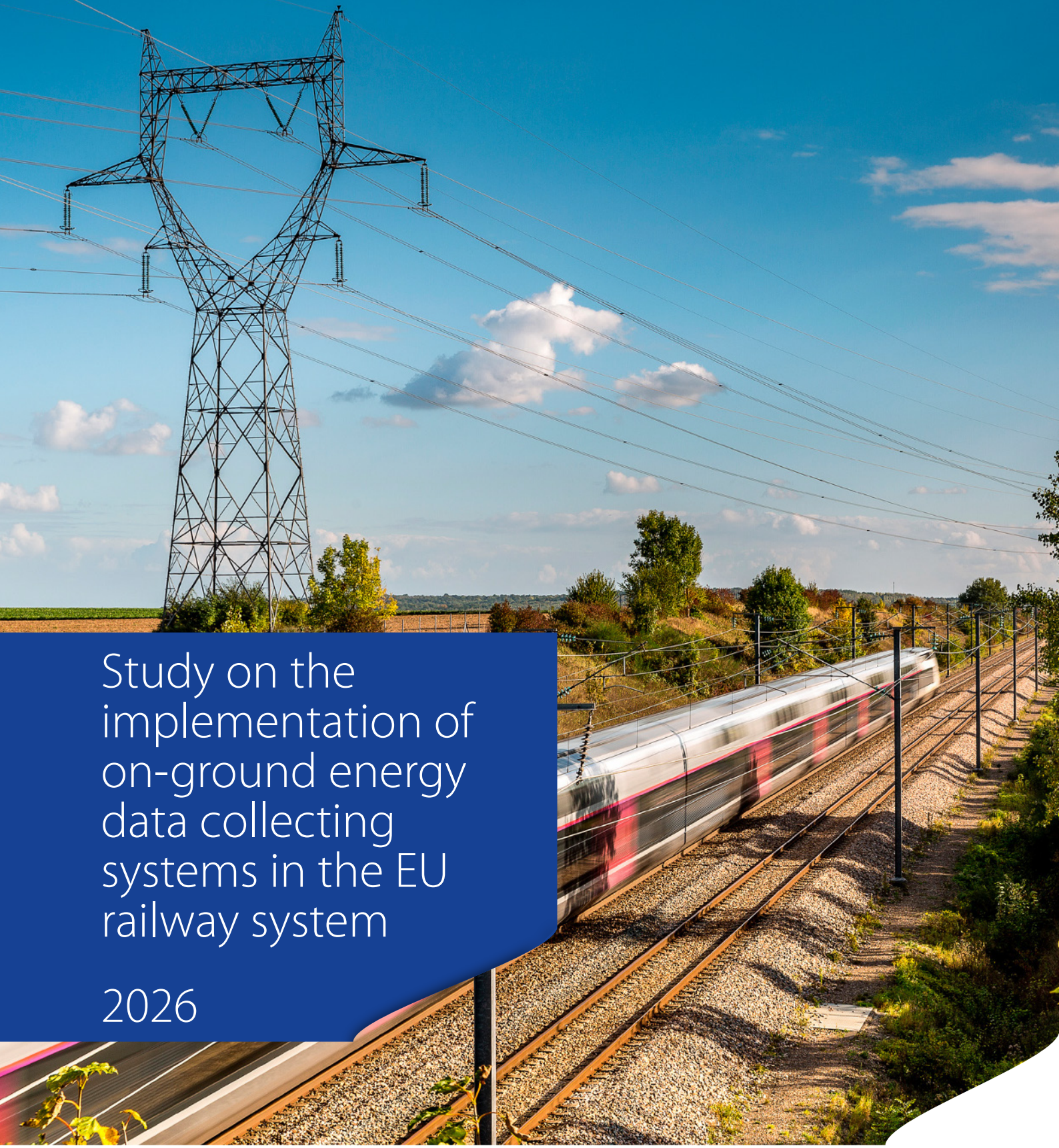

Study on the implementation of on-ground energy data collecting systems in the EU railway system

2026

EUROPEAN UNION AGENCY FOR RAILWAYS

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Contents

1. Glossary

1.1. List of abbreviations

ADIF	Administrador de Infraestructuras Ferroviarias
APIS	authorisation for placing in service rail infrastructure
BNA	Bundesnetzagentur
CEBD	compiled energy billing data
CENELEC	European Committee for Electrotechnical Standardization
DB	Deutsche Bahn
DCS	data collecting system
DeBo	designated body
DECOFER	Décompte Ferroviaire
DHS	data handling system
DSO	distribution system operator
EMF	energy measurement function
EMS	energy measurement system
EN	European Standard
EnWG	Energiewirtschaftsgesetz (Energy Industry Act)
ENE TSI	energy technical specifications for interoperability
ERA	European Union Agency for Railways
ERJU	Europe's Rail Joint Undertaking
EVN	European Vehicle Number
FRMCS	Future Railway Mobile Communication System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
IEC	International Electrotechnical Commission
IM	infrastructure manager
IRS	International Railway Solution
LOC & PAS TSI	locomotives and passengers technical specifications for interoperability
MID	Measuring Instruments Directive
NIP	national implementation plan
NoBo	notified body
NRIC	National Railway Infrastructure Company (Bulgaria)
NSA	national safety authority
ÖBB Infra	Österreichische Bundesbahnen-Infrastruktur
OCL	overhead contact line
PGE EK	Polska Grupa Energetyczna Energetyka Kolejowa
QMS	quality management system
R & D	research and development
RTE	Le Réseau de Transport d'électricité
RU	railway undertaking
SBB Infra	Schweizerische Bundesbahnen Infrastruktur
SNCF Réseau	Société nationale des chemins de fer français Réseau
TAF TSI	telematics applications for freight service technical specifications for interoperability
TEL TSI	technical specification relating to the telematics subsystem of the rail system in the European Union for interoperability of data sharing in rail transport
TAP TSI	telematics applications for passenger service technical specifications for interoperability
TSI	technical specifications for interoperability
TSO	transmission system operator

UIC	International Union of Railways
UTILTS	utilities time series message by the United Nations Directories for Electronic Data Interchange for Administration, Commerce and Transport
VIVENS	United Purchasing and Consumption of Energy on the Dutch Railway Network

1.2. Country codes present in figures

AT	Austria	ES	Spain	LV	Latvia
BE	Belgium	FI	Finland	NL	Netherlands
BG	Bulgaria	FR	France	NO	Norway
CH	Switzerland	HR	Croatia	PL	Poland
CZ	Czechia	HU	Hungary	PT	Portugal
DE	Germany	IE	Ireland	RO	Romania
DK	Denmark	IT	Italy	SE	Sweden
EE	Estonia	LT	Lithuania	SI	Slovenia
EL	Greece	LU	Luxembourg	SK	Slovakia

2. Executive summary

Rail traction energy is a key cost driver for railways and the lack of appropriate metering of energy consumption is detrimental for the energy and cost efficiency of the rail sector. Railways are a major consumer of electricity, but metering is particularly challenging due to the moving nature of trains as consumption points across countries, networks and grids. In fact, rolling stock needs to have installed onboard an energy metering system able to record and transmit consumption data and train positioning to a data collecting system on the ground. This data is then exchanged by different providers across borders and processed for settlement in order to invoice, to the correct railway undertaking, the consumed traction energy. The aim of this study was to evaluate the state-of-play regarding metering of rail traction energy, with a particular focus on the obligations defined since 2020 in energy technical specifications for interoperability (ENE TSI) for data collecting systems. We also investigated the key technical, legal and regulatory challenges for rail energy across the EU and we provided a list of recommendations. From January to December 2025, the EU Agency for Railways (ERA) conducted this study for the European Commission based on the better regulation guidelines and principles. Through desk research, a large web survey of all relevant stakeholders involved in rail traction energy metering and billing, 38 bilateral interviews, workshops and events and the analysis of more than 180 comments on the draft final report of this study, shared in writing and during a workshop by stakeholders, this study delivered on its objectives. By providing detailed findings and a set of 11 recommendations regarding rail traction energy, we have offered a comprehensive overview of the situation.

Among our key findings, we concluded that 13 EU Member States are not in line with ENE TSI either because have not yet set up a data collecting system (DCS) able to receive data from energy measurement systems (EMSs) installed onboard trains or because their DCS is limited to domestic trains and is thus not able to exchange energy consumption data across borders. Only in seven EU Member States can railway undertakings benefit from third-party access and the free choice of their energy supplier. Overall, rail traction energy metering is also affected in some countries by a fragmented implementation of sector-led data models for DCS, data exchange and settlement. Among our recommendations, beside ensuring enforcement of the existing ENE TSI basic requirements, we also called for analysing the opportunity to amend and extend the scope of application of ENE TSI. Most of the problems identified lie in fact in the exchange and settlement functions of energy consumption data which are currently left to self-regulation by the rail sector's standards and agreements. Moreover, there is no full clarity at the EU level on the boundaries between the energy market and the rail market legislation. In fact, rail traction energy infrastructure and rail infrastructure managers may be subject to both or some of the relevant requirements stemming from the energy and rail market legal framework.

A functioning rail traction energy metering system cannot be ensured without suitable and interoperable EMSs. Although installing EMSs on board has been mandatory since 2014, designing them according to the EN 50463 standard by European Committee for Electrotechnical Standardization, we identified that local or corporate requirements at the level of DCSs affect EMS's interoperability. This results in complicated processes for integration and vehicle authorisation but also sometimes in bespoke solutions requiring cross-border locomotives to adapt to different DCSs or even to install multiple EMSs. In our recommendations, we listed to analyse an expanded role of notified bodies for DCSs and EMSs and to consider the option of making EMSs an interoperability constituent for facilitating certification, authorisation and to ensure EMS cross-acceptance. It should also be clarified if the Measurement Instruments Directive (MID) is applicable to EMSs and how the requirements of EU cybersecurity legislation should be considered.

3. Background

3.1. Energy metering in railways

In 2022 electrified lines represented 57.4 % of the total railway lines in the EU, with the electrified railway network estimated to be approximately 115 442 km long ([1]). Electrification increased by 31 % in 2022 compared to 1990. However, as reported in Europe's Rail Joint Undertaking (ERJU) overview report on energy saving in rail ([2]), 88 % and 90 % of passenger and freight train-kilometres, respectively, ran on electricity in 2022 (traffic on non-electrified lines is therefore minor). Railways are therefore one of the largest consumers of electricity on the market, and traction energy stands as a key cost driver for railway undertakings (RUs). 86.7 % of electricity consumed by the railway system was reported to be used for freight and passenger traction power. Before the unbundling between infrastructure and train operations, the cost of traction current was charged within the whole operating cost of a rail system. Following the separation between infrastructure managers (IMs) and RUs, the use of catenary and, optionally, the provision of traction current are part of the services to be supplied to RUs as per Annex II to Directive 2012/34/EU (the Railway Market Directive). The Commission Implementing Regulation (EU) 2015/909 further specified that the use of catenary by running trains is a direct cost to be charged by the IMs to RUs, as the contact wire is subject to friction and wear and tear. On the contrary, the cost of other electric supply equipment for traction (e.g. cables, transformers not subject to wear and tear by the operation of train services) is not eligible to be charged as a direct cost.

Historically, the cost of traction current has been charged to RUs based on consumption estimations calculated according to different formulas, which may include as parameters train-km, tonne-km, train market segments, train types, historical records of overall traction current consumption and the geographical profile of lines. The main disadvantages of billing based on consumption estimations are the following.

- Estimations are usually higher than real consumption to make sure energy providers do not incur losses.
- RUs have no incentives to be energy efficient in their train operations, resulting in a higher consumption overall than what could be possible.
- The operating costs of RUs are not minimised, making rail less competitive versus other land transport modes.
- Train manufacturers are not pressed by RUs to supply energy-efficient vehicles.
- All RUs are charged the same for traction current in any given network, often regardless of load weight, train length or routes operated. Any innovative approaches for optimising operating costs are meaningless.

EMSs are digital meters able to transmit position and consumption data. In some countries they have been on board vehicles for more than 30 years. Energy metering in railways first appeared in EU legislation in 2007 with a request for a recommendation from the European Commission to the ERA. Following various updates to the EU legal framework, the rail sector made important commitments to ensure compliance in 2020 in the 'EU railway sector declaration on traction energy metering and settlement' (the sector declaration).

Since 2014, in EU law, EMSs have been mandatory for new vehicles. EMSs allow RUs to be charged for metered consumption of electric traction energy like any other consumer in industrial plants, offices or houses. The main advantages of billing based on real consumption metered by EMSs are the following.

- A fairer electricity bill for all RUs, which also have the incentive to minimise their consumption, positively affecting their operating costs. Freight RUs are the big-

([1]) European Commission: Eurostat, 'Length of railway lines by number of tracks and electrification of lines', 30 October 2025, https://doi.org/10.2908/RAIL_IF_LINE_TR.

([2]) ERJU, *Energy Saving in Rail: Consumption assessment, efficiency improvement and saving strategies, overview report*, 2024, https://rail-research.europa.eu/wp-content/uploads/2024/07/ERSIPB-EDSIPB-B-S2R-219-01_-_20240314_Energy_saving_measures_in_rail_report_changes__2_.pdf.

gest beneficiaries since the train length and the weight of the load transported directly affect traction current consumption. This makes the electricity bill to run an intermodal train cheaper than a heavier train carrying bulk iron ore, for example. Another example is the fair charging of trains when stabling or in parking/reserve mode when the pantograph is up.

- RUs have incentives to be energy efficient, resulting in an overall lower consumption for railways. In particular, benefits from regenerative braking (enabling recuperation of energy when the train brakes) and eco-driving (a more gradual driving style in terms of acceleration and braking according to the line gradient) are enabled.
- An incentive for research and development (R & D) by train manufacturers as RUs demand more energy-efficient vehicles.
- With smart EMSs, the ability of RUs to act on the liberalised electricity market for the free choice of the supplier offering the best rates (volume discounts, off-peak pricing, etc.) or a fully green energy mix.
- The possibility for RUs to use innovative financial instruments like futures and options to cover the risk of electricity price volatility.

Charging traction current with EMSs has a certain inherent complexity, as trains are quite unique consumption points. In fact, contrary to meters placed in buildings or at charging points of electric road vehicles, trains are moving while they consume electricity or feed-in into the grid. Moreover, especially when travelling across borders, different grids, catenary, voltage, suppliers and IMs are involved.

Therefore, energy metering requires the involvement of many stakeholders, namely IMs and EU Member States for the implementation and deployment of DCSs; RUs and lessors for the installation of on-board EMSs; manufacturers and EMS/DCS providers for the design and production of EMSs and DCSs; notified bodies (NoBos) and designated bodies (DeBos) for the certification of EMSs; and the ERA and national safety authorities (NSAs) for the vehicle authorisation process. Not only did the survey architecture for this study consider the multiple stakeholders involved, but the survey distribution and the interview process also ensured, together with the coverage of the stakeholder types, a complete geographical coverage across all the Member States.

EMSs, DCSs and settlement systems are necessary to guarantee improved energy efficiency in the rail sector. In fact, the systems are designed to enable billing based on actual energy consumption rather than on consumption estimates. The billing of the actual consumption values virtuous behaviours from RUs, like the choice to invest in innovative technologies such as regenerative braking systems, lightweight materials and aerodynamic designs, driver advisory systems and automatic train operations, all aimed at reducing energy consumption and emissions. By implementing meters, monitoring and analysis, or by optimising the specific behaviour or load of trains, it is possible to keep energy costs under control. The system also allows for more accurate billing as it takes into account the train driver's guiding style, valuing virtuous and eco-friendly driving behaviours. In fact, it has been observed that identical trains, running on the same track in the same period of the year, can report great variability in actual energy consumption, and this can be explained by different applications of acceleration or braking by the driver. Indeed, a more aggressive driving style corresponds generally to higher energy consumption, while a softer, calibrated and equilibrated style, known also as eco-driving, allows for lower energy consumption and therefore lower energy bills. Without meters, there would be no valorisation of a more efficient driving style, since the same energy consumption would be estimated for all the considered train paths on the same route, regardless of the train driver's style.

3.1.1. The energy measurement system and the data collecting system

The EMS is the system that measures the energy consumed by trains. It measures the electric energy taken from the overhead contact line (OCL) by the train's electric system, and the energy returned to the OCL during regenerative braking. EMSs are produced mostly by a few specialised manufacturers and follow the European Standard (EN) EN 50463 to ensure compatibility.

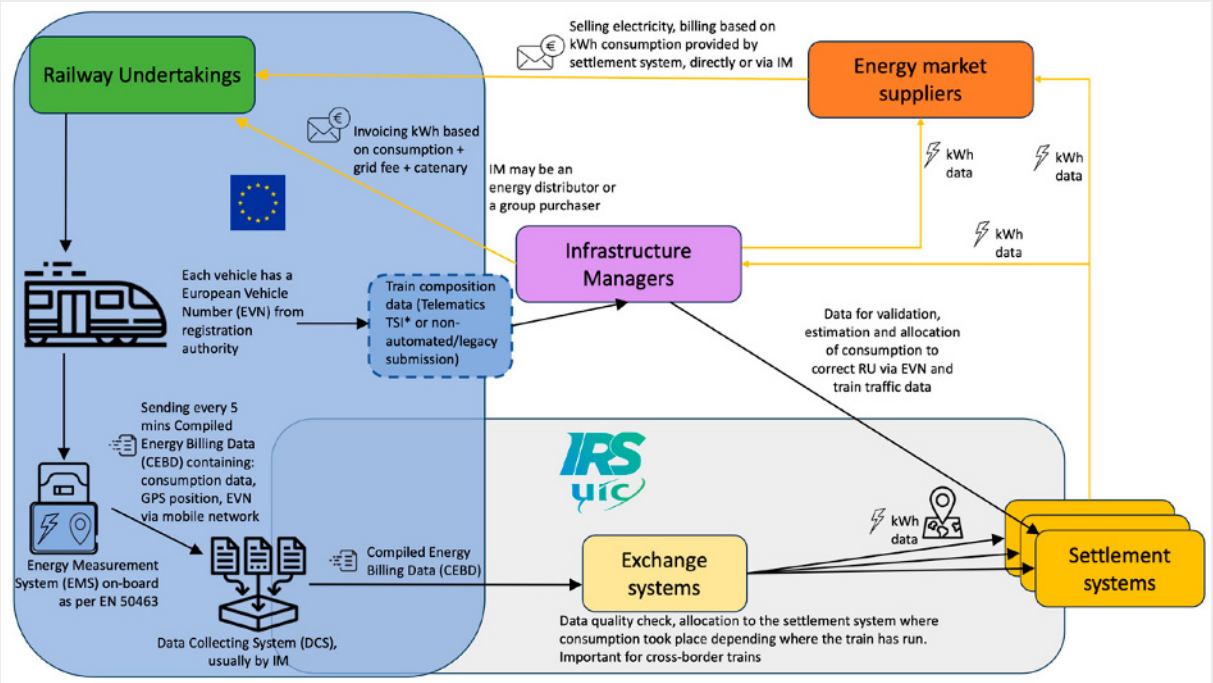
Among other things, the EMS includes two functions: the energy measurement function (EMF) and the data handling system (DHS). Through the EMF, the EMS ensures the measurement of the voltage and current and the calculation of the energy consumed. Subsequently it produces energy consumption data.

Through the DHS, the EMS creates the compiled energy billing data (CEBD) containing energy consumption information that are suitable for energy billing purposes. It does so by merging the data registered by the EMF with time data and with the geographical position of the train recorded by the Global Positioning System (GPS). Eventually, the DHS stores the CEBD and sends it to the on-ground DCS via mobile telecom connection. Usually the Global System for Mobile Communications (GSM) is used for this purpose.

The DCS works therefore as a centralised recipient of energy consumption data. It is basically a computer that stores and exports the CEBD coming from the EMS and consequently sends it to the on-ground settlement system of a given country. After the settlement system receives the CEBD from the DCS, and if the energy consumption took place in another country, the data is exchanged with the settlement system of that other country. Eventually, the settlement system validates the energy consumption data, estimates the missing consumption data and bills the energy consumption to the correct parties/users.

Figure 1 below provides a representation of the relevant energy metering processes and parties. EU law, through technical specifications for interoperability of energy (ENE TSI) and technical specifications for interoperability of locomotives and passengers (LOC & PAS TSI), only regulates the obligations (when applicable) to have an EMS compliant with EN 50463 installed on trains and for Member States to set up a compliant DCS able to receive data from EMSs and a settlement system for billing and data exchange. The transmission of train composition data to IMs for settlement purposes is currently not mandatory on the basis of legacy technical specifications for interoperability of telematics applications for freight service (TAF TSI) / technical specifications for interoperability of telematics applications for passenger service (TAP TSI). However, these two TSIs have just been repealed by Commission Implementing Regulation (EU) 2026/253, the technical specification relating to the telematics subsystem of the rail system in the European Union for interoperability of data sharing in rail transport (TEL TSI). This new TSI introduced the mandatory data sharing between IMs or third parties in charge of exchange and settlement. The data model and processes for settlement and the whole data exchange processes between DCSs, settlement systems, IMs and ultimately energy suppliers are not regulated in EU law but in a voluntary International Railway Solution (IRS) 90930 standard from the International Union of Railways (UIC) and applicable bilateral agreements between relevant parties.

Figure 1: The data and processes for rail traction energy metering today, with the scope of ENE TSI in blue



Source: ERA analysis with courtesy advice by UIC and CENELEC experts for the processes not covered by EU legislation.

3.1.2. The key stakeholders

Energy metering is a very specific part of the rail industry. The key stakeholders considered in this study are summarised below. Other relevant stakeholders outside of the rail industry are electricity suppliers, transmission system operators (TSOs) and distribution system operators (DSOs) as defined in Article 2 of Directive (EU) 2019/944 (the Energy Market Directive), and energy traders that are, for rail stakeholders, upstream suppliers of electricity and related services. TSO and DSO may also be in some countries DCS providers. The regulatory bodies in charge of market oversight in rail traction energy supply are primarily those referred to in Article 55 of the Railway Market Directive but also, depending on national arrangements, the regulatory bodies of the energy sector referred to in Article 57 of the Energy Market Directive.

Table 1: The key stakeholders in rail traction energy metering

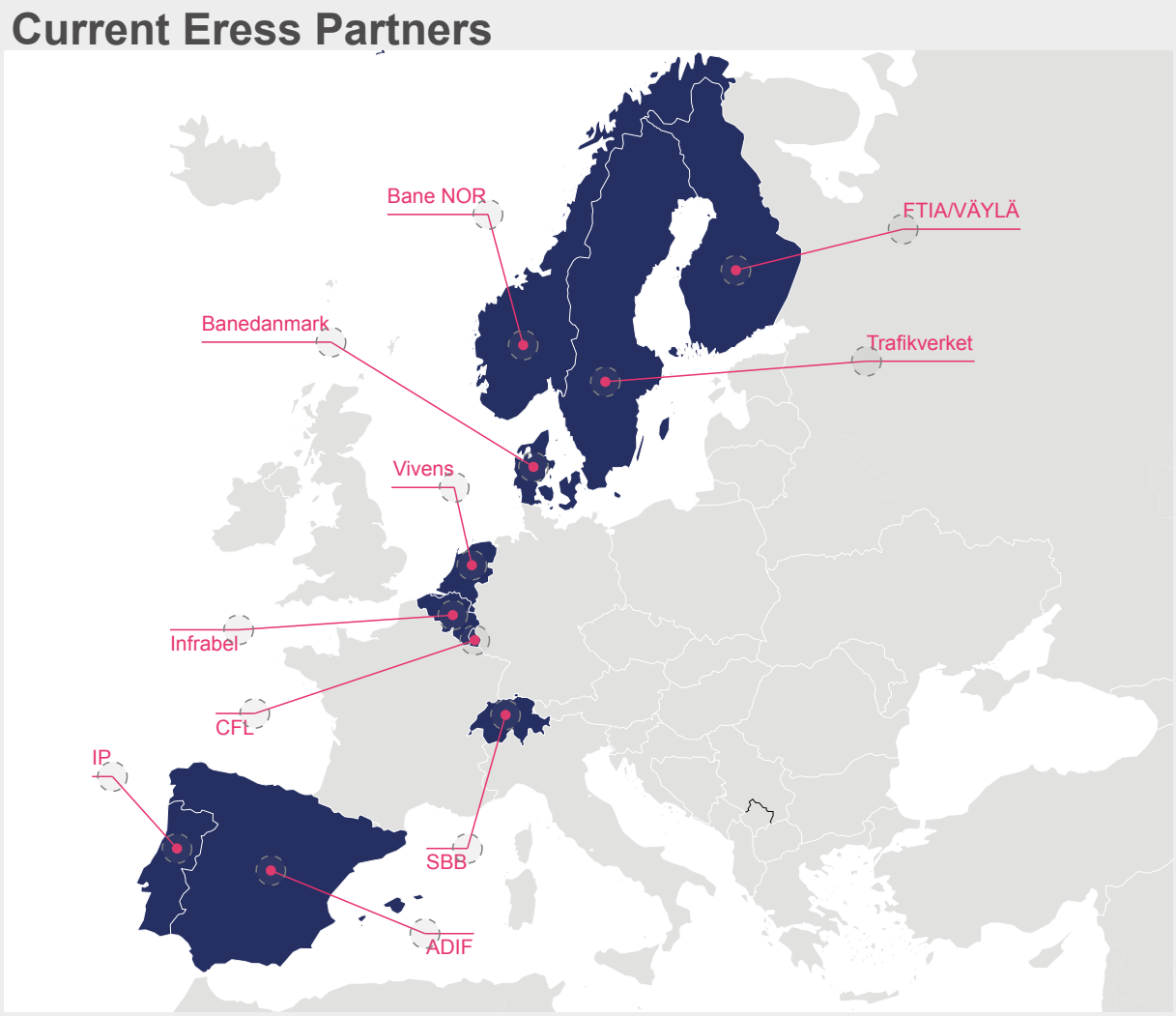
Key stakeholders, classified for the purposes of this study	
Railway undertaking (RU)	Freight or passenger railway undertaking, owner or keeper of tractive vehicles.
Lessor / vehicle keeper	Leasing company and/or vehicle keeper not operating as an RU.
Infrastructure manager (IM)	Manager of rail infrastructure. Depending on the country, it may also be the entity in charge of energy supply or energy transmission for rail traction. It is usually the owner of the catenary and is in charge of maintenance of the OCL.
Member State	All EU Member States plus Norway and Switzerland, as they are all part of the single European railway area.
Manufacturer of tractive rolling stock	Manufacturer of locomotives, electric multiple units, train sets and yellow fleet trains.
EMS manufacturer	Manufacturer of on-board EMSs, usually a specialised supplier of metering devices.
DCS provider	Provider of on-ground energy data collecting systems, provider of exchange systems for compiled energy billing data. In most Member States, the DCS provider is the rail IM, that is a provider of on-ground energy settlement systems. In some cases, TSO/DSO may be the DCS provider instead.
National safety authority (NSA)	National Rail Safety Authority, as per Article 3(7) of Directive (EU) 2016/798.
Notified body (NoBo)	Entity as per Article 3(17) of Directive (EU) 2016/798, involved in vehicle authorisations.
Designated body (DeBo)	Entity as per Article 15(8) of Directive (EU) 2016/797, involved in vehicle authorisations.

The DCS and exchange function for energy metering is closely linked with the settlement system generating data for invoicing traction energy. In some Member States, such as Austria, these activities are performed fully by the IM, while other Member States choose different solutions, either by pooling resources in a joint organisation or by involving a third party, as described below. ENE TSI does not mandate a specific governance approach for the DCS and exchange function, provided all solutions are interoperable and compliant. Details for each Member State are available in Section 5.1 of the report.

Table 2: Overview of the Eress solution for energy metering

The Eress solution for energy metering	
What is Eress?	Eress is a non-profit cooperation of railway infrastructure managers and other public bodies acting as contracting authorities with a national responsibility for the settlement of traction energy. It was founded more than 15 years ago by some Nordic IMs. It is currently made of 10 rail IMs in Europe and it is led by Bane NOR, the Norwegian rail IM. Eress is a service provider through the jointly owned Erex IT system to exchange and settle energy on the basis of consumption data in the partner countries and across borders. This allows a smooth connection and data exchange between the relevant DCSs including those outside Eress.
How it works	The data of electricity consumed by each tractive vehicle is sent to a DCS. IMs may keep on using their DCS or the shared Eress DCS. From there, data goes to Erex, the Eress exchange function, where it is sorted out (correct, incorrect) and allocated to the correct country (inside or outside of Eress countries). Each IM settles its own data coming from Erex, according to its own practices, before issuing a final invoice to the RU that has run a given train. Therefore, RUs get a correct invoice of energy when running in Eress countries, and the data management and matching consumption with a specific RU, especially for cross-border trains, is made with minimal effort by the IM.

Figure 2: The IMs partnering within Eress



Sources: Eress (for data), © EuroGeographics © OpenStreetMap (for administrative boundaries) and Eurostat (for cartography).

A few Member States have specific third parties involved in traction energy supply, transmission or metering.

Table 3: Member States with specific arrangements and stakeholders for rail traction energy supply and metering

Other set-ups for DCSs and energy supply where third parties are involved beyond the rail IM	
Germany	In Germany, Deutsche Bahn Energie (DB Energie) is a large multi-business company that is part of the Deutsche Bahn Group (DB Group) that supplies energy, provides the transmission network infrastructure and performs other activities. DB Energie is also the DCS and exchange function settlement provider, while the rail IM DB InfraGo remains the owner of the catenary. The DCS provided by DB Energie is able to collect data from EMSs with all compliant standards, including older EMSs.
France	In France, RUs enjoy free choice of electricity provider and a national DCS solution has been in place since 2018, namely the Décompte Ferroviaire (DECOFER) provided by Le Réseau de Transport d'électricité (RTE). RTE is the French TSO but the solution DECOFER allows RTE to be in charge of energy metering for all rail IMs in France (primarily Société nationale des chemins de fer français Réseau (SNCF Réseau)) and of the data exchange functions and settlement with any other European exchange system compliant with IRS 90930. Rail IMs remain owners of the catenary.
Netherlands	In the Netherlands, RUs cannot choose their energy provider at present. Third-party access will be possible starting on 1 January 2029 but only for those RUs with EMSs that can guarantee accurate measurements. When companies do not have 100 % of their fleet with meters installed, they will be covered by the current VIVENS (United Purchasing and Consumption of Energy on the Dutch Railway Network) collective contract for rail traction energy. VIVENS is at present a mandatory purchasing cooperative for rail traction energy joined by more than 20 RUs. In 2008, rail operators and ProRail established the cooperative to regulate and optimise the purchase and consumption of energy (diesel and electricity). VIVENS also operates fuelling facilities managed by ProRail and energy purchasing is handled through the VIVENS collective contract. Thanks to the collaboration between rail operators (both passenger operators and freight operators) and ProRail within VIVENS, all members have a transparent picture of the costs and the structure of energy rates. Joint purchasing provides benefits, such as lower rates and lower energy surcharges. VIVENS also serves as a consultation platform for rail carriers and ProRail on energy-related topics and joint energy interests are coordinated, for example, for the introduction of payment using energy meters, technical and/or environmental standards. The Netherlands is part of Eress and the DCS function is facilitated by the joint solution.
Poland	In Poland, the Polska Grupa Energetyczna Energetyka Kolejowa (PGE EK) is a supplier of rail traction electricity and diesel, along with the TSO and a DSO. The company is part of the PGE Group, a holding that is, among other things, responsible for of energy generation and energy distribution. PGE EK, which operates the rail grid, will be split into two different entities by 2026 (to separate energy supply from energy distribution). The DCS system currently provided by PGE EK is nevertheless a legacy DCS that is in the testing phase for the exchange of consumption data. At the moment, this legacy DCS only works and settles real consumption data to domestic RUs allowing third-party access for energy supply. A new DCS compliant with EU legislation is being implemented and tested with Eress and neighbouring countries and should be in place in 2026.

3.2. The framework for energy metering

3.2.1. The EU legal framework

Technical specifications for interoperability (as per Directive (EU) 2016/797)

Energy metering in railways is covered in the technical specifications for interoperability (TSIs), which are secondary EU legislation stemming from Directive (EU) 2016/797. In fact, while EN 50463 covers several features of EMSs, provisions in EU legislation were deemed necessary to ensure interoperability of energy metering across the whole single European railway area.

Since both vehicles and ground aspects are involved, energy metering is regulated by LOC & PAS TSI for the rolling stock (Commission Regulation (EU) No 1302/2014 and later modifications) and by ENE TSI for the ground (Commission Regulation (EU) No 1301/2014 and later modifications).

The key elements relevant for energy metering from both TSIs are the following.

- **From November 2014**, LOC & PAS TSI: on-board EMSs are mandatory on new, upgraded and renewed rolling stock.

Article 3(4) LOC & PAS TSI: 'The fitment of the on-board energy measurement system defined in clause 4.2.8.2.8 of the Annex is mandatory for new, upgraded and renewed vehicles intended to be operated on networks equipped with the on-ground energy data collecting system (DCS) defined in point 4.2.17 of Commission Regulation (EU) No 1301/2014.'

In the case of upgraded and renewed rolling stock, the installation of an EMS requires certain tests during the vehicle re-authorisation and NoBo certification. This is particularly important to ensure electromagnetic compatibility.

- **From July 2020**, amendment to ENE TSI: Member States have to ensure an on-ground settlement system capable of receiving data from a DCS and accepting it for billing. The on-ground settlement system shall be able to exchange CEBD with other settlement systems.

Article 9(4) ENE TSI: 'In addition to the implementation of the on-ground energy data collecting system (DCS) defined in point 7.2.4 of the Annex and without prejudice to provisions of point 4.2.8.2.8 of the Annex to Commission Regulation (EU) No 1302/2014, **Member States shall ensure that an on-ground settlement system capable to receive data from a DCS and accept it for billing is implemented, two years after the closing of the open points mentioned in point 4.2.17 of the Annex**. The on-ground settlement system shall be able to exchange compiled energy billing data (CEBD) with other settlement systems, validate the CEBD and allocate the consumption data to the correct parties. This shall be done by taking into account the relevant legislation concerning the energy market.'

- **From January 2022**, ENE TSI: Member States shall ensure that an on-ground energy DCS that is capable of exchanging CEBD with EMS is implemented.

Article 9(1) of ENE TSI: 'Section 7 of the Annex sets out the steps to be followed for the implementation of a fully interoperable energy subsystem. Without prejudice to Article 18 of Directive (EU) 2016/797, **Member States shall prepare a national implementation plan, describing their actions to comply with this TSI**, in accordance with Section 7 of the Annex. **Member States shall send their national implementation plan to the other Member States and the Commission by 31 December 2015**. Member States that have already sent their implementation plan do not have to send it again.'

Section 7.1(b) of the Annex of ENE TSI: 'Member States shall ensure that an on-ground energy data collecting system capable to exchange compiled energy billing data in accordance with point 4.2.17 of this TSI is implemented.' For this requirement, former section 7.2.4 of the ENE TSI Annex, which was eliminated in ENE TSI version 2023, already established a deadline of 1 January 2022.

An important novelty for energy metering is contained in the new TEL TSI. In point 2.5.1 of the Annex, titled 'Train composition', paragraph 16 states that train composition messages will include the information required to support the settlement process and that the IM will share the relevant data with the energy settlement system: 'The "train composition messages" shall include the information required to support the energy settlement process pursuant to Commission Regulation (EU) No 1301/2014 ("ENE TSI"), as referred to in Appendix A. It shall include in particular the European vehicle number of the traction units that is part of that train and that is referred to as consumption point id of the on-board energy measurement systems pursuant to Commission Regulation (EU) No 1302/2014 ("LOC & PAS TSI"), as referred to in Appendix A, and the total mass of the train. This information shall be part of the train composition message at departure time pursuant to paragraph (2), or at the latest 48 hours after departure in case of anomaly. The infrastructure manager shall share that data with relevant energy settlement systems pursuant to ENE TSI.'

Directive 2012/34/EU establishing a single European railway area

The provision of traction current and the related infrastructure is regulated by Directive 2012/34/EU establishing a single European railway area, also known as the Railway Market Directive.

- Annex I specifies which assets are part of the railway infrastructure: 'Plant for transforming and carrying electric power for train haulage: substations, supply cables between substations and contact wires, catenaries and supports; third rail with supports'.
- Annex II, point 1(e) includes among the services to be supplied to the RUs as part of the minimum access package: 'use of electrical supply equipment for traction current, where available'. Moreover, Commission Implementing Regulation (EU) 2015/909 further specifies that the use of catenary by running trains is a direct cost to be charged by the IMs to RUs, as the contact wire is subject to friction and wear and tear.
- Annex II, point 3(a) also provides that additional services to be supplied to RUs may comprise 'traction current, charges for which shall be shown on the invoices separately from charges for using the electrical supply equipment, without prejudice to the application of Directive 2009/72/EC'.

Directive (EU) 2019/944 and Regulation (EU) 2019/942 on common rules for the internal energy market

Directive (EU) 2019/944, recently amended by Directive (EU) 2024/1711, on common rules for the internal market for electricity and Regulation (EU) 2019/942, recently amended by Regulation (EU) 2024/1747, improving the EU's electricity market design, are key laws for the energy market. Following many repeals and amendments, the directive on common rules for the internal market for electricity is one of the successors of Directive 2009/72/EC quoted in the Railway Market Directive. Directive (EU) 2019/944 is also applicable to RUs which are major customers of energy suppliers, given their high volume of consumption. This key EU legislation, further amended in 2024, has, among other things, a few very important provisions relevant for RUs.

- Article 4 mandates a free choice of supplier: 'Member States shall ensure that all customers are free to purchase electricity from suppliers of their choice'.
- Article 6 mandates that all energy suppliers shall access to the distribution network to final customers: 'Member States shall ensure the implementation of a system of third-party access to the transmission and distribution systems based on published tariffs, applicable to all customers and applied objectively and without discrimination between system users'.
- Article 10 mandates that customers may purchase energy from any supplier in the EU: 'Member States shall ensure that all final customers are entitled to have their electricity provided by a supplier, subject to the supplier's agreement, regardless of the Member State in which the supplier is registered, provided that the supplier follows the applicable trading and balancing rules. In that regard, Member States shall take all measures necessary to ensure that administrative procedures do not discriminate against suppliers already registered in another Member State'.
- Article 15 mandates that customers may be entitled to act as active customers when generating energy, which is particularly relevant when trains perform regenerative braking: '1. Member States shall ensure that final customers are entitled to act as active customers without being subject to disproportionate or discriminatory technical requirements, administrative requirements, procedures and charges, and to network charges that are not cost-reflective. 2. Member States shall ensure that active customers are:

  (a) entitled to operate either directly or through aggregation;

(b) entitled to sell self-generated electricity, including through power purchase agreements'.

3.2.2. Energy metering as a test bed for cybersecurity in technical specifications for interoperability

ENE TSI and LOC & PAS TSI were chosen as the first step to develop the latest TSI revision mandate from the Commission to the ERA – specifically, 'assess the impact of the EU legal cybersecurity framework on the European rail system and amend TSIs accordingly'. Therefore, the mentioned TSIs are currently being analysed by the ERA to incorporate cybersecurity requirements in line with the EU legal framework for cybersecurity.

As part of these tasks, the cybersecurity experts from the ERJU are in contact with the ERA and the European Committee for Electrotechnical Standardization (CENELEC) working group 37 to harmonise cybersecurity requirements in the revision of the EN 50463 series, LOC & PAS TSI and ENE TSI, in line with the EU legal framework for cybersecurity. A special focus is on data/information-related interfaces processing, among other things:

- exchange of energy metering data for traction energy settlement;
- exchange between EMS and DCS;
- location data, polygons and border points;
- data and protocol defined in EN 50463;
- functions, roles and interchanges defined in IRS 90930.

3.2.3. EN 50463

Following a mandate from the Commission in 2007, CENELEC developed in 2012 the first version of EN 50463. This standard is quoted in LOC & PAS TSI and ENE TSI and it is fundamental to ensure standardisation and compatibility between EMSs and of the CEBD to be sent from EMS to DCS. The standard also provides a first protocol for communication between EMSs and DCSs, including GPS coordinates of the train at the time of energy absorption from the OCL. EN 50463 evolved to the latest 50463-4:2017 version.

Following a new mandate for CENELEC's working group 37, EN 50463 is currently being updated with the target release date of a new version in December 2026. The key changes being currently worked out are:

- distinguishing between the EMS and the consumption point;
- adaptations for the specific characteristics of hybrid trains;
- clarifying the process of commissioning and maintenance;
- introducing the possibility to have integrated EMFs, combining current measurement, voltage measurement and energy calculation;
- introducing secure protocols;
- adding the possibility of a direct connection on board;
- adding a standardised digital signature, uncompressed payloads and a mechanism for a batch of samplings at a higher frequency (e.g. every second);
- the same protocol will be used in EN 50463 and International Electrotechnical Commission (IEC) IEC 62888 at the global level – the goal is to have a merged version in 2030 from the IEC.

3.2.4. IRS 90930

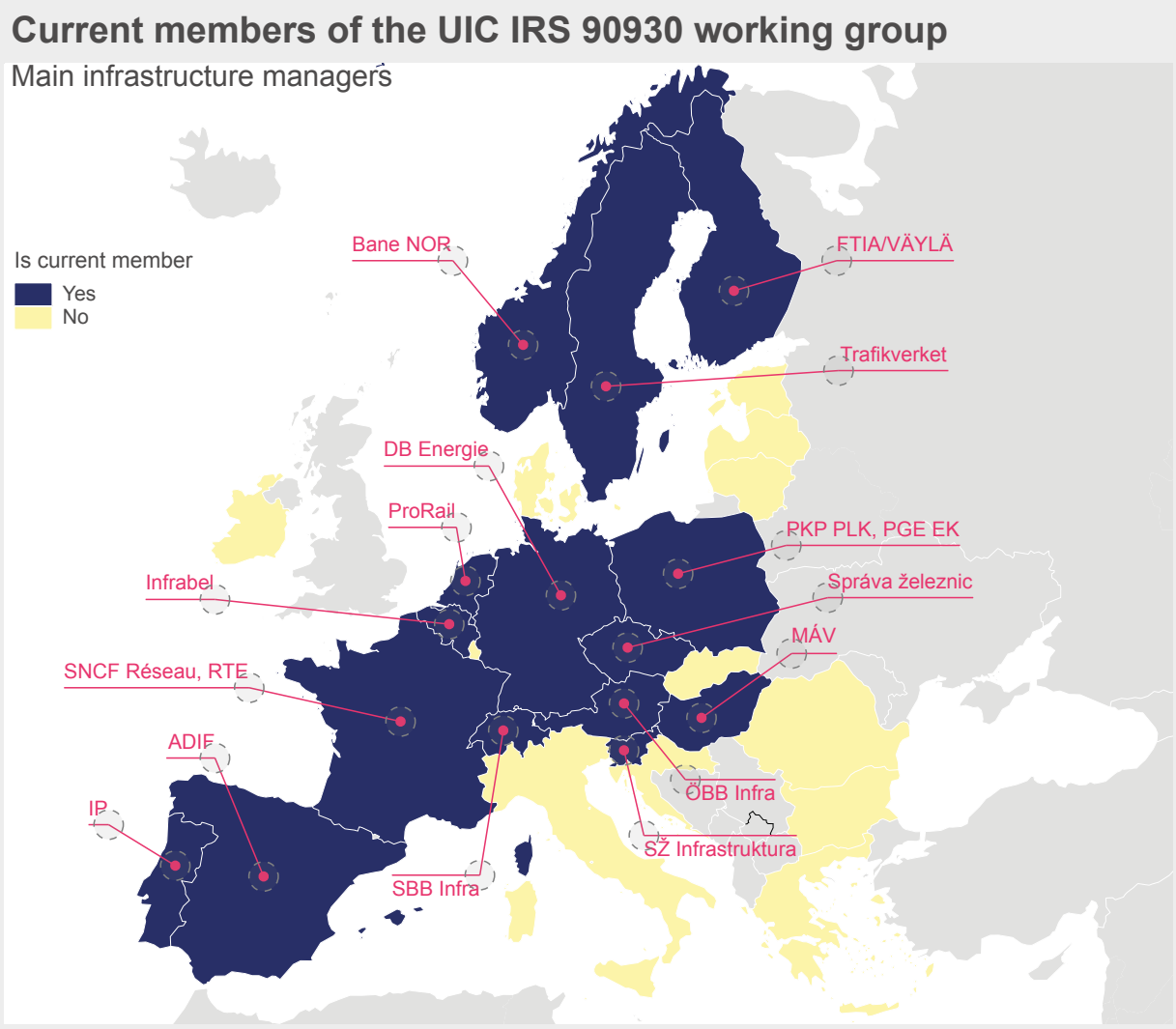
In 2020 the EU railway sector agreed to the Sector Declaration on Traction Energy Metering and Settlement. This declaration outlines how the railway sector intends to comply with European legislation, including the Railway Market Directive, the Energy Market Directive and Commission Implementing Regulation (EU) 2018/868. Among its key commitments, the declaration states that international data exchanges will be carried out in accordance with IRS 90930. This helps reduce implementation barriers and supports harmonised practices across the sector.

IRS 90930, titled 'Traction Energy Settlement and Data Exchange', is a UIC International Railway Solution (IRS) that defines the functional, technical and organisational framework for the settlement of traction energy use in European railways. It follows the UIC Leaflet 930 issued in 2009. The IRS document provides detailed guidance on roles, responsibilities and data flows for parties involved in energy metering and settlement, such as RUs, IMs and vehicle keepers. Its purpose is to ensure that all parties can exchange data efficiently and consistently across borders, in full alignment with European legislation and technical standards. The IRS defines key roles, including the consumer, the vehicle keeper, the EMS responsible and the DCS administrator, among others, and specifies their tasks across various phases, from EMS installation to traction energy use settlement. It introduces XML-based data structures and protocols to ensure efficient data collection, validation, storage and transfer, particularly for cross-border operations. A central feature is the concept of the exchange function, which allocates energy consumption to the correct geographical and operational zones. IRS 90930 is accessible free of charge from the UIC web shop.

Developed by the UIC working group on traction energy settlement ('the UIC IRS 90930 working group), the IRS complements EN 50463, which governs on-board energy measurement. It provides a harmonised framework for exchanging energy metering data through XML-based formats and for defining processes such as data collection, validation, transfer and allocation to consumers. IRS 90930 is maintained under UIC governance. Updates are coordinated by the UIC the UIC IRS 90930 working group, which ensures compatibility with evolving European regulations and market needs. Supplementary documents, such as appendices, agreed border point lists, XML schemas and implementation guides, are published and regularly updated on the UIC website.

IRS 90930 functions therefore as a standard and data model developed by incumbent rail sector stakeholders, mostly IMs, members of the UIC. Most data flows are relevant for IMs to implement the exchange and settlement function and to connect DCSs across borders. However, the implementation of IRS 90930 is voluntary and not all IMs of the single European railway area are members of the UIC IRS 90930 working group. Moreover, some members may have a rather passive representation without any actual implementation in the operations of the data collection and settlement function for traction energy.

Figure 3: The IM members of the UIC part of the IRS 90930 working group. Some companies are members of the UIC at the level of holding companies and may delegate participation in this working group to the controlled IM or partner DCS provider.



Sources: UIC (for data), © EuroGeographics © OpenStreetMap (for administrative boundaries) and Eurostat (for cartography).

4. Why this study

4.1. Request from the European Commission

After the last update of ENE TSI in October 2023, (Commission Implementing Regulation (EU) 2023/1694), the legal deadlines provided for energy metering through DCSs were already overdue. Stakeholders pointed out the delays and lack of compliance of several Member States in setting up a functioning DCS in accordance with the mandatory requirements. Therefore, during the preparation of the 2024–2030 TSI revision mandate from the Commission to the ERA, it was considered that, before adding or modifying requirements in a revised ENE TSI, more evidence was needed. Firstly, the Commission wanted to have details on the degree of non-compliance of Member States with the existing requirements on DCSs and energy metering, along with an investigation into the reasons for such delays. Secondly, the Commission wanted to research if the perceived scattered implementation of existing requirements was due to regulatory issues to be addressed in the upcoming ENE TSI revision or rather due to a lack of enforcement, cooperation of stakeholders involved, technical hurdles or other problems.

Considering the existing issues and the non-maturity of possible changes to ENE TSI to be discussed in the relevant ERA working group for considerations of amendments to the legal framework, the Commission decided to include in the TSI revision mandate sent to the ERA in 2024 a request for: a report on state-of-play of implementation of on-ground energy data collecting systems, based on benchmark from IMs, as defined in ENE TSI Article 9, point 4 and on on-ground settlement systems.

4.2. The objectives and scope of this study

Following the mandate received from the Commission and given the nature of the study being between *ex post* policy evaluation of existing ENE TSI, policy analysis and research, the ERA assigned the delivery of this study to its Monitoring, Analysis, Research and Stakeholders Unit supported by the Fixed Installations and Rolling Stock Unit in charge of energy matters at the ERA. This study is delivered to the Commission and to the public as per Article 8(3) and Article 41 of Regulation (EU) 2016/796.

The key objectives of this study can be summarised as:

- *ex post* evaluation on the degree of implementation and compliance of Member States, mostly through the IMs, of the existing ENE TSI requirements regarding the establishment of a DCS able to receive data from EMSs on board and to exchange CEBD through an exchange system with other settlement systems, to validate the CEBD and to allocate the consumption data to the correct parties;
- identification of issues hampering data exchange, settlement function and cross-acceptance of EMSs by different IMs/DCS;
- recommendations to ensure full compliance, either through enforcement actions following the study, capacity building and knowledge sharing activities, and/or amendments to the legal framework.

The scope of this study is primarily focused on on-ground energy consumption data collection and relevant exchanges between DCSs and IMs for billing. However, the on-board issues cannot be disregarded as EMSs and tractive vehicles are key elements for achieving a billing of traction energy based on real metered consumption.

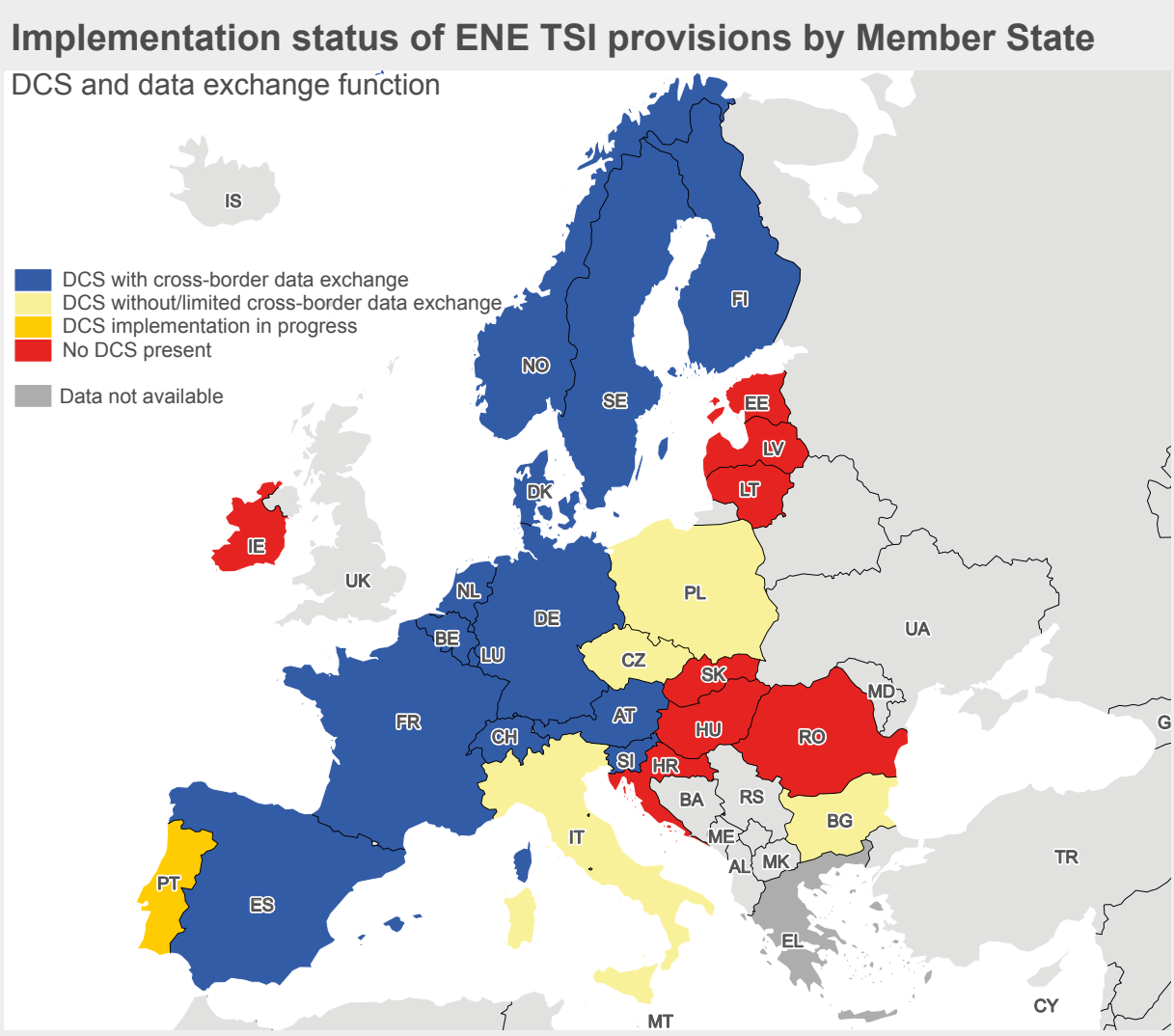
5. Key findings

5.1. Compliance with ENE TSI

Following a web survey and extensive bilateral interviews with many stakeholders, with more details on the methodology available in Section 7, a clear picture of the situation to date with regard to DCSs and compliance with the existing ENE TSI requirements is presented below. This section is an *ex post* evaluation of the legal framework applicable for the last few years.

A key conclusion is that, currently, DCSs being able to receive data from EMSs and RUs being able to be invoiced for real electricity consumption on the basis of metered data, cross-border exchange and settlement, is not a reality across the entire single European railway area. The existing provisions of ENE TSI are therefore not correctly implemented. The maps below provide a visual representation of the key findings, followed by detailed information about the situation in each Member State.

Figure 4: Overview on the implementation status of ENE TSI provisions by Member State



Sources: ERA analysis (for data). © EuroGeographics © OpenStreetMap (for administrative boundaries) and Eurostat (for cartography).

Table 4: Additional details on the implementation status of ENE TSI provisions by Member State

Member State ([3])	Overview
Austria	In Austria, the main IM, Österreichische Bundesbahnen-Infrastruktur (ÖBB Infra), provides a compliant DCS which follows EN 50463-2017 and IRS 90930. There is no information on other IMs. RUs are able to choose their own energy supplier; however, the DCS function is offered only to those RUs that have an EMS on board the railpower box. ÖBB Infra is a unique case whereby the IM is also a provider of meters, with a leasing model for RUs. ÖBB Infra remains the owner of the EMS and the leasing contract with RUs includes the DCS service, the exchange function and a dashboard where RUs can monitor consumption and pull data for their own internal use also via an application programming interface. The IM performs the meter calibration and electromagnetic compatibility tests and also provides relevant certificates to the vehicle owner. Customers are responsible for integrating the meter into their vehicle and for taking care of the relevant vehicle authorisation processes. For RUs that run in Austria without a railpower box, the IM requires them to submit the EMS certificates from a NoBo as a paper check in order to invoice energy based on metered consumption. Although technically possible as a commercial decision, ÖBB Infra does not offer the DCS service exchange function to vehicles equipped with an EMS other than the railpower box. If certificates are not available or vehicles are not equipped with a compliant EMS, invoicing is based on energy consumption estimations. The settlement system of the Austrian IM has recently, and following a decision of the rail regulatory body, been performing a matching of consumption data and train run data itself, based on the European Vehicle Number (EVN) and traffic management systems. This allows for the correct invoicing of energy to vehicle keepers. The EMS transmits the meter number and the EVN of the vehicle on which it is installed to the DCS. The train composition data is currently still required for RUs only as a backup in case the EVN is only partially available or is missing due to data quality issues. The ÖBB Infra's exchange function works well with Czechia, Germany, France, Slovenia and Eress partners. With Slovakia, Poland and Hungary implementation tests are ongoing.
Belgium	Infrabel is an Eress partner and uses the compliant Eress DCS for energy data collection and the Erex function for the exchange and settlement of energy consumption data following IRS 90930. Erex settlement is based on train run data available from the IM traffic management systems. This data can be based on TAF TSI messages or on other older formats. Metered consumptions are therefore validated and invoiced to RUs (knowing who operates a given train, EVNs, mass and distance), combined with meteorological data (temperature), and the total infeed in the OCL. Losses are underestimated and estimated consumption is adjusted to make sure that the sum of metered energy and estimated energy equals 96 % of the total infeed in the OCL. Some still active sensors follow a standard older than EN 50463-2012. Since 2019, RUs have been able to choose their own energy supplier other than Infrabel. However, to date, no RUs with EMSs installed opted for such a possibility due to the attractive rates offered by Infrabel. The IM is buying electricity on the open market and doesn't add any margin while invoicing to the RUs. Some RUs preferred supply contracts with larger part dependent on the spot market while others preferred supply contracts with larger part dependent on the forward market. Not all RUs running in Belgium have their fleet with EMSs installed and these are therefore charged energy based on estimations. One Belgian RU has its own DCS, different from Infrabel, which directly transmits data to the Erex exchange function. In particular, the RU in question uses the train computer as the DHS and sends all data to an on-ground data collection point. This on-ground server also fulfils obligations of the DCS, and transfers energy metering data to Erex exchange. This solution makes use of one-minute data (ReadingBlock), which has a higher granularity than the five-minute CEBD. This also makes the data more suitable for energy management. Erex is able to use ReadingBlocks in exchange and settlement.
Bulgaria	In Bulgaria there has been a DCS in place since 2010 provided by the rail IM, the National Railway Infrastructure Company (NRIC), which follows EN 50463-2012, which is not the latest version. All RUs have EMSs installed, are invoiced for real consumption and can choose their energy supplier from the free market. The NRIC does not provide traction energy. All EMSs on trains running in Bulgaria are compatible with the NRIC's DCS based on local standards, transmitted through GPS consumption data on a five-minute cycle, and the matching of data with RUs operating trains is done using train run data and EVNs. The Bulgarian DCS is not able to exchange data and settlement for cross-border trains and the whole energy metering charging is only available for domestic trains. The only exception seems to be Austria as some sort of data exchange is possible for Austrian RUs running in Bulgaria by interfacing with the ÖBB Infra DCS. Cross-border rail traffic using electric locomotives is very limited in Bulgaria, however.

([3]) According to EFTA and bilateral agreements, Directive (EU) 2016/797 and all other relevant EU rail legislation applies also in Norway and Switzerland. In this study, these two countries are considered equivalent to an EU Member State.

Member State ([3])	Overview
Croatia	Croatia has no DCS in place yet; however, Hrvatske željeznice Infrastruktura is reported to be investing with the aim of having a compliant DCS by 2027. Currently, a data exchange between RUs and the IM takes place via manual transmission of XML files to allow billing based on metered consumption. RUs are not able to choose their energy supplier.
Czechia	The Czech IM, Správa železnic, provides a DCS compliant with EN 50463-2017. There is no information on other IMs. The government provides support and EMSs supplied by a local manufacturer, POLL s.r.o, are available for RUs. Most tractive units have EMSs. However, some interviewed stakeholders reported that they need to install more meters on board because the same meter is not compatible with the Austrian, Polish and Czech DCSs (these Member States do not acknowledge each other's meter configuration). IRS 90930 is not followed and therefore the exchange function with other DCSs does not seem to be working effectively. Some stakeholders also reported IM requirements for homologation, making it difficult for different EMS types to be accepted in Czechia. RUs that do not have a compatible on-board meter with the Czech DCS are invoiced for estimated consumption. The RUs are not able to choose their own energy provider in Czechia.
Denmark	The Danish IM, Banedenmark, is an Eress partner. They set up, with government support, the Eress DCS and use Erex for the exchange and settlement of energy consumption data following IRS 90930. There is no information on other IMs. Less than half of the traction units running on the Banedanmark network are equipped with EMSs despite government support once available. However, a large portion of EMSs are compatible with EN 50463-2012 and there are ongoing discussions about whether the government could support financing the upgrade to the 2017 standard version. According to Eurostat (the statistical office of the European Union), only 33 % of the Danish rail network was electrified in 2022.
Estonia	According to Eurostat, only 12 % of the Estonian rail network was electrified in 2022. Estonia does not have a DCS and does not exchange data with other countries. Traction energy is charged according to consumption based on the meters installed at substations. It is not clear how losses are accounted for. Elron is the only RU operating electric trains in the Member State, with mostly passenger services in the Tallinn area. The Estonian rail network is designed with the 1 520 mm non-standard gauge. The upcoming Rail Baltica line will be electrified and built with the 1 435 mm standard gauge.
Finland	The Finnish IM is an Eress partner. Finland uses the Eress DCS for energy data collection, and the Erex function for the exchange and settlement of energy consumption data. However, cross-border traffic is very limited as the Finnish network is built with the non-standard 1 524 mm gauge and traffic to Russia is hampered by current geopolitical issues.
France	The main rail IM, SNCF Réseau, is the owner of the catenary and the energy supplier for RUs who have not chosen their own supplier but the DCS function and energy transmission are the responsibility of RTE, the national TSO. RTE is also the DCS for other smaller IMs. For collecting energy meter data and performing the exchange function, RTE developed its own system, DECOFER. It is able to exchange data with any other DCS following the IRS 90930 protocol, thus, data can already be exchanged with different DCSs such as: DB Energie for Germany, ÖBB for Austria and any country using the Eress exchange function. RUs are able to choose their energy supplier and are required to provide their train composition to the rail IM, as per the network statement. The allocation of consumption data to the operating RU is established using GSM-R and GPS data matched with the EVNs of operating vehicles shared with RTE. One stakeholder reported the unclear situation for trains travelling through the Eurotunnel, as different standards seem to be applied in the United Kingdom.

Member State ([3])	Overview
Germany	The main rail IM, DB InfraGo, is the owner of the catenary but the DCS function, energy transmission and energy supply are the responsibility of DB Energie, a separate company within the DB Group. There is no information on other IMs outside the DB Group. Since 2000 EMSs have been mandatory to access Germany, with a specific addendum to the rail IM network statement as the basis for this obligation. DB Energie provides an exchange solution to comply to the latest version of EN 50463. The most common meter in Germany is the TEMA box. Some stakeholders, however, reported the hurdle of additional requirements or checks by DB Energie on EMSs from different suppliers. The reported issues are homologation, testing and data encryption via a virtual private network, which limits the data use by RUs for their internal use cases of metered consumption. Since 2014 RUs can choose their energy supplier, with DB Energie as a supplier itself but mostly powering DB Group trains. However, some RUs reported that not all suppliers are accessible, as they need to have a prior agreement with DB Energie in place. The German DCS is almost fully compliant with EN50463-2017 as only HTTPS protocol is accepted instead of the existing requirement of the standard to support, ref. clause 4.3.6.1, HTTP and FTP Mailbox. Clause 4.3.6.1 is likely to be revised allowing, as in Germany, only HTTPS. The German DCS is compliant with IRS90930. The exchange function is operational and reported to work well with Austria, France, Slovenia and the Eress partners. Other DCSs are also interfacing based on the exchange functionality according to IRS 90930 but with limited functionalities such as one-way data exchange. As further explained in Section 5.4.2, in Germany the matching of consumption data with RUs running trains is not done on the basis of rail traffic data. Currently, DB Energie is in charge of the matching of data coming from EMSs with the EVNs and the RU actually operating a given train. RUs have to submit data on the usage time of their vehicles to DB Energie. Currently, when train run data are missing, DB Energie charges energy consumption to the vehicle owner as the ultimate solution if they do not know which RU had been operating a given train. As of July 2026, a new reporting scheme will be applicable. DB Energie will not be performing the data matching work anymore, as lessors will be required to collect train run data from their client RUs, check and match data and submit the relevant information to DB Energie for billing consumption.
Greece	Despite several attempts, no information is available on the situation in Greece.
Hungary	The main IM in Hungary is Magyar Államvasutak Infra (MÁV Infra). There is no DCS in place, RUs are not able to choose their energy supplier and no exchange function is possible. Despite several attempts, limited information is available on the situation in Hungary.
Ireland	According to Eurostat, only 3 % of the Irish rail network was electrified in 2022, with it mostly being the urban rail passenger services in the Dublin area (the Dublin Area Rapid Transit). It is not clear if such an electrified rail network, being possibly classified as light urban rail, is in scope of Directive (EU) 2016/797 on interoperability and therefore outside of the obligations of ENE TSI on energy metering. The Irish rail network is built with a non-standard gauge of 1 600 mm, and Iarnród Éireann is the only RU running passenger trains as part of the Dublin Area Rapid Transit. Ireland has no DCS in place and no exchange function for energy data.
Italy	Since 2022 the main rail IM, Rete Ferroviaria Italiana (RFI) has a DCS compliant with EN 50463-2017. Other smaller IMs do not have a DCS, nor an interface with the RFI's DCS. In Italy only a small share of the fleet has EMSs installed, however, for those domestic trains equipped, energy is billed according to real consumption through the data received from the DCS. The matching of data with RUs operating trains is done using train run data and EVNs. RUs that pay energy according to estimations do not have particular incentives to retrofit their trains with EMSs because traction energy is subsidised by the government and considered rather cheap. RUs are unable to choose alternative energy suppliers, the RFI's DCS is not able to exchange data and settlement for cross-border trains and the whole energy metering charging is only available for domestic trains.
Latvia	According to Eurostat, only 13 % of the Latvian rail network was electrified in 2022. Latvia does not have a DCS and does not exchange data with other countries. Traction energy is charged according to consumption based on the meters installed at substations. It is not clear how losses are accounted for. Only one RU is operating electric trains in the Member State, providing mostly passenger services. The Latvian rail network is designed with the 1 520 mm non-standard gauge. The upcoming Rail Baltica line will be electrified and built with the 1 435 mm standard gauge.
Lithuania	According to Eurostat, only 8 % of the Lithuanian rail network was electrified in 2022. Lithuania does not have a DCS and does not exchange data with other countries. Traction energy is charged according to consumption based on the meters installed at substations. It is not clear how losses are accounted for. Lithuania is investing to further electrify its network, and new electric and battery-powered rolling stock is being procured by the lead RU. The Lithuanian rail network is designed with the 1 520 mm non-standard gauge. The upcoming Rail Baltica line will be electrified and built with the 1 435 mm standard gauge.

Member State ([3])	Overview
Luxembourg	Luxembourg's IM is an Eress partner. Luxembourg uses the Eress DCS for energy data collection and the Erex function for the exchange and settlement of energy consumption data. One stakeholder reported some interfacing issues between locomotives and the billing system in use.
Netherlands	The Dutch IM, Prorail, is an Eress partner. They use the Eress DCS for energy data collection, and the Erex function for the exchange and settlement of energy consumption data. RUs are not able to choose their energy supplier, as joint purchase through the VIVENS purchasing cooperative is the only available option. However, free choice of supplier should be available in the near future. Some stakeholders reported some challenging local requirements for EMSs.
Norway	Norway's IM, Bane NOR, is one of the founding parties of Eress. Norway uses the Eress DCS for energy data collection, and the Erex function for the exchange and settlement of energy consumption data. RUs are unable to choose alternative energy suppliers.
Poland	In Poland, PGE EK is a supplier of rail traction electricity and DSO. The company is part of the PGE Group, while the main rail IM is the Polskie Linie Kolejowe (PLK). Although PGE is a member of IRS 90930, the DCS system currently in place is outdated and does not allow for the exchange of consumption data. This legacy DCS only works with and settles real consumption data to domestic RUs equipped with EMSs. RUs are free to choose their energy provider. A new DCS compliant with EU legislation is being implemented and tested with Eress and neighbouring countries and should be in place in 2026. Some stakeholders, though, reported issues of additional requirements imposed for data exchange, a lack of a data acknowledgement function when exchanging data, undue requirements on EMSs for their own calibration and sealing, and a lack of cross-acceptance of all EMSs, even if compliant with EN 50463, resulting in some cross-border RUs having to install multiple EMSs on the same locomotive. Some of these local requirements may be due to the DSO Network Code.
Portugal	The Portuguese IM has been an Eress partner since 2025. Portugal will soon use the Eress DCS for energy data collection and the Erex function for the exchange and settlement of energy consumption data. Cross-border traffic with Spain with electric trains is very limited, though, as only one border point is electrified. The fleet has either no EMSs or EMSs not compliant with the latest standard, therefore billing for traction energy is based on estimations. Meter data, sometimes collected by visual inspection, are only used for spot corrections. RUs are not yet able to choose their energy supplier.
Romania	The main IM in Romania is Căile Ferate Române (CFR) Infra. There is no DCS in place, although some feasibility studies seem to have been conducted. RUs are not able to choose their energy supplier and no exchange function is possible. It seems traction energy is mostly based on estimations and the fleet has either no EMSs or EMSs not compliant with the latest standard. Meter data, sometimes collected by visual inspection, are sometimes used for billing. Despite several attempts to contact the IM for an interview, limited information is available on the situation in Romania.
Slovakia	In Slovakia no DCS is present and, despite a national rule to meter traction energy consumption, billing is based solely on estimated consumption. However, RUs with EMSs are applied a lower rate. RUs are not able to choose their energy supplier. The Slovak IM seems to follow IRS 90930 even if no exchange function is yet in place. It seems a DCS will be set up in the near future, but high cost is the biggest perceived barrier.
Slovenia	The Slovenian IM, Slovenske železnice-Infrastruktura (SŽ-Infrastruktura), has recently set up a compliant DCS able to exchange data with other countries such as Eress members, Austria, Germany and others. The DCS is compliant with both the EN50463-2017 standard and IRS 90930. RUs are not able to choose their energy supplier.
Spain	The main Spanish IM, Administrador de Infraestructuras Ferroviarias (ADIF), is an Eress partner. ADIF has a compliant DCS for energy data collection and has used the Erex function for the exchange and settlement of energy consumption data since 2022. The first billing of traction energy based on EMS data dates to 2023. In accordance with national law, ADIF is the only provider of traction energy and therefore RUs are not able to choose their supplier. Only part of the fleet is equipped with EMSs and Spain has a dual-rail network. Most of this network is built with the Iberian gauge 1 688 mm, while the high-speed network is built with the 1 435 mm standard gauge and some lines allow, through a third rail, both gauges. Cross-border points with France are mostly electrified, but with Portugal only one border point is electrified. Cross-border rail traffic with electric trains is limited and mostly made up of high-speed passenger trains.
Sweden	The Swedish IM, Trafikverket, is one of the three Eress founding parties. Sweden uses the Eress DCS for energy data collection and the Erex function for the exchange and settlement of energy consumption data. RUs are not able to choose their energy supplier as Trafikverket is under the regulatory framework of the rail market rather than the energy market not allowing grid access to third parties other than RUs. The regenerative braking is applied on the basis of a formula rather than real data from the EMS. Some RUs have no EMSs installed and the applied consumption estimation charges seem to be generous as no gradient of different lines is considered.

Member State ([3])	Overview
Switzerland	Schweizerische Bundesbahnen Infrastruktur (SBB Infra) is an Eress partner but uses its own 2012-compliant DCS for energy data collection (to be updated in 2026) and the Erex function for the exchange and settlement of energy consumption data following IRS 90930. We have no information on other IMs. The matching of data with RUs operating trains is done using train run data and EVNs. RUs running in Switzerland can use EMSs from different manufacturers, however some reported national requirements to provide EMS certification. The only provider of traction energy is SBB Infra. Third-party access to the energy market is therefore not present, however some reported the pricing offered by SBB Infra, set by the government, as being competitive. Switzerland applies a 25 % surcharge on energy prices for RUs running without a functioning EMS installed and estimations are considered high.

5.1.1. The national implementation plans for ENE TSI

In accordance with Article 9(1) of ENE TSI, each Member State was required to submit a national implementation plan (NIP) by 31 December 2015 with information about DCSs being implemented. No Member State has a specific case derogation from the obligation to set up a DCS for collecting traction energy data from EMSs. Following a high-level analysis, the Commission received only six NIPs and each is of a different quality and level of detail. In fact, no specific template is required and all Member States failed to describe in their NIP the DCS implementation.

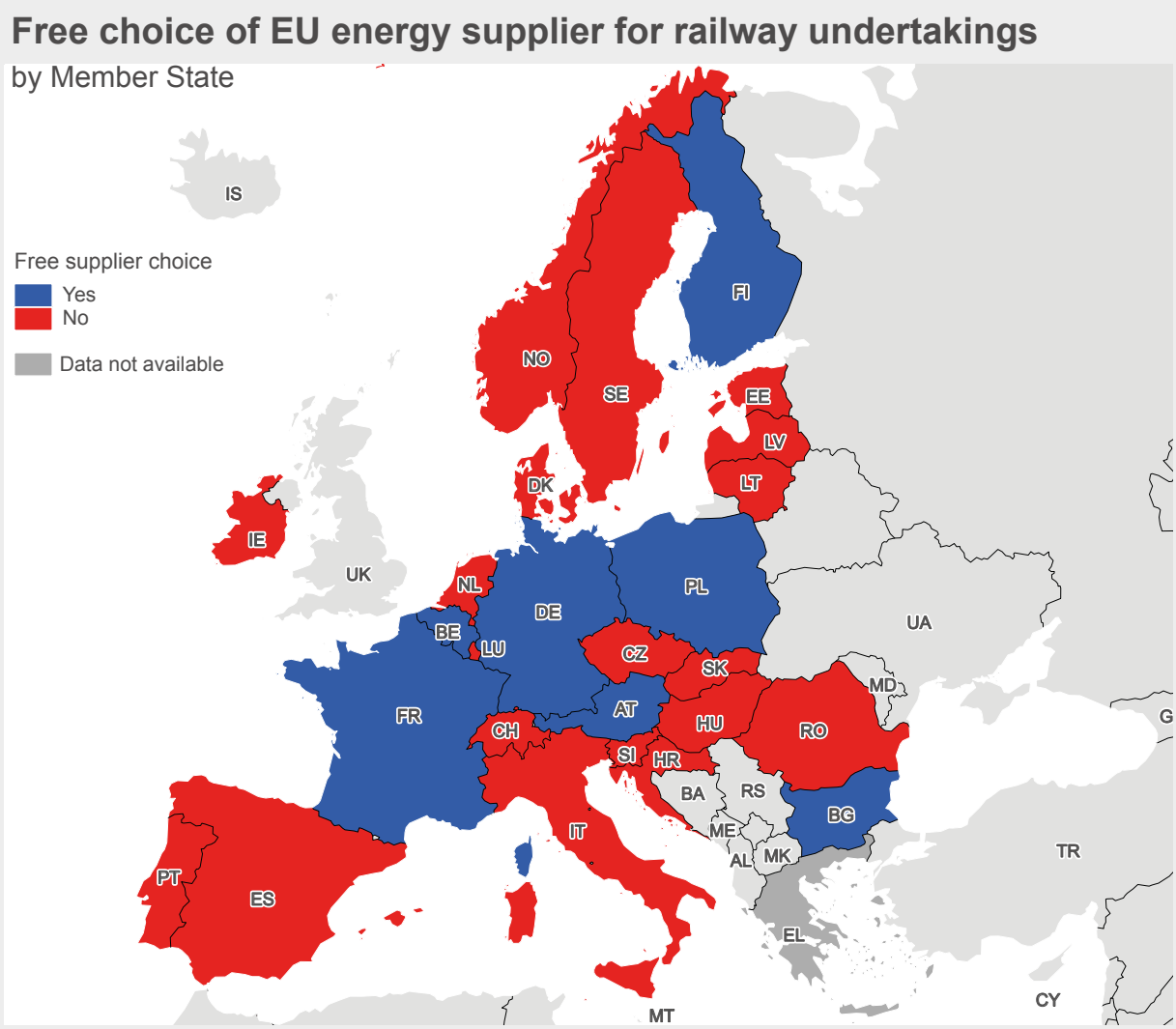
To date, the Commission has not started infringement procedures as per ENE TSI about the absence of NIPs or a lack of sufficient details on DCSs in the few NIPs submitted by the Member States.

5.2. Railways in the energy supply market

A key advantage of traction energy billing based on metered consumption is the ability for RUs to access the EU market for energy supply. Another advantage is a better use of traction current supply and transmission infrastructure thanks to energy efficient rail operations. In fact, being large consumers of electricity with predictable flows of consumption and, in the case of freight RUs, also being large off-peak consumers (freight trains run mostly at night), RUs are interesting customers for energy suppliers. Each RU could procure electricity from different competing suppliers, protect against the risk of price fluctuations with futures and achieve volume discounts from one or a few suppliers for trains running across the whole single European railway area. IMs can also act as group purchasers for all RUs running on their network, also achieving volume discounts from energy suppliers. However, the evidence collected shows that third-party access allowing free choice of supplier for RUs is currently not a reality in all Member States, as shown in Figure 5 ([4]). In some Member States, third-party access may not be possible as rail IMs are designated as a 'closed distribution system' according to the Energy Market Directive.

([4]) Independent Regulators' Group – Rail, the network of rail regulatory bodies, provided a similar clustering of Member States in their November 2024 paper 'Updated paper on charges for traction current'.

Figure 5: Overview of actual free choice of traction energy suppliers by RUs per Member State



Sources: ERA analysis (for data). © EuroGeographics © OpenStreetMap (for administrative boundaries) and Eurostat (for cartography).

5.3. Consistency of ENE TSI with EU legislation on energy

As noted above, RUs are still not able to choose their energy supplier from anywhere in the EU. The electricity market design legal framework has changed often during the last two decades and the degree of implementation of EU legislation by the Member States has varied. Amendments and Court of Justice of the European Union rulings were recorded and the latest reform entered into force on 16 July 2024, with amending Directive (EU) 2024/1711 and amending Regulation (EU) 2024/1747.

A full analysis of the consistency of ENE TSI with EU legislation on energy and the legal status of rail traction power infrastructure, the role of IMs as energy suppliers, generators or group purchasers, unbundling and setting the related grid fees, setting the exchange function energy settlement fees and the competences of energy or rail regulatory bodies, is beyond the scope of this study. However, it is worth noting that an unclear situation

exists with regard to the role of RUs as customers entitled to the free choice of suppliers and the role of IMs in the energy market together with their designation as 'closed distribution system'. It is also not fully clear what the remit of what is defined as energy or as railway infrastructure regarding components and segments of infrastructure for rail traction current. This makes it unclear how the large set of energy-related EU legislation, ENE TSI and Directive 2012/34/EU on the rail market should consistently apply to rail traction energy. The definitions and boundaries of each legal framework, energy- or rail-related, between catenary, transmission power networks, substations, DSOs and TSOs dedicated to serving railways, are not fully clear at the EU level.

This issue of lack of clarity at the EU level was discussed by academics, rail sector representatives and energy stakeholders in the Florence School of Regulation paper 'Electricity and infrastructure managers: Is there a need for regulation?' in February 2023. Independent Regulators' Group – Rail, the network of rail regulatory bodies, published a paper in 2022, 'Overview paper on charges for traction current', which was further updated in 2024 ('Updated paper on charges for traction current'). These papers provide valuable insights and can be the starting point to better clarify the situation at the EU level.

5.4. A focus on Germany

Germany is a key market for railways. It has the longest and busiest rail network by volume. Due to its geographic position and economic and trade links with many neighbouring countries, Germany has a substantial amount of cross-border passenger and freight rail traffic. Therefore, a well-functioning DCS and exchange function is important for the competitiveness of many railway stakeholders.

Germany has a long tradition of rail traction energy metering and DB Energie is a rather unique company in the EU railway sector. As a part of the DB Group, it is an energy generator, supplier for train traction and buildings and stations, an energy transmission operator (specifically a DSO), a diesel trains fuel supplier, a hydrogen and biofuel trains supplier, a provider of charging infrastructure for road vehicles and a DCS and settlement system for rail traction energy billing. DB Energie has more than 2 000 employees, almost 70 % of its traction energy is sourced from renewables and its revenues in 2024 totalled EUR 1 830 billion.

Due to its multi-business nature, DB Energie is subject to the regulatory oversight of the energy sector, which in Germany is a task of the Bundesnetzagentur (BNA). This federal entity is also the rail market regulator in charge of DB InfraGo oversight; however, separate departments oversee rail and energy.

5.4.1. The legal framework for energy in Germany

The legal and regulatory position of DB Energie, especially of its assets, businesses and charges, has been the subject of various amendments to the Energy Industry Act (Energiewirtschaftsgesetz (EnWG)), which is the German law transposing Directive (EU) 2019/944. The EnWG has also been, for more than a decade, a source of several rulings by the Court of Justice of the European Union, stating Germany did not correctly transpose the directive regarding the unbundling of vertical integrated undertakings, powers of the BNA about approving grid fees and self-consumption facilities. The legal aspects are of a high degree of complexity; however, for the interest of this study, it is worth noting the Federal Court of Justice of Germany ruling in the case EnVR 1/10 in 2010. The court decided that DB Energie's grid fees had to be approved by the BNA as the traction power network (Bahnstromnetz) of DB Energie falls within the scope of application of Section 3a of the EnWG, as it serves to supply railway vehicles with traction current. The same judgment also clarified the operational positions of DB Energie and DB Infrago (at the time DB Netz). DB Energie is the operator of the railway traction power network at 16.7 Hz (Bahnstromnetz) in the scope of the EnWG, the connection network between the public energy grid

(at 50 Hz), while the overhead catenary system (Oberleitungsnetz) is operated by DB InfraGo. This clarifies that DB Energie is a DSO, and its infrastructure and fees are under the oversight of the energy sector legislation and of the related BNA department.

Different from the unclear status at the EU level mentioned in the section above, German legislation and court rulings provided some clarity about the legal and regulatory framework applicable to rail traction energy infrastructure, market regulation and grid fees.

5.4.2. The upcoming reporting obligations for railway undertakings and lessors

The BNA issued an important decision (BK6-19-016) in 2022 that adapted, through special arrangements, the existing legal framework (EnWG) to the specific needs and nature of the railway infrastructure and of rail traction energy. For the interest of this study, this BNA decision mandated that access to the traction power network is possible only for trains equipped with ENE TSI compliant EMSs or other calibrated legacy meters, the right to freely choose a metering point operator envisaged by the Act on Metering Point Operation and Data Communication in Smart Energy Networks (Messstellenbetriebsgesetz) does not apply in the rail traction power network due to the fixed integration of metering systems in mobile traction units and temporary user associations.

The BNA decision has, above all, as the most important change for rail traction energy metering, a new reporting obligation imposed on vehicle owners or keepers. Like other DCSs, DB Energie is currently receiving consumption data from EMSs installed on trains, inclusive of GPS positions, EVNs and time stamps, as per EN 50463. This is particularly important as it seems, in Germany, different grids with different fees are powering the national rail network. However, different from DCSs and IMs in other Member States, DB Energie does not receive rail traffic data from DB InfraGo and struggles to match consumption to the RU actually operating a given train on the German network. BNA had, until TEL TSI was adopted, no legal basis to enforce data sharing from DB InfraGo. Therefore, DB Energie requires RUs to regularly provide them with the list of trains run on given dates/times with indications of the EVNs involved. Following this regular but manual data submission, subject to frequent data quality and gaps, DB Energie can match consumption data received from EMSs with the right RU entitled to be invoiced for traction energy. This is particularly important as, especially in the rail freight business, leasing and subcontracting of locomotives, even for the short term, is very common and it is possible that the vehicle owner or keeper is not necessarily the company that provided traction to a given train.

As of July 2026, the BNA decision BK6-19-016 will mandate a change in the reporting obligation to ensure the correct billing of traction energy. Soon vehicle owners and/or keepers, who in the rail freight business are often leasing companies, will be responsible for ensuring the matching of consumption data and accuracy. In fact, in case of leased or subcontracted traction vehicles, lessors or keepers will need to collect daily train runs, location and time from their client undertaking to be able to supply DB Energie with usage time per RU. They will have to match the EVNs and provide such datasets to DB Energie to ensure the correct billing of traction energy. In case of data quality issues hampering the identification of the RU running a given train, DB Energie will then be referring to the usage time reported by the vehicle keeper for its billing. As a consequence, the lessor or keeper will be ultimately responsible for settling the traction energy invoice when the operating RU cannot be identified.

It seems the BNA decision was not accompanied by a cost-benefit analysis but a consultation of stakeholders was conducted. As key findings, it can be stated that this new reporting obligation will ensure more reliable and accurate data on train runs to DB Energie, ensuring that all traction energy cost is billed to the appropriate consumer. However, vehicle owners or keepers, and in particular lessors, will become a new party in the existing reporting obligations of train run data in Germany, in addition to RUs. This will generate additional red tape for the rail sector, and additional complexity, costs and the likely need to revise leasing contracts, as lessors will need to get access to train run data from RUs.

Such data may be considered commercially sensitive by RUs that may be unwilling to share the detailed origin/destinations of their trains with their lessors. Leasing companies will also have to dedicate resources to perform the data matching work prior to the submission of data to DB Energie. It is likely that such a new task of lessors will be recharged to RUs via higher leasing fees for locomotives.

The BNA decision is not in the scope of ENE TSI as it regulates a matter of the exchange function and of the data exchanges between EMSs, DCSs and settlement systems. However, it remains unclear why other settlement systems across the EU are able to perform the matching of EMSs consumption data with train traffic data (using, for example, TEL TSI messages) from the IMs on the basis of the EVNs, as a back-office process, while DB Energie needs burdensome direct reporting from RUs or vehicle keepers/owners ([5]).

5.5. The role of notified bodies and national safety authorities

A DCS is part of the energy subsystem, in accordance with Annex II to Directive (EU) 2016/797. During the process of authorisation for the placing in service (APIS) of fixed installations, as per Article 18, by the NSA concerned, the compliance of this subsystem with the ENE TSI will be demonstrated by the applicant and assessed and confirmed by a NoBo ([6]). As DCSs are not safety-critical components, they are not assessed by NSAs when granting safety authorisations to IMs, as per Article 12 of Directive (EU) 2016/798.

EMSs are part of the rolling-stock subsystem, in accordance with Annex II to Directive (EU) 2016/797. During the vehicle authorisation process by the ERA and the NSAs concerned for the relevant area of use or solely by NSA for domestic vehicles, the compliance of this subsystem with the LOC & PAS TSI has to be demonstrated by the applicant and assessed and confirmed by a NoBo (and a DeBo in the case of applicable national technical rules and specific cases).

Further to the evidence provided, stakeholders indicated there are issues related to authorisations for DCSs and EMSs. These are hurdles to an effective implementation of rail traction energy metering. In particular, some solutions could be envisaged, such as the following.

- For DCSs, the EC verification procedure for subsystems, as per Annex IV to Directive (EU) 2016/797, is lacking. In fact, in Table B.1 in Appendix B to ENE TSI, a mandatory assessment of 'on-ground energy data collecting systems – 4.2.17' is not applicable. Therefore, the NoBo file does not necessarily contain an assessment of DCSs during design, installation or operation of railway lines requiring an APIS. Marking Table B.1 as applicable instead would likely facilitate the authorisation process and increase compliance with ENE TSI, especially in those Member States where a compliant DCS is lacking.
- For EMSs, these devices are not only subject to the applicable requirements of the LOC & PAS TSI and of EN 50463 but also to other transversal requirements for vehicle authorisations. These refer mainly to electromagnetic compatibility issues of EMSs that may require testing and are not always expected by vehicle authorisation applicants. Although some train manufacturers expressed doubts, the possibility of introducing on-board EMSs as interoperability constituents, in accordance with Directive 2016/797, would greatly simplify the vehicle authorisation process, limiting the assessment of the integration of the EMSs into a specific vehicle. In fact, the on-board EMSs would already be assessed prior to obtaining the inter-

([5]) As per the 2020 'EU railway sector declaration on traction energy metering and settlement', the use of TAF TSI / TAP TSI messages is recommended but 'other methods for validation and allocation are possible'. TEL TSI makes it mandatory for IMs to share train composition data received from RUs with settlement systems. This new TSI, once implemented, may make the new reporting obligation in Germany for RUs and lessors superseded.

([6]) NoBos are independent entities designated by Member States and monitored by the ERA under Directive (EU) 2016/797.

operability constituent certification. This solution would be particularly important when existing vehicles are retrofitted with EMSs for the first time or with the latest compliant EMSs, triggering the need for a new vehicle authorisation. However, the NoBo assessment should also consider the EMS accuracy of energy consumption values.

5.6. A focus on on-board energy measurement systems and interfacing with data collecting systems

The on-board EMS is a mandatory component for new, upgraded or renewed rolling stock operating in the single European railway area. EMSs' primary function is to measure and record the energy consumed by the traction unit and transmit this data to an on-ground DCS for billing and settlement purposes.

The regulatory basis for installed EMSs is established in the LOC & PAS TSI (Commission Implementing Regulation (EU) 1302/2014 and later modifications), which amended both the LOC & PAS TSI and the ENE TSI to close open points regarding the interface between EMSs and DCSs.

Technical requirements

- LOC & PAS TSI, point 4.2.8.2.8 specifies that the EMS must:
  - measure voltage and current accurately;
  - calculate energy consumption;
  - compile CEBD in compliance with EN 50463:2017 series;
  - transmit CEBD to the DCS using standardised communication protocols (conformity-assessment-guidelines-2017_web.pdf).
- The EN 50463 series provides harmonised standards for:
  - Part 1: General system requirements,
  - Part 2: Measurement functions (voltage, current, energy calculation),
  - Part 3: Data handling,
  - Part 4: Communication,
  - Part 5: Conformity assessment (See Conformity Assessment Guidelines V 2.0)

Compliance with EN 50463 ensures presumption of conformity with the essential requirements of the TSIs.

5.6.1. Vehicle authorisations and notified bodies

The installation of an EMS is assessed as part of the rolling-stock subsystem during the vehicle authorisation process. NoBos with their certificates play a key role in the management and issuance of vehicle authorisation by the ERA or NSAs. These independent commercial entities are monitored by the ERA, as per Article 34 of Regulation (EU) 2016/796, through an assessment scheme ensuring NoBos' competence, impartiality and consistent application of requirements across the EU.

Role of notified bodies

The conformity assessment of the rolling-stock subsystem, including the on-board EMS, is carried out by NoBos in accordance with the modules defined in Commission Decision 2010/713/EU. The choice of module depends on whether the assessment concerns the design phase, the production phase or both. The most relevant modules for EMS integration are the following.

- Module SB–EC type examination: applied to the design phase. The NoBo examines the technical design of the subsystem (including EMS integration) and verifies compliance with the applicable TSIs and harmonised standards (e.g. EN 50463). This includes reviewing design documentation, functional specifications and type tests.
- Module SD–EC verification based on a quality management system (QMS): applied to the production phase. The manufacturer operates an approved QMS for production, final inspection and testing. The NoBo audits the QMS and verifies that the subsystem produced conforms to the approved type.
- Module SF–EC verification based on product verification: also for the production phase, but instead of auditing a QMS, the NoBo performs direct inspections and tests on each manufactured subsystem or on statistically selected samples.
- Module SG–EC verification based on unit verification: used for individual vehicles or unique configurations. The NoBo verifies that a single subsystem (including an EMS) meets TSI requirements through full examination and testing.

Upon successful assessment, the NoBo issues an EC Certificate of Verification for the rolling-stock subsystem, in accordance with Directive (EU) 2016/797. This certificate is required for the successful delivery of vehicle authorisations by the ERA or NSAs.

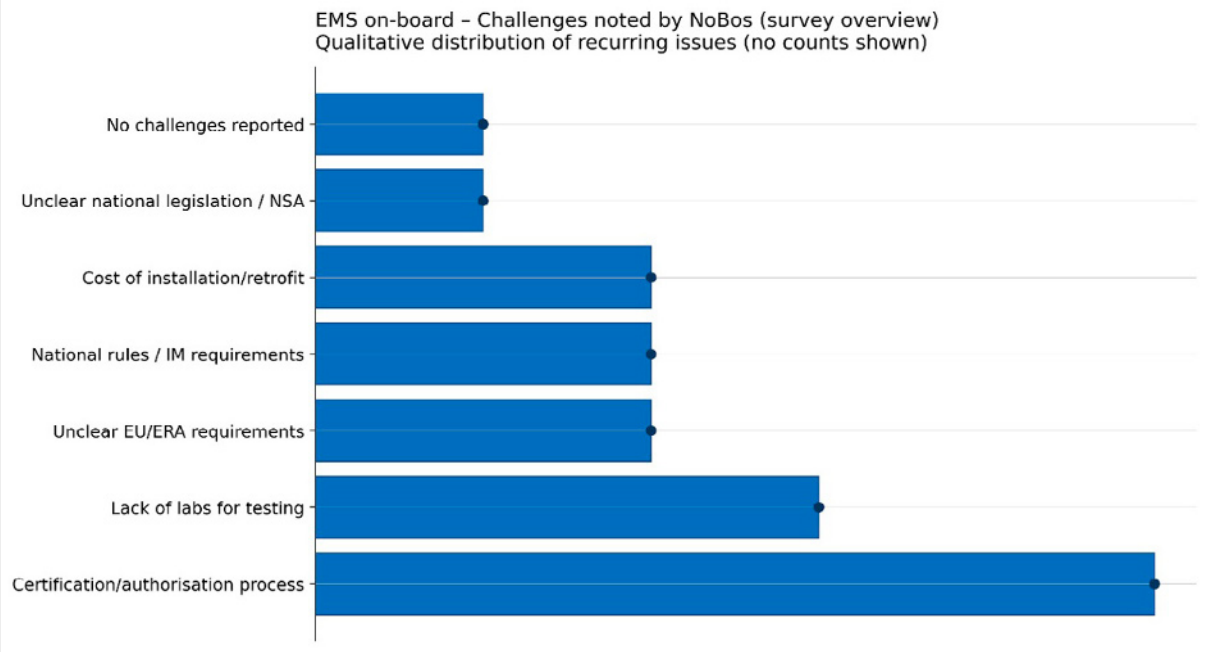
Feedback from notified bodies on energy management system implementation challenges

As part of this study, a survey was conducted among NoBos to gather insights on the challenges related to the installation or retrofitting of EMSs in compliance with the latest LOC & PAS TSI. Details are available in the Annex. The responses, provided on a voluntary basis, highlight several recurring themes.

Key challenges identified

- **Unclear or complex requirements**: some respondents indicated that EU-level requirements and ERA guidance are perceived as unclear or overly detailed, particularly regarding the fitment and integration of EMSs into vehicles.
- **Certification and authorisation process**: multiple NoBos reported that the certification process is complex and time consuming, requiring a detailed assessment for each case **since an EMS is not considered an interoperability constituent**.
- **National rules and infrastructure constraints**: certain challenges arise from national legislation or IM requirements, which may differ from EU-level specifications.
- **Cost implications**: the financial burden of EMS installation or retrofitting was mentioned as a significant barrier, especially for smaller operators or in markets with limited resources.
- **Lack of accredited laboratories**: several respondents highlighted the scarcity of testing facilities for EMS components, which can delay conformity assessments.
- **No significant challenges**: a minority of respondents reported no major issues with EMS implementation.

Figure 6: Result of the ERA web survey addressed to NoBos for the study



Source: ERA analysis.

General observations

- There is a need for clearer guidance from the ERA and harmonisation of national requirements to reduce complexity and uncertainty.
- Improved availability of accredited testing facilities would facilitate smoother certification processes.
- Stakeholders expressed interest in further dialogue and technical clarification to ensure consistent application of TSI requirements across Member States.

5.6.2. Compatibility and compliance issues detected

Across Member States, stakeholders reported that technical, procedural and legal mismatches still hinder a seamless EMS to DCS to settlement data-flow chain envisaged by LOC & PAS TSI and ENE TSI. More specifically, the points that follow.

(a) Mixed energy measurement system generations and data transfer practices

Interviewees reported fleets containing both EN 50463:2012 and EN 50463:2017 implementations. While backwards-compatibility is often achievable in practice (e.g. by converting legacy outputs to the current CEBD schema), differences persist around data handling, communication (on board and on board to ground), time granularity and geolocation. The 2017 series of the standard is explicit on the EMS purpose (billing-grade metering and CEBD to DCS) and defines roles for data handling (Part 3) and communication (Part 4) (see EN 50463-1, EN 50463-3 and EN 50463-4 overviews).

At borders, several IMs are migrating from historical utilities time series (UTILTS) message exchanges to IRS 90930. While both can be automated, stakeholders observed fewer ambiguities and better convergence with IRS 90930, which standardises roles, flows and files for cross-border settlement, including addenda on protocols and message sets (see the IRS 90930 overview and addenda and the UIC IRS 90930 workshop page).

(b) Data collecting systems' availability and maturity

Several IMs operate modern DCSs fully aligned with EN 50463-2017 interfaces. Others run legacy DCSs, sometimes limited to domestic RUs, while some IMs still lack a DCS. Where a DCS is missing or limited, billing often relies on substation metering and/or estimation models, which complicates cross-border interoperability and energy supplier choice (see Commission Implementing Regulation (EU) 2018/868, obligations on DCS/settlement).

(c) Exchange function heterogeneity (IRS 90930 – proprietary – legacy)

Interviewees described the following three operating patterns.

- IRS 90930-based exchanges with end-to-end automation and agreed timing on the data transfers from DCS to exchange and between exchange functions of different countries. This approach is used mostly by Eress partner members.
- Proprietary exchange stacks that implement IRS 90930 content but keep distinct interfaces.
- Legacy links (e.g. former UTILTS messages) under migration to IRS 90930 that explicitly target cross-border settlement harmonisation, and the sector's own EU railway sector declaration that encourages adoption and timely processing of exchange data (see the IRS 90930 overview and addenda and the EU railway sector declaration on traction energy and metering settlement).

Observed issues include:

- one-way data flows or missing acknowledgements to/from neighbouring DCSs;
- different timing rules (e.g. IRS expectations at borders versus on-board data packaging intervals in EN 50463 implementations);
- operational choices (e.g. some IMs providing exchange only for specific on-board solutions) that constrain international RUs.

These issues are not contradictions to EU law per se, but compatibility frictions encountered in practice during migration and bilateral coordination (interview evidence).

(d) Train identification and composition attribution

Several IMs match consumption using EVNs at the DCSs – sometimes with reduced-digit codes – while train composition is collected as a fallback. Whereas RUs do not provide consistent train data, unallocated energy may be charged via contractually agreed fallbacks (interview evidence). Stakeholders noted that optional telematics fields in operational message sets hamper deterministic matching; TEL TSI makes these elements mandatory and requires IMs to provide this data also to the appropriate settlement system.

(e) Legal–metrological frictions (Measuring Instruments Directive versus relevant TSIs and EN standard)

Some stakeholders raised concerns about the applicability of Directive (EU) 2014/32/EU (the Measuring Instruments Directive (MID)) to on-board railway meters versus the interoperability framework (ENE TSI / LOC & PAS TSI and EN 50463). The MID governs instruments placed on the market for legal measurements, including active electrical energy meters, with conformity assessment and metrological marks. However, ENE TSI / LOC & PAS TSI and EN 50463 define a distinct, sector-specific measurement and data chain for traction energy (see the MID and LOC & PAS TSI).

Given the narrow scope of ENE TSI (fixed installations) and the billing-ready purpose of EN 50463 on board, interviewees perceive grey zones when meter ownership, calibration and visual read-out requirements under the MID are invoked by market authorities, especially within closed distribution system regimes. This can generate parallel acceptance

paths and add cost/delay (see the Energy TSI page and the ERA's guide for the application of the LOC & PAS TSI).

(f) National rules, calibration and laboratory capacity

Some stakeholders reported that several countries impose national calibration/approval steps or require local test reports, creating interoperability barriers and delays, especially where accredited labs for EN 50463 measurements are scarce (interview evidence). These are precisely the kind of residual open-point practices that ENE TSI intended to reduce by fixing interfaces and promoting CEBD-based exchanges.

(g) Estimated versus metered consumption and treatment of losses

Where EMSs/DCSs are absent or incomplete, operators rely on estimation methods (train characteristics, path, km, service type), sometimes corrected against available meter reads or substation totals. Policies on regenerative energy vary: if not measured on board and settled, it is often not credited; network losses may be allocated via coefficients or borne by the IM, depending on national practice (interview evidence). The sector declaration recommends converging to metered, exchanged and validated CEBD to underpin fair billing (see the sector declaration).

5.6.3. Local requirements and compliance with EN 50463

While EN 50463:2017 is the harmonised reference for on-board traction energy measurement and LOC & PAS TSI and ENE TSI define the EMS/DCS obligations and interfaces, local frameworks and market models significantly influence the deployment pace and the actual billing chain. Interviews reveal a spectrum, from fully EMS-based settlement with IRS 90930 exchange to substation/algorithmic estimation with limited international data sharing (see LOC & PAS TSI and EN 50463-1).

(a) Patterns of local requirements

- **Network statement mandates and incentives.**
  Some IMs have required EMS fitment through network statements long before EU-law obligations; others offered tariff incentives (or historic surcharges for non-EMSs) or state subsidies for EMS/DCS roll-out. Conversely, some markets with energy cost support for rail report weak commercial incentives for EMS fitment. These choices affect EN 50463 adoption rates and data quality (interview evidence).

- **Acceptance and ownership models.**
  In some networks, on-board meters are owned/leased by the IM and integrated with the IM's DCS; elsewhere, RUs own the meters and must present NoBo certificates and calibration evidence for acceptance. As ENE TSI does not include a DCS conformity assessment by NoBos (fixed installations are currently out of scope for NoBo verification), strong local acceptance checklists exist in practice.

- **Exchange function governance.**
  Three clusters emerged:

  (a) fully IRS-compliant interface (including Eress-based exchanges/settlement);
  (b) IRS-compliant but proprietary interfaces;
  (c) legacy exchanges migrating to IRS.

  IRS 90930 provides a non-binding but widely used blueprint; for instance, Eress is using their own exchanges/settlements based on the IRS and in line with the sector declaration.

  A key remaining issue is the harmonised implementation of these exchange functions, settlement systems, data models and data exchanges. These processes are

beyond the scope of ENE TSI and left to sector-led self-regulation, with debatable results.

- **Market regulation and MID considerations.**
  Where the electricity market regulator requires MID-like compliance (e.g. independent calibration, controlled access and visual read-outs), railway actors face dual challenges: meet the MID and meet EN 50463/TSI requirements. Because ENE TSI focuses on fixed installations and LOC & PAS TSI on rolling stock, and neither of the two is a legal-metrology instrument, interpretation gaps can appear. Some stakeholders called for better scoping between directives and standards (see the MID and the ERA's guide for the application of the LOC & PAS TSI).

- **Absent or partial DCS.**
  A few networks still rely on substation metering and estimates; others have a DCS for domestic flows only, with plans to become fully compliant for international exchange by specific target dates. These situations diverge from ENE TSI expectations on the DCS and energy settlement capabilities.

(b) Compliance with EN 50463: typical gaps and mitigations

- **Measurement coverage and boundaries.**
  Legacy rolling-stock fleets with separate auxiliary supplies may need measurement at the main breaker or additional channels to ensure completeness; newer trains integrate auxiliary loads behind the traction device. Where the virtual-meter approach is used (algorithmic consumption models), regenerative energy is often not credited, and accuracy depends on the model inputs and calibration against real data (interview evidence). The EN 50463 chain (EMS to CEBD to DCS) remains the reference for billing-grade data (see EN 50463-1).

- **Communication, timing and geolocation.**
  Disparities exist between EN 50463 data packaging (e.g. five-minute intervals with GPS tags on some implementations) and IRS 90930 expectations at border points (sub-five-minute intervals). While both frameworks are compatible, operational alignment is required in bilateral agreements and test phases (see the IRS 90930 overview and addenda).

- **Data quality and fallbacks.**
  Common mitigations include store-and-forward on the meter, acknowledged exchanges and contractual estimation only for gaps. Using EVN-based matching and keeping the train consist as a back-up improves allocation robustness (interview evidence).

- **Laboratory and calibration capacity.**
  Where test capacity is scarce, acceptance queues delay projects. Sector guidance stresses using the harmonised EN 50463 series to minimise extra national checks.

(c) Suggestions from stakeholders

- Clarify legal scoping between the MID and rail-specific rules (e.g. a joint interpretation note or targeted amendments) to avoid duplicate metrology requirements on on-board meters (see the MID).
- Reference IRS 90930 more explicitly (via TSI guidance or sector agreements) to reduce bespoke exchanges and uneven implementations (see the IRS 90930 overview and addenda and the sector declaration).
- As national/particular provisions may apply in some Member States, standardise APIS/permitting and publish acceptance checklists for EMS onboarding, aligned with EN 50463 and TSI interfaces (see LOC & PAS TSI).

- Promote EVN-based matching with consistent master data and progressively make operational telematics fields mandatory where they reduce settlement disputes (sector practice; interview evidence).
- Encourage incentives (temporary surcharges, grants or accelerated depreciation) to accelerate EMS retrofits, mirroring positive experiences reported by several IMs (sector practice; interview evidence).
- Facilitate shared services (IRS-conformant hubs, e.g. Eress) for IMs with small networks to reduce capital expenditure and operating expenses and meet ENE TSI obligations faster.
- Consider the set-up of a 'reference DCS' to test and approve EMS compatibility to ensure interoperability with all DCSs, minimising the risk of local or corporate additional requirements impacting EMS cross-acceptance.

5.6.4. Energy measurement system manufacturers

The manufacturing landscape for on-board EMSs reflects both the progress achieved in standardisation and the persistent challenges in ensuring full interoperability across the single European railway area. Suppliers of EMSs include established firms such as – in alphabetical order – Alstom, HaslerRail, LEM, Microelettrica, ÖBB Infra, POLL, Sesto, Wabtec. While the EN 50463:2017 series provides the harmonised reference for measurement, data handling and communication, manufacturers report that practical implementation often requires additional adaptations to meet national requirements, customer-specific requests and evolving cybersecurity expectations.

Compliance and functional scope

Manufacturers confirm that compliance with EN 50463:2017 is generally achieved, but integration into rolling-stock platforms involves balancing core TSI requirements (approximately 70 % of functions) with country-specific and operator-specific features, which can trigger complexity and additional cost.

The need for software updates – particularly for cybersecurity patches – raises concerns about maintaining conformity without triggering full re-homologation. Stakeholders advocate for clearer provisions, enabling controlled updates without repeating the entire authorisation process.

Communication protocols and security

One of the most cited issues relates to data transmission protocols. The current EN 50463:2017 references FTP/HTTP, whereas many IMs, DCSs and operators now mandate secure protocols (e.g. HTTPS, FTPS). This misalignment forces manufacturers to implement non-standard solutions to satisfy local security policies, creating a divergence from the harmonised approach. The upcoming revision of EN 50463 is expected to address this gap by including secure communication options.

Interoperability and market fragmentation

Although the standard theoretically ensures interoperability, manufacturers report that:

- some IMs impose additional security or functional requirements beyond EN 50463;
- certain markets favour closed ecosystems, where only specific EMS types are accepted for integration with national DCS platforms;
- differences in data exchange governance (e.g. IRS 90930 versus proprietary solutions) and acknowledgement mechanisms can delay cross-border operations.

These factors increase the burden on manufacturers, which often maintain multiple EMS variants to satisfy divergent national specifications.

A key finding is that cross-acceptance of EMSs compliant with EN 50463 is not a reality across the single European railway area. A single market for EMS does not really exist. This eventually creates additional undue costs for vehicle keepers, requiring them sometimes to install more than one EMS if a vehicle is supposed to operate in multiple Member States where cross-acceptance of compliant EMS from any manufacturer is not ensured.

Operational and retrofit challenges

Retrofitting older fleets remains costly, particularly when legacy communication modules (e.g. 2G/3G) must be replaced alongside EMS hardware. Multi-system locomotives introduce calibration challenges for different voltage systems (e.g. 15 kV AC versus 25 kV AC), requiring precise configuration to maintain EMS measurement accuracy. Imprecise cabling for EMS may also affect the accuracy of measurements.

Emerging topics

- **Cybersecurity**: growing emphasis on data integrity and secure transmission is driving additional requirements not fully covered by current standards.
- **Hybrid and battery trains**: these raise questions about billing methodologies when actual energy drawn from the grid is zero or during charging, yet infrastructure access charges still apply.
- **Customer-driven features**: some operators request EMS data for driver performance monitoring and energy optimisation, expanding the EMS role beyond billing.

5.6.5. Research and development on future energy measurement system telecommunication

Rail traction energy is currently among the key research topics of Task 1 of the System Pillar (Railway System) activities of the ERJU. The scope of this study does not cover research needs on EMSs, energy efficiency or devices, tools or systems for energy metering. However, following input from a stakeholder, it would be worth considering dedicated R & D efforts on the telecommunication channels, devices and technologies of EMSs. In fact, EMSs currently send consumption data and GPS positioning to DCSs usually via an exclusive GSM connection and a dedicated antenna installed on tractive vehicles. Such a set-up is made to minimise electromagnetic compatibility issues with other systems on board trains, especially the signalling system, which is safety critical. Therefore, trains communicate today via telecom connections with multiple antennas and data connection channels (e.g. EMSs, signalling systems, GSM-R radio, on-board passenger information systems and on-board Wi-Fi offered commercially to passengers). Each of these systems has its own exclusive communication equipment and antennas, creating complex and expensive design solutions to ensure proper functioning of each device and service.

The European rail sector is currently embracing a major technological transformation of radio and data communication that is currently based on 2G GSM-R technology. The Future Railway Mobile Communication System (FRMCS), currently in development by UIC with the support of the ERJU, is supposed to replace GSM-R with modern 5G digital communication technology. GSM-R is a key component of the European Rail Traffic Management System for safe and interoperable traffic management and for the radio communication between train drivers and IM dispatchers. With the aim of reducing the number of antennas and communication systems on board trains, it would be useful if specific R & D on EMSs could explore the possibility of using the FRMCS for the transmission of energy meter data and GPS positioning.

6. Recommendations

The evidence collected, along with the key findings and analyses performed in this study, allows for the provision of a list of recommendations for future actions at the EU level that could improve rail traction energy metering.

Table 5: Final recommendations on rail traction energy metering

Recommendations	Details	Key benefits
1. Consider enforcing ENE TSI's existing requirements.	The legal provisions of ENE TSI requiring Member States to ensure that an on-ground energy DCS capable of exchanging CEBD are still not a reality in all Member States despite a long-overdue obligation. NIPs have not been followed up on and are lacking details.	▪ Credibility of EU legislation effectiveness. ▪ Enhanced interoperability of rail transport. ▪ Third-party access for RUs, allowing for different energy suppliers of their choice across the EU. ▪ Eco-driving and regenerative braking. ▪ Fairer invoicing of traction energy instead of consumption estimates.
2. Streamline the exchange and settlement processes for traction energy measurement and billing by making use of the already mandatory train composition messages data flow from RUs to IMs applicable in rail telematics.	Many IMs use the train composition data they receive from RUs for telematics, safety, capacity allocation or traffic management purposes also in energy settlement. This data contains the EVNs and the RU's name. These are the key elements a settlement system needs to know to match energy consumption data received from the EMS via DCS, also containing the EVN, with the RU actually operating a train. This data matching allows the settlement system to provide accurate data to invoice traction current to the correct RU. Some IMs do not use train composition data or refuse to share these with the exchange function/ settlement system, especially if operated by another entity, obliging bespoke processes for data matching (energy consumption, EVNs and RUs operating trains) and imposing additional reporting obligations on RUs or lessors.	▪ Reduced costs. ▪ Reduced red tape and reporting obligations. ▪ Digital automation of existing telematics data flow from RUs to IMs extended to energy/settlement system processes, systems or providers.
3. Improve dissemination and knowledge sharing on traction energy metering.	One key finding of this study is that traction energy metering is a true niche, even for people very experienced in the rail sector. The general level of knowledge of the EU legal framework, standards and processes is rather low or even non-existent in some Member States. This creates low awareness in decision-makers that affects planning and investment decisions.	▪ Increased awareness of the benefits of traction energy metering for the competitiveness of the rail sector. ▪ More detailed awareness that the overall benefits of EMSs and DCSs outperform the implementation costs. ▪ Increased engagement of national stakeholders through the ERA Academy, NSA training and conferences, and sector associations.
4. Analyse the opportunity to amend Table B.1 in Appendix B to ENE TSI.	Table B.1 in Appendix B to ENE TSI could require a mandatory assessment of 'On-ground energy data collecting systems – 4.2.17' for authorisation of place into service (APIS) of fixed installations. Today it is not applicable.	▪ Simplification of the APIS process. ▪ The NoBo is required to assess DCSs during design, installation or operations. ▪ Reduction of risks of possible national requirements imposed on IMs to obtain APIS of lines.

Recommendations	Details	Key benefits
5. Analyse the opportunity to extend the scope of application of ENE TSI into the data exchange function and settlement processes.	The EU railway sector declaration on traction energy metering and settlement and IRS 90930 are voluntary and self-regulating instruments of the rail sector. Based on the evidence collected and key requests from some stakeholders, having a legal basis for the data exchange function and settlement systems – regulating DCSs and settlement processes without deviations and interpretations – would ensure harmonised implementation and processes.	▪ Legal certainty of data exchange functions and settlement processes. ▪ Enhanced interoperability of DCSs and settlement systems across the whole EU. ▪ Less need for bilateral agreements between DCSs and IMs/settlement systems and less risk of divergent interpretations of data models and processes creating hurdles.
6. Explore the costs and benefits of one DCS and settlement system at the EU level.	The current text of ENE TSI puts the obligation on the Member State to ensure the set-up of a DCS. It is worth considering a revision of the legal text to avoid undue barriers to joint DCS and settlement system solutions at the EU level which already exist on the market. It could also be assessed whether the existence of a DCS and settlement system in each Member State (sometimes even in each IM of a Member State) is the most cost-effective and beneficial solution to perform the task of collecting EMS data, exchanging them, ensuring correct billing and providing data to IMs to issue traction energy invoices to the right RU. Moreover, the set-up of a single 'reference DCS' at the EU level could also be used only to test and approve EMS compatibility to ensure interoperability with all DCSs, minimising the risk of local or corporate additional requirements impacting EMS interoperability.	▪ Optimised interoperability of the DCS, EMS and settlement function. ▪ Minimisation of local or corporate requirements of DCS hampering EMS' interoperability ▪ Reduction of duplications and costs. ▪ Single central clearing house for producing data for traction energy invoices. ▪ Pooling of scarce IT expertise on traction energy metering and settling, which is a very specific process within the rail sector.
7. Analyse the opportunity to amend TSI LOC & PAS by making EMS an interoperability constituent.	Having EMSs as an interoperability constituent would facilitate vehicle authorisations, facilitate certification, minimise national or IM requirements for calibration, installation, etc., and achieve a full cross-acceptance of compliant EMSs everywhere in the EU, whichever the manufacturer.	▪ Less complex and faster vehicle authorisations. ▪ Higher certainty of and facilitated NoBo assessments, also of production requirements. ▪ Enhanced interoperability for RUs and reduced costs for EMSs. ▪ Increased competition among EMS suppliers. ▪ Real single market for EMSs.
8. Analyse and potentially clarify the applicability of Directive (EU) 2014/32/EU on measurement instruments (MID) to EMS.	It is not clear if and how the MID is applicable to EMSs installed on board trains. The MID has several provisions about the visual reading of meters, certifications, independent conformity assessments, degree of accuracy, etc., that seem not to be suitable for EMSs. However, in a regime of third-party access, energy suppliers may require for their legal safeguard MID compliance of EMS. Interpretative guidelines or a specific derogation in EU legislation could help the rail sector.	▪ Legal certainty. ▪ Avoidance of duplication of assessments or certifications.

Recommendations	Details	Key benefits
9. Consider the potential need to analyse the legal status of IMs and energy supply with regard to traction current infrastructure and services in Member States.	The scope of application of Directive (EU) 2019/944 and Regulation (EU) 2019/943 on common rules for the internal energy market with regard to RUs as customers of energy suppliers and the status of IMs, of their infrastructure and of the boundaries of what is in the scope of the rail infrastructure and what is part of the energy infrastructure is not fully clear at the EU level. This has implications for the setting of grid fees and exchange function energy settlement fees, for third-party access allowing free choice of energy supplier and for the remit of regulatory bodies from the energy or the rail sector. Interpretative guidelines or specific amendments to the energy market legislation and to Directive 2012/34/EU could be beneficial for the rail sector.	▪ Legal certainty. ▪ Clear compliance obligations. ▪ Reduced fragmentation of the single market resulting from diverging national interpretations.
10. Analyse the status of EMS and DCS in respect of EU cybersecurity legislation.	EMS and DCS should take into account all the relevant obligations stemming from the broad and complex legal framework on cybersecurity. TSI and the EN 50463 standard should minimise the risk of re-homologation of EMS when updates or security patches are to be implemented.	▪ Legal certainty. ▪ Clear compliance.
11. Consider R & D on EMS telecommunications.	Future R & D should be focused on exploring the benefits and the feasibility of having EMSs connected and sending data to DCSs via the FRMCS instead of the current dedicated communication channel.	▪ Simplification of products and the installation of EMSs on board trains. ▪ Lower costs.

7. Methodology and acknowledgements

7.1. Project delivery and methodology

This study was produced from January to December 2025 by in-house staff at the ERA. The methodology applied is inspired by the better regulation guidelines of the Commission for *ex post* evaluations. Key elements of the methodology applied for this study included detailed desk research and a large web survey followed up by 26 bilateral interviews conducted in person and via video conference.

The web survey was open from 7 April 2025 until 28 May 2025 and was dispatched by the ERA to RUs, IMs, NSAs, Member State authorities, train manufacturers, EMS/DCS suppliers, vehicle lessors, vehicle keepers, NoBos and DeBos. To reach such a large range of stakeholders across Europe, the ERA sent the survey to its network of representative bodies (European associations like the Community of European Railway and Infrastructure Companies, the European Rail Infrastructure Managers, the Union of the European Railway Industries (Union des Industries Ferroviaires Européennes), the Association of European Rail Rolling Stock Lessors, etc.), the NB Rail Association (a grouping of NoBos), Eress and the UIC IRS 90930 working group, asking to promote and disseminate the survey among their member companies. Moreover, the ERA sent the survey to direct contacts available from the ERA network of NSAs, ERA Reference Document Database (list of DeBos) and, with the support of the Commission, to the Member States' representatives in the Rail Interoperability and Safety Committee of the EU. There were 81 survey replies collected from a diverse range of stakeholders and locations, except for Member States authorities. More details on the web survey results are available in the Annex.

The project team also engaged with relevant stakeholders by attending two workshops on IRS 90930 by UIC, two webinars by Eress and the Eress Forum on 12 June 2025, where a summary of the intermediate results of the study's web survey was provided.

The draft final report has been shared for comments with the ERA's Economic Steering Group and with all interviewees, allowing each recipient to provide written comments. A final workshop was organised on 10 December 2025 online and in Brussels to present the draft final report and to discuss openly a selection of the comments received and the recommendations listed in this study.

The final report of this study took note of many of the constructive comments received from the rail sector stakeholders and of the discussions held at the final workshop.

7.2. Disclaimer

The key findings and recommendations contained in this study are based on the expert judgement of the ERA staff, supported by the evidence collected. The information stakeholders shared with the project team could not be verified but it was considered good and trustworthy as presented.

The compliance assessment of EU Member States with the provisions of ENE TSI is not based on the formal exchange of letters with the relevant Member State authorities, and it is without prejudice to the prerogatives and procedures of the Commission in monitoring and enforcing EU legislation. Moreover, only the Court of Justice of the European Union is competent to provide an authoritative interpretation of EU legislation, including TSIs.

This study is not an opinion of the ERA as per Article 10 of Regulation (EU) 2016/796. This study has been produced as per Article 8(3) and Articles 9 and 41 of Regulation (EU) 2016/796. This is a non-legally binding document of an analytical and explorative nature. It does not necessarily represent the views of other EU institutions and bodies.

7.3. Acknowledgments

The ERA would like to thank all stakeholders for their active involvement in and contribution to the delivery of this study. In particular, Eress, the UIC IRS 90930 working group and Bart Van der Spiegel from Infrabel (in his capacity as Convenor Traction Energy Measurement at CENELEC of the working group revising EN 50463) have been valuable partners for the successful finalisation of this study.

8. Annex

Annex – Web survey results

Below is a summary of the web survey results, as presented at the Eress Forum on 12 June 2025.

1

EUROPEAN UNION AGENCY FOR RAILWAYS

Organization types in our AS-03 web survey

- **RU** -> Railway Undertaking
- **LESSOR / VK** -> Lessor / Vehicle keeper
- **IM / DCS or ENE provider** -> Infrastructure Manager (or DCS or rail energy provider)
- **MS** -> Member State (Ministries)
- **MANUFACTURER** -> Manufacturer of tractive rolling stock
- **EMS / DCS supplier** -> Provider of on-board energy metering or trackside DCS equipment
- **NSA** -> National Safety Authority
- **NOBO** -> Notified Body
- **DEBO** -> Designated Body

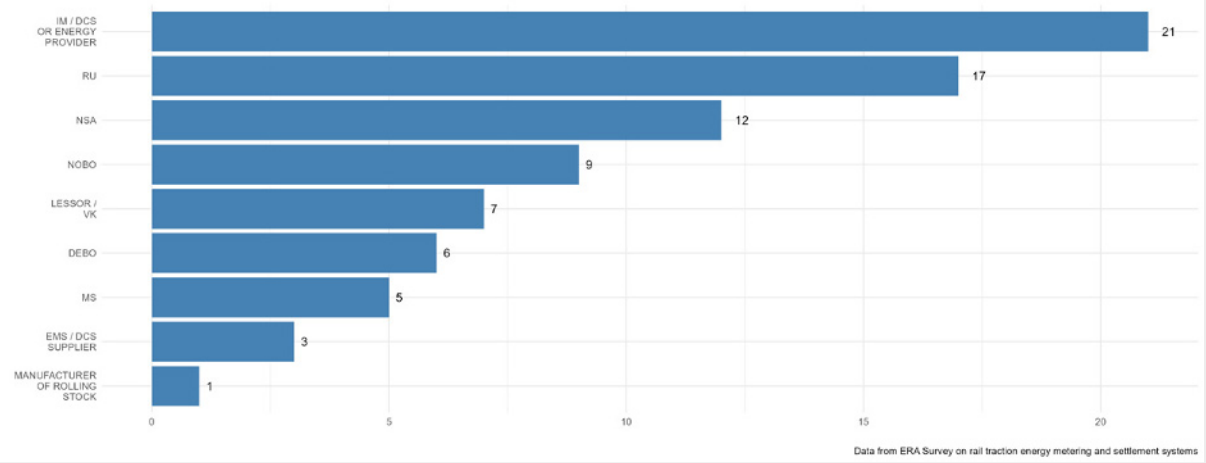
- The ERA web survey was disseminated to individual stakeholders via:
  - ERA Network of Representative Bodies (European associations like CER, EIM, UNIFE, AERRL, etc)
  - ERA Network of NSA
  - NB Rail association (grouping of NoBos)
  - ERA Reference Document Database (list of DeBos)
  - EU Member States + CH + NO reps in the Rail Interoperability and Safety Committee of the EU
  - UIC, Eress, individual contacts

2

EUROPEAN UNION AGENCY FOR RAILWAYS

81 replies to our survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



3

EUROPEAN UNION AGENCY FOR RAILWAYS

Countries of operations of survey respondents

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO

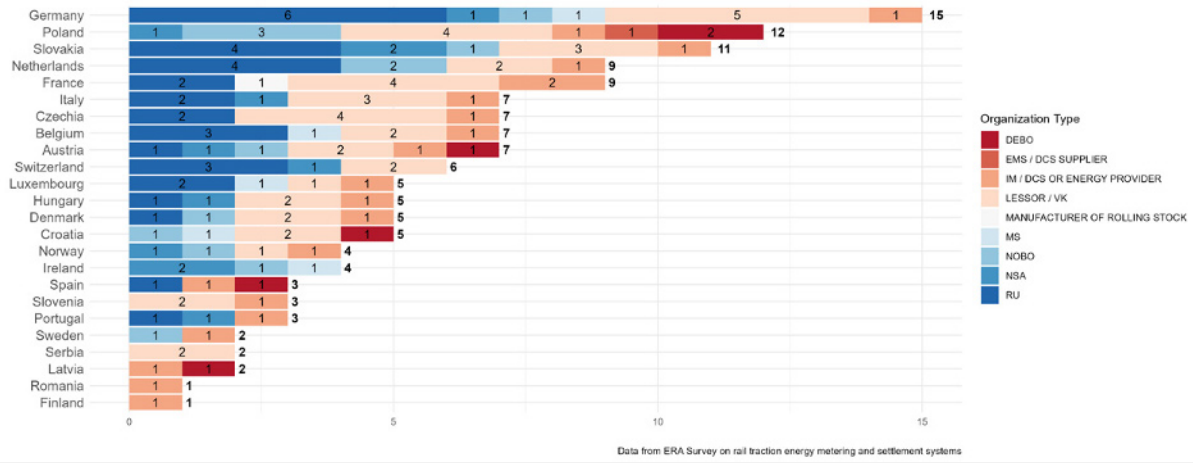
Data from ERA Survey on rail traction energy metering and settlement systems

4

EUROPEAN UNION AGENCY FOR RAILWAYS

Who replied to the survey and from where (country of operations)

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



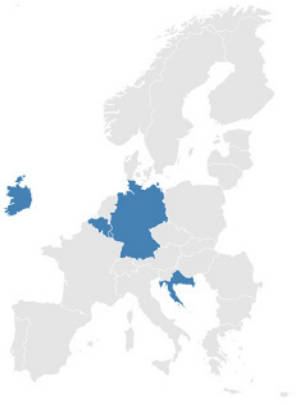
Data from ERA Survey on rail traction energy metering and settlement systems

5

EUROPEAN UNION AGENCY FOR RAILWAYS

Replies from 5 Member States (Ministries)

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



Data from ERA Survey on rail traction energy metering and settlement systems

Preliminary results of a selection of AS-03 survey questions

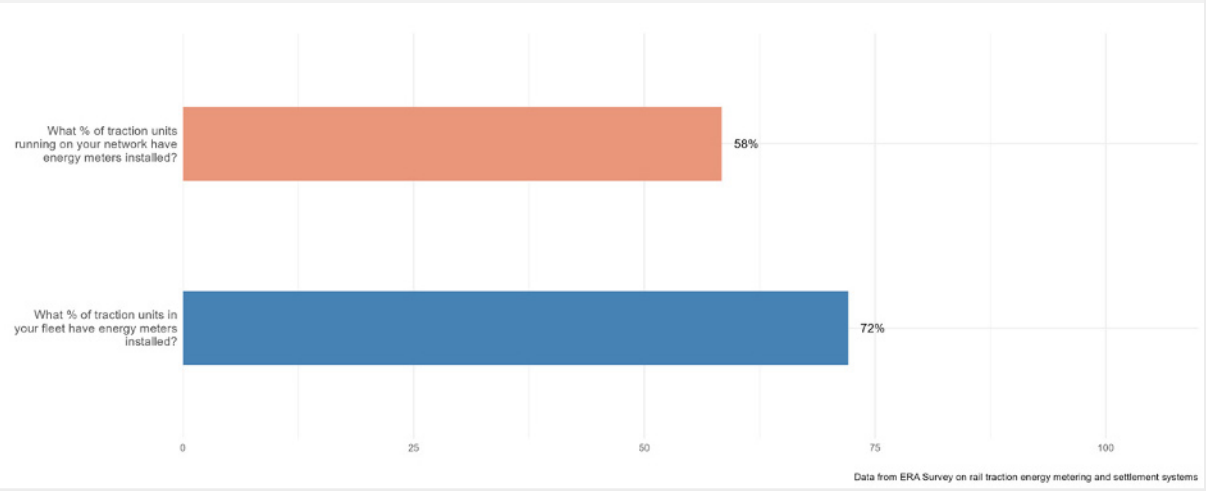
7

EUROPEAN UNION AGENCY FOR RAILWAYS

Average % of traction units with energy meters installed

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



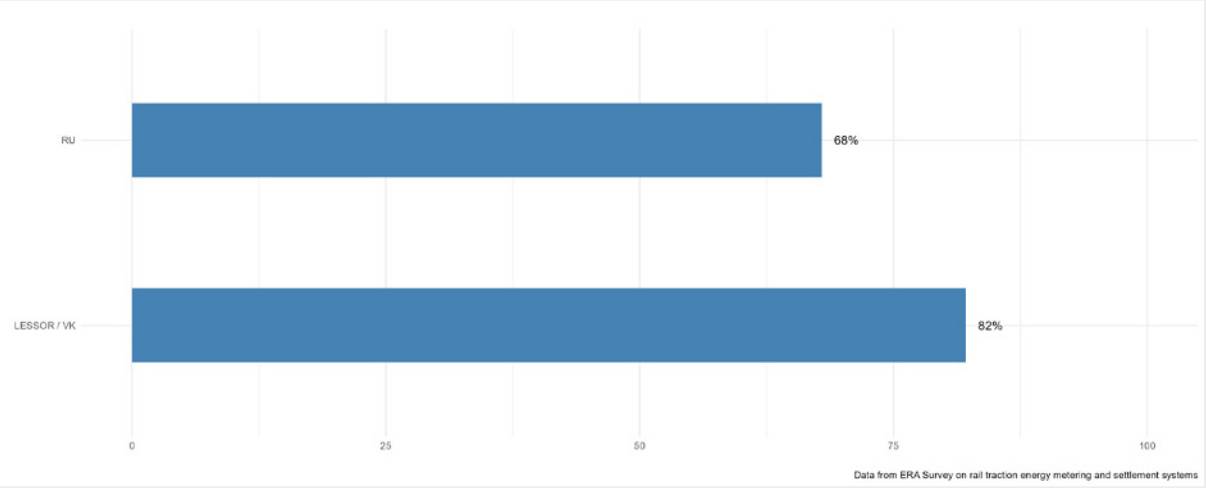
8

EUROPEAN UNION AGENCY FOR RAILWAYS

What % of traction units in your fleet have energy meters installed?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



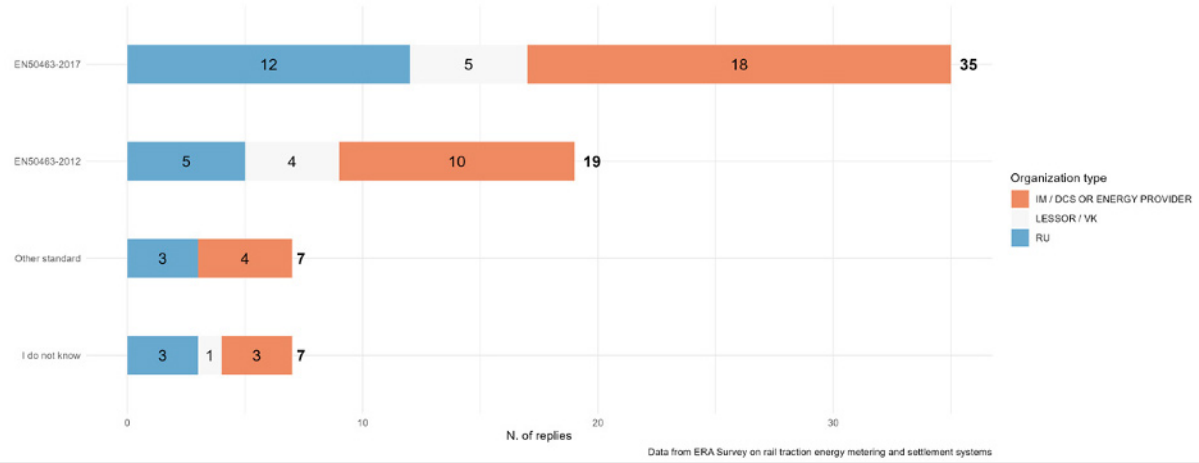
9

EUROPEAN UNION AGENCY FOR RAILWAYS

What standard do the EMS on-board follow?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



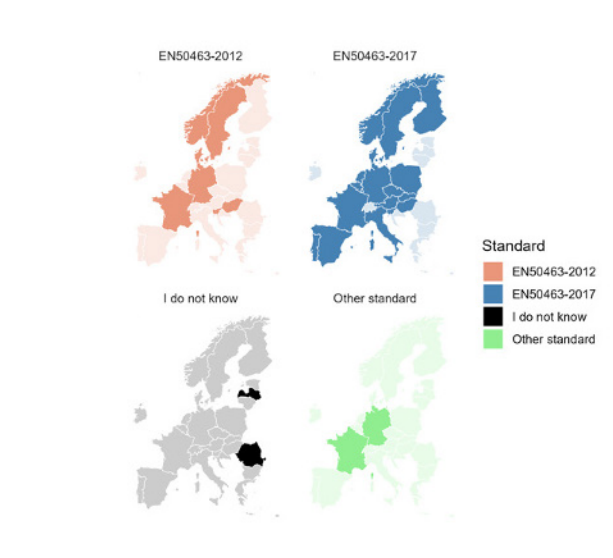
10

EUROPEAN UNION AGENCY FOR RAILWAYS

What standard do the DCS trackside follow?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



11

EUROPEAN UNION AGENCY FOR RAILWAYS

Traction units equipped with more than one EMS

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO

What % of your traction units are equipped <u>with more than one EMS?</u>

- Only 2 respondents:
- **1 reply** mentioning **6%** of traction units fleet
  - ➢ Due to **different IM requirements** and **voltages** between **two EU MS**
- **1 reply** mentioning **7%** of traction units fleet
  - ➢ Due to **manufacturing setup** (each current loop to the traction motors is measured by a separate EMS), **issue specific to one EU MS**

What % of your annual sales/installations concern traction units equipped <u>with more than one EMS?</u>

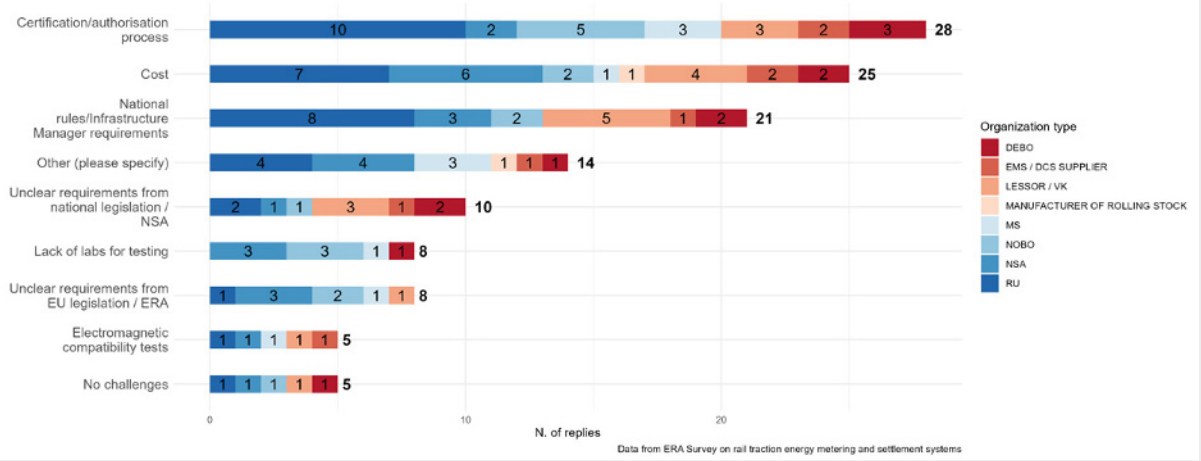
- Total **replies**: **3**
- **1 reply** mentioning **0%** of annual sales/installations
- **1 reply** mentioning **1%** of annual sales/installations
  - ➢ Due to the **technical requirement** of the **traction units (2 consumption points),** for **all EU countries**
- **1** reply mentioning **40%** of annual sales/installations
  - ➢ Due to normal-speed trainsets having **1 EMS per engine cab**, leading to 2 EMS per traction unit, **for one EU MS**

12

EUROPEAN UNION AGENCY FOR RAILWAYS

What are the key challenges to install/retrofit EMS on-board to comply with latest LOC&PAS TSI?

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO

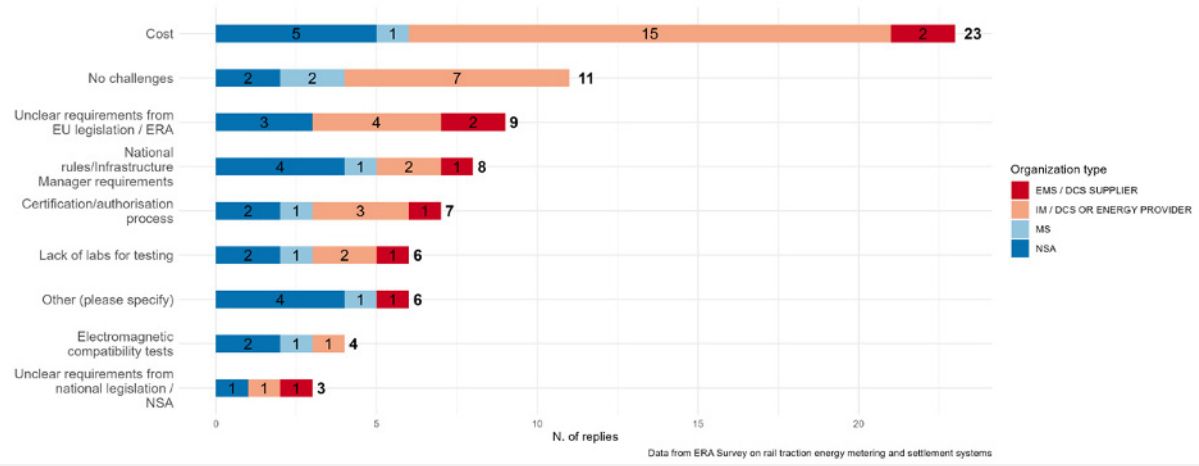


13

EUROPEAN UNION AGENCY FOR RAILWAYS

What are the key challenges to install Data Collection System (DCS) trackside complying with the latest ENE TSI?

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



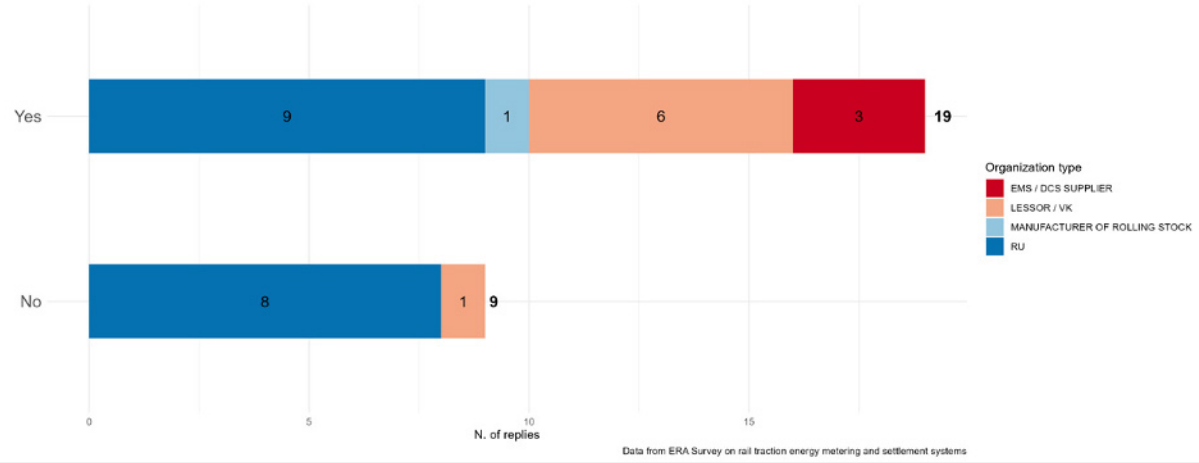
14

EUROPEAN UNION AGENCY FOR RAILWAYS

Do you expect to have more EMS meters in 2025?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



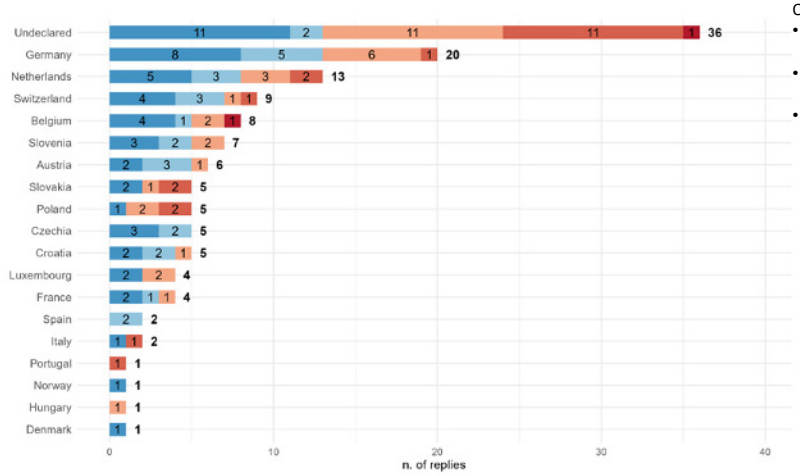
15

EUROPEAN UNION AGENCY FOR RAILWAYS

How is the installation of EMS on-board incentivised?

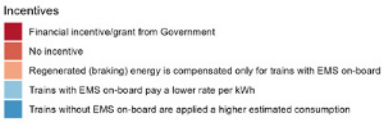
Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



Other incentives:

- Trains without EMS on-board pay a higher rate per kWh -> +25% cost (Switzerland)
- EMS guarantees better data and better knowledge of consumption (Denmark)
- Trains without meters pay for the unaccounted energy in the collective (Netherlands)



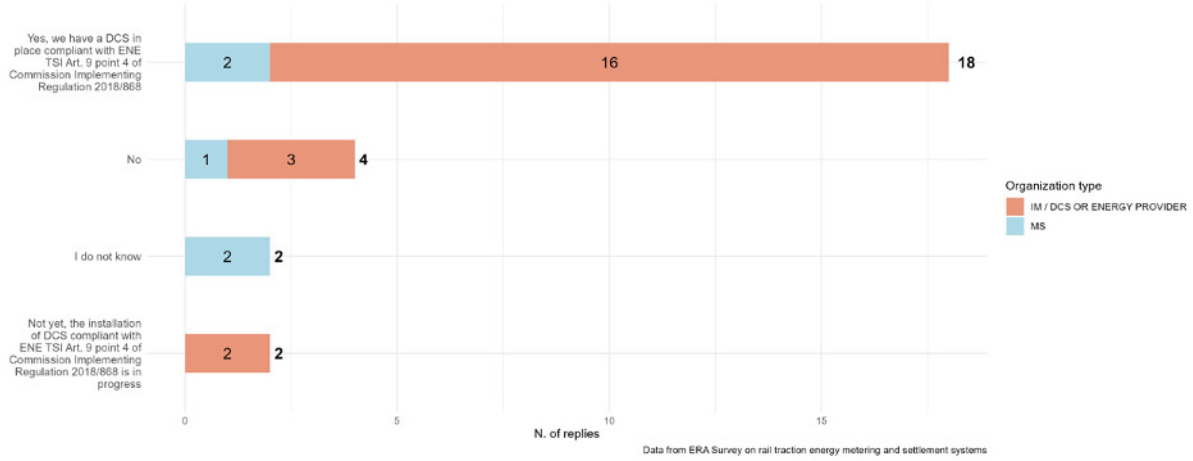
16

EUROPEAN UNION AGENCY FOR RAILWAYS

Do you have a DCS trackside in your country to correctly gather energy metering data from trains for billing purposes?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



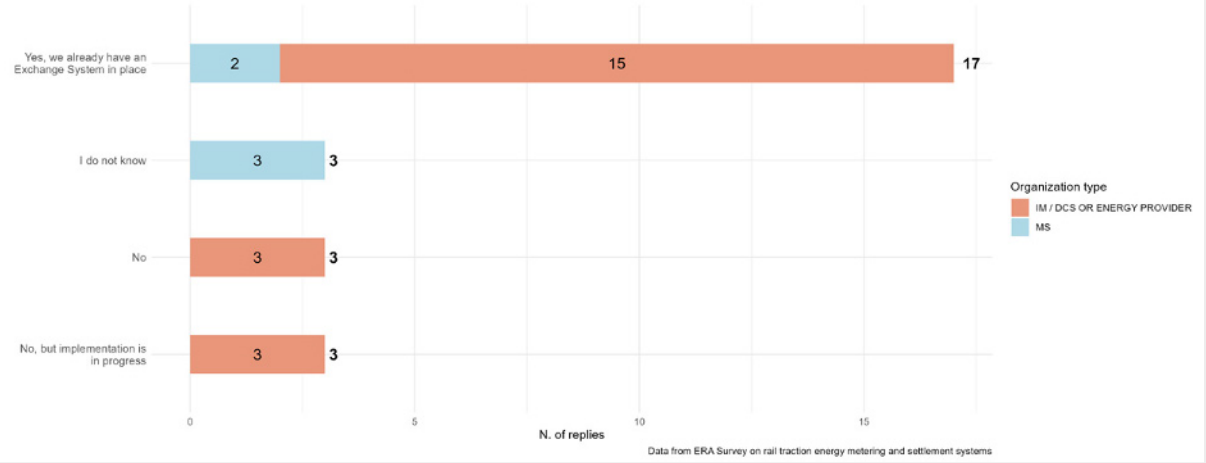
17

EUROPEAN UNION AGENCY FOR RAILWAYS

Do you have an Exchange System in your country to correctly distribute energy metering data from trains to other countries for billing purposes?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO

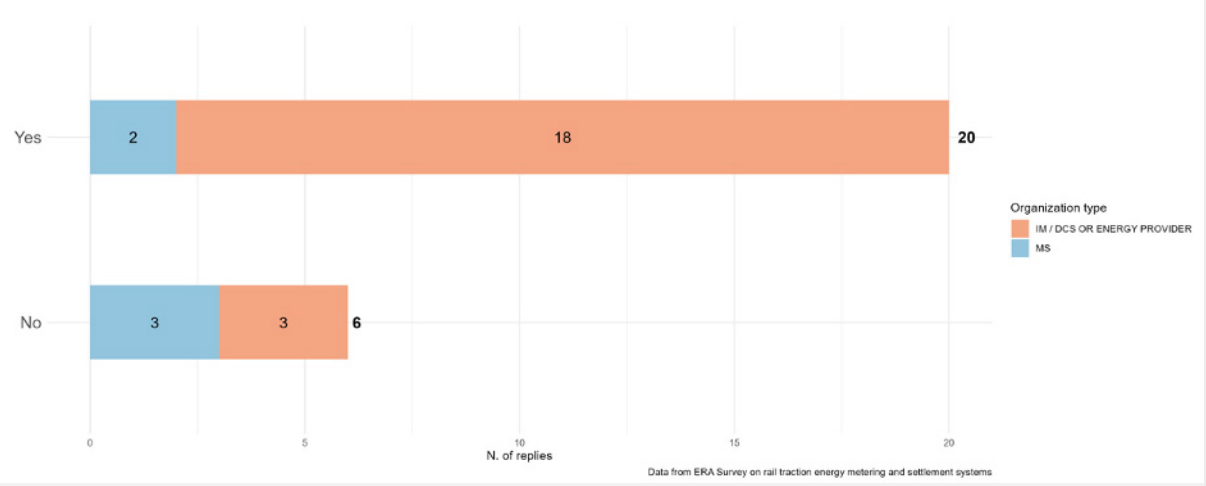


18

EUROPEAN UNION AGENCY FOR RAILWAYS

Do you apply the UIC standard IRS 90930 for this Exchange System with other countries?

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



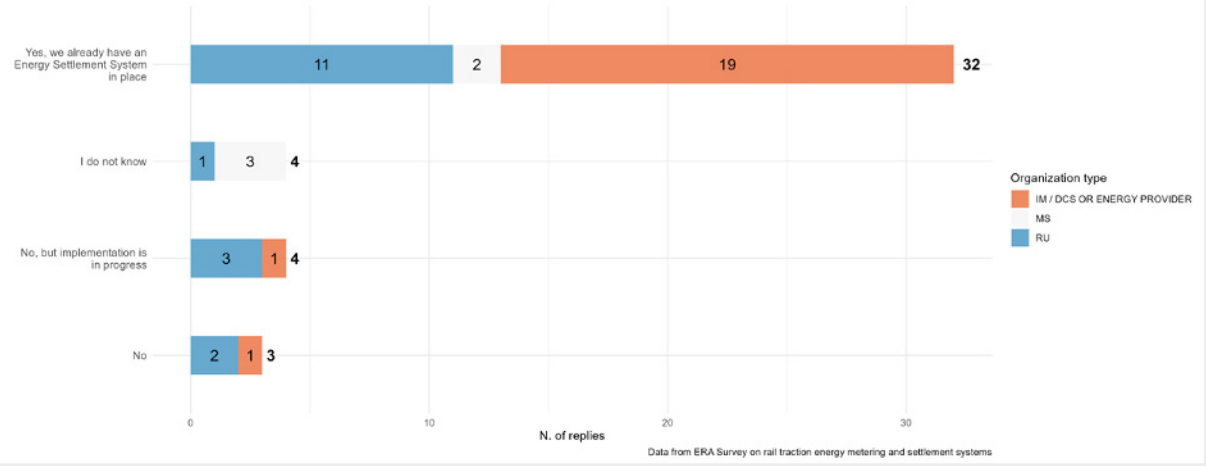
19

EUROPEAN UNION AGENCY FOR RAILWAYS

Do you have an Energy Settlement System in your country to correctly handle energy metering data from trains for billing purposes?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



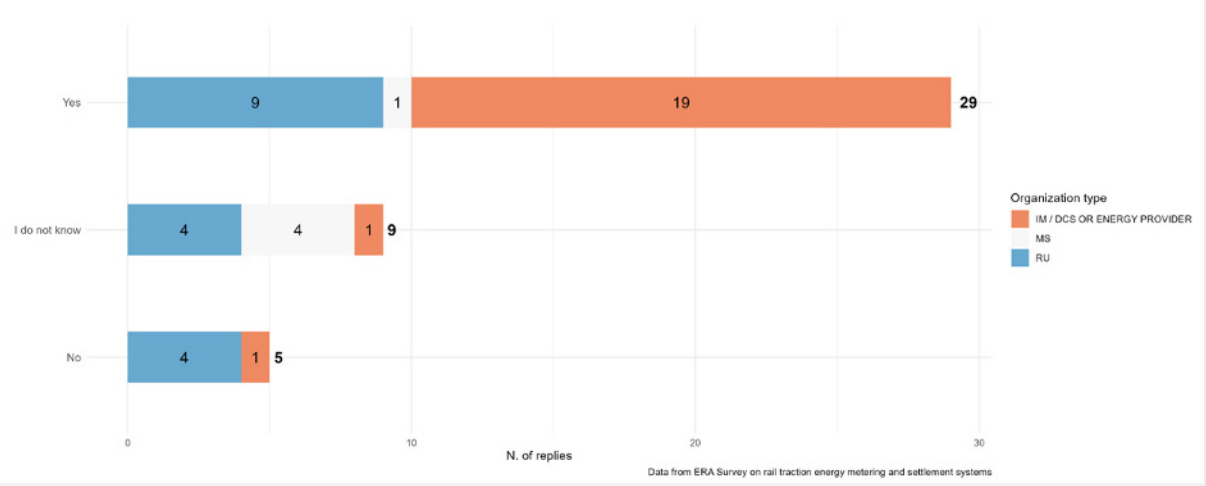
20

EUROPEAN UNION AGENCY FOR RAILWAYS

Do you have a non-discriminatory solution in your country to correctly invoice train companies that use meters?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



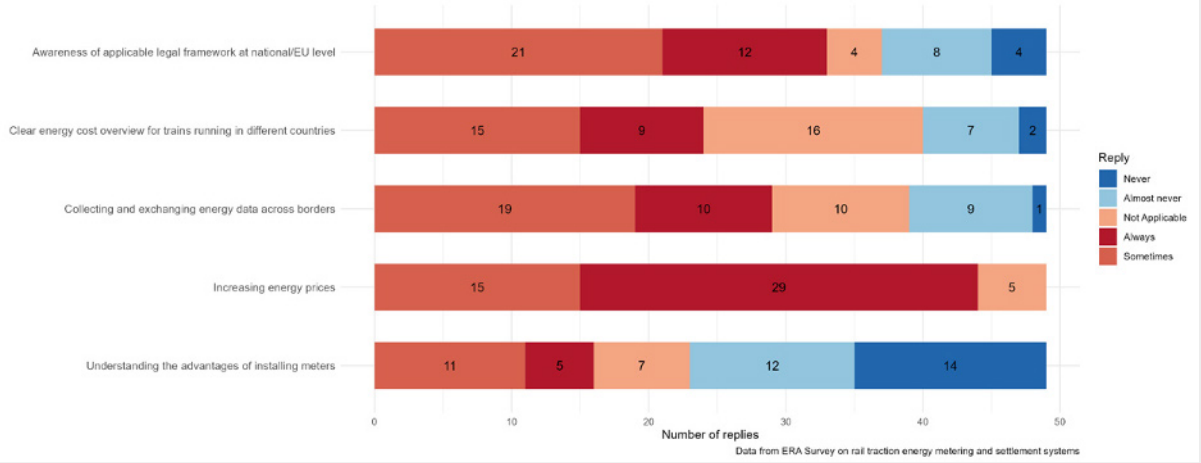
21

EUROPEAN UNION AGENCY FOR RAILWAYS

Which challenges are you facing regarding energy?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



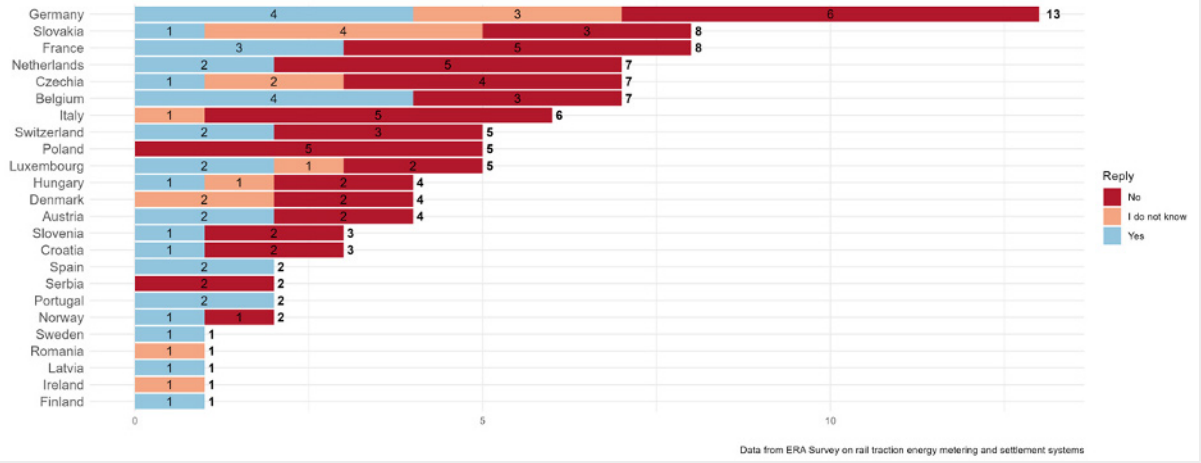
22

EUROPEAN UNION AGENCY FOR RAILWAYS

Do you think that the cooperation between IMs and RUs in the EU is effective regarding traction energy metering?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



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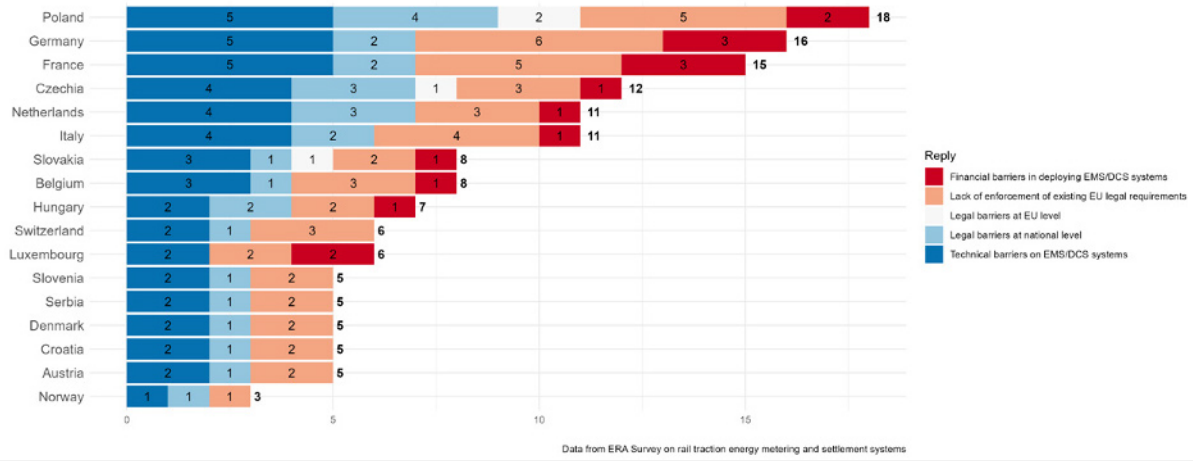
EUROPEAN UNION AGENCY FOR RAILWAYS

What type of barriers for effective IM-RU cooperation do you perceive?

Update of past Eress survey

RU
LESSOR / VK
IM / DCS or ENE PROVIDER
MS
MANUFACTURER
EMS / DCS SUPPLIER
NSA
NOBO
DEBO



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In person

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