Energy Metering Systems (EMS) requirements and ordering information Nordic Countries

1 Introduction

Use of the European Railway Energy Settlement System (Erex) includes installation and use of Energy Measurement Units (EMU) in traction units. The main components of the EMU are an Energy Meter, a GPS unit, a GSM/GSM-R modem and Data Handling System which handles the processes and data storage. The equipment in the train also includes Voltage Sensors, Current Sensors, an antenna and the linked cables. The Energy Measuring Assembly is the combination of the Voltage Sensors, the Current Sensors and the Energy Meter.

Installed EMUs transmit data periodically to a central data-gathering unit (EIServer). Periodically the EIServer forwards the gathered and validated data to the Erex, where it is linked up with other data (i.e. energy prices etc.) and then processed to form the basis for invoicing. Each railway undertaking can get access to their data through a common web portal.

This document describes the processes and requirements when ordering, installing and operating EMUs. It includes references to other documents for more details on certain issues, and it is intended for railway undertakings that are planning to install EMUs in their traction units.

2 Ownership and financial terms.

Eress is a partnership between Banedanmark, Infrabel (Belgian Railway Infrastructure Manager), Jernbaneverket and Trafikverket. From 2013 the Finnish Transport Agency, becomes a member of the Eress organisation.

Erex is the energy settlement system developed from the Eress organisation.

The costs of operation will be charged to the railway undertakings as administrative costs. Repairs (etc.) of the EMUs will be charged in the same way (i.e. as administrative costs) distributed between all affected railway undertakings.

Infrastructure Managers in Sweden and Denmark will pay the costs of acquisition of their EMUs, and these costs will be charged to the railway undertakings as administrative costs over a given period. In Norway and Belgium the EMUs will be purchased directly by the railway undertakings, and the railway undertakings will thus be invoiced directly by the EMU supplier. The railway undertakings in all countries will purchase antennas and antenna cables directly from suppliers.

In Denmark, Norway and Sweden the Infrastructure Manager will have the ownership of the EMUs. In Belgium and Finland the Railway Undertakings will have the ownership of the EMUs.

In all countries subscription costs and charges for communication via GSM / GSM-R will be charged to the railway undertakings as administrative costs.

3 Planning

Energy metering circle includes signal from voltage transformer and signals from current transducer. Then the energy meter need power supply, normally 24V dc is used. For data communication a combined gps/gsm antenna needs to be used.
Voltage transformer (VT) is mainly used for traction, but the VT normally has and output that can be used for connection/signal to the energy meter.
Before ordering energy measurement units, the train company needs to declare the specifications for the existing Voltage transformer. A current transducer needs to be installed if there not are available in the Train already (normally not if energy metering not have been used before).

4 Ordering

4.1 Ordering EMUs

Railway Undertakings/ Train Companies request purchase and installation of EMUs by submitting the specific data for each type of traction units the *Customer order form for Energy Measurement Unit,* see Attachment 1.
A completed form is returned to the following e-mail address: **energiavregning@jbv.no**. The Erex System Operator will go through the details and order EMUs on the basis of the information received.

Date of delivery depends on the total number of EMUs ordered. Expected delivery is within 17 weeks.

The antenna and antenna cables can also be ordered through our contract with the EMU supplier. Cost of shipment and delivery will be charged in addition according to price list.

Railway undertakings can order approved antennas and antenna cables directly from their own suppliers. For a detailed description see *Requirement Specification Energy Metering System (Section 3.6 GSM-R/GSM antenna)* and *Installation manual-web RTU Z1-Rail.*

In order to reduce administration, production costs, carriage & forwarding costs (and so forth), the manufacturer prefers collective orders and delivery sites for EMUs whenever this is possible.

Infrastructure Manager will order SIM cards on the basis of the orders placed for EMUs by the Railway Undertakings. The SIM cards will be installed in the EMUs prior to dispatch to the Railway Undertakings.

5 Technical specifications and premises

5.1 Absolute precision

Energy metering equipment in traction units can have a maximum total uncertainty factor of 1,5% for a.c. and 2,0% for d.c. The EMU usually supplied is class 1.0. Other classes may be supplied upon request, but additional costs must be expected. Older Equipment with sensors of class 0.5 is according to specification. Traction units with sensors installed prior to January 01. 2006, is allowed a total uncertainty factor of up to 5%.

Total metering system uncertainty of a traction unit shall be documented, see Attachment 2 *Calculating total uncertainty in the energy measuring equipment for trains*. The form shall be completed and returned to: **energiavregning@jbv.no**.

Temperatures

The EMUs were developed and tested for the following range of temperatures:

Storage (not installed):	- 40 °C to + 70 °C
Tolerance (function not guaranteed, but will not suffer damage):	- 40 °C to + 70 °C
Ability to transmit data:	- 25 °C to + 55 °C
Reading of GPS coordinates:	- 30 °C to + 70 °C
Energy measurements can be carried out:	- 35 °C to + 70 °C

EMUs that will be operating near the upper and lower limits of the temperature ranges, will suffer from reduced lifetime and possible malfunctions. It is recommended that the EMUs be installed in a temperate environment (not exposed to extremes of cold, heat, ice, snow, dampness or pollution). Approved antennas are tested for temperatures between (- 40 °C to + 70 °C).

5.2 Measuring sensors

The railway undertakings are responsible for the purchasing and installation of measuring sensors. Phase shift must not occur in the installed measuring sensors.

Current Sensors (Transducers)

The current sensor must measure the total energy flow from the contact wire through the current collector. The EMU shall not measure consumption from other connections (i.e. external train heating outlets etc.).

For EMU's used in Norway, Sweden and Denmark, for catenary voltage level 15 kV/2 kV there are 5 categories of EMUs, based on their acceptance level for maximum current levels on the secondary sides of the Current sensor.

25 mA – 50 mA:	Type energy measuring unit:	LCE-AAAH
50 mA – 200 mA:	Type energy measuring unit:	LCE-AAAE
0,5 A – 1,5 A:	Type energy measuring unit:	LCE-AAAG
1,5 A – 5 A:	Type energy measuring unit:	LCE-AAAD
1,0 A	Type energy measuring unit:	LCE-AAAC

The provider of the energy equipment units and the Infrastructure manager will define the correct type of EMU, based on information received from the Train Company in EMU Order form.

EMUs to handle current levels beyond the intervals in the list above can be obtained. These must be ordered directly from the EMU supplier, and additional costs must be expected.

The railway undertakings must install cables from the current Sensor to the EMUs terminal block. To protect EMC influence, we require use of shield cables.

The Voltage sensors

The voltage sensor/transformer has to be made for transmission from 15kV or 25 kV or both depending on the voltage level for the power supply in the actual countries where the train is driving.

The secondary side of the sensor/transformer can have a voltage level of 90 - 300V AC (16 2/3 or 50 Hz). Voltage levels of 100, 150 and 200 are normally used.

The railway undertakings must install cabling for voltage signals between voltage sensor and the EMUs terminal block. To protect EMC influence, we require use of shield cables.

5.3 Power supply

The equipment installed in the traction units requires a power supply of 24 V DC. The required power supply must be installed by the railway undertaking on to the EMUs terminal block. The power supply shall be connected to the battery. If disconnection is necessary (for example during maintenance in workshop) the EMUs metering data must first be exported by using the *Send key for the automatic transmission of data*.

Main data for the power supply:

- Input voltage: 24V DC
- Fuse (slow): 3.15A
- Tolerance: 19.2 – 31.2V DC (-20% to +30%)
- Average energy consumption: 4W
- Maximum energy consumption: 12W

For more details, see *Requirement Specification Energy Metering System (Section 3.2.1 Power Supply).*

5.4 Physical dimensions

EMU boxes have the following specifications:

- Dimensions: 300 x 300 x 130mm
- Resistance/protection class: IP65
- Weight 4,5 kg

For more details, see *Requirement Specification Energy Metering System (Section 3.5 Box for EMU)*.

5.5 Antenna and antenna cables

The EMU installation also requires the installation of antenna and antenna cables for GSM / GSM-R and GPS. Currently approved antennas for use in trains are:

- Sencity Rail antenna from Huber + Suhner (can be ordered from the EMU supplier)
- Kathrein Train antenna.

When ordering the Kathrein Train antenna, an external additional low-noise GPS amplifier must be ordered.
Both the approved antennas are combined GSM-R/GSM/GPS antennas.

For more details on antennas, see *Installation Manual – Web RTU Z1 Rail (page 27-29)*.

It is necessary to install two separate antenna cables from the EMU to the antenna. The cables should be as short as possible, and if the length of each cable exceeds 25 metre, it must be approved before installation. A connector type"N" Male, must be affixed to both ends of the antenna cable, i.e. towards both the EMU and the antenna.

We recommend the use of the following cable types:

- Huber+Suhner GX_07272D-04 Coaxial Cable Connector, when length is shorter than 25 metres.
- Type 9913X RG-8 /U and RG213 AU for both GSM/GSM-R and GPS, when length shorter than 10 metres.

For more details on cabling, see *GSM / GPS Antenna Wiring Instructions* in *Installation Manual – Web RTU Z1.*

5.6 Send key for the automatic transmission of data. (Not a requirement from Trafikverket)

A *Send key for the automatic transmission of data* shall be installed in the EMU (already prepared) by the railway undertakings. When a traction unit is due for maintenance or is about to be set out of operation for a longer period of time, the stored data in the EMU shall be transmitted to the Elserver by using this key, prior to shutdown /disconnection of the power supply to the EMU.

For more details, see *Requirement Specification Energy Metering System (Section 3.2.5 Two Isolated Inputs)* and *Installation Manual –Web RTU Z1.*

6 Installation

The railway undertakings are responsible for the planning, engineering and installation of all necessary equipment in the trains. Experience shows that it will be a good solution to secure the measurement unit for over voltages, with a fuse between the secondary side of voltage transformer and the measurement unit.
For more detailed information/specifications for the installation, see the *Installation Manual –Web RTU Z1,* this document is available on request.

7 Physical sealing of the energy measuring units

The EMU units are required to be physically sealed. When installing the EMU, the physical seal shall be installed by the railway undertaking or the company carrying out the installation of behalf of the railway undertaking.

The seal shall be affixed to the external box by attaching the seal to the bottom right corner (see picture below), or (if this is impractical) to the top left-hand corner. The railway undertakings will receive sealing equipment (on loan), prior to EMU installation(s).

Detailed view of an EMU, showing sealing of the LEM meter.

The sealing may only be broken when the Erex system operator, Jernbaneverket Bane Energi has received a written notification by e-mail to: **energiavregning@jbv.no**

8 Testing of the installation

In order to verify a successful installation, the person/company that has carried out the installation must run a system check in accordance with the *EMU Test sheet (*see Attachment 3), and complete the Test sheet with test results and signature confirming that all tests have been carried out. All fields denoting the railway undertaking as the responsible party must be completed. The exception is the field for consumption, which can be left blank if it is not possible to verify this at the time of installation.

The completed and signed Test sheet shall be sent to the Erex System Operator on **energiavregning@jbv.no**

When a completed test Sheet has been received, the EMU will be registered in our data collection system and set in operational mode.

9 Rectify faults and errors

If there are errors in data received from the EMU, the following actions shall be taken:

1) The Erex System Operator shall carry out a thorough examination and test of its systems in order to identify possible causes and sources of errors.
2) The railway undertaking will be contacted if assistance is required on the affected traction unit.

3) If a fault is identified in an EMU, it is likely that the EMU unit must be sent to the EMU supplier for repairs or replacement. Choice of action is decided between the Infrastructure Manager, Erex System Operator and the affected railway undertaking.
4) If an EMU must be sent for repairs or replacement, the railway undertaking is responsible for disconnecting, removing and shipping the EMU unit. That also includes installation of a new unit or the reinstallation of a repaired unit.

10 List of Attachments

Attachment 1: Customer order form for Energy Measurement Unit
Attachment 2: Calculation of total uncertainty in energy metering equipment for trains
Attachment 3: EMU Test sheet

11 List of referred documents

Referred document 1: Requirement Specification Energy Metering System
Referred document 2: Installation manual-web RTU Z1-Rail
The referred documents can be sent by e-mail on request to energiavregning@jbv.no

12 Contact information

If you have questions or want further more information you can send an e-mail to energiavregning@jbv.no

Information is also available on our web site www.eress.eu

13 Attachments

Attachment 1: Customer order form for Energy Measurement Unit (EMU)

Train Company:	
Train type:	
Train Number:	
System 1	
CT Rated transformer ratio (total):	
CT Type	
VT Rated transformer ratio (total):	
VT Type:	
Max train current primary side (A):	***I nominal value*** ***I inrush value***
Expected max power pr.5 min. (kW)	
Expected max generation power pr. 5 min.(kW)	
System 2	
CT Rated transformer ratio (total):	
CT Type	
VT Rated transformer ratio (total):	
VT Type:	
Max train current primary side (A):	***I nominal value*** ***I inrush value***
Expected max power pr.5 min. (kW)	
Expected max generation power pr. 5 min.(kW)	
Invoice address:	
VAT number:	
Date:	
Information given by (name):	

Remarks:

The order has to be send to Erex system operator, Jernbaneverket Bane Energi on e-mail: energiavregning@jbv.no

The order has to be send to Jernbaneverket Bane Energi on e-mail: energiavregning@jbv.no

Attachment 2: Calculation of total uncertainty in energy metering equipment.

Complete the form below. (Double-click on picture to open Excel sheet)

Jernbaneverket

Yellow fields to be completed and the form sent to:
energiavregning@jbv.no

Calculation of uncertainty in energy metering equipment in trains
on the basis of measuring classes for current and voltage transducers

Train company	
Materials	
Executed by	
Date	

Voltage transformer/transducer

	No.1	If appl. No. 2
Manufacturer		
Type		
Class in %		

Current transformer/transducer

	No.1	If appl. No. 2
Manufacturer		
Type		
Class in %		

Energy meas. unit

Man. & type	EMT4
Class in %	1 %

Cover factor (k)	2

	Voltage transformer/transducer		Current transformer/transducer		Energy meas. unit
	No. 1	No. 2	No. 1	No. 2	
Class	0,0 %	0,0 %	0,0 %	0,0 %	1,0 %
Standard deviat.	0,000 %	0,000 %	0,000 %	0,000 %	0,577 %
Variance	0,000 %	0,000 %	0,000 %	0,000 %	0,003 %

	Total energy measuring equipment
Standard deviat.	0,577 %
Cover factor	2
Meas.uncert	1,155 %

Measuring uncertainty for the total energy measuring equipment is 1,15%

The following preconditions apply:
- the calculated measurement uncertainty applies to all components at full load,
- at lower loads measurement uncertainty can be much higher
- it is presumed that measurement uncertainty of all components are independent of each other
- rectangular distribution of measurements to each component was presumed i.e. that all
- deviations within the interval of the +- component's class are equally probable
- it is presumed that the sum of uncertainties of the random variables are distributed normally
- the method in for calculating total measurement uncertainty was developed by BIPM (International Bureau of Weights and Measures)
- all instruments/components are calibrated
- it is usual to presume the cover factor of k=2 provides measured values within the specified uncertainty in 95% of cases

Explanation of calculations

Standard deviation with rectangular distribution:	std(x) = kl/rot(3)	(kl = klassifisering)
Variance:	var(x) = (std(x))^2	
Summarising unsure independent variables:	var(x+y) = var(x) + var(y)	
Measurement uncertainty = Standard deviation x Cover factor		

JBV/SD nov. 2005

Attachment 3: EMU Test sheet.

To be sent as a single document.