



AI-informed Holistic Electric Vehicles Integration Approaches for Distribution Grids

D1.3

Regulatory Landscape Analysis

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EXECUTIVE SUMMARY

AI-informed Holistic Electric Vehicles Integration Approaches for Distribution Grids (AHEAD) will create a simulation environment capable of predicting the most convenient locations to place EV charging stations while optimising both the usage of the power grid resources and that of the charging stations in urban and rural areas.

This report provides a comprehensive review of the regulatory and policy landscape governing electric vehicles (EVs), heavy-duty vehicles (HDVs), and vessels at EU level and within pilot locations of the AHEAD project: Portugal, Italy, Denmark, and Slovenia, with particular attention to incentives, emissions standards, taxation, charging infrastructure deployment, and grid integration frameworks, including bidirectional and smart charging capabilities.

The analysis shows that the European regulatory framework, including key instruments such as Alternative Fuels Infrastructure Regulation (AFIR), Energy Performance of Buildings Directive (EPBD), Renewable Energy Directive III (RED), FuelEU Maritime, and the Electricity Market Reform, has significantly supported the transition to e-mobility. However, substantial disparities persist across Member States in grid readiness, HDV charging infrastructure availability, permitting procedures for charging infrastructure deployment, and support mechanisms for maritime and heavy-duty electrification.

Overall, the report concludes that accelerating the transition to e-mobility requires a more harmonised regulatory environment enabling investments across the EU. Key priorities include faster grid permitting and grid connection processes, stronger anticipatory grid investment, enabling regulatory framework for mass-scale adoption of smart and bidirectional charging, expanded high-power and shore-side charging infrastructure, and targeted incentives for HDVs and vessels. Enhanced interoperability, cybersecurity standards, and coordinated transport-energy planning will be essential to ensure a resilient, efficient, and scalable electrification of the transport sector, while supporting EU industrial competitiveness and long-term decarbonisation goals.

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List of acronyms

AC	Alternating Current
ACER	EU Agency for Cooperation of Energy Regulators
ADAS	Advanced driver assistance systems
ADS	Automated driving systems
AFIR	Alternative Fuels Infrastructure Regulation
BEV	Battery electric vehicle
B2B	Business-to-Business
CPO	Charging Point Operator
DC	Direct Current
DKK	Danish Krone
DSO	Distribution System Operator
EPBD	Energy Performance of Buildings Directive
EU	European Union
EV	Electric vehicle
GW	Gigawatt
HDV	Heavy-Duty Vehicle
ICEV	Internal combustion engine vehicle
ICT	Information and Communications Technology
kW	Kilowatt
LDV	Light-Duty Vehicle
MCS	Megawatt Charging System
MW	Megawatt
OEM	Original Equipment Manufacturer
OPS	On-shore power supply
OTA	Over-The-Air
RED	Renewable Energy Directive
SDV	Software-Defined Vehicle
TEN-T	Trans-European Transport Network
TSO	Transmission System Operator
VAT	Value Added Tax
V2G	Vehicle-to-Grid

1 INTRODUCTION

AI-informed Holistic Electric Vehicles Integration Approaches for Distribution Grids (AHEAD) will create a simulation environment capable of predicting the most convenient locations to place EV charging stations while optimising both the usage of the power grid resources and that of the charging stations in urban and rural areas.

This report provides a thorough analysis of the policies and regulations governing EVs, HDVs, and vessels within the regions involved in the project, namely at the national level in Portugal, Italy, Denmark, Slovenia and the European Union (EU) level. It encompasses a comprehensive review of the existing and evolving regulatory landscape that directly impacts the deployment, operation, and integration of these vehicles into the transportation sector. This includes examining incentives, subsidies, emission standards, and taxation related to e-mobility, and regulatory framework that may affect the accessibility and growth of charging networks, and regulations related to integrating these vehicles into the electrical grid (smart and bidirectional charging capabilities, grid interactions). In terms of methodology, the data collection in the report has relied on the extensive expertise of the AHEAD Task 1.3 members as well as the literature review.

The findings of this report will be beneficial to the AHEAD project in the sense of suggesting possible improvements to facilitate the integration of electric vehicles (EVs), heavy-duty vehicles (HDVs), and vessels by anticipating and projecting how regulatory frameworks may evolve.

2 REGULATORY FRAMEWORK

2.1 EU

The EU has a complex decision-making system involving both Member State governments and supranational institutions, with powers divided by policy area. Under the EU treaties, energy and transport are areas of shared competence, meaning Member States may act unless the EU has exercised its authority, and may resume acting if the EU stops doing so. Therefore, both EU institutions and Member States share responsibility for energy and transport policy decisions.

The EU legislative system includes regulations, directives, decisions, and recommendations/opinions. Regulations, directives, and decisions are legally binding, while recommendations and opinions are not. New EU laws on energy and transport are usually adopted as regulations or directives. EU regulations are binding in both substance and implementation across all Member States and apply uniformly from a specified date. EU directives are binding only as to the result to be achieved, leaving Member States discretion over implementation in national law. Consequently, EU regulations are more suitable than directives for achieving a swift and uniform transition to e-mobility across the EU, given that EU regulations are directly applicable at all Member States whereas the EU directives require timely national transposition.

2.1.1 EVS, HDVS & VESSELS

2.1.1.1 ALTERNATIVE FUELS INFRASTRUCTURE REGULATION (AFIR)

The EU's Alternative Fuels Infrastructure Regulation (AFIR), adopted in 2023 and implemented from April 2024, marks a major step toward more efficient, user-friendly public EV charging infrastructure and cleaner transport across the EU. Consistent interpretation across Member States is essential to accelerate infrastructure deployment, investment, competitiveness, and consumer benefits.

AFIR establishes binding rules for publicly accessible EV charging infrastructure, including rollout targets, payment requirements, common technical standards supporting mass deployment of V2G, and pricing rules. Member States must align public charging capacity with EV adoption, install charging hubs along the Trans-European Transport Network (TEN-T) core network, and enable ad hoc payments for public charging sessions.

Recommendations:

- The EU policymakers should create enabling conditions (regulatory and financial) for the deployment of charging infrastructure, both for light- and heavy- duty vehicles.
- For achieving demand side flexibility, the EU should create an enabling regulatory framework for smart and bidirectional charging, supported by harmonisation of communication standards and protocols.

2.1.1.2 ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE (EPBD)

The revised EU Energy Performance of Buildings Directive (EPBD), adopted in April 2024, is key to expanding home and destination EV charging across the EU. It sets requirements for charging infrastructure, pre-cabling, and ducting in residential and non-residential buildings, making EV charging easier at home and work.

The revision also introduces a legal definition of pre-cabling for BEV charging and supports grid flexibility through smart and bi-directional charging. In addition, Member States must simplify and accelerate the installation of charging points in new and existing buildings, remove regulatory barriers, and streamline permitting processes, particularly for co-owner associations. Requests from tenants or co-owners to install private chargers may only be denied on serious and legitimate grounds. When it comes to implementation at Member States, challenges remain regarding installing charging infrastructure deployment in multi-dwelling buildings. Finally, the revised EPBD addresses fire safety in buildings with batteries and charging infrastructure by requiring the European Commission to prepare guidance for Member States.

Recommendation:

- The EU Member States should keep a record of the number of private recharging points in their territory to better plan the electricity grids.

2.1.1.3 ELECTRIFICATION ACTION PLAN

As the electrification of transport is key to decarbonise European industries, in 2026, the EU is going to announce its Electrification Action Plan. The objective of the Plan is to promote decarbonisation by addressing key barriers and identifying priority policy actions to accelerate the cost-effective and system-friendly electrification of the EU's energy consumption,

accompanied by continuous investments in clean energy and flexibility. The electrification of ports also has an important role to play on the path to decarbonisation.

Recommendations:

- EU Member States should prioritise the electrification of depots and transport hubs to address gaps in decarbonisation of the EU industries.
- The EU regulatory framework should encourage the uptake of EVs and increase the share of electricity in transport by promoting social leasing schemes and supporting the development of a robust second-hand EV market.

2.1.1.4 EUROPEAN GRIDS PACKAGE

In December 2025, the European Commission presented its European Grids Package to accelerate EV charging infrastructure deployment, improve use of existing grid capacity, and support future grid planning. As part of the package, the Commission proposed a Directive to speed up permitting for energy infrastructure projects, including transmission and distribution grids, storage, recharging stations, and renewable energy projects. It entails:

- No administrative permits for small recharging stations (≤ 100 kW), except for grid connection;
- A maximum 6-month permitting period for larger recharging stations (> 100 kW);
- Tacit approval, excluding environmental decisions, where authorities fail to respond within deadlines;
- Overriding public interest status for recharging stations;
- Forward-looking grid planning with anticipatory investments.

The Commission also issued non-binding guidance to help Member States deliver faster and more efficient electricity grid connections and reduce grid-connection queues. The recommendations, addressed to EU institutions, regulators, system operators, grid users, ENTSO-E, and the EU DSO Entity, focus on grid planning and development, connection procedures, and supporting demand-side flexibility, transparency and incentives. Most notably, the Commission recommends replacing the traditional first-come, first-served approach to grid-connection applications and making grid capacity maps available across the EU.

Recommendations:

- EU Member States should move away from a first-ready, first-served to first-ready first-served approach in granting grid connection for supporting electrification.
- European co-legislators should raise the threshold for power capacity of recharging pools to 1MW to be excluded from all administrative permits, including environmental assessment, thereby aligning the regulatory framework with market realities. charging pool at this power level can also be built on already built environment.
- European co-legislators should make recharging pools with a power capacity of above 1MW eligible for flexible connection agreements to support earlier commissioning of high-power charging infrastructure during the permit-granting procedure.
- Member States should swiftly establish grid capacity maps and integrate them into their future grid network planning, both at distribution and transmission levels.
- European Commission should adopt updated grid network code regulations (Network Code on Demand Response and Network Code on Requirements for Grid Connection of Generators) without further delay.
- In its next multi-annual budget planning, the European Commission should increase the EU and national funding for grid expansion, modernisation and digitalisation.

2.1.1.5 RENEWABLE ENERGY DIRECTIVE (RED) III

In October 2023, the EU adopted the revised Renewable Energy Directive (RED III), effective November 20, 2023. RED III streamlines permitting for renewable energy and grid projects, increases the share of renewables in final energy consumption, and accelerates renewable deployment across all sectors. For transport, Member States must require fuel suppliers to achieve by 2030 either a 29% share of renewable energy sources or a 14.5% reduction in greenhouse gas intensity. Countries may implement this through either an energy-based or carbon-intensity target.

Under Article 25, all Member States must have established a credit mechanism by May 21, 2025. Under this framework, Member States are required to establish a mechanism for fuel suppliers to exchange credits for renewable energy supplied to transport. Economic operators supplying renewable electricity to EVs through public recharging points shall receive and may sell credits to fuel suppliers. Private EV charging points may be included if the supplied renewable electricity is used exclusively for EVs. Currently, RED III credit mechanisms exist only in Austria, Belgium, France, Germany, and the Netherlands.

Recommendation:

- EU Member States should credit electricity as a transport fuel not only in public recharging points as mandated by RED III, but also in private recharging points. This would lower EV ownership costs and encourage greening corporate fleets through providing financial incentive.

2.1.1.6 ELECTRICITY MARKET REFORM

In response to recent high electricity prices and market volatility, the Council of the EU adopted the Electricity Market Reform, encompassing amendments to the Electricity Market Directive, and Electricity Market Regulation. The reform aims to protect consumers, improve energy cost stability and predictability, and increase electricity grid flexibility. It amends the EU Electricity Regulation and Directive, as well as parts of the EU Agency for Cooperation of Energy Regulators (ACER) Regulation and the RED.

The reform provides greater investment certainty for renewable energy. It also supports grid expansion and optimisation through measures on grid tariffs, anticipatory grid investments, flexible connection agreements, and non-fossil flexibility. These changes are intended to accelerate the integration of renewable energy into the grid, addressing a key bottleneck in several EU countries. The amendments were published in the Official Journal of the EU on 26 June 2024.

Recommendations:

- EU Member States should accelerate roll out of smart meters by swiftly transposing the EU's Electricity Market Design into their national laws.
- EU Member States should endorse a properly defined legal framework for bringing EV flexibility to the market as well as demand response and storage to access wholesale markets, or to participate in ancillary and congestion management services, ensuring that remuneration is provided via market-based mechanisms.
- EU Member States should also simplify the technical and administrative entry points into balancing markets as this will allow aggregators and EV users to contribute more easily to grid stability by participating in demand side flexibility.

2.1.1.7 CO₂ EMISSION PERFORMANCE STANDARDS FOR CARS

European companies have committed over €200 billion to building Europe's EV ecosystem, including vehicles, batteries, materials, and charging infrastructure, supported by certainty from the EU's 2035 CO₂ target.

The European Commission's proposed 90% emissions target introduces flexibility allowing all vehicle technologies post-2035 if offset requirements are met. While electrification remains central and provides some reassurance, this flexibility increases market uncertainty for long-term investments in EV infrastructure and technologies, which depend on stable policy conditions. The proposal also requires manufacturers to offset additional emissions to use the 10% post-2035 flexibility. In addition, a proposed three-year averaging of 2030 CO₂ limits (2030–2032) would allow manufacturers to smooth compliance with the 55% reduction target. Further extending this to five years would likely delay EV rollout and weaken investment conditions during the critical scale-up period.

Recommendation:

- European policymakers should avoid any further erosion of the CO₂ emission performance standards for cars and vans to ensure that a core of technology clarity is kept alongside new technology neutrality allowances.

2.1.1.8 GREENING CORPORATE FLEETS INITIATIVE

The European Commission's proposal for EU Regulation on Clean Corporate Vehicles is a key tool to boost EU demand for electric cars and vans. The e-mobility sector will benefit in particular from Member State targets for large companies and from shifting fiscal support toward zero- and low-emission vehicles.

The planned phase-out of financial support for non-zero- and low-emission corporate vehicles from 2028 is a positive step, but additional demand-side measures are still needed to drive fleet electrification across the EU. Policymakers should also ensure stable enabling conditions so authorities, fleet operators, and investors can plan confidently, coordinate infrastructure, and scale up zero-emission vehicle deployment in line with EU climate and industrial goals. Finally, the "Made in Europe" provisions should be designed to genuinely strengthen European manufacturing capacity and value chains.

Recommendation:

- EU policymakers should reduce residual value risk for professional fleets via guarantees, risk-sharing, or resale support schemes.

2.1.1.9 CYBERSECURITY FRAMEWORK

In 2026, the European Commission introduced a new EU cybersecurity package to strengthen cyber-resilience and cybersecurity capabilities. Under the revised framework, EVs, charging infrastructure, and e-mobility platforms are classified as information and communications technology (ICT)-dependent systems. This includes software-defined vehicles (SDVs), over-the-air updates (OTA), automated driving systems (ADS), and advanced driver assistance systems (ADAS), which are increasingly treated as:

- Cyber-physical systems relying on ICT products, services, and processes
- Digitally connected assets integrated with energy, transport, and communications systems
- Systems with strategic ICT supply-chain dependencies, potentially subject to EU-level risk assessment and mitigation measures

This represents a major shift in the e-mobility ecosystem: cybersecurity is no longer just a technical or compliance issue, but a structural requirement for market access and adoption. In particular, the Cybersecurity Act 2 expands oversight to the full lifecycle of SDVs and OTA systems, while cybersecurity requirements for ADAS and ADS are increasingly linked to vehicle safety and public trust.

Recommendation:

- The review of AFIR should complement, not replicate, the existing EU cybersecurity framework by filling any remaining gaps.

2.1.1.10 FUELEU MARITIME

The FuelEU Maritime regulation, part of the European Commission's "Fit for 55" package, aims to accelerate the decarbonisation of the maritime sector by promoting renewable and low-carbon fuels as well as clean energy technologies for ships. Fully applicable since January 2025, it sets progressively stricter limits on the greenhouse gas intensity of energy used by ships over 5,000 gross tonnage calling at EU ports, targeting an 80% reduction by 2050 compared to current levels. The regulation also encourages the use of on-shore power supply (OPS) in ports to reduce air pollution. By adopting a technology-neutral and goal-based

approach, FuelEU Maritime supports innovation while giving ship operators flexibility in choosing the most suitable compliance strategies and sustainable energy solutions.

Recommendation:

- Accelerate OPS deployment in all major EU ports.

2.1.1.11 FUTURE LANDSCAPE

The European EV charging industry operates under multiple jurisdictions and differing national rules for measuring instruments, increasing compliance complexity and business costs. A harmonised EU-wide regulatory framework is needed to enable economies of scale, ensure Single Market compliance, and strengthen competitiveness. It would also support deployment targets under the AFIR and EPBD by enabling fair pricing through accurate metering, facilitating smart charging for grid support, and reducing cross-border compliance burdens.

Bidirectional charging offers valuable demand-side flexibility but is currently hindered in Europe by double taxation, charging both when electricity enters the vehicle and when it is returned to the grid. This discourages participation, undermines prosumer models, and adds administrative complexity. The EU should remove this barrier in the revision of the Energy Taxation Directive by recognising EV or battery owners providing flexibility as redistributors when feeding electricity back to the grid. The fiscal framework should explicitly avoid double taxation to incentivise electrification and support grid balancing. To further support EV adoption, the EU should introduce targeted incentives, reduce administrative burdens, and lower costs for manufacturing and ownership of small, affordable EVs.

2.2 SLOVENIA

2.2.1 EVS

Slovenia is a small but steadily growing EV market in Central and Eastern Europe. In 2025, it registered 6,419 battery-electric vehicles (BEVs), accounting for 11.15% of new passenger cars, with BEV registrations more than doubling compared to 2024 [1]. Despite its small market size, EV adoption has accelerated due to EU climate targets, expanding charging infrastructure, and national subsidies for low-emission vehicles. Earlier projections estimated up to 200,000 electric or plug-in hybrid passenger vehicles by 2030 (around 17% of the fleet), plus partial electrification of light commercial vehicles [2]. Growth is further supported by EU regulations, including fleet CO₂ limits and the CO₂ standards for 2035, providing a structural driver for continued EV uptake in Slovenia. This is reinforced by expanding fast-charging

infrastructure along TEN-T corridors as well as by the electrification of commercial and urban delivery fleets and the growing use of smart-charging technologies that improve grid integration and flexibility.

2.2.1.1 INCENTIVES AND TAXATION

Slovenia supports EV adoption mainly through purchase incentives and broader transport decarbonisation policies aligned with EU frameworks. The Eco Fund has provided subsidies for buying BEVs, available to individuals, companies, and municipalities, to offset higher upfront costs and speed up adoption. EV ownership is also supported by relatively favourable taxation compared with conventional vehicles, including lower energy costs and no fuel excise duties. However, compared with some Western European countries, Slovenia's incentives are more limited and have varied over time, contributing to fluctuations in EV sales growth.

National strategies for alternative fuels and sustainable mobility aim to significantly expand the EV market in the coming decade. At the municipal level, additional measures such as preferential parking and urban access benefits, further support EV uptake.

2.2.1.2 CHARGING INFRASTRUCTURE

The expansion of charging infrastructure has been a key driver of Slovenia's EV market growth. As of December 2025, there were about 2,545 public charging points, including 2,041 Alternating Current (AC) chargers and 504 Direct Current (DC) fast charger [1]. The expansion of fast-charging capacity has closely tracked the rapid rise in BEV registrations. Growth has been driven by a mix of private investment, EU funding, and energy-sector involvement, rather than a single national operator. Charging-point operators, utilities, retailers, and energy companies have all contributed. Recent examples include retail-charging partnerships deploying ultra-fast hubs at supermarkets, with chargers up to 400 kW plus contactless payment and roaming services.

Slovenia also benefits from its position on major European transport corridors, supporting the rollout of high-power motorway charging stations for cross-border travel and alignment with EU AFIR targets for charging infrastructure deployment.

Recommendation:

- Increasing deployment of fast and ultra-fast chargers requires stronger coordination with distribution-system operators (DSO) to ensure sufficient grid capacity.

2.2.1.3 GRID INTEGRATION AND EMERGING TECHNOLOGIES

Slovenia's electricity system is relatively well suited to transport electrification due to its low-carbon generation mix, including nuclear, hydropower, and growing renewables, which lowers EV lifecycle emissions compared with fossil-fuel-based systems.

Regulatory frameworks at EU and national level integrate EV charging into the broader electricity system and support smart charging, distributed energy resources, and energy communities, although large-scale vehicle-to-grid (V2G) deployment remains limited. However, grid connection procedures and distribution network capacity can still constrain rollout, particularly for high-power charging hubs requiring medium-voltage grid upgrades.

Recommendation:

- Establish transparent grid-connection procedures by publishing available capacity maps for medium- and low-voltage networks and defining predictable timelines for connection approvals to reduce deployment delays.

2.2.2 HDVS

Electrification of HDVs in Slovenia remains at an early stage and is concentrated mainly in public-transport fleets and pilot projects rather than freight transport. Electric buses are gradually being introduced in urban transport systems, while electric trucks still account for only a very small share of the national fleet.

In 2025, Slovenia registered 9 battery-electric trucks, representing a market share of about 0.41% [1] whereas Slovenia registered 6 electric buses in 2025, around 2.3% of new registrations [1]. Overall, HDV electrification in Slovenia remains in an early transition phase, driven primarily by pilot projects and municipal procurements. However, national forecasts indicate that over 40% of buses and more than a quarter of HDVs may use alternative fuels by 2030, in line with EU climate and clean-transport goals [3]. Electric truck adoption is expected to grow more slowly, focusing first on urban logistics and short-haul distribution. The pace of electrification could be accelerated by introducing truck-specific incentives, deploying high-power public charging infrastructure, and meeting the grid-connection needs for megawatt-scale charging hubs.

2.2.2.1 INCENTIVES AND POLICY FRAMEWORK

Slovenia has no comprehensive national incentive scheme specifically for electric trucks. Electrification of HDVs is instead driven by municipal initiatives, EU cohesion funding, and

public-transport fleet renewal programmes. Municipalities such as Kranj and Maribor have introduced battery-electric buses through co-financing from the national Eco Fund and EU instruments [4]. In Ljubljana, the European Regional Development Fund has supported electric bus purchases to modernise public transport and improve air quality [3].

Recommendation:

- Introduce targeted incentives for electric trucks and depot charging infrastructure to help accelerate the electrification of freight transport and support early HDV market development.

2.2.2.2 CHARGING INFRASTRUCTURE

Charging infrastructure for HDVs in Slovenia is mainly fleet-specific and depot-based, especially for municipal electric buses. Pilot projects in Ljubljana have demonstrated the feasibility of fast charging for urban bus fleets using 300–350 kW chargers [5]. National planning is also beginning to address electric freight transport. The transmission-system operator (TSO) ELES is developing plans for megawatt-scale charging hubs near major highway corridors to support future electric trucks and long-distance freight electrification [3]. However, Slovenia still lacks a nationwide public HDV charging network, with most infrastructure remaining within controlled fleet environments.

Recommendation:

- Develop a national roadmap for HDV charging infrastructure, particularly along major logistics corridors and near industrial hubs, to comply with EU AFIR requirements.

2.2.2.3 GRID INTEGRATION AND EMERGING TECHNOLOGIES

Future large-scale electric-truck charging hubs are expected to require medium- or high-voltage grid connections, potentially requiring network upgrades or dedicated substations. This highlights the importance of coordination between grid operators, municipalities and charging-infrastructure developers as HDV electrification progresses [6].

Recommendation:

- Establish a national regulatory framework that enables smart and bidirectional charging.

2.2.3 VESSELS

Unlike coastal countries with large maritime sectors, Slovenia has limited vessel electrification due to its small maritime industry and short coastline centred on the Port of Koper. Efforts, therefore, focus mainly on electrifying port infrastructure and meeting EU regulations rather than deploying electric ships at scale. However, EU climate policy and infrastructure requirements are expected to drive future development of zero-emission maritime transport in Slovenia.

2.2.3.1 INCENTIVES AND TAXATION

Slovenia does not offer national incentives for purchasing electric or zero-emission vessels. Instead, maritime decarbonisation is driven mainly by EU regulations and port infrastructure investments. Its policies align with EU initiatives such as FuelEU Maritime and AFIR, which require ports to expand shore-side electricity access and reduce emissions from vessels at berth.

2.2.3.2 CHARGING INFRASTRUCTURE

The Port of Koper is Slovenia's main maritime hub and a key site for future electrification. EU maritime policy requires core ports to install OPS, allowing ships to switch off onboard engines while docked and connect to the grid, reducing emissions of nitrogen oxides, sulphur dioxide and particulate matter. OPS deployment is part of wider EU decarbonisation goals, and Koper is expected to gradually implement shore-side power accordingly. However, dedicated electric vessel charging infrastructure is still limited, with current efforts focusing mainly on shore power rather than battery-electric charging for ships.

Recommendation:

- Implement OPS infrastructure at the Port of Koper, in line with EU FuelEU Maritime and AFIR requirements.

2.2.3.3 GRID INTEGRATION

Port electrification requires substantial grid capacity and close coordination between port authorities, electricity network operators, and infrastructure providers. OPS systems typically need high-voltage grid connections and dedicated substations to supply large vessels simultaneously. In smaller maritime systems like Slovenia's, these investments are usually phased and often supported by EU infrastructure programmes. Because Slovenia's maritime

sector is relatively small compared to other EU coastal states, large-scale electrification is currently limited and grid integration challenges remain manageable.

Recommendation:

- Ensure that port-electrification projects are integrated with grid-capacity planning and renewable-energy deployment.

2.3 PORTUGAL

2.3.1 EVS

Portugal is one of Southern Europe's fastest-growing EV markets, reaching about 220,000 BEVs by the end of 2025, equivalent to roughly 3% of the national car fleet [7]^[OBJ*OBJ]. Growth has been driven by EU emissions targets, national tax exemptions and purchase incentives, and early investment in the interoperable MOBI.E public charging network, enabling rapid adoption despite the country's EV market. BEVs captured a 21.2% share of new passenger car registrations in 2025, with electric vehicles now representing around 9% of all drivers. The EU's 2035 CO₂ standards regulation adds regulatory pressure that reinforces local benefits and accelerates the shift to e-mobility.

Central to Portugal's early EV uptake is MOBI.E, a state-owned public company acting as Managing Entity of the Electric Mobility Network since 2015, responsible for the management and monitoring of electric charging stations regarding energy, information, and financial flows. Rather than owning or operating chargers directly, MOBI.E provides a digital platform connecting all publicly accessible charging points (operated by licensed private Charging Point Operators) into a single interoperable network, integrating more than 70 CPOs and 25 mobility service providers. As discussed further below, recent regulatory reforms are gradually shifting MOBI.E's role from direct network management toward coordination and interoperability oversight as the charging market becomes more decentralised [8].

2.3.1.1 INCENTIVES AND TAXATION

Portugal combines strong purchase incentives and favourable tax policies to drive EV adoption. For individuals, the Environmental Fund in 2025 allowed pre-approval and offers up to €4,000 for a new BEV [9].

Taxation further supports EV adoption as follows: BEVs are fully exempt from registration tax and from annual road tax for the first five years [8]. Home charging is subsidised, covering 80% of equipment costs (up to €800 per charger) and 80% of installation costs (up to €1,000

per parking space), with limits of one charger per owner and up to 10 per residential building, prioritising multi-unit housing [8]. For companies, incentives are equally strong. In 2025, businesses can receive €6,000 per electric light commercial vehicle (N1), up to four vehicles per company [10]. Corporate tax advantages include BEV exemption from autonomous taxation, full Value Added Tax (VAT) deduction for BEVs up to €62,500 (ex-VAT), and the same registration tax [9, 11].

At the local level, municipalities add further benefits such as free or reduced parking, lower fees, and access advantages to restricted zones, reinforcing national policy efforts [12]. Lisbon's restrictions on older combustion vehicles are one example of this approach [13]. At the local level, municipalities add further benefits such as free or reduced parking, lower fees, and access advantages to restricted zones, reinforcing national policy efforts [12]. Lisbon's restrictions on older combustion vehicles are one example of this approach [13].

Portugal is expected to maintain and even reinforce its incentives over the coming years. The Environmental Fund was renewed in late 2025 with €17.6 million and retroactive coverage from January 2025, signalling continued commitment rather than a phase-out [14]. Corporate tax benefits for EVs also remain unchanged, with no planned reductions.

Recommendations:

- Shift in national incentives toward smart charging and flexibility services rather than pure vehicle purchase support.
- Ensure greater municipal harmonization regarding EV parking benefits and low-emission zones

2.3.1.2 CHARGING INFRASTRUCTURE

Portugal's e-mobility ecosystem has expanded rapidly over the past decade. By early 2025, the public charging network reached 6,091 stations and 11,319 sockets, including over 2,330 fast/ultrafast chargers, representing roughly 38% of the network [15] March 2025 alone saw 660,000 charging sessions, up 48% year-on-year, reflecting strong EV adoption and continued infrastructure growth [8]. The charging network is projected to grow, with fast and ultrafast infrastructure playing an increasingly central role. With the EU AFIR in force, MOBI.E is gradually shifting from operational management to a coordination and interoperability role as charging becomes more decentralised and market driven.

At home charging level, most EV owners install and manage their own wallboxes, while charging point operators (CPOs) focus on public and business-to-business (B2B) charging. However, recent regulatory reforms, notably Decree-Law 93/2025, which liberalizes the sector, and ERSE's (Portuguese energy services regulatory authority) [16].

Unlike residential charging, which benefits from financial incentives, public charging deployment has mainly relied on private investment, municipal concessions, and EU co-funding rather than direct national subsidies. Operators such as Galp, EDP, Powerdot, and Atlante are developing fast-charging corridors and urban hubs, increasing network density [17]. Deployment is coordinated locally through municipal concessions, tenders, and site approvals, with municipalities facilitating rollout in line with national guidance rather than through a single centralised mechanism. To implement AFIR, ERSE updated its Electric Mobility Regulation in late 2025, strengthening interoperability, roaming, consumer protection, service standards, and reporting, while setting a transition period until end-2026 for operators still tied to legacy MOBI.E systems.

Recommendation:

- Enforce the implementation of the AFIR

2.3.1.3 GRID INTEGRATION AND EMERGING TECHNOLOGIES

In Portugal, the Network Operation Regulation defines electricity flow management, flexibility procurement, and participation in European balancing platforms such as PICASSO (aFRR) and MARI (mFRR), reflecting a shift toward a flexibility-based system [18]. This is reinforced by national Decree-Law 15/2022, which restructured the national electricity system and strengthened the national legal framework for self-consumption, energy communities, aggregation, storage, and improved grid planning by forming the basis for future EV integration as distributed energy resources.

At present, the use of EVs as flexibility resources in Portugal remains very limited. A nationwide V2G remuneration framework is not yet in place, but the Network Operation Regulation and the gradual liberalisation of charging under DL 93/2025 already enable smart charging and bidirectional services. Ongoing pilot projects are expected to shape future V2G market rules.

Cybersecurity in Portugal is governed by Decree-Law 65/2021, transposing the EU cybersecurity framework, assigning oversight to the National Cybersecurity Centre. The

Portuguese Network Operation Regulation also includes grid-specific cybersecurity requirements, treating EV charging infrastructure as critical national infrastructure.

System architecture is partially decentralised in Portugal. TSO remains centralised as in EU practice while the EV charging market is being liberalised after the former MOBI.E centralised model [18]. The national framework of DL 93/2025 further decentralises charging operations, allowing independent CPOs and direct energy procurement.

The public sector still plays a structuring role in Portugal as ERSE defines the regulatory framework, technical rules and transition timelines while municipalities license public-space charging infrastructure and coordinate deployment. In addition to that, the central Portuguese government defines the legal framework such as DL 15/2022, and DL 93/2025, as well as ensures alignment with the EU regulatory framework.

Overall, Portugal combines a centrally regulated electricity grid with an increasingly decentralised, competitive charging market, enabling flexibility services, future V2G integration, and robust cybersecurity for critical infrastructure.

Recommendations:

- Streamline permitting and grid-connection procedures, especially for fast-charging sites
- Establish a V2G remuneration framework while accelerating deployment of smart meters
- Ease access for small aggregators and CPOs to participate in flexibility markets by publishing clear and proportionate operational requirements
- Integrate self-consumption charging models such as the combination of PV, energy storage and EV
- Coordinate closely between DSOs and CPOs to reduce low- and medium-voltage grid-connection bottlenecks

2.3.2 [HDVS](#)

Electrification of HDVs in Portugal is uneven across segments and is driven mainly by public-sector procurement and EU regulation, rather than a comprehensive national strategy. Policy support and funding focus on urban public transport, while freight HDV electrification remains

limited and largely project-based. As a result, electric trucks (N2/N3) account for well below 1% of Portugal's HDV fleet, with only small annual registrations and no sustained growth trend comparable to some other EU countries [19].

On the other hand, electric heavy passenger vehicles (M3 buses) have more visible but still limited penetration. In Porto, STCP operates 446 buses, with 15% fully electric in early 2025 [20], rising to 20% after deliveries in January 2026, and a target of 30% by end-2026 [21]. Nationally, zero-emission buses remain in the single digits, though Portugal's Recovery and Resilience Plan-funded procurements are expected to significantly increase this share in the coming years, especially in metropolitan and medium-sized cities [22].

2.3.2.1 1. INCENTIVES AND TAXATION

Unlike passenger and light commercial vehicles, electric trucks in Portugal are not eligible for recurring purchase subsidies from the Environmental Fund. Support for freight HDVs is limited to ad-hoc participation in EU demonstration projects or generic investment schemes under Portugal 2030, with no HDV-specific design.

In contrast, electric buses receive targeted, large-scale public funding. The Portugal's Recovery and Resilience Plan allocated €90 million under "Apoio à aquisição de veículos limpos para o transporte coletivo de passageiros" to purchase 413 zero-emission buses (battery-electric and hydrogen) and 184 charging points across Lisbon, Porto, and other regions [23]. A later revision of Portugal's Recovery and Resilience Plan expanded this to over 800 buses, expected to operate in more than 70 municipalities by 2026 [24]. On taxation, electric HDVs benefit mainly indirectly through the absence of diesel excise and CO₂ fuel taxes, rather than from dedicated exemptions. Portugal does not currently apply HDV-specific vehicle tax instruments comparable to those for light vehicles.

Regulatory drivers for HDV electrification are almost entirely at the EU-level, with Portugal applying EU Regulation on CO₂ Standards without additional national CO₂ standards or diesel phase-out dates.

Recommendation:

- Introduce electric truck-specific purchase incentives

2.3.2.2 2. CHARGING INFRASTRUCTURE

Charging infrastructure for HDVs in Portugal is mainly depot-based and vehicle-specific. Portugal's Recovery and Resilience Plan-funded electric bus projects focus on dedicated

depot and terminal chargers, typically for overnight or opportunity charging [25]. Public charging suitable for electric trucks is still very limited. Although Portugal has a relatively dense passenger EV charging network, most fast and ultra-fast chargers are not suitable for HDVs due to insufficient power, limited physical access, or unsuitable dwell times. Truck-focused charging hubs and rest-area installations are still at an early planning or pilot stage, with no nationwide network yet in place.

Future HDV charging deployment is expected to be mainly shaped by the implementation of the EU's AFIR while private investment is still constrained by uncertainty around utilisation rates and grid connection conditions.

Recommendation:

- Create enabling conditions for accelerating the deployment of HDV charging infrastructure such as financial tools to de-risk investments

2.3.2.3 3. GRID INTEGRATION AND EMERGING TECHNOLOGIES

For high-power HDV charging, grid connection lead times can exceed a year depending on location and required upgrades, making grid access a key bottleneck for scaling HDV charging infrastructure in Portugal.

The Portuguese Decree-Law 15/2022 sets general rules for self-consumption, storage, and aggregation, but there is no HDV-specific framework for managed charging, flexibility services, or V2G participation. As a result, HDV charging is currently treated as large, inflexible demand, with no participation in flexibility or balancing markets. Moreover, emerging technologies such as solid-state transformers are not yet used in Portugal.

Recommendation:

- Address the grid-connection constraints for high-power installations

2.3.3 VESSELS

Portugal's maritime electrification is still early but advancing through municipal fleet upgrades, EU-funded port projects, and OPS deployment in major ports. Although there is no dedicated national zero-emission vessel strategy, these initiatives indicate a clear move toward lower-emission maritime mobility. Overall, Portugal's progress in vessel electrification is expected to remain incremental but project-driven.

2.3.3.1 INCENTIVES AND TAXATION

Portugal does not provide vessel-specific incentives for zero-emission ships, such as purchase subsidies, VAT exemptions, or tax reductions. Instead, support is indirect, coming from public transport investment, municipal projects, and EU cohesion funding rather than dedicated maritime incentives. Examples include:

- 1) Aveiro Municipality's €9 million EU co-financed investment in the fully electric ferry *Salicórnia*, replacing a diesel vessel on the São Jacinto–Forte da Barra route [26].
- 2) Lisbon Metropolitan Area's investment in 10 fully electric ferries for the Transtejo/Soflusa network [27].
- 3) EU-funded port vessels at Sines, including an electric harbour tug and an electric pilot transfer vessel under construction [28].

Recommendation:

- Introduce national-level incentives for low- and zero-emission vessels

2.3.3.2 CHARGING INFRASTRUCTURE

Vessel charging infrastructure in Portugal is currently developed on a project-by-project basis. OPS deployment will be crucial for maritime transport decarbonisation and for reducing cruise-related air pollution in Lisbon, where ships currently run auxiliary engines while at berth.

Recommendations:

- Accelerate the roll-out of OPS
- Implement clear technical standards for maritime charging in coordination with the EU framework

2.3.3.3 GRID INTEGRATION AND EMERGING TECHNOLOGIES

Grid integration is closely tied to major port-electrification projects as Portugal does not yet have a unified regulatory framework for maritime charging, power-quality requirements or grid-service participation by vessels.

Recommendation:

- Expand port-grid capacity to support OPS and vessel charging

2.4 ITALY

2.4.1 EVS

Italy's EV fleet includes about 409,000 BEVs, just 1% of all vehicles [29]. However, the market is growing rapidly as BEVs and PHEVs are accounted for around 15% of new registrations in early 2026, up from 12% in 2024 and 7% in 2023.⁴⁰ Following that, in Italy, charging-point availability relative to vehicle fleet and road network is aligned with major European countries and, in some cases, among the best, ranking 2nd for DC charging points per BEV in circulation. Incentives, tax policies, and expanding charging infrastructure are key to sustaining this growth and meeting the EU emission targets.

2.4.1.1 INCENTIVES AND TAXATION

As of April 2025, Italy operates a multi-layered incentive and tax framework to accelerate BEV adoption and charging infrastructure. The system combines direct purchase subsidies, tax exemptions, corporate incentives, regional top-ups, and major infrastructure funding under the national recovery programme.

The main national incentive is the “Ecobonus” D.M.08/08/25 scheme, refinanced for 2026 [30]. EV purchase subsidies range from €6,000 (without scrappage) to €11,000 (with scrappage). For households with the Equivalent Economic Situation Indicator below €30,000, incentives increase by 25%, reaching up to €13,750 when scrapping a Euro 0–2 vehicle [31]. The scheme therefore combines decarbonisation goals with social equity by targeting lower-income households and the replacement of highly polluting vehicles. On the other hand, Italy does not impose a CO₂-based registration tax. Only a provincial registration tax (IPT) is due on new registrations; the IPT is equal to €150.81 for vehicles up to 53 kW and above 53 kW approximately €3.51 is added for each kW exceeding 53 kW. In many provinces the IPT is fully waived for electric vehicles (or sharply reduced) as a local policy. They are also exempt from the annual vehicle circulation tax (“bollo”) for five years after registration and subsequently pay only 25% of the standard rate. Several regions provide additional relief. Lombardia and Piemonte permanently exempt EVs from road tax beyond the initial five-year period, while Valle d’Aosta extends the exemption to eight years. These measures significantly reduce long-term ownership costs relative to internal combustion engine vehicles (ICEVs).

Corporate fleet electrification is supported mainly through favourable company car taxation. From 2025, the taxable value of a company EV for private use is reduced to 10% of the standard amount compared to 50% for conventional vehicles. Although no dedicated EV super-depreciation schemes exist and standard VAT and deductibility rules apply (22% VAT,

40% VAT deductibility, and 20% cost deductibility up to €18,076 for mixed-use company cars), the government has also allocated €4.6 billion to support the automotive industry and fleet electrification, including future measures for business fleets. Italy's fiscal approach therefore, relies more on direct incentives and ownership tax relief than VAT-based measures.

Regional and local authorities also provide stackable incentives. Lombardia offers rebates of up to €4,000 for electric cars and €8,000 for electric vans for SMEs scrapping older vehicles. Bolzano grants €2,000 for new EV purchases or leases, often complemented by utility contributions reaching €4,000 in total. Other regions, including Trentino Alto Adige, Piemonte, and Veneto, periodically introduce additional rebates or scrappage bonuses. EVs also benefit from non-financial advantages such as free or discounted parking and access to restricted traffic zones in cities including Milan, Bologna, and Rome, improving their attractiveness in urban areas.

Italy also strongly supports EV charging infrastructure deployment. The “Bonus Colonnine” scheme (Decree 11 June 2025) covers 80% of charger purchase and installation costs for private users, up to €1,500 for individuals and €8,000 for condominiums for 2024 installations. Businesses and professional users can receive a 40% grant, with caps ranging from €2,500 for 7.4–22 kW AC chargers to €75,000 for DC chargers above 100 kW. In addition, the National Recovery and Resilience Plan allocate €740 million to deploy around 21,000 public charging points by 2025 through Ministry of Environment and GSE-managed calls, addressing infrastructure availability as a key condition for mass EV adoption [32]

Overall, Italy's policy framework combines subsidies, tax advantages, corporate fleet incentives, and infrastructure investment in a comprehensive multi-level approach. Although VAT treatment remains neutral and some measures require periodic refinancing, this mix of fiscal and non-fiscal incentives helps reduce total ownership costs and supports Italian and EU transport decarbonisation goals.

Recommendation:

- Shift from direct purchasing incentives to structural infrastructure investments

2.4.1.2 CHARGING INFRASTRUCTURE

The 2025 data on Italy's public charging network shows clear progress in geographic coverage and the expansion of high-power charging systems. The 2025 MASE Ecobonus saw extremely high demand and was fully allocated within hours, confirming strong public willingness to adopt e-mobility when enabling conditions exist. However, the sector still faces

short-term challenges that require a step change to achieve balanced, widespread development.

As of 31 December 2025, Italy had 73,047 charging points across 38,854 stations and 24,187 locations, including 7,947 sites with at least one fast DC charger [33]. Of these, 62,145 are operational, while 14.9% are still awaiting grid connection [29]. Since 2019, charging points have grown at an average annual growth rate of 38% [33]. The share of low-power stations continues to decline, reflecting a shift toward faster, higher-power infrastructure better suited to e-mobility needs.

The market is also increasingly prioritizing high-power DC infrastructure to shorten charging times and support long-distance travel. According to the data, between 2019 and 2025, Italy's high-power charging infrastructure grew at an average annual rate of 77%, [29] reflecting strong demand for solutions supporting vehicles with increasingly large batteries. Growth accelerated further in 2025, with 5,388 new DC charging points installed [33]. Of these, 2,011 were ultra-fast chargers above 150 kW, a 52% year-on-year increase [29]. This trend shows the Italian network is increasingly shifting toward high-power infrastructure, seen as essential for reducing charging times and enabling long-distance travel.

Recommendations:

- Address energy procurement costs and system charges for charging stations
- Establish a national strategic plan for EV charging including the expansion of coverage in currently underserved areas, the deployment of additional high-power charging points along major national transport corridors and an increase in the number of charging points per station to improve reliability and reduce waiting times during peak travel periods.

2.4.1.3 GRID INTEGRATION AND EMERGING TECHNOLOGIES

The growth of e-mobility requires a charging network that is not only sufficient in size but also technically integrated with the power system and able to support evolving markets for both light- and heavy-duty vehicles. EV grid integration in Italy is advancing through pilot projects on smart charging and V2G, targeting peak demand management, improved grid stability, and greater renewable energy penetration. Key stakeholders of Terna, E-Distribuzione, and RSE, are enabling EVs as distributed energy resources in Italy, providing ancillary services such as frequency regulation.

Recommendations:

- Simplify authorization and grid connection procedures for charging stations in line with the EU Grid Package
- Enhance the potential for flexibility that charging can give to the network and through price signals and dynamic tariffs throughout the day.

2.4.2 HDVS

Italy's HDV charging infrastructure is still under development. Four dedicated charging sites are currently operational, mainly in Northern Italy, with a fifth site in the south expected soon. All use CCS2 connectors delivering up to 600 kW, enabling electric trucks to recharge in about 30–40 minutes, compatible with driver rest periods and short-haul logistics needs.

The most advanced site, in Northern Italy, hosts the country's first Megawatt Charging System (MCS) connector. Delivering up to 1,000 kW, MCS is the next step in ultra-fast HDV charging, reducing downtime to levels closer to diesel refuelling. The standard is designed for next-generation battery-electric trucks with 600–800+ kWh batteries.

To reduce the infrastructure gap between Northern and Southern Italy, more than ten new charging sites have been planned and funded through the European funding programmes. Over the next two to three years, these projects will create a motorway and near-motorway charging network forming a "Digital Green Corridor" linking Northern and Southern Europe.

Electric buses represented 12.25% of new registrations in Italy in 2025 [34]. However, adoption varies significantly by region, reflecting targeted local policies and infrastructure conditions. Lombardy and Piedmont, for example, have introduced dedicated targets and funding schemes to accelerate electric bus deployment in major cities such as Milan and Turin. [29][30]. Continued government support and infrastructure expansion will be essential to achieve broad heavy-duty transport electrification in Italy by 2030.

2.4.2.1 INCENTIVES AND TAXATION

As of 2024, Italy's HDV incentive and tax framework strongly supports the transition to zero-emission trucks and buses, aligning with EU Green Deal goals and CO₂ targets. The system combines purchase subsidies, tax exemptions, sectoral measures, and fiscal incentives to accelerate fleet renewal and electrification.

Purchase subsidies are central to this policy. Electric buses receive substantial incentives: up to €20,000 for buses with more than eight seats and a maximum mass below 5 tonnes, and

up to €78,000 for larger M3 city and intercity buses. In addition, Italian National Recovery and Resilience Plan provides up to 60% subsidies for e-bus purchases through DM 530/2021, supported by a €1.915 billion fund for renewing urban bus fleets with zero-emission vehicles [35].

Furthermore, the Ministry of Infrastructure and Transport decree DM 07 [36] [31] .

Electric HDVs benefit from favourable taxation, including exemption from vehicle circulation tax for the first five years and payment of only 25% of the standard rate thereafter. Regions such as Lombardia and Piemonte provide permanent exemptions. Since 2025, fringe benefit taxation further favours electrification, taxing mixed-use company EVs at 10% of the reference rate, compared to 20% for plug-in hybrids and 50% for conventional vehicles. At the EU level, additional measures applicable in Italy include proposals to exempt zero-emission trucks and buses from tolls and user charges until 30 June 2031 to offset higher upfront costs. These measures complement stricter EU CO₂ standards.

Recommendations:

- Shift from direct purchasing incentives to structural infrastructure investments
- Incentives for areas currently experiencing market failure, identifiable through the single national platform to make the distribution of charging points more uniform, especially in the south of the country

2.4.2.2 CHARGING INFRASTRUCTURE

In line with EU legislation, Italy supports HDV charging infrastructure through national policies, including €600 million in the National Recovery and Resilience Plan funding under Ministerial Decree D.M. 315/2021, partly allocated to regional charging infrastructure, and the National Strategic Plan for Sustainable Mobility.

Recommendation:

- Simplify, digitalize, and harmonize permitting procedures, which today are affected by the different sensitivities and competences of individual municipalities

2.4.2.3 GRID INTEGRATION AND EMERGING TECHNOLOGIES

Electric HDV grid integration in Italy is central to the energy transition, supporting rising electricity demand from electric trucks and buses while enabling renewable energy uptake. It combines public fast-charging hubs and private depot charging with smart charging to balance loads and reduce grid constraints. However, HDVs' high-power demand requires major grid reinforcement by 2030; energy storage systems could offset up to 20% of peak demand. V2G technologies further enable HDVs to act as flexible energy assets, storing excess renewable power, stabilizing the grid, and reducing fossil-fuel dependence. These efforts are driven by EU and national policies, including AFIR and Italy's National Integrated Energy and Climate Plan, which support charging infrastructure and grid upgrades. Regional studies, especially in Latium and key logistics hubs, help optimize charging and prevent peak overloads, while EU demonstration projects integrate battery-electric HDVs into logistics fleets by coordinating charging with depot operations and driver rest periods.

Recommendation:

- Greater collaboration in planning network investments

2.4.3 VESSELS

In Italy, port electrification is currently limited to ship repair terminals and cargo-handling cranes, but expansion is underway in line with the National Recovery and Resilience Plan in 2026. Cruise ships at berth can each require up to 10 MW, and with multiple vessels often docked simultaneously, this will create substantial new electricity demand. Building on current investments in OPS and marine charging networks, Italy aims to extend shore-side electrification across core TEN-T ports by 2030, in alignment with European policy targets. Meeting this demand will require building or upgrading high-voltage infrastructure to ensure adequate quality, reliability, and safety of supply. Coordinated planning between the national grid operator, local distributors, and Port System Authorities is essential to implement these works efficiently and in time to support decarbonisation targets.

2.4.3.1 INCENTIVES AND TAXATION

Italy is pursuing an ambitious maritime electrification strategy aligned with EU decarbonisation goals and the Green Deal. In 2024, the European Commission approved a €570 million State aid scheme (2024–2033) for shore-side electricity (“cold ironing”), allowing ships at berth to switch off diesel auxiliary engines and plug into the grid. The scheme offers up to a 100% reduction in general system charges on electricity for ship operators, improving the economic

viability of shore power versus fossil fuels. Alongside this, Italy's National Recovery and Resilience Plan's "Green Ports" investments fund port electrification infrastructure and streamline permitting, while a 2026 €3.5 billion energy package helps offset high energy costs and improve operational sustainability.

On the vessel side, Italy subsidises leisure boating electrification through grants covering up to 50% of costs for electric motors and batteries under the national Law 206/2023. Managed by the Ministry of Enterprises and Made in Italy, the scheme targets both private users and companies in recreational, sport, and commercial boating. Eligible systems include 0.5–12 kW electric propulsion units (outboard, inboard, sterndrive). Grants are capped at €2,000 for integrated-battery outboards and €10,000 for systems with external batteries, with total limits of €8,000 for individuals and €50,000 for companies [35].

Flagship initiatives, such as the INES project in the Port of Genoa, cruise terminal electrification in La Spezia, and wider shore power installations across Italian ports, demonstrate tangible implementation progress and position Italy as a leading actor in European maritime electrification.

Recommendation:

- Shift from direct purchasing incentives to structural infrastructure investments

2.4.3.2 CHARGING INFRASTRUCTURE

Italy is rapidly expanding charging infrastructure for maritime electrification, focusing on high-power charging for electric leisure and small commercial vessels and OPS for large ships at berth. Marine charging networks are deploying DC fast chargers at key locations such as Marina Genova, Sardinia, Lake Garda, and Lake Maggiore, forming emerging coastal charging corridors. At the same time, ports are investing in cold ironing: Genoa and Savona are installing high-power converters to allow ships to shut down diesel engines at berth, while Trieste, Monfalcone, and Livorno are expanding OPS systems with strong public support. Despite this progress, grid capacity limits, lack of standardization, and scalability challenges for large vessels remain, requiring further coordinated investment to fully enable maritime electrification.

Recommendation:

- Expand cold ironing capacities to meet "Fit for 55" EU targets

2.4.3.3 GRID INTEGRATION AND EMERGING TECHNOLOGIES

The integration of OPS systems into Italy's electricity grid is a key enabler of port electrification but also creates major technical and infrastructure challenges. As ports like Genoa, Trieste, and Livorno deploy high-power OPS, electricity demand rises significantly, requiring upgrades to substations, medium- and high-voltage networks, and load management systems.

Ports are increasingly becoming energy hubs, combining renewables, storage, and smart grid technologies to manage peak demand and maintain stability. However, limited grid capacity, regulatory complexity, and slow connection processes can delay deployment. Addressing these issues requires coordinated planning between port authorities, DSOs, and TSOs, along with digital energy management and demand-side flexibility. While progress is underway, further investment and regulatory alignment are needed for scalable and efficient integration.

2.5 DENMARK

Denmark is among the leading countries in EV adoption in Europe. As of January 2024, Denmark's combined fleet reached 0.425 million vehicles equal to 15% of the fleet [37]. These developments have been driven by favourable regulations that encourage EV ownership in Denmark.

2.5.1 EVS

EVs are increasingly considered central to Denmark's 2030 climate target of a 70% emissions reduction, including a goal of 1.5 million EVs [38]. To enable this, the government applies strong financial and regulatory incentives to EVs.

2.5.1.1 INCENTIVES AND TAXATION

The main support is a heavily reduced registration tax. Normally, Denmark applies a very high progressive tax on cars: 25% up to 72,900 Danish Krone (DKK), 85% from 72,900–226,600 DKK, and 150% above 226,600 DKK. EVs benefit from two key reductions: they pay only 40% of the calculated tax, and receive a basic allowance of up to 165,500 DKK [39]. These benefits are being phased out by 2035. Together, these measures have already pushed EVs and hybrid EVs to over 50% of new registrations since late 2024 [40]. Additionally, Euro 5 or older vehicles are banned from entering Copenhagen unless fitted with a particle filter, indirectly encouraging replacement with EVs [41].

Daily-use incentives also matter. Electricity used for EV charging was effectively subsidized until the pause in the electricity tax during 2026-27 took effect [42]^[66]: although electricity is taxed at 0.9 DKK/kWh, 0.86 DKK/kWh is refunded if charging is metered and reported via

certified operators, typically CPOs, making CPO-based charging systems effectively required for the rebate. Parking policy also supports EVs: while blanket free parking has been reduced since 2025, EVs can still park free while actively charging, and charging bays are reserved for EVs in high-demand urban areas.

2.5.1.2 CHARGING INFRASTRUCTURE

Charging infrastructure is rapidly expanding through both private and public actors. CPOs compete aggressively while cooperating with municipalities and the state to deploy slow, fast, and ultra-fast chargers (>100 kW). Many EV owners rely on CPO-managed home charging both for convenience and to access the electricity tax rebate, reinforcing CPO dominance in the system. Furthermore, Danish law stipulates that housing associations must allow owners of EVs to establish a charging point, however the electrical preparations must be paid for by the owner. This causes worry that housing associations might be slow to install the first chargers, since the cost for the EV owners are high. An alternative path is seen in Norway, where the law requires the housing association to pay as a collective. However, the secondary effect of the Danish setup is that housing associations go big and install many chargers, when they electrify, requiring outside control. These points have made Denmark's charging network relatively centralised. As a result, CPOs and EV aggregators are classified as critical infrastructure, subject to strict cybersecurity rules shaped partly by heightened European security concerns after Russia's invasion of Ukraine. This strengthens confidence in the resilience of the system. Operationally, competition among well-resourced CPOs leads to high reliability: faults are actively monitored, users are promptly informed, and maintenance is handled quickly to maintain uptime.

The public sector, led by the Danish Road Directorate, ensures compliance with EU AFIR requirements along major and minor roads. It coordinates with private operators via tenders, helps secure EU funding, and is prepared to build charging stations itself if private investment is insufficient, later handing operation to CPOs.

2.5.1.3 GRID AND EMERGING TECHNOLOGIES

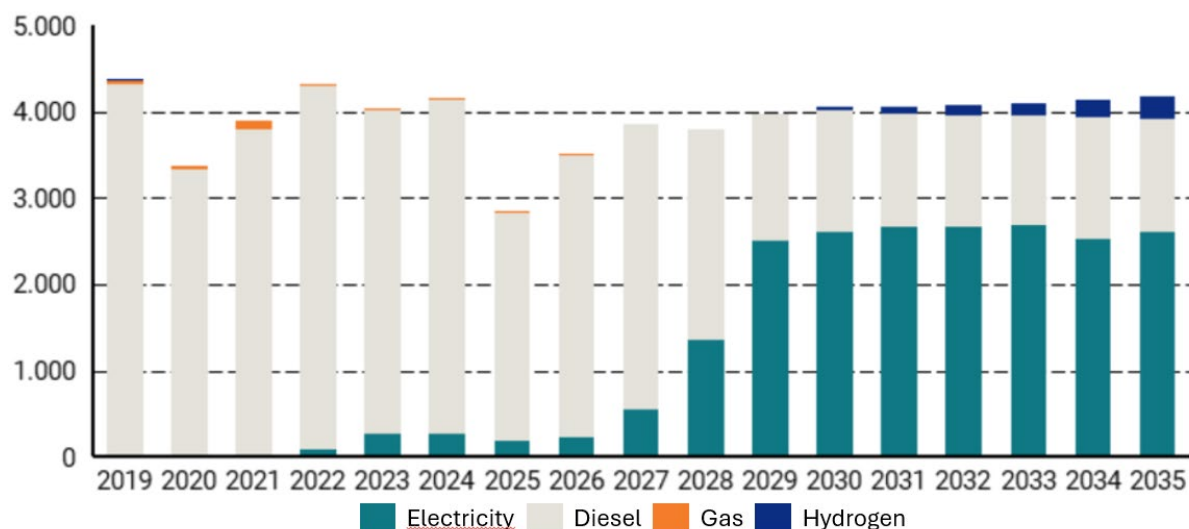
EVs are expected to provide ancillary services and grid flexibility, supporting a greener power system. However, the current regulatory framework restricts their participation. EV aggregators must be accountable for the energy imbalances created by their fleets, something often not ensured today, so EVs are largely excluded from energy-intensive ancillary service markets. While the EU is developing new rules that would allow aggregators to use energy meters in chargers to measure imbalances, enabling access to a wider range of ancillary services, the Danish TSO Energinet is introducing aligned national regulations expected in

2026. This regulatory shift is also key for enabling V2G, since market participation requires imbalance accountability. As such, these changes are a prerequisite for V2G, and Energinet is actively preparing for a future where EVs play a larger role in ancillary services and grid stability.

2.5.2 HDV

The current HDV electric selling percentage is about 5% and it is expected to significantly grow in the next 5 years as shown in the following graph on the number of HDV in Denmark, historical and forecasted [43].

Figure 1 – Number of HDV in Denmark in terms of historical and forecasted



Even though Denmark is actively preparing for the electrification of heavy-duty transport, there are certain remaining barriers to HDV electrification.

2.5.2.1 INCENTIVES AND TAXATION

Policy support is essential to accelerate HDV electrification in Denmark. Fiscal incentives, such as subsidies for vehicles and infrastructure, toll exemptions, and tax breaks, can help achieve TCO parity. Long-term regulatory clarity is needed to ensure investment security and encourage stakeholder participation.

A shift from tailpipe-only CO₂ metrics to well-to-wheel assessments is recommended to better reflect the environmental impact of different powertrain technologies. Technology-neutral policies can allow market-driven solutions to emerge and support a broader range of zero-emission options.

Recommendation:

- Innovative business models, such as leasing and transport-as-a-service, can reduce upfront costs and improve access to capital.

2.5.2.2 CHARGING INFRASTRUCTURE

Grid capacity expansion can take up to two years, delaying charging infrastructure rollout. High upfront costs for charging systems and grid upgrades further slow the transition, while limited semi-public access at private depots restricts third-party logistics participation in electrification. Depot charging is currently the most viable solution for urban and regional transport. However, long-haul operations still require high-capacity batteries and fast-charging technologies such as MCS, which are not yet fully developed.

Recommendations:

- Cities can serve as ecosystems for early adoption, especially in last-mile delivery and regional distribution.
- Collaborative initiatives involving municipalities, utilities, and logistics operators can accelerate infrastructure deployment.

2.5.2.3 GRID AND EMERGING TECHNOLOGIES

Standardization of charging protocols and V2G capabilities is necessary to ensure interoperability and maximize grid benefits. Full implementation of V2G is expected in the coming years, contingent on regulatory and technical alignment.

Recommendation:

- Strategic planning and stakeholder engagement are key.

2.5.3 VESSELS

Denmark is emerging as a European frontrunner in maritime electrification, particularly in the ferry sector. Danish operators such as Molslinjen are deploying large battery-electric ferries, while ports are investing in shore-side charging infrastructure and OPS. Copenhagen's Nordhavn port is developing one of Europe's largest shore power facilities, supporting compliance with FuelEU Maritime requirements. However, further electrification is increasingly constrained by grid capacity limitations and long connection timelines in several ports. Industry

stakeholders highlight the need for accelerated grid upgrades, stronger coordination between ports and electricity network operators, and better integration with Denmark's expanding offshore wind capacity. Continued public and private investment will therefore be essential to scale up charging infrastructure, support wider electric vessel adoption, and maintain Denmark's progress in zero-emission maritime transport.

Recommendation:

- Channel financing to support charging infrastructure deployment at ports, grid reinforcement and mass-scale deployment of emerging smart energy technologies.

3 CONCLUSION

This report analysed the evolving regulatory landscape for e-mobility across the European Union and selected Member States participating in the AHEAD project, namely Portugal, Italy, Denmark and Slovenia, with a focus on EVs, HDVs, and vessels. It examined the policy and market frameworks shaping charging infrastructure deployment, grid integration, taxation, incentives, emissions standards, and emerging technologies such as smart and bidirectional charging. The analysis demonstrated that while significant progress has been achieved through enabling EU regulatory framework including AFIR, EPBD, RED III, FuelEU Maritime, and the Electricity Market Reform, major disparities remain across the EU Member States in charging infrastructure readiness for HDVs, grid capacity, permitting procedures for deployment of charging infrastructure, and support mechanisms for heavy-duty and maritime electrification.

The findings highlight that accelerating the transition to e-mobility requires a more harmonised, predictable, and investment-oriented policy framework. Priority actions include streamlining permitting and grid-connection procedures, strengthening anticipatory grid investments, enabling smart and bidirectional charging through clear market rules, and accelerating the deployment of high-power charging and OPS infrastructure. In addition, targeted incentives for HDVs and vessels, improved interoperability and cybersecurity standards, and stronger coordination in planning between transport and energy sector representatives will be essential. A predictable and coherent regulatory framework at both the EU and national levels will be critical to scale up electrification of the transport sector, support EU industrial competitiveness, and ensure an efficient and resilient energy system in the EU.

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