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Workforce implications

How investing in a green, future-proof workforce can enable the transition towards BE-CHE

ZEPA Zero Emission Port Alliance

This document provides an overview of key steps and supporting analyses required for the transition to electric container handling equipment

About this document

This document highlights **workforce implications in the shift to battery-electric container handling equipment** (BE-CHE). It outlines expected role and skill changes, **especially in maintenance and safety departments**, and offers guidance for planning smooth, collaborative transitions. This document is designed to support terminal operators, port authorities, OEMs, and other stakeholders. It aims to reduce implementation hurdles of BE-CHE by offering a clear understanding of workforce impacts. It is part of the broader ZEPA effort to accelerate port decarbonisation and ensure that green investments include workforce readiness.

About ZEPA

The Zero Emissions Port Alliance (**ZEPA**) was formed expressly to **accelerate port decarbonisation**. Container terminals are our focus because the electrification of container-handling equipment is one of the most immediately addressable source of port emission. ZEPA aims to **accelerate take-up of battery-electric container handling equipment** (BE-CHE) among terminal operators by making BE-CHE **affordable and accessible by 2030**.

The Secretariat is hosted by **Systemiq** and is responsible for managing ZEPA's day-to-day operations and coordinating member activities, including research and analysis, project management, and industry engagement.

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Executive Summary (1/2)

Investing early in reskilling the workforce will be key to ensuring a seamless transition towards battery electric container handling equipment (BE-CHE)

Developing BE-CHE skills in the workforce will enable adoption

- **The container terminal workforce** plays a central role in enabling a sustainable, low-carbon economy
- Jobs across the terminal value chain will **evolve**, but most changes are **positive, gradual and manageable** for the workforce
- Investing in electric equipment must go hand in hand with **investing in workers' skills, safety, and success**[1]

The shift is not radical but a natural evolution of existing capabilities, within the terminal and in the wider port ecosystem

- **Within the container terminal, maintenance crews experience the most significant changes, shifting from mechanical to electrical and digital work. Operators, schedulers and first responders will see minor changes:**
  - **Maintenance roles** will require (re)skilling in electrical systems. These changes will be gradual, as electric vehicles get phased in while the diesel fleets reaches end of life
  - **Operators** will experience health benefits, such as low-vibration driving, less noise, no exhaust gas, and only require minimal retraining
  - **Schedulers** may need to adapt workflows to accommodate BE-CHE charging, depending on the charging strategy used
  - **Emergency response roles** stay largely unchanged, but the response protocol for battery fires will need to be updated
- **Outside the terminal, more electrotechnical capabilities will be required in the full value chain of battery-electric container handling equipment** (OEMs, infra, and port)

Notes: **[1]** More information can be found on WRI, Systemiq (2025), Jobs and skills for the new economy – An action agenda for people-centered climate transition

Executive Summary (2/2)

Investing early in reskilling the workforce will be key to ensuring a seamless transition towards battery electric container handling equipment (BE-CHE)

From insights to action - Reskilling needs must be mapped, invested in, and co-designed and delivered together with the workforce and wider ecosystem

Three actions for a future-ready workforce:

- **Map and invest:** Identify evolving skills needs and invest early to build capacity
- **Co-design:** Build training with work forces, OEMs, unions and training providers
- **Deliver:** Roll out curriculum with OEM, national regulator, port authority and union input, using best practices and promoting inclusive strategies

As the transition to BE-CHE gains momentum, workforce (re)skilling is essential to ensure a smooth transition and build tomorrow's green careers

Why workforce skills matter in the transition towards battery-electric

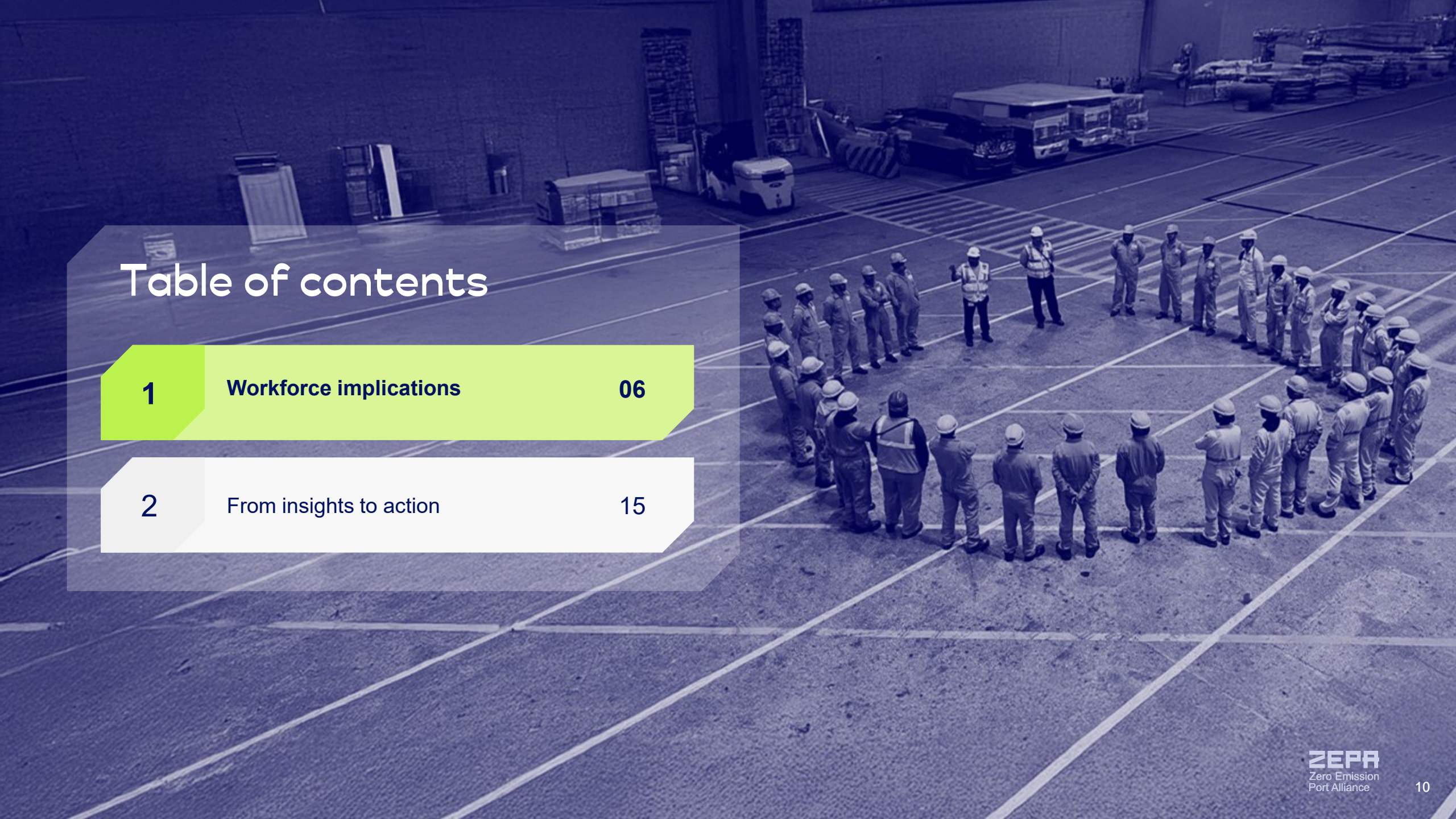
Build tomorrow's green careers

- **Protects jobs** by ensuring today's workforce has the skills to thrive in tomorrow's low-carbon terminals.
- **Supports worker growth and retention**, as people are more likely to stay when they see clear investment in their development.
- **Preserves critical know-how** by helping experienced staff transition into new technical roles rather than losing expertise.

Ensure a smooth transition to BE-CHE

- **Keeps workers and operations safe** as high-voltage systems and batteries introduce new risks that require updated competencies and standard operating procedures.
- **Prevents bottlenecks** by ensuring sufficient operators and technicians can use and maintain BE-CHE reliably and at scale.
- **Reduces downtime and avoidable damage**, enabling better battery and charger performance; critical for unlocking total cost of ownership benefits.

Sources: WRI, Systemiq (2025), Jobs and skills for the new economy – An action agenda for people-centered climate transition; ZEPA member interviews



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Jobs across the container handling equipment value chain will evolve, but most changes are positive, gradual and manageable

Within the terminal operators' organisation

Ease of (re)skilling transition: Easy | Moderate | More extensive

	Operators	Maintenance	Schedulers	Emergency responders
Role changes	• Reduced health impact from noise, vibrations, exhaust fumes, and lift torque enables higher precision • Added charging duties	• Shift from mostly **mechanical systems** (ICE[1] engines) **to more electrical and digital systems** (motors, batteries, power electronics)	• Charging strategies may affect how tasks are scheduled • Battery charge levels and charger availability become part of daily planning	• Similar role, but different risks, e.g., fire incidents are less frequent but need to be managed differently
Skills changes	• Executing charging tasks • Recognizing and managing battery fire risks and hazards	• Increase in electro (technical) maintenance skills • Use of remote monitoring tools • Recognising and managing battery fire risks and hazards	• Digital monitoring of vehicles and chargers • Coordination of charging schedule & managing potential charge outages	• Updating emergency response protocols • Recognizing and separating battery and ICE[1] fire risks • Handling battery fires
Transition outlook	• **Only limited familiarization with new vehicle needed** • **Overall, increased operator satisfaction**	• **Significant shift in skills toward electrical systems,** but the transition will be **gradual** as diesel fleets are phased out	• **Moderate increase in planning complexity** especially during transition phase, but digital systems of BE-CHEs and chargers will offer clearer insight into terminal activities	• **Targeted (re)skilling is required as BE-CHE are phased in,** ensuring emergency responders can safely handle new risks

Overarching port ecosystem

- Key stakeholders include component OEMs, vehicle and charger OEMs, supporting infrastructure providers (e.g., grid operators), overarching terminal managers and ports authorities.
- New technical skillsets are emerging in areas such as **large battery cell and pack design and manufacturing, high-voltage safety, power systems engineering, permitting and safety.**

Notes: 1. Internal Combustion Engine = ICE
Sources: ZEPA member interviews

Deep dives on next pages

As electrified vehicles closely resemble diesel vehicles, only limited reskilling is required for operators

Operator cabin of a diesel-based terminal tractor

Operator cabin of an electric terminal tractor

Terminal operators note it only takes operators 1-2 hours to become familiar with driving and charging BE-CHE as the vehicles are almost identical

The material differences which will require reskilling are:

- **Driving**: manage stronger acceleration and deceleration of electrified vehicles
- **Charging**: learn the correct charging procedure
- **Fire safety**: learn how to identify early warning signs of fire and evacuation procedures

Sources: Input and pictures from ZEPA members

Operators will benefit greatly from BE-CHE, through reduced health impact

Transitioning to BE-CHE provides large (health) benefits for operators

- **Quieter operation**
- **Smoother, low-vibration driving**
- **Cleaner air with no exhaust fumes**
- **Better lift torque allowing for more precise handling**

Which lead to positive response from operators

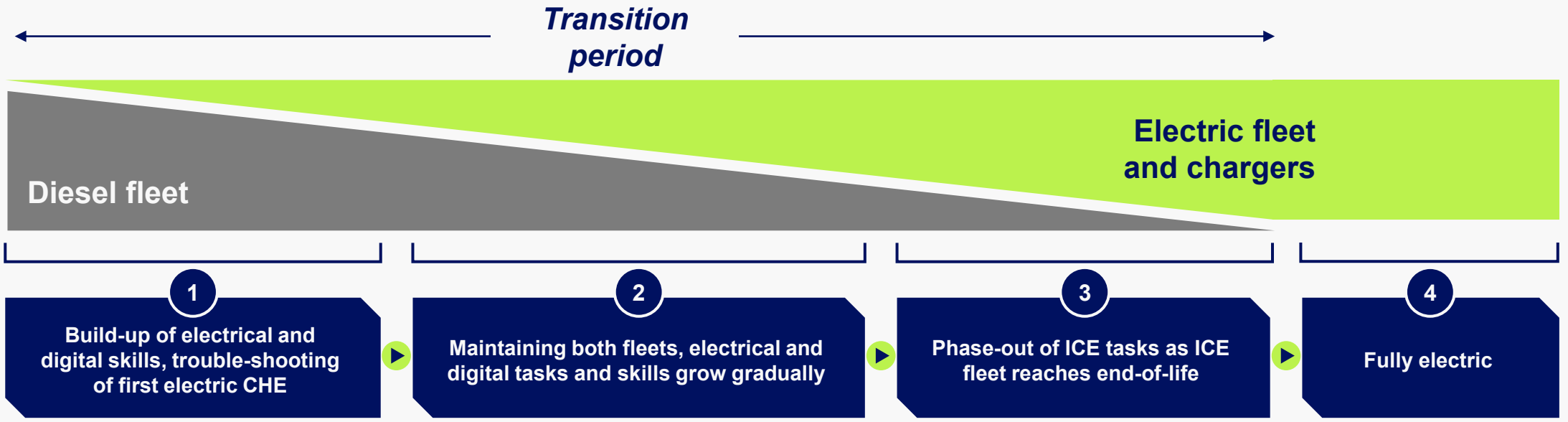
> ***The electrical Terminal Tractors are much more comfortable to drive***
>
> – DP WORLD OPERATOR IN CALLAO (PERU)

> ***The control panel is clear and the joystick response is faster***
>
> – AQABA CONTAINER TERMINAL

> ***New electric trucks are comfortable and fast - operators are keen to get behind the wheel***
>
> – PATRICK TERMINALS

Sources: ZEPA member interviews

The changes for maintenance crew will be gradual, as electric vehicles get phased in while the diesel fleet ages



Maintenance implications

Dual-fleet maintenance may require extra space as both systems have different requirements (isolation, floors, tools, etc.)

As diesel phases out, terminals can scale up existing electrical expertise and skills developed through maintaining STS[1] cranes, RTGs[2], and other electrified equipment

Growing share of BE-CHE increases the need for further ramping up OEM-led training to build technician capability in high-voltage diagnostics and software-based troubleshooting.[3]

With a largely electric fleet, **digital monitoring and smart charging enable predictive diagnostics, earlier fault detection,** and more reliable, data-driven maintenance.

Notes: 1. Ship-to-Share crane; 2. Rubber-Tyred Gantry crane; 3. Please note, OEM training and any national certification requirements must already start from the beginning of the transition period.
Sources: ZEPA member interviews

With the shift to electrical vehicles, tasks related to the power train will shift, raising need for electrical expertise

- **BE-CHE** have **fewer moving parts,** reducing **maintenance time spent on the vehicle**[1]
- Maintenance focus shifts from **mechanical** to **electrical systems**

	Diesel vehicles	Electric vehicles
Main maintenance tasks for fleet	Hydraulic System Service	
	Tire changes	
	Brake system service	
	Structural repairs	
	Air Filter Replacement	
	Suspension	
Powertrain-specific maintenance tasks	Oil changes	Electrical system and connections inspections
	Cooling System Service	Digital (predictive) maintenance monitoring
	Exhaust Systems Service	Battery maintenance (cooling liquid, pack change)
	Engine and Transmission Service	
Fueling specific	Fuel System Service	Charger maintenance

Notes: 1. E.g., ZEPA members highlight a decrease of ~60% in maintenance time vs diesel, highlighting 2.5 hours versus 6 hours per 250 hours of use for electric terminal tractors and straddle carriers.
Sources: NAM Rentals (2025) Electric vs Diesel equipment; ZEPA member interviews

Depending on the charging strategy, schedulers may need to adapt workflows to integrate BE-CHE charging

Charging strategy	Implications for scheduling
Diesel CHE	• Reference case: scheduling currently aligned to diesel
Vehicle rotation	• If the charging strategy is “vehicle rotation”, the **scheduling changes because of drive time to/from charger and operator rotation time**[1] • Risk of high scheduling disturbance if power is unavailable to charge the vehicles
Depot charging	• If the charging strategy is “depot charging”, **high precision in break timing** is required to avoid scheduling or empty-battery disruptions throughout shifts • Risk of high scheduling disturbance if vehicles charge insufficiently during breaks
Depot charging with staggered breaks	• If the charging strategy is “depot charging with staggered breaks”, **work planning becomes more complex** because groups **pause and resume activities on different schedules**. • Risk of high scheduling disturbance if vehicles charge insufficiently during breaks
Opportunity charging	• If the charging strategy is “opportunity charging”, difficult-to-predict waiting time and charging add **high complexity in scheduling** • Risk of high scheduling disturbance if idle time is insufficient for charging
Battery swapping	• If the charging strategy is “battery swapping”, **the scheduling changes because of drive time to/from swapping station and the associated time it takes to swap batteries** • Risk of high scheduling disturbance if swapping station fails, no manual alternative

The shift to BE-CHE and smart charging also enhances **real-time visibility across the yard,** giving schedulers insight into vehicle location, vehicle status, battery level and charger status for more efficient planning and dispatch

Note: **[1]** Specific impact depends on if rotation schedule is organised per ‘crew’ or terminal wide.
Sources: Expert input

Interested to learn more?

Read more detailed information on charging strategies in ZEPA’s Voluntary Standards

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Emergency response roles stay largely unchanged, with minor updates to manage changing battery fire risks

Local training and learning is key to manage new (battery) risks

Local Health, Safety, and Environment (HSE) team	**Set up battery-fire safety workshop with operating staff, emergency response team and fire operators**. Expand knowledge and ensure team stays informed as best practices evolve within the container handling industry.
Local maintenance team	Include equipment thermal monitoring in preventive maintenance plans. **Practice drills for hazard identification and battery isolation.** Drills should be conducted with safety team, local fire brigade and OEM.
Local operators	**Be trained on how to identify early warning signs of fire (e.g., popping sounds, hissing, vapor) and evacuation procedures**. Training materials must be visual and language-adapted, focused on what signs to notice and how to act. Perform regular inspection of battery / equipment and telemetry monitoring for equipment malfunction.
Local Fire Department	**Participate in joint site walkthroughs and understand EV-specific hazards** (e.g., reignition risks, battery disconnect method to reduce electrocution risk, expected duration of fire incident).

Interested to learn more?

Read more about the transitioning fire risk in ZEPA's report on BE-CH Battery Fire Risk and Safety report

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The full value chain is transitioning; OEMs, infrastructure, terminals and ports will also require more electrotech capabilities

Across the full value chain, ICE[1] power train related capabilities will gradually be phased out, while electrotechnical capabilities will be in high demand. Key new capabilities include **large battery cell and pack design and manufacturing, high-voltage safety, power systems engineering, permitting and safety.**

Overview of phased-out ICE aspects and phased-in electrified aspects or the container handling value chain

	Component OEMs	Vehicle and charger OEMs	Supporting infrastructure operators	Port authorities
ICE system – phased out aspects	• ICE power train manufacturing	• Diesel vehicles manufacturing	• Fuel production, delivery and storage • Simple grid connection	• Fuel bunkering oversight
Electrified system – new aspects	• Large battery cell and pack manufacturing • Electric drivetrain manufacturing • Inverters, power electronics handling	• Electric vehicles manufacturing • Charging systems manufacturing • Vehicle-charger-Energy Management System communication systems	• Renewable power generation, transmission, distribution, storage and load management • High-capacity grid connection	• Port-wide grid planning & oversight • Electrical safety compliance monitoring

Notes: Notes: 1. Internal Combustion Engine = ICE
Sources: ZEPA member interviews

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To accelerate the BE-CHE transition, reskilling programs should be developed in close coordination with the wider port ecosystem

	Terminal Operators	OEMs	Wider port ecosystem
1 Map needs & Invest	• **Invest early in workforce (re)skilling** to create structured (re)skilling paths for roles most affected, especially maintenance. • **Map evolving tasks and skill needs** across operations, maintenance, safety, and scheduling for mixed diesel–electric and full-electric fleets. *Deep dive on next page*	• **Map electrical systems in maintenance manuals** with clear, self-explanatory and comprehensive illustrations and guidance, ensuring manuals are available in the appropriate local language to avoid barriers	• **Promote inclusive reskilling strategies** ensuring access for existing workers and new entrants
2 Co-design	• **Include workforce in the design of (re)skilling** programmes to ensure training relevance and engagement • **Partner with OEMs and training providers** to assess standard training availability and costs, and (where needed) co-design modules and certification programs. • Optionally, **include digital tools such as AR/VR** where relevant[1]	• **Develop clear technical documentation** and open access to diagnostics and maintenance and spare parts manuals	• **Leverage synergies with other (emerging) high volume electrification market segments** to leverage best practices and reduce transition complexity *Deep dive on next page*
3 Deliver	• **Deliver curriculum** with OEM, national regulator, port authority and union input • Where possible, **collaborate with local and technical schools**	• **Provide training packages** adequate to the specific local needs of terminal teams	• **Share best practices and certification standards** to harmonise training across ports

Notes: 1. Augmented and virtual reality could improve overall retention, motivation and training effectiveness (an example can be found here).
Sources: ZEPA member interviews

ZEPA Zero Emission Port Alliance

Investing in a future-proof, green workforce delivers broader benefits, from talent retention and attraction to social license to operate

Talent retention

94%

of employees would stay at a company longer if it invested in their career

Talent attraction

92%

of employees prioritize learning and development when choosing between employers

License to operate

Investing in skills that align with future-proof, green jobs increases companies' license to operate

Workforce transitions are most successful when workers are partners in the process, not passive recipients. Codesigning training with the targeted employee group increases relevance, uptake, and trust.

CASE STUDY

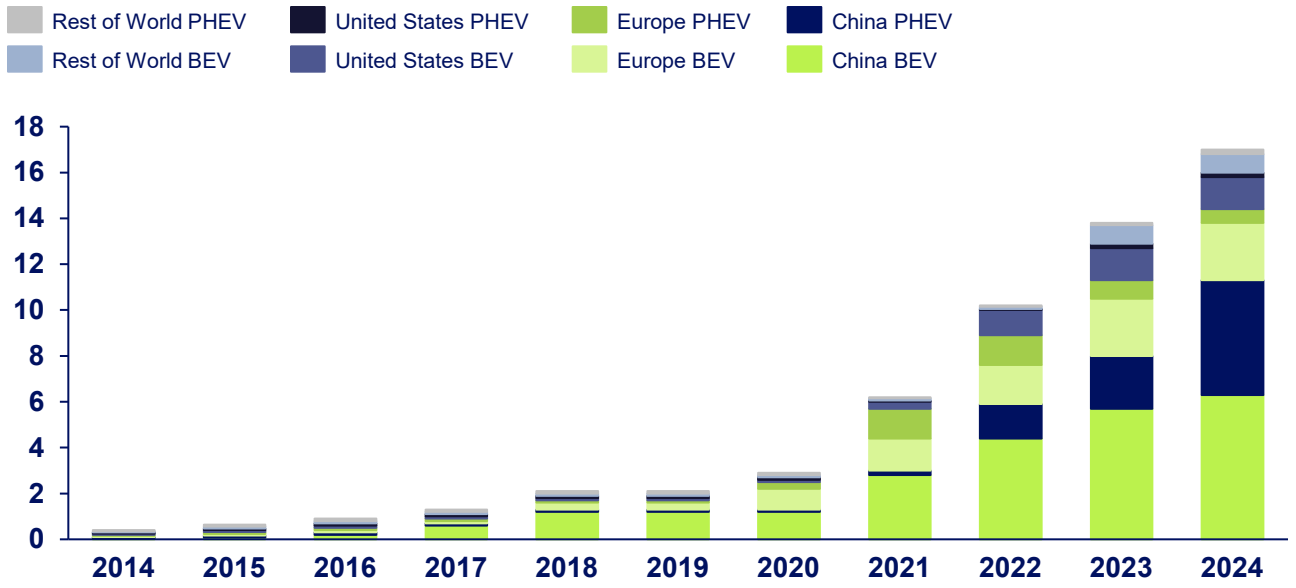
At Patrick Terminals Fremantle, a training team consisting of experienced and respected operators was instrumental in the successful adoption of electrified TTs. The training team was brought along to the TT OEM to get a first look at the vehicles, instructed the operators on how to use the vehicles, and acted as feedback channel from operators to terminal management throughout the transition. Terminal operators were also included in selecting the charger locations, to limit workflow disturbances.

Sources: Linkedin (2025) Workplace Learning Report; Linkedin Developing Employees and Improving Performance; Schreer IMC, the data behind the Great Upskill

As other sectors electrify, leveraging synergies with (emerging) high volume market segments can ease the transition

Relevant high-volume market segments such as passenger cars are electrifying rapidly

Global electric car sales, 2014-2024, millions



These sectors are facing **similar workforce shifts**, such as:

- Training operators on **charging procedures**
- (Re)skilling **maintenance personnel**
- Preparing emergency responders for **battery fire risks**

Using cross-sector synergies can help container handling operations move up the learning curve faster

Adopting **standardized components and protocols** can streamline training and support an efficient workforce transition, while also supporting **interoperability**

Sourcing key **maintenance skills, maintenance-as-a-service and emergency response protocols** from **high-volume adjacent markets**, such as passenger EVs can increase accessibility

Integrating **standardized training and certification frameworks** from other battery-electric equipment sectors can accelerate workforce readiness and facilitate mobility between terminals and sectors

Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid vehicle. Includes new passenger cars only.
Sources: IEA (2025) Global EV Outlook 2025

Disclaimer

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Acknowledgements

The Zero Emissions Port Alliance (ZEPA) is a cross-value-chain port alliance set up by its members to tackle BE-CHE adoption challenges together. ZEPA has multiple members for the 2025 Work Programme, whose activities span the container handling sector.

This report has been developed by Systemiq and constitutes a collective view of participating organizations in the Zero Emission Port Alliance. ZEPA members have supported and validated the analyses, and have agreed to endorse the findings as presented in this report.

ZEPA Zero Emission Port Alliance

For further information

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