Electric traction energy metering on German Railways and the impact of European standardisation on the energy billing process in Germany

K. Weiland
DB Energie GmbH, Germany

Abstract
With the onset of liberalisation of energy markets and the formation of DB Energie Inc. as a wholly owned subsidiary of Deutsche Bahn AG (German Railways), proper billing of electric energy to railway-based consumers has become an important issue. Hence, DB Energie had to develop and implement a revenue metering scheme for traction energy consumed by railroad vehicles. The impact of international interoperable traffic has been considered. Keywords: energy meter, metering on-board trains, traction energy, railways.

1 Initial situation
In close co-operation with instrument manufacturers, DB Energie has devised and developed an on-board metering device for electric railway vehicles. The device is derived from a standard, utility grade load profile meter used widely in the power distribution business, but complemented with a GSM-modem and antenna for radio data transmission.

2 National requirements
The meters have to meet German and European calibration standards and regulations, and require approval for use in commercial revenue metering applications. Accordingly, the meters and the adjacent instrument transformers need to be of Class 1 and 0.5, respectively. Both are officially certified for both 16.7 Hz and 50 Hz applications [1, 2, 4].
3 Technical concept

Though the device has four-quadrant capability, the vehicles’ power factor is not of an immediate interest, because the majority of traction drives employ state of the art power electronics and thus operate at unity power factor.

The recorded data of the meter is transmitted by a GSM radio to a central control and data processing station, where the raw data for billing the respective operators will be generated. The meters allow to store either a 5-minute or a 15-minute load profile in its built-in memory. The revenue data are downloaded on a daily basis through a poll request transmitted by the central control station. The data storage and processing scheme allows then for a variety of analysis. One may – for instance – derive a graph of the power and energy consumption for a single train journey.

![Figure 1: Structure of the billing system for traction energy.](image-url)

The energy consumption will be combined with the railroads operative data like planned and actual schedules, train configuration data like weight, number of cars etc. Based on this input, DB Energie will produce individual bills for each train journey on its system. Some customers even use this information for their own management-information-systems as well as for energy saving programs [8].

As shown in the picture above, the optical interface located on the front panel of the meter serves for local downloads. Using this data link, the loco-operators have a means to verify and double check billing data received from DB Energie’s data processing system.

The communication interface allows data transmission in compliance with Standards EN 62056-21 [5] or IEC 870-5-2 [6], and the central control station...
will poll the meter. The specification of metering code follows the national standard VDEW – Specifications 2.1 (see picture 3) [7].

The maximum power demand of the meter in the instrument transformer circuit is 50 mVA.

![Energy Meter Diagram](image)

**Figure 2:** Meter used on board trains.

![Compact Meter Diagram](image)

**Figure 3:** Compact meter on board trains and load profile codes.

## 4 Experiences of DB Energie

As of 2002, electrically propelled vehicles such as locomotives and self propelled trains (MTUs) operating on the German railway infrastructure have
been furnished with this device, allowing DB Energie to meter and analyse the vehicles individual energy consumption profile including regenerative breaking.

Since January 2003, billing of electrical traction energy is entirely and exclusively based on metered values. The on board meters have proven their worthiness for this routine in day-to-day business. It turned out, though, that the availability of the radio communication system is an actual bottleneck in this remote metering scheme. Once a vehicle moves into an industrial site with narrow paths, the probability of loss of communications link increases drastically. This may happen, for instance, when a locomotive is moved into a service station or workshop. The following graph depicts the proportion of non-connected vehicles (missing radio data link) and the duration of this link outage over a month’s period.

![Figure 4: Proportion of non-connected vehicles and the duration of link outage over a month’s period.](image)

**5 European standardisation process**

Within the Europe-wide effort to furnish all electric trains with standardized meters, several manufactures focus on the development of such devices. As a next step, systems for DC traction power are expected to appear in the market soon.

In December 2002, CENELEC TC9X called for experts for survey/working group “Metering On Board Trains”. The target of this standardisation group is to facilitate the interoperability of trains and the compatibility of technologies in the various European countries. Under the guidance of Italian Railways (RFI) the requirements stipulated in the different national regulations were collected. Subsequently, in June 2003, the survey group specified the scope and content of the standard to be drafted.
The paper describes the process of compiling and balancing the different interests brought up by the participating countries, which in turn are due to different states of implementation of the European Union’s guidelines concerning the liberalisation of European Single Market (ESM) in the field of energy and railway business.

Implementing the German energy market rules as agreed upon by utilities and traders, private and foreign railway operators are entitled to be billed on metered electrical energy consumption exclusively.

Denmark, Sweden and Germany are frontrunners in this effort, because their respective national regulations already mandate on-board metering.

Therefore, the concerned railway infrastructure utilities bear the risk that a future European standard does not match with today’s technology. The process of European standardisation will provide a framework for future on-board meters for trains allowing to employ state-of-the-art metering technology. Also, it follows the known national regulations. Optionnally, a meter can be designed as a modular system consisting of a separate modem, a location module, and an antenna. Data transmission should comply with Standard EN 62056-21 [5] or IEC 870-5-2 [6]. The protocols can be adopted to different digital telegrams. This standard permits national system solutions like GSM-R [3] for data transmission, and also the correlation of an individual locomotive (via its meter) with the momentary energy utility when operating in international, cross border traffic or for the idenification of different energy grid operators.

The present course of standardisation promises an roadmap towards a common meter suitable for almost any train operating on European tracks. Centralised control stations with standard databases store common data formats, and railroad utilities would be able to meet commercial contract requirements for billing energy to any European customer.

Though this process of international standardisation, a forum has been established for European railroad operators, for railway infrastructure companies, and not at least for equipment and instrument manufacturers to start a dialogue about their individual needs and expectations. The aim is to eventually harmonise technical and operational standards throughout Europe in order to facilitate a reliable and dependable, cross-border proof revenue metering scheme accepted by all participants. A first major step in this direction has been accomplished by the foundation of CENELEC TC9X.

This ongoing standardisation process will eventually set the basis for an effective and precise energy billing scheme within the liberalised Trans-European railroad community.

References