EV FireSafe

E-mobility Devices on Rail - Jurisdictional Review

Final Report

Office of the National Rail Safety Regulator

3 February 2026

→ The Power of Commitment

Project name		E-mobility Devices on Rail - Jurisdictional Review					
Document title		E-mobility Devices on Rail - Jurisdictional Review | Final Report					
Project number		12681176					
File name		12681176 E-mobility Devices on Rail Review Report FINAL.docx					
Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S3	-	Eleanor Short Lauren Fraser Rebecca Green Tarni Pereira Emma Sutcliffe	Jon Cheesmond Prof. Paul Christiansen	On file	Eleanor Short	On file	12/12/2025
S4		Eleanor Short Lauren Fraser Tarni Pereira	Jon Cheesmond Emma Sutcliffe Mark Cooney	On file	Jon Cheesmond	On file	30/01/2026
S4	1	Eleanor Short Lauren Fraser Tarni Pereira	Jon Cheesmond	On file	Jon Cheesmond		03/02/2026

GHD Pty Ltd ABN 39 008 488 373
Level 15, 133 Castlereagh Street
Sydney, NSW 2000, Australia
T +61 2 9239 7100 | **F** +61 2 9239 7199 | **E** sydmail@ghd.com | **ghd.com**

Acknowledgement of Country

GHD acknowledges Aboriginal and Torres Strait Islander peoples as the Traditional Custodians of the land, water and sky throughout Australia on which we do business. We recognise their strength, diversity, resilience and deep connections to Country. We pay our respects to Elders of the past, present and future, as they hold the memories, knowledges and spirit of Australia. GHD is committed to learning from Aboriginal and Torres Strait Islander peoples in the work we do.

Glossary

Table 1-1: List of abbreviations

Term/Acronym	Meaning
ACCC	Australian Competition and Consumer Commission
AESF	Agencia Estatal de Seguridad Ferroviaria
ARISO	Australian Rail Industry Standards Organisation (previously RISSB)
ARR	Australian Road Rules
ATM	Autoritat del Transport Metropolità
CNMC	Comisión Nacional de los Mercados y la Competencia
CO	Carbon Monoxide
EBA	Eisenbahn-Bundesamt
EN15194	European safety standard for e-bikes titled 'EN15194 – Cycles – Electrically Power-Assisted Cycles (EPAC bicycles)'. Includes mandatory safety and performance tests for electrical, battery and fire safety. This is the technical standard used in Europe to determine if an e-bike is a legal 'pedal-assist bicycle' rather than a motor vehicle.
EPAC	Electrically Power-Assisted Cycle
EU	European Union
EV	Electric Vehicle
EVFS	EV FireSafe
FDNY	Fire Department of New York
FRA	Federal Railroad Administration
FSRI (US)	Fire Safety Research Institute (US)
FY	Financial Year
GB17761	Chinese standard for e-bikes. GB17761 - Safety Technical Specification for Electric Bicycle, implemented in 2025.
HCN	Hydrogen Cyanide
HF	Hydrogen Fluoride
HHA	Hamburger Hochbahn AG
ILT	Inspectie Leefomgeving en Transport
LIRR	Long Island Rail Road
LiB	Lithium-ion Battery
LTA	Land Transport Authority
MMD	Motorised Mobility Device
MTA	Metropolitan Transportation Authority
NFPA (US)	National Fire Protection Association (US)
NS	Nederlandse Spoorwegen
NSW	New South Wales
NYC	New York City
ONRSR	Office of the National Rail Safety Regulator
ORR	Office of Rail and Road

Term/Acronym	Meaning
PMD	Personal Mobility Device
RIM	Rail Infrastructure Manager
RISSB	Rail Industry Safety and Standards Board (now ARISO)
RSNL	Rail Safety National Law
RSO	Rolling Stock Operator
RTO	Rail Transport Operator, means: – Rail Infrastructure Managers (RIMs); or – Rolling Stock Operators (RSOs); or – operators that are both.
SFAIRP	So Far As Is Reasonably Practicable
SMS	Safety Management System
SMRT	Singapore Mass Rapid Transit
TfL	Transport for London
TfNSW	Transport for New South Wales
TMB	Transports Metropolitans de Barcelona
TTC	Toronto Transit Commission
UK	United Kingdom
UL	Underwriters Laboratories
UL2272	North American safety standard for electrical systems and fire safety of personal e-mobility devices (e.g. e-scooters and e-skateboards) titled 'ANSI/CAN/UL 2272 – Electrical Systems for Personal E-Mobility Devices'. Includes mandatory safety and performance tests for electrical, battery and fire safety.
UL2849	North American safety standard for electrical systems and fire safety of personal e-bikes, titled 'ANSI/CAN/UL 2849 – Electrical Systems for E-Bikes'. Includes mandatory safety and performance tests for electrical, battery and fire safety.
UQ	University of Queensland
UNSW	University of New South Wales
USA	United States of America

Executive summary

Overview

E-mobility devices such as e-bikes and e-scooters have been increasing in popularity in Australia. Rail passenger networks are seeing significant increases in passengers travelling on services with these devices. This poses new safety risks, particularly associated with the lithium-ion batteries (LiBs) in e-mobility devices. This report outlines how the safety risks posed by e-mobility devices on rail are being managed globally by rail safety regulators and Rail Transport Operators (RTOs).

Completed in late 2025, this review used desktop research to understand how rail safety regulators and RTOs manage risks from e-mobility devices on the rail network. In consultation with ONRSR, eight subject jurisdictions (countries) were selected, and one RTO was featured within each of these. The countries are Canada, the United States of America, Great Britain, the Netherlands, Germany, Spain, China and Singapore. The context for Australia is also discussed.

Consequences from thermal runaway in e-mobility devices

A fire in a LiB is known as thermal runaway and has specific characteristics and hazards. The four primary consequences of thermal runaway in the LiBs of e-mobility devices are (Austroads, 2025):

- **Off-gassing** – A toxic, flammable cloud of vaporised electrolyte caused by rapidly heating LiB cells that typically occurs before ignition. The toxicity and gas mix depends on the battery cell form type, chemistry and state of charge. Off-gassing can result in fatalities and short-term or long-term injuries from hydrogen fluoride (HF), carbon monoxide (CO) and hydrogen cyanide (HCN) (Vamosi, 2023).
- **Ignition** – When the off-gassing ignites, the pressure of the escaping vapours forms a jet-like directional flame. Thermal runaway fires are difficult to extinguish and require larger volumes of water than other fire types due to the self-propagating nature of the fire. Fire can result in fatalities.
- **Projectiles** – LiB packs contain dozens of individual battery cells. During thermal runaway these can detach from the main pack and form projectiles. These can strike people and/or spread fire through railway carriages. Projectiles could result in serious injuries.
- **Vapour cloud explosion** – Where off-gases are unable to escape, they may build up and cause a vapour cloud explosion. This has been observed in scenarios where a battery pack is within an enclosed space, such as an electric car in a small garage or an e-bike in a bedroom. An explosion can result in multiple fatalities.

A further challenge is secondary ignition, where a partially burned battery pack can re-ignite at a later stage. As such, RTOs need to consider safe handling, storage and disposal of LiBs after any incident.

Approaches to management of e-mobility devices on rail

Four types of controls have been identified to address risks associated with e-mobility devices in the rail environment. These are:

- **Prohibition:** A ban on transporting certain types of e-mobility devices on the rail network. These can be:
  - Total prohibition of an e-mobility device category (e.g. e-scooters on the Transport for London network) or
  - Partial prohibition of sub-categories of e-mobility devices based on their characteristics (e.g. any device with a battery over 100 Wh on China Railways, and non-folding e-bikes on the Transport for London network)
- **Storage controls:** Rules and regulations for how e-mobility devices are stored during transport (e.g. folding smaller devices for transport as luggage in Singapore)
- **Certification requirements:** Requirements for safety certification for any device being transported on rail (e.g. Certification to UL2849/UL2272 required for travel on subway in New York City, United States of America)
- **Time of day/year controls:** Limits on the times of day or the year during which e-mobility devices can be transported on the rail network. Often this is based on space constraints, which also restricts pedal bikes at peak times (e.g. the Netherlands). A winter ban on e-mobility devices on rail is in place in Toronto.

Following three e-mobility thermal runaway incidents on the Australian road network in 2025, several RTOs have undertaken reviews and introduced control measures. For example, in NSW, converted e-bikes and their batteries are prohibited on Sydney Trains, Sydney Metro and NSW TrainLink. In Victoria converted e-bikes are prohibited on the Metro and V-Line, and there are restrictions for standard e-bikes and e-scooters (e.g. must be turned off and not charging). South Australia has prohibited modified e-bikes and e-scooters from the Adelaide Metro and is completing a review.

Key themes

Key themes emerging from the assessment are:

a. The wider context on both active travel context and national regulation of e-mobility devices in the jurisdiction is likely to influence the approach taken.
b. Many approaches are linked to perceived risk factors such as restricting uncertified or modified devices. It is not clear from the research what level of evidence or research was used to inform the approaches adopted, or how specific decisions were made. Typically, a precautionary approach appears to have been applied, particularly if a thermal runaway incident with an e-mobility device has occurred on rail in the jurisdiction reviewed.
c. The majority of approaches are 'bottom-up' from operators, rather than being driven by regulators, and are not covered in national legislation.
d. Storage controls typically mirror those for pedal bikes and are predominantly based on space constraints and access rather than LiB considerations. No evidence was found of additional fire alert or suppression systems linked to storage requirements.
e. Enforcement is linked to existing practices, through use of rail staff. Aside from signage and information, no specific physical enforcement measures have been introduced.

Conclusions

The controls and approach taken by the eight jurisdictions have been identified, and a high-level analysis of control effectiveness and cost has been completed. Thermal runaway in e-mobility devices in the rail environment is a known risk. Several events have occurred on Australian rail networks (see Section 3.2), highlighting the potential for significant consequences. There are issues with low levels of public awareness of the risk that e-mobility devices pose, and evidence of unsafe practices have been identified from both survey results (NSW EPA, 2025) and incident investigations.

With the increasing uptake of e-mobility devices in Australia, the likelihood of further incidents is increasing, particularly in the absence of stronger regulation for e-scooter sales outside of NSW. Although there have not been any fatalities associated with thermal runaway in e-mobility devices in the rail environment to date, this is possible. Some inhalation injuries have been observed in footage of incidents, but the severity of these injuries cannot be verified.

Globally, there is a wide range of approaches to the restriction and management of e-mobility devices on rail networks. In most cases restrictions are in response to safety risks posed by LiBs, but in some cases, these are aligned to wider approaches to pedal bikes on trains (e.g. space related reasons). Agencies typically differentiate between e-bikes and e-scooters, with 'other' e-mobility devices typically either separate or grouped with e-scooters.

Control measures range in their costs and effectiveness. Some measures reduce the likelihood of incidents occurring (e.g. prohibiting e-mobility devices), some reduce the severity of incidents (e.g. prohibiting only larger size devices) and others address both issues (e.g. the use of battery bags for devices under a certain size in China). Costs are typically low for measures which have been introduced to date, as they largely rely on existing systems and enforcement practices.

Overall, the case studies and wider incidents of thermal runaway occurring globally on e-mobility devices in the rail environment highlights the need for a robust assessment of the risks and consideration of the appropriate response for each jurisdiction's circumstances. RTOs can be reasonably expected to have considered and documented an approach to manage the risk of thermal runaway in e-mobility devices in the rail environment So Far As Is Reasonably Practicable (SFAIRP) and this is included within their Safety Management System (SMS).

Contents

Table index

Figure index

1. Introduction

1.1 Purpose of this report

The Office of the National Rail Safety Regulator (ONRSR) is established under the Rail Safety National Law (RSNL) to enforce safe railway operations and promote and improve rail safety across Australia.

E-mobility devices such as e-bikes and e-scooters have been increasing in popularity in Australia. Rail passenger networks are seeing significant increases in passengers travelling on services with these devices. This poses new safety risks, particularly associated with the lithium-ion batteries (LiBs) in these devices.

This report was commissioned to outline how the safety risks posed by e-mobility devices on rail are being managed globally by rail safety regulators and Rail Transport Operators (RTOs).

1.2 Report structure

This report includes the following:

- **Project context (Chapter 2):** Provides an overview of the Australian regulatory and legislative context relevant to this project, as well as an outline of key trends, hazards and risks associated with e-mobility devices.
- **Management of e-mobility devices on rail (Chapter 3):** Explains the categories of approach which can be taken to the management of e-mobility devices on the rail network, including how these are currently applied in Australia. This Chapter also provides details of e-mobility device incidents in general and specifically in the rail environment in Australia and globally.
- **International review (Chapter 4):** Outlines the approach to e-mobility devices on rail taken by 8 selected operators globally and includes selected incident case studies.
- **Risk and cost analysis (Chapter 5):** Presents a risk analysis in the form of a bowtie diagram and includes high-level commentary on the cost and effectiveness of the controls identified in the report.
- **Discussion and Conclusions (Chapter 6 and 7):** Provides a summary of the key themes emerging from the desktop review.

1.3 Scope

This report has focused on heavy passenger rail, not light rail (trams) or freight. Metro systems and heavy rail are considered a high-risk environment, with enclosed areas and limited evacuation options particularly in tunnels and underground systems. It is expected that the analysis in this report could be tailored to light rail systems.

The report examines the approach taken to e-bikes, e-scooters and other e-mobility devices up to 250Wh, not including Motorised Mobility Devices (MMD).

1.4 Approach

This report used a desktop research approach to understand rail safety regulator and RTO approaches to managing risks from e-mobility devices on the rail network. Research was completed in late 2025.

In consultation with ONRSR eight subject jurisdictions (countries) were selected, and one RTO within each of these. The jurisdictions and RTOs were selected to include:

- A broad geographical spread globally (i.e. covering Europe, North America and Asia).
- Different types of rail operation (i.e. national or intercity networks, and city-based services).
- Different network types (i.e. above ground and underground Metro services).
- A range of controls and approaches to management of e-bikes, e-scooters and other e-mobility devices.
- Some jurisdictions where e-mobility device incidents on the rail network had occurred, in order to include case studies of these (i.e. Toronto, New York City, London and Madrid).

A brief commentary on any noteworthy approaches from other operators in the same country was also included as appropriate.

Case studies from the EV Fire Safe incident database were used to develop the report case studies, with supplementary research completed as necessary. The database research, which is funded by the Australian Department of Defence, collates verified incidents of thermal runaway in electric vehicles including cars, buses, trucks, trains, aircraft and specialist equipment. Identified incidents start from 2010 onwards, and are sourced from media reports, online reports, fire and emergency agencies, witnesses and owners. This data is not available for public viewing.

The costs and effectiveness of the measures were assessed using professional judgement at a high level, based on the desktop research.

Conversations with several international and industry contacts were also held during the project, including from some of the subject jurisdictions.

1.5 Disclaimer

2. Project context

2.1 Terminology

Device types

Terminology relating to e-mobility varies across Australia and globally. The terminology adopted within this report and its meaning is as follows:

- **e-mobility device:** motorised, electrically powered devices, designed to transport a single person. Includes e-bikes, e-cargo-bikes, high-powered e-bikes, e-scooters, e-skateboards and less common items such as self-balancing hoverboards, segways and e-unicycles. Under the Australian Road Rules (ARRs) these are referred to as 'Personal Mobility Devices' (PMDs).
- **e-bike:** bicycle equipped with an integrated electric motor that assists the rider while pedalling, which must comply with European standard EN15194. There are specific regulations in Australia on what is classified as an 'Electrically Power-Assisted Cycle (EPAC)' based on power and speed limits. These can have a motor power output of up to 250 W and assistance must cut off at 25 km/h. Under NSW regulations motor output for e-bikes can be up to 500 W, with the same 25 km/h cut-off. In Europe these may be referred to as 'pedelecs'. Sub-types of e-bikes can include:
  - **'Fat-bikes':** Short for 'fat tyre e-bike'. These are e-bikes with extra-wide 3.8-5-inch tyres. They are designed to ride on soft, unstable terrain like sand and mud, they are becoming increasingly popular with young people and are associated with several safety concerns (ABC News, 2023). As per other e-bikes, road legal fat e-bikes are limited to 25 km/h, whereas off-road fat bikes can go from 40 to 70 km/h and above. An example is shown in Figure 2-1.
  - **e-cargo-bike:** A type of e-bike specifically designed with a large cargo capacity, e.g. front-loading boxes or three-wheeled trikes. These are built to carry heavy loads, including goods or small children.
  - **Converted e-bikes:** Pedal bikes which have been converted to e-bikes, with the addition of a motor and battery. This can be done with or without a specific conversion kit.
  - **Modified e-bikes:** E-bikes which have been modified from their legal factory configurations, for example by increasing the motor power, removing speed limiters or changing throttle behaviour. This may make them non-compliant with e-bike regulations (i.e. to become unregistered motor vehicles). Altering e-bike batteries can put them at increased risk of thermal runaway (see Section 2.3.3).
- **Bicycle:** refers to both e-bikes and pedal bikes together (e.g. in the context of bicycle storage areas).
- **Pedal bike:** traditional bicycle, without a battery.
- **e-scooter:** scooter equipped with an integrated electric motor that assists the rider while scooting. From 2025, in NSW, these must comply with a series of safety rules including for their batteries, but there is no national approach. Under the Australian Road Rules these are classified as Personal Mobility Devices (PMDs), which exclude moped and motorbikes by design and dimensions.
- **Motorised Mobility Device (MMD):** mobility scooters and powered wheelchairs designed for people with mobility impairments. Treated as pedestrians by the law in Australia, if they cannot exceed 10 km/h on level ground and can carry a person with walking difficulties.
- **speed pedelec (or s-pedelec):** e-bike with motor power up to 4000 W, which offers pedal assist up to speeds of 45 km/h. These are more powerful and faster than a standard pedelec. In the EU, speed pedelecs are classified as mopeds, and require registration, insurance and sometimes a licence (Regulation 168/2013) (European Union, 2013). Examples are shown in Figure 2-2. As speed pedelecs are classified as mopeds and achieve greater speeds than is legal in the Australian road context, they have not been included in the detailed analysis in this report. Some commentary about them is included within the case studies of European countries.

E-mobility devices contain batteries, which are typically LiBs. This report does not consider larger electric powered vehicles such as electric cars.

Figure 2-1: DiroDi Rover Pro 'fat tyre e-bike' – a popular model increasingly common in Australia (250 W motor, limited to 25 km/h) (DiroDi, 2025)

Figure 2-2: Speed pedelecs examples. Left: Ellio Original speed pedelec, 1500 W motor, speeds up to 45 km/h (Ellio, 2026) Right: Gazelle Eclipse speed pedelec, 750 W motor, speeds up to 45 km/h (Gazelle Bikes, 2026)

Other terminology

Other terminology used in this report includes:

- Wh – Watt hours. A measure of the **capacity** of a LiB on an e-mobility device. The higher the capacity, the more energy storage and an increased range. Typically, in the range of 300 Wh to 700 Wh for standard e-bikes, and up to 1250 Wh for dual battery long-range or high-end devices. Standard e-scooters have a slightly smaller capacity, typically ranging from 200 Wh to 400 Wh. Larger battery devices are available, but may not be road legal.
- W – Watts. A measure of the **power output** of the LiB on an e-mobility device. 250 W maximum in most of Australia for road-legal devices, and 500 W in NSW.

2.2 Regulatory and legislative context

2.2.1 Rail regulation

Introduced in 2012, the Rail Safety National Law (RSNL) replaced 46 separate state and territory laws, creating a nationally consistent framework overseen by ONRSR. ONRSR oversees accreditation, compliance, and enforcement across all jurisdictions, applying a risk-based approach to regulation. The law imposes general duties

to ensure safety and mandates that RTOs implement an SMS and demonstrate that their risks to safety from railway operations are eliminated, and if that is not possible, any remaining risks are managed So Far As Is Reasonably Practicable (SFAIRP). Operators have flexibility to innovate and manage risks in ways that suit their operations, while ensuring accountability through audits, reporting, and enforcement by ONRSR. ONRSR also conducts research, collects and publishes information relating to rail safety.

The RSNL is adopted by each state and territory through local Acts, allowing for jurisdiction-specific provisions (Parliament of Australia, 2025). The Australian Rail Industry Standards Organisation (ARISO) (previously the Rail Industry Safety and Standards Board (RISSB)) seeks to harmonise industry practices under the co-regulatory model by publishing rail industry standards.

For the purpose of this report, the types of regulatory models referred to are defined in Table 2-1.

Table 2-1: Types of regulatory models

Regulatory Model	Definition
Prescriptive	Means a system where detailed safety requirements and standards are set by government regulations.
Co-Regulatory	Means a system where government sets the framework and industry collaborates to develop and enforce detailed rules under regulatory oversight.
Self-Regulatory	Means a system where an industry or organisation independently creates and enforces its own standards without direct government approval.

2.2.2 E-mobility standards and national regulation

This section discusses the overall regulation of e-mobility devices broadly, not the specific approach to rail. The approach adopted for railways is discussed in Section 3.

2.2.2.1 Inquiries, standards and legislation

Having identified an increase in incidents involving LiBs in different types of devices, the Australian Competition and Consumer Commission (ACCC) reviewed potential hazard prevention strategies in relation to LiBs in 2023 (Australian Competition and Consumer Commission, 2023). These highlighted recommendations including development of a nationally consistent requirement for testing, certification and labelling (i.e. to UN 38.3), which could help improve the safety of e-mobility on the rail network.

The NSW Government inquiry on LiBs in 2024 noted that batteries used in personal mobility devices present higher fire risks than batteries used in other electric vehicles. Reasons for this include an increased likelihood of defective batteries in e-bikes and e-scooters, because of the existence of poor-quality products, lack of regulation and overcharging of the devices (NSW Government, 2024).

The Queensland Government launched a parliamentary inquiry into e-mobility device safety, with public submissions closing in June 2025 (Twyford, 2025). The inquiry was to assess injury data, current regulations, and infrastructure to determine the need for safety or legislative changes. Findings have not been published at the time this report was issued.

2.2.2.2 E-bike approach

Australia broadly follows the European Pedelec Standard EN15194 which defines an e-bike as a pedal assist only bicycle, with a motor power limit of 250 W continuous rated, and a speed cut off of 25 km/h. These rules allow e-bikes to be treated as pedal bikes under the ARR, so no registration or licence is required.

The Road Vehicle Standards Amendments (Safer E-bikes) Bill is currently before Parliament to formalise national standards for e-bike safety and classification (Parliament of Australia, 2025). The Bill aims to reduce injuries and battery fire risks linked to poor quality e-bikes. If passed, the Bill will require the Minister for Transport to issue national safety standards for e-bikes within six months of the Bill passing. It also includes compulsory statements of compliance from importers and manufacturers. It is noted that these national safety standards could reduce the risk that e-bikes pose on the rail network, but that legacy e-mobility devices which do not meet the new standards would remain in use and there are no plans to remove these.

2.2.2.3 E-scooter approach

E-scooters can currently be imported from overseas with no regulation or checks on safety and no standard approach to testing or labelling, aside from in NSW. That means that there are 'low quality LiB products' on the market, which poses risks to consumer safety (Australian Competition and Consumer Commission, 2023).

2.2.2.4 NSW standards

NSW is leading Australia in e-mobility regulation. E-bikes, e-scooters, e-skateboards, self-balancing scooters and their LiBs are now 'declared electrical articles' under the Gas and Electricity (Consumer Safety) Act 2017, and must meet mandatory safety standards before they can be sold (NSW Government, 2025c). Further safety requirements are planned such as, from 1 February 2026, testing, certification and marking of declared e-mobility devices and batteries will be required prior to sale in NSW.

Currently in NSW only scooters operated through shared hire schemes are allowed to travel on the rail network. These have been operating on a trial basis in cities such as Wollongong (Neuron Mobility) and Forster-Tuncurry (Beam). Riding privately owned e-scooters in public places in NSW is currently illegal, though this does happen, and TfNSW is planning to legalise this (NSW Government, 2025a).

2.3 E-mobility device context

2.3.1 E-mobility device trends

There has been significant growth in e-bike and e-scooter (e-mobility devices) sales and usage recently, both in Australia and globally (The Business Research Company, 2025). Some of the recent Australian data is as follows:

- In the 2021-22 financial year, the number of e-bikes and e-scooters imported to Australia was estimated to be around 350,000 units (Latz, 2023).
- Between 2020 and early 2025, sales of e-bikes have nearly tripled in Australia (UNSW Sydney, 2025).
- An estimated 193,000 e-bikes were sold in Australia in 2022 (a 250% increase from 2020) (We Ride Australia, 2023).
- Projections indicate that revenue in the e-bike market in Australia will reach over $550 million by the end of 2025 (Statista, 2025).
- Based on data from 2023, Mordor Intelligence identifies that nearly 99% of e-bikes in Australia use a LiB (Mordor Intelligence, 2024).
- By the end of 2025, national sales of e-scooters are projected to be 35,740 vehicles, with a revenue of over $26m, steadily increasing (Statista, 2025).

E-bikes are widely used across major Australian cities for food delivery services (e.g. UberEats and DoorDash). These offer benefits to delivery drivers such as easy parking and manoeuvring through heavy traffic compared to cars. A recent Monash University study monitored 27,000 two-wheeled vehicles across eight Melbourne sites and found that 47% were e-bikes used for the purpose of food delivery (Chung, 2025). With the rapid increase of the gig-economy, the demand for e-bikes among food delivery drivers is expected to continue.

There is evidence to suggest that many e-bikes in Australia are being modified from their factory settings to increase their performance. Tampering with batteries introduces a risk of thermal runaway occurring. A study from Monash University found over 20% of delivery e-bikes exceeded the 25 km/h speed limit (Delbosc, et al., 2025). Police operations in 2025 found 9% of e-bikes checked in NSW were non-compliant, and 52% in VIC were overpowered (Bicycle Network, 2025a; Bicycle Network, 2025b).

2.3.2 E-mobility device thermal runaway characteristics

If a LiB is abused (e.g. by crushing or overcharge), reactions can be triggered that produce large volumes of toxic and explosive gas and heat. Heat speeds up these processes, generating more heat and gas. When these reactions become self-sustaining, positive feedback occurs and the LiB is in thermal runaway. Heat can be transferred from cell to cell (which does not require fire) triggering thermal runaway in a cascade effect (thermal propagation). Heat can also spread to adjacent devices and cause them to also enter thermal runaway.

Thermal runaway has specific characteristics and consequences. The four primary consequences associated with thermal runaway in the LiBs of e-mobility devices, which are different to other typical fire types in a rail environment, are outlined below (Austroads, 2025):

– **Off-gassing** – A toxic and flammable cloud of gas, vaporised electrolyte and longer-chain products of thermal runaway caused by pyrolysis of the electrolyte (i.e. a vapour cloud) due to rapid heating of LiB cells that typically occurs at the earlier stages of thermal runaway before ignition. The toxicity and gas mix depends on the battery cell form type, chemistry and state of charge. Off-gassing can cause fatalities and long-lasting injuries from hydrogen fluoride (HF), carbon monoxide (CO) and hydrogen cyanide (HCN) (Vamosi, 2023). Whilst toxic, off gases are also highly flammable and typically burn up quickly where flame is present, thereby producing smoke and other products of combustion. Some anecdotal evidence suggests inhalation injuries may occur following contact with remnant pollutants on clothing and/or surfaces following a thermal runaway event, however that is yet to be verified. Very little global research currently focuses on this risk, and it is an area requiring greater testing to inform safety measures, both during and post-incident.
– **Ignition** – When the off-gassing ignites, the pressure of the escaping vapours forms a jet-like directional flame. Depending on battery pack size, this can extend 1-2m from the device (compared to 2 to 3 metres for electric cars). Thermal runaway fires are difficult to extinguish and require larger volumes of water than other fire types due to the self-propagating nature of the fire. ‘Delayed ignition’ may occur, when damage occurs to a battery (e.g. from mechanical abuse or salt-water ingress), but thermal runaway does not occur until later.
– **Projectiles** – LiB packs contain dozens of individual battery cells. During thermal runaway these can detach from the main pack and form projectiles. These are a hazard as they may hit passengers or equipment. In addition, if these cells are also in thermal runaway, they can cause spot-fires and spread fire through railway carriages.
– **Vapour cloud explosion** – Where off-gases are unable to escape, they may build up and cause a vapour cloud explosion. This has been observed in scenarios where a battery pack is within an enclosed space, such as an electric car in a small garage, or an e-bike in a bedroom.

Fires and gas clouds pose a significant risk in rail environments due to constrained spaces, including train and tram carriages, tunnels and stations. Even a small thermal event in a carriage can cause passenger harm, but also damage to rolling stock, evacuation complexity, and service disruption. This hazard is the reason some global rail regulators and operators are introducing restrictions on the carriage of e-mobility devices on rail.

LiBs are also present in smaller, everyday electronic devices including mobile phones and power-banks. The smaller battery size in these devices poses a lower risk level.

Secondary ignition

Secondary ignition is an additional hazard associated with LiB thermal runaway, which needs to be managed in a rail environment. LiBs that do not completely burn out during a thermal runaway event can still pose a fire risk due to ‘stranded energy’ in live cells. This risk of secondary ignition remains until the battery is fully de-energised and disposed of properly. RTOs need to consider safe storage and disposal of any burned out e-mobility devices and their battery packs, if these are not removed by emergency services. Techniques can include physical separation from exposures, and use of containment units which can be filled with water in the event of secondary ignition (Austroads, 2025).

2.3.3 E-mobility device risk factors

There are a number of risk factors related to e-mobility devices which can be considered by transport agencies and rail operators in introducing restrictions. These are summarised in Table 2-2.

Table 2-2: Summary of risk-factors related to e-mobility devices on the rail network

Risk factor	Commentary
E-MOBILITY DEVICE RELATED FACTORS	
Size of battery	Larger batteries provide additional energy and can therefore burn for longer and emit more heat and gases during thermal runaway.
State of charge of battery	A higher state of charge leads to more energy which can cause more intense and longer lasting thermal runaway. At lower levels of charge (up to 40%), off-gassing may be more of a hazard if it does not ignite.
Charging of device	Incident data shows that e-mobility devices do not have to be charging to be a fire risk. Fire + Rescue NSW (FRNSW) data shows that only 34% and 44% of LiB powered devices were connected to charging at the time of going into thermal runaway in 2022 and 2023 respectively (Fire and Rescue New South Wales, 2024b).
Damage to battery	Damage to EV battery packs from road traffic collision is a leading cause of battery fires in EVs, however modifications and incorrect charging practices are believed to be more common with e-mobility device fires. This is based on the data in EV FireSafe's global database.
Modifications to battery packs (including lack of safety certification)	Uncertified modifications to e-mobility devices may cause battery damage and increase risk (see above). Numerous incidents have occurred when people have been making their own modifications to LiBs (Fire and Rescue New South Wales, 2024a; Government of South Australia, 2022). This is based on the data in EV FireSafe's global database.
Lack of safety certification (or its enforcement)	Compliance to relevant local safety standards reduces the risk of incidents. Note the level of standards vary between countries. This is discussed in Section 2.2.2.
Age of device	As e-mobility devices have become more popular in the last few years, it is not yet clear if increasing age increases the risk of incidents. This should be kept under review.
Inappropriate charging (e.g. with incorrect devices)	Incompatible or counterfeit chargers may deliver incorrect voltage or current, damaging the battery. Failure in Battery Management Systems (BMS) in poor quality devices may lead to overcharging and internal short circuits.
Lack of public awareness of e-mobility device fire safety risks and warning signs	Recent incidents show lack of public awareness of e-mobility device fire safety risks, with members of the public often reacting slowly to e-mobility device fires, unaware of the potential for explosion and fire escalation. An NSW Government survey undertaken in 2025, highlighted a low level of understanding of the risks associated with the use of LiBs, with only 44% of respondents saying they understand these (NSW EPA, 2025). Despite this understanding, the group reported that they still engage in risky behaviours when charging their devices (e.g. 51% use low quality chargers or batteries, 70% charge batteries near living spaces or exits). 32% of people said they did not know how to implement safety measures.
RAIL RELATED FACTORS	
Operating environment	Tunnel or underground operating environments will present additional challenges for incident response compared to above ground operations.
Distance between stations	Larger distances between stations may: (a) increase time to the next station to support safe evacuation of passengers, leading to (b) increased exposure to off-gassing, smoke and fire and (c) increased risk of evacuation between stations being required.
Crowding on services	On busy services, there is a greater risk of injury to passengers should an incident occur. This is due to more passengers being present and risks from injuries due to unsafe crowd behaviour.
Station environment	Ease of access to and quantity of water supply at stations will impact firefighting and emergency response. Water supply at stations will be designed for specific fire scenarios, and it should be noted that LiB fire management involved large volumes of water. If sufficient water is not available, 'water relays' from fire trucks, or additional fire trucks may be needed to secure additional water.
Vehicle emergency exit arrangements	Number and location of emergency exits and windows for ventilation, including relative to the fire, will impact on incident outcomes.
Carriage characteristics	Carriage design (e.g. open metro style or more separate carriages) will impact on incident impacts including exposure to gases, ability of passengers to move away from the fire, projectile and explosion risks. Age of rolling stock and design may impact on fire load and on-board fire suppression systems.

2.3.4 UK research on e-mobility fires

In 2024 the UK Office for Product Safety and Standards reported 211 fires involving e-bikes or e-scooters, to help identify product safety issues. This included 170 fires with e-bikes, 39 with e-scooters, one with an e-unicycle and one with a mobility scooter. Of the e-bike fires, 77 of these incidents (45%) involved post-market conversions (Hoey, 2025). Based on market data, conversion kit sales and consumer behaviour, converted e-bikes are estimated to make up under 20% of the fleet, meaning incidents involving them are disproportionately high. Converted e-bikes were also disproportionately represented in charging-related fires with 49% of incidents occurring during charging, compared to 35% for non-converted e-bikes.

2.4 Global e-mobility device injuries and fatalities

Due to the lack of national level reporting, the number and types of injuries from e-mobility device thermal runaway incidents in Australia is not available. Australian fatalities are tracked where available by EV FireSafe.

Injuries from e-mobility device thermal runaway incidents

When discussing injuries, it is important to note that the long-term effects of exposure to the main consequences of thermal runaway (e.g. toxic off-gassing, flame, projectiles and explosion) are currently unknown. However, a growing body of anecdotal evidence suggests:

– Exposure to off gases can occur even when not standing in the visible gas cloud.
– Inhalation injuries from toxic gases may differ and not be immediately recognised or distinguished from smoke inhalation.
– Inhalation and burn injuries do not always respond to traditional medical care methods.
– Inhalation injuries may (rarely) occur following an incident where a person is directly exposed to the toxic pollutants left on clothing or other surfaces.

It should also be noted that global research on the impact to human health of thermal runaway exposure is in its infancy, and very few testing programs consider this risk.

A ‘Green Sheet’ from the Sacramento Fire Department, USA, outlined the inhalation injuries sustained by five firefighters exposed to a secondary ignition event from a burning electric car in April 2025 (Sacramento Fire, 2025). Five crew members were exposed to toxic off gases for between one and five minutes. Their injuries included reduced lung function, sinus infection, elevated heart rate and tachycardia, mouth blisters turned into lesions, renal problems, and high concentrations of sulphur, phosphorus and lithium in blood tests.

Only one of those firefighters is back to full duties, with four still off work and suffering ongoing health impacts six months later, as of 28 September 2025.

While that recorded incident involved an electric car, with a far larger battery pack than an e-mobility device, there is a serious risk to human health from both the off-gassing of a battery pack inside a train carriage, and potentially from post-incident exposure to remnant pollutants on surfaces and furnishings within the carriage.

Fatalities from e-mobility device thermal runaway incidents

Where it can be verified during fire investigation that an e-mobility device was responsible for a thermal runaway event that led to a fatality, EV FireSafe has distinguished two categories:

– Fatality from inhalation of toxic off-gases
– Fatality from fire

Globally and outside Australia, there have been at least seven deaths attributed to inhalation, across two incidents:

– On 23 June 2022, in Buenos Aires, Argentina: A family of five were killed by inhalation of gases while sleeping, when an e-skateboard went into thermal runaway in the room they shared (MercoPress, 2022).
– On 19 July 2024: A young couple were killed by inhalation of ‘fumes’ from an e-bike, in Blackpool, England. Their children were away for the night (Burnell, 2024).

Numerous deaths have been directly attributed to e-mobility device fires and/or explosions globally, including many victims caught in building fires due to devices that did not belong to them. In one such example, a battery

pack left charging overnight in an e-bike hire and repair shop in New York City's Chinatown district in June 2023 caused the deaths of four residents living above the shop, two of whom were elderly and unable to escape easily (Chan, 2023).

2.5 Australian e-mobility device incidents (non-rail)

Thermal runaway events involving battery packs of e-mobility devices are now one of the fastest-growing sources of household fires in Australia. While national data on e-mobility device battery fires is not collected, some fire agencies release reported figures following parliamentary or media enquiries, on an annual basis or as part of public awareness campaigns.

Australian LiB fire data

Data collected by Fire + Rescue New South Wales (FRNSW) shows a significant year-on-year increase from 2022, which mirrors that seen in other major global cities, such as London, New York City and Paris. FRNSW data on LiB-related fires show there were (Fire and Rescue New South Wales, 2024b):

– 171 LiB fires in 2022, 23 of which involved e-mobility devices
– 285 LiB fires in 2023, 67 of which involved e-mobility devices
– 324 LiB fires in 2024, with the number related to e-mobility devices not specified

Data from the Western Australian Department of Fire and Emergency Services (DFES) data shows a similar increasing trend. There were 110 LiB incidents recorded for the full year in 2023, and at least 70 thermal runaway events had been attended by DFES firefighters over 5 months in 2024 (1st January to 7th June), 20 of them involving e-mobility devices (Government of Western Australia, 2024).

In Queensland, where e-mobility devices are street-legal, the number of fatalities due to e-mobility device thermal runaway incidents is the highest in Australia. The Queensland Fire Department (QFD) submission to a parliamentary enquiry outlined 124 'known incidents' involving e-mobility devices between 1 July 2023 and 30 April 2025 (20 months). Of these, 72 were e-scooters, 30 were e-bikes and the remainder were unspecified (Queensland Fire Department, 2025).

In Victoria, agencies Fire Rescue Victoria and the Country Fire Authority released a public safety warning in August 2023, stating both agencies "…are responding to at least one significant lithium-ion battery related fire each week," highlighting concerns around the use, charging, storage and disposal of e-mobility devices and their battery packs (Fire Rescue Victoria, 2023).

Fatalities in Australia from e-mobility device thermal runaway

Tragically, there have been ten verified fatalities in Australia since 2022 due to e-mobility devices going into thermal runaway, all of which have occurred in private homes (EV FireSafe database, 2025). These are:

– Emerald, Queensland, 7 November 2025: A 5-month-old boy, 1-year-old girl, a teenage girl and a 36-year-old man were killed when an e-scooter went into thermal runaway in their home before 7 am in the morning (Queensland Police Service, 2025).
– Guildford, NSW, 17 February 2025: A 21-year-old male student, working as a food delivery driver, was trapped and killed when an e-bike battery went into thermal runaway in his bedroom while he was asleep (ABC, 2025).
– Unknown location, Queensland, 2024: A man was killed in an e-scooter fire (further details unknown).
– Teralba, NSW, 29 February 2024: Two women sleeping in a double storey home were killed when an e-bike was being repaired or modified on the ground floor of the home and caused a fire (Fire and Rescue New South Wales, 2024a).
– Brisbane, Queensland, 22 March 2022: A 22-year-old male was killed, and his heavily pregnant partner was seriously injured, when a second-hand e-scooter was overcharged with a non-genuine cable, leading to thermal runaway; the build-up of a vapour cloud caused an explosion leading to the top of the caravan to be blown apart.
– in Brisbane, Queensland on 24th November 2025: an e-scooter caused a fire that killed a 13-year-old girl.

3. E-mobility devices on rail

3.1 Summary of management approaches

Established rail safety systems include fire and smoke control measures such as misting and deluge systems in carriages and tunnels as required, tunnel ventilation, cross-passages for access and evacuation and established emergency procedures. These are covered by specific standards and requirements which vary by jurisdiction and would assist in the management of an incident involving a LiB in thermal runaway.

There are four types of approach which have been identified to specifically address risks associated with e-mobility devices in the rail environment. These are defined in Table 3-1 as:

– Prohibition (both full and partial)
– Storage controls
– Certification requirements and
– Time of day/year controls.

These measures can apply to all types of e-mobility device, or more commonly the approach is tailored for different types of device (e.g. between e-bikes and e-scooters). All jurisdictions included in this report have adopted at least one type of measure for the management of e-mobility device on the rail network. The term restriction is used in reference to various forms of control in this report.

Table 3-1: Details of different approaches to management of e-mobility devices on rail networks globally

Approach		Definition	Sub-approaches and example(s)
	**Prohibition (Full)**	– Ban on transporting all or certain types of e-mobility devices on rail network – Some prohibitions also include batteries when transported separately – Scale of prohibition may vary – **Total prohibition covers** whole device types (e.g. e-scooters) – **Partial prohibition** on specific sub-categories of a device (e.g. based on battery capacity or modifications)	– Prohibition of all e-mobility devices over 100 W (e.g. China Railways) – Prohibition of modified e-bikes only (e.g. Sydney Trains)
	**Prohibition (partial)**		
	**Storage controls**	– Rules and regulations for how e-mobility devices are stored during transport	– Removal of batteries for transport (e.g. China Railways) – Folding smaller devices for transport as luggage (e.g. Singapore) – Mandatory use of designated bicycle storage facilities
	**Certification requirements**	– Requirements for safety certification for any device being transported on rail – Linked to certification approaches in place at a national level	– Linked to prohibition of modified devices
	**Time of day/year controls**	– Restriction on times of day or times of the year at which e-mobility devices can use the rail network	– e-bikes only permitted at off-peak times (e.g. the Netherlands) – e-mobility devices prohibited in winter months (Nov to April) in Toronto – Often related to space constraints rather than safety matters, as same measure may apply to pedal bikes

It should be noted that some jurisdictions support e-bikes on their rail services. For example, Trenitalia in Italy has e-bike charging points available in their bicycle storage areas (Trenitalia, n.d.). These approaches were not reviewed in detail in this report.

3.2 Australian incidents in the rail environment

There have been three reported thermal runaway events involving e-mobility devices on Australian rail networks. These are set out in Table 3-2.

Table 3-2: Australian e-mobility device incidents in the rail environment

Incident location	Date	Incident Description
Union Station, Melbourne, Victoria	March 2025	An e-bike went into thermal runaway onboard a train, mid-section, filling the carriage with gases, fire and smoke leading to an evacuation at the next stop – Union Station. Metro Trains Victoria (MTV) network.
Blacktown Station, Sydney, NSW	April 2025	A reportedly converted e-bike went into thermal runaway inside a station lift. No official report is available. Sydney Trains network (part of TfNSW).
Liverpool Station, Sydney, NSW	August 2025	A converted e-bike went into thermal runaway at the station. No official report is available. Sydney Trains network (part of TfNSW).

These incidents prompted the introduction of restrictions on e-mobility devices in both NSW and Vic (see Section 3.3.1).

With the increasing number of thermal runaway incidents involving e-mobility devices across Australia, and the increasing uptake of these devices outlined earlier in this report, there is a real risk of future incidents on the Australian rail network.

Case studies of four incidents related to the jurisdictions selected for the project are included in detail in Chapter 4. These are in Toronto (Canada), New York City (United States of America), London (Great Britain) and Madrid (Spain). This includes details of associated injuries.

3.3 Current approach to e-mobility devices on rail in Australia

Although not the focus on this study, a brief commentary on the current approach to e-mobility devices on rail in Australia is provided as context. This is summarised in Table 3-3, and some further commentary is provided below the table.

Table 3-3: Current approach for e-mobility devices on rail across Australia (selected operators)

	E-bike approach	Details	E-scooter approach	Details	Notes
Sydney (Sydney Trains, Sydney Metro and NSW TrainLink) (Transport for NSW, 2025)	Prohibition (partial)	Converted e-bikes and their batteries prohibited. Converted e-bike batteries are prohibited whether they are attached to the bike or separate.	No measures (but not required as personally owned scooters not allowed on roads)	N/A	e-bike restriction began November 2025. Only hire scheme e-scooters allowed in NSW currently.
Victoria (Metro and V/Line) (Victoria State Government, 2025)	Prohibition (partial)	Converted e-bikes prohibited. Standard e-bikes to be switched off and not charged onboard or in stations (Transport Victoria , 2025).	Various controls apply.	Must be switched off and cannot be ridden, or charged onboard, on platforms or in station precinct.	Introduced in December 2025.
Queensland (Queensland Rail)	Storage in first and last carriages only.	Current capacity limits and restrictions to first and last carriage (Queensland Rail, 2025).	No measures currently in place. Under consultation.	Parliamentary Inquiry underway (Queensland Government, 2025).	
South Australia (Adelaide Metro) (Adelaide Metro, 2025)	Prohibition (partial)	Modified e-bikes prohibited.	Prohibited	All other e-mobility devices (e.g. e-skateboards) prohibited on Adelaide Metro in the short term.	Approach under review by DIT (Government of South Australia, 2025).
Australian Capital Territory (Canberra Light Rail)	Storage controls (for all bicycles)	Storage racks provided on light rail, enter via middle carriages.	Space and weight restrictions apply (Canberra Metro Operations, 2025)	e-scooters must be under 25kg and under 1250mm long, 700mm wide and 1350mm high.	Shared e-scooters not allowed.
Western Australia (TransPerth) (Transperth, 2025)	Time-limited (for all bicycles)	All bicycles restricted at peak times in peak direction.	Allowed at all times, space permitting	Can be restricted by staff at peak times due to crowding.	E-bike approach is space related, not safety related.
Northern Territory	N/A - No dedicated passenger rail network except long distance services.				Private e-bikes and e-scooters are only allowed to be ridden on private property (Northern Territory Government, 2025). Shared e-bikes and e-scooters available in Darwin (City of Darwin, 2025).
Tasmania	N/A - No dedicated passenger rail network.				Regulation review for e-bikes completed in 2024 (Tasmanian Government, 2025)

Key: = Item fully prohibited. = Item partially prohibited. = Control in place for storage, certification or timing. = No restriction = Not applicable.

3.3.1 NSW rail network

Converted e-bikes are pedal bikes which have been converted to an e-bike by adding a motor and battery. Converted e-bikes and their batteries were banned from travel on Sydney Trains, Sydney Metro and NSW TrainLink from 1 November 2025. This applies to the LiBs in the converted e-bikes, whether attached to the bike or carried separately (Transport NSW, 2025).

The ban only applies to train carriages and platforms. Converted e-bikes are still allowed through station concourses and in bicycle storage areas at stations.

The ban followed a consultation process and was in response to safety concerns with these devices. TfNSW notes they are more likely to catch fire due to “DIY setups, poor wiring and low quality or second-hand parts”.

The ban is being enforced by a “hotspot blitz” with fines ranging from $400 to $1,100, which is aligned to the fine for bringing petrol powered devices on trains.

3.3.2 Victorian rail network

After a public consultation in July and August 2025, the Victorian Department of Transport and Planning updated regulations regarding converted e-bikes on public transport from late 2025 (Victoria State Government, 2025).

Converted e-bikes are banned on metropolitan and V/Line trains and within ticketed areas. E-bikes, e-scooters and other rideable e-devices must be switched off and cannot be ridden or charged on board, on platforms or in station precincts. The penalty for breaching the rules is over $500 for adults and over $100 for children.

These measures were taken in response to public feedback, which highlighted that Victorians wanted a targeted approach focusing on the highest risk devices (Victoria State Government, 2025).

The Victorian regulations only cover the converted e-bikes. This is different to the NSW regulations which also cover the battery packs from converted e-bikes when transported separately.

3.3.3 South Australian rail network

Adelaide Metro explicitly prohibits *modified* e-bikes (Adelaide Metro, 2025), but does not specifically define these itself. Under SA law, e-bikes are illegally modified if they have certain characteristics (e.g. motor assistance does not cut off at 25 km/h) and become unregistered motor vehicles (Government of South Australia, 2025).

In the short term, other forms of e-mobility device are prohibited from Adelaide Metro trains, trams and buses. This is in response to safety issues with these devices in other Australian states (see Section 3.2). This approach is under review.

4. International review

4.1 Overview

4.1.1 National level certification of e-mobility

Before considering the approach to e-mobility devices on rail, it is important to consider the context of national regulation for these devices, specifically if there are certification requirements. Some jurisdictions have national certification approaches in place for e-bikes, e-scooters and other e-mobility devices. These certifications include robust safety standards and testing requirements to help reduce incidents. The requirements by country are summarised in Table 4-1, along with a high level commentary on the approach in the rail environment, which is detailed further in Section 4.1.2.

Table 4-1: Summary of national and rail-specific e-bike and e-scooter certification requirements in subject jurisdictions

Country	National e-bike certification	e-bike approach on rail	National e-scooter certification	e-scooter approach on rail
Australia	In progress. Broadly **EN15194.** New Bill currently being considered in Parliament.	Multiple restrictions in place.	No. No national certification for e-scooter manufacture and sale. State based approach only developed in NSW to date.	Multiple restrictions in place.
Canada	No. No national certification. Each province has their own regulations.	Seasonal prohibition (Toronto)	No. No national certification. Each province has their own regulations.	Seasonal prohibition (Toronto)
USA	No. No national certification. Each state has their own laws and regulations.	Restrictions (New York City)	No. No national certification. Each state has their own laws and regulations. New York is the strongest, requiring **UL2849** for e-bikes and **UL2272** for e-scooters and other e-mobility devices since 2023.	Restrictions (New York City)
United Kingdom	Yes. Must comply with the **Electrically Assisted Pedal Cycle Regulations (EAPC 2015).** Minimum age 14. Implemented 6 April 2015 (UK Government, 2024)	Restrictions (London)	No. No national certification. New bill being considered in Parliament. Illegal to use a privately owned e-scooters in public across the UK (Police UK, 2025).	Prohibited (London)
Netherlands	Yes. **EN15194**. E-bikes are classified under the same regulation as pedal bikes, supported by country specific legislation. Speed pedelecs are regulated under the same guidelines as mopeds, which are considered road motor vehicles and not allowed on rail.	Space restrictions only	Yes. **Dutch Framework for Light Electric Vehicles (LEVs).** Mandatory approval needed by the Netherlands Vehicle Authority (RDW) (Ministry of Infrastructure and Water Management, 2022). Implemented 1 July 2025.	Not restricted
Germany		Not restricted (Hamburg)	Yes. **Small Electric Vehicles Ordinance (eKFV).** Mandatory type-approval and registration. Implemented 15 June 2019 (Federal Motor Transport Authority, 2025).	Prohibited (Hamburg)
Spain		Not restricted (Madrid)	Yes. Regulations as per General Directorate of Traffic (DGT). All e-scooters must be certified. Minimum age 16. Implemented 22 January 2024 (Ensor, 2023).	Prohibited (Madrid)
China	Yes. Regulations are under **"GB17761 - Safety Technical Specification for Electric Bicycle".** Mandatory product certification and registration of all e-bikes. Implemented on 1 September 2025, based on EN15194 (The People's Republic of China, 2025).	Prohibited (over 160 Wh) and approval needed (100Wh to 160 Wh)	Yes. Various 'GB' standards cover regulation of e-scooters as consumer products including national safety standard for LiBs. Road traffic regulations set at local government level.	Prohibited (over 160 Wh) and approval needed (100Wh to 160 Wh)
Singapore	Yes. **EN15194.** Must be type-approved, sealed and registered by the LTA. Minimum age 16 (Land Transport Authority, 2025b).	Folding and certified only.	Yes. **UL2272**. Mandatory registration and online theory test. Minimum age 16 (Singapore Legal Advice, 2024).	Folding and certified only.

Key: = No regulation in place. = Regulation forthcoming. = Regulation in place.

4.1.2 Controls for e-mobility on rail globally

A summary of the international review is shown in Table 4-2, including the range of approaches adopted in each subject jurisdiction, including controls including prohibition, storage controls, certification and time of day. A summary of the controls by device type, including batteries alone is given in Table 4-3. The colour coding key is used throughout this document.

Table 4-2: Summary of international approaches to e-mobility devices on metro/heavy rail

Jurisdiction	Regulator	Operator included in report	E-bike approach				E-scooter approach				Other devices	Notes
			Prohibition	Storage controls	Certification	Time of day	Prohibition	Storage controls	Certification	Time of day		
Toronto, Canada	Transport Canada	Toronto Transit Commission*	Prohibited seasonally – Nov to April	No requirement	No requirement	Restricted at peak times – April to November	Prohibited seasonally - Nov to April	Yes - must be carried	No requirement	No requirement	Prohibited seasonally	Electric wheelchairs and other mobility devices for people living with disability are exempt.
New York City, United States of America	Federal Railroad Administration (FRA)	Metropolitan Transportation Authority (MTA)*	Not prohibited	Yes	Yes - Certification to UL2849 required	Restricted at peak times	Not prohibited	Yes	Yes - Certification to UL2272 required	Restricted at peak times	Prohibited	Certification to UL2849/UL2272 required. Other devices such as hoverboards not permitted.
London, Great Britain	Office of Rail and Road (ORR)	Transport for London (TfL)*	Non-folding e-bikes prohibited	No requirement	Yes – national approach is EAPC 2015	No requirement	Prohibited	N/A	N/A	No requirement	E-unicycles prohibited	Ban on e-scooters introduced in December 2021 following incident on London Underground in November 2021. Non-folding e-bikes added March 2025.
Netherlands	Transport Inspectorate (ILT)	Nederlandse Spoorwegen (NS)*	Not prohibited**	Yes	Yes – national approach is EN15194.	Restricted at peak times	Not prohibited	Yes	No requirement	No requirement	No requirement	E-bikes restricted to off-peak times and bicycle storage areas. E-scooters allowed any time, when folded as luggage. Other e-mobility devices permitted as hand luggage but must be within size limits.
Hamburg, Germany	Federal Railway Authority (EBA)	Hamburger Hochbahn*	Not prohibited**	Yes	Yes – national approach is EN15194.	Restricted at peak times	Prohibited	N/A	N/A	No requirement	No requirement	Hamburger Hochbahn has banned e-scooters on its network (as of 24 August 2023) due to recommendations from an assessment into the risks posed to passengers from smoke inhalation in constricted area (tunnels and underground networks).
Madrid, Spain	Agencia Estatal de Seguridad Ferroviaria (AESF)	Metro de Madrid S. A.	Not prohibited**	No requirement	Yes – national approach is EN15194.	No requirement	Prohibited	N/A	N/A	No requirement	E-unicycles prohibited	The Consorcio Regional de Transportes de Madrid (CRTM) is a planning and coordinating authority for the Madrid area. CRTM ratified the ban on e-scooters and e-unicycles, as opposed to the operator or regulator.
China	National Railway Administration (NRA)	China Railway*	Prohibited (over 160 Wh) Approval needed for devices 100 Wh to 160 Wh	Yes - Controls in place	Yes - National standard GB 17761-2024	No requirement	Prohibited (over 160 Wh) Approval needed for devices 100 Wh to 160 Wh	Controls in place	Yes - National standard GB 17761-2024	No requirement	Prohibited (over 160 Wh)	E-mobility devices restricted for 100-160Wh and prohibited over 160Wh,which covers the majority of devices. Batteries must be detached and individually protected for storage. High level of screening at stations for national heavy rail.
Singapore	Land Transport Authority (LTA)*	SMRT (Singapore Mass Rapid Transit)	Prohibited if non-folding and over a certain physical size	Yes - Controls in place (must be folded)	Yes - Certification to EN15194 and LTA registration required	No requirement	Prohibited is non-folding and over a certain physical size	Yes - must be folded	Yes - Certification to UL2272 and LTA registration required	No requirement	Must be certified to UL2272 device safety standard	E-mobility devices must be under 120cm by 70cm by 40cm and folded. All devices must be sealed, registered and type-approved by the LTA.

Notes: * = Organisation implementing restrictions, ** = Speed pedelecs are classified as mopeds (road motor vehicles) and are therefore prohibited.

Key: = Item fully prohibited. = Item partially prohibited. = Control in place for storage, certification or timing. = No restriction = Not applicable.

Table 4-3: Overview of international approach to e-mobility device type and LiBs on metro/heavy rail

Jurisdiction	Regulator	Operator included in report	National Certification in place?		Battery only	E-bikes (micro-mobility)			E-scooter	Other e-mobility devices	Speed pedelec
			e-bike	e-scooter		Converted e-bike	E-bike (unconverted)	Folding e-bike			
Toronto, Canada	Transport Canada	Toronto Transit Commission*	✖	✖	✖	✖	✖	Not specified	✖	✖	Not specified
New York City, United States of America	Federal Railroad Administration (FRA)	Metropolitan Transportation Authority (MTA)*	✓ (State based)	✓ (State based)	✓	✖✖	T ◆	◆	T ◆	✖	Not specified
London, Great Britain	Office of Rail and Road (ORR)	Transport for London (TfL)*	✓	✖	Not specified	✖✖	✖✖	✓	✖✖	✖	Not specified
Netherlands	Transport Inspectorate (ILT)	Nederlandse Spoorwegen (NS)*	✓	✓	Not specified	T ◆	T ◆	✓	◆	Not specified	✖✖
Hamburg, Germany	Federal Railway Authority (EBA)	Hamburger Hochbahn*	✓	✓	Not specified	T ◆	T ◆	Not specified	✖✖	✓	✖✖
Madrid, Spain	Agencia Estatal de Seguridad Ferroviaria (AESF)	Metro de Madrid S. A.	✓	✓	Not specified	✓	✓	✓	✖✖	✖	✖✖
China	National Railway Administration (NRA)	China Railway*	✓	✓	◆ ■	✖	✖	Not specified	✖	✖	Not specified
Singapore	Land Transport Authority (LTA)*	SMRT (Singapore Mass Rapid Transit)	✓	✓	Not specified	✖	✖	◆	✖	✖	Not specified

Notes: * = Organisation implementing restrictions

Key: ✓ = Certification scheme in place ✖ = No certification scheme in place, ✖✖ = Total prohibition ✖ = Partial prohibition ✓ = No restriction T = Time-based control ◆ = Storage/size control ■ = Capacity-based control

= Not specified.

4.2 Toronto Transit Commission, Toronto, Canada

4.2.1 Rail context

In Canada, the rail regulatory framework has two primary bodies: the Canadian Transport Authority (CTA) and Transport Canada. The CTA regulates economic aspects of the rail industry (Government of Canada, 2025) and Transport Canada is the regulator responsible for safety, certification, and incident reporting and investigations (Government of Canada, 2020).

Toronto Transit Commission (TTC) is the transport authority responsible for the operation of public transport services in Toronto and the surrounding municipalities (City of Toronto, 2025). This includes subways and light rail covering hundreds of kilometres and carrying millions of passengers per day.

4.2.2 Case study: E-bike fire on Toronto Subway, Canada (Sheppard-Yonge Station)

Table 4-4: Incident overview - e-bike fire on Toronto Subway, Canada (Sheppard-Yonge Station), December 2023

Item	Details
Date and time	Sunday 31 December 2023. Afternoon, around 3:00 p.m.
Location	First car of a Toronto Transit Commission (TTC) subway train arriving at Sheppard-Yonge Station, North York, Toronto, Ontario, Canada.
Device(s) involved	Reported as a LiB powered e-bike.
Incident type	An e-bike LiB pack failure and thermal runaway aboard subway train.
Duration	The train carriage was evacuated at the station; service was reportedly resumed between Sheppard-Yonge and Bayview shortly after. The specific timeline of fire duration has not been made public.
Operator	Toronto Transit Commission (TTC)
Attendance and response	TTC transit staff and the Fire Department of Toronto (FDT) responded and evacuated passengers.
Injuries	At least one rider, the owner of the e-bike, was taken to hospital with second-degree burns to their hands. A second patient was also treated for non-life-threatening injuries, believed to be the train operator who suffered from smoke inhalation.

Incident description

According to published reports, a passenger's e-bike 'lit up' inside the first carriage of a TTC subway train. A witness described hearing a flare-like noise followed by 'smoke', then flames (Westoll & Mackey, 2024). The train stopped at Sheppard-Yonge Station, the carriage was evacuated and responders moved in. The fire chief indicated the failure was consistent with a previously damaged LiB pack.

The fire was described as 'significant and aggressive' by Toronto's Fire Chief. The train was removed from service, investigations followed, and the incident became a high-profile example of an e-mobility battery fire risk in public transit environments. Images of the incident are shown in Figure 4-1.

Rail operator actions

The TTC evacuated the train carriage at Sheppard-Yonge Station and removed the vehicle from service. According to media coverage, normal service resumed between Sheppard-Yonge and Bayview shortly afterward. The incident triggered internal reviews of e-bike and e-scooter carriage policy, storage and charging behaviour, and emergency preparedness for battery fire incidents.

Images

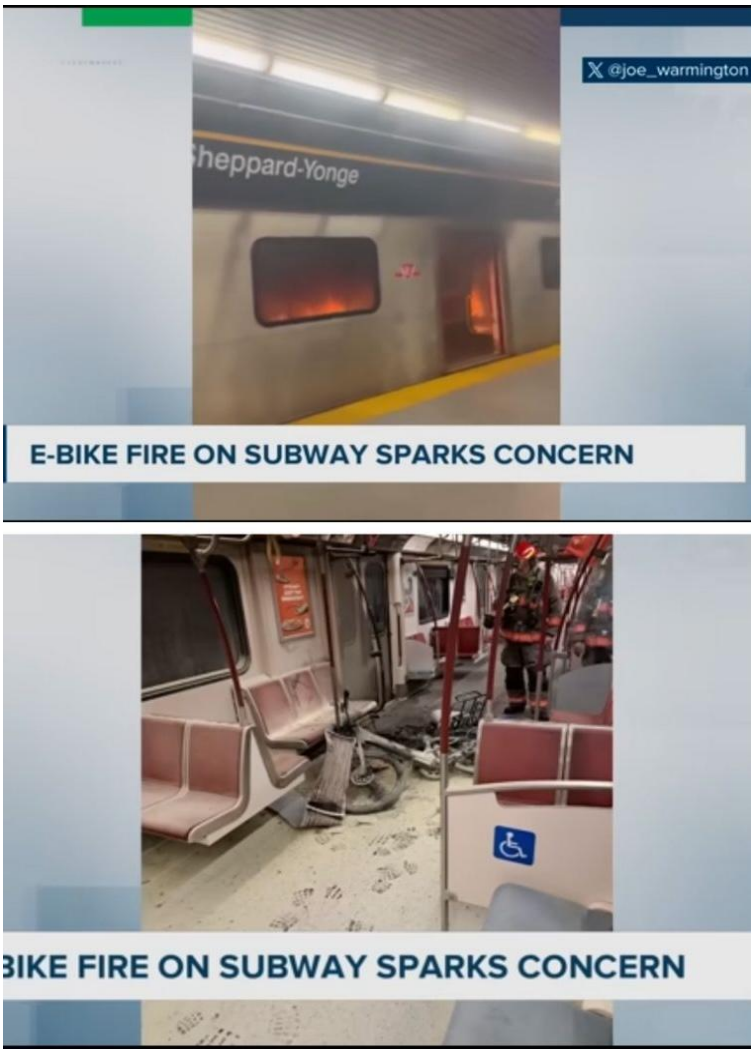


Figure 4-1: Images from e-bike fire on Toronto Subway, December 2023 (CityNews, 2024)

Incident implications

The incident raised significant concern among safety and transit agencies. Commentators and fire professionals cited the event as evidence for stronger regulation of LiB devices aboard public transit, and more robust incident data and testing for battery fires in enclosed rail environments. The city's fire services also confirmed they are reviewing tactics for LiB fires (CBC News, 2024).

This incident highlights how a LiB on an e-mobility device within a transit vehicle created a significant fire incident. It demonstrates that even small battery-powered vehicles can trigger hazardous events in tightly enclosed transit systems.

4.2.3 Summary of approach to e-mobility devices on rail

Saltwater ingress into batteries is a known risk factor for thermal runaway, which may be worse in wintertime due to gritting of roads. Following the incident outlined in the case study, the TTC introduced a winter-only prohibition on the carriage of 'battery powered micromobility devices' on trains and inside stations in November 2024. The winter only ban was implemented due to an increase in fires during colder weather (Toronto Transit Commission, 2025), though the data for this has not been publicly released. Further details of the approach taken by TTC are provided in Table 4-5.

Table 4-5: Summary of approach to e-mobility devices on rail from Toronto Transit Commission, Toronto, Canada

Rail environment				
Rail regulator	Transport Canada			
Regulatory approach and relevant legislation	**Co-regulatory** The safety functions of Transport Canada are defined in the following legislation (Government of Canada, 2019): – Railway Safety Act – The Safe and Accountable Rail Act			
Rail operator selected for case study	Toronto Transit Commission (TTC)			
Network summary (*approximate values)*	– Subway: 4 lines, 77 km, 55 km of tunnels, 75 stations, 1.1 million passengers per day (Metro Line Hub, 2025). – Streetcar (light rail): 11 lines, 83 km, 1.1 km of tunnels, 685 stops, 248,300 passengers per day (American Public Transportation Association, 2025). – Total: 15 lines, 160 km, 56 km of tunnels, 760 stations/stops, 1.3 million passengers per day			
Restrictions on rail				
Restriction type	**Prohibition**	**Storage**	**Certification needed?**	**Timing restrictions**
E-bikes	Yes – prohibited during winter (November 15 – April 15)	No	No – no national or State-based approach in place	Yes – no bicycles permitted during peak times in the summer period (6 – 9am and 4 – 6pm weekdays).
E-scooters		Yes – must be carried by passengers on trains and in stations		
Other e-mobility devices		No		
Details of restrictions				
Restriction implemented by	Operator	The seasonal ban is not legislated. It is TTC policy enforced under TTC's own rules and municipal by-laws.		
Date introduced	November 2024	The seasonal ban was introduced in November 2024 in response to the incident outlined in the case study, as well as several other incidents in Toronto, and complaints received about battery safety and bulky e-mobility devices posing tripping hazards (Toronto Transit Commission, 2024).		
Capacity related?	No	No specific differences for devices of different capacities.		
Modification related?	No	No specific difference for modified devices.		
Enforcement approach	Enforcement is through signage and announcements, and TTC staff, who will educate non-complying patrons on the ban and direct them to leave the network. Refusal to comply could result in a fine or possible arrest, in accordance with TTC By-Law No.1 Sec 3:13(a) Failure to comply with posted sign or the Trespass to Property Act (Toronto Transit Commission, 2025).			
Further details	– There is no national level certification approach to e-bikes or e-scooters in place in Canada, or any State-based approach for Ontario. – The ban includes the batteries themselves, whether installed or carried separately, due to the risk of LiB fires in enclosed spaces (Toronto Transit Commission, 2025). – Storage is available near subway station entrances or in dedicated storage rooms. – Time of day restriction, which mean e-bikes are only allowed off-peak, applies to all bicycles. This suggests this is space-related, not related to LiB thermal runaway risk. – Electric wheelchairs and other mobility devices for people living with disability are exempt.			
Commentary on restrictions				
Commentary	The prohibition is limited – seasonal and contingent upon consistent enforcement and compliance to established regulations (e.g. not carrying batteries removed from e-mobility devices). Risk mitigation is limited from April to November, and evidence relating to incidents in summer vs winter was not available to review during this study. Nonetheless, the implementation of multiple rules and regulations addresses the risk associated with fires at times they apply.			

Source: (Toronto Transit Commission, 2025)

4.2.4 Other Canadian rail operators' approaches

GO Transit, in Toronto, allows e-bikes unless it is a peak traffic window on a weekday, these are between the hours of 6:30-9:30am and 3:30-6:30pm (GO Transit, 2024). E-bikes must be kept in designated bicycle zones on each train. A maximum amount of two bicycles is allowed in each designated zone. E-scooters are prohibited on all GO Transit trains (GO Transit, 2023).

Further, Metrolinx has introduced eight new, refurbished bicycle-specific carriages to GO Transit trains in and out of Toronto in response to the number of e-bikes on its network. These carriages are equipped with fire retardant to slow or stop the spread of flames at a cost of around $900,000 (Callan & D'Mello, 2024).

4.2.5 Policy response challenges

While e-mobility devices are easy to recognise, there is significant anecdotal evidence to suggest some transit passengers in Toronto are storing their e-bikes or e-scooters in the provided areas but removing the battery pack and carrying it to their destination within a bag or satchel. This is against the regulations which specifically cover battery packs but is very difficult for authorities to identify and therefore enforce. This non-compliant behaviour will compromise the effectiveness of this measure.

4.3 Metropolitan Transit Authority, New York City, USA

4.3.1 Rail context

In the United States of America, the Federal Railroad Administration (FRA) is the national rail regulator, created by the Department of Transportation Act 1966. The FRA aims to enable the safe, reliable and efficient movement of people and goods in the United State of America (U.S. Department of Transportation, 2024). Carriage rules are set by operators and vary by state. Transit services, including the MTA are regulated by the Federal Transit Administration (FTA). This includes subways, light rail and commuter rail.

The Metropolitan Transportation Authority (MTA) is the transport authority responsible for the operation of the public transport system in the area surrounding New York City, Long Island, southeastern New York State and Connecticut (Metropolitan Transportation Authority, 2025a). This includes the New York City Subway, the Long-Island Rail Road and the Metro-North Railroad. MTA runs services on many lines covering thousands of kilometres, carrying millions of passengers every day.

4.3.2 Case study: E-scooter thermal runaway fire, NYC subway car

Table 4-6: Incident overview – NYC thermal runaway fire aboard subway car, February 2025

Item	Details
Date and time	Saturday 8 February 2025.
Location	An in-service New York City Transit subway carriage.
Device(s) involved	Public and specialist sources describe the device as an e-scooter; however, images and videos are not clear.
Incident type	An e-scooter battery pack failure and 'slow' thermal runaway on a train carriage
Duration	Public video and reporting indicate the visible event was short. Smoke and small flames were observed during the ride and extinguished by firefighters at the next stop. However, the exact incident duration from ignition to full extinguishment is not published.
Operator	Metropolitan Transportation Authority (MTA)
Attendance and response	New York City subway staff, New York Fire Department (FDNY)
Injuries	Unknown. E-scooter owner and other passengers left the scene prior to FDNY attendance.

Incident description

While this was the first publicly reported e-mobility device battery fire on the New York City subway network, the risk of such an incident had been discussed in specialist commentary for some time.

This was primarily in relation to the high incident rate in New York City itself, and the associated high injury and fatality rates of e-mobility device thermal runaway events across New York City. This included a fire in an e-bike repair and rental shop on June 21st, 2023, where gases, smoke and fire spread to an apartment building above the shop, killing four people.

In the case study incident, passengers were essentially trapped as the train travelled between stations, with the e-scooter exhibiting a relatively contained and 'lazy' fire when compared with the jet-like flame and often violent behaviour typically exhibited. While not confirmed, this points to the battery pack being at a low state of charge, meaning it had less energy to expend.

Video footage shows passengers sitting in the near vicinity of the e-scooter, being enveloped in smoke and potential off-gases, which present a short- and longer-term risk to health. Some passengers can be seen walking back and forth to the e-scooter, others opening windows, while some are filming, laughing and discussing the fire, apparently aware of the fire risk, but unable to escape.

The carriage continued to the next stop where subway staff evacuated the train and FDNY responded to extinguish the fire. By the time fire marshals arrived, the owner was not present, and some reports say the e-scooter had also been removed from the train.

Rail operator actions

Passengers, subway staff and the FDNY attended and extinguished the fire. Some reports say the e-scooter had been removed prior to FDNY arrival. No publicly-confirmed injuries from this specific subway car event have been reported.

Images

Figure 4-2: Images from e-mobility device fire on New York City subway, February 2025 (Fire Engineering, 2025)

Incident implications

In April 2023, the MTA adopted a policy placing controls on e-bikes and e-scooters on transit and prohibited charging on trains and buses. However, this incident was used by specialists and commentators as evidence of continued concern among first responders and safety professionals.

Reports indicate MTA and FDNY have had ongoing dialogue about the risks of e-mobility devices on transit and had planned to collaborate on a testing program. This plan was to put three e-mobility device battery fires into a train carriage, creating thermal runaway and to use this for training. However, the test was cancelled.

FDNY has continued running strong and successful public information campaigns warning against indoor charging and storage of e-mobility devices. This is not specific to the rail network and despite a significant increase in incidents, this education campaign has supported a drop in fatalities in the city.

Despite this incident intensifying calls for stricter controls on e-mobility devices on public transport and better regulation of batteries used in the city, there have been no policy changes directly attributable to this incident.

4.3.3 Summary of approach to e-mobility devices on rail

MTA has adopted restrictions on the type of e-mobility device allowed on its rail network, and the times at which they are permitted. A summary of the approach is given in Table 4-7.

Table 4-7: Summary of approach to e-mobility device on rail from Metropolitan Transportation Authority, USA

Rail environment				
Rail regulator	Federal Transit Administration (FTA)			
Regulatory approach and relevant legislation	**Prescriptive** The safety functions of the FTA are defined in the following legislation (SAM.gov, 2025): – Department of Transportation Act 1966 – Rail Safety Act 1970			
Rail operator selected for case study	Metropolitan Transportation Authority (MTA)			
Network summary (*approximate values*)	– New York City subway: 36 lines, 1070 km, 233 km of tunnels, 472 stations/stops, 3.2 million passengers per day Long-Island Rail Road: 11 lines, 193 km, 10 km of tunnels, 126 stations/stops, 285,000 passengers per day – Metro-North Rail Road: 3 lines, 620 km, 2 km of tunnels, 124 stations/stops, 186,000 passengers per day – Total: 50 lines, 1,883 km, 245 km of tunnels, 722 stations/stops, 3.7 million passengers per day			
Restrictions on rail				
Restriction type	**Prohibition**	**Storage**	**Certification needed?**	**Timing restrictions**
E-bikes	No	Yes - Long-Island Rail Road (weekdays max. 2 in first and 2 in last carriage, weekends max. 1 per carriage), Metro-North (weekdays max. 2 per carriage, weekends - max 2 per carriage)	Yes – State based, UL2849 for e-bikes and UL2272 for other e-mobility devices required since 2023.	Yes - peak hour restrictions for all e-mobility devices and pedal bikes (space related). Applies to railroad Long-Island Rail Road and Metro-North and certain holidays/special events
E-scooters	No			
Other e-mobility devices	Yes - hoverboards, shared/rented e-mobility devices not permitted.			
Details of restrictions				
Restriction implemented by	Operator	MTA is the governing body that sets and enforces rules for the New York City public transit system.		
Date introduced	January 2016	Hoverboards are specifically banned following a high number of fire incidents involving these devices (Klausner, 2016).		
	April 2023	Size limits and certification introduced in an effort to balance safety constraints and further enhancing first and last mile connectivity and encouraging the uptake of active transport (Metropolitan Transport Authority, 2023b). Devices cannot exceed 100 pounds in weight (45 kg), 27 inch (69 cm)wheel diameter, 80 inch (203 cm) length and 48 inch (122 cm) height.		

Time of day	Peak hour (weekday)	– Long-Island Rail Road: Restrictions on inbound trains between 6 am and 10 am, and outbound trains between 3 pm. and 8 pm. – Metro-North: Restrictions on inbound trains between 6 am and 10 am, and outbound trains between 4 pm. and 8 pm – These apply to all e-mobility devices and pedal bikes.
Capacity related?	No	No specific differences for devices of different capacities.
Modification related?	Yes	– Since 2023, all e-mobility devices and their batteries sold in New York must meet UL-certified safety standards, and therefore not be modified. – Enforcement action is increasingly being taken to remove uncertified devices from circulation (Campanile, 2025). No shared/rented e-mobility devices allowed on rail.
Enforcement approach	Any conduct within MTA facilities that is unsafe or obstructs passengers or operations, as defined by MTA guidelines, may result in fines (up to US$100), penalties, or ejectment from the system.	
Further details	– UL-certified safety standards applied in New York since 2023 are the strongest in the USA. These do not apply at a national level. – E-mobility devices are subject to the same transport regulations as pedal bikes, in accordance with the MTA agency policies. Foldable e-mobility devices will be regarded as equivalent to foldable pedal bikes and therefore restrictions are space related. – Rules and regulations do not apply to mobility devices defined under ADA (Americans with Disabilities Act). – Charging is prohibited. – Riding e-mobility devices on MTA trains and stations is prohibited.	
Commentary on restrictions		
Commentary	Certification rules for e-mobility devices will support the sale and use of certified and tested devices. The prohibition is limited to hoverboards and shared/rented e-mobility devices. The restrictions are contingent upon consistent enforcement and compliance with established regulations. The implementation of multiple rules and regulations addresses the risk associated with LiB fires.	

Sources: (Metropolitan Transportation Authority, 2023a; Metropolitan Transportation Authority, 2025b; UL Research Institutes, 2023)

4.3.4 Wider context

New York City has extensive e-bike and e-scooter hire schemes, some which are specifically for food delivery drivers (e.g., JOCO and Whizz). These e-mobility devices are certified and comply with safety standards, encouraging food delivery drivers to not use their own unregulated e-mobility device. In June 2025, New York City Department of Transportation (NYC DOT) started an E-Bike Trade-In Program which aims to get unsafe e-bikes, illegal mopeds and LiBs out of New York City (New York City Department of Transportation, 2025). The program allows eligible food delivery workers to trade-in their personal e-mobility device for a certified, high-quality e-bike. Participants receive a Whizz Storm 2 e-bike, like a Whizz hire e-bike, and a spare battery.

To mitigate the risk of LiB fires during battery charging, NYC DOT have an agreement that allows property owners and tenants to have an outdoor e-bike battery swapping/charging cabinet adjacent to their buildings.

Case Study: JOCO e-bike rental for food delivery

JOCO is a service in New York and other US cities that allows delivery drivers to hire a fully charged, certified, e-bike specifically tailored for food delivery (JOCO, 2026a). JOCO e-bikes can be rented and unlocked using the JOCO app with prices starting from $15 USD per six hours, with daily and weekly passes available (JOCO, 2026c). Stations for e-bike pick-up and return are open 24 hours and drivers are able to lock their bike between deliveries. JOCO also has two 'garages' in partnership with food delivery service GrubHub that serve as a pitstop for delivery drivers (Bellan, 2024). This allows them to rest, charge their phones, use kitchen facilities and return or pick-up their bikes.

Figure 4-3: Image of a JOCO e-bike station (Sibayam, 2024)

JOCO has also pioneered LiB charging cabinets, creating FDNY-approved cabinets equipped with smoke detection, temperature monitoring, fire protection and extinguishing systems (JOCO, 2026b). These are already widely used across the USA in 100+ locations both residential and commercial.

Other food delivery e-bike services such as Whizz and Zoomo offer longer term e-bike rentals where the driver has to store the bike and charge the battery themselves (Bellan, 2024). This approach presents the same battery charging related risks associated with owning a personal certified e-bike and does not assist in minimising the number of e-bikes travelling on trains. JOCO's model avoids these issues, making it innovative in e-bike safety and the gig economy industry.

4.3.5 Other US rail operators' approaches

Every US rail operator allows e-bikes and e-scooters on trains with each operator having slightly different approaches to restrictions. The Port Authority Trans-Hudson (PATH) rail system connecting New York City and New Jersey is the exception (Shenk, 2021). They have a total ban on both e-bikes and e-scooters.

NJ Transit, New Jersey's local train network, follows similar guidelines to MTA, allowing e-bikes and e-scooters on board at off-peak times and prohibiting other e-mobility devices (NJ Transit, 2025).

Sound Transit in Seattle, Washington allows e-bikes on all trains with no time restriction. However, there are size restrictions and mandatory battery certifications. All e-bikes are also subject to safety inspections by Sound Transit personnel. E-scooters are prohibited unless they can be folded and stored under the passenger's seat (Sound Transit, 2025).

Amtrak, a cross-country rail network, allows e-bikes provided they are nationally certified, have a motor less than 750Wh and a maximum speed of 32 km/h (Amtrak, 2025). E-scooters are permitted provided they have no seat, a steering handlebar, two axles and are designed to be driven only by the rider on that vehicle.

Most other operators (e.g. SEPTA in Pennsylvania, Skyline Honolulu, RTA Rapid Transit Cleveland, Metra Chicago, LA Metro and Miami Metro) allow e-bikes and e-scooters provided they are in designated areas.

4.4 Transport for London, London, Great Britain

4.4.1 Rail context

In Great Britain, the Office of Rail and Road (ORR) is the independent regulator for economic and safety on the railways. The ORR holds the railway industry to account for the performance of Britain's railways and for how they spend money (Office of Rail and Road, 2025c). This includes authorising new services and rolling stock, signing off on major station works, overseeing ticketing, licensing, complaints and safety, setting accessible travel standards and publishing data. It operates under a legislative framework and is accountable through Parliament and the courts (Office of Rail and Road, 2025a).

Transport for London (TfL) is the transport authority responsible for the operation of London's public transport network, which includes rail comprising of the London Underground, Docklands Light Railway, London Overground and Elizabeth Line (Transport for London, 2025e). TfL runs services on many lines covering hundreds of kilometres across London, carrying millions of passengers every day.

4.4.2 Case study: E-scooter fire on London Underground, London

Table 4-8: Incident overview – E-scooter fire on London Underground, November 2021

Item	Details
Date and time	3 November 2021, Friday evening.
Location	Parsons Green station, London Underground (District Line).
Device(s) involved	Privately owned LiB powered e-scooter.
Incident type	E-scooter battery pack failure and explosion on a train carriage.
Duration	The fire event occurred rapidly and was followed by smoke filling a carriage. Response and evacuation took place, and service was disrupted.
Operator	Transport for London (TfL).
Attendance and response	London Fire Brigade and British Transport Police responded. TfL evacuated passengers.
Injuries	At least one person suffered smoke inhalation, but no life-threatening injuries were reported.

Incident description

On the evening of 3 November 2021, passengers on a District Line tube train were forced to abandon the carriage at Parsons Green station after an e-scooter caught fire. According to media reports, the battery 'exploded' or failed violently, producing thick grey smoke that filled part of the carriage.

The train driver ordered an immediate evacuation, and the passengers were moved to the platform. Video footage shows people coughing, one person very violently and consistently, and a man using a fire extinguisher as smoke and gases were emanating from the device.

London Fire Brigade was called to the scene and assessed the event as caused by a defective LiB, this was later confirmed in TfL's statements.

Rail operator actions

TfL immediately evacuated the train once smoke was detected. British Transport Police and fire services responded to the incident to secure the carriage and platform. TfL carried out an internal review and attributed the fire to a LiB failure.

Images

Figure 4-4: Images from e-scooter fire on London Underground, November 2021 (BBC, 2021)

Incident implications

At the time of the incident, e-scooter regulation and product safety standards in Britain were relatively new.

Following the incident, TfL publicly communicated the danger of e-scooters on its network. On 9th December, 2021, they announced a ban on privately owned e-scooters and e-unicycles across the transport network. This was effective from 13th December 2021.

London Fire Brigade publicly supported the ban, citing serious fire risk from defective LiBs that could ignite without warning and release toxic smoke.

The incident contributed to broader public transport policy changes and raised awareness of the dangers of LiBs in e-mobility devices. This also led to campaigns like the ChargeSafe program led by the London Fire Brigade, aimed at improving e-bike and e-scooter safety (London Fire Brigade, 2025).

4.4.3 Summary of approach to e-mobility devices on rail

TfL has adopted restrictions on the type of e-mobility device allowed on its rail network between December 2021 and March 2025, largely consisting of bans of certain types of e-mobility device, with only foldable e-bikes allowed. A summary of the approach is given in Table 4-9.

Table 4-9: Summary of approach to e-mobility devices on rail from Transport for London, Great Britain

Rail environment	
Rail regulator	Office of Rail and Road (ORR)
Regulatory approach and	**Co-regulatory** The safety and economic functions of the ORR are defined in the following legislation:

relevant legislation	– the Railways Act 1993, the Railways Act 2005 – the Railways and other Guided Transport Systems (Safety) Regulations 2006 – the Rail Vehicle Accessibility Regulations 2010 – the Health and Safety at Work Act 1974			
Rail operator selected for case study	Transport for London (TfL)			
Network summary (*approximate values*)	– London Underground (Tube): 11 lines, 402 km, 182 km of tunnels, 272 stations, 5 million passengers per day – Docklands Light Railway (DLR): 7 lines, 38 km, <5 km of tunnels, 45 stations, 271,000 passengers per day – London Overground: 6 lines, 174 km, <5 km of tunnels, 82 stations, 494,000 passengers per day – Elizabeth Line: 5 lines, 118 km, 42 km of tunnels, 41 stations, 800,000 passengers per day – Total: 29 lines, 732 km, 234 km of tunnels, 440 stations, >6 million passengers per day			
Restrictions on rail				
Restriction type	**Prohibition**	**Storage**	**Certification needed?**	**Timing restrictions**
E-bikes	Yes – non-folding e-bikes prohibited	No	Yes – national level	No - applies at all times
E-scooters	Yes	N/A	N/A	
Other e-mobility devices	Yes – e-unicycles are prohibited	N/A	N/A	
Details of restrictions				
Restriction implemented by	Operator	The ban is not legislated. It is a TfL operational safety policy enforced under TfL bylaws.		
Date introduced	December 2021	The e-scooter and e-unicycle ban was introduced in December 2021 following a review TfL undertook into the safety of e-mobility devices on the TfL network, related to fire incidents with e-scooters and e-unicycles on TfL services/infrastructure.		
	March 2025	The restriction for foldable e-bikes only was introduced in March 2025 following a review TfL undertook in collaboration with the London Fire Brigade into safety of e-bikes on the TfL network, following non-foldable e-bikes fire incidents.		
Capacity related?	No	No specific differences for devices of different capacities.		
Modification related?	No	No specific differences for modified devices.		
Enforcement approach	Enforcement is through TfL's uniformed enforcement officers, who may refuse non-complying patrons entry, direct non-complying patrons to leave the network or impose fines of up to £1000 GBP if prosecuted under the bylaws.			
Further details	– E-bikes must comply with the Electrically Assisted Pedal Cycle Regulations (EAPC 2015), and riders must be at least 4 years old. – Storage is available near many stations or near stations in Cycle Hubs. – Electric wheelchairs and other mobility devices for people living with disability are exempt. – Current rules do not specify whether LiBs are allowed to be transported separately from e-mobility devices. Discussions with TfL (January 2026) indicated that passengers have been transporting LiBs separately to e-mobility devices. Although it is not explicitly prohibited, the rules are under review.			
Commentary on restrictions				
Commentary	Certification requirements for e-bikes are in place at a national level, and private e-scooter use is currently prohibited in public places. Prohibition includes non-folding e-bikes and e-unicycles. Restrictions are comprehensive.			

Sources: (Office of Rail and Road, 2025a; Office of Rail and Road, 2025b; Transport for London, 2025a; Transport for London, 2025e; Transport for London, 2021; Transport for London, 2025d; Transport for London, 2025b; Transport for London, 2025c)

A TfL internal review identified that bikes which have been converted from pedal bikes to e-bikes are the riskiest. As it can be hard to differentiate between modified and unmodified bikes, the TfL ban included all non-folding e-bikes. Folding bikes are still permitted as they are less likely to be converted, and TfL did not identify any evidence of fires caused by folding e-bikes (Transport for London, 2025d). Discussions with TfL (January 2026) indicated that yearly reviews of the restrictions are being undertaken.

4.4.4 Wider context

E-mobility hire schemes in London

London has a substantial number of e-mobility devices available for hire across the city, reducing the need for privately owned devices. TfL operates an e-bike scheme with over 12,000 bikes at 800 dedicated docking stations (TfL, n.d.). There are also multiple independent dockless e-bike operators. Discussions with TfL (January 2026) indicated an estimate of a further 60,000 e-bikes available through these schemes. Some of these providers offer discounted rates for delivery riders, which supports uptake of certified devices. E-scooter hire is regulated by TfL under a formal trial across 11 London Councils and London boroughs, with about 4,000 devices available (UK Government, 2025).

British approach to e-bikes on rail

Rail Partners was a trade body in the UK for private-sector passenger train owning groups and rail freight companies. Before it was closed in March 2025 due to the UK government bringing most rail operations back into public ownership, it published the ‘Rail Industry electric bicycle (e-bike) Guidelines’ (Rail Partners, 2025). This one-page, industry wide technical document set out a clear approach on e-bikes on rail from a safety perspective. This includes the following controls:

– Charging of e-bikes not permitted on trains.
– Batteries must remain on the e-bike (unless designed to be removed for folding).
– E-bikes with damaged batteries are not permitted.
– Spare e-bike batteries cannot be carried.
– Modified e-bikes are not permitted on trains.
– E-bikes must be stored in designated cycle storage areas, not blocking entrances, exits or aisles.
– E-bikes may not be locked to parts of the train, so they can be removed quickly in an emergency if needed.
– In the event of a fire, passengers should evacuate the area and follow relevant on-board procedures to notify the driver or train crew. This will be explained in posters or signed in the vehicle.
– The guideline notes that, apart from for hire devices, the majority of e-scooters are not road legal in the UK. As such e-scooters are banned from the national rail network and London Underground at the time of publication.

The Guideline also includes controls on the use of e-bikes at stations, such as use of dedicated charging facilities only, and storage and other behaviour rules in line with those for pedal-bikes (e.g. no riding on platforms).

This is one of the few examples of published, national system level guidance that were identified in this project, the other being Singapore.

Other British rail operators’ approaches

Local rail operators, Avanti West Coast and Transport for Wales both permit e-bikes on trains in line with the ‘Rail Industry electric bicycle (e-bike) Guidelines’ provided there are prior bookings (Avanti West Coast, 2025; Transport for Wales, 2025). London North Eastern Railway (LNER) allows e-bikes provided a cycle space is booked prior and the device weighs under 25kg (London North Eastern Railway, 2025). LNER also prohibit charging on board but there is no other evidence to prove that they have adopted the ‘Rail Industry electric bicycle (e-bike) Guidelines’.

London Northwestern Railway allows e-bikes at off-peak hours provided they align with the ‘Rail Industry electric bicycle (e-bike) Guidelines’, unless they are foldable in which case they can be taken on the train at any time as luggage (London Northwestern Railway, 2025).

Each of the mentioned operators and all 26 other rail operators across the UK (e.g. Scotrail, Southern Rail, Gatwick Express, Thameslink, Great Northern, etc.) have bans on e-scooters, following the TfL incident (Rail Business UK, 2023). These bans came into effect in June 2023.

4.4.5 Policy response challenges

The TfL transport network is large, and passengers frequently attempt to bring e-mobility devices onto trains, with at least 27 people convicted after bringing private e-scooters onto TfL services (London Daily, 2025). TfL also reported that enforcement officers have intervened on numerous occasions to prevent travellers bringing banned e-mobility devices onto their services (Greater London Authority, 2025). Many privately owned e-scooters use low-cost, uncertified LiBs, making it difficult to know which models pose most risk.

4.5 Nederlandse Spoorwegen, the Netherlands

4.5.1 Rail context

In the Netherlands the Transport Inspectorate (ILT) is the national safety authority, responsible for compliance with national and European railway safety legislation. Its role includes approval and enforcement of safety certificates and monitoring of safety management systems and standards. It operates under the Dutch Railway Act 2005, which is aligned to EU Directives and Regulations. Carriage rules are set by operators.

Nederlandse Spoorwegen (NS) is the largest passenger rail transport company in the Netherlands. It runs services on over 2,000 km of railway and carries over 1 million rail passengers a day. Network infrastructure is managed by ProRail. Other operators deliver regional services on a further 14 lines and 700 km of track, including high speed international services to other European countries.

4.5.2 Summary of approach to e-mobility devices on rail

The Netherlands have a number of restrictions around bicycles on the rail network. Regular (non-folding) pedal bikes, and e-bikes are not permitted at peak times, except in the months of July and August. They must be stored in dedicated areas. Folding e-bikes and e-scooters under 45cm x 86cm x 80cm can be taken on rail at any time, provided they are folded and are treated as luggage.

E-hoverboards and e-unicycles are not legally allowed on Dutch roads and pavements, and so are unlikely to be commonplace (SWOV Institute for Road Safety Research, 2021). However, there are no specific rules identified about their carriage on trains.

A summary of the approach is given in Table 4-10 and a separate commentary on speed pedelecs is included below the table.

Table 4-10: Summary of approach to e-mobility devices on rail from Nederlandse Spoorwegen, the Netherlands

Rail environment	
Rail regulator	Human Environment and Transport Inspectorate (ILT)
Regulatory approach and relevant legislation	**Prescriptive** The safety functions of ILT are defined in the following legislation: – Dutch Railway Act 2005
Rail operator selected for case study	Nederlandse Spoorwegen (NS) - using network infrastructure managed by ProRail.
Network summary (*approximate values)*	Total (intercity and international): 78 lines, 3,223 km, 30 km of tunnels, 262 stations, 1.1 million passengers per day

Restrictions for rail				
Restriction type	**Prohibition**	**Storage**	**Certification needed?**	**Timing restrictions**
e-bikes	No	Yes – designated areas for all bicycles	Yes – national level EN15194.	Yes - Non-folding bikes not allowed during peak times most of the year (6:30-9am and 4-6:30pm weekdays), except in July and August when all day travel is permitted. Folding e-bikes allowed any time.
E-scooters	No	Yes – folded as luggage	No	No
Other e-mobility devices	Not specified, but not allowed on Dutch roads and pavements	N/A	N/A	N/A

Further details of restrictions		
Restriction implemented by	Operator	NS has some restrictions on standard e-bikes. These are related to travel at peak times, and are the same as the rules for pedal bikes, due to space constraints. This is not included in legislation. Speed pedelecs are classified as mopeds, and are therefore not permitted on trains.
Date introduced	June 2013	The restrictions on time of day were introduced in June 2013 due to limited space to support comfort for passengers.
Time of day	All times	Size limits and storage restrictions apply at all times.
	Peak times	Restrictions for e-bikes apply during peak times during most of the year (6:30-9am and 4-6:30pm weekdays September – June).
Capacity related?	No	N/A
Modification related?	No	No specific differences for modified devices.
Enforcement approach	Enforcement is through ticketing (an off-peak bicycle ticket 'Fietskaart Dal') and conductor checks. Penalties may include a fine and being asked to leave the train. Boarding can be denied if designated bicycle storage areas are full.	
Further details	– E-bikes in the Netherlands must comply with EN15194 safety standard. – Folding e-bikes are allowed at any time when folded. – E-cargo-bikes and trailers are not permitted. – E-scooters are treated as hand luggage and should not occupy bicycle spaces. They are allowed any time and must be folded to 85 cm x 85x cm x 85 cm. – Other e-mobility devices are treated as hand luggage or sports equipment. They are allowed if turned off, within size limits (85 cm in any dimension) and not blocking passageways. – Mobility aids (e.g. MMDs) are exempt from the restrictions.	

Commentary on restrictions	
Commentary	Restrictions are not specifically aimed at reducing risk associated with e-mobility devices. It is not clear if the relatively low level of restriction and control in the Netherlands (aside from speed pedelecs) is due to a lack of incidents, that risk levels are understood to be low, or if this has not been considered as an issue needing attention to date.

Source: (Nederlandse Spoorwegen, 2025b; Nederlandse Spoorwegen, 2025d)

Approach to speed pedelecs

EU regulation 168/2013 Annex I defines speed pedelecs as mopeds (category L1e-B), as they are capable of more than 25 km/h and up to 45 km/h with a continuous power of up to 4000 W (European Union, 2013). As such these are not allowed on trains. This is separate to any consideration related to LiB thermal runaway risks. The Dutch adopted a local version of this legislation on speed pedelecs in 2017.

4.5.3 Active travel context in the Netherlands

Cycling is deeply ingrained in the Dutch culture, with bicycle ownership and usage at very high levels. Large cycling facilities such as bicycle storage are well integrated at stations, as well as e-bike hire operations. NS operate an e-bike fleet called OV-ebike which can be rented by passengers from four stations on the network and are linked to their public transport accounts (Nederlandse Spoorwegen, 2025c). They also have a partnership with shared e-bike operator Dott which has over 2200 e-bikes across major Dutch cities (Nederlandse Spoorwegen, 2025a). Extensive bicycle storage at stations, and a ‘bike tag’ system to help park faster are available for both pedal bikes and e-bikes.

4.5.4 Other Dutch rail operators’ approaches

Regional rail operators in the Netherlands, including Keolis, Arriva, RRReis, and Blauwnet, typically follow a similar approach to NS with e-bikes not permitted at peak times, due to space constraints.

There are no bans on e-bikes, except for speed pedelecs. These are forbidden on the whole Dutch rail network, as they are classified as mopeds. These devices can travel at speeds greater than any Australian road-legal e-bike.

The approach to e-scooters is similar across the country, with most Dutch operators allowing them onboard provided they meet size restrictions.

4.6 Hamburger Hochbahn, Hamburg, Germany

4.6.1 Rail context

In Germany, the rail regulatory framework has two primary bodies; the Bundesnetzagentur (BNetzA) and the Federal Railway Authority, the Eisenbahn-Bundesamt (EBA). The BNetzA is responsible for economic regulation, and the EBA is responsible for safety licensing and compliance. The EBA is an independent authority under the Federal Government that oversees licensing and supervision, safety oversight, passengers rights, vehicle registration, approvals and funding.

Hamburger Hochbahn AG (HHA) is the public transport authority responsible for the operations of Hamburg’s public transport network, which includes the Hamburg U-Bahn (metro). HHA runs metro services on four lines, covering over 100 kilometres across Hamburg, carrying 540,000 passengers every day (Public Transportation and Metro Rail Information, 2025).

4.6.2 Summary of approach to e-mobility devices on rail

HHA has adopted controls on the type and timing of e-mobility device allowed on its rail network, including banning e-scooters on its network (as of 24 August 2023). This is due to recommendations from an assessment into the risks posed to passengers from smoke inhalation in constricted areas (tunnels and underground networks). A summary of the approach is given in Table 4-11.

Table 4-11: Summary of approach to e-mobility devices on rail from Hamburger Hochbahn, Germany

Rail environment				
Rail regulator	Eisenbahn-Bundesamt (EBA)			
Regulatory approach and relevant legislation	**Prescriptive** The safety functions of the EBA are defined in the following legislation – Directive 2004/49/EC			
Rail operator selected for case study	Hamburger Hochbahn AG (HHA)			
Network summary (*approximate values*)	Hamburg U-Bahn (metro): 4 lines, 104 km, 44 km of tunnels, 91 stations, 540,000 passengers per day			
Restrictions on rail				
Restriction type	**Prohibition**	**Storage**	**Certification needed?**	**Timing restrictions**
E-bikes	No	Yes – e-bikes must be held by passengers	Yes – national level EN15194.	Yes – no bicycles permitted during peak times (6-9 am and 4-6 pm weekdays).
E-scooters	Yes – prohibited	N/A	N/A	At all times
Other e-mobility devices	No	No	No	No
Details of restrictions				
Restriction implemented by	Operator	E-scooter ban and restrictions are not included in national law; restrictions are operational only.		
Date introduced	August 2023	The e-scooter ban was introduced in August 2023, due to recommendations from an assessment into the risks posed to passengers from smoke inhalation in constricted areas (tunnels and underground networks).		
Capacity related?	No	No specific differences for devices of different capacities.		
Modification related?	No	No specific differences for modified devices.		
Enforcement approach	Enforcement of restrictions is the duty of station staff (both at the station and on board), additional signage and announcements are provided at stations to inform patrons.			
Further details	– E-bikes in Germany must comply with EN15194 safety standard. – Electric wheelchairs and ride-on electric scooters are considered by HHA to have an appropriate level of safety and are not affected by the ban. – Time of day restriction, which means e-bikes are only allowed off-peak, applies to all bicycles, suggesting this is space related, not related to LiB thermal runaway risk.			
Commentary on restrictions				
Commentary	Certification approaches for e-bikes are in place at a national level. Only e-scooters are prohibited. The restrictions are contingent upon consistent enforcement and compliance with established regulations. Nonetheless, the implementation of multiple rules and regulations addresses the risk associated with fires.			

Sources: (Hamburger Verkehrsverbund, 2025; Public Transportation and Metro Rail Information, 2025; Hochbahn, 2023; Federal Railway Authority, 2025)

Approach to speed pedelecs

EU regulation 168/2013, Annex I was introduced in 2013 (European Union, 2013). It defines speed pedelecs as mopeds (category L1e-B), as they are capable of more than 25 km/h and up to 45 km/h with a continuous power of up to 4000 W. As they require insurance plates and are legally classified in Germany as motor vehicles, they are not permitted on any U-Bahn or S-Bahn services, including the Hamburg U-Bahn (Hamburger Verkehrsverbund, 2025). This came into effect in 2013 in Germany and is separate to any consideration related to LiB thermal runaway risks.

4.6.3 Other German rail operators' approaches

Deutsche Bahn is Germany's largest rail operator with both domestic and international passenger trains (Zeus Train, 2024). It requires reservations for e-bikes on certain trains. There is no charging of devices allowed at stations or on trains. E-scooters must be folded and carried as luggage provided they meet size and weight restrictions (German Rails, 2025).

Several other local operators have banned e-scooters following the Hamburger Hochbahn report and ban, including BVG Berlin, MVG Munich, Wuppertal Suspension Railway (WSW) and Rheinbahn Düsseldorf (Levy, 2024).

4.7 Metro de Madrid S.A., Madrid, Spain

4.7.1 Rail context

In Spain, the rail regulatory framework has two primary bodies, the Comisión Nacional de los Mercados y la Competencia (CNMC) and the Agencia Estatal de Seguridad Ferroviaria (AESF). The CNMC is the rail market regulator overseeing fair competition and non-discriminatory access and the AESF is the rail safety regulator, overseeing safety standard compliance and accident investigations (Leedeo Engineering, 2019; European Commission, 2025b).

Additionally, the Consorcio Regional de Transportes de Madrid (CRTM) was created by Law 5/1985, as a public body that concentrates the competencies in the field of regular passenger transport in the Community of Madrid. The CRTM coordinates all modes of regular public passenger transport in the region: Metro de Madrid, EMT de Madrid and other urban buses in the region, intercity buses, Light Rail and Parla Tramway, as well as Cercanías ferroviarias (Consorcio Transportes Madrid, 2025a).

Metro de Madrid is the transport authority responsible for the operation of the Madrid Metro (Metro Madrid, 2025b). Metro de Madrid runs services on 16 lines covering over 300 kilometres across Madrid, carrying millions of passengers every day.

4.7.2 Case study: E-scooter battery fire and explosion on Madrid Metro, Spain

Table 4-12: Incident overview – e-scooter battery fire and explosion on Madrid Metro, October 2023

Item	Details
Date and time	Tuesday 17 October 2023.
Location	Madrid Metro, Line 2. Incident occurred near La Elipa station
Device(s) involved	Privately owned, LiB-powered e-scooter
Incident type	An e-scooter battery pack failure and explosion on a train carriage
Duration	The immediate event was brief, a single battery failure/thermal event. Service on the affected section was suspended for several hours while the carriage and infrastructure were inspected and cleared.
Operator	Madrid Metro
Attendance and response	Madrid Metro staff and emergency services attended the scene. Passengers were evacuated from the affected carriage.
Injuries	Public reports indicated no serious injuries. Initial accounts described smoke and localised carriage damage.

Incident description

An e-scooter being carried aboard a metro carriage on Line 2 of the Madrid Metro experienced a violent battery failure. This was reported as an ‘explosion’ and an ‘energetic thermal event’ by expert commentators (The Olive Press, 2023).

Witnesses described smoke and a sudden, forceful event that damaged the floor and door area of the carriage. This produced visible smoke in the immediate vicinity, which is indicative of a vapour cloud explosion caused by rapid thermal runaway.

While public reporting emphasised the violent nature of the event, no public forensic report identifying the precise technical root cause has been released at the time of writing.

Rail operator actions

Madrid Metro staff evacuated passengers from the affected carriage and ensured no one remained in the immediate hazard zone. Emergency responders inspected the scene to ensure the device was made safe. The Line 2 service was suspended between adjacent stations while safety checks were conducted. Normal service resumed only after carriage removal and inspection.

The affected carriage was withdrawn from service and inspected for damage, and affected infrastructure and rolling stock components were visually checked.

The operator issued public notices about the service disruption and later media statements about the incident and subsequent safety reviews (Metro Madrid, 2023).

Images

Figure 4-5: Images from e-scooter thermal runaway on Madrid Metro, October 2023 (The Olive Press, 2023)

Incident implications

The policy response to the incident was quick. It consisted of operational restrictions, reviews by the regulator and operator, and public messaging. Transport authorities moved to restrict or temporarily ban the carriage of powered e-mobility devices on the metro and public buses pending further review of safety implications.

Transit operators and local authorities were prompted to review carriage rules, signage, and passenger guidance relating to e-mobility devices, and to engage with emergency services about response protocols.

Authorities reinforced messaging that powered devices should not be charged or left in confined passenger spaces and highlighted the need for safer storage/transport behaviours.

4.7.3 Summary of approach to e-mobility devices on rail

Metro de Madrid has adopted restrictions on the type of e-mobility devices allowed on its rail network, largely consisting of bans of certain types of e-mobility devices, with only e-bikes allowed since October 2023. A summary of the approach is given in Table 4-13.

Table 4-13: Summary of approach to e-mobility devices on rail from Metro de Madrid S.A., Spain

Rail environment				
Rail regulator	Agencia Estatal de Seguridad Ferroviaria (AESF)			
Regulatory approach and relevant legislation	**Prescriptive** The safety functions of the AESF are defined in the following legislation: – Ley 38/2015 del Sector Ferroviario – Real Decreto 1072/2014 – Real Decreto 929/2020 – EU Railway Safety Framework			
Rail operator selected for case study	Metro de Madrid S.A.			
Network summary (*approximate values*)	– Madrid Metro: 13 lines, 296 km, 287 km of tunnels, 302 stations, 2 million passengers per day – Metro Ligero (light rail): 3 lines, 27.8 km, 7 km of tunnels, 37 stations, 300,000 passengers per day			
Restrictions on rail				
Restriction type	**Prohibition**	**Storage**	**Certification needed?**	**Timing restrictions**
E-bikes	No	No	Yes – national level EN15194.	Always applies
E-scooters	Yes – prohibited	N/A	N/A	
Other e-mobility devices	Yes – e-unicycles are prohibited	N/A	N/A	
Details of restrictions				
Restriction implemented by	Planning and Coordinating Authority	The ban is ratified by the CRTM and will affect all Metro facilities and trains.		
Date introduced	October 2023	The e-scooter and e-unicycle ban was introduced in October 2023 following an incident of a LiB from an e-scooter or e-unicycle exploding inside a suburban train station.		
Capacity related?	No	No specific differences for devices of different capacities.		
Modification related?	No	No specific difference for modified devices.		
Enforcement approach	Enforcement is through Metro de Madrid's enforcement officers and staff at stations, who may refuse non-complying patrons entry. Direct non-complying patrons may be asked to leave the network or be subject of fines of up to €200 if prosecuted under the byelaws. Additional signage and announcements are provided at stations to inform patrons.			
Further details	– E-bikes in Spain must comply with EN15194 safety standard. – No evidence has been found on whether the ban includes the batteries themselves, whether installed or carried separately. – Electric wheelchairs and other mobility devices for people living with disability are allowed (Metro Madrid, 2025a).			
Commentary on restrictions				
Commentary	Certification approaches for e-bikes are in place at a national level. The restrictions are limited to e-scooters and e-unicycles. The restrictions are contingent upon consistent detection and adherence to established regulations. Nonetheless, the implementation of multiple rules and regulations significantly mitigates the primary risk associated with fires.			

Sources: (Consorcio Transportes Madrid, 2025b; Metro Madrid, 2024; Metro Madrid, 2025a; Metro Madrid, 2023)

Approach to speed pedelecs

EU regulation 168/2013 Annex I was introduced in 2013 (European Union, 2013). It defines speed pedelecs as mopeds (category L1e-B), as they are capable of more than 25 km/h and up to 45 km/h with a continuous power of up to 4000 W. This regulation was adopted in Spain in 2020, with registration, a licence, helmets and insurance required for their use. As speed pedelecs are classified as mopeds, they are not allowed on trains.

4.7.4 Other Spanish rail operators' approaches

Other rail operators across Spain have different approaches to e-mobility rules. Iryo Trains, a long-distance, cross-country travel network has a total ban on both e-bikes and e-scooters (Iryo, 2025). Renfe, a regional, cross-country and high-speed rail only bans e-scooters and allows e-bikes provided a booking is made in advance (Renfe, 2025).

Barcelona Metro

The metropolitan area of Barcelona, including the city and surrounding municipalities, has the Metropolitan Transport Authority (ATM), which is an inter-administrative consortium to which all administrations that hold public collective transport services may adhere (Autoritat del Transport Metropolità, 2025a).

Transports Metropolitans de Barcelona (TMB) is the transport authority responsible for the operation of Barcelona's public transport network, which includes rail in the form of the Barcelona Metro (Transports Metropolitans de Barcelona, 2025b). TMB runs metro services on 12 lines covering over 100 kilometres across Barcelona, carrying approximately 645,000 passengers every day (City Transit Data, 2025).

The TMB, in conjunction with the ATM, implemented the ban of e-scooters and e-unicycles on public transport in February 2023. The ban was initially introduced for a six-month period following an explosion of an electric scooter battery in a train carriage and was later made indefinite. The intent of the restrictions is to improve the safety of staff and users of their rail network (Autoritat del Transport Metropolità, 2025b; Autoritat del Transport Metropolità, 2023; Catalan News, 2023).

The ban is not legislated; the Board of Directors of the ATM asked public transport operators to amend their services' general terms and conditions to include the temporary prohibition. Compliance is monitored by the staff of the operating companies. Breaches of the ban on transporting electric scooters and monowheels in vehicles and at facilities beyond the ticket barrier will result in a penalty of €200 (Autoritat del Transport Metropolità, 2023).

E-bike sharing schemes in Spain

There is strong and growing e-bike uptake in Madrid, including through the public e-bike sharing scheme called BiciMAD. This is Government run and is one of the largest e-bike sharing schemes in Europe, with over 9.9 million trips in 2024, a 30% increase from 2023 (European Commission, 2025a). E-bike sharing and e-mobility device parking at stations is widely used.

AMBici is an e-bike sharing service operating in 15 municipalities in the Barcelona metropolitan area, connecting public transport with e-mobility (Transports Metropolitans de Barcelona, 2025a). It covers 204 stations, 2600 e-bikes, with 16,386 active subscribes, and 1.62 million users.

Bicibox is a secure bicycle and scooter parking service in the Barcelona metropolitan area, free for citizens, promoting sustainable transport and supporting public transport by providing safe storage (Barcelona Metro Bus Rodalies, 2024). There are over 250 in the Barcelona area offering secure storage and insurance coverage for theft, fire or damage.

These sharing services, combined with parking facilities at public transport facilities, help reduce demand for people to take their personal e-mobility devices onto public transport.

4.7.5 Policy response challenges

In Spain, e-mobility regulation is governed by multiple municipal and national rules. Aligning transport policy with product safety and electrical standards is complex. Due to the wide variety of privately owned e-mobility devices in

Spain, and differing battery types, capacities and labelling, enforcing consistent carriage rules is operationally difficult here, as in many other countries.

4.8 China Railways, China

4.8.1 Rail context

In China, the National Railway Administration (NRA) is the rail regulator, which is part of the Ministry of Transport. The NRA provides safety oversight and accident prevention, and there is a tiered approach with eight local railway supervisory units. These agencies enforce the Railway Law of the People's Republic of China (May 1991) which defines centralised railway control and legal obligations of railway enterprises.

China Railway (China State Railway Group Co. Ltd) operates the national heavy rail and national high-speed rail network (long-distance). This includes over 200,000 km of rail network, of which 45,000 km is high speed rail.

4.8.2 Summary of approach to e-mobility devices on rail

All e-bikes sold in China must meet the national safety standard GB 11761-2018. This was updated in 2025 and includes fire safety requirements for batteries. E-mobility devices over 160 W are prohibited by China Railway, and those between 100 Wh and 160 Wh are subject to restrictions and approvals. Batteries must be detached and individually protected (e.g. in a battery bag) for storage. Screening and security checks at stations support enforcement of these rules. A summary of the approach is given in Table 4-14.

Table 4-14: Summary of approach to e-mobility devices on rail from China Railways, China

Rail environment				
Rail regulator	National Railway Administration (NRA) formed in 2013, under the Ministry of Transport.			
Regulatory approach and relevant legislation	**Prescriptive** The safety functions of the NRA are defined in the following legislation: – Railway Law of the People's Republic of China (May 1991)			
Rail operator selected for case study	China Railway (China State Railway Group Co. Ltd)			
Network summary (*approximate values*)	– Conventional: >100 lines, 108,000 km, 20,000 km of tunnels, >5,000 stations, 6.4 million passengers per day – High speed: >16 lines, 48,000 km, 10,000 km of tunnels, >1,500 stations, 15 million passengers per day – Urban rail and metro: 325 lines, 10,000 km, 9,000 km of tunnels, >6,000 stations, 88 million passengers per day – Total: >400 lines, >200,000 km, 40,000 km of tunnels, >12,500 stations, 109.4 million passengers per day			
Restrictions on rail				
Restriction type	**Prohibition**	**Storage**	**Certification needed?**	**Timing restrictions**
E-bikes E-scooters Other e-mobility devices	Devices with over 160 Wh batteries prohibited Devices with 100-160 Wh batteries need approval[1]	Yes – batteries must be detached and individually protected (e.g. in a battery bag)	Yes – national standard GB 17761-2024 for e-bikes and GB/T 3565-2024 for e-scooters applies for devices sold from December 1, 2025. Existing older e-mobility devices are still in circulation with 'trade-in for new' policies in place.	Applied at all times

[1] Only a very small proportion of e-mobility devices will have batteries with a 100-160 Wh capacity (e.g. children's e-scooters or low-end models).

Details of restrictions		
Restriction implemented by	Operator (China Railways) with advice from Ministry of Transport	Ministry of Transport issued transport safety notices in 2021 and 2022 to ban or restrict e-bikes and e-scooters on trains, enhance screening at stations and provide education to passengers to improve safety. This is included in operator's passenger conditions, not included in national legislation.
Date introduced	November 2023	In 2023 the Ministry of Industry and Information Technology (MIIT), National Railway Administration (NRA), and China State Railway Group Co., Ltd. jointly issued the Guide on Railway Transportation of Consumer-grade Lithium Batteries. This guide standardised transport conditions and emphasised safety management for LiBs.
Capacity related?	Yes	– Between 100-160 Wh may require airline style approvals. – Over 160 Wh not allowed.
Modification related?	No	No specific differences for modified devices.
Enforcement	Enforcement is through China Railway's screening and security checks at stations, and penalties typically result in refusal of boarding and confiscation of the device.	
Further details	Charging on board is not allowed.	
Commentary on restrictions		
Commentary	Restrictions are comprehensive and enforcement involves screening, which is likely to support a high level of compliance.	

Sources: (National Railway Administration of the People's Republic of China, 2023; ChemLinked, 2023; ESU Vehicle, 2025)

The number of e-mobility devices with batteries in the 100 Wh to 160 Wh range is very small. Almost no commercially sold e-bikes have batteries under 160 Wh, and only low-end or children's e-scooters have this size battery. This includes the Swagton Swagger e-scooter, with a battery size of 98Wh, which has been subject to a product safety warning in the US (Consumer Product Safety Commission, 2025).

4.8.3 Other Chinese rail operators' approaches

Urban metro systems including Beijing Subway and Ghangzhou metro have bans on e-scooters and e-bikes in subways and railway stations. These are typically enforced by local transport bureaus or police.

4.8.4 Alignment with aviation battery restrictions

The size limits on LiBs on China Railways' trains mirror those adopted in international air travel regulations. The International Air Travel Association (IATA) Battery Guidance Document on 'Transport of Lithium metal, Lithium-Ion and Sodium-Ion Batteries' (International Air Transport Association, 2025) sets out clear guidelines on power banks and LiBs. These include prohibiting devices over 160 Wh capacity, with approval needed and limits on the number of devices in the 100 Wh to 160 Wh range.

Aviation regulations are aimed at passengers traveling with mobile phones, power banks, and similar devices, rather than e-mobility devices which typically have larger batteries. This explains why when adopting the capacity limits from aviation, the China Railways regulations prohibit most e-mobility devices.

Under new UN3481, from 1 January 2026 batteries shipped in the same package as equipment (i.e. spare batteries - PI 966) must be shipped under a 30% state of charge. Installed batteries (PI 967), are recommended to be under 30% state of charge but this is not mandatory. Limits on state of charge would be challenging to enforce in the rail context.

Battery bags

'Battery bags' are bags which are designed to contain and mitigate the effects of LiB thermal runaway by allowing gases to escape, reducing the risk of explosion. They are used widely by aviation companies and can be made to certified standards. An example is shown below. The effectiveness of these products is not currently clear and should be kept under review.

Figure 4-6: Example 'battery bag' for e-bike batteries from LithiumSafe (LithiumSafe, 2025)

4.9 Mass Rapid Transit, Singapore

4.9.1 Rail context

In Singapore, the Land Transport Authority (LTA) is responsible for planning and managing the public transport system, maintaining existing rail and bus assets, developing new transit lines, and ensuring the reliability and efficiency of the network (Land Transport Authority, 2025e). LTA collaborates with public transport operators to deliver safe, reliable, and comfortable train services. LTA and rail operators operate under a regulatory framework encompassing four areas: asset maintenance, incident management, operating performance standards and penalty framework under the Rapid Transit Systems Act.

Singapore Mass Rapid Transit (SMRT) is the transport authority responsible for the operation of public transport services in Singapore. This includes Mass Rapid Transit and Light Rail Transit. SMRT runs services on many lines covering almost 200 km carrying millions of passengers every day (SMRT Corporation, 2025).

National regulation

Singapore has a clear and structured national approval system for e-mobility devices, which includes technical certification, registration, identification and approval for legal use. These are summarised in **Error! Reference source not found.**. All modifications are prohibited.

Table 4-15: Summary of national e-mobility device regulations in Singapore

	Certification	Registration	Speed and other restrictions
e-bike (Land Transport Authority, 2025b)	– European Safety Standard EN15194 – Specific local battery safety requirements.	– Pass LTA inspection and receive approval – Display orange seal – Have a number plate – Min age 16 – Mandatory online theory test	– 25 km/h maximum speed – Motor output must not exceed 250 W
e-scooter and other PMD (Land Transport Authority, 2026)	– UL2272, a fire safety standard which includes resistance to overheating, battery faults and electrical fires – Specific local battery safety requirements.	– Register with LTA – Clearly display registration ID	– 25 km/h maximum speed

4.9.2 Summary of approach to e-mobility devices on rail

SMRT has adopted restrictions on the type, size, and certification of e-mobility devices allowed on its rail network, as well as storage requirements and travel time recommendations.

E-bikes and e-scooters are allowed on MRT and LRT trains. They must also comply with the national regulations, and be foldable to meet specific size limits. A summary of the approach is given in Table 4-16.

Table 4-16: Summary of approach to e-mobility devices on rail from Singapore Mass Rapid Transit, Singapore

Rail environment				
Rail regulator	Land Transport Authority (LTA)			
Regulatory approach and relevant legislation	**Prescriptive** The safety functions of LTA are defined in the following legislation: – Land Transport Authority of Singapore Act 1995 – Rapid Transit Systems Act 1995			
Rail operator selected for case study	SMRT (Singapore Mass Rapid Transit)			
Network summary (*approximate values*)	– Mass Rapid Transit (MRT): 4 lines, 180 km, >150 km of tunnels, 120 stations, 3.65 million passengers per day – Light Rail Transit (LRT): 1 line, 8 km route length, 0 km of tunnels, 13 stations, 210,000 passengers per day – Total: 5 lines, 188 km, >150 km of tunnels, 133 stations, 3.76 million passengers per day			
Restrictions on rail				
Restriction type	**Prohibition**	**Storage control**	**Certification needed?**	**Timing restrictions**
E-bike restrictions	Yes. Devices over 120 cm by 70 cm by 40 cm and non-folding are prohibited.	N/A – prohibited	N/A - prohibited	N/A - prohibited
E-scooter restrictions				
Other e-mobility devices				
Folding device restriction	No. Permitted under 120cm by 70cm by 40cm when folded	Yes. Folding devices must be folded at all times and cannot block aisles or doors. Must be switched off when inside stations and trains.	Yes. All devices to be registered with LTA with ID/approval mark clearly displayed. Scooters must be registered with LTA and certified to UL2272 device safety standard. E-bikes must comply with EN15194.	No specific rules
Details of restrictions				
Restriction implemented by	Regulator	The Land Transport Authority (LTA) enforces these restrictions under the Active Mobility Act (AMA), noting that this is not specific to rail.		
Date introduced	June 2017	Size limits and storage requirements introduced to balance space constraints and further enhancing first and last mile connectivity, encouraging the uptake of active transport.		
	May 2018	E-scooter and PMD registration and certification requirements introduced in an effort to balance safety and further enhancing first and last mile		

		connectivity and encouraging the uptake of active transport (Land Transport Authority, 2025d).
	June 2025	UL2272 certification definition was updated (Land Transport Authority of Singapore, 2025).
Capacity related?	No	No specific differences for devices of different capacities.
Modification related?	Yes	Modifications are prohibited under the Singaporean licensing system for both e-bikes and e-scooters.
Enforcement approach	– Enforcement is through station staff, who may stop commuters from boarding the train if they fail to comply with the rules. Failure to comply with the rules can incur fines up to $500 for each offence. – Fines for riding a non-compliant e-mobility device elsewhere on the network are up to $20,000 or a jail term of up to 24 months, or both	
Further details	– FAQs from the LTA note the folding requirements are to comply with size limits, but do not explicitly state this is due to storage and space reasons. – No evidence has been found on whether the ban includes the batteries themselves, whether installed or carried separately. – Electric wheelchairs and other mobility devices for people living with disability are allowed if they are within 1.5 m x 0.7 m x 1.2 m and <300 kg (Handicaps Welfare Association, 2025). – Storage requirements additionally include that wheels must be wrapped if they are dirty or wet, that protruding parts that may cause injury or damage must be covered/retracted, and that devices should be held or carried.	
Commentary on restrictions		
Commentary	Restrictions are comprehensive and certification and registration apply to e-mobility devices holistically (not just on rail), which is likely to support a high level of compliance.	

Sources: (Land Transport Authority, 2025a; Land Transport Authority, 2025b; Land Transport Authority, 2025c; Land Transport Authority, 2025d; Land Transport Authority, 2025e; Singapore Legal Advice, 2024; SMRT Corporation, 2025)

The LTA have published rules and guidelines on ‘personal mobility devices’ on rail which summarises the approach outlined in this table (Land Transport Authority, 2025c).

4.9.3 Other Singaporean rail operators’ approaches

SBS Transit is one of Singapore’s largest public transport operators, it is responsible for the transport lines that are not operated by SMRT. It operates two Mass Rapid Transit lines and two Light Rail Transit lines under the LTA (SBS Transit, 2025). As SBS Transit operates under the LTA, it follows the same rules as SMRT; e-bikes and e-scooters are allowed on all trains provided they are folded and remain within size limits of 120 cm by 70 cm by 40 cm (Land Transport Authority, 2025c).

5. Risk and cost analysis

5.1 Control measure assessment

Table 5-4 provides a summary of all the control measures identified in the international review, along with a high-level assessment of their indicative cost and effectiveness based on information reviewed and professional judgment. Details about the control measures are as follows:

– Some control measures reduce the likelihood of an incident occurring (e.g. prohibiting e-mobility devices), some measures reduce the consequences of an incident such as injuries or fatalities (e.g. separating e-mobility devices from passengers).
– In many cases, a number of control measures would be implemented together. For example security screening would be used alongside a specific prohibition or restriction.
– Some control measures are related to Escalation Factors (e.g. controls which help to manage e-mobility device non-compliance). Refer to Section 5.2 for more information on Escalation Factors and refer to Appendix A where the controls relating to Escalation Factors are presented in the bowtie diagram.

Control measures were assessed for cost and effectiveness:

– The cost of control measures for the RTO has been evaluated in a qualitative way, considering the necessary infrastructure and analysis needed to put the control measure in place. Costs are typically low for control measures which have been introduced to date, as they largely rely on existing systems and enforcement practices. It is acknowledged that RTO costs are only part of the total cost for some control measures. Additional costs to other parties (such as government or manufacturers) are not considered here. For example, it is assumed that the cost associated with establishing and maintaining a product safety certification scheme would not be borne by the RTO.
– The effectiveness of control measures has been evaluated in a qualitative way, considering how much the control measure will effectively reduce the likelihood of the incident or consequence occurring. Some control measures have operational enforcement challenges, such as identifying particular battery sizes or type of device. The effectiveness is stated independently of how well control measures are understood, complied with and enforced. Separately, whether the enforcement challenges are high, medium or low is stated in Table 5-4. It should be noted that some of these control measures could be supported, or even made redundant, by wider regulations on e-mobility device manufacturers.

The cost, effectiveness and enforcement challenges have been classified as high, medium or low, as described in Table 5-1, Table 5-2 and Table 5-3. Low levels of cost and enforcement challenges are positive, so have been coloured green, with high coloured red. Conversely, a low level of effectiveness is problematic, so low has been coloured red, and high as green. These aspects of cost and effectiveness have been rated individually, rather than providing a single overall rating which over-simplifies the complexity of each measure.

Table 5-1: Cost assessment attributes

Cost Assessment	Description
Low	Minimal effort from the operator to implement (e.g. signage, bans). This does not consider costs associated with enforcement, or costs borne by third parties.
Medium	A more substantial, but not significant, cost required from the operator to implement (e.g. evacuation planning, dedicated areas for e-mobility devices within existing rolling stock carriages).
High	Significant cost required from the operator to implement (e.g. dedicated rolling stock carriages for active transport and e-mobility devices where these are not already in place).

Table 5-2: Effectiveness assessment attributes

Effectiveness Assessment	Description
Low	Control will not significantly reduce the likelihood of the consequence occurring (e.g. restricting e-mobility devices with a battery above a particular size) and/or the impact of an incident.
Medium	Control is somewhat effective at reducing the likelihood of the consequence occurring (e.g. separating e-mobility devices from passengers in a separate carriage) and/or the impact of an incident.
High	Control is very effective at reducing the likelihood of the consequence occurring (e.g. total prohibition of e-mobility devices on the rail network) and/or the impact of an incident.

Table 5-3: Compliance and enforcement challenges

Enforcement Challenges	Description
Low	Enforcement requires minimal additional resources to avoid non-compliances and is straightforward.
Medium	Enforcement requires some additional resources or methods to avoid non-compliances, or moderate challenges with ability to enforce.
High	Likelihood of non-compliance is high without significant additional enforcement resources or methods, or significant practical challenges with enforcement.

Table 5-4: List of possible controls for e-mobility device risks on rail, indicative cost and effectiveness

Control measure	Addresses likelihood vs consequence	Indicative cost to RTOs	Effectiveness independent of compliance challenges*	Enforcement challenges for RTOs	Subject jurisdiction									Commentary
					Toronto	NYC	London	Netherlands	Hamburg	Madrid	China	Singapore	Other	
Ban all e-mobility devices from train networks	Reduces likelihood of incident	Low	High	Medium	-	-	-	-	-	-	-	-	x	Removes risks from both e-scooters and e-bikes. Clear to enforce as all devices treated the same. No need to determine if a device is modified or a certain capacity etc. Effectiveness highest if carriage of device batteries separately is also prohibited. **Other jurisdiction**: The Port Authority Trans-Hudson (PATH) rail system connecting New York City and New Jersey, USA.
Ban e-scooters from train networks (but not other e-mobility devices)	Reduces likelihood of incident	Low	Medium	Medium	-	-	x	-	x	x	-	-	-	Removes the likelihood of e-scooter incidents, but not e-bike incidents.
Ban converted e-mobility devices from train networks	Reduces likelihood of incident	Low	Medium	High	-	x	x	-	-	-	-	x	x	Hard to identify devices and enforce. Only partially mitigates risks. **Other jurisdictions**: Sydney Trains, Sydney Metro and NSW TrainLink, Sydney NSW. Metro and V/Line, Victoria.
Ban modified e-mobility devices from train networks	Reduces likelihood of incident	Low	Medium	High	-	-	-	-	-	-	-	-	x	Hard to identify devices and enforce. Only partially mitigates risks. Certification requirements mean modified devices are effectively prohbiitied. **Other jurisdiction**: Adelaide Metro, South Australia (modified e-bikes, e-scooters and other e-mobility devices prohibited).
Ban non-folding e-mobility devices from train networks	Reduces likelihood of incident	Low	Medium	Medium	-	-	x	-	-	-	-	-	-	Removes risk from non-folding e-bikes only. TfL research found folding e-bikes are unlikely to be converted, so addresses risk from converted devices.
Assign a ticket type for passengers with e-mobility devices, to monitor compliance	Reduces likelihood of incident. Escalation Factor control	Medium	Low	Medium	-	-	-	x	-	-	-	-	-	Administrative measure, mainly linked to space issues for all bicycles. Does not change risk level. The Netherlands' approach also applies to all bicycles, for space related reasons.
Restrict e-mobility devices with a battery above a particular size (Wh)	Reduces consequences of incident. Escalation Factor control	Low	Low	Medium	-	-	-	-	-	-	x	-	-	Aligned with airline regulations. Risk remains for smaller devices. May be challenging to enforce if devices not clearly labelled.
Restrict e-mobility devices above a particular physical size (cm)	Reduces consequences of incident. Escalation Factor control.	Low	Low	Medium	-	x	-	x	-	-	-	x	-	Risk remains for smaller devices. Smaller devices likely need less power, so battery size is likely to be smaller.
Restrict e-mobility devices during peak hours	Reduces consequences of incident. Escalation Factor control	Low	Medium	Medium	x	x	-	x	x	-	-	-	-	Reduces risks only at peak times when services may be busier and incidents would have greater impact. Does not address risk at other times.
Ban e-mobility devices during winter months (when gritting occurs)	Reduces likelihood of incident. Escalation Factor control	Low	Medium	Medium	x	-	-	-	-	-	-	-	-	Evidence unclear on how risks change seasonally. Does not address risks in summer months.
Separate e-mobility devices from passengers in a dedicated carriage	Reduces consequences of incident (on people)	High	Further investigation required and potential mixed impacts – see notes.	Medium	-	-	-	-	-	-	-	-	x	Reduced immediate impact of incident on people. However, this approach may increase the severity of an incident if thermal runaway propagates between different e-mobility devices in close proximity. This needs further understanding. **Other jurisdiction**: Go Transit, Toronto, Canada.
Implement a designated area for e-mobility devices on rolling stock carriages (with passengers)	Reduces consequences of incident. Escalation Factor control.	Medium	Further investigation required and potential mixed impacts – see notes.	Medium	-	-	-	x	-	-	-	-	-	Would allow fire suppression measures to be targeted (see below), separates passenger from incident and may support improved evacuation practices. May also result in larger scale incident as thermal runaway in one battery can spread to others in close proximity.

Control measure	Addresses likelihood vs consequence	Indicative cost to RTOs	Effectiveness independent of compliance challenges*	Enforcement challenges for RTOs	Subject jurisdiction									Commentary
					Toronto	NYC	London	Netherlands	Hamburg	Madrid	China	Singapore	Other	
Designated area for e-mobility devices that has additional fire ratings and fire controls	Reduces consequences of incident	Medium	Medium	N/A	-	-	-	-	-	-	-	-	x	As above. Toronto – new Go Transit train carriages equipped with fire retardant to slow or stop the spread of flames **Other jurisdiction**: Go Transit, Toronto, Canada.
Design rolling stock carriages with increased design fire load according to e-mobility fire modelling research	Reduces consequences of incident	Unknown. Potentially medium	Medium	N/A	-	-	-	-	-	-	-	-	-	Needs further research to understand effectiveness of current measures for LiB thermal runaway, additional systems needed and cost. Existing fire modelling techniques may need modification. Could focus suppression on designated storage areas. No confirmed examples (GHD suggestion).
Batteries must be detached and individually protected (e.g. in a certified battery bag)	Reduces likelihood of incident	Low	Medium	Medium	-	-	-	-	-	-	x	-	-	Likely effective in containing fire if certified and safe battery storage is used, however off-gassing still occurs. May be practical issues with enforcement. Further evidence needed to confirm effectiveness.
Ban blockage of egress path with a e-mobility device or locking an e-mobility device up within a train	Reduces consequences of incident. Escalation Factor control.	Low	Low	Medium	-	-	-	x	-	-	-	x	-	Challenging to enforce.
National level certification requirements for e-mobility devices	Reduces likelihood of incident	Low	High	Medium	-	x	x	x	x	x	x	x	-	Enforced at national level. Challenges relate to illegally modified or converted devices, or devices sold prior to certification rules coming into effect, therefore Medium enforcement challenges. National regulation of both e-bikes and e-scooters is present in Singapore, the Netherlands, Germany and Spain.
Ban charging of e-mobility devices on trains	Reduces likelihood of incident	Low	Low	Medium	-	x	-	-	-	-	x	-	-	Reduces risk associated with incidents during charging (e.g. from overcharging or faulty chargers), but not other causes.
Remove or block power points on trains	Reduces likelihood of incident. Escalation Factor control.	Low	Medium	N/A	-	-	-	-	-	-	-	-	-	Will physically prohibit charging taking place. May have adverse consequences for other passengers (e.g. for charging laptops). No confirmed examples.
Implement an evacuation strategy plan that considers potential thermal runaway of an e-mobility device	Reduces consequences of incident	Medium	Medium	N/A	-	-	-	-	-	-	-	-	-	Plan should be broadly aligned with existing emergency procedures and EN50553 (Railway applications – Requirements for running capability in case of fire on board of rolling stock). Should include specific consideration of thermal runaway. May be low or medium cost if additional modelling and significant change to plans needed. No confirmed examples.
Post-incident removal or cleaning of contaminated materials	Reduces consequences of incident	Medium	Unknown – no confirmed examples.	N/A	-	-	-	-	-	-	-	-	-	Some anecdotal evidence suggests inhalation injuries may occur following contact with remnant pollutants from off-gassing on clothing and/or surfaces following a thermal runaway event. This is yet to be verified and greater testing is needed. No confirmed examples.
Education of passengers on the risks of e-mobility devices	Reduces likelihood of incident. Escalation Factor control.	Low	Medium	N/A	x	-	x	-	-	-	x	-	-	Wider action beyond rail environment. May have some impact on reducing incident likelihood due to increase in safe practices, and on incident impacts due to increased awareness of warning signs/risks.
Implement security checks including baggage screening at stations for e-mobility devices and their batteries	Reduces likelihood of incident. Escalation Factor control.	High (for new systems)	High	N/A	-	-	-	-	-	-	x	-	-	Highly effective at monitoring compliance. Overall effectiveness will depend on control being monitored. Will incur passenger delay. Cost low (or zero) if security check facilities already apply.
Existing staff to monitor and enforce compliance to e-mobility device rules	Reduces likelihood of incident. Escalation Factor \control.	Low	Depends on specific rule	N/A	x	x	x	x	x	x	x	x	-	Some controls easier to enforce than others. Not including security screening.

*Further research and risk analysis required to verify these effectiveness ratings.

Key: = High cost / low effectiveness / high enforcement challenges. = Medium cost / medium effectiveness / medium enforcement challenges = Low cost / high effectiveness. - = Does not apply. X = control adopted jurisdiction.

5.2 Bowtie analysis

A bowtie diagram is a visual tool to illustrate how hazards are managed and controlled. A top event, representing the point where control is lost over a hazard, sits at the centre, with the left side showing causes that could lead to the top event and the right side showing potential consequences if the event occurs. Between these, the diagram maps preventive controls (on the left) that reduce the likelihood of the hazard event and mitigative controls (on the right) that minimise the impact if it happens.

The bowtie diagram shown in Figure 5-1 represents the risk event of a thermal runaway of an e-mobility device battery on a train. The bowtie diagram includes all possible controls identified as part of this review, and shows the potential effectiveness and cost of each proposed control, consistent with Section 5.1. A SFAIRP assessment could be generated for this hazard by identifying which controls would be adopted and rejected for a particular jurisdiction. This is out of the scope of this review.

In addition to the causes, consequences and controls identified, there are also Escalation Factors, which are factors that could reduce the effectiveness of controls. These have been identified as follows and could be considered when implementing policies and restrictions:

– Non-compliance (e.g. with transit rules, such as passengers carry batteries in their bags or bring banned devices onto the network).
– Non-compliance with charging rules.
– Blockage of egress paths (e.g. passenger locks their e-mobility device to a train in transit, congestion, e-mobility device blocks doors or exits).
– Size of e-mobility device LiB is larger than the fire load supported by train carriage.

Some of the control measures that can be implemented to control these Escalation Factors include:

– Education of passengers on the e-mobility device risks and signs of thermal runaway.
– Security checks including baggage screening at stations support enforcement.
– Assign a ticket type for passengers with e-mobility devices to monitor compliance.
– Remove or block PowerPoints on trains.
– Ban e-mobility devices during peak hours.
– Implement a designated area for e-mobility devices on rolling stock carriages.
– Restrict e-mobility devices with a LiB above a particular size.
– Ban blockage of an egress path with an e-mobility device or locking an e-mobility device up within a train.

The full bowtie diagram, including Escalation Factors and associated controls, is presented in Appendix A.

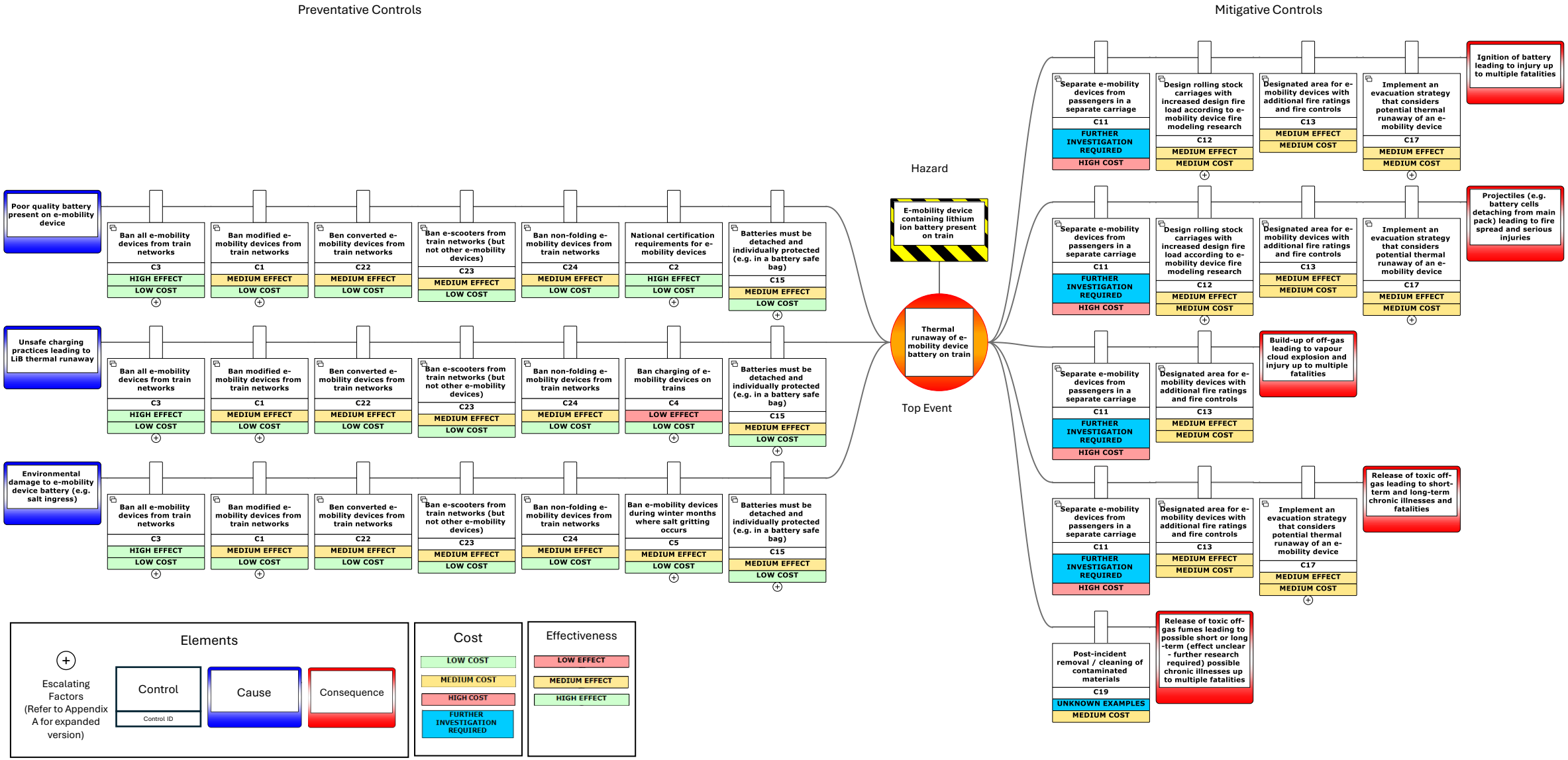


Figure 5-1 Bowtie diagram – Thermal runaway of e-mobility device battery on a train

6. Discussion on global practices

This section summarises a number of themes and lessons arising from the research. These are:

- The wider context on both active travel context and national regulation of e-mobility devices in the jurisdiction is likely to influence the approach taken.
- Many approaches are linked to perceived risk factors such as restricting uncertified or modified devices. It is not clear from the research what level of evidence or research was used to inform the approaches adopted, or how specific decisions were made. Typically, a precautionary approach appears to have been applied, particularly if a thermal runaway incident with an e-mobility device has occurred on rail in the jurisdiction reviewed.
- The majority of approaches are 'bottom-up' from operators, rather than being driven by regulators, and are not covered in national legislation.
- Storage controls typically mirror those for pedal bikes and are predominantly based on space constraints and access rather than LiB considerations. No evidence was found of additional fire alert or suppression systems linked to storage requirements.
- Enforcement is linked to existing practices, through use of rail staff. Aside from signage and information, no specific physical enforcement measures have been introduced.

6.1 Wider context on e-mobility regulation and active travel

It is important to consider the approach to e-mobility devices on rail in the wider context of both LiB regulation and active travel in the city or country in question. Where countries have a higher level of regulation and certification practices in place which have been established for a long time period to increase safety, they are likely to experience less incidents associated with e-mobility devices. As such, they may have reduced risks associated with incidents on public transport and therefore fewer controls.

Some important questions on the regulatory and mobility context include:

- What are the regulation, certification and labelling requirements for e-bikes and how long have these been in place to support safety?
- What are the regulation, certification and labelling requirements for e-scooters and other e-mobility devices and how long have these been in place to support safety?
- What are the regulation and certification requirements for other e-mobility devices and how long have these been in place to support safety?
- Does the RTO restrict other types of bicycles at any time for space or other reasons?
- What storage is provided for pedal bikes and e-mobility devices at stations and in what location(s)? Does this have any additional fire detection or control infrastructure?
- Does the RTO or related transport agency operate any e-mobility device hire schemes or have other policies favourable to e-mobility? Does this change their risk appetite or the need for e-mobility devices on rail?
- What is the cultural context regarding riding and wheeling? (e.g. How high is uptake and what for? Personal commuting vs food delivery services etc)
- Are e-bike or e-scooter hire schemes available to complement a ban on e-mobility devices on rail?

E-mobility is an important part of many end-to-end journeys. When considering restrictions for safety purposes, it is important to also consider accessibility to work, leisure and other opportunities for groups which may depend on these modes. However, many passengers are unaware of the specific LiB (e.g. risks associated with aftermarket modifications) and there is also an important role for increased information and education about this issue more widely.

6.1.1 Approach to e-scooters vs e-bikes

Section 4.1.1 provides a summary of the national regulations for e-bikes and e-scooters in the jurisdictions studied, as well as the high-level approach to their carriage on an example rail network for the subject jurisdictions (see Chapter 4 for further details). This demonstrates:

– An increased level of national regulation overall for e-bikes (in six of eight jurisdictions) compared to e-scooters (present in four of eight jurisdictions).
– All the countries which had a national regulation for e-scooters also had them in place for e-bikes, but the reverse was not true. Transport for London, Hamburger Hochbahn and Metro de Madrid S.A have banned e-scooters without banning e-bikes.
– National regulation for both e-bikes and e-scooters are in place in the EU countries (the Netherlands Germany and Spain). These countries allow standard e-bikes on their networks with relatively few restrictions[2] (other than space-restrictions in the Netherlands). However e-scooters are prohibited on rail in both Hamburg and Madrid.
– Countries may have State-based, Province-based or another geographical basis for their rules, depending on their Governance arrangements. While the USA and Canada do not have national regulation, specific jurisdictions have introduced their own approaches for rail, which is supported by State based regulation in New York.
– E-scooter restrictions on the rail network were identified in seven of the eight jurisdictions studied, of which 3 were total prohibition. In comparison, e-bike restrictions on rail existed in six of the eight jurisdictions, but none of these were total prohibition.

E-scooters are often seen as a higher fire risk due to less regulated batteries and rough handling, whereas e-bikes (especially from reputable brands) often use certified battery systems and face different risk factors, with many fires tied to DIY modifications rather than factory-built bikes (BBC, 2023). The lack of consistent data collection around total device numbers and incidents means it is not possible to have a definitive view on the risk profile of different device types (see Section 6.2).

6.2 Risk-based approach

A lack of standardised incident reporting and forensic data on e-mobility battery failures makes evidence-based policy slow to develop, and does not support operators to act on data, leaving them to rely on a precautionary approach. Better incident data collection, standardised reporting (to capture device type, battery condition, charging status) and controlled testing on carriage environments would inform safer policy.

The restrictions identified were typically implemented in response to incidents either in the subject jurisdiction or in other countries in close proximity. Many of the approaches identified seemed to be linked to perceived risk levels of different types of devices, battery sizes and other factors. It is not clear from the research what level of evidence or research was used to inform the approaches adopted, or how specific decisions were made. Typically, a precautionary approach appears to have been applied.

The most common risk-based approach was only allowing devices certified to recognised standards (e.g. EN15194 and UL2272). This included sub-sets of banning specific devices which are not regulated in the country (e.g. e-scooters in Great Britain) and also banning modified devices which cannot be certified (e.g. MTA and Sydney Trains).

Other examples included limits related to battery capacity, and on specific device sub-types (e.g. folding e-bikes in London). With increased risks associated with larger capacity batteries, China Railways have restrictions related to battery capacity, mirroring those used in the aviation sector.

Other controls such as restrictions in time of day and use or particular carriages or storage areas would also help reduce the impact of incidents but seem to be in place for other practical reasons not related to LiB safety (see below).

[2] While speed pedelecs are prohibited from the rail network, this is because they are classified as mopeds.

6.3 Regulator-led compared to RTO-led actions

Six of the eight jurisdictions reviewed had a regulator with a prescriptive approach, requiring adherence to technical and safety standards (see Table 6-1). Further, in six of the eight countries reviewed, controls on e-mobility on rail were implemented by operators, not regulators. Singapore has implemented legislation about active transport including e-mobility devices. Spain also has an alternative approach with a planning and coordinating authority, Madrid Regional Transport Consortium (CRTM), who have banned e-scooters and e-unicycles on all Metro facilities and trains. Germany, Spain and the Netherlands have all adopted EU legislation related to speed pedelecs.

Although not explored specifically in this study, Union involvement may also play a role in informing the decision making, implementation and enforcement approach of measures related to e-mobility devices on the rail network.

As Australia takes a co-regulatory approach (Office of the National Rail Safety Regulator, 2020), it is expected that the RSNL covers all safety scenarios and would be used as a tool for enforcement without specific legislation. This could be supported by development and issue of fact sheets or guidelines related to the risks associated with e-mobility devices.

Table 6-1: Regulatory approach in subject jurisdictions

Regulator	Subject Jurisdiction	Regulatory Model
Federal Transit Administration	United States of America	Prescriptive
Transport Canada	Canada	Co-regulatory
Office of Rail and Road (ORR)	Great Britain	Co-regulatory
Human Environment and Transport Inspectorate (ILT)	Netherlands	Prescriptive
Eisenbahn-Bundesamt (EBA)	Germany	Prescriptive
Agencia Estatal de Seguridad Ferroviaria (AESF)	Spain	Prescriptive
National Railway Administration (NRA)	China	Prescriptive
Land Transport Authority (LTA)	Singapore	Prescriptive

6.4 Storage controls mirror those for pedal bikes, with some additions

Storage controls for e-mobility devices were identified in most jurisdictions, and typically these align with those already in place for pedal bikes, including dedicated storage areas and restrictions around peak time travel. For example, in some cases like the Netherlands there are e-bike restrictions at peak times, but these are the same for pedal bikes, due to space priorities and allowing passenger movement.

While there would be increased potential injury at peak times of day with more passengers travelling, this is not the primary reason for restrictions around peak-travel (e.g. in Toronto, New York City, the Netherlands, and Hamburg). Similarly, restrictions on using specific carriages or areas for bicycle and e-mobility storage appear to be a more practical operational consideration. No evidence was identified that these measures are related to fire suppression or emergency routes. Several jurisdictions were found to impose requirements in relation to folding e-mobility devices, which also appears to be space related in the case of the Netherlands and Singapore.

6.4.1 Charging during rail travel is generally prohibited

No evidence was found that charging of any e-mobility device while travelling on rail was allowed in any of the subject jurisdictions. In some jurisdictions no specific evidence was found in relation to charging while travelling. Some agencies operate their own hire e-bike networks and have storage for these in proximity to the station environment (e.g. the OV-ebike service run by NS in the Netherlands). Charging is not available at these locations and is handled separately by NS off-site.

6.4.2 Batteries must typically stay on devices for transport

The majority of the jurisdictions studied (with the exception of China) required passengers to leave their batteries in place with their e-mobility device during transport. This was not the case in China, where batteries must be removed and stored individually in ‘battery bags’. While these bags may reduce the impact of a LiB fire, there is currently limited evidence to confirm their effectiveness, and clear safety standards would need to be applied.

6.4.3 Rolling stock and fire suppression

The literature review did not identify any measures taken for rolling stock in terms of retrofitting or incorporation of sprinkler systems inside passenger train carriages for new carriages due to the risk of LiB fires.

The US National Fire Protection Association (NFPA) is a nonprofit organisation that develops and publishes fire safety codes and standards. NFPA standards are widely adopted by jurisdictions and industries worldwide for fire prevention and protection. *NFPA130 Standard for Fixed Guideway Transit and Passenger Rail System* covers fire suppression in the rail environment (National Fire Protection Association, 2023). While it does not explicitly address e-mobility, the same principles apply, including use of fire-resistant materials and early detection sensors.

The NFPA work on LiBs to date has primarily focused on stationary energy storage systems (ESS), and there is not a dedicated code for e-mobility fire suppression. Guidance focuses on safe charging practices, storage away from exits and combustibles and public education.

The US National Fire Sprinkler Association (NFSA) has published guidance on the hazards from LiBs, which suggests fire suppression systems for LiBs in rail depots, but does not cover passenger cars (National Fire Sprinkler Association, 2025). Battery-powered trains have specific fire safety requirements, which vary globally.

6.5 Enforcement practices leverage existing systems

In all cases, enforcement practices are carried out using existing processes, for example via conductors. This means little additional ongoing costs are incurred once measures are established and communicated to passengers. There may be some additional costs associated with increased signage and information provision on the new rules.

RTOs may choose to significantly increase staffing to enforce any new rules, at least in the short term while controls are new. Greater levels of staff presence and clear guidelines to identify any non-compliant e-mobility devices will support enforcement. However, this will also incur additional operational costs.

Where policies require staff to identify battery pack size or other features of e-mobility devices (e.g. modification status) to enforce carriage rules, the variety of privately owned devices and differing battery types, capacities and labelling makes this operationally difficult. Training would likely be needed, as well as periodic refresher sessions as available devices and technology change rapidly over time.

Fines apply for rule breaches, typically ranging from $150 AUD to $2,000 AUD, and people in breach of regulations may be asked to leave the network. In several incidents, such as the New York City subway thermal runaway fire, the device owners left their devices at the scene, resulting in limited information about the events leading up to and during the incident.

Desktop research does not clarify rule enforcement or compliance. There is anecdotal evidence that passengers remove batteries and transport these without their e-bikes and e-scooters, given these are high value parts of the devices. Effective restrictions should address both devices and batteries, since detached batteries still pose a thermal runaway risk. Of eight jurisdictions studied, three regulate separate LiBs from e-mobility devices, while five do not specify this.

Where there is specific screening in place, for example on China Railways, this was already in place for wider security reasons. Adding additional screening and enforcement for e-mobility regulation compliance at scale on busy rail networks is expensive and resource intensive and may cause both costs and delays to passengers.

7. Conclusions

7.1 Conclusions

7.1.1 International review findings

Overall, the case studies and other incidents of thermal runaway occurring globally on e-mobility devices in the rail environment highlight the need for a robust assessment of the risks and consideration of the appropriate response for each jurisdictions' circumstances.

Globally, there are a wide range of different approaches to the restriction and management of e-mobility devices on rail networks. In most cases restrictions are in response to safety risks posed by LiBs, but in some cases these are aligned to wider approaches to pedal bikes on trains, for example for space related reasons.

Agencies typically differentiate between e-bikes and e-scooters, with 'other' e-mobility devices typically either separate or grouped with e-scooters.

In six of the eight jurisdictions, controls on e-mobility on rail were implemented by operators, rather than regulators. Singapore has implemented legislation about active transport including e-mobility devices, and Spain has alternative approach – a planning and coordinating authority, Madrid Regional Transport Consortium (CRTM) – who have banned e-scooters and e-unicycles on all Metro facilities and trains.

Control measures range in their costs and effectiveness. Costs are typically low for measures which have been introduced to date, as they largely rely on existing systems and enforcement practices. Some measures reduce the likelihood of incidents occurring (e.g. prohibiting e-mobility devices), some reduce the severity of incidents (e.g. prohibiting only larger size devices) and others address both issues (e.g. the use of battery bags for devices under a certain size in China).

7.1.2 Application to Australia

Under RSNL, RTOs must implement a Safety Management System (SMS) and demonstrate that their risks are eliminated or if that is not possible, managed So Far As Is Reasonably Practicable (SFAIRP). Thermal runaway in e-mobility devices in the rail environment is a known risk. Several events have occurred in Australia (see Section 3.2), and the consequences can be serious. With increasing uptake of e-mobility devices, the likelihood of further incidents is increasing, particularly in the absence of increasing regulation for e-scooters, and also e-bikes outside of NSW. Although there have not been fatalities associated with thermal runaway in e-mobility devices in the rail environment to date, this is possible. Some inhalation injuries have been observed in footage of incidents, but severity is not able to be verified.

RTOs can reasonably be expected to have considered and documented an approach to manage the risk of thermal runaway in e-mobility devices in the rail environment within their SMS using a risk-based approach. This should consider:

– Risk identification – using the best available information (locally and globally).
– Risk likelihood and consequence assessment.
– Systematic and comprehensive consideration and assessment of all available controls.
– Rationale for decisions made on controls – both adopted and rejected (including within wider mobility context).
– How the approach aligns with SFAIRP management approach.
– Residual risk.
– Actions to further mitigate residual risks (e.g. thermal runaway specific incident response procedures).

It is good practice for transport agencies to develop and review their policies in collaboration with emergency services, in order to best understand hazards, risks and feasible emergency response.

It is worth noting that RTOs are often part of wider transport organisations which focus on multi-modal operations and end-to-end journey for their passengers. Decision making about e-mobility devices on rail will also likely

consider the wider context of usage of these devices to support accessibility and the ability to generate an income (e.g. for delivery riders) in the context of the wider role of e-mobility.

There is a lack of awareness from the public of the risk that e-mobility devices pose, and evidence of unsafe practices from both survey results (NSW EPA, 2025) and known incidents.

Australian safety standards for e-bikes are currently being considered as part of the Road Vehicle Standards Amendments (Safer E-bikes) Bill. Standards like this could reduce the risk that e-mobility devices pose on the rail network and, therefore, reduce the need for prohibitive controls on the rail network. ONRSR and RTOs should liaise closely with government counterparts to understand the flow-on effect of regulations and standards imposed on manufacturers, roads and the e-mobility device industry to rail.

References

ABC News, 2023. *Fat bikes numbers in Sydney on the rise, but e-rideable safety sparks concern.* [Online]
Available at: https://www.abc.net.au/news/2023-09-13/fat-bike-boom-in-sydney-sparks-safety-fears/102823330
[Accessed 16 January 2026].
ABC, 2025. *E-bike battery behind fatal house fire at Guildford in Sydney's west.* [Online]
Available at: https://www.abc.net.au/news/2025-02-18/nsw-fatal-house-guildford-fire-ebike-battery/104948908
[Accessed November 2025].
Adelaide Metro, 2025. *Taking items on board.* [Online]
Available at: https://www.adelaidemetro.com.au/how-to-use-public-transport/taking-items-on-board
[Accessed 14 November 2025].
American Public Transportation Association, 2025. *Public Transportation Ridership Report,* Washington, DC: American Public Transportation Association.
Amtrak, 2025. *Bring Your Bicycle Onboard.* [Online]
Available at: https://www.amtrak.com/bring-your-bicycle-onboard
[Accessed 9 December 2025].
Australian Competition and Consumer Commission, 2023. *Lithium-ion batteries and consumer product safety,* Canberra: Australian Competition and Consumer Commission .
Austroads, 2025. *Incident response for low and zero emission vehicles, Research Report AP-R746-25,* Sydney: Austroads.
Autoritat del Transport Metropolità, 2023. *Temporary ban on electric scooters on public transport.* [Online]
Available at: https://www.atm.cat/en/w/np_
[Accessed November 2025].
Autoritat del Transport Metropolità, 2025a. *Autoritat del Transport Metropolità.* [Online]
Available at: https://www.atm.cat/en/atm/the-consortium
[Accessed 9 December 2025].
Autoritat del Transport Metropolità, 2025b. *Frequently Asked Questions.* [Online]
Available at: https://www.atm.cat/en/atencio-informacio/atencio-a-persones-usuaries/preguntes-frequents
[Accessed November 2025].
Avanti West Coast, 2025. *Bikes.* [Online]
Available at: https://www.avantiwestcoast.co.uk/travel-information/onboard/bikes
[Accessed 26 November 2025].
Barcelona Metro Bus Rodalies, 2024. *What is Bicibox and how much does it cost?.* [Online]
Available at: https://www.barcelonametrobusrodalies.com/que-es-y-cuanto-cuesta-bicibox/
[Accessed November 2025].
BBC, 2021. *E-scooters: Fire on Tube prompts call for London transport ban.* [Online]
Available at: https://www.bbc.com/news/uk-england-london-59148069
[Accessed 12 December 2025].
BBC, 2023. *E-scooters banned by train operators over fire risk.* [Online]
Available at: https://www.bbc.com/news/articles/c729l54glwro.amp
[Accessed 22 January 2026].
Bellan, R., 2024. *Joco almost died at launch. Now, it's a lifeline for e-bike delivery riders — and a profitable business.* [Online]
Available at: https://techcrunch.com/2024/11/30/joco-almost-died-at-launch-now-its-a-lifeline-for-e-bike-delivery-riders-and-a-profitable-business/
[Accessed 20 January 2026].
Bicycle Network, 2025a. *Police fine hundreds of overpowered e-bikes.* [Online]
Available at: https://bicyclenetwork.com.au/newsroom/2025/09/22/police-fine-hundreds-of-overpowered-e-bikes/
[Accessed 27 January 2026].
Bicycle Network, 2025b. *Sydney cracks down on illegal e-bike riders.* [Online]
Available at: https://bicyclenetwork.com.au/newsroom/2025/07/25/sydney-cracks-down-on-illegal-e-bike-riders/
[Accessed 27 January 2026].
Burnell, P., 2024. *E-bike battery fire caused couple's deaths - coroner.* [Online]
Available at: https://www.bbc.com/news/articles/c4gx2n6dl7wo
[Accessed 28 January 2026].
Callan, I. & D'Mello, C., 2024. *New carriages coming to Metrolinx GO trains as part of bike rules review.* [Online]
Available at: https://globalnews.ca/news/10376331/new-carriages-metrolinx-go-trains-bike-rules-review/
[Accessed 9 December 2025].

Campanile, C., 2025. *NYC's new e-bike battery crackdown includes push to confiscate 'uncertified' batteries.* [Online]
Available at: https://nypost.com/2025/09/07/us-news/nycs-new-e-bike-battery-crackdown-includes-push-to-confiscate-uncertified-batteries/
[Accessed 21 January 2026].
Canberra Metro Operations, 2025. *Always keep a safe distance from LRVs!.* [Online]
Available at: https://cmet.com.au/safety/cyclists/
[Accessed 14 November 2025].
Catalan News, 2023. *E-scooters banned from public transport in Barcelona from February 1.* [Online]
Available at: https://www.catalannews.com/society-science/item/e-scooters-banned-from-public-transport-in-barcelona-from-february-1
[Accessed 9 December 2025].
CBC News, 2024. *After subway e-bike blaze, Toronto fire chief shares tips to avoid battery fires.* [Online]
Available at: https://www.cbc.ca/news/canada/toronto/toronto-e-bike-battery-fire-1.7072547
[Accessed November 2025].
Chan, W., 2023. *Four more people just died in an e-bike fire. If nothing changes, they won't be the last.* [Online]
Available at: https://www.theguardian.com/us-news/2023/jun/22/ebike-battery-fire-new-york-gig-workers
[Accessed December 2025].
ChemLinked, 2023. *Chine Releases Guide on Railway Transportation of Consumer-grade Lithium Batteries.* [Online]
Available at: https://chemical.chemlinked.com/news/chemical-news/china-releases-guide-on-railway-transportation-of-consumer-grade-lithium-batteries
[Accessed 9 December 2025].
Chung, J., 2025. *Alarming e-bike delivery rider behaviour revealed in new study.* [Online]
Available at: https://www.news.com.au/technology/motoring/alarming-ebike-delivery-rider-behaviour-revealed-in-new-study/news-story/79c02077e1b6d56e23f26b1064e35f27
[Accessed 20 January 2026].
City of Darwin, 2025. *E-scooters & E-bikes.* [Online]
Available at: https://www.darwin.nt.gov.au/community/about-darwin/getting-around/e-scooters-e-bikes
[Accessed 12 January 2026].
City of Toronto, 2025. *Toronto Transit Commission.* [Online]
Available at: https://www.toronto.ca/city-government/accountability-operations-customer-service/city-administration/city-managers-office/agencies-corporations/agencies/toronto-transit-commission/
[Accessed November 2025].
City Transit Data, 2025. *Barcelona.* [Online]
Available at: https://citytransit.uitp.org/barcelona
[Accessed November 2025].
CityNews, 2024. *E-bike fire on subway sparks safety concerns.* Toronto: CityNews.
Consorcio Transportes Madrid, 2025a. *About us.* [Online]
Available at: https://www.crtm.es/conocenos/
[Accessed 9 December 2025].
Consorcio Transportes Madrid, 2025b. *Metro Network.* [Online]
Available at: https://www.crtm.es/tu-transporte-publico/metro/?lang=en
[Accessed 9 December 2025].
Consumer Product Safety Commission, 2025. *CPSC Warns Consumers to Immediately Stop Using Swagtron SG-5 Swagger 5 Boost Commuter Electric Scooters Due to Fire and Burn Hazards; Risk of Serious Injury and Death.* [Online]
Available at: https://www.cpsc.gov/Warnings/2025/CPSC-Warns-Consumers-to-Immediately-Stop-Using-Swagtron-SG-5-Swagger-5-Boost-Commuter-Electric-Scooters-Due-to-Fire-and-Burn-Hazards-Risk-of-Serious-Injury-and-Death
[Accessed 20 January 2026].
Delbosc, A., Rose, G. & Lawrence, B., 2025. *Commercial e-bikes and the application of regulations,* Melbourne: Victorian Automotive Chamber of Commerce.
DiroDi, 2025. *DiroDi Rover Pro.* [Online]
Available at: https://dirodi.com.au/shop/dirodi-rover-pro-1669?category=28#attr=4399,4397,4398,4403,4401,4402,4404,4468,4400,4469,4405,4475,4476,4491,4470,4406,4409,4407,4408,4421,4417,4416,4412,4410,4415,4480,4414,4411,4413,4481,4422,4425,4423,4482,4427,4428,4429,4430
[Accessed 16 January 2026].

Ellio, 2026. *Ellio Original.* [Online]
Available at: https://www.rideellio.com/model/ellio-original-step-through
[Accessed 16 January 2026].
Ensor, J., 2023. *New DGT Rules Target Spain's Scooter Users.* [Online]
Available at: https://euroweeklynews.com/2023/12/05/new-dgt-rules-target-spains-scooter-users/
[Accessed 24 November 2025].
ESU Vehicle, 2025. *2025 China E-Bike Latest Policy & Practical Guide.* [Online]
Available at: https://www.e-techpro.com/news/blog/industry-news/2025-china-e-bike-policy-buying-guide-new-standards-safety.html
[Accessed 22 January 2026].
European Commission, 2025a. *EMT Madrid achieves record-breaking passenger numbers in 2024.* [Online]
Available at: https://urban-mobility-observatory.transport.ec.europa.eu/news-events/news/emt-madrid-achieves-record-breaking-passenger-numbers-2024-2025-01-29_en
[Accessed 19 January 2026].
European Commission, 2025b. *Regulatory bodies.* [Online]
Available at: https://transport.ec.europa.eu/transport-modes/rail/market/regulatory-bodies_en
[Accessed 9 December 2025].
European Union, 2013. *EUR-Lex.* [Online]
Available at: https://eur-lex.europa.eu/eli/reg/2013/168/oj/eng
[Accessed 16 January 2026].
Federal Motor Transport Authority, 2025. *Personal Light Electric Vehicles.* [Online]
Available at:
https://www.kba.de/EN/Themen_en/Typgenehmigung_en/Informationen_TGV_en/ABE_Elektrokleinstfahrzeuge_en/ABE_Elektrokleinstfahrzeuge_node_en.html
[Accessed 24 November 2025].
Federal Railway Authority, 2025. *The Federal Railway Authority.* [Online]
Available at: https://www.eba.bund.de/EN/home_node.html
[Accessed 9 December 2025].
Fire and Rescue New South Wales, 2024a. *Appeal for extra caution around battery use after apparent first Lithium-Ion fire deaths in NSW - Teralba.* [Online]
Available at: https://www.fire.nsw.gov.au/incident.php?record=recoIEO1Vo689xrem
[Accessed November 2025].
Fire and Rescue New South Wales, 2024b. *Lithium-Ion Battery Incidents,* Sydney: Fire and Rescue New South Wales.
Fire Engineering, 2025. *Battery Fires and Micromobility Bans: When Will MTA Act?.* [Online]
Available at: https://www.fireengineering.com/fire-safety/fire-prevention/battery-fires-and-micromobility-bans-when-will-mta-act/
[Accessed November 2025].
Fire Rescue Victoria, 2023. *Victorian fire agencies and regulator urge caution over lithium-ion battery fire risks.* [Online]
Available at: https://www.frv.vic.gov.au/victorian-fire-agencies-and-regulator-urge-caution-over-lithium-ion-battery-fire-risks
[Accessed November 2025].
Gazelle Bikes, 2026. *Eclipse Speed.* [Online]
Available at: https://www.gazellebikes.com/nl-be/elektrische-fietsen/eclipse-speed
[Accessed 21 January 2026].
German Rails, 2025. *Railways Policies.* [Online]
Available at: https://germanrails.com/en/faq/railways-policies/can-i-take-my-scooter-on-the-train
[Accessed 26 November 2025].
GO Transit, 2023. *SCOOTY e-Scooter Rentals Are Now Live in Brampton.* [Online]
Available at: https://www.gotransit.com/en/partners-and-promotions/scooty-e-scooters
GO Transit, 2024. *Metrolinx Bicycle Policy.* [Online]
Available at: https://www.gotransit.com/en/your-commute-to-go/biking-and-go-transit/bicycle-policy
Government of Canada, 2019. *The Railway Safety Act.* [Online]
Available at: https://tc.canada.ca/en/rail-transportation/rail-safety-canada/railway-safety-act
[Accessed November 2025].
Government of Canada, 2020. *Rail transportation.* [Online]
Available at: https://tc.canada.ca/en/rail-transportation
[Accessed November 2025].

Government of Canada, 2025. *Canadian Transportation Agency.* [Online]
Available at: https://www.canada.ca/en/transportation-agency.html
[Accessed November 2025].
Government of South Australia, 2022. *Lithium-ion battery fire spike sparks new campaign.* [Online]
Available at: https://www.premier.sa.gov.au/media-releases/news-archive/lithium-ion-battery-fire-spike-sparks-new-campaign#:~:text=Over%20the%20past%20five%20years%2C%20MFS%20callouts,mobility%20devices%20such%20as%20e%2Dbikes%20and%20e%2Dscooters
[Accessed 27 January 2026].
Government of South Australia, 2025. *Personal mobility devices.* [Online]
Available at: https://www.sa.gov.au/topics/driving-and-transport/cycling/motorised-wheeled-recreational-devices
[Accessed 12 January 2026].
Government of South Australia, 2025. *Riding a power-assisted bicycle.* [Online]
Available at: https://www.sa.gov.au/topics/driving-and-transport/cycling/riding-a-power-assisted-bicycle
[Accessed 19 January 2026].
Government of Western Australia, 2024. *Authorities warn home fires by lithium-ion batteries on the rise.* [Online]
Available at: https://www.wa.gov.au/government/media-statements/Cook%20Labor%20Government/Authorities-warn-home-fires-by-lithium-ion-batteries-on-the-rise-20240614
[Accessed December 2025].
Greater London Authority, 2025. *E-Bike Enforcement.* [Online]
Available at: https://www.london.gov.uk/who-we-are/what-london-assembly-does/questions-mayor/find-an-answer/e-bike-enforcement
[Accessed 9 December 2025].
Hamburger Verkehrsverbund, 2025. *Bicycle transport.* [Online]
Available at: https://www.hvv.de/de/service/fragen-und-antworten/fahrrad
[Accessed November 2025].
Handicaps Welfare Association, 2025. *Personal Mobility Aids (PMAs) for traveling on public buses and trains (Update).* [Online]
Available at: https://hwa.org.sg/2024/02/13/personal-mobility-aids-pmas-for-traveling-on-public-buses-and-trains/
[Accessed 9 December 2025].
Hochbahn, 2023. *No e-scooters in subways.* [Online]
Available at: https://www.hochbahn.de/de/presse/pressemitteilungen/keine-e-scooter-in-u-bahnen-58270
[Accessed 9 December 2025].
Hoey, I., 2025. *Nearly half of e-bike fires in 2024 linked to post-market conversions.* [Online]
Available at: https://internationalfireandsafetyjournal.com/nearly-half-of-e-bike-fires-in-2024-linked-to-post-market-conversions/
[Accessed 23 January 2026].
International Air Transport Association, 2025. *Battery Guidance Document,* Montreal: International Air Transport Association.
Iryo, 2025. *Railway policies.* [Online]
Available at: https://railyo.com/en/faq/railways-policies/can-i-take-my-bike-on-the-train
[Accessed 26 November 2025].
JOCO, 2026a. *About Us.* [Online]
Available at: https://ridejoco.com/aboutus
[Accessed 20 January 2026].
JOCO, 2026b. *Battery Charging Cabinets.* [Online]
Available at: https://ridejoco.com/charging-cabinet
[Accessed 20 January 2026].
JOCO, 2026c. *Pricing plans.* [Online]
Available at: https://ridejoco.com/pricing-plans
[Accessed 20 January 2026].
Klausner, A., 2016. *MTA bans hoverboards from New York City public transit.* [Online]
Available at: https://www.dailymail.co.uk/news/article-3420810/Hoverboards-banned-NYC-transit-system.html
[Accessed 9 December 2025].
Land Transport Authority of Singapore, 2025. *Active Mobility (Amendment) Regulations 2025,* Singapore: Singapore Statutes Online.
Land Transport Authority, 2025a. *New Rail Financing Framework.* [Online]
Available at:
https://www.lta.gov.sg/content/ltagov/en/who_we_are/our_work/public_transport_system/rail/new_rail_financing_framework.html
[Accessed 14 November 2025].

Land Transport Authority, 2025b. *Power-Assisted Bicycle (PAB).* [Online]
Available at: https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/vehicle-types-and-registrations/PAB.html#technical_requirements
[Accessed 14 November 2025].
Land Transport Authority, 2025c. *Public Education Poster,* Singapore: SBS Transit.
Land Transport Authority, 2025d. *Rules & Code of Conduct.* [Online]
Available at: https://www.lta.gov.sg/content/ltagov/en/getting_around/active_mobility/rules_and_public_education/rules_and_code_of_conduct.html
[Accessed 17 November 2025].
Land Transport Authority, 2025e. *Who We Are.* [Online]
Available at: https://www.lta.gov.sg/content/ltagov/en/who_we_are.html/#our_organisation
[Accessed 20 November 2025].
Land Transport Authority, 2026. *E-scooters.* [Online]
Available at: https://onemotoring.lta.gov.sg/content/onemotoring/home/buying/vehicle-types-and-registrations/E-Scooters.html
[Accessed 19 January 2026].
Latz, P., 2023. *Our First Look at Six Years of E-Bike Import Data.* [Online]
Available at: https://thelatzreport.com.au/news/trade/our-first-look-at-six-years-of-e-bike-import-data/#:~:text=These%20charts%20are%20showing%20that%20e%2Dbike%20imports,peak%20of%20359%2C858%20units%20in%20in%202021%2D22.&text=That%20would%20mean%20that%20for%20the%
[Accessed 6 February 2025].
Leedeo Engineering, 2019. *How is the railway industry organized in Spain?.* [Online]
Available at: https://www.leedeo.es/l/spanish-railway-sector/
[Accessed 9 December 2025].
Levy, M., 2024. *E-scooter ban now also implemented at BVG Berlin.* [Online]
Available at: https://www.urban-transport-magazine.com/en/e-tretroller-vebot-jetzt-auch-bei-der-bvg-berlin/
[Accessed 8 December 2025].
LithiumSafe, 2025. *LithiumSafe™ Battery Bag 750 for safely containing 750 Wh e-bike batteries.* [Online]
Available at: https://www.lithiumsafe.com/fire-safety-bag-e-bike-batteries/
[Accessed 21 November 2025].
London Daily, 2025. *E-scooter riders pay for flouting Tube ban.* [Online]
Available at: https://londondaily.com/e-scooter-riders-pay-for-flouting-tube-ban
[Accessed 9 December 2025].
London Fire Brigade, 2025. *#ChargeSafe: e-bike and e-scooter safety advice..* [Online]
Available at: https://www.london-fire.gov.uk/chargesafe/
[Accessed November 2025].
London North Eastern Railway, 2025. *Travelling with your bike.* [Online]
Available at: https://www.lner.co.uk/our-trains/travelling-with-bicycles/
[Accessed 8 December 2025].
London Northwestern Railway, 2025. *Can I Travel With My Bike Or Scooter On The Train?.* [Online]
Available at: https://www.londonnorthwesternrailway.co.uk/travel-information/onboard-facilities/cycle-spaces
[Accessed 25 November 2025].
MercoPress, 2022. *Faulty lithium batteries caused the fire that killed Jewish family in Buenos Aires.* [Online]
Available at: https://en.mercopress.com/2022/06/25/faulty-lithium-batteries-caused-the-fire-that-killed-jewish-family-in-buenos-aires
[Accessed 27 January 2026].
Metro Line Hub, 2025. *Toronto TTC Metro Real-time Map.* [Online]
Available at: https://www.metrolinehub.com/en/canada/toronto
[Accessed November 2025].
Metro Madrid, 2023. *The Community of Madrid will prevent electric scooters from accessing public transport to ensure the safety of users.* [Online]
Available at: https://www.metromadrid.es/en/press-release/2023-10-27/the-community-of-madrid-will-prevent-electric-scooters-from-accessing-public-transport-to-ensure-the-safety-of-users
[Accessed November 2025].
Metro Madrid, 2024. *The Community of Madrid extends the ban on access to public transport with electric scooters to 2027.* [Online]
Available at: https://www.metromadrid.es/en/press-release/2024-05-31/the-community-of-madrid-extends-the-ban-on-access-to-public-transport-with-electric-scooters-to-2027
[Accessed 9 December 2025].

Metro Madrid, 2025a. *Accessibility.* [Online]
Available at: https://www.metromadrid.es/en/accessibility
[Accessed 9 December 2025].
Metro Madrid, 2025b. *Who we are.* [Online]
Available at: https://www.metromadrid.es/en/who-we-are/we-are-centenary
[Accessed 9 December 2025].
Metropolitan Transport Authority, 2023b. *MTA Announces Policy Permitting Personal Electric Vehicles on Subways, Buses and Commuter Railroads, Fulfilling a Goal of Micromobility Strategic Action Plan.* [Online]
Available at: https://www.mta.info/press-release/mta-announces-policy-permitting-personal-electric-vehicles-subways-buses-and-commuter
[Accessed 9 December 2025].
Metropolitan Transportation Authority, 2023a. *Guidelines for bringing Personal Electric Vehicles (PEV) in MTA systems.* [Online]
Available at: https://www.mta.info/safety-and-security/personal-electric-vehicle-policy
[Accessed 13 November 2025].
Metropolitan Transportation Authority, 2025a. *About the MTA.* [Online]
Available at: https://www.mta.info/about
[Accessed November 2025].
Metropolitan Transportation Authority, 2025b. *Taking your bike on MTA subways, buses, and railroads.* [Online]
Available at:
https://www.mta.info/guides/bikes#:~:text=Bikes%20are%20not%20allowed%20on%20rush%20hour%20trains,across%20some%20MTA%20bridges%20or%20through%20MTA%20tunnels.
[Accessed 13 November 2025].
Ministry of Infrastructure and Water Management, 2022. *Dutch framework for Light Electric Vehicles,* The Hague: Ministry of Infrastructure and Water Management.
Ministry of Transport, 2024. *Written Reply to Parliamentary Question on Checks on Personal Mobility Devices or Power-Assisted Bicycles Before These Are Allowed on Trains.* [Online]
Available at: https://www.mot.gov.sg/news/in-parliament/Details/written-reply-to-parliamentary-question-on-checks-on-personal-mobility-devices-or-power-assisted-bicycles-before-these-are-allowed-on-trains
[Accessed 17 November 2025].
Mordor Intelligence, 2024. *E-bike Market Size & Share Analysis – Growth Trends and Forecast 2025–2030.* [Online]
Available at: https://www.mordorintelligence.com/industry-reports/e-bike-market
[Accessed 10 February 2025].
National Fire Protection Association, 2023. *Standard for Fixed Guideway Transit and Passenger Rail Systems,* Quincy: National Fire Protection Association.
National Fire Sprinkler Association, 2025. *Announcing NFSA's Lithium-Ion Batteries and Fire Sprinklers Guide.* [Online]
Available at: https://nfsa.org/2025/05/05/announcing-nfsas-lithium-ion-batteries-and-fire-sprinklers-guide/
[Accessed 2021 November 2025].
National Railway Administration of the People's Republic of China, 2023. *Guiding opinions of the State Railway Administration, the Ministry of Industry and Information Technology, and China National Railway Group Co., Ltd. on the railway transportation of consumer lithium battery cargo.* [Online]
Available at: https://www.nra.gov.cn/xxgk/gkml/ztjg/gfzd/gfxw/zuti/jgzf/202311/t20231102_343598.shtml
[Accessed 21 January 2026].
National Transport Commission, 2024. *Rail Safety National Law.* [Online]
Available at: https://www.ntc.gov.au/laws-and-regulations/rail-safety-national-law
[Accessed 1 December 2025].
Nederlandse Spoorwegen, 2025a. *Dott shared ebike.* [Online]
Available at: https://www.ns.nl/en/business/door-to-door/shared-bike/dott
[Accessed 11 November 2025].
Nederlandse Spoorwegen, 2025b. *Nederlandse Spoorwegen.* [Online]
Available at: https://www.ns.nl/en
[Accessed November 2025].
Nederlandse Spoorwegen, 2025c. *OV-ebike.* [Online]
Available at: https://www.ns.nl/en/door-to-door/ov-fiets/ov-ebike
[Accessed 11 November 2025].
Nederlandse Spoorwegen, 2025d. *Travelling by train & bicycle.* [Online]
Available at: https://www.ns.nl/en/travel-information/bikes-on-the-train.html
[Accessed 9 December 2025].

New York City Department of Transportation, 2025. *E-Bike Programs.* [Online]
Available at: https://www.nyc.gov/html/dot/html/bicyclists/ebikeprograms.shtml#onsidewalk
[Accessed 9 December 2025].
NJ Transit, 2025. *First/Last Mile Connections: Bikes, E-Bikes, Scooters, and More.* [Online]
Available at: https://www.njtransit.com/bikes
[Accessed 9 December 2025].
Northern Territory Government, 2025. *Electric scooters and bikes.* [Online]
Available at: https://nt.gov.au/driving/safety/electric-scooters-and-bikes
[Accessed 14 November 2025].
NSW EPA, 2025. *Spate of lithium-ion fires and NSW Government survey sparks community wakeup call on battery risks.* [Online]
Available at: https://www.epa.nsw.gov.au/news/epamedia/250210-spate-of-lithium-ion-fires-and-nsw-government-survey-sparks-community-wakeup-call-on-battery-risks
[Accessed 12 December 2025].
NSW Government, 2024. *Inquest to examine deaths and serious fires caused by Lithium-ion batteries.* [Online]
Available at: https://dcj.nsw.gov.au/news-and-media/media-releases/2024/inquest-to-examine-deaths-and-serious-fires-caused-by-lithium-io.html
[Accessed November 2025].
NSW Government, 2025a. *Legalising e-scooter riding in public places.* [Online]
Available at: https://www.nsw.gov.au/driving-boating-and-transport/bikes-e-bikes-e-scooters/e-micromobility-action-plan/related-projects-programs/legalising-e-scooter-riding
[Accessed November 2025].
NSW Government, 2025b. *Nation-leading safety and information standards for lithium-ion battery products now in effect.* [Online]
Available at: https://www.nsw.gov.au/ministerial-releases/nation-leading-safety-and-information-standards-for-lithium-ion-battery-products-now-effect
[Accessed 20 November 2025].
NSW Government, 2025c. *Requirements for manufacturers and suppliers of e-micromobility products.* [Online]
Available at: https://www.nsw.gov.au/housing-and-construction/safety-home/electrical-safety/lithium-ion-battery-safety/new-standards-for-lithium-ion-batteries-e-micromobility-devices
[Accessed 20 November 2025].
NSW Government, 2025d. *Riding electric scooters in NSW.* [Online]
Available at: https://www.nsw.gov.au/driving-boating-and-transport/bikes-e-bikes-e-scooters/electric-scooters
[Accessed 8 December 2025].
Office of Rail and Road, 2025a. *The law and our duties.* [Online]
Available at: https://www.orr.gov.uk/about/what-we-do/law-and-our-duties
[Accessed November 2025].
Office of Rail and Road, 2025b. *Train Operating Company key statistics,* London: UK Government.
Office of Rail and Road, 2025c. *What we do.* [Online]
Available at: https://www.orr.gov.uk/about/what-we-do
[Accessed November 2025].
Office of the National Rail Safety Regulator, 2020. *The ONRSR Way.* [Online]
Available at: https://www.onrsr.com.au/operator-essentials/the-onrsr-way
[Accessed 19 January 2026].
Parliament of Australia, 2025. *Road Vehicle Standards Amendment (Safer E-Bikes) Bill 2025.* [Online]
Available at:
https://www.aph.gov.au/Parliamentary_Business/Bills_Legislation/Bills_Search_Results/Result?bId=r7364
[Accessed 20 November 2025].
Police UK, 2025. *E-scooters and electric bikes.* [Online]
Available at: https://www.police.uk/advice/advice-and-information/rs/road-safety/advice-escooters/
[Accessed 24 November 2025].
Public Transportation and Metro Rail Information, 2025. *Hamburg U-Bahn.* [Online]
Available at: https://metroeasy.com/germany/u-bahn-hamburg/
[Accessed November 2025].
Queensland Fire Department, 2025. *Inquiry into e-mobility safety and use in Queensland,* Brisbane: Queensland Government.
Queensland Government, 2025. *Parliamentary inquiry into E-scooter and E-bike safety.* [Online]
Available at: https://www.tmr.qld.gov.au/travel-and-transport/parliamentary-inquiry-into-e-scooter-and-e-bike-safety
[Accessed 14 November 2025].
Queensland Police Service, 2025. *Fatal house fire investigation appeal, Emerald.* [Online]
Available at: https://mypolice.qld.gov.au/news/2025/11/07/fatal-house-fire-investigation-appeal-

emerald/#:~:text=At%206.48am%2C%20emergency%20services,people%20were%20located%20deceased%20inside.
[Accessed December 2025].
Queensland Rail, 2025. *Travelling with your bike or e-scooter.* [Online]
Available at: https://www.queenslandrail.com.au/forcustomers/plan/travelling-with-your-bike
[Accessed 14 November 2025].
Rail Business UK, 2023. *Train operators ban e-scooters because of fire risk.* [Online]
Available at: https://www.railwaygazette.com/uk/train-operators-ban-e-scooters-because-of-fire-risk/64190.article
[Accessed 8 December 2025].
Rail Partners, 2025. *Rail Industry electric bicycle (e-bike) Guidelines,* London: National Rail.
Renfe, 2025. *Bring your bike or scooter on the train.* [Online]
Available at: https://www.renfe.com/es/en/travel/informacion-util/luggage/bicycles-and-kick-scooters-_non-electric_
[Accessed 26 November 2025].
Sacramento Fire, 2025. *Green Sheet: Electrc Vehicle MVA and ensuing fire - causing respiratory injuries to fire fighters,* Sacramento: s.n.
SAM.gov, 2025. *Federal Railroad Administration (FRA).* [Online]
Available at: https://sam.gov/organization/100076812
[Accessed November 2025].
SBS Transit, 2025. *About Us.* [Online]
Available at: https://www.sbstransit.com.sg/about-us
[Accessed 8 December 2025].
Shenk, H. B., 2021. *The PATH Train Just Quietly Banned E-Bikes at All Times.* [Online]
Available at: https://nyc.streetsblog.org/2021/06/23/the-path-train-just-quietly-banned-e-bikes-at-all-times
[Accessed 9 December 2025].
Sibayam, R. R., 2024. *E-bike delivery workers in Hoboken.* [Online]
Available at: https://www.nj.com/galleries/VMHUVWOVFVDOZOXNHYF2S6BQDU/
[Accessed 20 January 2026].
Singapore Legal Advice, 2024. *Guide to E-Scooter and PMD Laws for Singapore Riders.* [Online]
Available at: https://singaporelegaladvice.com/law-articles/e-scooter-laws-singapore
[Accessed 17 November 2025].
SMRT Corporation, 2025. *Network Map.* [Online]
Available at: https://www.smrt.com.sg/public-transport/train-information/network-map/
[Accessed November 2025].
Sound Transit, 2025. *Bringing your bike or scooter.* [Online]
Available at: https://www.soundtransit.org/ride-with-us/know-before-you-go/bikes-scooters
[Accessed 26 November 2025].
Statista, 2025. *Electric Bicycles - Australia.* [Online]
Available at: https://www.statista.com/outlook/mmo/micromobility/bicycles/electric-bicycles/australia#revenue
[Accessed December 2025].
SWOV Institute for Road Safety Research, 2021. *Which LEVs are allowed on Dutch public roads?.* [Online]
Available at: https://swov.nl/en/fact/lev-which-levs-are-allowed-dutch-public-roads
[Accessed January 16 2026].
Tasmanian Government, 2025. *E-bikes in Tasmania.* [Online]
Available at: https://engage.stategrowth.tas.gov.au/e-bike-regulations
[Accessed 14 November 2025].
TfL, n.d. [Online]
Available at: https://tfl.gov.uk/modes/cycling/santander-cycles
[Accessed 30 01 2026].
The Business Research Company, 2025. *Electric Bikes and Scooters Global Market Report 2025.* [Online]
Available at: https://www.thebusinessresearchcompany.com/report/electric-bikes-and-scooters-global-market-report
[Accessed 10 February 2025].
The Olive Press, 2023. *'Explosion' on Madrid's underground Metro: Carriage is left destroyed after faulty E-SCOOTER battery causes blast.* [Online]
Available at: https://www.theolivepress.es/spain-news/2023/10/18/explosion-on-madrids-underground-metro-carriage-is-left-destroyed-after-faulty-e-scooter-battery-causes-blast/
[Accessed November 2025].
The People's Republic of China, 2025. *China releases new e-bike safety standards enforcement guidelines.* [Online]
Available at: https://english.www.gov.cn/news/202507/24/content_WS6881e17ec6d0868f4e8f464b.html
[Accessed 24 November 2025].

Toronto Transit Commission, 2024. *TTC bans e-bikes and e-scooters during winter months.* [Online]
Available at: https://www.ttc.ca/news/2024/December/TTC-bans-e-bikes-and-e-scooters-during-winter-months
[Accessed November 2025].
Toronto Transit Commission, 2025. *Bikes on TTC Vehicles.* [Online]
Available at: https://www.ttc.ca/riding-the-ttc/Bike-and-ride/Taking-your-bike-on-TTC-Vehicles
[Accessed November 2025].
Transperth, 2025. *Taking Items on Board.* [Online]
Available at: https://www.transperth.wa.gov.au/using-transperth/taking-items-on-board
[Accessed 14 November 2025].
Transport for London, 2021. *TfL announces safety ban of e-scooters on transport network.* [Online]
Available at: https://tfl.gov.uk/info-for/media/press-releases/2021/december/tfl-announces-safety-ban-of-e-scooters-on-transport-network
[Accessed 9 December 2025].
Transport for London, 2025a. *London Overground.* [Online]
Available at: https://tfl.gov.uk/modes/london-overground/
[Accessed November 2025].
Transport for London, 2025b. *Cycles on public transport.* [Online]
Available at: https://tfl.gov.uk/modes/cycling/cycles-on-public-transport
[Accessed 9 December 2025].
Transport for London, 2025c. *Cycle parking.* [Online]
Available at: https://tfl.gov.uk/modes/cycling/cycle-parking#on-this-page-0
[Accessed 9 December 2025].
Transport for London, 2025d. *TfL announces safety ban of non-folded e-bikes on its transport network.* [Online]
Available at: https://tfl.gov.uk/info-for/media/press-releases/2025/march/tfl-announces-safety-ban-of-non-folded-e-bikes-on-its-transport-network
[Accessed 9 December 2025].
Transport for London, 2025e. *What we do.* [Online]
Available at: https://tfl.gov.uk/corporate/about-tfl/what-we-do?intcmp=2582#on-this-page-1
[Accessed November 2025].
Transport for NSW, 2025. *E-bike ban on NSW trains and Metro takes effect tomorrow.* [Online]
Available at: https://www.transport.nsw.gov.au/news-and-events/media-releases/e-bike-ban-on-nsw-trains-and-metro-takes-effect-tomorrow
[Accessed 19 January 2026].
Transport for Wales, 2025. *Taking your bike on the train.* [Online]
Available at: https://tfw.wales/ways-to-travel/cycling/bikes-on-board
[Accessed 26 November 2025].
Transport NSW, 2025. *Train passenger update: Converted e-bike ban.* [Online]
Available at: https://transportnsw.info/news/2025/train-passenger-update-converted-e-bike-ban
[Accessed 14 November 2025].
Transport Victoria , 2025. *Bicycles, e-bikes and e-scooters on public transport.* [Online]
Available at: https://transport.vic.gov.au/plan-a-journey/public-transport-tools-and-resources/travel-tips-and-resources/bringing-items-on-public-transport/bicycles-and-public-transport
[Accessed 14 January 2026].
Transports Metropolitans de Barcelona, 2025a. *AMBici.* [Online]
Available at: https://www.tmb.cat/en/barcelona/ambici
[Accessed November 2025].
Transports Metropolitans de Barcelona, 2025b. *Home.* [Online]
Available at: https://www.tmb.cat/en/home
[Accessed 9 December 2025].
Trenitalia, n.d. [Online]
Available at: https://www.trenitalia.com/en/services/travelling-with-your-bike.html
[Accessed 30 01 2026].
Twyford, C. L., 2025. *e-Mobility Safety and Use,* Brisbane: Queensland Family & Child Commission.
U.S. Department of Transportation, 2024. *About FRA.* [Online]
Available at: https://railroads.dot.gov/about-fra/about-fra
[Accessed November 2025].
UK Government, 2024. *EAPC standards and legal requirements.* [Online]
Available at: https://www.gov.uk/government/publications/electrically-assisted-pedal-cycles-eapcs/electrically-assisted-pedal-cycles-eapcs-in-great-britain-information-sheet
[Accessed 24 November 2025].

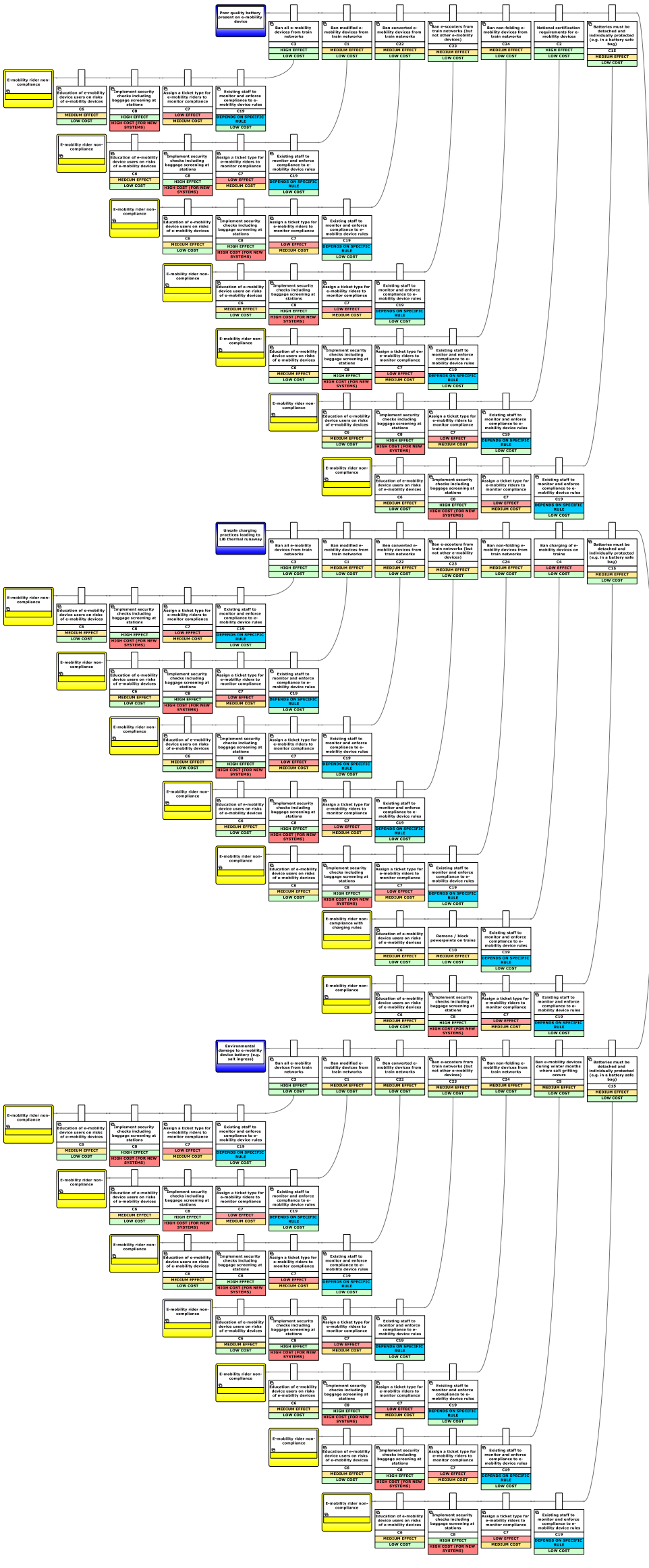
UK Government, 2025. [Online]
Available at: https://www.find-tender.service.gov.uk/Notice/058582-2025
[Accessed 30 01 2026].
UL Research Institutes, 2023. *UL Research Institutes, UL Standards & Engagement, and UL Solutions Commend New York City Council for Lifesaving Micromobility Safety Legislation.* [Online]
Available at: https://ul.org/press-releases/ul-research-institutes-ul-standards-engagement-and-ul-solutions-commend-new-york-city-council-for-lifesaving-micromobility-safety-legislation/
[Accessed 13 November 2025].
UNSW Sydney, 2025. *E-bike popularity is booming. But are they as safe as regular bikes?.* [Online]
Available at: https://www.unsw.edu.au/newsroom/news/2025/01/e-bike-popularity-is-booming-but-are-they-as-safe-as-regular-bikes
[Accessed December 2025].
Vamosi, T. J., 2023. *Toxicology of the Lithium Ion Battery Fire,* Boston: Commonwealth of Massachusetts.
Victoria State Government, 2025. *Conduct on Public Transport Regulations.* [Online]
Available at: https://engage.vic.gov.au/public-transport-regulations
[Accessed 14 November 2025].
We Ride Australia, 2023. *The Australian Cycling and E-Scooter Economy in 2022,* Canberra: We Ride Australia.
Westoll, N. & Mackey, M., 2024. *Toronto subway e-bike fire highlights dangers of incidents involving lithium-ion batteries.* [Online]
Available at: https://toronto.citynews.ca/2024/01/01/ttc-sheppard-yonge-subway-train-fire-ebike-lithium-ion-batteries/
[Accessed November 2025].
Zeus Train, 2024. *Deutsche Bahn (German Railways).* [Online]
Available at: https://zeustrain.com/deutsche-bahn/
[Accessed 8 December 2025].

Appendices

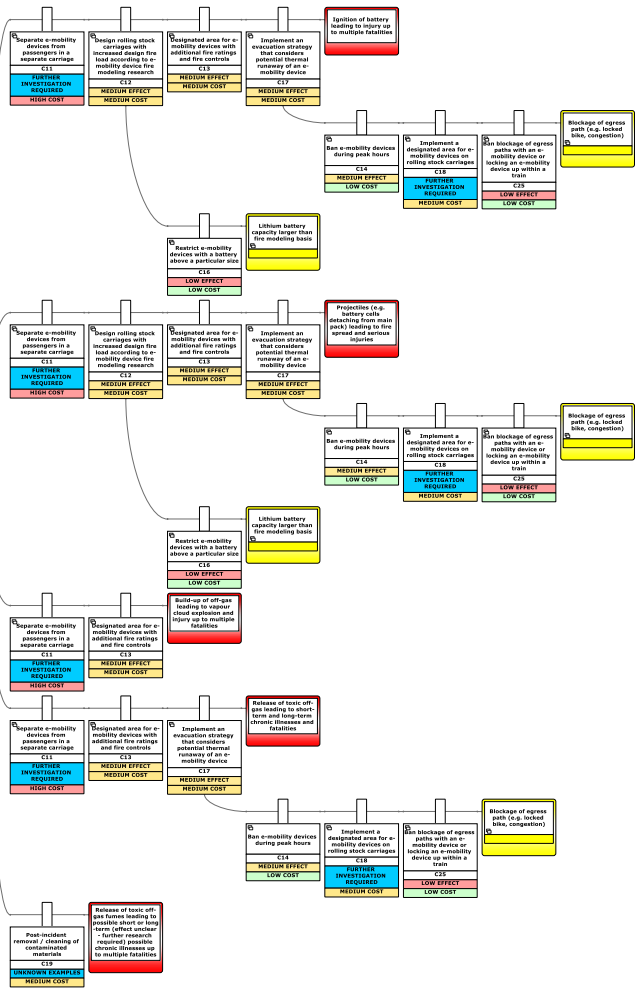
Appendix A

Bowtie diagram

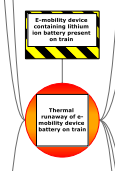
Preventative Controls



Mitigative Controls

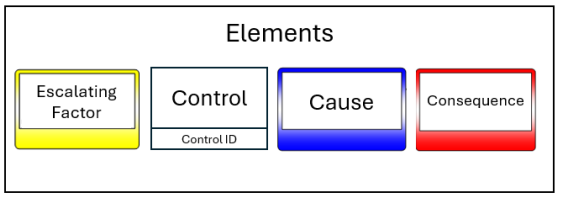


Hazard

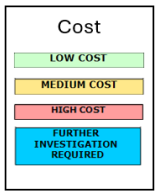


Top Event

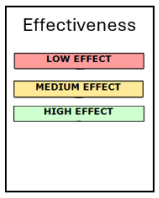
Elements



Cost



Effectiveness



ghd.com

→ The Power of Commitment