lack of harmonization and the impact of refueling / charging (time and frequency)*
enablers	**Rentals & customers | high adoption growth rate** ► Foster economies of scale by committing to volumes **OEMs | technology choices** ► Find the right balance between performance (i.e. battery size and chemistry) and cost **Public authorities | regulatory framework** ► Tax externalities, incentivize the adoption of low carbon technologies	**Rentals | energy-as-a-service solutions** ► Facilitate your customers' energy transition by providing energy supply services **Public authorities & DSOs* | grid connection facilitation** ► Optimize grid connection lead times ► Both technical (grid congestion) and administrative gains to be achieved	**Rentals and industry associations | consolidation of needs** ► Coordinate to express needs related to charging standardization **Public authorities | standardization** ► Following the example of the automotive industry charging harmonization, impose common rules to the industry **OEMs | product harmonization**
	economics	*operations*	

*Distribution System Operators | Sources: EY analysis; OEM and rental companies surveys

Battery electric solutions can be prioritized on stationary sites with grid access while biofuels and H2 could be preferred on remote sites with mobile activities

The appropriate choice of low carbon solution mainly depends on local criteria at site and city levels

Operational conditions

- Urban
- Stationary
- Grid access* (>12 kVA) or 1-day operation (no need to refuel or charge)
- Strong client and policy drivers
- -10 °C to 40 °C

Preferred low carbon solutions

Battery-electric equipment

Drivers

- Zero emission policies
- Greater client demand for low carbon solutions

Operational conditions

- Power supply solutions

Operational conditions

- Remote
- Mobile
- No grid access
- Low client and policy drivers
- <-10 °C or >40 °C

Preferred low carbon solutions

HVO and Hydrogen (ICE or fuel cells)

Drivers

- Low demand for zero tailpipe emissions (client and policy drivers)

Operational conditions

- Prioritization of storable and transportable energy

***Note:** in addition to grid access on work sites, it is important to assess power requirements for electric equipment charging in depots

Impacts on business models – Investigate the opportunity to develop energy-as-a-service offers

Mobile batteries

A **mobile battery pack is a portable energy storage unit** designed to provide electrical power in locations where grid access is limited or unavailable.

Battery packs provide benefits compared to ICE power generation, including GHG emissions and noise reduction. They are easy to transport and deploy to different sites, could be used as the main supply power on site or as a back-up, paired with a generator.

- Two types of business models can be identified:

1 Charging on demand, electricity supply service

Offer description: mobile battery packs rental and battery packs are charged during the day using fast-charging stations on rental company's electric truck.

📋 *"A solution to that hourly rate issue would be to drive a change of business model, to go from an hourly rate scheme to a global service scheme"*

Advantages :

- Could be offered to multiple customers within the **same geographical area** (easier to deploy in city centers).

📋 *"Charging on demand is designed as a city solution, allowing networks of customers within an area."*

- Particularly relevant in urban areas where customers are required to have access to electricity, such as **zero-emission zones.**
- **The willingness to pay for this premium service** could be high in such cases where alternatives are limited.

Challenges: Cost and GHG emissions associated with the use of a dedicated truck, the energy consumed by the truck, and the personnel to transport and recharge battery packs.

2 Traditional equipment rental

- The value proposition lies in the rental company's ability to offer the right battery size to meet charging needs, no business model evolution compared to traditional rental.

Swappable batteries

Swappable batteries are portable energy storage units **designed for easy replacement**. They can be quickly exchanged when depleted, ensuring continuous power supply without downtime. Ideal for construction sites and remote locations, they offer convenience and efficiency in energy management.

Due to handling constraints (battery weight), they are more suitable on small devices.

- As for mobile battery, two types of business models can be identified:

1 Charging on demand offer

Offer description: Swappable batteries can be rented. Once discharged, the rental company will retrieve them from the site, provide the client with fully charged replacements, and recharge the previous ones.

2 Traditional equipment rental

Offer description: Swappable batteries can be rented. Once discharged, customers change and recharge the swappable batteries themselves.

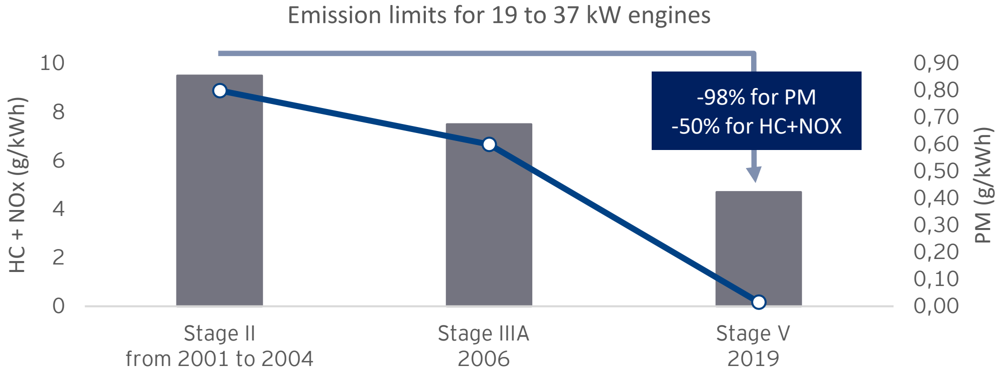
Micro-grids

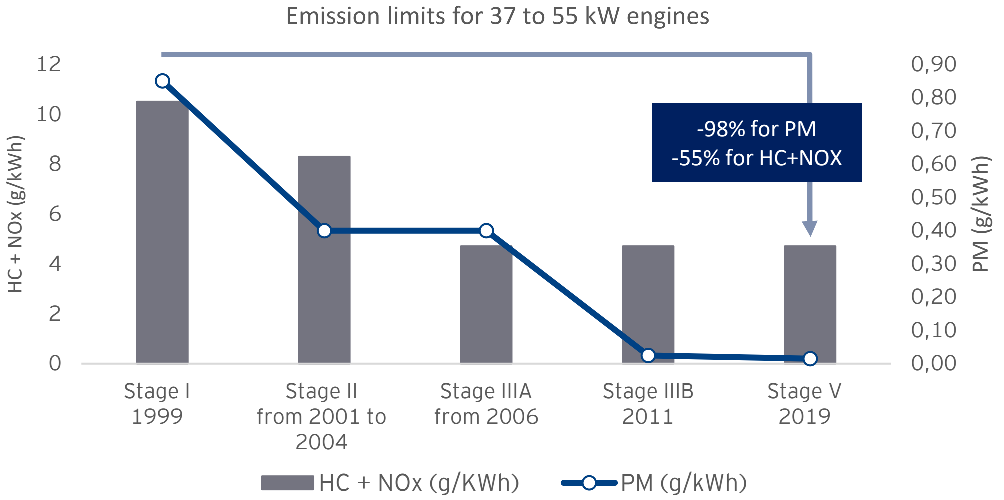
- For long-term projects, microgrids—both AC and DC—will emerge, integrating multiple energy sources such as grid power, solar, wind, hydrogen, storage, and HVO-powered generators. This approach will optimize the total cost of ownership (TCO) and significantly reduce CO_2 emissions.
- For rental companies, this marks a significant shift from offering standalone generators to providing more complex, high-value solutions that benefit both customers and the environment.

📋 Data collected through interviews and/or survey

The EU Non-Road Mobile Machinery (NRMM) regulation sets pollutant emission limits for construction equipment but does not foster a shift from fossil fuels to low carbon solutions

Emission limits from Stage I to Stage V (HC + Nox and PM)





Nox (nitrogen oxides), PM (particulate matter), and HC (hydrocarbon).

Key takeaways

Scopes

- NRMM is defined as any mobile machine, transportable equipment, or vehicle, not intended for the transport of passengers or goods on road. Most construction equipment types are thus in the scope of the regulation, as well as generating sets.
- The regulation only applies to engines and equipment that are placed on the market for the first time. It does not impact the 2nd hand market.

Goals

- Stage V extends the scope of the NRMM to engines below 19kW or over 560kW and introduces new PM emission requirements.
- These emission limits can be achieved by using exhaust aftertreatment technologies (e.g. particulate filters) **and are not a decarbonization driver**.

Regarding biofuels

- Stage V NRMM engines are certified for the use of fuels compliant with the Directive 98/70/ EC or CEN standard EN 228 (diesel or non-road gas-oil, sulphur-free or ultra-low sulphur, cetane number ≥ 45 and fatty acid methyl ester content ≤ 8%).
- HVO and biodiesel blends up to B7 can thus be used on Stage V engines, but diesel particulate filters are still required. For higher biodiesel blends, specific type-approval tests must be performed to obtain stage V certification.

No evolution of the regulation, such as a stage VI new set of thresholds, is studied for the moment.

| Sources: [Regulation (EU) 2016/1628](); [European Stage V non-road emission standards](); [NRMM Guide – Pages](), [Emission Standards: Europe: Nonroad Engines]()

The European Emission Trading Scheme (EU ETS2) will increase the cost of operating fossil fuel equipment from 2027, enhancing low-carbon solution adoption

EU ETS Implementation

- The upcoming EU ETS2* will introduce a carbon price to non-road fuels used by industry and construction, starting in 2025[1]. This will become fully operational in 2027.
- Fuel suppliers will be required to monitor and report their emissions. The additional cost should be reflected in the fuel price.
- According to the European Commission, during the three first years of implementation, the price of allowances should not exceed €45/tCO2e[1].
- The adjacent illustration shows the impact of such allowances' price on energy OPEX.

Although they both refer to 'Non-Road Mobile Machinery' and aim to reduce emissions, the EU ETS focuses on greenhouse gases from specific sectors (such as manufacturing industries and construction), while the NRMM regulation targets pollutant emissions from off-road machinery. These regulations also apply to hand-held equipment and power generation sets.

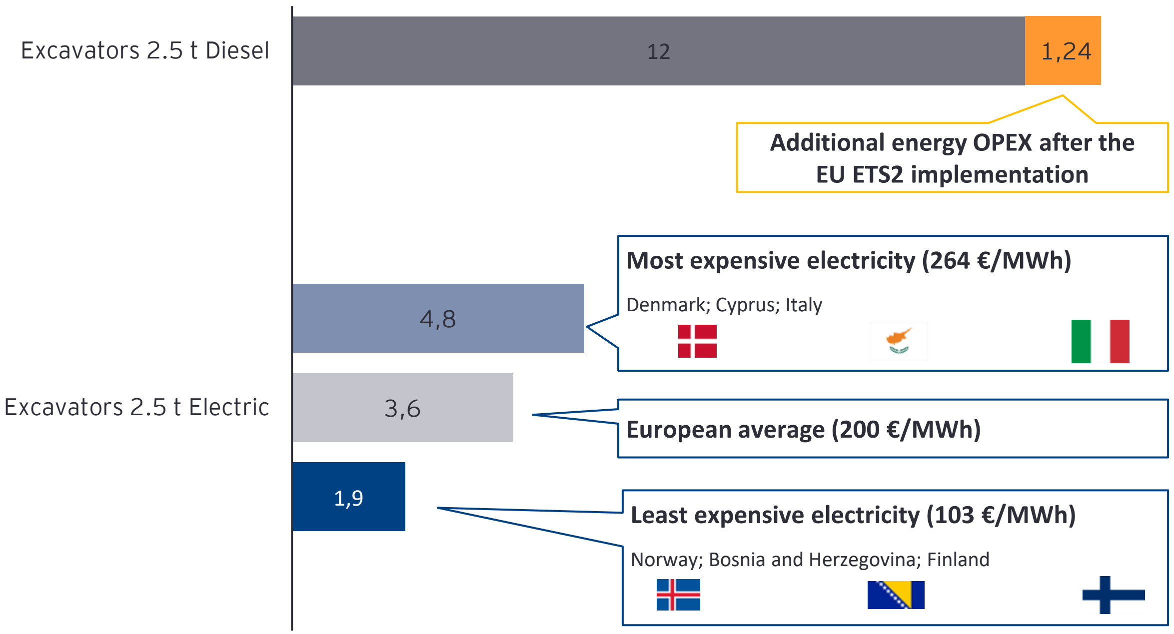
In case of exceptionally high gas or oil prices in 2026, the start of the ETS2 system could be postponed to 2028 to ensure a smooth implementation.
An entity subject to a national carbon tax may be exempted from surrendering allowances until 2030.

Illustration – Energy OPEX for a 2.5 tons excavator after EU ETS2 implementation

When considering a price of €45/tCO2e for allowances, **EU ETS2 will increase diesel fuel OPEX by up to 10%, from 2027.**

In comparison, shifting towards a battery-electric 2.5 tons excavator would significantly decrease energy OPEX (-73% between a diesel 2.5t excavator and a battery-electric one, with European average electricity prices of 200 €/MWh).

Energy OPEX (€ / rental day)



| *Extension of the European Emission Trading Scheme, including the construction sector | Sources: [1]ETS2: buildings, road transport and additional sectors

The revision of the Energy Taxation Directive will increase tax rates on fossil fuels to align with the "Fit for 55" climate strategy and promote the use of low-carbon solutions

Current state of the Directive

- The Energy Taxation Directive (ETD) (2003/96/EC), implemented in 2003, sets EU-wide minimum taxation levels on energy products – when used as motor or heating fuel – and electricity.
- The ETD was set to harmonize rules for the taxation of energy products and electricity to prevent distortions of trade and competition that can result from differences in national tax systems.
- Minimum level of taxation applicable to motor fuels using gasoil in stationary motors and plant and machinery used in construction (Article 8) is 21€/1000L (≈0.6€/GJ) since 2010.
- The ETD is no longer aligned with the new objectives of the "Fit for 55" package.

Energy Product		**Current rates (Article 8)**	
	Petrol, gas oil and non-sustainable biofuels	21 €/1000L	0.60 €/GJ
	Sustainable biofuels and sustainable biogas	21 €/1000L	0.61 €/GJ
	Advanced sustainable biofuels, biogas and RFNBOs*	21 €/1000L	0.61 €/GJ
	Electricity	0.5 €/MWh	0.14 €/GJ

Revision proposal of the Energy Taxation Directive

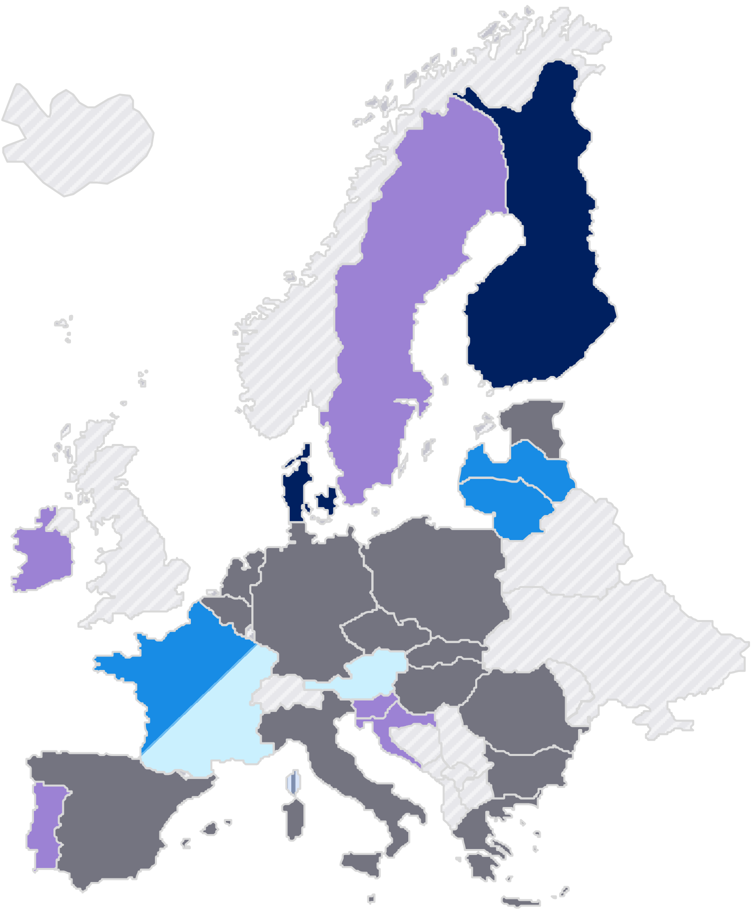
- In 2021, the Commission tabled a proposal for a revision of the ETD, starting in July 2021. Work in both the Council and the European Parliament is ongoing.
- The objective of the revision is to modernize the energy taxation framework, and ensure a taxation aligned with EU's current energy and climate policies under the "Fit for 55" package.
- The main proposed updates focus on two areas:
  - Proposition of a fundamental change from the current volume-based system towards a framework based on energy content (expressed as € per Gigajoule (GJ)) to encourage biofuels adoption.
  - Broadening of taxable base by including more products with a continuous update of minimum rates and removing some exemptions and reductions.
- The ETS 2 covers "Manufacturing Industries and Construction sector", which:
  - Includes: emissions from fuels combustion in industry, including combustion for the generation of electricity and heat for own use in these industries; emissions from fuel combustion in any off-road or mobile machinery as well as head offices of industrial companies.
  - Excludes: The larger installations that are already covered by ETS1, and fuels used for non-energetic purposes for process input, such as chemical reactant (e.g. natural gas for ammonia production) or reducing agent (e.g. iron & steel industry)."
- The future review date of the Energy Taxation Directive (ETD) is unknown.

Energy Product		**Proposed rate (Article 8)**		**Var.**
	Petrol, gas oil and non-sustainable biofuels	31.5 €/1000L	0.9 €/GJ	**+50%**
	Sustainable biofuels and sustainable biogas	15.4 €/1000L	0.45 €/GJ	**-26%**
	Advanced sustainable biofuels, biogas and RFNBOs*	5.25 €/1000L	0.15 €/GJ	**-75%**
	Electricity, advanced sustainable biofuels, biogas and RFNBOs*	0.54 €/MWh	0.15 €/GJ	**+8%**

| * renewable fuels of non-biological origin | Sources: Fit for 55: how the EU plans to revise energy taxation – Consilium; Revision of the Energy Taxation Directive: Fit for 55 package, Proposal for a council directive restructuring the Union framework for the taxation of energy products and electricity (recast), ETIP_B_Factsheet_HVO_feb2020.pdf; European Commission – General Guidance for ETS2 regulated entities., 2024

To promote the adoption of biofuels, European countries are implementing tax incentives, while the ongoing revision of the ETD proposes a tax system based on the climate impact of fuels.

Tax incentives for biofuels in Europe, in the transport sector [1]



◼ **No tax incentives**
Biofuels do not benefit from any tax advantages compared to fossil fuels.

◻ **Lower tax for low biofuels blends**
Biofuels blends with a percentage of fossil fuels content above 70% benefit from lower taxation rates.

🟦 **Lower tax for high biofuels blends**
Biofuels blends with a percentage of fossil fuels content below 70% benefit from lower taxation rates.

⬛ **Taxation based on the energy/CO2 content**
Biofuels are taxed according to their energy content (calorific value) and their average C02 emissions.

🟪 **No excise duty*/exempted from certain taxes (components)**
Biofuels are not subject to exercise duties or are exempt from certain taxes. E.g. Exemption from carbon tax.

▨ **No data**

Key takeaways

- In the EU, all liquid fuels used for a particular purpose or within a specific sector are presently taxed at comparable rates.
- Nevertheless, some EU Member States have introduced specific tax incentives to promote the use of biofuels in the transportation sector.
- The ongoing revision of the Energy Taxation Directive (ETD), which is part of the Fit for 55 package, suggests implementing a tax system based on the climate impact of fuels and energy: [2]
    - Fuels will be taxed based on their energy content and environmental performance instead of their volume. This approach ensures that the environmental impact of each fuel is more accurately represented, aiding both businesses and consumers in making cleaner, more climate-friendly decisions.
    - The categorization of energy products for taxation is streamlined to ensure that the most environmentally harmful fuels are taxed the highest. Products under the Directive are categorized and ranked according to their environmental performance, with fuels having the most detrimental environmental impact facing higher minimum tax rates.

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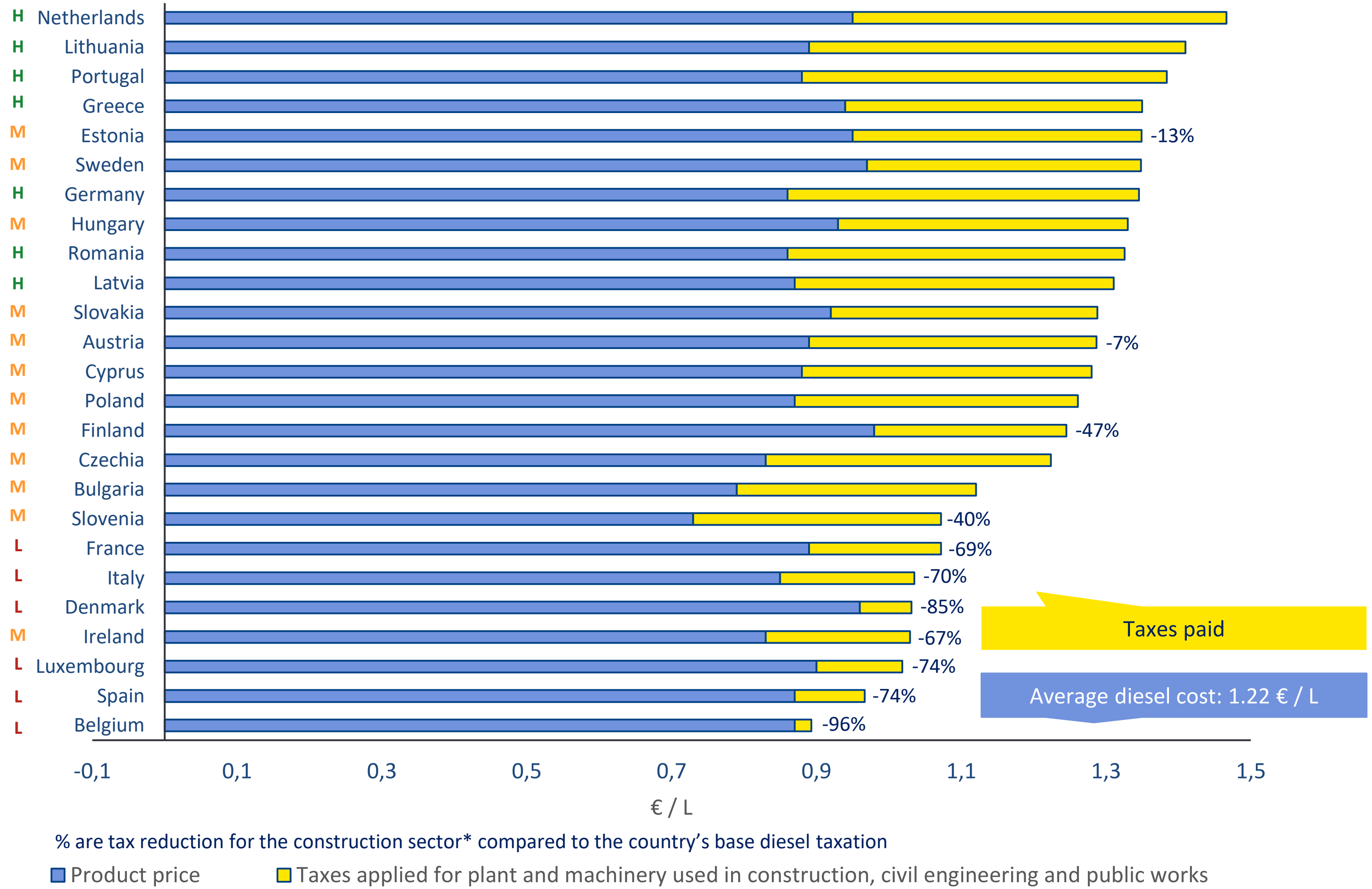
* Excise duties are indirect taxes on the sale or use of specific products such as alcohol, tobacco, energy products and electricity. | Sources: [1] FuelsEurope, 2024 Statistical report, 2024, [2] Revision Energy Taxation Directive - European Commission

National diesel taxes increase diesel machines operational spendings – such taxes vary from € 2cts (Belgium) to € 52 cts per liter (Netherlands)

Diesel prices paid by construction companies across Europe (2024, sector-specific taxation factored in) [1,2]



% are tax reduction for the construction sector* compared to the country's base diesel taxation

Key takeaways

Diesel tax policies vary significantly between sectors across Europe, reflecting different regulatory, environmental and economic objectives.

L *0 – 0.19 €/L*

Low Taxation Countries: Countries with the lowest taxes on diesel for the construction sector offer significant tax reductions compared to the country's base diesel taxation.

M *0.20 – 0.40 €/L*

Moderate Taxation Countries: Countries with moderate taxes on diesel for the construction sector, which are lower than the taxes applied to the rest of the diesel usage or similar.

H *0.40 – 0.52 €/L*

High Taxation Countries: Some countries apply high taxes on diesel for the construction sector, which are the same as the country's base diesel taxation.

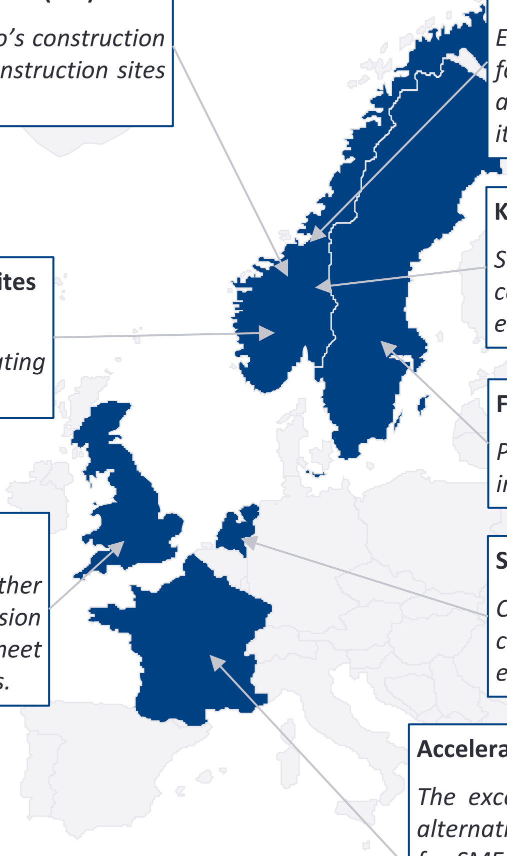
The higher the tax the higher the need to shift to low-carbon solutions.

*Prices of product used in this analysis are the one applied in February 2024 and taxes are the most recent taxes in force

** Information presented on this page is related to European Taxation, UK not comparable.

ERA Energy Transition in Rental | * "plant and machinery used in construction, civil engineering and public works" in the regulation | Sources: [1] FuelsEurope, 2024 Statistical report , [2] EY analysis from European Commission data, Taxes in Europe Database v4 - Advanced Search

Some national and local regulations prohibit the use of internal combustion engine machines or impose GHG emission caps, financial incentives are being developed



Regulations limiting the use of ICE

Climate and environmental requirements for the City of Oslo's construction sites (NO):

Contains standard climate and environmental requirements for the City of Oslo's construction sites, as part of the City's ambitions to have fossil-free and zero-emissions construction sites from 2025.

Prohibition on the use of mineral oil for heating and drying on construction sites for buildings (NO):

From January 1, 2020, use of mineral oil (oil from fossil sources) for heating buildings has been prohibited.

London's Low Emission Zone for Non-Road Mobile Machinery (UK):

Initiative aiming at reducing air pollution from construction equipment and other non-road machinery operating within the city. The zone sets strict emission standards for NRMM used on construction sites, requiring machinery to meet specific criteria for particulate matter (PM) and nitrogen oxides (NOx) emissions.

It is important that regulations are effectively enforced to ensure a fair level playing field.

Financial incentives for low-carbon solutions

Enova Support Scheme (NO):

Enova, a company owned by Norway's Ministry of Climate and Environment, aims to facilitate the country's transition to a low-emission society by managing the Climate and Energy Fund, providing grants to the adoption of low-carbon equipment through its "Emission-free construction machinery" program.

Klimasats Financial Support Scheme (NO):

Support scheme for municipalities and county authorities to help developing low-carbon projects. It has provided funding for zero-emission construction sites and zero-emission machinery.

Financial support from the Swedish Energy Agency (SE):

Possibility of applying for aid from the Swedish Energy Agency: 20-50% of the investment cost for machines with an output of more than 15 kW.

Subsidy for Clean and Zero Emission Construction Equipment (SSEB) (NL):

Construction companies in the Netherlands, that own equipment, and/or rent out construction equipment can apply for this subsidy if they retrofit or buy zero-emission equipment.

Accelerated depreciation of investments in less polluting non-road machinery (FR):

The exceptional deduction scheme allows companies to invest in non-road vehicles using alternative fuels to non-road diesel. Companies can deduct 40% of the original value, and 60% for SMEs. This scheme applies to companies in construction, public works, and other sectors, for vehicles acquired new between January 1, 2024, and December 31, 2026. The vehicles must meet emission criteria and not be intended for road use.

| Sources: EY Analysis on local regulation, [T&E - Reducing emissions from non-road mobile machinery]

Some national and local initiatives are establishing fossil-free sites, creating a positive dynamics for low-carbon solutions deployment

Initiatives of fossil-free sites at country and city levels

Joint Statement of Demand for Emission-free Construction Site Machinery:

Statement for a transition to fossil fuel-free construction machinery by 2025 and a target of at least 50% emission-free machinery by 2030. Signatories, including the cities of Barcelona, Bodø, Copenhagen, Helsinki, Oslo, and Vantaa, commit to requiring fossil-free construction machinery in their public projects, starting with at least 20% emission-free machinery in 2025 and increasing to 50% by 2030, where available.

🔍 Zoom on Oslo next slide

The Dike Reinforcement Project Tiel-Waardenburg (NL):

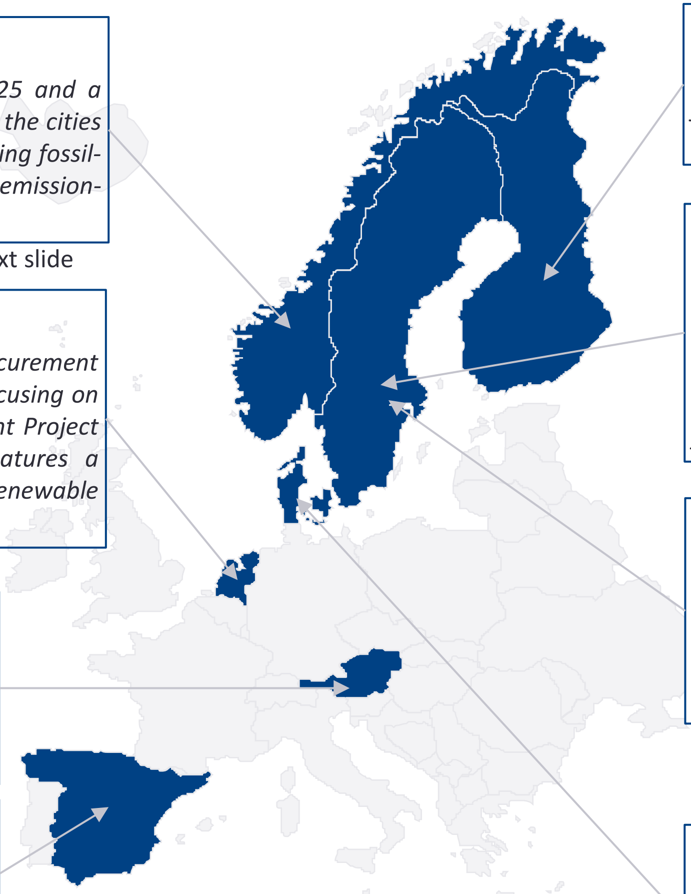
The Big Buyers Working Together (BBWT) Project is exploring sustainable procurement solutions for public authorities, with a recent Study Visit in the Netherlands focusing on Zero Emission Construction Sites. Participants observed the Dike Reinforcement Project Tiel-Waardenburg, which utilizes 42 retrofitted electric machines and features a charging station, designed to support electric construction vehicles with renewable energy sources.

Practical tests for emission-free construction sites in Vienna (AU):

***I**mplementation and evaluation of innovative technologies and practices to eliminate emissions from construction activities. These tests include the use of electric and hydrogen-powered machinery and other renewable energy sources.*

Zero emission construction pilot test in Barcelona (SP):

In 2024, a pilot test using 100% electric machinery, including electric excavators and other equipment, was conducted in Barcelona, promoted by the municipal entity BIMSA.



Finnish Green Deal (for the non-road mobile machinery sector) (FI):

The Finnish Green Deal aims at 100% fossil-free construction sites from 2025, 20% of which using electricity, biogas or hydrogen as an energy source.

Slakthusområdet construction site in Stockholm, 100% fossil-free site (SE):

The Slakthusområdet area in Stockholm is transforming with a CO_2 emission reduction of 1,808 tons, thanks to collaboration among Stockholm City and equipment manufacturers, with electric equipment contributing 421tons. The project mandates a 100% fossil-free site, the use of HVO100 fuel, and at least 10% electric operation.

Södermalm construction site in Stockholm, 100% fossil-free site (SE):

The city of Stockholm has implemented a fully electric construction site in Södermalm. The site utilizes a mobile charging station to address the challenges of limited grid power and ensure that electric machinery, such as excavators, can operate throughout the day.

The CPH 2025 Climate Plan (DK):

Launch zero-emission construction sites in Denmark, to bring down CO_2 emissions as well as reducing noise and pollution. The city is collaborating under the C40 to influence the market and to transition to zero-emission construction machinery.

"initiatives" presented on this map differ from "hard-law" restrictions on the previous page.

Sources: EY Analysis on local regulation; [T&E - Reducing emissions from non-road mobile machinery]

Zoom – Oslo’s emission free construction sites policy shows the key role of public authorities as buyers, regulators and facilitators

City councils have three main levers

Public procurement

- **Oslo City Council accounts for 20%** of the local market’s contract value.
- In 2019, **Oslo City Council introduced procurement criteria** to encourage municipal projects to use emission-free construction.

Regulation

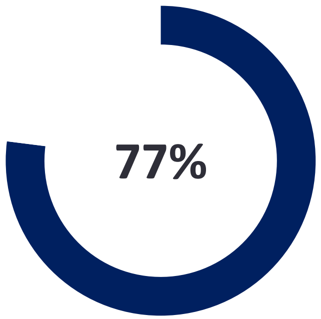
- From 2025, **emission-free construction equipment are mandatory for all public projects.**

Facilitation

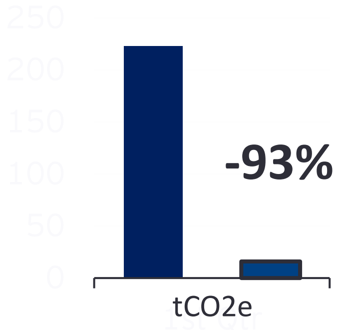
- The Oslo City Council is **active in industry initiatives facilitating knowledge exchange and good practice sharing across Europe** (C40 Cities’ VISIBLE project, FutureBuilt project).

- SMEs, make up 99% of the construction sector, need funding and assistance.
- Oslo **has phased in environmental requirements gradually** to accommodate smaller businesses.

Results achieved in Oslo



of municipal building sites are emission-free



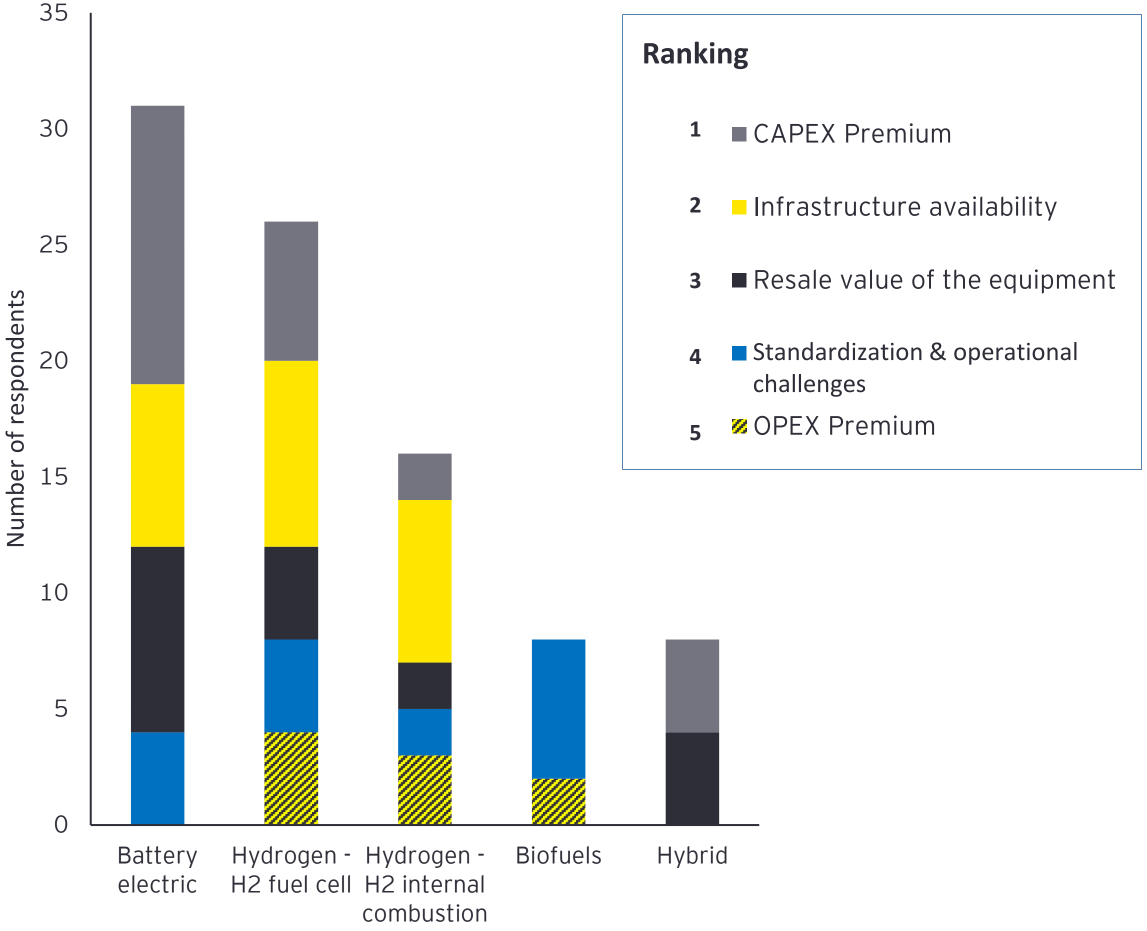
GHG emission reduction

on the Sophie’s Minde’s site compared to conventional building sites

| Sources: C40, Exploring the future of clean construction in Oslo, January 2025

The higher rental price induced by the CAPEX premium is considered the top barrier to adoption of low-carbon solutions, closely followed by operational challenges

Top barriers to adoption per low-carbon solution
(OEM survey)



Rentals point of view *(interviews)*

*"clients do not want to pay a **price premium**"*

*"**CAPEX** are up to x2-2.5 today depending on the products"*

*"critical point right now, solutions **need to have economical advantage**"*

*"there is a real challenge in supporting the **change in practices**"*

*"not only a higher CAPEX per asset, **indirect OPEX will rise in the short term (training),** but direct cost like maintenance will also be lower"*

*"there is even less standards on **hydrogen** and a lot more of caution from the clients, **infrastructure is not** there to provide this kind of equipment."*

Customers point of view *(interviews, construction industry)*

*"our **industry's margin ranges from 3 to 5% on average**, we can't afford to pay the premium for low carbon equipment.*

*"it is **up to our clients to pay for the premium** associated with low carbon"*

OEM point of view *(survey)*

88% of OEMs declare uncertainty as the most prominent barrier to low carbon technologies development

Survey respondents perceive biofuels and hybrid solutions as having the least barriers to adoption

ERA Energy Transition in Rental | * 15 survey respondents ~90% of survey respondents are Europe based | Sources: EY Energy transition project survey

Data collected through interviews and/or survey

ERA has identified four equipment types representative of the European rental market to assess the potential shift to low-carbon solutions, which were included in the use case analysis

Selection of criteria

Four criteria have been identified

#1 Criterion 1:
- **Equipment widely rented in Europe**

#2 Criterion 2:
- **Time of use per day (h/day)**

#3 Criterion 3:
- **Average GHG emissions per operating hour (kgCO2e/h)**

#4 Criterion 4:
- **Is used in other sectors than construction?**

Equipment selection

ERA identified key construction equipment to analyze:

Category	Equipment name	
Power generators	Generator	
Earthmoving	Mini & Mid excavator <10t	
Material handling	Telehandler	
Powered access	Telescopic boom lift	

Equipment analysis

Criterion #1	Criterion #2 h/day	Criterion #3 *kgCO2e/h*	Criterion #4
Yes	5	75	Yes
Yes	3	12	No
Yes	3	21	Yes
Yes	3	19	Yes

These product categories rank the highest in the survey responses to the answer: "what products do you sell or rent?"

Power gen. Telehandler Mini excavator Boom lift

ERA Energy Transition in Rental | Sources: Meeting on Jan 20th (EY, Sunbelt, Mateco, Boels); Other project team meetings and interviews; Data from ERA, Climate Neutral Group, Carbon footprint of Construction equipment, 2019.

Six factors define the key characteristics of construction sites and were used to develop use cases representative of such construction sites

1 LOCATION

- **Urban:**

Usually subject to environmental regulations, good grid access (connection lead-time to be factored in)

- **Suburban:**

Potentially less subject to environmental regulations, moderate grid access (less congested than city centers)

- **Remote:**

Potentially even less subject to environmental regulations, no grid connection available

2 CLIENT AND POLICY DECARBONIATION DRIVERS

- **Strong drivers:**

Zero emission zones fostering strong willingness to pay from clients

- **Moderate drivers:**

Voluntary decarbonization commitments from clients (moderate willingness to pay)

- **No driver**

3 MOBILE OR STATIONARY

- **Stationary:**

Likely to have access to grid access or “complex” energy management (optimized power gen.)

- **Mobile:**

Complex energy management and logistics

4 ELECTRICITY ACCESS

- **Access to power:** *More than 12 kVA*

Allows to charge several machines simultaneously on the same site

- **Limited access to power:** *3 kVA to 12 kVA*

Power availability is a constraint although the connection allows to slow charge machine

- **No access:** *Less than 3 kVA*

Power supply to the site is a challenge

5 WORK DURATION

- **<2 days**

Depending on the machine range, rental without a refueling solution to be considered

- **2 days to 2 months:**

Typical grid connection lead time on a stationary site (can vary greatly, up to a year)

- **> 2 months:**

Work site to be connected to the power grid depending on its location

6 TEMPERATURE CONDITIONS

- **Standard operating temperature range:** *Between 10 °C and 40 °C*

Battery performance is not or not significantly affected by temperatures (mostly determined by the use of HVAC and heating systems)*

- **Extreme temperatures:** *<-10 °C and >40 °C*

Battery performance can be significantly affected (up to 40% at -20°C[1,2]). In addition, battery is to be charged before use to be heated

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ERA Energy Transition in Rental | *Heating, ventilation, and air conditioning | Sources: EY analysis, Interviews, Volvo CE , [1]Effects of ambient temperature on electric vehicle range considering battery Performance, powertrain Efficiency, and HVAC load, Jigu Seo et al, [2]Geotab analysis,

Data collected through interviews and/or survey

Based on the 4 equipment to be investigated and the 6 feasibility factors for a construction site to conduct an energy transition, 3 use cases (scenario) have been prioritized

Scenario	Location	Stationary vs. mobile	Duration	Grid access & power supply	Equipment	Challenges analyzed
#1 Building construction in city centers a. Before grid connection b. After grid connection	Urban 🟢	Stationary 🟢	1 year 🟢	12 kVA 🟢 (lead time of ~2 to ~6months) 🟠	a. Before grid connection b. After grid connection	Strong pollution reduction requirements Grid connection lead time and limited power (12 kVA)
#2 Short duration public works in city centers a. <2 days b. 2 to 10 days	Urban 🟢	Mobile 🟠	1 to 10 days 🟠	No access 🟠		Strong pollution reduction requirements Energy supply logistics
#3 Remote road work	Remote 🟠	Mobile 🟠	6 to 24 months 🟢	No access 🟠		Remote location Energy supply logistics

The use cases were considered for temperatures between -10°C and 40°C

Power gen. Telehandler Mini excavator Boom lift

🟢 Enabling factors 🟠 Challenges

Scenario #1a – Building construction in city centers without grid access require large battery or HVO powered mobile machines

Scenario characteristics	**Urban**	**Building construction**	**Stationary**	**1 year**	No grid connection		First weeks: no grid connection, mini excavators are used

In the initial phase of a building construction project in a city center, mini-excavators are commonly used and **no access to the power grid is available.** In this context, **several energy supply options are to be considered**.

Being located **in a zero-emission zone and the client's willingness to pay a premium** price are key decision-making criteria.

Option choice

Equipment type

Power generation

Comparison HVO / Electric*

HVO

2.5 tons ICE mini excavator fueled with HVO, used 5 hours per days
- Consumption: 12 L/day

→ The mini excavator is fueled with HVO. Minimum of 12 liters per day are needed on site to refuel.

+ Ease of use	- Energy OPEX
+ Rental fees	- Noise
+ Operates in low temp.	- Pollution

Electric

2.5 tons battery electric mini excavator, used 5 hours per day
- Battery size: 40 kWh
- Consumption: 36 kWh/day

The client's objective is to choose equipment that is as energy self-sufficient as possible for a full workday.

OR

Mobile battery pack
- __Option 1:__ One mini excavator accepting Type 2 plug three-phase, enabling to charge the machine between one and two hours to reach 80% charge during lunch break with a battery pack
- __Option 2:__ One mini-excavator accepting Type 2 plug mono-phase not enabling to fully charge the equipment during the lunch break
    - Solution: Use a mobile battery pack with fast charge.
    - Challenge: Need a fast charger designed by the same OEM as the machine.

Hydrogen Generator

One Hydrogen Generator could be used for power generation on-site. In view of the operational constraints, this case should only be considered if this solution is deployed for the entire duration of the project.

+ Energy OPEX	- Operational constraints
+ Pollution	- Rental fees
+ Noise	

** From customer's point of view*

● Enabling factors ● Challenges

ERA Energy Transition in Rental | Sources: EY analysis on data collected through OEM and rentals interviews; ERA, Climate Neutral Group, Carbon footprint of Construction equipment, 2019 (for data on HVO consumption).

Scenario #1a – Zoom – Onboard chargers' specifications have a strong impact on charging time and therefore determine users' ability to conduct day-time charging

Main challenges for equipment day-time charging

- Equipment type with similar battery capacity (from 35 to 40kWh) may have different onboard charges. Some onboard charges types are too slow for the device to be charged with the grid during the day.
- Equipment with mono-phased plugs need a longer charging time. For these types of equipment, a fast-charger is therefore needed to be charged during lunch break.
- However, fast chargers are not interoperable between different manufacturers: a specific fast charger is required for each brand of equipment.

Differences between onboard charges (three-phase or mono-phase) for charging:

	Onboard charge type specification	Charging duration	Specifications needed for day-charge
Three-phase plug	400 volts, 16 A, 32 A or 63 A	From 1 to 2 hours	The machine can be charged with onboard charge during lunch break with no specific device.
Mono-phase plug	230 volts, 16 A or 32 A	More than 2 hours	The equipment need a specific fast-charger to be charged during lunch break.

| Sources: EY analysis on data collected through OEM and rentals interviews

Scenario #1b – On building construction sites in city centers, once grid connection is available, battery can be used to fast-charge equipment

Scenario characteristics	**Urban**	**Outdoor, building construction**	**Stationary**	**1 year**	12 kVA **+**		After 2 months : grid connection available, mini excavators, telehandlers and boom lifts are used

In the second phase of a building construction project in a city center, the working site is finally **connected to the grid.** During this phase, there are several equipment on-site including mini excavators, boom lifts and telehandlers. In this context, **one main energy supply options must be considered**.

Being located **in a zero-emission zone and the client's willingness to pay a premium** price will be key decision-making criteria.

Option choice

Electric

Equipment type

2.5 tons electric mini-excavator, used 3 hours per day
- Battery size: 40 kWh
- Consumption: 22 kWh/day

6 m battery electric telehandler, used 3 hours per day
- Battery size: 24 kWh
- Consumption: 15 kWh/day

20 m battery electric boom lift, used 3 hours per day
- Battery size: 22 kWh
- Consumption: 22 kWh/day

Power generation

The electrical grid charges both the mobile machine and the battery pack used as a backup

Connection to the grid
- Grid power: 12 kVA

The mini excavator, the boom lift and the telehandler are slow-charged on grid, on-site during the night.

With a back up fast charge battery pack

If the device is used 3 hours per day, there is no need of a battery pack as a back-up.

If the machine is used more 3 hours per day, a back up fast charge battery pack could needed to fast-charge equipment during the day.

The battery pack is slow-charged on grid, on-site.

Comparison versus diesel equipment*

- + Energy OPEX
- + Pollution
- + Noise

- - Rental fees
- - Operational constraints

** From customer's point of view*

● Enabling factors ● Challenges

Scenario #1b – Zoom – Example of a power generator providing a charge during lunch break on a 12 kVA grid connection

Typical grid power on construction sites

Voltage on site:

- Mono-phase: 230 volts (needed when small equipment are operated)
- Three-phase: 400 volts (needed when *heavy equipment such as cranes are operated)*

Amperage on site:

- Mono-phase: 16 A to 32 A
- Three-phase*: 16 A, 32 A or 63 A*

Power on site:

***Mono-phase:** from 3.7 kVA to 7.4 kVA*

***Three-phase:** from 6.4 kVA to 25 kVA*

Limiting factors impacting the choice of battery size and power delivered

Grid capacity on site:

- Depending on the power delivered on site by the grid, a battery with a higher capacity will be needed to charge all equipment during lunch break.

Number of equipment to be charged:

- Depending on the number of equipment to be charged, the power delivery and battery capacity will differ.

Charging speed:

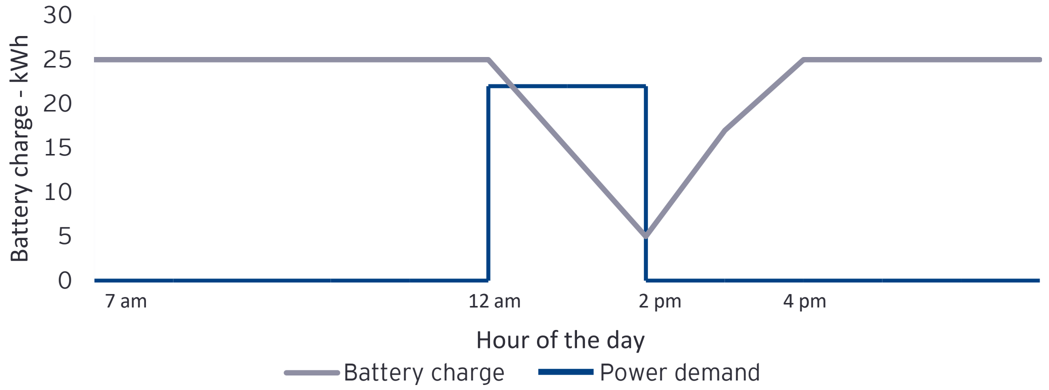
- Depending on the plug type of the equipment, the power delivered by the battery *will be limited and a fast-charger will be needed*

Scenario 1b

Battery pack and grid capacity	Equipment used	Charging time
▸ Battery pack of 30 kWh ▸ Power delivered by the battery: 25 kVA ▸ Grid power: 12 kVA	▸ 1 mini-excavator of 40 kWh ▸ 1 telehandler of 24 kWh ▸ 1 boom lift of 22 kWh Every equipment has a mono-phase plug onboard	▸ 1 mini-excavator is charged at 12 pm ▸ 1 boom lift is charged at 1 pm ▸ 1 telehandler is charged at 2 pm

→ A battery pack of at least 25 kWh delivering at least 25 kVA of power can provide necessary energy to charge 3 equipment during lunch break from 0 to 50 %.

Scenario 1b – Power need for a charge during lunch break with an external charge



| Sources: EY analysis on data collected through OEM and rentals interviews

Scenario #2 – Public works in city centers without grid access mainly influenced by work duration required HVO or a mobile battery pack

Scenario characteristics	**Urban**	**Outdoor, public works**	**Mobile**	**1 to 10 days**	No grid connection		Repair work on electrical pylons in the city center, 1 to 10 days. A boom lift is used.

Public works are mobile operations, thus grid access is not available. Duration is a key choice criterion as a battery boom lift can operate **1 day without recharging** (with a range extender if needed).

Being located **in a zero-emission zone and the client's willingness to pay a premium** price will be key decision-making criteria for longer operations.

Option choice		Equipment type	Power generation	Comparison HVO / Electric*	
Electric	*1 day work*	**20 m electric boom lift,** used 3 hours per day • Battery size: 22 kWh • Consumption: 22 kWh/day • Range extender to be added if operations >3 hours	No charging or access to power supply solution needed	⊕ Energy OPEX ⊕ Pollution ⊕ Noise	⊖ Operational constraints ⊖ Rental fees
	1 to 10 days work	**20 m electric boom lift,** used 3 hours per day • Battery size: 22 kWh • Consumption: 22 kWh/day	**Mobile Battery pack** The boom lift is fast-charged during the lunch break (1 hour) every day. The battery pack is charged on the grid at the depot during the night.		
HVO	*1 to 10 days work*	**20 m ICE boom lift,** used 3 hours per day • Consumption: 18 L/day	The boom lift is fueled with HVO. Minimum of 18 liters per day are needed on site to refuel.	⊕ Ease of use ⊕ Rental fees	⊖ Energy OPEX ⊖ Noise ⊖ Pollution

** From customer's point of view*

● Enabling factors ● Challenges

ERA Energy Transition in Rental | Sources: EY analysis on data collected through OEM and rentals interviews; ERA, Climate Neutral Group, Carbon footprint of Construction equipment, 2019 (for data on HVO consumption).

Scenario #3 – Remote construction sites, such as road works, are the most challenging to decarbonize due to energy supply logistics

Scenario characteristics	Remote	Outdoor, road construction	Mobile	6 to 24 months	No grid connection		Other equipment types used on site include wheel loader and rollers.

Remote works are mobile operations, thus grid access is not available, and **no access to the power grid is available.** In this context, **several energy supply options are to be considered**.

The client's willingness to pay a premium price and **operational constraints** will be key decision-making criteria for longer operations.

Option choice | Equipment type | Power generation | Comparison between solutions*

On site power generation

Important power generation capacities can be decarbonized and supply power to electric mobile machinery

2.5 tons electric mini-excavator
- Battery size: 40 kWh
- Consumption: 21 kWh/day

6 m battery electric telehandler
- Battery size: 24 kWh
- Consumption: 15 kWh/day

HVO Power generator (example below)
- Tank capacity: 220 L
- Refueled monthly if the generator is used every night to charge equipment to 100 %.

Equipment is slow-charged by the HVO generator on-site during the night.

+ Ease of use, Rental fees
- Energy OPEX, Noise, Pollution

Mobile Battery pack (example below)
- Battery size : At least 45 kWh
- Power delivered: 45 kVA

Equipment accept Type 2 three-phase enabling fast-charged on-site by the mobile battery pack. The mobile battery pack is slow-charged during the night on grid at the depot.

+ Ease of use, Rental fees, Pollution, Noise
- Operational constraints

H2 ICE power generator or Fuel cell H2 generator (example below)

Equipment is slow-charged on-site during the night.

In view of the operational constraints, this case should only be considered if this solution is deployed for the entire duration of the project.

+ Rental fees, Pollution
- Energy OPEX, Noise, Operational constraints

HVO or H2

HVO or low-carbon hydrogen are used as energy vectors to fuel mobile machinery

2.5 tons ICE mini excavator with HVO, 3 used hours per day
- HVO Consumption: 7.2 L/day

6 m telehandler fueled with HVO, used 3 hours per day
- HVO Consumption: 12 L/day

→ The ICE mini excavator and the telehandler are fueled with HVO or H2. Minimum of 19.2 liters of HVO per day are needed on site to refuel.

Equipment fueled with H2, used 3 hours per days → Need to size the on-site H2 tank capacity to meet equipment needs, enabling weekly delivery.

HVO
+ Ease of use, Rental fees
- Energy OPEX, Noise, Pollution

H2
+ Pollution, Noise
- Energy OPEX, Rental fees, Operational constraints

** From customer's point of view*

● Enabling factors ● Challenges

ERA Energy Transition in Rental | Sources: EY analysis on data collected through OEM and rentals interviews; ERA, Climate Neutral Group, Carbon footprint of Construction equipment, 2019 (for data on HVO consumption).

Impacts on business models – Rental companies can play a facilitation role in the energy transition

Rental companies' value proposition

- **The energy transition requires professional expertise and important CAPEX** compared to "business-as-usual" diesel powered machines.
- Customers interviewed as part of the energy transition project expect **rental companies to help them navigate these two challenges.**

Flexibility & Risk mitigation

- Offer your clients the opportunity to **trial low-carbon solutions**
- **Mitigate their investment risks** associated with the purchase of machines featuring new technologies
- Allow them to **optimize cash flows** through the choice of rental vs. acquisition

Expertise

- Leveraging on the **feedback from your client portfolio and ERA membership,** you are able to best advise your clients (e.g. technology choice, onsite power generation optimization)

Avoiding the "chicken-and-egg" situation

- Expertise, flexibility and risk mitigation benefits offered to customers **come at a cost for rental companies.**
- **ERA members have shared their concerns about the risk of investing** in new technologies without securing the volumes and prices required to balance their income statements.
- **Engaging with clients to ensure balanced risk-sharing is needed to avoid a "chicken-and-egg"** situation where customers are waiting for rental companies to offer low-carbon solutions and rental companies are waiting for firm long-term commitments to secure their revenues.

Energy-transition clauses in framework contracts

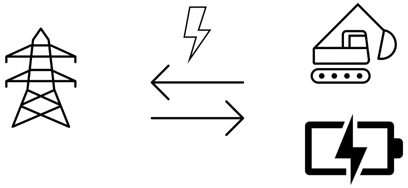
- Energy transition technology developers need long-term visibility to engage in the necessary investments for scaling up. In Europe, investment decisions in sustainable aviation fuel or green hydrogen production projects, for example, are made after the announcement of securing a sales volume.
- For example, they could investigate the possibility of adding clauses to framework contracts that **commit their customers to dedicating a certain percentage of their spending to the rental of low-carbon equipment.**
- This would **secure the investments of rental companies and enable them to secure to volumes with OEMs.**
- Rental companies could engage in an **open discussion with their customers to determine whether other options for de-risking investments are to be considered**.

Data collected through interviews and/or survey

Impacts on business models - Assessing the potential monetization of stored equipment's battery capacity could create another source of revenues

Bi-directional charging to sell electricity to the grid

- **Vehicle-to-Grid (V2G)** is a more advanced type of charging, allowing the bidirectional transfer of electricity from the grid to the vehicle's battery storage and vice versa. This system can therefore be applied to provide flexible power and help balance the grid. This can also apply to storage equipment (flexibily exchanging power with the grid).



Decision making criteria

- Country regulation
- Country power market fundamentals and potential BESS* revenues
- Rental agency location and grid capacity (e.g., need for grid reinforcement?)
- Rental agency customer use patterns (when are the machines unused?)

Revenues

i) Price arbitrage: make a revenue from the price spread

- Store electricity during low price periods
- Inject back on the grid during peak hours

ii) Other business cases (**ancillary services, capacity markets**)

Costs

- Additional battery degradation
- V2G charging infrastructure
- Additional grid connection investments

Use-case example

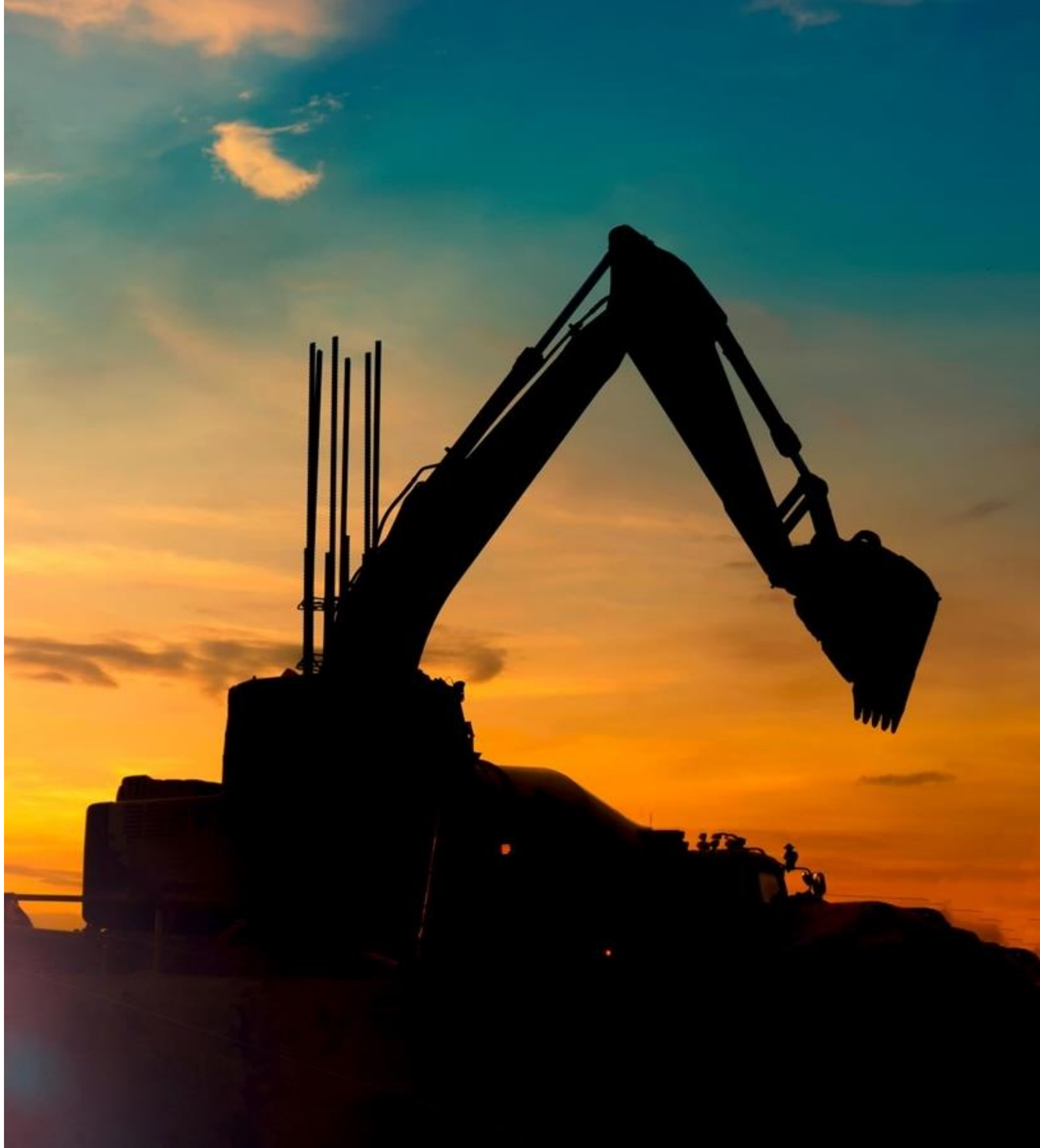
V2G in a truck depot in Germany (2024 study)

- 30 trucks: 30% with a 250 kWh battery, 70% with a 500 kWh battery; 100 kVA max. charging;
- Based on real life data, savings and revenues modelling between

€ 3,000 to 10,000 / year / truck

| *Battery Energy Storage Systems | Sources: [1] Transport & Environment; Fraunhofer

3. Focus on battery electric standards and interoperability



A focus on battery technologies, charging standards and implied training needs has been conducted to assess battery electric standards and interoperability challenges

This section focuses on battery electric technologies, and intends to analyze the following elements:

Battery technologies

- Assessment of the different batteries' chemistries:
    - Lead Acid batteries
    - Lithium Ferro Phosphate (LFP) batteries
    - Nickel-Manganese-Cobalt (NMC) batteries
- Presentation of the evolution of energy density and trends in production costs for LFP and NMC batteries
- Presentation of emerging battery technologies

Charging standards

- Presentation of charging modes (AC / DC) and connectors existing on the market: Type 2; Combined Charging System (CCS); CHArge de MOve (CHAdeMO); Megawatt Charging System (MCS)
- Presentation of the **differences in EU regulations regarding charging communication protocols for CCS fast-charging** between road vehicles and non-standardized Non-Road Mobile Machinery
- Presentation of interoperability challenges regrading CCS (Combined Charging System) fast-charge standard

Training needs

- Review of training needs among the value chain to operate electric equipment
- Both regulatory safety training requirements and voluntary skills development to be anticipated

Formulation of recommendations for ERA to take action in favor of greater standardization and harmonization of battery electric equipment charging across Europe.

Several battery chemistries are available on the market, with LFP and NMC batteries dominating in Europe, North America and China

Three types of batteries have been analyzed (Pb-Acid, LFP, NMC)

- Several type of batteries exist on the market. The main developed types are Lead-acid (Pb-Acid) batteries, LFP (Lithium Ferro Phosphate) and NMC (Nickel Manganese Cobalt) batteries.
- These batteries differ in their chemistry, the materials used in their manufacturing, their cost, safety of use, lifespan, charging duration, energetic performance, and recyclability.

	Materials	*Maturity level*
Lead Acid	Lead and sulfuric acid	Created in 1859, mainly used in SLI* batteries and storage stationary batteries
LFP *Lithium Ferro Phosphate batteries*	Lithium, iron and phosphate as the cathode material	**Start of industrial production around 2010**
NMC *Nickel-Managanese –Cobalt batteries*	Nickel, manganese and cobalt as the cathode material	**Start of industrial production around 2000, but massive adoption since 2020**

**Starting, Lighting and Ignition batteries*

In the construction sector, LFP and NMC dominate the market

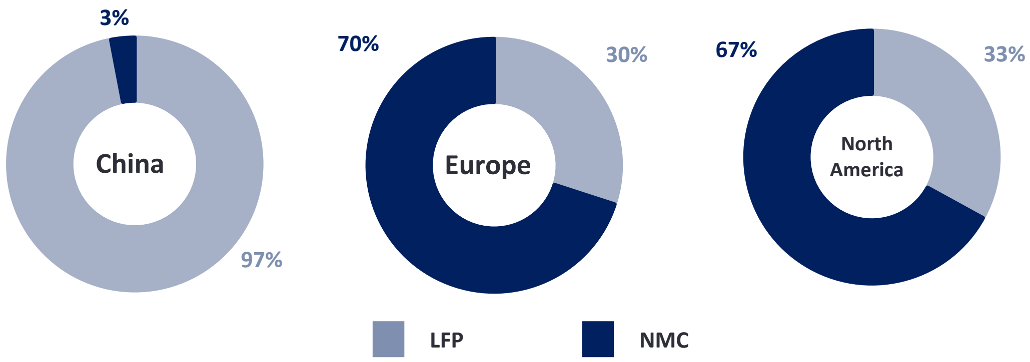
Battery chemistries

- Early electric construction machines used lead-acid (Pb-Acid) batteries. With advancements in Li-ion technology and the increase in machine size, lead-acid batteries are losing their advantages and are gradually being replaced.
- LFP (Lithium Ferro Phosphate) and NMC (Nickel Manganese Cobalt) batteries are used in relatively equal proportions.

Battery chemistries regional segmentation [1]

- *In China* - LFP batteries are used in most cases.
- *In North America and in Europe* – In both regions, NMC batteries are primarily used, yet LFP batteries continue to hold a considerable market share.

Market share by battery chemistry and by region



Sources: [1] The Electric Future of Construction: EV Machines On The Rise, IDTechEx, 2024.

Battery chemistry choices consist in a trade-off between performance and costs — when high performance is unnecessary, machines can be equipped with lower-cost batteries

While NMC batteries offer the highest performance, particularly due to their higher energy density and lower energy losses, they face growing competition from LFP batteries, which have lower manufacturing costs and steadily improving performance.

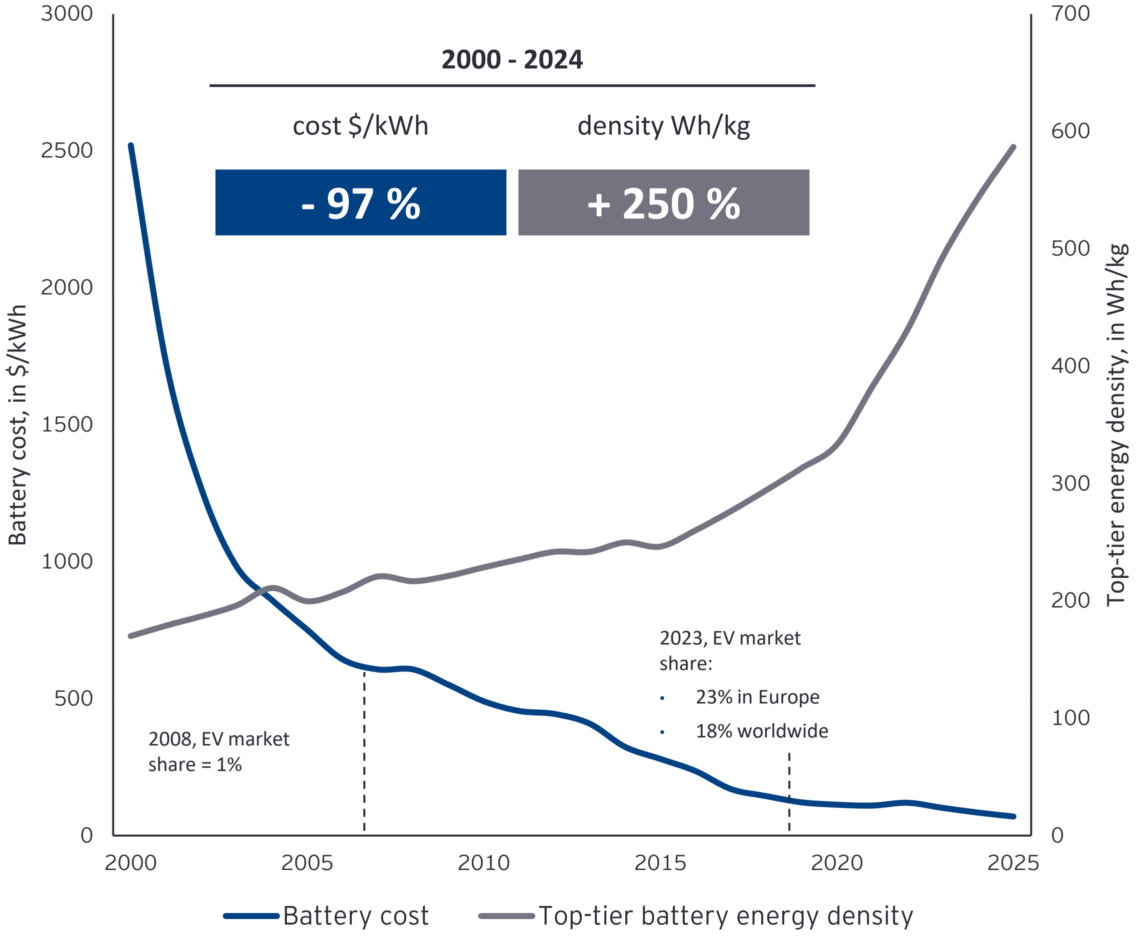
Chemistry	Energy density	Cost	Safety	Charging speed	Lifespan	Specific power	Energy losses	Recyclability	Material criticality
Lead acid *Low performance, low cost*	■□□ 35-40 Wh/kg	■■■ Cheaper than lithium batteries ~$50/kWh	■□□ Low hazard of thermal runaway Made of toxic material, can leak	■□□ 4 times slower than LFP	■□□ 500-1,000 cycles	■□□ Energy capacity drops at high discharge rate	■□□ Self-discharge rate 5 times greater than for a lithium battery 70% to 85% charging efficiency	■■■ Widely recycled	■■■ No need for critical materials
NMC *High performance, high cost*	■■■ 150-220 Wh/kg ~1.7x higher density compared to LFP	■□□ Manufacturing cost: $110.6/kWh	■□□ Thermal runaway : 210°C Fire risk at high charge	■■■ 3h typical charge time Possibility to be fast-charged	■■□ 1,000-2,000 cycles	■■□ Max discharge rate: 1C-2C*	■■■ Energy losses at high temperature 95 % charging efficiency	■■□ Recycling is economical at scale	■□□ High need for critical materials
LFP *Average cost and performance*	■■□ 90-120 Wh/kg	■■□ Manufacturing cost: $75.2/kWh	■■■ Thermal runaway : 270°C Very stable, made of less toxic materials than NMC	■■■ 3h typical charge time Possibility to be fast-charged	■■■ 2,000-6,000 cycles	■■□ Max discharge rate: 1C-2C	■■□ Energy losses at low temperature 95 % charging efficiency	■□□ Easier to recycle than NMC, but not economical at scale yet	■■□ Low need for critical materials

ERA Energy Transition in Rental | *Discharge rate. A discharge rate of 1C means that the battery can fully discharge in 1h, In 30min if 2C, in 15min if 4C, … | Sources: EY Analysis, IEA, Power Sonic, ELB Energy Group, CoreMax; ; The Rise of Batteries in Six Charts and Not Too Many Numbers - RMI

■□□ Low performance ■■□ Medium performance ■■■ High performance

Zoom on energy density and cost – The simultaneous decline in costs and improvement in energy density is making electric batteries increasingly capable of meeting user requirements

Vehicles' electric batteries costs keep on falling while energy density rises*



Key takeaways

- For electric vehicles, the cost of batteries has experienced an inverse trend to that of energy density, with a reduction of 97% in cost between 2000 and 2024, while energy density has increased by 250% over the same period.
- The growth of the electric vehicle market has driven technological developments that have led to these observed trends. Differences still exist between NMC and LFP batteries:
    - NMC batteries are more expensive than LFP batteries
    - NMC batteries have a greater energy density than LFP
- As battery costs drop and energy density increases, a "battery domino effect" emerges, bringing forth new applications and reinforcing the trend observed since 2000.

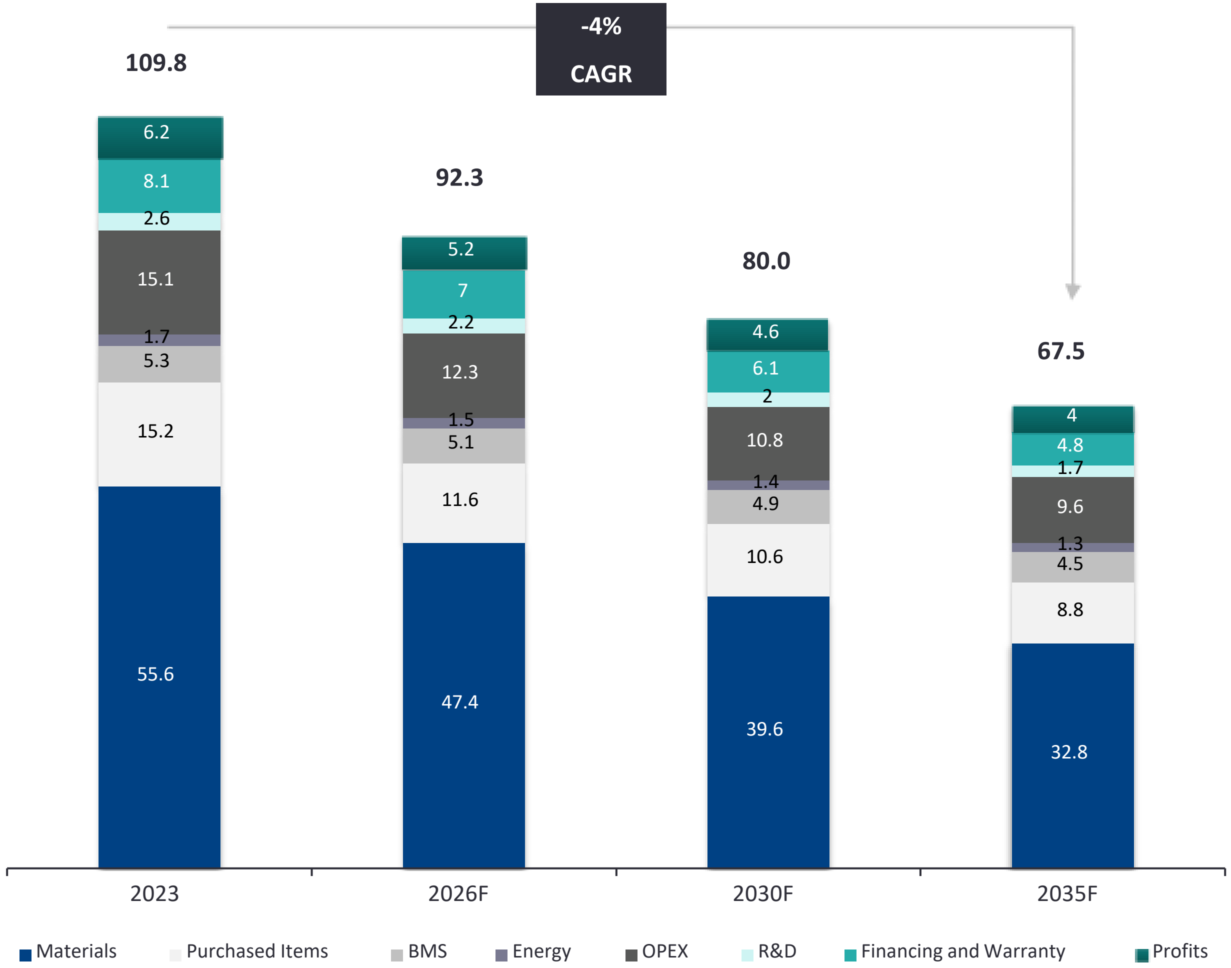
The critical minerals issue

- It is to be noted that battery production growth required to electrify mobility and other sectors requires important amounts of minerals. Forecast quantities pose a risk of supply on these materials.
- The International Energy Agency identifies that anticipated mine supply announced projects meets only 70% of copper and 50% of lithium requirements by 2035.

| * Costs displayed apply to the EV industry. The equipment sector produces lower volumes and thus pay higher prices | Sources: International Energy Agency; The Rise of Batteries in Six Charts and Not Too Many Numbers – RMI, Tracking global data on electric vehicles - Our World in Data, European Market Monitor: Cars and vans 2024 - International Council on Clean Transportation; EY Analysis

NMC manufacturing costs are expected to decline in the coming years, despite being currently higher

Global NMC battery cell manufacturing costs, US$/kWh



Key takeaways

- **Manufacturing cost decline:**

The cost of producing EV batteries fell from approximately US$125/kWh in 2022 to about US$110/kWh in 2023, driven by increased production capacity and declining raw material prices across the supply chain, despite lower-than-expected demand growth.

The cost of NMC battery cell is expected to continue declining, forecasted to reach US$92.3/kWh by 2026, US$80/kWh by 2030, and US$67.5/kWh by 2035, driven by technological advancements and greater manufacturing efficiency.

- **Demand growth and production:**

Battery demand for electric vehicles and stationary energy storage is increasing at an annual rate of 53%, reaching roughly 950 GWh in 2023. However, manufacturers have reported lower plant utilization rates and revised production targets, affecting overall pricing.

- **Regional variations:**

In 2023, the average cost of battery production was lowest in China at US$108.2/kWh, while costs in the US and Europe were about 2.5% higher, reflecting less mature markets and higher production expenses in these regions.

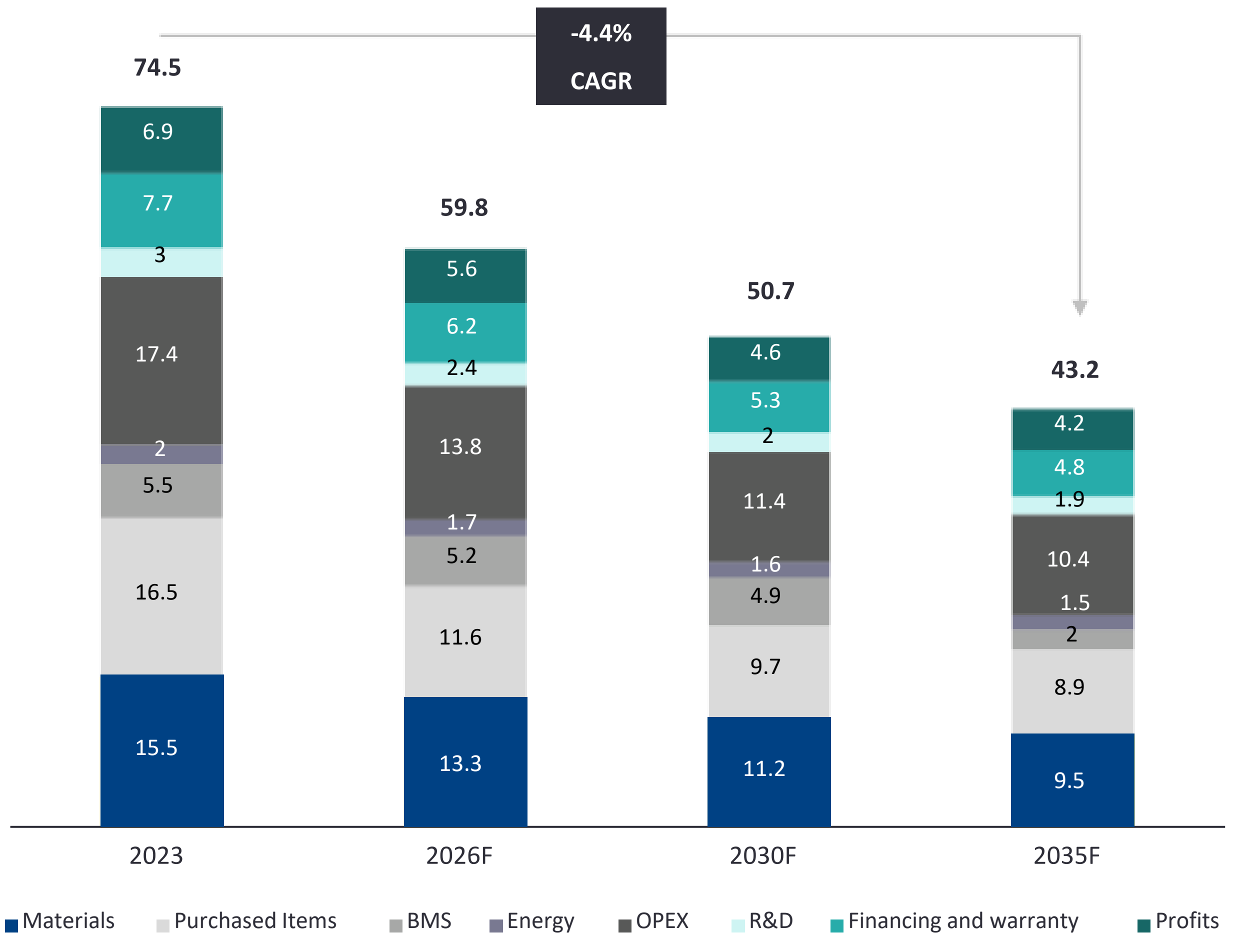
- **Impact of localization and policies:**

Efforts to localize battery manufacturing in the US and Europe may initially increase costs due to higher energy and labour expenses. However, incentives such as the Battery Innovation Fund (EU call for projects) could help offset some of these additional costs.

| Sources: EY Analysis from Bloomberg New Energy Finance and Standard & Poors data

The adoption of LFP batteries is rapidly increasing, driven by their inherently lower manufacturing costs and a continuous decline in costs

Global LFP battery cell manufacturing costs, US$/kWh



Key takeaways

- **LFP Production Cost Outlook:**
The cost of LFP battery cells is projected to decline steadily and is expected to drop to US$59.8/kWh by 2026, US$50.7/kWh by 2030, and US$43.2/kWh by 2035, driven by technological advancements and increased investments from Chinese firms.

- **Increased Investments in LFP Batteries:**
Chinese conglomerates have significantly increased their investments in LFP batteries due to their lower costs and enhanced safety, leading to a preference for LFP over NMC batteries in the domestic EV sector. Key investments include Gotion High-Tech's US$1.3 billion gigafactory in Morocco and Tsingshan Holding Group's US$233 million LFP plant in Chile. Consequently, LFP's market share in the automotive industry is expected to increase, including in Europe, especially if lithium prices remain low.

- **Oversupply Risks:**
The rapid growth of the LFP sector, coupled with lower barriers to entry, has created potential oversupply risks, particularly for lower-end LFP producers who may face challenges with underutilization and margin pressures.

- **Performance and Cost Trade-offs:**
While LFP batteries are more cost-effective, NMC batteries provide higher energy density and better performance in colder climates.

| Sources: EY Analysis from Bloomberg New Energy Finance and Standard & Poors data

The battery industry evolves fast with new technologies currently under development and expected to be commercially available by 2026

Technology	Pros	Cons	Expected date of commercial availability
Sodium-Ion Batteries	► Lower cost due to abundant materials (sodium, aluminum). Improved safety with reduced risk of thermal runaway. ► Better performance in cold temperatures.	► Lower energy density compared to lithium-ion batteries. ► Slower charging times due to larger ion size. ► Still in early commercialization stages with limited real-world testing.	► Commercial-scale production has begun, with wider availability expected by 2026 in the US.
Lithium Metal Anode Batteries	► Higher energy density and specific capacity compared to traditional lithium-ion batteries. Potential for faster charging times. Lighter weight due to higher energy density.	► Safety concerns due to lithium dendrite formation, which can cause short circuits. ► Challenges in manufacturing and scaling up production. ► Higher cost due to complex manufacturing processes.	► Some commercial batteries are already available, with wider adoption expected by 2027.
Solid-State Batteries	► Higher energy density compared to conventional lithium-ion batteries. ► Improved safety due to the absence of flammable liquid electrolytes. ► Potential for faster charging times and longer lifespan.	► Higher manufacturing costs due to complex production processes. ► Challenges in scaling up production and ensuring consistent performance. ► Some current designs still contain small amounts of liquid or gel electrolytes.	► Expected to be commercially available by 2027-2030, with some hybrid designs already in limited production.

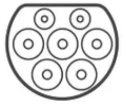
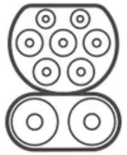
Comments regarding wide scale adoption

- So far, technology development is led by the automotive industry.
- Battery manufacturers invested billions in the development of NMC (majority in EU) and LFP (more popular in Asia).
- These giga factories cannot be easily re purposed to manufacture other chemistries.
- **Inertia is expected before alternative technologies are widely used.**

ERA Energy Transition in Rental | Sources: EY Analysis; IdTech Ex Sodium-ion Batteries 2024-2034: Technology, Players, Markets, and Forecasts; Apricum, Sodium ion batteries

So far, European automotive standards are not the most commonly used in the equipment sector

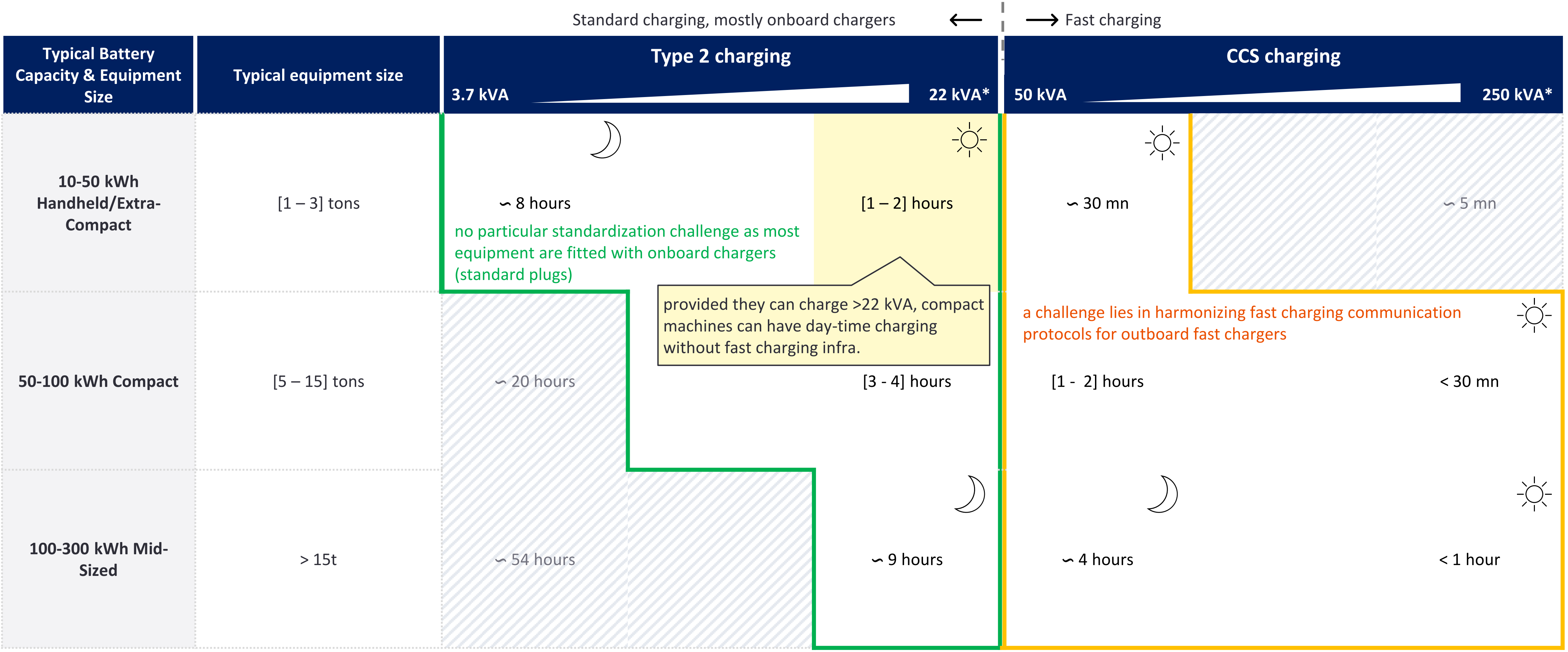
Charging connector standards

	Technology description			Advantages	Drawbacks
Charging connectors	*EU standard (AFIR*)* **Type 2**		▶ **Official automotive European standard** (“Type 2 Mennekes”)**.** It can deliver up to 43 kVA. ▶ AC charger standard, for mode 1, 2 and 3 conductive charging.	▶ Type 2 stations have a detachable connect cable, allowing to connect a type 2 cable (European standard). ▶ It works in mono-phase or three-phase.	▶ Less stringent safety protocols compared to chargers compatible with DC fast charging applications.
	EU standard (AFIR)* **CCS *(Combined Charging System)***		▶ **Official European standard** (“CCS - combo 2”). It can deliver up to 350 kVA. ▶ Uses both AC and DC voltage to charge the vehicle. Combines an AC type 2 plug and a DC plug.	▶ Supports both AC slow charging and DC fast charging. ▶ Most of European charging stations offer CCS charging plugs, as it is an official charging standard.	▶ Higher investment cost than type 2 charging infrastructures. ▶ Unidirectional in standard application, can be bidirectional depending on the charging technologies.
	CHAdeMO *(CHArge de Move)*		▶ **Official Japanese standard**, widely used throughout the world. It can deliver up to 400 kVA. ▶ DC charger standard, for fast conductive charging (mode 4).	▶ Bidirectional (enables V2G applications).	▶ Higher investment cost than unidirectional chargers. ▶ Faster battery degradation. ▶ Requires an adapter for AC charging.
	MCS *(Megawatt Charging System)*		▶ Future international standard. It has been developed by the ChargIN global association. ▶ DC charger standard. It can deliver up to 3 750 kVA.	▶ Convenient for fast charging of very large batteries. ▶ Technologically mature. MCS charging stations already in development. ▶ Bidirectional (enables V2G applications).	▶ The standard is still under implementation. ▶ Not relevant for small and mid-size equipment. Could damage the battery. ▶ Significantly higher investment cost than other charging solutions.

| * AFIR: Alternative Fuel Infrastructure Regulation | Sources: EY Analysis, EU AFIR.

Standard charging (batteries <50 kWh) meets the needs of most compact equipment and poses less standardization challenges than fast charging for heavier machines

Based on **i) typical battery size per equipment type** and **ii) charging specifications** (determined by both grid connection specifications, charger features and the battery maximum power intake), the scenarii below are defined:



Standard charging, mostly onboard chargers ⟵ | ⟶ Fast charging

Typical Battery Capacity & Equipment Size	Typical equipment size	Type 2 charging 3.7 kVA	Type 2 charging 22 kVA*	CCS charging 50 kVA	CCS charging 250 kVA*
10-50 kWh Handheld/Extra-Compact	[1 – 3] tons	☾ ~ 8 hours	☼ [1 – 2] hours	☼ ~ 30 mn	▨ ~ 5 mn
50-100 kWh Compact	[5 – 15] tons	▨ ~ 20 hours	[3 - 4] hours	[1 - 2] hours	☼ < 30 mn
100-300 kWh Mid-Sized	> 15t	▨ ~ 54 hours	☾ ~ 9 hours	☾ ~ 4 hours	☼ < 1 hour

no particular standardization challenge as most equipment are fitted with onboard chargers (standard plugs)

provided they can charge >22 kVA, compact machines can have day-time charging without fast charging infra.

a challenge lies in harmonizing fast charging communication protocols for outboard fast chargers

Caption: ☼ Possibly day-time charging ☾ Preferably night-time charging ▨ Unrealistic scenario

ERA Energy Transition in Rental | * min and max values were defined according to commonly observed specifications, they do not represent theoretical min and max. | Sources: EY analysis from OEM information

The lack of standardization on charging connectors and communication protocols leads to increased costs and a loss of operational efficiency

Charging connectors: 3 main challenges

1

Harmonization issues for a given type of connector

A same connector type can present specificities leading to a loss of charging efficiency between two pieces of equipment.

Example: a 20 kWh battery machine on a grid delivering 22 kVA :

Connector type	Charging time
Type 2 mono-phase	2 hours
Type 2 three-phase	1 hour

2

Harmonization issues between connector types

Several plug types are currently available on the market (Type 2 mono and three phased, CCS chargers, REMA chargers…) reducing interoperability of equipment and increasing the costs for dedicated peripheral devices.

3

Harmonization issues between OEMs and equipment types

Depending on the charging connector, the equipment type and the OEM, the device will need a dedicated fast-charger, increasing the costs for dedicated peripheral devices.

Communication protocols

Even with harmonized plug types, interoperability may not be possible because of different communication protocols between equipment, depending on the OEM.

"Every producer is developing a machine that competitors don't have, leading to different plugs, making standardization difficult"

To standardize charging connectors and communication protocols, ERA has two options:

- Advocate for the **adoption of automotive standards** on charging connectors and communication protocols*
- Develop the industry's own standards by proposing the adoption of a European Standard (EN)

---

* Although there is still a debate regarding the suitability of automotive standards for DC charging below a certain voltage (80 to 100V) | Sources: EY Analysis, OEM and rentals interviews

Automotive industry standards address the main issues raised on charging connectors and communication protocols in the European equipment rental market

The automotive standards already existing on charging connectors and communication protocols can respond to the challenges faced by the European rental market:

Scope	Rental equipment requirements	Existing automotive standards responding to the needs
Power need	Small and medium size equipment need a power of at least 22 kVA to be fast-charged during lunch break	Existing standard meet the power requirements for small and medium size equipment with CCS connectors delivering up to 350 kVA CCS connectors accept both AC and DC
On-board and off-board chargers Plugs, socket-outlets, equipment connectors and equipment inlets	Avoid discrepancies within a same type of charging connector and enable interoperability of peripheral equipment between OEMs and equipment types	IEC 61851 has set standards on the conductive charging of EVs, covering general requirements, electromagnetic compatibility, DC charging stations requirements and safety measures IEC 62196 has set standards ensuring compatibility and interoperability among different charging systems for both AC and DC charging connections
Communication protocol	Harmonization of communication protocols between equipment and charging infrastructures, enabling the interoperability of equipment and costs reduction	ISO 15118 is a standard defining communication protocols between electric vehicles and charging stations or devices

Conclusion

Automotive standards have been designed with the growth of the EV market and respond to the standardization needs of the European rental market

The creation of a new European Standard (EN) to respond to the market needs would trigger a lengthy process of standard creation and a dependence on standard bodies

Aligning with automotive standards will allow to use existing VE charging stations where possible

ERA's role

Coordinate with the construction industry and customer associations to initiate the alignment project with automotive standards

Ensure the accurate translation of the European rental market needs to the OEMs

DC charging

The need for a voltage-based approach for DC charging was discussed during the March 2025 Technical Committee meeting.

- For "high" voltage, CCS Combo 2 would be the preferred solution
- For "low" (not precisely defined in the industry, usually below 80 or 100 V), another plug standard may be preferred.

| Sources: EY Analysis, OEM and rentals interviews

The transition to low carbon solutions means changes in the way maintenance is made, from the OEMs' dealership network to the customers' operation sites

Customers

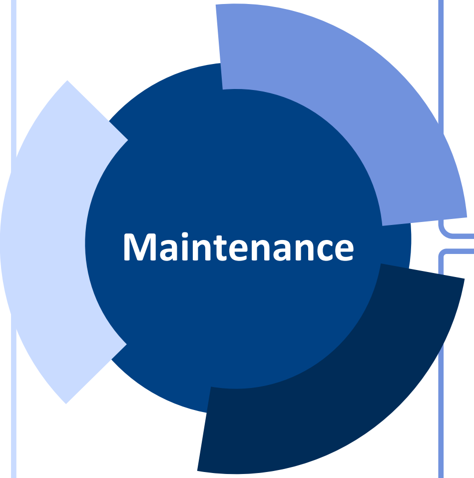
Cost saving:

- 🟢 **-25% to -35% in engine maintenance costs** for electric equipment compared to their diesel counterparts.

Time saving:

- 🟢 **-20% in maintenance needs for electric equipment** compared to diesel (thanks to the absence of engine, even if the battery system adds complexity).
- 🟠 **+5% in maintenance needs for hybrid equipment** compared to diesel (because it requires both engine and battery system knowledge).

📋 *"Maintenance costs are the same as diesel, except for engine maintenance which enables savings of around 30% compared to diesel"*



Rental companies

Maintenance responsibility transfer from customers to rental agencies:

- 🟢 Opportunity for rental agencies to develop a maintenance service offering.
- 🟠 Need to train employees on the maintenance of low-carbon equipment (cf. next slide).

📋 *"Compared to diesel equipment, higher levels of training are needed if a reparation must be performed"*

Spare parts:

- 🟢 Less spare parts inventories,
- 🟠 but spare parts inventories and network are to be built.

📋 *"Regarding electrification, one remaining challenge is the spare parts network for maintenance"*

Important metrics to be monitored include the state of health (SOH) and state of charge (SOC) which can help identify when a lithium-ion battery needs maintenance or when it's nearing the end of its useful life.

Moderate operating temperatures is an important parameter for both LFP and NMC batteries lifespan optimization. Proper diagnostics tools can help ensure NMC batteries operate within the right temperature range.

OEMs

Maintenance responsibility transfer from customers to OEMs:

- 🟢 Opportunity for OEMs to develop a maintenance service offering.
- 🟠 Need to train employees on the maintenance of low-carbon equipment.

| Sources: EY analysis on data collected through OEM and rentals interviews

📋 Data collected through interviews and/or survey 🟢 Opportunities 🟠 Challenges

In addition to changes in maintenance requirements, new skills are to be developed across the value chain to facilitate the energy transition

Customers

Skills development:

🟠 Need to train employees on the use of low-carbon equipment (e.g. assessing power and capacity needs, sizing optimal power generations solutions).

Safety (regulatory):

🟠 Need to train employees on the risks associated with the use of low-carbon equipment and safety procedures.

Lithium-ion batteries require careful handling:

- Never expose batteries to elevated temperature, sparking, open flame, or direct sunlight.
- Stored on non-combustible materials in cool and dry place within the temperature limit stated by the manufacturer. Never store batteries on the charger (need to be removed from the charger when the charging operation bas been completed). Never use of store batteries in explosive environments (corrosive gas atmospheres must be avoided).
- Keep batteries away from other metal objects, rain, moisture, liquids, salts and other corrosive materials.
- Regularly inspect batteries for signs of damage are needed.
- Only transport batteries if they are protected from shock and vibration.
- Always use chargers recommended by the battery's manufacturer

Lithium-ion batteries with an >100 Wh are classified as **Class 9 dangerous goods** under international transport law. Their transportation is to be conducted following UN ADR 2025 (Accord Dangerous Routier) requirements. *See details*.

Low Voltage Directive (LVD) (2014/35/EU): ensures that electrical equipment within certain voltage limits (50-1000V AC and 75-1500V DC) provides a high level of protection for users. *See details*.

ATEX Directive (2014/34/EU): provides safety requirements for equipment and protective systems intended for use in potentially explosive atmospheres. *See details*.

Rental companies

Skills development:

🟠 Higher levels of training needed to perform reparation on low carbon equipment than on diesel equipment (e.g. understanding power and capacity needs, on-site power management challenges).

📋 *"As the solutions are becoming more and more complex, machines are becoming complex to use and need training to be used, there is a skills gap."*

Safety (regulatory):

🟠 Need of certification of employees for high voltage maintenance operations.

🟠 Same regulatory safety training as customers (see box on the left).

📋 *"Staff needs to be certified for high voltage operations. This is a recommendation, and it is not mandatory everywhere"*

OEMs

Skills development:

🟠 Training staff to carry out preventive and corrective maintenance on electric batteries: calibration, reprogramming of electric components, secure storage of components, etc.

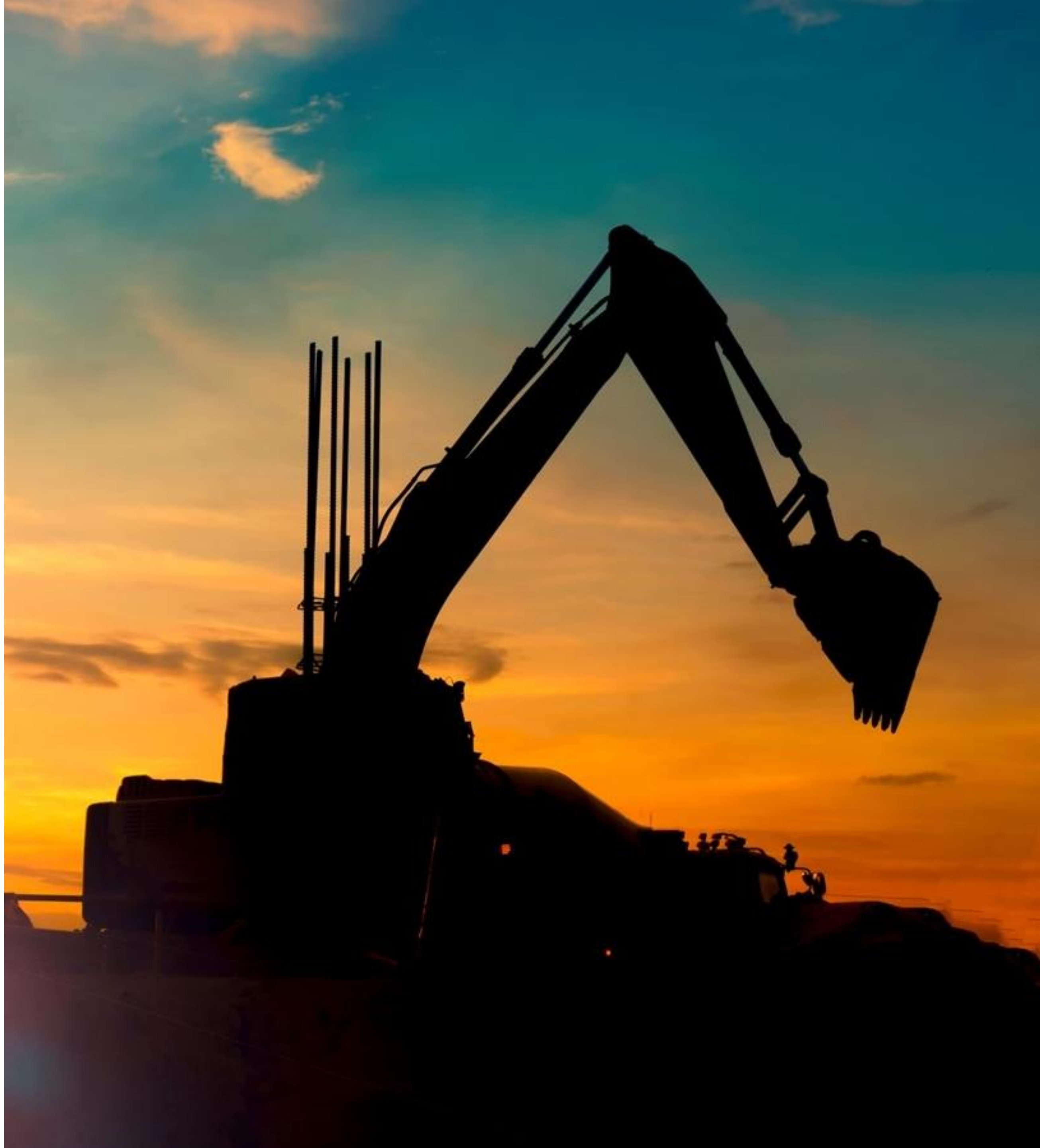
🟠 OEMs acknowledge the importance of supporting their clients through training and are actively involved in educating their customers via their networks

📋 *"There is no specific safety protocol regarding the maintenance of battery electric equipment, as soon as you are not opening the battery"*

📋 Data collected through interviews and/or survey 🟢 Opportunities 🟠 Challenges

ERA Energy Transition in Rental | Sources: EY analysis on data collected through OEM and rentals interviews, Guidance from HAE on Lithium-ion battery safety.

4. Impacts on the TCO model



The Total Cost of Ownership is significantly impacted by the energy transition, due to both CAPEX and OPEX changes

Low-carbon solutions bring cost structure changes

*"there is a **communication difficulty on TCO aspects** regarding the benefits of electrical solutions"*

*"**presentation of the daily rental cost including the total rental with energy** works well with customers"*

*"TCO is very critical point, solution needs to have **economical advantage at the end of the lifespan**"*

*"the **significant CAPEX of electric machines is passed on to the customer**, who does not always benefit from the OPEX gain"*

*"alternative equipment is used when **incentives and OPEX gains are superior to CAPEX**"*

*"customers are willing to pay more for low carbon technologies with **clear economical benefit**"*

An accurate TCO model will allow to precisely factor them in to…

Build profitable business cases

Conduct sensitivity analysis to key assumptions, such as

- CAPEX
- Energy OPEX
- Utilization rate
- Resale value

based on the above listed factors,

prioritize the right clients and use cases

develop your low-carbon offer at a lower risk, based on informed decisions

Advocate

To clients

- On the economic benefits beyond upfront cost (rental fee or CAPEX)

To policy makers

- Build robust fact-based arguments to support your policy advocacy
- Highlight the fossil vs. low carbon solutions cost gap

Share knowledge

With sales teams

- On cost optimization levers (e.g. utilization rate, proper battery sizing)
- On how to appropriately advise clients based on their use cases

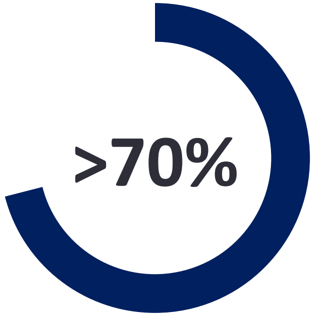
With clients

- On how to accurately factor in cost considerations on technology choice

Data collected through interviews and/or survey

Zoom - At the end of their first life, the opportunity to resale machines and batteries through different channels is to be assessed

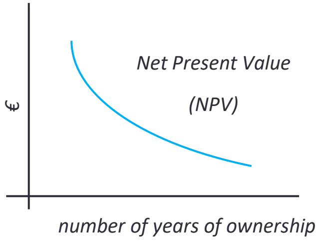
Battery residual value's importance in rentals' business models



of the survey respondents* declared that uncertainty on electric equipment resale value is a barrier to adoption

The weight of resale value in business decisions is a function of:

- The value discount rate (%)
- The number of years the machine is owned in the portfolio (years)



Uncertainty around resale value will be easier to manage for companies that plan on keeping low carbon machines in their portfolio for a longer time than the industry's average.

End-of-first-life batteries can be resold through different channels

- Whereas ICE machines are commonly sold as a whole, the condition of a battery may deteriorate at a different rate from the rest of the machine.
- Different options are to be investigated to maximize this revenue stream.

Battery state**	Most relevant resale stream	Valuation
70% - 100%	Machine & battery pack to be sold together	Ownership of the complete asset package transfers to the new owner and residual value has to be calculated for the complete asset.
30% - 70%	Battery to be sold for secondary applications (e.g. stationary or mobile storage)	Battery ownership transfers, and equipment ownership is retained with the original owner. The residual value is calculated separately for battery and equipment.
0% - 30%	Battery to be sold for recycling	

Data collected through interviews and/or survey

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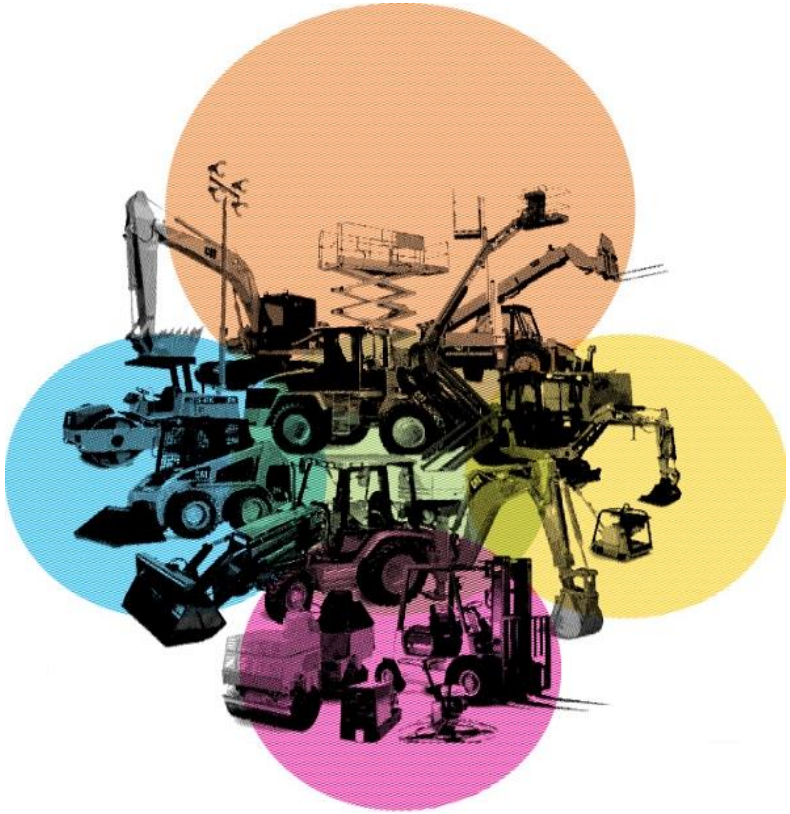
* both OEMs and rental companies; ** examples, to be analyzed case by case

Glossary

Acronym	Meaning
AC	Alternative Current
ADR	Accord Dangerous Routier
AFIR	Alternative Fuel Infrastructure Regulation
B100	Biodiesel (100%)
B7	Fuel-oil and biodiesel blend (7%)
BESS	Battery Energy Storage System
BMS	Battery Management System
CAGR	Compounded Annual Growth Rate
CAN	Controller Area Network
CAPEX	Capital Expenditure
CCS	Combined Charging System
CHAdeMO	ChArge de Move, battery standard
C2V	Cloud to Vehicle
DC	Direct Current
ERA	European Rental Association
ETD	Energy Taxation Directive
EU ETS	European Emission Trading Scheme
EV	Electric Vehicule
GHG	Greenhouse Gas
H2	Hydrogen
HC	Hydrocarbon
HQ	Headquarters
HVO	Hydrotreated Vegetable Oil
IC-CPD	In-Cable Control- and Protection Device

Acronym	Meaning
ICE	Internal Combustion Engines
IEA	International Energy Agency
LA	Lead-acid, battery chemistry
LCA	Life Cycle Analysis
LFP	Lithium Ferro Phosphate, battery chemistry
LVD	Low Voltage Directive
MCS	Megawatt Charging System, charging standard
NMC	Nickel-Manganese-Cobalt, battery chemistry
Nox	The sum of the quantities of nitrogen monoxide (NO) and nitrogen dioxide (NO_2).
NRMM	Non-Road Mobile Machinery
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PM	Particulate Matter
R&D	Resarch and Development
RFNBO	Renewable Fuels of Non-Biological Origin
Sox	Sulfur oxides
SSEB	Subsidy for Clean and Zero Emission Construction Equipment
TCO	Total Cost of Ownership
TTW	Tank-to-Wake
V2G	Vehicle-to-Grid
V2C	Vehicle to Cloud
WACC	Weighted Average Cost of Capital
WTT	Well-to-Tank

Prepared in collaboration with EY



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