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Policy Framework for Zero-Emission Trucks Adoption at Major Ports in India

Report / October 2025

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Executive Summary

The Ministry of Ports, Shipping and Waterways (MoPSW) has introduced the *Harit Sagar — Green Port Guidelines*,[1] setting a target for 50% of port equipment and vehicles to be electric by 2030. Nearly 24,000 trucks move goods within and beyond the boundaries of India's 12 Major Ports.[i] Almost all of these trucks run on diesel fuel, contributing to rising pollution and operational costs. Building on the MoPSW's targets and goals, there is an urgent need to transition from diesel trucks across port operations to cleaner alternatives like zero-emission trucks (ZETs), including electric trucks (fixed or swappable batteries) and fuel cell electric trucks. ZETs can reduce emissions and operational costs for fleet operators.

Recognising this opportunity, stakeholders have initiated early adoption of ZETs at a few Major Ports. Pilot projects and small-scale deployments are underway at Jawaharlal Nehru Port and Kamarajar Port for intra- and inter-terminal movement, and at Visakhapatnam Port for short-distance port-to-hinterland operations. Key lessons from these pilots indicate that ZETs can perform equivalent to diesel trucks in terms of payload capacity, one-to-one replacement of ZETs with diesel trucks is possible, and driver comfort is significantly improved. The deployments also highlight the need to reduce electricity tariffs to fully capture ZET efficiency advantages.

These initial deployments are helping build stakeholder confidence in the technical and operational viability of ZETs. Collectively, the 12 Major Ports have indicated demand for around 800 ZETs by 2030, representing roughly 3% of the total truck fleet at the ports. Nearly all of these trucks will be deployed for movement within port premises.

Photo Credit: JM Baxi Group

i Major Ports refer to the 12 ports under the administrative control of the Ministry of Ports, Shipping and Waterways (MoPSW), Government of India, governed by the Major Port Authorities Act, 2021.

However, the total cost of ownership for current use cases and pilots shows that ZETs remain 4% to 20% more expensive than diesel trucks, largely due to higher up-front purchase costs and elevated operational expenses caused by electricity tariffs. To bridge this gap and accelerate deployment in line with the *Harit Sagar — Green Port Guidelines*, a comprehensive policy framework specific to ZET adoption at ports is required.

This policy framework is centred on solution categories including strategic planning and market development, fiscal and nonfiscal measures, infrastructure development, and capacity-building measures, supported with global case studies (see Exhibit ES1).

Exhibit ES1 **Policy measures and proposed solutions**

Policy measures	Proposed solutions	Case study
Strategic planning and market development	**ZET transition plans** — A comprehensive ZET transition plan for each port can be developed, serving as the central planning document for systematic adoption of ZETs.	**Clean Air Action Plan, Ports of Los Angeles and Long Beach, United States**
	ZET adoption requirements — All concession agreements signed or renewed with terminal operators can incorporate ZET adoption requirements increasing over time.	
	Demand aggregation for ZET procurement — Demand can be aggregated across terminal operators and transporters and shared with original equipment manufacturers for consolidated procurement.	
Fiscal and nonfiscal measures	**Up-front fiscal incentives** — An up-front fiscal incentive, supplementary to any national- or state-level incentives, can be provided to reduce the capital cost associated with ZETs.	**Low-Emission Technology Initiative, Port of Vancouver, Canada**
	Green surcharges — A green surcharge can be levied on diesel truck movement within port premises and further pooled into a green mobility fund for ZET adoption-related expenses.	
	Green channel and certification — A dedicated incentive system can be instituted offering reduced port-related charges, priority gate allocations, and cargo access for green-certified ZET fleets.	**Green Priority Initiative, Port of Gothenburg, Sweden**
	ZET contractual agreements for revenue certainty — Longer tenures and minimum load guarantees for fleet operators can be embedded in concession agreements between terminal and fleet operators.	

Exhibit ES1 **Policy measures and proposed solutions (continued)**

Policy measures	Proposed solutions	Case study
Infrastructure development measures	**Reducing electricity tariffs** — Availing state-based electric vehicle-specific tariffs and incorporating renewable energy at ports can be introduced as pathways to reduce electricity tariffs.	**Dedicated funding for charging infrastructure at ports, United States**
	Incentives for capital and installation costs — Capital subsidies can be availed for ZET charging equipment and installation expenses.	
	Identification of land parcels — Suitable land parcels can be identified and allocated within ports, specifically for charging and energy hubs for ZETs.	
	High-tension connection and grid upgrades — Grid capacity assessment and upgrades for ZET charging can be integrated into port master plans.	
Capacity-building measures	**ZET workforce training programmes** — A dedicated ZET workforce training programme can be developed to equip drivers and service providers with essential skills.	**Portable Innovation Open Network for Efficiency and Emissions Reduction Solutions (PIONEERS) initiative, Ports of Antwerp-Bruges, Barcelona, Venlo, and Constanta**
	Documentation and knowledge sharing — Records of operational learnings from ZET deployment can be maintained in a centralised knowledge repository.	
	Monitoring and evaluation — Annual and periodic convenings can be hosted to review progress and share operational experiences, ensuring consistent oversight and accountability.	

RMI Graphic. Source: RMI analysis

This framework can be implemented in phases. Near-term priorities (zero to one years) can include aggregating ZET demand, creating a transition plan, accelerating adoption through fiscal and non-fiscal incentives, support to avail state electric vehicle (EV) tariffs, and workforce training. In the medium and long term (more than one year), the focus can expand to embedding ZET adoption in concession agreements, surcharges to fund clean mobility projects, and reinforcing infrastructure through grid upgrades and renewable pathways. Continuous monitoring, evaluation, and knowledge sharing will ensure scalable and sustainable deployment.

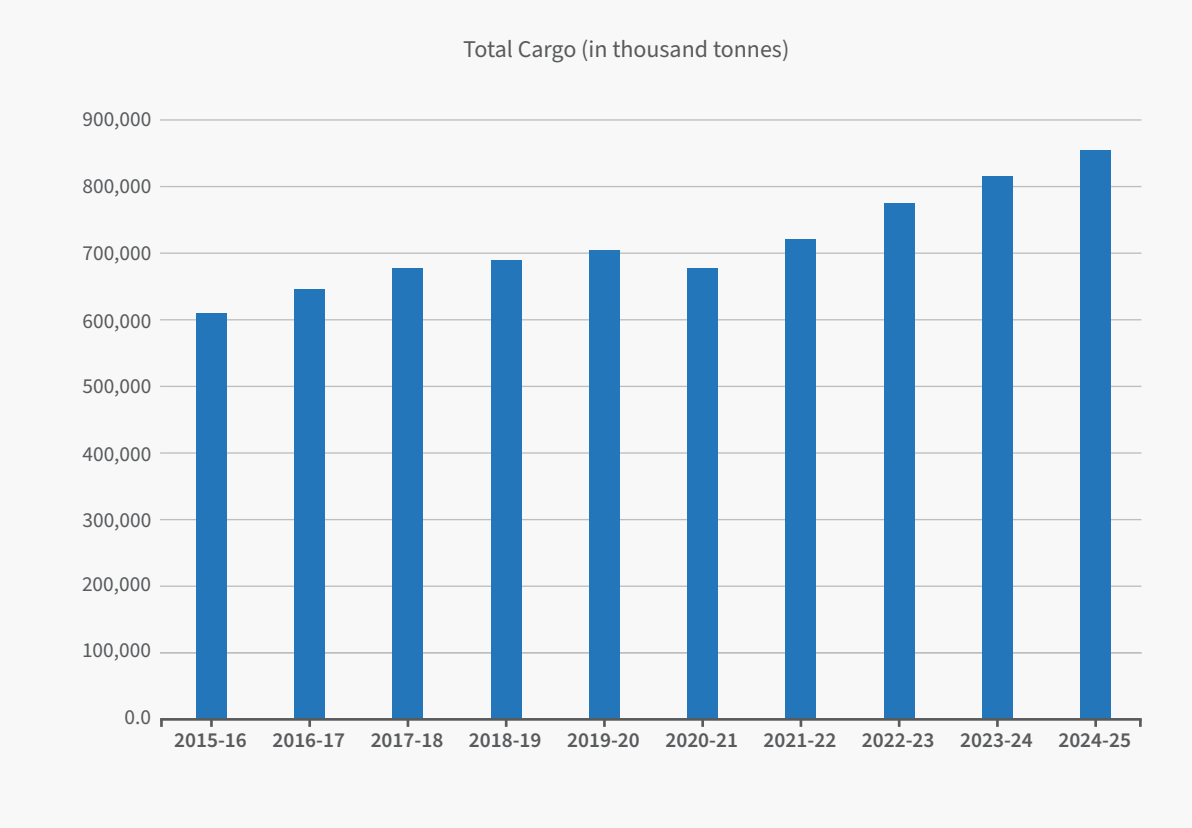
The pathways outlined in this policy framework, combined with coordinated action among public and private stakeholders, can help India's Major Ports transition from ZET pilots to large-scale ZET deployment, positioning them as global leaders in a sustainable maritime future.

1. Introduction

India's maritime trade has been expanding rapidly, with cargo volumes at the 12 Major Ports growing at an average annual rate of 4.1% over the past five years, resulting in a cumulative increase of 41% between 2015 and 2025 (see Exhibit 1).[2] The sector forms the backbone of national commerce, handling close to 95% of India's trade by volume and 65% by value.[3] This sustained growth is placing increasing demands on port-connected freight systems, where trucks act as the vital link both within port terminals and between ports and inland distribution networks.

Exhibit 1

Total cargo handled at Major Ports of India over the past decade



RMI Graphic. Source: *Monthly Cargo Traffic Handled at Major Ports up to and During March 2025*, Transport Research Wing (TRW) under the Ministry of Ports, Shipping and Waterways (MoPSW), March 2025

Nearly 24,000 conventional diesel trucks currently support operations at India's Major Ports, facilitating cargo movement within terminals, to nearby logistics hubs, and across extended hinterland corridors.[4] Although indispensable to port operations, these trucks contribute to rising pollution and operational costs. As maritime trade continues to expand, the demand for trucking services will increase correspondingly. It is essential to switch to cleaner alternatives to ensure long-term sustainability of the maritime sector. Zero-emission trucks (ZETs), including electric trucks (e-trucks) with fixed and swappable battery technologies as well as fuel cell electric trucks, can be prioritised as those cleaner alternatives at ports due to:

- **Government targets:** The Ministry of Ports, Shipping and Waterways (MoPSW) has issued the *Harit Sagar — Green Port Guidelines*, setting an ambitious target for 50% electrification of port equipment and vehicles by 2030 and 90% by 2047.[5] Accelerating ZET deployment will be critical to achieving these targets.

- **Emissions and operational cost reductions:** ZETs feature more efficient powertrains than diesel trucks, resulting in lower energy consumption per kilometre, reduced CO_2 emissions (dependent on grid emissions factors), and lower fuel costs. ZETs also do not emit any tailpipe pollutants like particulate matter (PM) and nitrogen oxide (NOx).

- **Use-case applicability:** Trucking operations at ports typically follow closed-loop systems with fixed routes and schedules, characterised by frequent but relatively short trips. These operational patterns enhance the feasibility of ZET deployment because charging infrastructure can be strategically located to ensure seamless operations, and well-defined movement patterns enable efficient use of charging assets.

Recognising the need and advantages of deploying ZETs at ports in India, this report presents a comprehensive policy framework to drive port ZET adoption. The scope of the analysis and recommendations in the report are centred on the 12 government-administered Major Ports, which are under the purview of MoPSW.

The report provides an overview of trucking operations at the Major Ports, including the types of commodities transported, key use cases, and truck weight segments. It documents notable ZET deployments and pilots at these ports to date, along with planned future deployments. It then presents total cost of ownership (TCO) analysis of existing ZET deployments, highlighting the TCO gap between diesel and ZETs and underscoring the need for targeted policy support for ZET deployment at ports. Drawing on these insights, the report proposes a comprehensive policy framework, highlighting the key solutions needed to accelerate ZET adoption across ports.

2. Port Trucking Landscape

2.1. Overview of Major Ports in India

India has 12 Major Ports (see Exhibit 2), which serve as critical trade hubs, linking ocean transport with inland logistics.

Exhibit 2 **Major Ports of India**

RMI Graphic. Source: Ministry of Ports, Shipping and Waterways

In fiscal year (FY) 2024–25, these ports (see Exhibit 1) collectively handled 853.57 million tonnes (Mt) of cargo, with the top five — Paradip (150.41 Mt), Deendayal (150.16 Mt), Jawaharlal Nehru (92.12 Mt), Visakhapatnam (82.62 Mt), and Mumbai (67.64 Mt) — together accounting for more than 60% of the total volume.[6]

By cargo category, petroleum, oil, and lubricants (POL) and crude products led the mix, making up 29.63% of total cargo. Containerised cargo was the second-largest category, at 22.66%. Other significant segments included coal, iron ore, fertilisers, and miscellaneous goods (see Exhibit 3).[7]

Exhibit 3

Key commodities handled at Major Ports of India in FY2024–25

S.No.	Principal commodities	Cargo handled (tonnes)	Share of total cargo handled (%)
1	POL and crude products	252,935,635	29.63
2	Container	193,405,037	22.66
3	Coal	186,311,887	21.83
4	Other commodities	140,232,772	16.43
5	Iron ore	49,393,420	5.79
6	Fertiliser	25,764,708	3.02
7	Food/grains	5,525,078	0.65

RMI Graphic. Source: *Monthly Cargo Traffic Handled at Major Ports up to and During March 2025*, Transport Research Wing (TRW) under the Ministry of Ports, Shipping and Waterways (MoPSW), March 2025

2.2. Truck operations and movement patterns at Major Ports in India

Most Major Ports in India operate under a landlord model, where terminal operations are leased to private terminal operators through long-term concession agreements. Port trucking operations typically involve three key stakeholders: the port authority, the terminal operator, and the fleet operator. Data from Major Ports indicates that, with few exceptions, such as Adani Terminal operating its own fleet at Kamarajar Port, neither port authorities nor terminal operators directly own trucks. Instead, trucking operations are generally outsourced to fleet operators, who provide services under contractual arrangements. Typical movement of trucks at the ports include:

- **Intra-terminal movement:** From vessel to a storage yard or rail yard (1–3 km per trip)
- **Inter-terminal movement:** Between terminals within port boundaries (2.5–8 km per trip)
- **Port to nearby areas:** To nearby container freight station (CFS) or warehouses (5–20 km per trip)
- **Port to hinterland:** To inland regions (typically 100 km or more)

Currently, an estimated 23,893 trucks are in operation across the 12 Major Ports, serving four primary use cases (see Exhibit 4).

Exhibit 4

Number of trucks deployed in 12 Major Ports for various use cases

	Inter-terminal	Intra-terminal	Port to nearby areas	Port to hinterland	Grand total
Chennai Port	4	45	—	—	49
Cochin Port	31	57	109	8	205
Deendayal Port	—	28	—	—	28
Jawaharlal Nehru Port	194	314	4,050	7,100	11,658
Kamarajar Port	—	36	—	6,420	6,456
Mormugao Port	37	—	—	395	432
Mumbai Port	—	12	12	400	424
New Mangalore Port	10	91	95	683	879
Paradip Port	—	532	—	160	692
Syama Prasad Mookerjee (Kolkata) Port	25	70	—	589	684
V.O. Chidambaranar Port Authority	220	49	443	605	1,317
Visakhapatnam Port	136	43	735	155	1,069
Grand total	**657**	**1,277**	**5,444**	**16,515**	**23,893**

Note: In most ports, trucks are used interchangeably by fleet operators and terminal operators for both inter-terminal and intra-terminal movements.
RMI Graphic. Source: Data shared by Major Ports to MoPSW as of 26 September 2025. For Chennai and Deendayal Ports, the data was shared to IPA as of 30 March 2025

Analysis of fleet deployment across different movement types and use cases shows that around 30% of the trucks are engaged in movements within ports or from ports to nearby areas such as warehouses and CFSs. The remaining 70% are primarily used for longer port-to-hinterland operations.

Most trucks operating across the Major Ports are heavy-duty vehicles with a gross vehicle weight rating (GVWR) of more than 12 tonnes. Only about 2% fall within the 12–25 tonne GVWR range, while the remaining 98% exceed 25 tonnes.

3. Opportunity for ZET Deployment at Ports

This section explores the emerging opportunity for ZET deployment at Major Ports. It highlights key learnings and challenges from early deployments and pilot projects, outlines demand projections from Major Ports, and presents a comparative TCO analysis to evaluate economic viability across key port use cases.

3.1. Existing ZET deployment and pilots

Port authorities and terminal operators have begun piloting ZET deployment at Major Ports. Although some initiatives have been limited to short-term pilot projects, others have advanced towards more sustained and large-scale fleet conversion. Exhibit 5 summarises current ZET deployments and pilot initiatives, followed by the key lessons emerging from these efforts.

Exhibit 5 **Case Studies for ZET deployment at Major Ports**

	CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
	 Photo credit: RMI	 Photo credit: RMI	 Photo credit: RMI	 Photo credit: Switchlabs
Port	**Jawaharlal Nehru Port**	**Jawaharlal Nehru Port**	**Kamarajar Port**	**Vishakhapatnam Port**
Key stakeholders	**Terminal operator:** JM Baxi **OEMs:** SANY, BYD, Foton **Fleet operator:** Owned and operated by Jyothi Transport	**Terminal operator:** DP World and PSA **OEMs:** Ashok Leyland and IPLTech **Fleet operator:** Jyothi Transport and Transvolt	**Terminal operator:** Adani Terminal **OEM:** BYD **Fleet operator:** Owned and operated by Adani Terminal	**Terminal operator:** Bothra Group **OEM:** I-Board **Fleet operator:** Switchlabs
Use case and commodity	Intra-terminal container movement	Intra-terminal container movement	Intra-terminal container movement	Port to nearby areas; bulk cargo
Deployment date/trial duration	Deployed since August 2024	Five days; December 2024 (Ashok Leyland) and January 2025 (IPLTech)	Deployed since December 2023	Four days; 16 to 19 April 2025

Exhibit 5 **Case Studies for ZET deployment at Major Ports**

	CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
No. of vehicles	7 ZETs (e-trucks)	1 ZET (e-truck)	24 ZETs (e-trucks)	1 ZET (e-truck)
Vehicle specifications	**GVWR:** 55 tonne tractor trailer **Battery size:** • SANY (282 kWh) • BYD (250 kWh) • Foton (282 kWh) **Efficiency:** 0.50 km/kWh	**GVWR:** 55 tonne tractor trailer **Battery size:** • Ashok Leyland (302 kwh) • IPLTech (258 kWh) **Efficiency:** 0.48 km/kWh	**GVWR:** 55 tonne tractor trailer **Battery size:** • BYD (250 kwh) **Efficiency:** 0.46 km/kWh	**GVWR:** 35 tonne tipper **Battery size:** • I-Board (262 kwh) **Efficiency:** 0.60 km/kWh
Charging setup	**Fixed charging:** One 240 kW CCS2 charger installed. **Battery swapping:** Two battery swap stations installed, each with power output of 1.2 MW. Each station operates with three batteries in 3+1 configurations, with three batteries actively charging and one slot reserved for storing the swapped battery.	**Fixed charging:** **Ashok Leyland:** OEM provided mobile charger for charging. **IPLTech:** Used existing GB/T charger installed at the terminal.	**Fixed charging:** Three dual-gun chargers of 240 kW installed in terminal area.	**Fixed charging:** Temporary charging station provided by the OEM.
Daily distance travelled	~100 km per truck	~125 km per truck	~120 km per truck	~150 km per truck

Note: kWh = kilowatt-hour; MW = megawatts; OEM = original equipment manufacturer. These include pilots and deployments until 15 September 2025. Given the time in reporting and collecting data, deployments after 15 September 2025 were not considered for analysis.

RMI Graphic. Source: Information shared by stakeholder terminal operators and fleet operators with RMI, and RMI analysis

Key learnings from ZET pilots/deployments

These deployments provide key insights about ZET performance, operational efficiency, costs, and driver experience, which can serve as a foundation for other stakeholders interested in ZET deployment at Major Ports. The insights include:

Performance

- Payload capacity and pulling power of ZETs were consistently on par with diesel trucks.
- In some cases, a 1:1 replacement ratio of ZETs with diesel trucks was maintained, avoiding the need for additional trucks.

Operational efficiency

- A slight reduction in efficiency was observed in port operations due to frequent start–stop movements, even with regenerative braking, compared with steady-speed operations outside ports and along highways.
- Optimal charging strategies were critical to maintaining battery state of health.

Cost considerations

- While higher capital expenditure for ZETs is expected to be offset by lower operating expenditure, elevated electricity tariffs and surcharges increased operating costs for fleet operators.
- Lower insurance costs were noted for trucks operating within port boundaries because the entire port perimeter is already insured.
- Higher maintenance costs are anticipated, driven by frequent braking and start–stop cycles that reduce tyre life, and exposure to saline water, which accelerates vehicle body corrosion, relative to steady speed operations outside ports and along highways.

Driver experience

- Drivers benefitted from reduced fatigue due to automatic transmission and the absence of engine vibrations.
- Improved cabin comfort and ease of driving contributed to positive operator feedback.
- Overall port operations were notably quieter with ZETs compared with diesel trucks.

3.2. Future ZET deployment plans at Major Ports

Building on these initial ZET deployments, India's Major Ports have indicated demand for approximately 804 ZETs by 2030 (see Exhibit 6). This represents about 3% of the fleet currently engaged in port operations.

Exhibit 6 **ZET deployment plans at Major Ports**

S. No.	Port	Vehicle GVWR (tonnes)	Use case	Cumulative number of ZETs targeted for deployment by 2030	Plan for deployment (annual trucks)				
					2025–26	2026–27	2027–28	2028–29	2029–30
1	**Jawaharlal Nehru Port***	35 to 55	Intra-terminal and Inter-terminal	540	50	490	—	—	—
2	**Visakhapatnam Port**	7.5 to 12	Intra-terminal and Inter-terminal	25	—	—	—	10	15
		12 to 18.5		65	—	—	—	5	60
		35 to 55		40	—	40	—	—	—
3	**New Mangalore Port**	35 to 55	Intra-terminal and Inter-terminal	90	20	15	15	20	20
4	**V.O. Chidambaranar Port**	35 to 55	Intra-terminal	25	—	12	4	4	5
5	**Kamarajar Port**	35 to 55	Intra-terminal	19	—	19	—	—	—
6	**Cochin Port**	—	—	Plan is under development and feasibility studies are under way					
7	**Kolkata Port**	—	—	Port is currently in the planning stages and the matter is being discussed with concerned stakeholders					
8	**Mumbai Port**	—	—	Exploring feasibility for ZET adoption					
	Total	—	—	**804**	**70**	**576**	**19**	**39**	**100**

Note: This exhibit only shares information from ports that have indicated ZET deployment numbers or are thinking about ZET deployment. Ports that do not have any plan for deployment are not shared here.

RMI Graphic. Source: Information shared by Major Ports to MoPSW, per data received through 26 September 2025 and "India's First Fleet of EV Trucks with Swappable Batteries Flagged Off at JNPA by Sarbananda Sonowal," Jawaharlal Nehru Port Authority, September 25, 2025, **https://www.jnport.gov.in/uploads/media_center/1/1121/PR_JNPA_EV_Fleet_Sustainable_Logistics_25_sept.pdf**.

50 ZETs (e-trucks) flagged off at Jawaharlal Nehru Port Authority

Photo credit: JM Baxi Group

Shri Sarbananda Sonowal, Hon'ble Minister of Ports, Shipping and Waterways, flagged off 50 ZETs (e-trucks) with swappable batteries at the Nhava Sheva Distribution Terminal in Jawaharlal Nehru Port on 25 September 2025.[8] These ZETs are 55 tonne GVWR tractor trailers, using a 282 kilowatt-hour (kWh) battery pack, supported by one swapping station. The trucks will be primarily used for container movement within terminal areas and for transporting goods from the port to nearby CFSs.

This milestone is critical to achieving MoPSW's climate goals under the *Harit Sagar — Green Port Guidelines* and can serve as a springboard for large-scale deployment in the future.

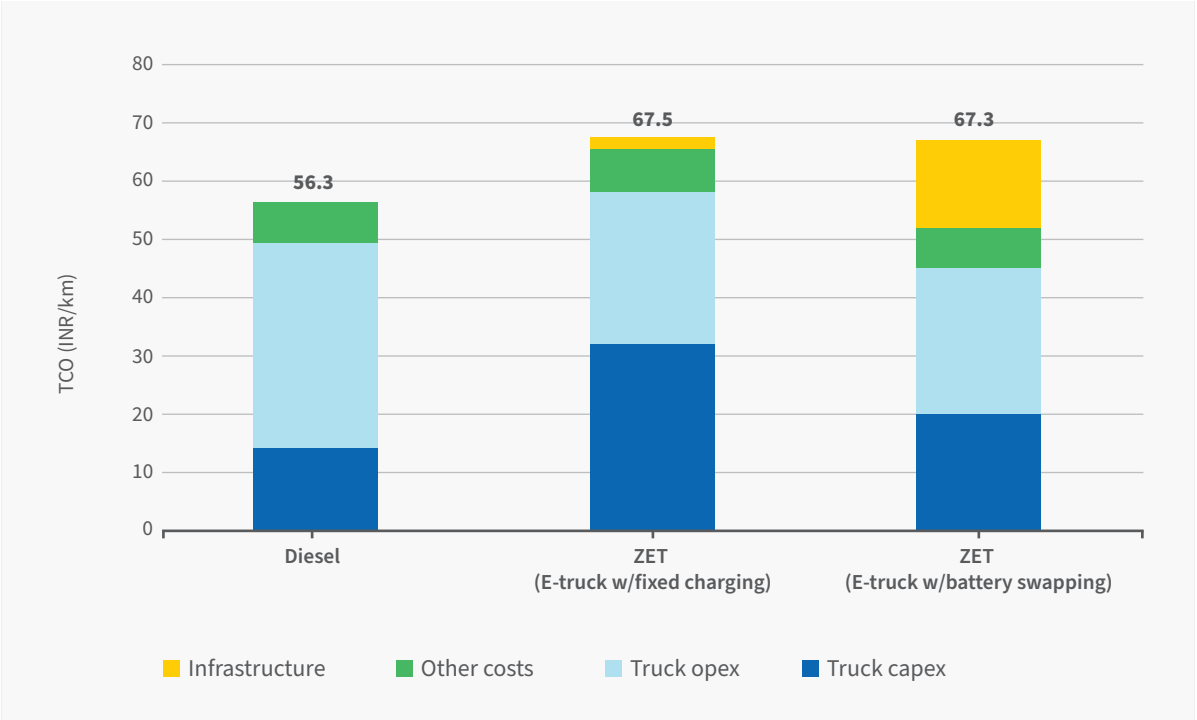
3.3. Techno-economic assessment of ZETs at ports

This section evaluates the TCO of ZETs compared with diesel trucks across the case studies mentioned above where ZETs have already been deployed or piloted.

In case studies 1 and 2 at Jawaharlal Nehru Port, the analysis includes fixed charging and battery swapping models because both have been implemented at the port. The TCO for ZETs using fixed charging is approximately 20% higher than for diesel trucks, while the TCO for battery swapping is about 19.5% higher (see Exhibit 7). These differentials stem from high operational costs due to high electricity tariffs (₹16/kWh), high up-front purchase price (for fixed charging only), and swapping infrastructure expenses (for battery swapping only).

Exhibit 7

TCO analysis for intra-terminal container movement at Jawaharlal Nehru Port

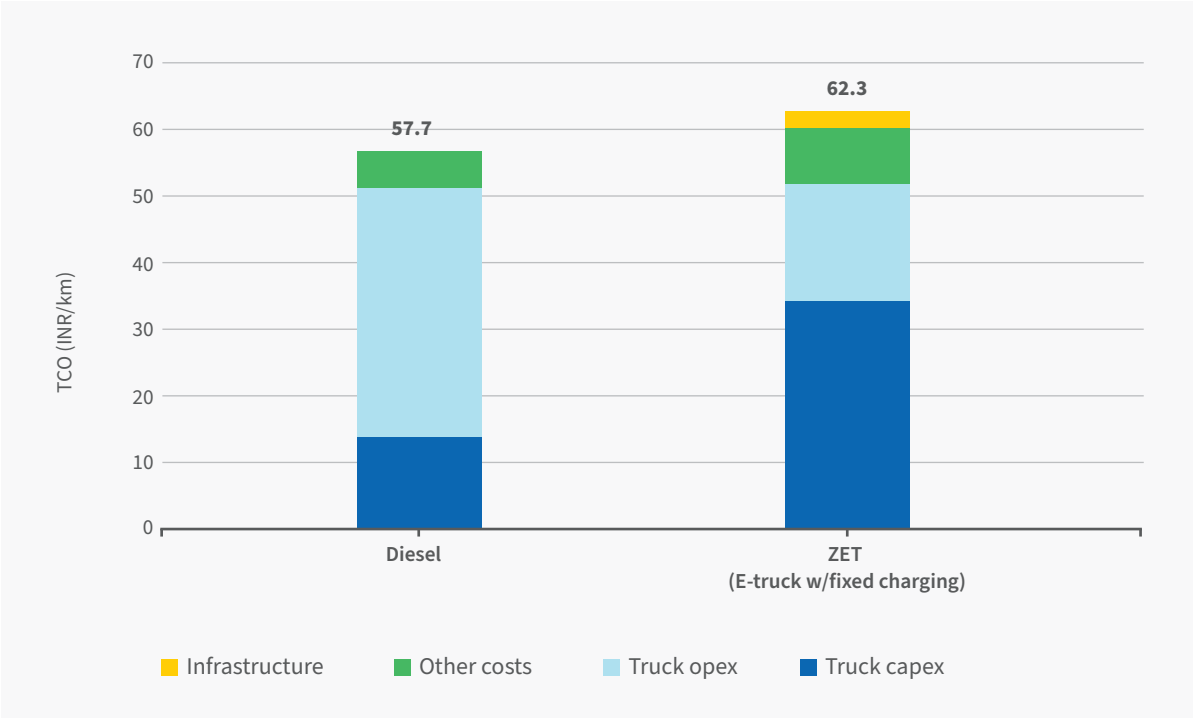


Note: TCO time period = 7 years; Truck GVWR = 55 tonnes; daily distance = 125 km; battery capacity, fixed charging = 300 kWh, swapping = 282 kWh. The ZET TCO is inclusive of the PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) vehicle incentives worth INR 9.3 Lakh.
RMI Graphic. Source: RMI analysis of data shared by fleet operators and terminal operators for ZET deployment and pilots

In case study 3, at Kamarajar Port, the TCO for ZETs with fixed charging is about 8% higher than for diesel trucks, but lower than the TCO observed at Jawaharlal Nehru Port (see Exhibit 8). The difference is due to a lower electricity tariff at Kamarajar Port (₹10.5/kWh) compared with Jawaharlal Nehru Port.

Exhibit 8

TCO analysis for intra-terminal container movement at Kamarajar Port

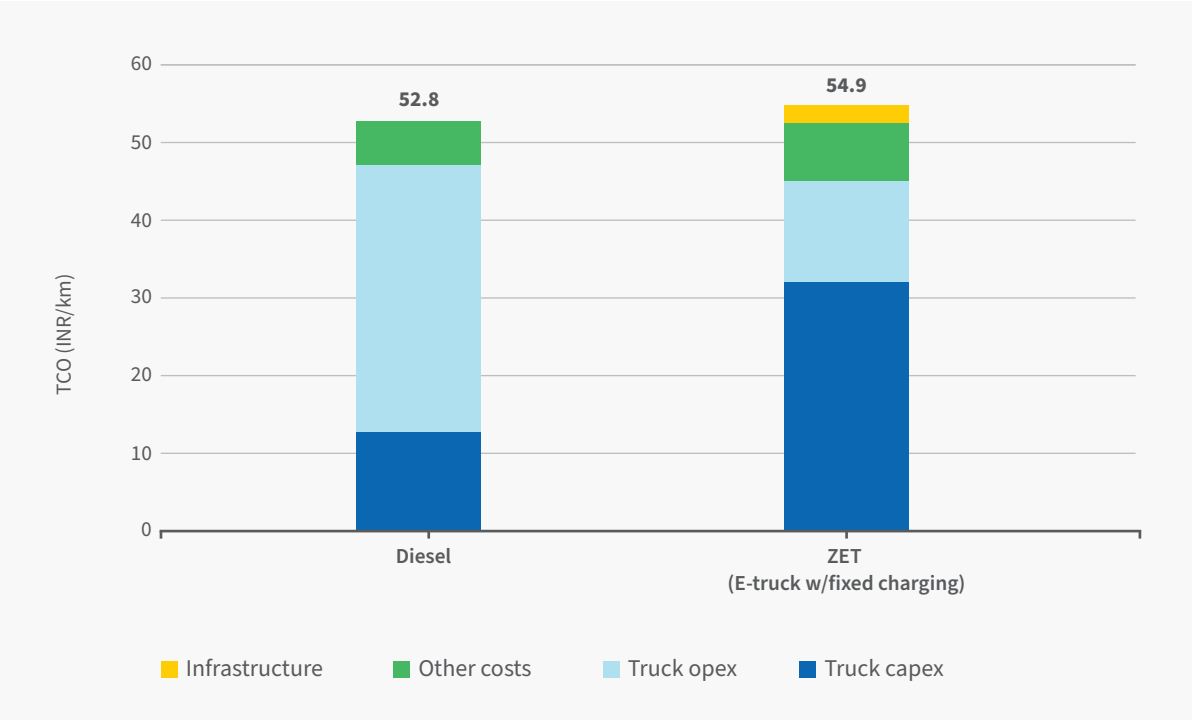


Note: TCO time period = 7 years; Truck GVWR = 55 tonnes; daily distance = 120 km; battery capacity, fixed charging = 250 kWh. The ZET TCO is inclusive of PM E-DRIVE vehicle incentives worth INR 9.3 Lakh.
RMI Graphic. Source: RMI analysis of data shared by fleet operators and terminal operators for ZET deployment and pilots

In case study 4, at Visakhapatnam Port, the pilot for bulk cargo movement from port to nearby areas shows that ZET TCO is about 4% higher than diesel (see Exhibit 9). Despite longer daily distance (around 150 km/day) and a slightly cheaper electricity tariff relative to the other two locations (₹9.72/kWh), the TCO gap remains.

Exhibit 9

TCO analysis of bulk cargo for port-to-nearby areas movement at Visakhapatnam Port



Note: TCO time period = 7 years; Truck GVWR = 35 tonnes; daily distance = 150 km; battery capacity, fixed charging = 262 kWh. The ZET TCO is inclusive of PM E-DRIVE vehicle incentives worth INR 9.6 Lakh.
RMI Graphic. Source: RMI analysis as per data shared by freight and terminal operators for ZET deployment and pilots

The TCO analysis indicates that ZETs currently have higher TCO than diesel trucks in port applications, with TCO gaps ranging from 4% to 20%. Although this gap persists, it is not prohibitive. An enabling policy framework tailored to ZET adoption at ports can help close the cost differential to enable the initial deployments that can then help achieve scaled deployments as aimed for under the *Harit Sagar — Green Port Guidelines* targets.

4. Enabling Policy Measures That Can Accelerate ZET Deployment

The techno-economic analysis indicates that ZETs currently have a higher TCO than conventional diesel fleets. However, this gap can be bridged with targeted interventions that catalyse early deployments. Fiscal incentives, infrastructure enablers, strategic planning, and market development measures, when embedded within a comprehensive policy framework, can help improve the TCO by reducing capital and operating costs, de-risking investments, and providing certainty of fleet utilisation and revenue streams to stakeholders. Importantly, aligning these measures with national initiatives such as PM E-DRIVE, the *Harit Sagar — Green Port Guidelines* and the Vision 2030 will ensure that port-linked transport decarbonisation is not limited to isolated pilot projects, but becomes part of a coordinated national transition.[9]

This section presents a framework outlining strategic planning and market development, fiscal and nonfiscal measures, infrastructure development, and capacity-building measures (see Exhibit 10) that can be institutionalised over the next five years. For each policy measure, global case studies are highlighted, followed by supporting policy solutions that can be adapted or adopted for the Indian port ecosystem.

Exhibit 10 **Policy measures and proposed solutions**

Policy measures	Proposed solutions	Case study
Strategic planning and market development	**ZET transition plans** — A comprehensive ZET transition plan for each port can be developed, serving as the central planning document for systematic adoption of ZETs.	**Clean Air Action Plan, Ports of Los Angeles and Long Beach, United States**
	ZET adoption requirements — All concession agreements signed or renewed with terminal operators can incorporate ZET adoption requirements increasing over time.	
	Demand aggregation for ZET procurement — Demand can be aggregated across terminal operators and transporters and shared with OEMs for consolidated procurement.	

Exhibit 10 **Policy measures and proposed solutions (continued)**

Policy measures	Proposed solutions	Case study
Fiscal and nonfiscal measures	**Up-front fiscal incentives** — An up-front fiscal incentive, supplementary to any national- or state-level incentives, can be provided to reduce the capital cost associated with ZETs.	**Low-Emission Technology Initiative, Port of Vancouver, Canada**
	Green surcharges — A green surcharge can be levied on diesel truck movement within port premises and further pooled into a green mobility fund for ZET adoption-related expenses.	
	Green channel and certification — A dedicated incentive system can be instituted offering reduced port-related charges, priority gate allocations, and cargo access for green-certified ZET fleets.	**Green Priority Initiative, Port of Gothenburg, Sweden**
	ZET contractual agreements for revenue certainty — Longer tenures and minimum load guarantees for freight operators can be embedded in concession agreements between terminal and freight operators.	
Infrastructure development measures	**Reducing electricity tariffs** — Availing state-based EV-specific tariffs and incorporating renewable energy at ports can be introduced as pathways to reduce electricity tariffs.	**Dedicated funding for charging infrastructure at ports, United States**
	Incentives for capital and installation costs — Capital subsidies can be availed for ZET charging equipment and installation expenses.	
	Identification of land parcels — Suitable land parcels can be identified and allocated within ports, specifically for charging and energy hubs for ZETs.	
	High-tension (HT) connection and grid upgrades — Grid capacity assessment and upgrades for ZET charging can be integrated into port master plans.	
Capacity-building measures	**ZET workforce training programmes** — A dedicated ZET workforce training programme can be developed to equip drivers and service providers with essential skills.	**Portable Innovation Open Network for Efficiency and Emissions Reduction Solutions (PIONEERS) initiative, Ports of Antwerp-Bruges, Barcelona, Venlo, and Constanta**
	Documentation and knowledge sharing — Records of operational learnings from ZET deployment can be maintained in a centralised knowledge repository.	
	Monitoring and evaluation — Annual and periodic convenings can be hosted to review progress and share operational experiences, ensuring consistent oversight and accountability.	

Note: OEM = original equipment manufacturer.

RMI Graphic. Source: RMI analysis

4.1. Strategic planning and market development

The market for ZETs at India's Major Ports is in the initial stages of development. Some ports and stakeholders are witnessing the early wave of deployments, while others are beginning to conduct pilots to assess the technical and economic viability of ZET operations. During these initial stages, it is critical to guide and direct terminal and fleet operators towards adoption of ZETs through measures that convey market signals. These include requiring ports to develop their individual ZET transition plans and setting requirements for adoption. Simultaneously, aggregating demand for ZETs for low-cost procurement will provide a necessary impetus for near-term deployments.

Port-specific ZET transition roadmap

Dedicated ZET transition plans can provide a structured pathway towards trucking decarbonisation by serving as central guiding documents for port authorities and terminal and fleet operators to fast-track ZET adoption. These plans can be developed by individual port authorities, based on each port's fleet composition, its terminal and fleet operators' plans to transition to ZETs, prominent commodities and use cases, and alignment with an overall port decarbonisation plan, if it exists.

Port authorities can ensure that the plans are aligned with national-level policies and guidelines and that the plan's goals and objectives serve the broader initiatives like the *Harit Sagar— Green Port Guidelines* and the Government of India's net-zero targets. These plans can also outline how they support state-level EV policies, whether meeting the vehicle adoption targets or availing EV tariffs. To indicate each port's ambitions and convey the long-term direction, Port authorities can set near-term (zero to two years), medium-term (three to five years), and long-term (more than five years) targets for ZET adoption. This will help the terminal and freight operators strategise their deployment plans accordingly, generating overall alignment among port authorities and the private sector. Achieving these targets will require additional support from the ports. Port authorities can outline a set of measures as part of the plan that will help meet the targets and generate confidence among terminal and fleet operators to fast-track ZET deployment. These measures can include developing supporting upstream and charging infrastructure within and around port premises to support ZET operations and ensuring dedicated land allocation for installing the infrastructure. Finally, for ports where ZET adoption has not kicked off, demonstration projects can be encouraged to generate practical learnings, showcase technical and economic feasibility, and build confidence among operators before large-scale deployment.

These plans must be developed in consultation with terminal and fleet operators to ensure the plan outcomes are ambitious but also rooted in reality.

ZET adoption requirement

In most Major Ports, port authorities ("concessioning authority") have long-term concession agreements with terminal operators ("concessionaire"). These agreements allow the terminal operator to execute cargo movement and handling operations at these ports in exchange for fees and royalties for using the port infrastructure and land. Embedding ZET requirements into these agreements can ensure that transition to ZETs becomes a contractual obligation. All concession agreements signed or renewed can include requirements for adoption, with an increasing share of ZETs in the fleet serving a terminal operator's operations over time. This will create demand certainty, supporting ports and the private sector as they plan required infrastructure and streamline ZET manufacturing plans for original equipment manufacturers (OEMs).

These requirements, indicating a certain percentage-share of ZETs in the overall fleet over time, can be decided by port authorities, in consultation with the terminal operators, based on the adoption targets outlined in their ZET transition plans. A monitoring and evaluation framework can be set up to ensure compliance, capturing fleet composition and proportion of ZETs in operation, and fiscal penalties can be levied for noncompliance.

Demand aggregation for ZET procurement

While ZET transition plans and ZET adoption requirements indicate the port's ambitions and provide a strategic direction to deploy ZETs, demand aggregation can serve as a complementary measure to meet the targets. Currently, ZET adoption at Major Ports is limited to fragmented orders from individual freight and terminal operators, which prevents OEMs from offering to commit to dedicated ZET supply and competitive pricing.

To address this, port authorities, through a designated nodal agency assigned by MoPSW, can aggregate demand across terminal and fleet operators. Port authorities have collectively signalled demand for 764 ZETs by 2030. Building on this, the nodal agency can work on harmonisation of technical specifications, including vehicle tonnage and battery capacity. These consolidated procurement requirements can be shared with OEMs, who can then provide price quotes based on pooled volumes.

The nodal agency can facilitate procurement agreements, enabling terminal and freight operators to benefit from reduced per-unit costs, assured supply, and faster deployment.

Case study for strategic planning and market development: Clean Air Action Plan for the Ports of Los Angeles and Long Beach

The twin Ports of Los Angeles and Long Beach (also called the San Pedro Bay Ports)[10] are ranked first and second in terms of total container throughput across the United States, respectively. Around 22,000 trucks operate at these ports daily. Together, they have developed the Clean Air Action Plan (CAAP).

CAAP was originally developed in 2006 with the goal of reducing emissions from maritime goods movement within these ports, and updates to the plan were made in 2010 and 2017. Between 2006 and 2017, the plan helped reduce diesel PM by 87%, NOx by 56%, and greenhouse gas emissions by 18%. One of the elements of this plan is the Clean Trucks Program (CTP) launched in 2008.

CTP aims to reduce pollution from trucking operations for the two ports and comprises key strategies, including:

- **Ban on older diesel trucks:** One of the first strategies when CTP was launched in 2008 included a phased ban on diesel trucks older than 2007 engine model year (MY). By 2012, all remaining older diesel trucks were banned from transporting goods within port premises, and 100% of the fleet were 2007 engine MY or younger. This led to a 90% reduction in truck-related emissions.

- **Adoption targets for ZETs:** A CTP update in 2017 included a 100% ZET adoption target for trucks doing intra-terminal movement by 2030. Additionally, it also outlined the targets for drayage trucks (trucks that move back and forth from ports to nearby warehouses and logistics hubs) to be 100% ZETs by 2035.

- **Clean truck fund rate:** In 2020, as part of CTP, the ports launched a clean truck fund (CTF) rate, which levies a US$10 per twenty-foot equivalent unit (TEU) fee on cargo moved by diesel trucks. This will generate revenue worth US$70–US$80 million for the ports, which can be utilised to incentivise purchase of ZETs and setup of associated charging infrastructure. Fleet operators will be able to receive up-front incentives worth US$75,000–US$100,000 per truck as part of funds received under the CTF.

- **ZET deployment pilot:** Under CTP, a major pilot project was undertaken to deploy 100 ZETs serving the two ports in collaboration with Volvo and Daimler as OEMs for a duration of one year. Although 1:1 replacement was not entirely possible due to 10% higher downtime for ZET charging relative to diesel trucks, ZETs have been performing on par relative to diesel trucks on an individual vehicle basis.

The initiatives under this plan have led to 546 ZETs being deployed at the Ports of Los Angeles and Long Beach as of June 2025. Overall, the CAAP highlights the importance of long-term plans in providing strategic guidance and a comprehensive framework for ZET adoption.

4.2. Fiscal and nonfiscal measures

Fiscal and nonfiscal measures are required to accelerate deployment of ZETs at ports. Fiscal measures include providing up-front incentives to lower up-front costs associated with a truck. They also include levying a surcharge on operations via diesel trucks to disincentivise fleet operators from using these trucks and incentivise transitioning to ZETs. Nonfiscal measures complement the fiscal measures by ensuring ZETs get access to priority lanes and loading/unloading berths and longer contract tenures offered by terminal operators to fleet operators. These ensure higher utilisation of ZETs and long-term revenue certainty. Together, fiscal and nonfiscal incentives enhance financial viability and build a strong business case for ZET adoption by fleet operators.

Up-front fiscal incentives

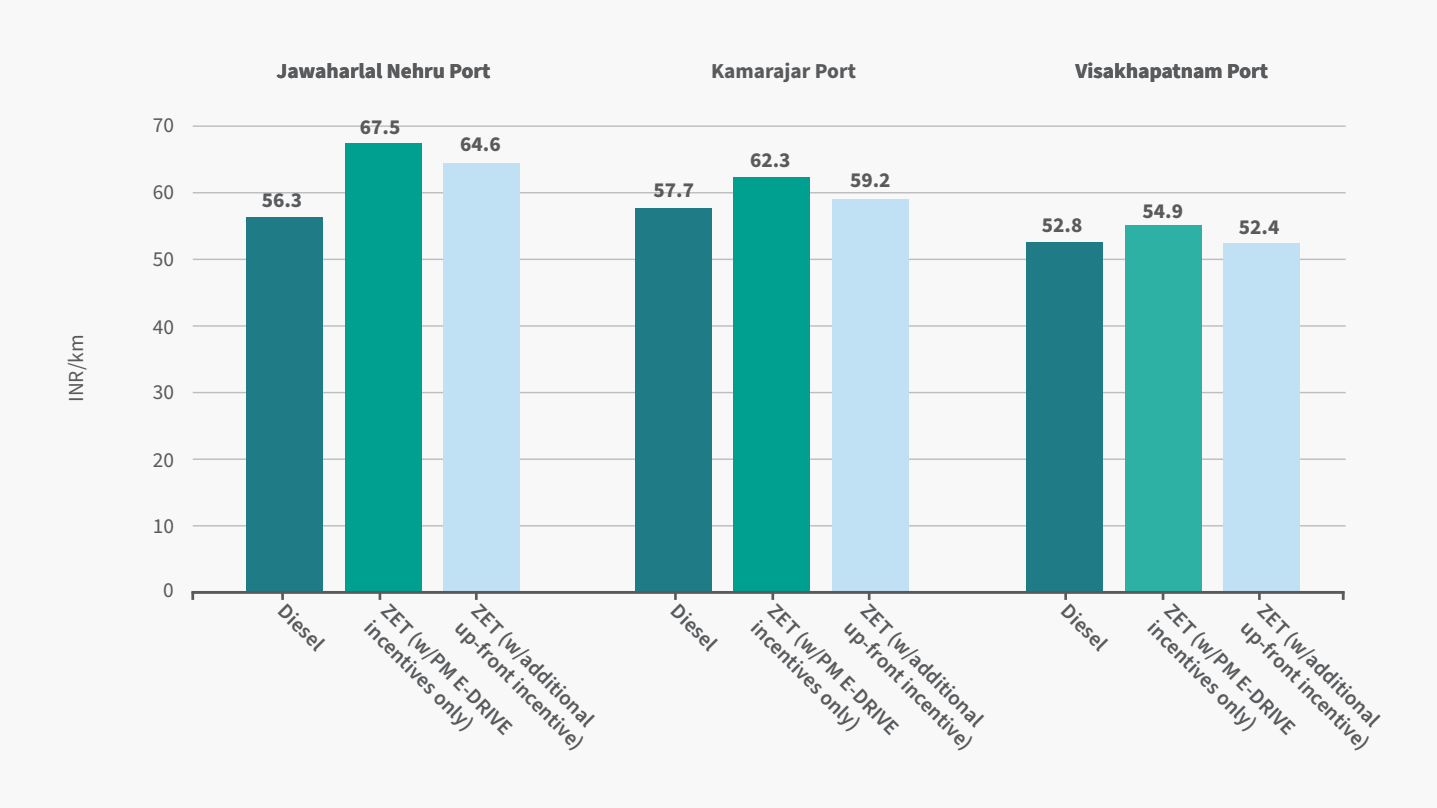
Up-front fiscal incentives are a financial mechanism that lowers the capital cost of ZETs at the time of purchase, which in turn helps lower their TCO. The Ministry of Heavy Industries (MHI), under the PM E-DRIVE scheme, offers an up-front incentive equalling the lowest of ₹5,000/kWh of battery capacity, 10% of the truck's up-front price, or a maximum incentive amount based on GVWR.[11,ii] Building on this, a supplementary up-front incentive equal to the incentive being offered under the PM E-DRIVE scheme can be provided. This incentive can be earmarked for ZETs being deployed for one of the four use cases relevant to trucking operations at Major Ports.

ii The maximum incentive amount is ₹9.6 lakhs for trucks with GVWR from 18.5 to 35 tonnes, and ₹9.3 lakhs for trucks with GVWR over 35 and up to 55 tonnes.

By applying this incentive to the three use cases across the three different ports (Jawaharlal Nehru, Kamarajar, and Visakhapatnam) where existing deployments have happened, ZET TCO can be lowered by 4%–5%. This leads to ZETs achieving TCO parity with diesel trucks in the case of Visakhapatnam Port, and close to TCO parity in the case of Kamarajar Port (see Exhibit 11).

Exhibit 11

Impact of up-front fiscal incentives (on top of PM E-DRIVE incentives) on the TCO of ZETs



RMI Graphic. Source: RMI analysis

Green surcharge

A green surcharge is a pricing mechanism that ports can implement by applying an additional fee on conventional diesel trucks entering port premises. The surcharge creates a financial signal that discourages diesel use, while revenues collected can be reinvested to support ZET adoption.

The measure can be applied either as a fixed fee per truck entry or a fee based on tonne-kilometres travelled within port boundaries. Importantly, ports can acknowledge proactive efforts by terminal operators by granting partial or full waivers where mutually agreed upon ZET adoption milestones are achieved.

All proceeds from the surcharge can be pooled into a dedicated fund managed by the port authority. This fund can then be reinvested into building ZET charging and refuelling infrastructure, providing purchase subsidies to fleet operators, and training drivers and mechanics for safe and efficient ZET operations.

Green channel and certification

Current systems for gate processing and cargo handling for trucks operating at ports work on a first-come, first-served basis, agnostic of truck technology choice. A green channel, instituted as an incentive system, can address this by offering operational and financial advantages exclusively for ZETs.

This channel would function through three core measures. First, it could allow dedicated gate lanes for ZETs. This would reduce delays at entry and exit points and help bypass congestion faced by diesel trucks during peak hours. Second, the channel could include priority cargo handling measures by allocating premium loading and unloading slots to ZET operators, ensuring competitive service levels and reducing turnaround times. Third, it could include reduced port charges, providing direct financial benefits through exemptions from gate fees, internal tolls, and discounted handling services.

Fleet operators deploying ZETs for port-linked freight could receive green certification based on defined eligibility criteria set by port authorities. This certification would serve as the formal process to access the green channel's operational and financial benefits.

ZET contractual agreements for revenue certainty

Current contracts between terminal operators and fleet operators for trucking operations typically span only one to three years, whereas ZETs require longer time horizons to recover high up-front costs. Without long-term service assurance and guaranteed cargo volumes, fleet operators face the risk of underutilisation and stranded assets, while lenders remain hesitant to finance early-stage ZET deployment. Contractual incentives can address this challenge by embedding revenue certainty directly into service agreements between port authorities, terminal operators, and fleet operators.

Two key provisions can be embedded in these contracts. First, a minimum contractual tenure of seven years can be specified for ZET deployment, subject to satisfactory performance and compliance with operational standards. Given the typical loan tenures of five years for buying a vehicle, ZETs will typically start incurring profits after the loan payments are completed and the contract periods of seven years or more help build a stronger business case. Second, monthly load guarantees can be included alongside the longer tenure requirement. These guarantees, based on cargo flow forecasts and terminal throughput capacity, provide operators with baseline revenue assurance and protect against underutilisation. Together, these provisions enhance ZETs' financial viability while also strengthening confidence among lenders to offer loans for ZET procurement.

Case studies for fiscal and nonfiscal measures

Case Study 1: Port of Vancouver — Low-Emission Technology Initiative

The Vancouver Fraser Port Authority, in partnership with the Province of British Columbia and port community stakeholders, is piloting low- and zero-emissions fuels and technologies to meet its target of phasing out all port-related emissions by 2050.

Through the Low-Emission Technology Initiative,[12] the port authority and the province have each committed CAD$1.5 million to support projects enabling the transition to low-emissions energy. Funded projects include deployment of battery-electric terminal tractors at container terminals and early adoption of electric heavy-duty trucks for drayage between terminals and nearby facilities. By offsetting the vehicle's purchase costs, the initiative allows operators to test ZETs in daily port logistics while generating operational data to guide broader scale-up.

At Seaspan Ferries' Tilbury Marine Terminal on the Fraser River, two battery-electric terminal tractors were procured with Low-Emission Technology Initiative support. The Vancouver Fraser Port Authority contributed CAD$250,000 towards the purchase, with the remainder funded by Seaspan and the province. Seaspan is now evaluating the performance of these units and assessing replacement of its remaining 22 diesel-powered trucks with battery-electric alternatives.[13]

Case Study 2: Port of Gothenburg — Green Priority Initiative

The Port of Gothenburg introduced a green priority system to incentivise cleaner fleets by granting electric- and hydrogen-powered trucks priority passage through dedicated lanes and fast-track handling at container terminals.[14]

Launched in March 2023, the initiative ensured that ZETs could bypass queues during loading and unloading, reducing turnaround times and mitigating range anxiety for operators. With three terminals now implementing the system, covering nearly 90% of truck movements at the port, this measure has delivered clear operational benefits while signalling the port authority's long-term commitment to decarbonisation.

By embedding nonfiscal incentives directly into daily operations, the green priority initiative has strengthened the business case for fleet operators by enabling higher throughput, improving productivity, and increasing revenue potential.

4.3. Infrastructure development

Scaling ZET adoption at ports depends heavily on the availability of low-cost and reliable charging infrastructure. Currently, several barriers are deterring terminal and fleet operators from planning large-scale charging infrastructure deployment. These include high electricity tariffs, expensive hardware and installation costs, significant power requirements that strain the grid, and the need for dedicated land within constrained port premises.

Addressing these challenges will require coordinated interventions that reduce costs, expand access to land, and strengthen grid readiness. A structured set of infrastructure measures can ensure that charging capacity grows in line with ZET adoption and is integrated into broader port development plans.

Reducing electricity tariffs

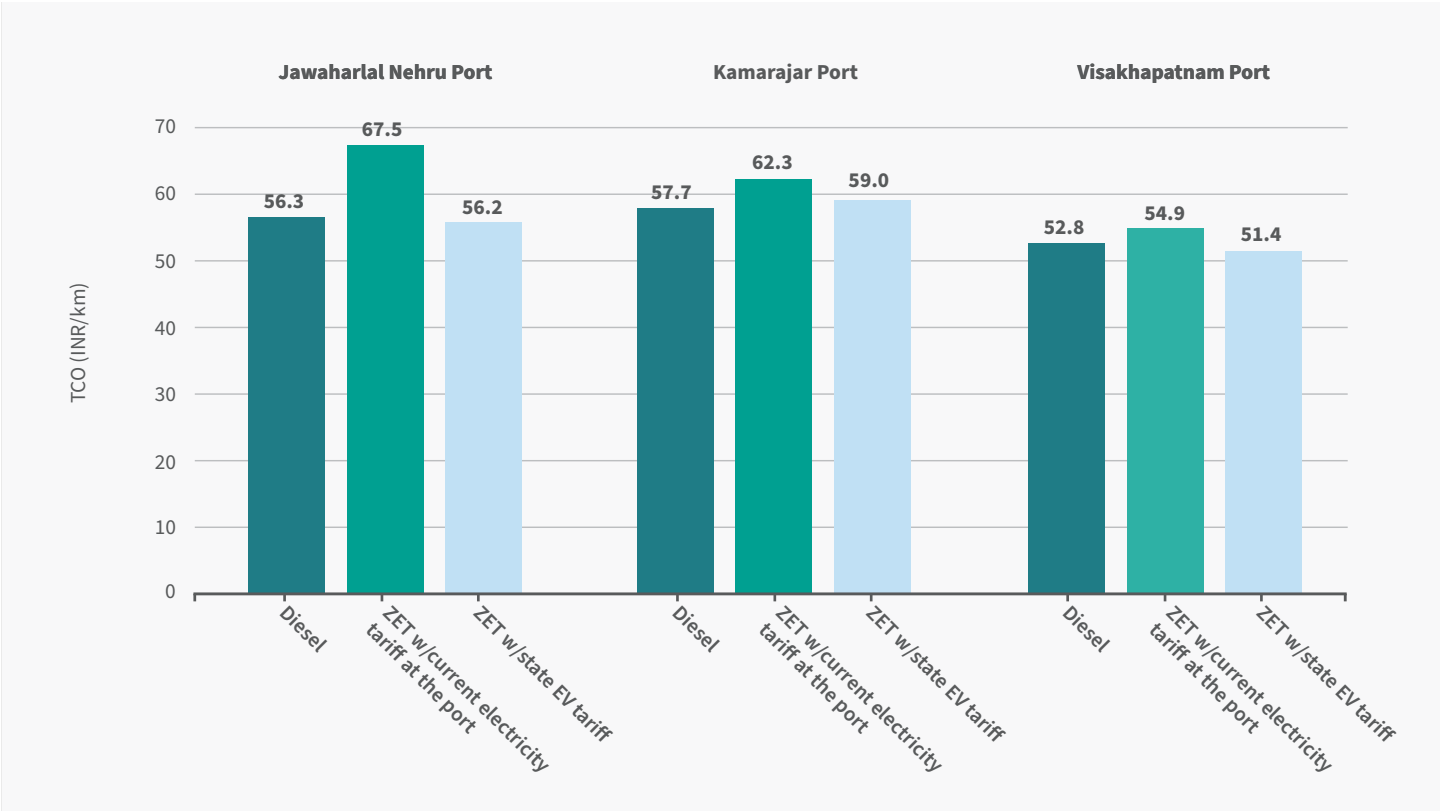
Operating expenses due to electricity costs represent 20%–30% of ZET TCO at Major Ports. Electricity tariffs levied at the Major Ports for ZET charging range between ₹6/kWh and ₹16/kWh. Such high tariffs hamper the business case for fleet operators by increasing the operational costs and negating the efficiency advantages that ZETs offer.

Two key pathways can be adopted to lower the electricity tariff at the ports:

- **Availing state EV tariff:** Most states are incentivising EV adoption by offering EV-specific tariffs, which can be lower than the industrial or commercial rates. Ports are encouraged to explore pathways with distribution companies (DISCOMs) to avail EV tariffs in their premises. State EV tariffs are about 23% lower than electricity tariffs currently charged on average across the 12 Major Ports.[15] This can lower TCO and improve affordability for early ZET adoption. Availing EV tariffs can lower ZET TCO by 5%–17%, bringing it to parity with diesel trucks in most cases (see Exhibit 12).

Exhibit 12

Impact of availing EV tariff on TCO of ZETs

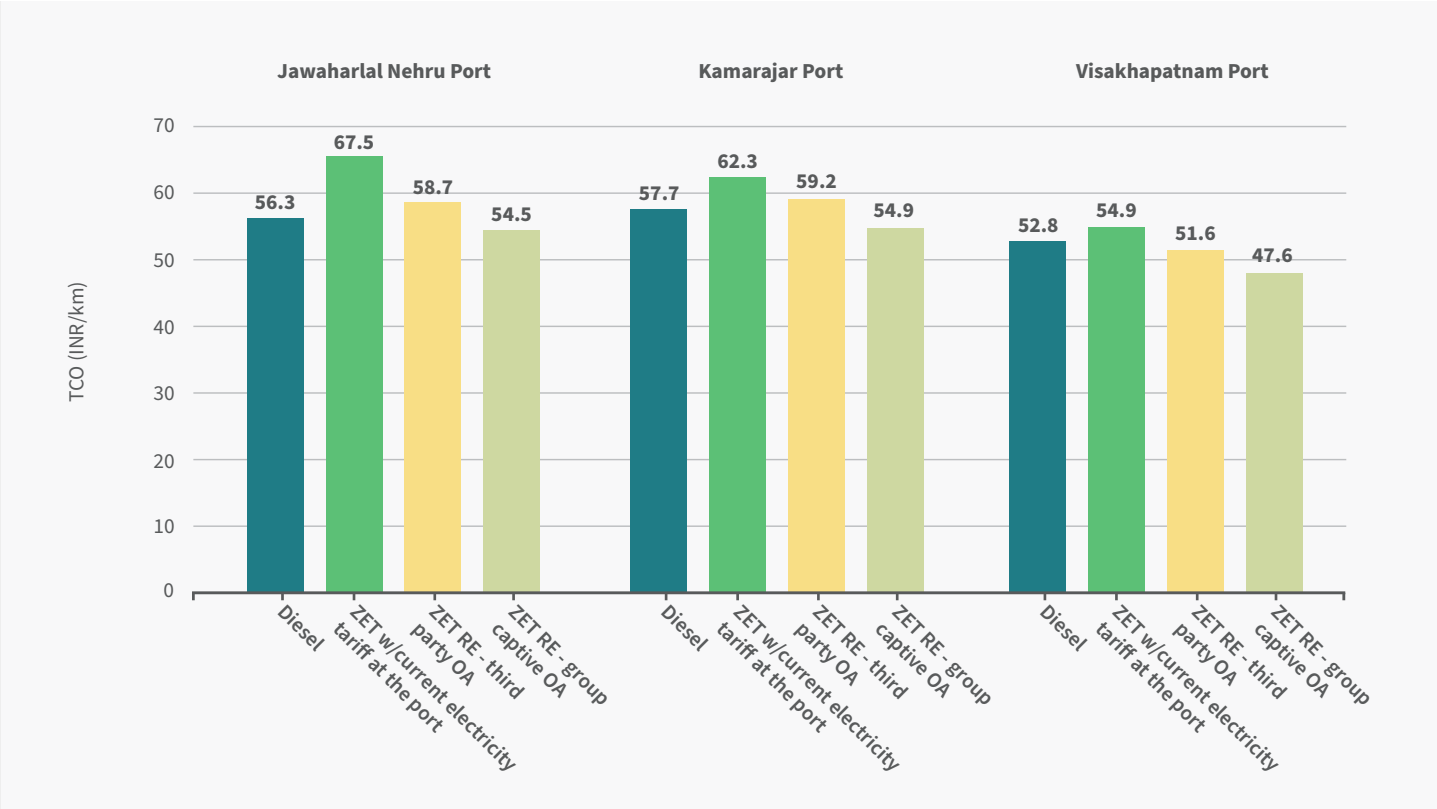


Note: This analysis was done for a ZET (e-truck with fixed charging model) for the ports and use cases where existing deployments have happened, as outlined in Section 3.1. Tariff details can be found in the Appendix.
RMI Graphic. Source: RMI analysis

- **Incorporating renewable energy (RE) pathways:** This involves meeting ports' electricity needs — including charging for e-trucks — through RE. In line with the *Harit Sagar — Green Port Guidelines*, ports are expected to achieve more than 60% RE share by 2030 and 90% by 2047. Various pathways exist for RE procurement from on-site renewable generation or procuring power from off-site sources through

open access (OA) or group captive arrangements. For example, by adopting open access or group captive renewable power, a terminal or fleet operator can lower the TCO of ZETs by 5%-19%, bringing them to parity with diesel trucks (see Exhibit 13).

Exhibit 13 **Impact of RE procurement on TCO of ZETs**



Note: This analysis was done for a ZET (e-truck with fixed charging model) for the ports and use cases where existing deployments have happened, as outlined in Section 3.1. Tariff details can be found in the Appendix.
RMI Graphic. Source: RMI analysis

Overall, in the near term, ports where there are significant differences between the state EV tariff (if notified by the state) and the tariff levied may consider facilitating the application of the state EV tariff for ZET adopters. Where EV tariffs are not applicable or do not exist, and in the longer term more generally, port authorities can transition to RE procurement strategies to reduce tariffs and decarbonise their own operations.

Incentives for capital and installation costs

Early charging infrastructure deployments at ports often face two critical barriers: high up-front capital requirements for hardware and installation, and low utilisation. Together, these factors increase financial risk for terminal operators and fleet operators, slowing first-mover adoption. Targeted incentives can be provided to directly offset the cost of equipment procurement and installation-related civil and electrical works, de-risking early projects and attracting private investment.

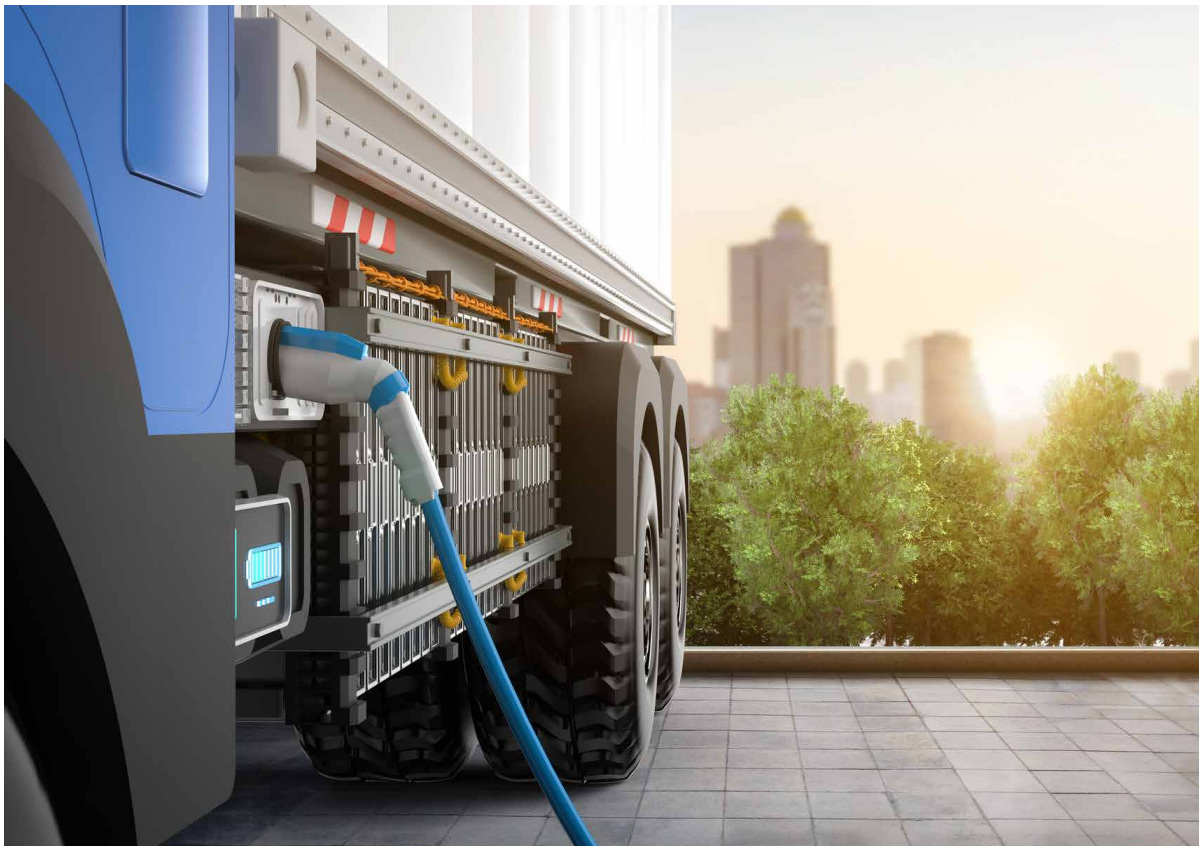
Under the PM E-DRIVE scheme, MHI has earmarked ₹2,000 crore for the deployment of electric vehicle public charging stations (EV PCS). On 26th September 2025, MHI released operational guidelines detailing the process for availing subsidies for charging infrastructure.[16] As per these guidelines, all ports are eligible to access the subsidy. The scheme provides financial support covering 80% of upstream infrastructure costs and 70% of electric vehicle supply equipment. For battery swapping stations, only the upstream infrastructure is eligible for an 80% subsidy.

For the Major Ports, MoPSW will serve as the nodal agency responsible for aggregating demand and submitting formal subsidy requests to MHI. All Major Ports are encouraged to leverage this subsidy, as the targeted incentives are projected to reduce the TCO for ZET's by an estimated 2%–3% across the three identified use cases and ports where ZET deployments have already commenced.

Identification of land parcels

Charging stations require proximity to cargo movement routes, container yards, and terminal gates to ensure efficiency and minimise dead mileage. Port authorities can identify and earmark suitable land parcels within their premises for ZET-supportive infrastructure. These parcels can be zoned in port master plans and integrated with cargo handling layouts to ensure infrastructure development does not conflict with port expansion or cargo operations.

Additionally, the land allocated for charging infrastructure can be designed to enable shared access by both captive fleets and third-party logistics operators to increase utilisation. Where feasible, infrastructure should be developed as common-use charging hubs, ensuring interoperability and open access for all port-linked freight operators.



High-tension (HT) connection and grid upgrades

ZET charging requires large, continuous loads that exceed the capacity of low-voltage connections commonly used at ports today. High-tension (HT) connections, therefore, can ensure grid stability and prevent localised overload. Port authorities can assess site-specific load requirements and projected future demand for charging hubs, depots, and common-use charging stations.

The approach to grid upgrades will depend on the regulatory status of each port. Ports operating as distribution licensees or franchisees and those already authorised to manage internal electricity distribution can plan and implement upgrades directly, including substations and internal HT lines. In contrast, ports acting as general electricity consumers will need to coordinate with DISCOMs and state regulators to secure HT connections, obtain timely approval of load-enhancement applications, and plan phased upgrades aligned with forecasted ZET demand. To keep pace with adoption, Port authorities, in consultation with DISCOMs or internal licensees, can also undertake grid capacity assessments every two to three years, linked to port-specific ZET transition plans.

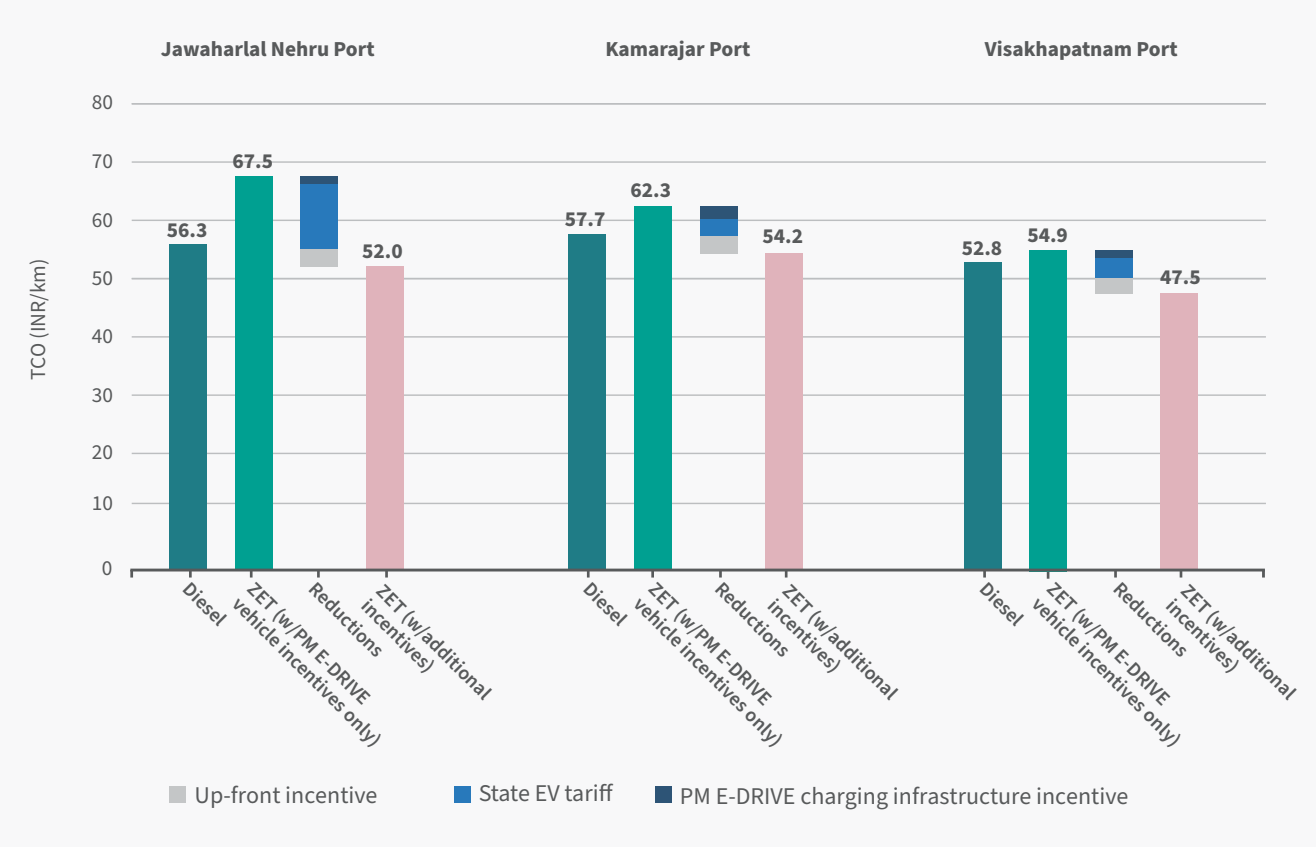
Where feasible, grid reinforcement projects (e.g., new substations, additional transformers, or feeder augmentation) can be integrated into port master plans and financed through institutional mechanisms such as a Maritime Development Fund or multilateral support.

Case study for infrastructure development measures — Dedicated funding for charging infrastructure at ports in the United States

The United States has prioritised charging infrastructure at ports through large-scale federal initiatives. The US Environmental Protection Agency's Clean Ports Program committed US$3 billion to reduce emissions from port operations, with a significant amount directed specifically to zero-emissions infrastructure projects at ports.[17] Grants have supported both fixed and portable charging systems, ensuring that first-mover deployments are not stalled by high capital costs or early underutilisation risks.

An example is the Port of Savannah, Georgia, which received a US$15.3 million grant from the US Department of Transportation's Federal Highway Administration to develop large-scale charging infrastructure for ZETs and help the port transition to Class A EVs.[18] Of this, US$7.8 million was allocated to Voltera, a company specialising in commercial EV charging. In collaboration with Georgia Power, Voltera will offer up to 23 megawatts of charging capacity and more than 120 charging bays for Class 8 electric drayage trucks at the port. This would potentially reduce emissions by up to 37,000 tonnes annually.[19] The remaining US$7.5 million will fund a four-year pilot programme to transition 621 port vehicles from fossil fuels to renewable low-emissions alternatives.[20]

Exhibit 14 **Impact of policy measures on the TCO of ZETs**



Note: This analysis was done for the ports and use cases where existing deployments have happened, as outlined in Section 3.1.
RMI Graphic. Source: RMI Analysis

As Exhibit 14 illustrates, in the absence of the proposed policy measures, ZETs remain more expensive, 4%–20% higher in TCO than their diesel counterparts. However, when supported by a package of fiscal and infrastructure incentives, ZET TCO achieves parity with diesel trucks. Up-front fiscal incentives, supplementary to PM E-DRIVE incentives, availing EV tariffs, and subsidies on charging equipment, lead to reductions in ZET TCO of 13%–23%, depending on the port and the use cases.

4.4. Capacity building

Fleet operators are starting to get oriented to electric drivetrains and charging protocols, while drivers and mechanics lack training in the safe operation and maintenance of ZETs. Such gaps are common in the early phases of any new technology adoption. Hence, capacity-building efforts are needed to establish systems that equip the trucking ecosystem with essential skill sets while capturing learnings for broader knowledge sharing.

ZET training programmes for end-to-end skilling ecosystem

Fleet operators are hesitant to transition to ZETs because of the limited pool of drivers and technicians trained in electric drivetrains, battery systems, and charging protocols. A dedicated ZET workforce training programme can be implemented by MoPSW to address this gap by building a comprehensive skilling ecosystem.

The programme can include tailored modules targeted towards preparing drivers and service providers for the ZET transition. Drivers could be trained in safety and emergency protocols, charging schedule planning, driving techniques to maximise vehicle efficiency, and ZET- and battery-related repairs and basic troubleshooting. Service providers could learn to service high-voltage drivetrains, battery systems, and digital diagnostic tools, ensuring support is available at ports and along freight corridors. Certified training centres can provide a standardised curriculum and recognised credentials, creating a trusted foundation for workforce readiness as ZET adoption scales.

Documentation and knowledge sharing

With ports beginning to deploy ZETs, valuable insights are emerging on performance, costs, maintenance, and utilisation. Capturing and sharing these lessons can help operators strengthen fleet economics, guide infrastructure planning, and inform supportive business models and regulations.

A centralised knowledge repository can make these learnings widely accessible. Port authorities could document their ZET deployment experience, including economics and operational data, maintenance requirements, and infrastructure strategies. This can also include details on financing mechanisms, especially on how blended financing mechanisms can be structured across public and private sector stakeholders to distribute the financial risks. This information can be consolidated into a national repository that also houses model templates, operational toolkits, and case studies. By making such resources available across the port network, the entire port ecosystem will gain access to practical guidance and evidence-based solutions. This will ensure that early experiences are not siloed but instead provide a foundation for replication and scale.

Monitoring and evaluation

ZET deployment in port operations requires continuous oversight to track progress and address gaps as they emerge. Without clear monitoring systems, issues such as infrastructure readiness, electricity supply constraints, or downtime from maintenance can remain unnoticed until they affect operations.

A structured monitoring and evaluation framework can ensure consistent oversight and accountability. Each port's progress can be reviewed against its ZET transition plans, including adoption targets. In addition, periodic convenings among port authorities, terminal operators, fleet operators, and infrastructure providers can be held to assess operational readiness and address emerging challenges. These sessions would track measurable indicators such as the share of ZETs in port fleets, charging infrastructure uptime, vehicle performance, and maintenance turnaround times.

Case study for capacity-building measures — Ports of Antwerp-Bruges, Barcelona, Venlo, and Constanta — The Portable Innovation Open Network for Efficiency and Emissions Reduction Solutions (PIONEERS) Initiative

The PIONEERS initiative is a collaboration between four ports with different characteristics but a shared commitment to transforming European ports into climate-neutral hubs by 2050.[21]

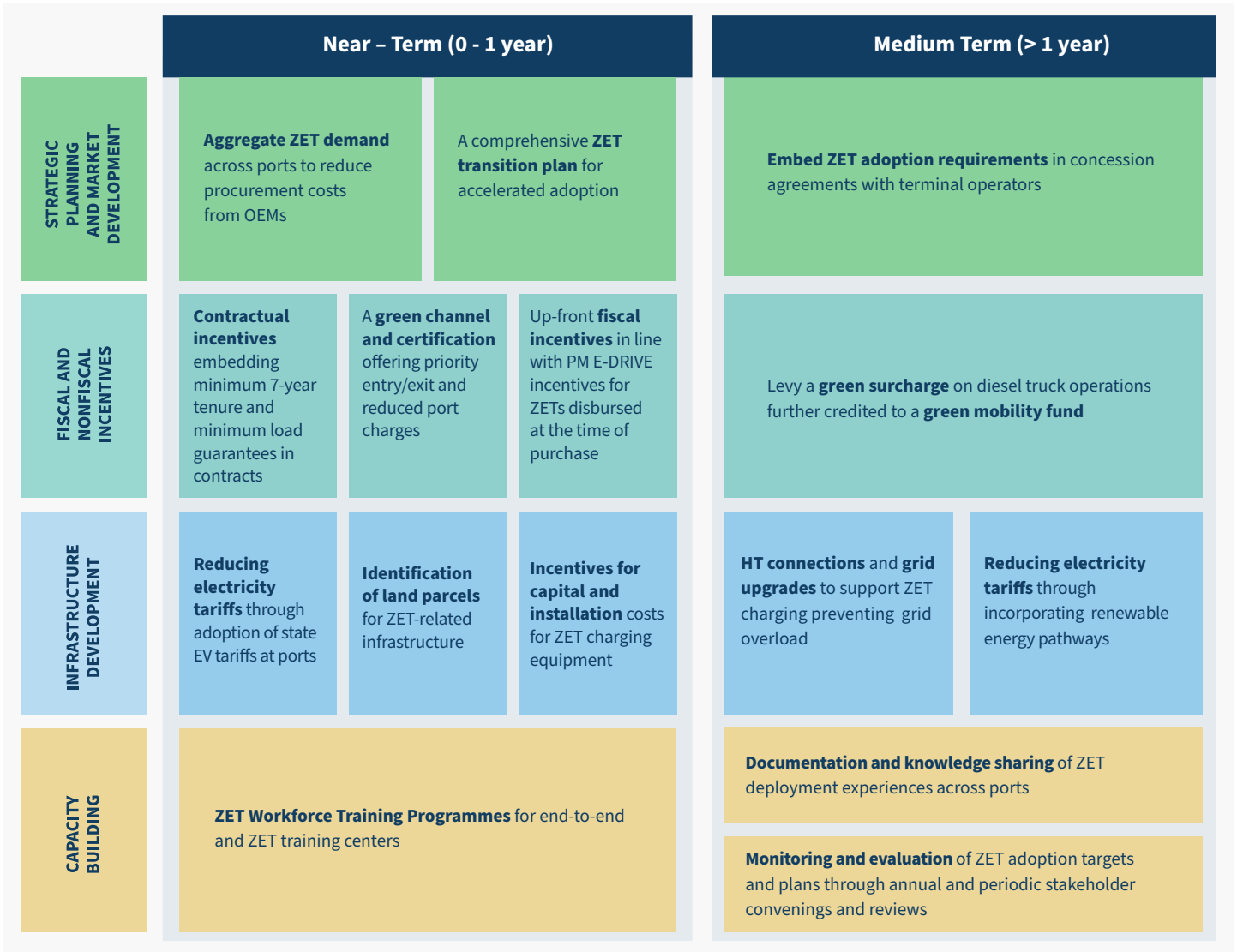
Bringing together more than 45 partners across industry, academia, government, and civil society, the initiative develops and tests solutions across four pillars: clean energy generation, sustainable port design, modal shift and flow optimisation, and digital transformation. Because much of the freight transportation at the PIONEERS ports is carried out by heavy diesel-powered vehicles, last-mile mobility, ports, and logistics partners such as FIER, Venlo, and Supply Chain Valley are piloting 100% electric terminal tractors to accelerate the electrification of logistics operations and supporting infrastructure. This kind of technology deployment is paired with capacity-building measures to ensure readiness for scale. From a capacity-building perspective, PIONEERS emphasises institutional readiness and collaborative learning.

The initiative establishes training programmes, ideathons, and innovation roundtables to prepare port stakeholders for decarbonisation while consolidating lessons into a transferable green port master plan. The training programmes focus on practical skills for zero-emissions operations, including modules on greening port handling equipment and specialised courses such as electric green last mile for on-site logistics operations. The ideathons invite students and young professionals to cocreate solutions, exchange ideas, and propose innovative pathways for deploying new green technologies at ports. Meanwhile, the innovation roundtables convene industry, academia, and government actors to share learnings from pilots, align on technology readiness, and foster cross-sector collaboration.

5. Phased Policy Framework

Port-based ZET policy measures can be introduced progressively through a structured framework that balances ambitious targets with operational feasibility. The framework can be designed for implementation in the near term (up to one year) and medium term (greater than one year) with the aim to help accelerate ZET adoption to achieve targets set under the *Harit Sagar — Green Port Guidelines*. Early actions should focus on demand aggregation, providing green channels for ZETs, availing EV tariffs, and allocating land for charging infrastructure, reducing entry barriers for fleet operators. Later phases should focus on embedding requirements for ZET adoption for terminal operators, levying a green surcharge on diesel trucks, and procuring electricity through renewable sources for truck charging (see Exhibit 15).

Exhibit 15 **Proposed phased policy framework for ZET adoption at ports**



RMI Graphic. Source: RMI analysis

5.1 Near term (up to one year)

The near-term phase can focus on creating market confidence, sending market signals, and demonstrating proof points for techno-economic feasibility. Establishing a ZET transition plan by each Major Port in this phase provides early clarity on adoption timelines and targets that send a clear message about a port's long-term focus on ZETs and reduces uncertainty for industry stakeholders. Alongside planning, it is equally important to aggregate ZET demand in the near term, which prevents fragmented procurement and allows ports to send a strong signal of scale to OEMs, which helps them scale manufacturing of ZETs. Additionally, to bridge the initial cost gap and give fleet operators long-term revenue certainty, up-front fiscal incentives paired with contractual incentives must be implemented. Simultaneously, green channels for ZET through dedicated entry/exit gates and lanes and reduced port charges must be prioritized.

In parallel, lower costs related to charging infrastructure in the near term set the stage for eventual large-scale deployment. Measures such as availing state EV tariffs and charging equipment incentives can reduce operational costs, while allocating land for charging hubs can help make build-out of required infrastructure faster. Workforce capacity must also keep pace with technology deployment through dedicated training programmes. Finally, monitoring of progress and initial documentation of key learnings from early deployments can begin in this phase.

5.2 Medium term (greater than one year)

The medium-term phase can focus on creating systems that unlock pilots to scaled adoption. By this time, early deployments and fiscal incentives are expected to have built sufficient operational familiarity and stakeholder confidence to enable more binding measures. These include requiring phased ZET adoption for terminal operators embedded in their concession agreements and introducing a green surcharge on goods movement by diesel trucks to accelerate fleet turnover.

On the infrastructure side, electricity tariffs can be further reduced through incorporating RE pathways. Additionally, to manage the higher power demand from scaled deployments, grid capacity must also be reinforced through HT connections and phased upgrades that are timed with increasing adoption levels.

To ensure sustained momentum towards ZET adoption, continued documentation of deployment experiences and knowledge sharing across ports is essential. During this phase, stakeholder convenings and pilot deployments can be used as instruments for learning and iterative refinement, ensuring that challenges observed at early-adopter ports are systematically captured and addressed before broader scaling.

The transition to ZETs at ports cannot be achieved through isolated measures. It requires careful and structured sequencing. By coupling early readiness and demand aggregation with progressively binding measures, ports can create a clear, phased pathway that builds confidence in the near term and ensures accelerated, large-scale ZET adoption in the medium term.

Conclusion

India's Major Ports are poised to play a pivotal role in the country's transition to zero-emissions freight transportation. Their closed-loop operational characteristics, predictable routes and schedules, and concentrated infrastructure requirements make them ideal for ZET transition.

Ports have started demonstrating how ZETs can successfully perform critical freight functions. Initial ZET pilots at Jawaharlal Nehru, Kamarajar, and Visakhapatnam Ports already show that these trucks can match their diesel counterparts in payload and operational performance, giving fleet and terminal operators confidence in their viability.

However, ZETs currently face a higher TCO compared with diesel trucks. Although TCO analysis confirms that electric trucks for intra-terminal movement and port-to-nearby trips are nearing cost parity with diesel, achieving wider adoption will require policy measures for ZETs at ports that can bridge the cost gap. A comprehensive policy framework inclusive of ***strategic planning and market development*** that sends signals to industry to kick-start deployment, ***fiscal and nonfiscal measures*** that improve the business case, ***infrastructure development measures*** that incentivise charging ecosystem development, and ***capacity-building measures*** that equip the workforce can serve as the necessary enablers for widespread ZET adoption at ports.

Through a phased policy roadmap framework, ports can balance ambition with the feasibility of deploying ZETs, demonstrating readiness in the near term and institutionalising adoption through structural reforms in the medium term. With sustained policy support, India's ports can meet the *Harit Sagar — Green Port Guidelines* target of 50% fleet electrification by 2030 and evolve into catalysts for freight decarbonisation across the country. By establishing replicable models for scale, ports can extend the impact of zero-emissions adoption well beyond their boundaries, reshaping national logistics networks into cleaner, more efficient systems. Although the scope of the analysis and recommendations in this report were focused on the 12 Major Ports, the key learnings can also be applied to other ports in India deploying ZETs.

Appendix

TCO analysis evaluates the economic viability of ZETs relative to diesel trucks by evaluating both capital and operating costs. Capital costs include up-front expenses such as a vehicle's purchase price (down payment, loan repayment, and vehicle registration fees) and charging infrastructure expenses (equipment and installation). Operating costs capture recurring expenses, including fuel cost (diesel or electricity), operation and maintenance, insurance, and driver salaries. Exhibit A1 outlines the key parameters undertaken for TCO analysis.

Exhibit A1 **Key parameters for TCO analysis**

Parameter	Unit	Case Studies 1 and 2, Jawaharlal Nehru Port		Case Study 3, Kamarajar Port		Case Study 4, Vishakhapatnam Port	
		Diesel	ZET	Diesel	ZET	Diesel	ZET
Vehicle model and GVWR	—	55 tonne, tractor trailer		55 tonne, tractor trailer		35 tonne, tipper truck	
Battery size	kWh	—	302 (fixed charging) 282 (swapping)	—	250	—	262
Up-front purchase price	₹	45 lakh	1 crore	45 lakh	1 crore	50 lakh	1.2 crore
PM E-DRIVE subsidy included	₹	—	Yes, 9.3 lakhs	—	Yes, 9.3 lakhs	—	Yes, 9.6 lakhs
Daily distance	km	125		120		150	
TCO time period	Years	7					
Loan term	Years	5					
Loan interest rate	%	10	15	10	15	10	15
Financed amount	%	80% of up-front purchase price					
Diesel price	₹/L, with increase of 1% YoY	91	—	92.4	—	96.3	—
Electricity tariff at the port	₹/kWh	—	16	—	10.5	—	9.72

Exhibit A1 **Key parameters for TCO analysis**

Parameter	Unit	Case Studies 1 and 2, Jawaharlal Nehru Port		Case Study 3, Kamarajar Port		Case Study 4, Vishakhapatnam Port	
		Diesel	ZET	Diesel	ZET	Diesel	ZET
State EV tariff	₹/kWh	—	7.84	—	6.5 to 9.75 (dependent on time of charging)	—	6.7
RE — third-party open access tariff	₹/kWh	—	9.65	—	8.3	—	7.35
RE — group captive OA	₹/kWh	—	6.62	—	6.21	—	5.35

RMI Graphic. Source: RMI analysis

Endnotes

1. *Harit Sagar — Green Port Guidelines*, Ministry of Ports, Shipping and Waterways, 2023, **https://shipmin.gov.in/sites/default/files/Harit%20Sagar%20-%20Green%20Port%20Guidelines%20.pdf**.

2. *Monthly Cargo Traffic Handled at Major Ports up to and During March 2025*, Transport Research Wing (TRW) under the Ministry of Ports, Shipping and Waterways (MoPSW), March 2025, **https://shipmin.gov.in/sites/default/files/Report%20Monthly%20Major%20Port%20March%202025.pdf**.

3. *Harit Sagar – Green Port Guidelines*, 2023.

4. Based on data received by MoPSW from port authorities shared in September 2025.

5. *Harit Sagar Green Port Guidelines*, 2023.

6. *Monthly Cargo Traffic Handled at Major Ports*, 2025.

7. *Monthly Cargo Traffic Handled at Major Ports*, 2025.

8. "India's First Fleet of EV Trucks with Swappable Batteries Flagged Off at JNPA by Sarbananda Sonowal," Jawaharlal Nehru Port Authority, September 25, 2025, **https://www.jnport.gov.in/uploads/media_center/1/1121/PR_JNPA_EV_Fleet_Sustainable_Logistics_25_sept.pdf** .

9. *Maritime India Vision*, 2030, Ministry of Ports, Shipping and Waterways Government of India, November 2021, **https://sagarmala.gov.in/sites/default/files/MIV%202030%20Report.pdf**.

10. *Clean Air Action Plan 2017*, San Pedro Bay Ports, **https://cleanairactionplan.org/wp-admin/admin-ajax.php?juwpfisadmin=false&action=wpfd&task=file.download&wpfd_category_id=205&wpfd_file_id=4984&token=&preview=1**; "Port of Los Angeles Clean Truck Program," Port of Los Angeles, accessed September 28, 2025, **https://www.portoflosangeles.org/environment/air-quality/clean-truck-program**; *Clean Air Action Plan Implementation Progress Report 2023*, San Pedro Bay Ports, **https://cleanairactionplan.org/wp-admin/admin-ajax.php?juwpfisadmin=false&action=wpfd&task=file.download&wpfd_category_id=204&wpfd_file_id=5293&token=&preview=1**; "Port of Los Angeles Hammers Down on Zero-Emission Drayage Trucks," CleanTrucking, June 3, 2025, **https://www.cleantrucking.com/battery-electric/article/15747589/the-port-of-la-pursues-zev-drayage-trucks**; Thomas Werdine, "Top U.S. Ports in 2024," *ThinkFreight*, February 10, 2025, **https://www.thinkfreight.io/top-us-ports-in-2024/**.

11. "Incentives for E-Trucks under PM E-DRIVE," Ministry of Heavy Industries, Government of India, July 10, 2025, **https://pmedrive.heavyindustries.gov.in/docs/policy_document/Gazette%20264519-E-Trucks%20dated%2010.07.2025.pdf**.

12. "Low Emission Technologies Tested at the Port of Vancouver," *The Maritime Executive*, December 12, 2022, **https://maritime-executive.com/article/low-emission-technologies-tested-at-the-port-of-vancouver**.

13. "Seaspan Ferries Begins Electrification Trials with Battery-Powered Terminal Trucks," *Seaspan*, August 30, 2021, **https://www.seaspan.com/press-release/seaspan-ferries-begins-electrification-trials-with-battery-powered-terminal-trucks/**.

14. "Green Priority for Electric Trucks," Port of Gothenburg, accessed September 28, 2025, **https://www.portofgothenburg.com/services/cargo/container/green-priority/**.

15. RMI analysis of electricity tariffs at Major Ports compared with state-notified EV tariffs across India.

16. *Operational Guidelines for Deployment of EV Public Charging Stations (EV PCS) under the PM E-DRIVE Scheme*. Government of India Ministry of Heavy Industries, September 26, 2025, **https://pmedrive.heavyindustries.gov.in/docs/policy_document/EV%20PCS%20operational%20guidelines_F.pdf**.

17. "Clean Ports Program," US Environmental Protection Agency, accessed September 28, 2025, **https://www.epa.gov/ports-initiative/cleanports**.

18. "Biden-Harris Administration Announces Nearly $150 Million in Grants to Help Reduce Truck Air Pollution Near America's Ports," Federal Highway Administration, April 24, 2024, **https://highways.dot.gov/newsroom/grants-help-reduce-truck-air-pollution-ports**.

19. "Voltera Secures $96M Federal Grant to Electrify Savannah, Los Angeles, and Long Beach Ports," *EV C&ID*, August 7, 2024, **https://www.evcandi.com/news/voltera-secures-us96m-federal-grant-electrify-savannah-los-angeles-and-long-beach-ports**.

20. "Georgia Ports Authority Receives $15M Grant for Infrastructure Improvements," *WSAV*, May 2024, **https://www.wsav.com/news/local-news/georgia-ports-authority-receives-15m-grant-for-infrastructure-improvements/**.

21. The Portable Innovation Open Network for Efficiency and Emissions Reduction Solutions (PIONEERS) initiative, accessed September 28, 2025, **https://pioneers-ports.eu/**.

Policy Framework for Zero-Emission Truck Adoption at Major Ports in India, RMI, 2025, **https://rmi.org/insight/policy-framework-for-zero-emission-trucks-adoption-at-major-ports-in-india**.

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