Introduction of energy metering, settlement and billing at SBB

In 2012, the Board of SBB (the Swiss Federal Railways) decided on a new energy strategy, with efficiency and saving being one of the strategic directions. SBB plans to reduce its yearly energy consumption by 600 GWh, which is about 20% of its total energy consumption, by 2025. Approximately 80% of the total SBB energy consumption is produced by its own hydro power stations. With the planned reduction, SBB intends to operate exclusively on electricity from renewable sources, thus supporting the strategy of Switzerland for sustainable energy production and consumption. SBB's Gisela Hinrichs, Programme Manager for Energy Settlement and Billing, and John Hegarty, Programme Manager for Energy Metering, explain further.

One of the most important conditions for managing energy efficiency is the introduction of a meter-based energy settlement and billing system. For years SBB has been billing the rail energy consumption using approximate consumption factors and planned gross tonne-kilometres. The consumption factors differ according to various train categories which had been estimated based on reference measurements. These are published as part of the yearly SBB Infrastructure List of Services. Changes to the factors have to be decided approximately 18 months before they come into effect; thus it has been difficult to reflect individual efforts of Railway Undertakings (RU) to reduce energy consumption, let alone to enable an immediate payback. Billing based on measured consumption values will radically change this situation. Trying to cut down on their operational costs will lead RUs to invest in energy efficiency. Energy savings by the Swiss RUs are the key success factor for SBB's energy saving programme.

The change towards metered energy settlement at SBB requires a two-fold approach: Firstly to adapt the train path settlement and billing system of SBB infrastructure to handle metered energy consumption, and secondly to equip the existing fleet of vehicles with energy meters. Both projects are headed by the Energy Department within SBB Infrastructure.

Energy billing – part of train path settlement

Unlike other infrastructure managers, SBB is billing the rail energy as an integrated part of the train path settlement. Being part of this process sets some very high requirements: train path settlement is a highly

automated process which allows three train path vendors to settle over 10,000 train runs a day. Train path costs are calculated for each individual section of every train run. The monthly billing process is finished on the fifth working day of the following month when invoices are sent to the customers. The SBB solution for metered energy settlement and billing had therefore to fulfil the very same constraints.

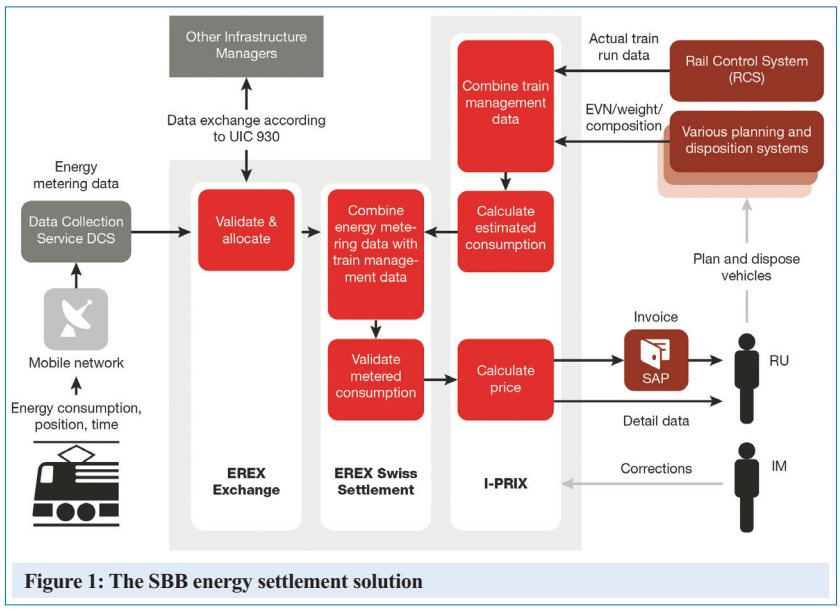

Figure 1: The SBB energy settlement solution

ERESS – an experienced partner

For the realisation of this concept, SBB decided to cooperate with ERESS (the European Partnership for Railway Energy Settlement Systems) and became a partner in February 2014. This step posed several advantages for SBB. Whereas SBB did not have any experience with energy metering for trains, ERESS had already started to introduce meter-based rail energy settlement in 2004. Even more important, SBB could make use of the existing rail energy settlement and billing system EREX (European Rail Energy eXchange) which is developed by ERESS and has now been in operation for nine years; the module EREX Exchange which is common to all ERESS Partners. It carries out the validation of metered data and the data exchange with other infrastructure managers as established in the UIC 930 leaflet. To meet special SBB requirements, a customised solution of the EREX settlement module was developed for Switzerland.

The Swiss solution – fully automated

The aim of the Swiss solution was to integrate the metered data into the train path settlement process. Furthermore, the energy consumption should be established per train for each individual train run section. All actual train run information for trains operating on the SBB network is available in the Rail Control System (RCS), a powerful IT-application managing the rail traffic on a real-time basis. Additionally, information on the vehicles such as weight, composition and above all EVN (European Vehicle Number) is needed. Various planning and disposition systems for both passenger and cargo trains deliver this information. All of the vehicle data is received by the SBB train path settlement system I-Prix where the vehicle information is linked to each train run. I-Prix transmits the information via a web interface to the Swiss settlement module of EREX where the train management data is linked to the energy consumption data, the key identifier being the EVN.

The energy consumption is then validated and established per train run section and sent back to I-Prix where the price is calculated. For trains without meters, the energy consumption is estimated based on the actual train run data and the published consumption factors. This process runs daily and is especially time critical at the end of each month when the invoice is due to be sent out to the customers. The system also offers train path vendors the possibility to take corrective actions in order to update train information, if necessary.

With this solution, customers do not need to provide train run information manually. However, RUs have to make sure that their systems deliver the EVN, which sometimes is an operational challenge. As long as all data is delivered completely and correctly, the system can provide a 100% billing quota. Of course the benefit of the system can only be realised with metered vehicles. SBB is therefore installing meters into all vehicles of its passenger and cargo fleets.

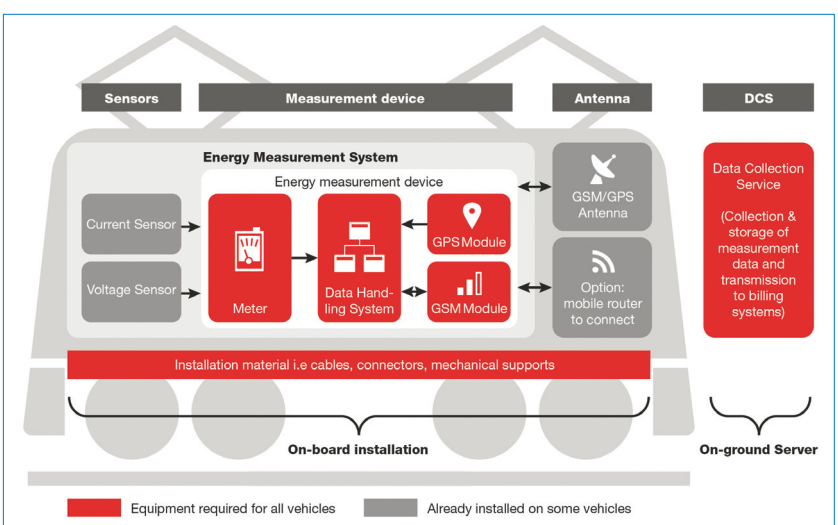

Figure 2: Components of the Energy Measurement System (EMS)

The challenge – one solution fits all

SBB operates a fleet of approximately 1,200 traction units of many different types. In order to minimise operation and maintenance costs, a single uniform solution for all vehicle types was sought. As the available space for mounting new equipment is extremely limited, a key success factor of the one-solution-fits-all concept was to design a compact system which would fit in all vehicle types. SBB also set the goal to implement energy measurement systems which would conform with the new European standard for energy measurement on-board trains, EN 50463, released in 2012.

Technical solution – not just for billing

From a high-level perspective, the technical

implementation of an energy measurement system in a train is quite simple. Install an electricity meter, connect it via voltage and current transducers to the overhead line, add a data handling unit to compile the energy data with the location data. Finally, connect the unit to an antenna to provide GPS-information and transmit the compiled energy billing data via the mobile network to a ground server.

As many vehicles are already equipped with transducers suitable for energy measurement, a modular system was chosen whereby the energy calculation and data handling functions are implemented in a separate device. This gives more flexibility in the installation design and also better investment protection due to the different lifetimes of the components. Following a public tender, SBB selected the Ecomodule rail energy measurement device from Microelettrica Scientifica SA, as the central component of its solution. The Ecomodule incorporates the energy calculation and data handling functions together with GPS and GSM interface units into a single compact device.

In addition to the standard energy billing data in 5-minute intervals, as defined by the EN50463 standard, SBB's system also supports 1-minute billing data to allow a more accurate allocation of energy data to train runs as well as for detailed analysis of energy use for efficiency management. The system can also provide 1-second measurement of voltage, current and energy which opens the potential for detailed analysis of traction performance and new applications such as power management in the rail energy network.

The installation of an additional antenna on the roof of each vehicle is not only costly, but in some cases almost impossible due to conflicts with existing roof installations. For this reason a mobile router will be used on many vehicles which will allow the energy measurement system to connect to the existing antenna of the vehicle application platform.

Conformity – uncharted territory

A major challenge in the project is conformity assessment. Rail energy in Switzerland falls under the railway regulatory and legal framework. However, at the beginning of the project, the railway regulations contained few specifications for energy measurement and billing. EN50463 was only first released in December 2012 so that experience in conformity testing and certification to this standard was very limited, both within industry and test institutions.

The process defined in the standard required a phased conformity assessment of the components, the system integration and the integration of the system into the vehicle. In the course of the project, a modular approach was developed which builds on the existing certification of the system components and utilises the standard technical documentation prepared for the installation personal. In this way the additional documents required specifically for the conformity verification is minimised and the assessment process becomes almost a by-product of the regular engineering and installation process.

At the end of 2015, test vehicles for most of the different SBB vehicle types have been equipped. The rollout of the installations will be ramped up in 2016, and by the end of 2018 SBB intends to have all vehicles equipped with energy measurement systems. At latest by then every kilowatt-hour saved will count.

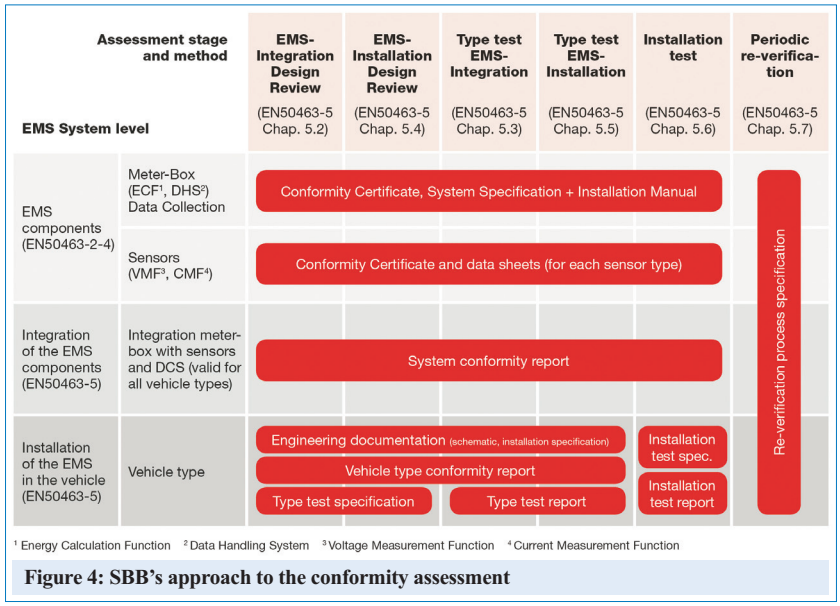

Figure 4: SBB's approach to the conformity assessment

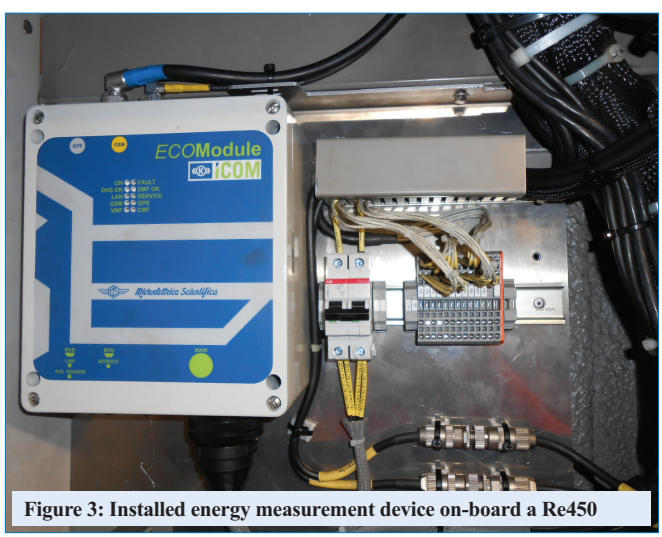

Figure 3: Installed energy measurement device on-board a Re450

Gisela Hinrichs is currently Programme Manager for Energy Settlement and Billing at the Swiss Federal Railways (SBB), and since 2013 has been responsible for the introduction of energy settlement and billing at SBB Infrastructure. She joined SBB in 2006, holding programme management and executive positions in the areas of ETCS and asset management. Prior to this, Gisela worked as a Project Manager for light-rail vehicles, industrial automation and customer information projects in Germany, Mexico, the USA and Switzerland. Gisela holds master's degrees in Electrical and Electronic Engineering from the University of Erlangen and in General Management from the University of Berne.

John Hegarty is currently working as Programme Manager for Energy Metering at the Swiss Federal Railways (SBB), and since 2013 has been responsible for a 5-year programme to equip all of SBB's vehicles with energy metering equipment for billing and energy efficiency management purposes. Previously, John held different management functions within SBB and in the telecommunications sector as well as board membership for a number of SBB subsidiary companies. He holds a degree in Electrical Engineering from the National University of Ireland and a master's degree in Business Management from the Bern University of Applied Science and the University of London.