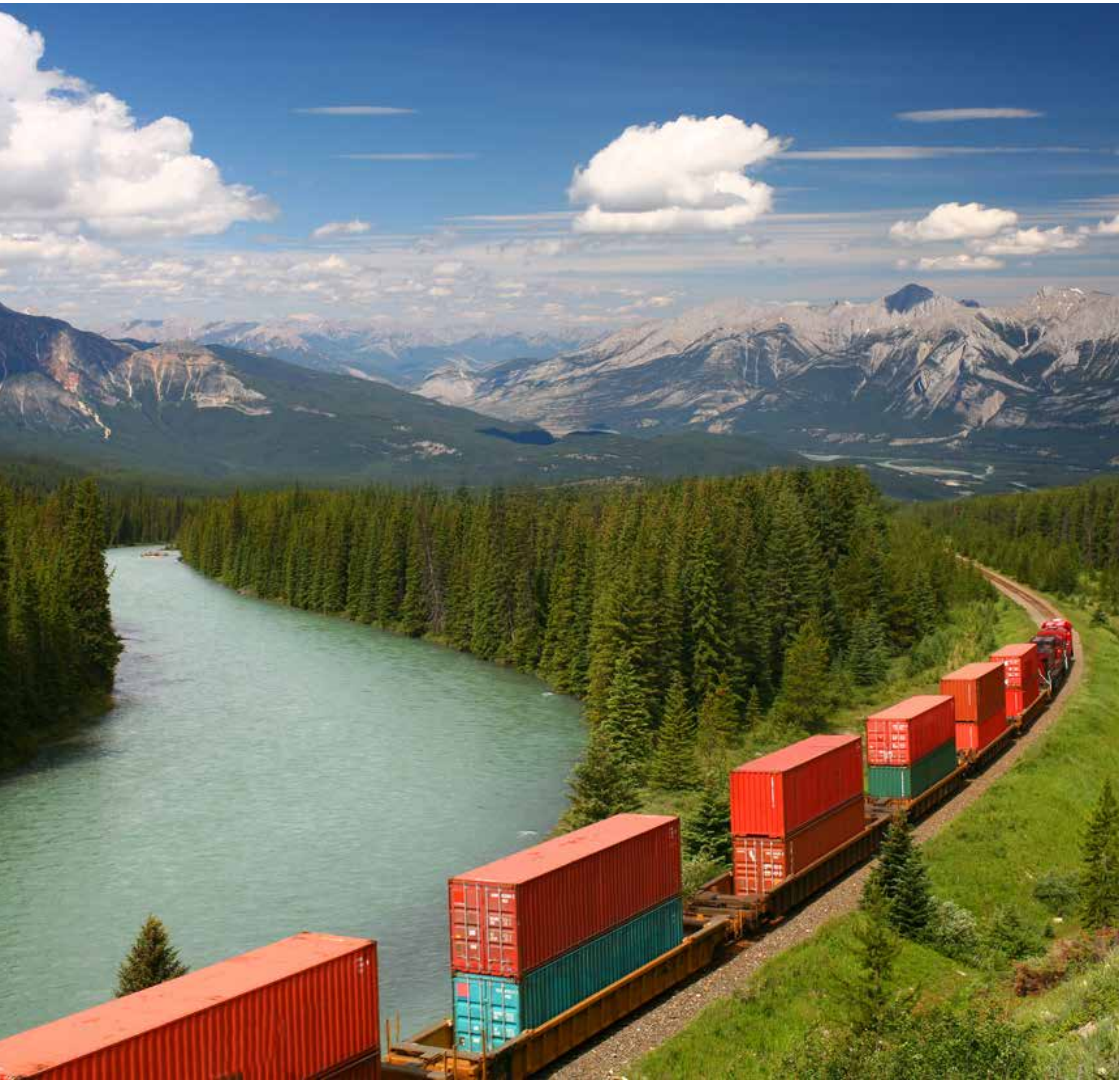
Hybrid trains

This brochure is for Train Builders, Infrastructure Managers, Manufacturers of Energy Measurement Systems, Railway Undertakings, Vehicle Keepers and Standardization Committees



Introduction

We expect to see a lot of new hybrid trains to enter the market in the next ten years. With this document we want to assess possible issues affecting on-board Energy Measurement Systems, exchanging energy data, train run data and the correct settling / invoicing of traction energy.

Hybrid trains

With hybrid trains we refer to trains still having a current collector (to take energy from and return energy to a contact line), but already having an on-board energy source (like diesel or hydrogen) and/or an on-board energy storage (like a battery).

We invite the working groups of UIC and CENELEC to list all possible Use Cases in relation to hybrid trains. This can also result in extra needs of data to be collected on-board and transferred to ground. This can also result in requests to other groups, e.g. dealing with Driver Advisory Systems (DAS) and Automatic Train Operations (ATO) and also with Europe's Rail Innovation Pillar and System Pillar (topic C25 in Standards and TSI Input Plan is dealing with hybrid trains).

Energy Measurement System

The on-board Energy Measurement System (EMS) shall measure all energy taken from and returned to the contact line. This doesn't change. Data of EMS shall be sent to a Data Collecting System, further handled in Exchange and finally used in Settlement (where it gets validated, where missing or not-validated data is replaced by estimations and where it is allocated to the correct end consumer). So in principle, there are no changes.

But in order to be able to validate the data, extra information is useful. The EMS won't measure anything when energy is used from the on-board energy source or from the on-board energy storage. The EMS will measure more consumption while charging the on-board energy storage.

The EN 50463 revision, which started on January 2024 is taking this into account. The text below is the input given at the start of the revision of EN 50463. Full revision will likely take about 2-3 years.

It should be possible to add a status (charging, discharging, no energy flow to battery) and/or real measurement data for the energy coming from on-board energy source and/or from on-board energy storage (sub-element Regenerated will be used for charging of the battery).

For part 1 the following is proposed:
Add a clause for hybrid trains. Describe different types of hybrid trains. Define possible ways to measure different flows and how EMS can handle hybrid trains:
• Adding flags indicating other sources that are in use and direction of energy flow.
• Adding extra channels or measurement points for other on-board energy sources and for flow from/to on-board energy storage (like battery).

For part 3 the following is proposed:
Add extra digital inputs for hybrid trains:
• Identifying what sources are used.
• Identifying flow e.g. towards battery.

For part 4 the following is proposed:
Adjust CEBDBlock and ReadingBlock to enable to add extra data for hybrid trains, e.g.:
• Add optional elements EnergySource (binary or enumerated list) and EnergyFlowToBattery (no flow, charging, discharging, charging and discharging) under CEBD and Reading.
• Add optional elements EnergyType (from Overhead Contact Line, from diesel engine, from hydrogen fuel cell, from other energy source on-board, from on-board battery) under Channel.
• Add optional elements DistributedMeasurementPoint to collect energy information from distributed measurement points (e.g. to measure the energy consumed by specific subsystems over time). This is an alternative for using a Channel for consumption coming from on-board energy source or from on-board energy storage.

An alternative digital input can be the position of pantograph. Measurement of energy from and to on-board energy storage or from on-board energy source can have a higher permitted error than required in the TSI (Technical Specification for Interoperability) for the energy taken from or returned to the Overhead Contact Line. These energy flows aren't used for energy invoicing. If this energy measurement is relevant e.g. for ancillary services of the public electricity grid, this measurement might still need to have a high accuracy.

We will have to wait and see what will be proposed in this new WG 37 of CENELEC.

Exchange of energy data

The Exchange function allocates energy metering data (CEBD Block or Reading Block) to a settlement area, splits the data and forwards it to the Exchange function of the correct settlement area.

Extra data collected via EMS shall be handled in Exchange function and forwarded to other settlement areas.

The Exchange function has a validation on energy metering data. It compares the speed on a straight line between two measured locations with a max speed of the Traction Unit Type (TUT) in the masterdata.

The Exchange function also has a validation on the maximum power. The power in the energy metering data is compared with the max power of the TUT in the masterdata.

The new version appendix A of IRS 90930 will likely have the following explanation:

“Aim is to define the Maximum Power at pantograph that can be measured with an on-board Energy Measurement System. This power can be used for traction, hotel loads for the passenger vehicles (lights, heating, cooling, ventilation, restauration, power plugs for the passengers) and charging of on-board batteries.

Use the maximum power a train can take from the contact line (setting of protection relay on main circuit breaker of the traction unit combined with the maximum voltage Umax2 as define in EN 50163, table 1). This value shall be the maximum value of all applicable traction systems.”

Train Run Data

The sending of Train Run Data is regarded as country specific in the IRS 90930. So implementation hasn’t been standardised.

Eress is still using a first import created around 2010. It was designed to only send Train Run Data for the electrified lines.

If train run data was wrongly sent for parts where diesel traction was used, the mass of the Traction Unit in that part can be corrected to zero, which will result in 0 as estimation of electric usage. These parts are then excluded from settlement.

Maybe it's time to adjust the Train Run Data and add a flag for the non-electrified parts. On such parts a bi-mode diesel + contact line won't have any energy consumption measured through the EMS.

Also a hybrid train with an on-board energy storage, won't measure anything on these lines. But the energy was charged earlier while running or at standstill from contact line to the on-board energy storage. Validation rules can handle the energy estimated to be used from on-board energy storage differently and add e.g. 15% (this value is based on 85% efficiency of charging/discharging) in order to take into account the electricity lost by charging and discharging.

More complex will be the handling of trains with an on-board energy source and an on-board energy storage. It is not possible to make a distinction in Train Run Data between both on-board sources. This will likely always be the case on a hydrogen train that is also able to take energy from a contact line. The only way to improve validation in this case will be to have extra data from the EMS. This data must be sent by DCS and Exchange if we want to include information from other sources on-board in Settlement.

Traction energy settlement

Hybrid trains can have movement without consumption. Having flags and/or extra measurement channels in the EMS will be useful. Otherwise this validation will be put out of service for hybrid trains.

It will be very difficult to estimate consumptions for hybrid trains. It is possible to consider that hybrid trains with an on-board energy source and without an on-board energy storage won't consume energy on non-electrified lines.

Extra information for a better settlement can come from improved Energy Metering Data and/or from improved Train Run Data.

The more complex the hybrid train, the bigger the need to have not only flags in Energy Metering Data but also measurement data on the flow from on-board energy source and from/to on-board energy storage. As these measurements are only intended to validate the real Energy Metering Data (taken from or returned to contact line), these measurements might have a higher permitted error (i.e. a poorer accuracy class or thus a higher value for the accuracy class).

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