PASSENGER TRAINS IN SLOVENIA AND CONSUPTION OF ENERGY

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Especially at present, energy saving has an important bearing on energetics. It is well known that energy consumption is increasing daily, and there are a significant number of countries which are not able to generate enough energy to cover their needs. In such countries energy is more important and expensive. The Protocol on reduction of greenhouse gas has a key role in this process. What is the situation of greenhouse emissions in Slovenia? Each kilowatt hour (kWh) of electric energy produced in Slovenia equals 0.446 kg of CO_2 .

Keywords: passenger trains, energy saving, consumption of energy, railway, GPS

PUTNIČKI VOZOVI U SLOVENIJI I POTROŠNJA ELEKTRIČNE ENERGIJE

U današnje vreme štednja električne energije ima važno mesto u energetici. Poznato je da je potrošnja energije iz dana u dan sve veća, a veliki je broj država koje nisu u mogućnosti da proizvedu energiju približno svojim potrebama. U tim zemljama, energija je utoliko važnija i skuplja. Posebno mesto u tom procesu ima dogovoreno sniženje emisije toplogrednih gasova. Kakvo je stanje emisije toplogrenih gasova u Sloveniji? Svaki kilovat sat (kWh) električke energije, proizvedene u Sloveniji znači 0,446 kg $C0_2$.

Ključne reči: putnički vozovi, ušteda energije, potrošnja energije, železnica, GPS

INTRODUCTION

The question posed by Slovenian Railways (SŽ) is how much electric energy is consumed by passenger trains and which trains in Slovenia are the most economical? This is a very important question, above all with regard to the replacement of motor-coach trains and locomotives. Is it perhaps better to acquire passenger coaches and modern locomotives? With regard to statements that the consumed energy represents as much as 1/3 of total costs during the lifetime of each motor-coach train, are the listed questions significant for decisions related to purchasing new transport facilities? This paper presents some facts, which were established by means of data analyses of electric energy consumption with meters installed in traction vehicles. It is likely that these facts will be of interest to all those involved in train traction.

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REPORT ON ENVIRONMENTAL PROTECTION ON THE RAILWAYS OF SWITZERLAND

The State Railways of Switzerland transport 28 % of all freight and 16 % of all passengers, but they consume only 3.4 % of all energy consumed by the transport sector in the country. In 2006 they consumed 9.6 kWh per passenger carried over a distance of 100 km, which equals 1.1 litre of Diesel fuel. For the transport of 1 ton of freight over the same distance they consumed 6.7 kWh, which according to their calculation is equal to 0.7 litre of Diesel fuel. With goods traffic they replace 25 000 trucks in a day. In the year 2006 they improved the energy efficiency and reduced the consumption of electric energy by 3 %. 70% of their own consumption of electric energy is produced in Swiss owned hydroelectric power plants and power plants, where they have part ownership. Three quarters of the production is used for train traction [1].

EVALUATION OF FAVOURABLE USE OF ELECTRIC ENERGY

In most European railway administrations today they use the term ‘consumption of energy per gross ton kilometre’, which is rather inaccurate. A more accurate metering of consumption proved that the energy consumption of passenger trains is completely different to that of goods trains. This is actually completely logical as there are different speeds, masses, and accelerations involved.

The specific consumption of passenger trains is incomparably higher than in goods trains. This is a fact which is easy to understand because passenger trains are continually stopping and accelerating, and they travel at higher speeds. This is the reason why the consumption should be metered more accurately to find out which trains are the cheapest for the transportation of passengers. It should be of interest how much energy is consumed for the transportation of one passenger over a certain distance. If this amount of energy is to be as low as possible, all factors which have an influence on this must be known. Most important is the decision about the selection of the most suitable type of train for a given travelling distance or region. Slovenia, for example, cannot be compared with Switzerland, where an enormous number of people travel by train. Trains, composed of ten double-decker coaches with approximately 1000 seats, which, as a general rule, are completely filled, would travel practically empty on Slovenian railways and would actually consume energy for transportation of “dead mass” only. Classic trains, composed of a locomotive and coaches, waste a large amount of energy. However, it is possible to eliminate this weakness – in very long trains with many seats for example, the dead weight is quickly divided favourably among the seats [2].

The graph on figure 1 shows the comparison of consumed energy for running a passenger train with various traction vehicles between Ljubljana and Dobova in Slovenia.

On this track section, the following traction units are in use: the French electric locomotive Series 363 (Figure 2), the Italian electric locomotive Series 342 (Figure 3), the Polish four-part motor-coach train Series 311 (Figure 4), and the Siemens three-part motor-coach train Series 312 (Figure 5) [3].

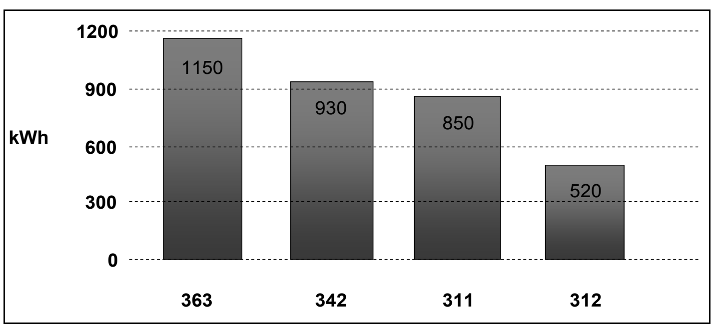

Figure 1. Electric energy consumption with various traction vehicles for running a passenger train between Ljubljana and Dobova in Slovenia

Figure 2.The French locomotive Series 363, rated output 2, 75 MW

Figure 3. The Italian locomotive Series 342, rated output 1,9 M

Figure 4. The Polish four-part motor – coach train Series 311, rated output 1,4 MW

Figure 5. The Siemens three-part motor – coach train Series 312, rated output 1 MW

THE MAIN FACTORS OF ELECTRIC ENERGY CONSUMPTION

It is very simple: the mass, the speed, and the acceleration are the factors that dictate the energy consumption. But how is it possible to influence all three listed factors? First of all, this can be achieved by reducing the mass in the manufacturing phase. Namely, the dead weight of an economical train per passenger seat must be as low as possible. Speed and acceleration are “a different category”. Regarding the speed, we make a decision in accordance with our bid, but the acceleration is, to a large extent, prescribed by the timetable, although it can be partially managed by the driving mode.

Thus, it is the dead weight! At this point we are confronted by the tendency to introduce motor-coach trains to passenger traffic. Motor-coach trains have an incomparably more favourable ratio of dead weight per passenger seat than classic trains with locomotives. This especially applies to regions like Slovenia, where the number of passengers is relatively low. A logical choice would be a relatively small motor-coach train that can be coupled together and joined in case a larger necessity for passenger traffic arises. From the standpoint of energetics, the Siemens motor-coach train Series 312 is a very good choice for Slovenian railways. It is a lightweight and compact train. Probably the only problem is the small number of these trains. Comparing the dead weight per passenger seat the following result is obtained: the three-coach motor-coach train Series 312, with a weight of 99 tons and 190 seats – approximately 521 kg per seat; the Polish motor-car train with a weight of 194 tons and 252 seats is already less favourable - 769 kg per seat. Let us have a look at classic trains, which sometimes replace the unavailable motor-coach trains: on average one coach weighs 42 tons and has 58 seats. If we take four coaches and the locomotive, the total weight amounts to wasteful 1100 kg or more per seat. This depends of course on the traction locomotive and the type of coaches. Compared to the Siemens motor-coach train, energy must be provided to move double the dead weight per passenger seat [2].

CONSUMPTION OF ELECTRIC ENERGY IN FAST TRAINS

In fast trains everything is more expensive because of the speed at which these trains travel. The construction of such trains is adapted for this purpose. For this reason the mass of the train is also greater. The comfort level is higher although today nobody can say that fast travelling is a luxury. The number of seats is increasing and there are more and more passengers travelling. There is an increased demand for the TGV Duplex. The double-decker TGV has 516 seats, 8 coaches and 2 traction units. The dead weight is approximately 380 tons, which amounts to 736 kg per seat. This is very advantageous in comparison with Cisalpin, which consists of 9 parts and has the same origin as our SŽ 310 (Figure 6), but is a great deal heavier simply because of its two-system technology. It weighs 498 tons and has 475 seats, which means over 1000 kg of dead weight per seat. For comparison, the data for our SŽ 310: 152 tons of dead weight and 166 seats, which means slightly more than 900 kg per seat. It should be mentioned that the buffet car on the train is using up a good deal of seat space, which is very unfavourable for a short train like ours. One more thing should be mentioned: Austrian railways made quite a few decisions to order fast trains, composed of classic coaches and a locomotive, equal to our SŽ 541. This is very wasteful from the standpoint of energy consumption and it is not a very good decision, especially as there are lots of excellent fast trains available in Europe. It is likely they have a lot of other reasons for such a decision, and that they will compensate for the high operational costs somewhere else [2].

Figure 6. The fast train of Slovenian railways Series SŽ 310

DOUBLE BOTTOM MOTOR – COACH TRAINS AND COACHES

Double bottom motor-coach trains and coaches are being introduced into traffic practically everywhere where passenger traffic is increasing. The reduction of dead weight per seat is considerable, and maintenance costs are not rising significantly. If the decision is clear, then the infrastructure can be adapted to this introduction without hesitation.

There is an important difference between the old Polish motor-coach train Series 311 and the new Siemens motor-coach train Series 312. The greatest difference is in the technology of the driving unit as well as in relation to the passengers – the passenger section is air-conditioned. Such installations swallow up a lot of energy but, as mentioned before, this Siemens motor-coach train weighs less and is for this reason saving energy. The control system is also more advanced. Not long ago, as a general rule, the engine driver was instructed to accelerate as fast as possible to disconnect the starting resistors which served for a gradual increase of the voltage on traction motors and thereby a gradual increase of speed, but now the situation is completely reversed. Modern motor-coaches possess an enormous power output and are capable of rapid accelerations, because the speed control is continuous and provided by electronics. Engine drivers must get used to new practices for an economical driving mode. It is no longer necessary to pay attention to the starting resistors and it is now important to handle the acceleration process moderately, or to accelerate in accordance with the requirement to keep the timetable. On average, this kind of driving can save about 10 % of electric energy. But unfavourable traffic conditions can cause “wasteful” driving. Prolonged stops followed by the “chase” to compensate for the delay are the worst examples of wasting energy and, consecutively, money. If such a complicated situation on the tracks cannot be avoided, then the solution lies in improved communication between the dispatch service and the engine driver, who can control the driving in such a way that braking and accelerating are moderate [2].

MEASUREMENT AND ANALYSIS OF ELECTRIC ENERGY CONSUMPTION DATA IN ELECTRIC TRACTION VEHICLES OF SLOVENIAN RAILWAYS

Slovenian railways started the modernization of analysis of electric energy consumption data in driving electric traction vehicles. The principle is shown in Figure 7 [4].

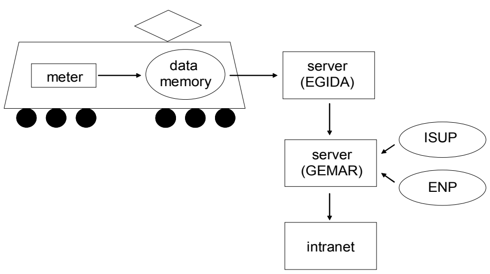

Figure 7. Modernization of metering and analysis of electric energy consumption in electric traction vehicles of Slovenian railways

A meter for electric energy is installed on the traction vehicle. The meter is read by the data memory, where the data on consumed electric energy and data from GPS are combined. This data are transmitted to the EGIDA server, where the data of all locomotives is collected. From here the data is transmitted to the GEMA.R server which combines the data from the Traffic Management Information System (ISUP) and the railway substations (ENP). GEMA.R transmits the data of the consumer to the INTRANET. The graph in Figure 8 shows the comparison of consumption of electric energy between the new Siemens three-part motor coach Series 312 and the old Polish four-part motor coach Series 311 for the run of the train between Ljubljana and Dobova, measured by the new method with the use of GPS [5]. Figure is showing diagram speed of both trains and curves of electricity consumption on distance Ljubljana – Dobova. The old Polish motor coach Series 311 (upper curve) uses up a lot any more electrical energy as the Siemens motor coach Series 312 (lower curve).

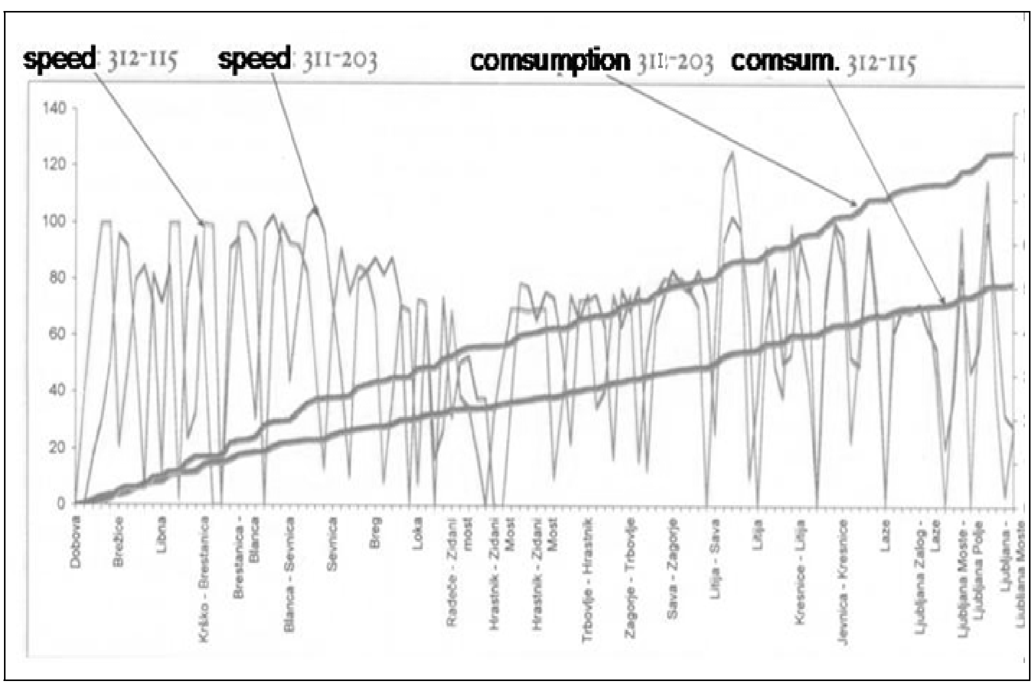

Figure 8. Comparison of electric energy consumption for running a passenger train on the section between Ljubljana and Dobova between the three-part motor-coach train Series 312 and the old Polish four-part motor-coach train Series 311

CONCLUSION

How should we sum up the findings and analyses conducted so far, made possible by means of the electric energy meters installed? Without any measurements it is impossible to recognize the facts and take steps in the right direction. But now it is possible to monitor the consumption of passenger trains exactly. It was logical that the indicators equalized with goods traffic, based on the gross ton kilometre are not correct, but there was no tool available to calculate the consumption in a different way. Furthermore, the achievements of new passenger trains are now evident. The new technology is not only evident in the design and manufacture of the motor-coach trains, but also in the improved traction control significant which hold significant benefits in the field of energy usage. The best practice is in driving and managing these trains. The easier supervision of energy consumption, will be used by the personnel of traction vehicles for economical driving. In conjunction with this, there are already certain projects being conducted by the Traction Service, who as a model are promoting the achievements of German railways which managed to reduce the specific consumption of energy on average by almost 10 %. By implementing an as economical mode of driving as possible, we also anticipate a favourable response from the traffic management as the dispatchers are in a position to save a considerable amount of energy via proper organization of the train traffic.

In addition to the points made above, the meters also register the amount of electric energy, returned back into the overhead traction network. The amount of generated and returned energy depends on the situation of the railway line and its trains, which can use this energy. In the course of time, the knowledge helping to efficiently use such energy, will be developed. It should be emphasized that each kWh saved reduces the emission of greenhouse gases. It is necessary to fully acquaint the government with this issue, as in this way we help to accomplish the goals set by signing the Kyoto Protocol for reduction of CO_2 emissions.

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