NES	RECOMMENDATION	R 02
NORDIC ELECTRIC POWER CO-OPERATION	FROM THE NES GROUP	PAGES: 9 ENCLOSURES: - DATE: 25.03.2002

ENERGY SETTLEMENT.
METER-BASED SETTLEMENT.

SYNOPSIS:

The aim of this report is to compare current methods and to contribute towards establishing a common Nordic set of rules for railway energy settlements. The same rules for energy settlements will then apply to the operators of railway traffic within the areas of the Norwegian National Rail Administration (JBV), the Swedish National Rail Administration (BV), the Finnish Rail Administration (RHK) and the Danish National Railway Agency (BS).

The report is concerned with energy settlement for trains with energy meters. The following issues are described:

- current situation for energy settlement used by each of the Nordic railway administrations
- how common rules for energy settlement with energy meters for border-crossing traffic Denmark – Sweden and Sweden – Norway can be in the future
- how each of the Nordic railway administrations carry out energy settlement when trains from more than one traffic operator are present in their network simultaneously

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The Nordic Technical Directors
JBV, BV, RHK and BS

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1 Introduction

The aim of this project is to try to produce a uniform Nordic standard for how power settlement using electricity meters on trains should take place and to prepare a draft standard for measuring equipment, which will be elaborated separately in another report.

The rail administrations in the respective countries are today responsible for buying electrical power for the operation of trains (does not apply in Finland). This responsibility also entails the task of distributing the cost of electricity purchases between the various train operators. The fairest way in which to distribute costs is to do so using electricity meters on board the trains. When ordering new locomotives, it is easy to have an electricity meter installed at a reasonable cost. However, it is both more expensive and more complicated to install electricity meters in existing locomotives.

The Nordic railway administrations agree that electricity meters will be in place in all locomotives in the future as new trains are delivered with meters already fitted. The big question is how fast to proceed with the existing locomotives. Should we immediately ensure that meters are installed in these locomotives or should we wait until they are replaced by new locomotives?

The participants in the project group were:

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Poul Wathne Banestyrelsen (BS) (Danish National Railways Agency)
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2 Summary

This report deals with the requirements which should be made for the equipment which will measure power consumption with energy meters on the railways in the Nordic countries to facilitate the distribution of costs and to be able to measure the results of energy-saving measures. The demands on equipment for energy messuring is specially dealed with in this report.

The accuracy of measurement should be at least 2%. Existing measuring transformers should be used, if possible. If their accuracy class is poorer than

that required to achieve 2% accuracy overall, there is no reason to replace them if the total accuracy is maximum 5%. They should still be used.

GSM-R should if possible be used for automatically remote reading and measured data collection from locomotives to a central collection unit/invoicing system. The data format of these measured values should be compatible with EDI-EL, which is used throughout the electrical power sector. It should also be possible to add additional functions such as driver information, a kilometer counter, train weight, train number and train position

The losses in the net is not possible to mesure but instead we compensate the losses by adding this to the energy price or add the amount of losses to the consumption of each operator. If we use meters the information we get from the meters can be used to create a power (kW) component in our billing system. Apart from that we can also deal with powerfactor and disharmonics in each vehicle.

Another reason for measuring consumption on board trains is to see the effect of energy-saving measures on power consumption.

3 Tasks of the Project Group

* The group's aim is to contribute, via information and exchange of experience, to common principles being applied to the distribution of electricity costs by means of electricity measurement on board trains in the Nordic countries.

* The group is to produce common Nordic requirements for measuring equipment with regard to accuracy, crossing borders, reading off, format of measured values, etc.

* The group is to examine the extent to which there are already meters on board trains and how they are constructed.

* The group is also to examine whether there are other projects in Europe dealing with electricity meters on board trains.

4 Current Situation in the Nordic Countries

4.1 Denmark

The Danish Railways Agency works in accordance with Law number 124-27/12/2001. This Law states, among other things, that railway companies

which use electrically powered locomotives have to fit relevant locomotives with electricity meters approved by the Danish Railways Agency. Consumption is reported to the Danish Railways Agency monthly. The Danish Railways Agency is able to check the electricity meters in the railway companies' electrically powered locomotives. Meters are installed in all locomotive types apart from the EA locomotive, but installation of meters is planned for these too. Accuracy of measurement is currently 5%. The locomotive manufacturers say that it is not possible to achieve better accuracy. In order for customers to be able to account for electricity tax themselves, the Danish tax authorities require that the accuracy of measurement be at least 2%.

4.2 Finland

Meters are installed only in certain SR2 locomotives and there are currently no plans to install any more meters. However, the accuracy should be at least 2%.

4.3 Norway

Meters are currently installed in EL18 7B7, BM71 and BM73 locomotives. There are currently no plans to install meters in other train types.

4.4 Sweden

Meters are installed in approximately 10 locomotives of various types. These meters have been used to produce the patterns currently used for charging. However, there is a desire from several transport operators in Sweden to introduce measurement on board trains. Some have said that if the Swedish National Rail Administration does not produce measuring equipment, they will do so themselves. If the transport operators produce measuring equipment themselves, there will be problems with reading the meters, etc. where the transport operators do not do this themselves. In order for the Swedish National Rail Administration to be able to handle charging in a satisfactory manner, we must have measuring equipment which can be read off remotely using the same system for all transport operators.

5 Other Projects in Europe

5.1 DB Energie

A visit was paid to DB Energie on 12 December 2000 by Poul Wathne, Marianne Nyebak and Lars Johansson. French Railways were also represented. DB Energie has produced measuring equipment for installation on board trains in a project called TEMA. The project has been successful and they will now proceed to install measuring equipment on all locomotives which belong to Reise und Touristik, i.e. the passenger transport company within DB. Installation will begin during 2001.

The German measuring equipment consists of a measuring box containing a meter, a GSM telephone, a GSM aerial and a memory unit which stores the measured values. This equipment costs DEM 2000 and installation costs DEM 500-1000, depending on the type of locomotive. This concept makes use of the existing measuring transformers in the locomotives. Where they do not come up to standard with regard to accuracy, this is accepted in all cases because the cost of replacing transformers is so high. The memory unit is able to save measured values for 6 months. The components in the measuring box are standard components which have been slightly modified.

The central communication unit, which call the train and collects the measured values, costs approximately EUR 250,000.

DB Reise und Touristik pays for the meters and installation and DB Energie pays the maintenance costs for the meters. They expect to have to replace approximately 5% of them each year.

When the trains cross a national border, for example with Austria, the meters measure the consumption for the whole journey. The electricity consumption while travelling in Austria is then settled in the invoicing system. Data is obtained from the train number system, which knows when the train crosses the border.

6 Measurement Technology Requirements

6.1 Why Measure Electricity Consumption on Board Trains?

Electricity consumption in train operations varies a great deal, depending on the train type, the train weight, the topography of the track, the conduct of the locomotive driver, cold, train transport management, etc. In order to be able to distribute costs as fairly as possible, this should be done using electricity meters. Billing with meters do not register the net losses. The losses shall be payed by the operators and it could be compensated by adding the cost for losses to the price or add the amount of losses to the consumption of each operator. In this way, it is possible to distribute the costs between each train if necessary. This is something which some transport operators have already requested as they want to know the electricity cost of a certain transport. In many cases, this is a requirement from their customers in turn.

Another reason for measuring consumption on board trains is to see the effect of energy-saving measures on power consumption. As long as the costs are distributed and calculated on the basis of patterns, it is difficult to follow up on energy-saving measures other than at overall level. The result is that only major measures are visible or that many small measures are implemented, but it is not possible to see which measure or measures produced the best result. Moreover, in this case, a major operator may implement major energy-saving

measures which result in the pattern level falling and small operators benefiting as well although they may have done nothing themselves or conversely a small operator may work hard to save energy but it is not noticed at all overall, which means that this operator has no benefit from its energy-saving work.

If you messure the energy consumption on the trains it gives us a possibility to take care of the powerconsumption in the tariff. Apart from that it is possible to compensate for powerfactor and disharmonics in constuction of the tariff.

6.2 Requirements for Measuring Equipment

6.2.1 General Requirements

The project group has agreed that, in order to measure power consumption on board trains, measuring equipment is required which should be as follows:

The measuring equipment must consist of an electricity meter capable of recording consumption per hour. It must also be possible to read the meter remotely. The meter must record in both directions, i.e. electrical power recovered must be registered separately. The operators shall be compensated for regenerative energy in a grade that at least is de same as the benefit that this energy gives to the infrastructure administator. Moreover, it must be possible to add other functions such as driver information, a kilometer counter, train weight.

The measuring equipment must be constructed in such a way that it cannot be manipulated by the transport operator or the train owner. Therefore, it cannot be measuring equipment which receives signals via the train computer. It must be completely self-contained.

6.2.2 Accuracy Class

Existing measuring transformers must be used, if possible. The measuring transformers must, as a minimum, be of class 0.5, i.e. max. 0.5% measurement error. Existing measuring transformers which are not of class 0.5 may still be used on account of the high cost of replacing transformers. The electricity meters must, as a minimum, be of class 1.0, i.e. max. 1.0 % measurement error. This ought to mean that the equipment's overall measurement error does not exceed 2.0%. Trains with measuring equipment already installed do not need to upgrade to meet the requirements if the accuracy does not exceed 5%. Making an accuracy requirement of 2.0% may seem unreasonable, considering that the losses in the network which are not measured amount to 10-20%. The reason for making this requirement despite this is that measuring equipment usually has this accuracy and that the cost will probably not be lower if the requirement is made less strict. Moreover, for example, the Danish tax authorities make the requirement 2% if customers are to account for their electricity tax themselves.

6.2.3 Measured Value Format

In order that measured values can easily be used in charging systems, the format must be compatible with EDI-EL, which is the existing industry standard in this area. All power suppliers, network owners and other players in the power market use this standard, for which reason we consider that it should also apply in this respect.

6.2.4 Remote Reading

It must be possible to read meters remotely, as the number of electricity meters will be too large to handle manually when measuring equipment is installed in the majority of our trains. In order to ensure that no measured values disappear, the memory in the equipment should be able to store measured values for at least 30 days. However, it is possible that remote reading may not be necessary from the very start as the number of locomotives with meters will be limited. Remote reading may be done to advantage via GSM-R when this is well developed. However, other mobile networks may also be used. GSM-R is the special mobile telephone network developed for the railways. It is already in operation in parts of Sweden. All trains will be fitted with a GSM-R telephone, which can then be used for measured value transfer.

6.2.5 How Do We Handle Trains Which Cross National Borders?

With meters installed on board trains, a problem arises when trains cross national borders. The meter records electricity consumption even if the train crosses a national border with the same electricity system. Where it is necessary to change electricity systems, the train must have two meters, one for each electricity system, which solves the problem. If the same electricity system is used on both sides of the border, the metering equipment must automaticly register when the train cross a border and tell the meter to stop recording or to record in a different register. In the German version, the electricity meter is simply allowed to continue to record and the power consumed in a different country is settled in connection with invoicing. This still requires that data on when the train left/entered the country can be introduced somewhere in the chain. Another alternative is to use GPS or ATC to send the measuring equipment a signal to stop recording or to record in a different register.

7 Recommendation

The project group agrees that meters on board trains will be introduced. However, the rate of introduction may vary from country to country. However, it should be a requirement that meters be installed in new locomotives. We are

also convinced that we should try to use existing measuring transformers as far as possible, as this reduces costs considerably.

The accuracy of the measuring equipment should involve a maximum 2% measurement error in connection with installation in new locomotives. It should also record power recovered separately. In connection with installation in existing locomotives, the same accuracy should be the objective. However, if the measuring transformers do not have to be replaced, it is sufficient if the other equipment has the correct accuracy. The total accuracy must not exceed 5%.

Regenerative energy shall be messured in a separatly register så that the owner of the vehicle can be compensated i a grade that is at least as big as the benefit for the infrastructure administrator is.

Standard components should be used as far as possible when creating measuring equipment. GSM-R should if possible be used for remote reading and measured data collection from locomotives to some form of central collection unit/invoicing system. A standardised data protocol EDI-EL should be used, to facilitate communication with other measured data systems and between the Nordic countries. It should also be possible to add additional functions to the system such as driver information, train weight, a kilometer counter, train number and train position.

Net losses shall be payed by the operators and we can compensate them by adding the cost for losses to the price or by adding the amount of losses to the energy consumption.

The metering equipment must automaticly register when the train cross a border and tell the meter to stop recording or to record in a different register, so that the meter does not just measure consumption and we do not know how much of the power was consumed in the respective countries.

The accountingsystem is not treated in this report and because of that we recommend the 4 nordic countries that they together make a more detailed report for the energy messuring system.