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ELECTRIC RAIL TRACTION IN CZECH REPUBLIC AND LEVEL OF EFFECTIVENESS AND ENERGY SAVING MEASURES

This measure aims to reduce the peak usage of energy for trams and trolley buses in order to limit the contracted reserve capacity and the related costs. As final result, in 2012 DPMB contracted 6.24% less of additional reserve capacity due to new system. At the moment 380 electric vehicles (240 trams and 140 trolleybuses) are equipped with this system, which was certificated by Czech Railways Authority and can now be implemented by all other public operators in Czech Republic.

Brief history of electric rail traction in Czech Republic

Railway transport

The history of railway transport in Czech Republic began in 1827 when the first section of horse railway České Budějovice/Budweis – Linz (Austria) was opened. The first railway route operated by steam locomotives was section Břeclav – Brno (1839) of the Northern line from Vienna (first section Vienna – Deutsch Wagram opened in 1837). In 1903 the first electric railway, the local line Tábor – Bechyně went into operation (24 km in standard gauge, traction 2x700 V DC, today 1500 V DC). In 1912 there followed a second local line Rybník – Lipno nad Vltavou (22 km in standard gauge, traction 1200 V DC, from 1955-2003 with 1500 V DC, since 2003 with 25 kV AC/50Hz).

The next step was the electrification of the railway ring in Prague 1926-1928 (about 30 km standard gauge, traction 1500 V DC, since 1962 with 3000 V DC). Then it took nearly 20 years until the next extension: In 1957 there went into operation the first electrified long distance railway line Praha – Česká Třebová with a length about 160 km and traction 3 kV DC. From this time most of the main Czech (and also Slovak) railway routes have been continuously electrified. An important step has been made in 1965 with the electrification of the line Kutná Hora – Jihlava (90 km) with traction 25 kV AC/50 Hz. The existence of two traction systems in formerly Czechoslovakia, however, in the 1970s caused problems in flexible operation (there existed only locomotives or electrical units with one of the two tractions). Therefore company Škoda in 1974 delivered the first dual-system locomotives. Today, Czech Railways (ČD) operate even three-system electrical units (class 680 „Pendolino“) and locomotives (class 380) which are able to operate also in Austria and Germany (with traction 15 kV AC/16.7 Hz).

Very important for the development and research on electric traction is the large test circuit of VUZ (Railway Research Institute) in Velim near Prague, which exists since 1963 and enables power supply either AC or DC current system (25 kV AC/50 Hz, 15 kV AC/16.7 Hz, 3 kV DC, 1.5 kV DC) and therefore allows the testing of many rail vehicles of European railway operators.

At the end of 2013 overall 3217 km of the 9468 km long railway network of SŽDC (the state owned Railway Infrastructure Administration of Czech Republic) are electrified (these are 34%) with the following traction systems:

- 1788 km with 3 kV DC (mainly in the north);
- 1391 km with 25 kV AC/50 Hz (mainly in the south);
- 24 km with 1.5 kV DC (local line Tábor – Bechyně);
- 14 km with 15 kV AC/16.7 Hz (line Šatov/near Austrian border – Znojmo, operated by trains of ÖBB/Austrian Federal Railways).

The allocation of today's electric traction systems can be seen on the following map (fig. 1).

Public urban transport (tram, metro, trolleybus)

History of electric urban rail transport in Czech Republic began in 1891 with the opening of the first tram line in Prague. Today tram systems exist in 7 cities (resp. agglomerations) with a total length of 356 km (2012). All systems are operated at voltages of approximately 600 V DC. The Czech Republic is also well known for its production of tramcars: Company ČKD-Tatra manufactured with tramcar T3 the most numerous type of tram in the world (about 14.000 units).

The only city with metro system in the Czech Republic is Prague. The first section opened in 1974 and today 3 lines with a total length of 59 km

are in operation. The traction is performed at voltage 750 V DC by third rail. For the future there are planned extensions of the existing lines as well as the construction of a fourth line.

Another speciality of electric urban rail transport in Czech Republic is the trolleybus which is considered here as railway (because of his overhead wire). The first trolleybus line was opened in 1936 in Prague. Today trolleybus systems exist in 13 cities (resp. agglomerations) with a total length of 393 km (2012). Most systems are operated at voltages of 600 V DC, two of 750 V DC.

The allocation of today's electric urban rail transport can be seen on the following map (fig. 2).

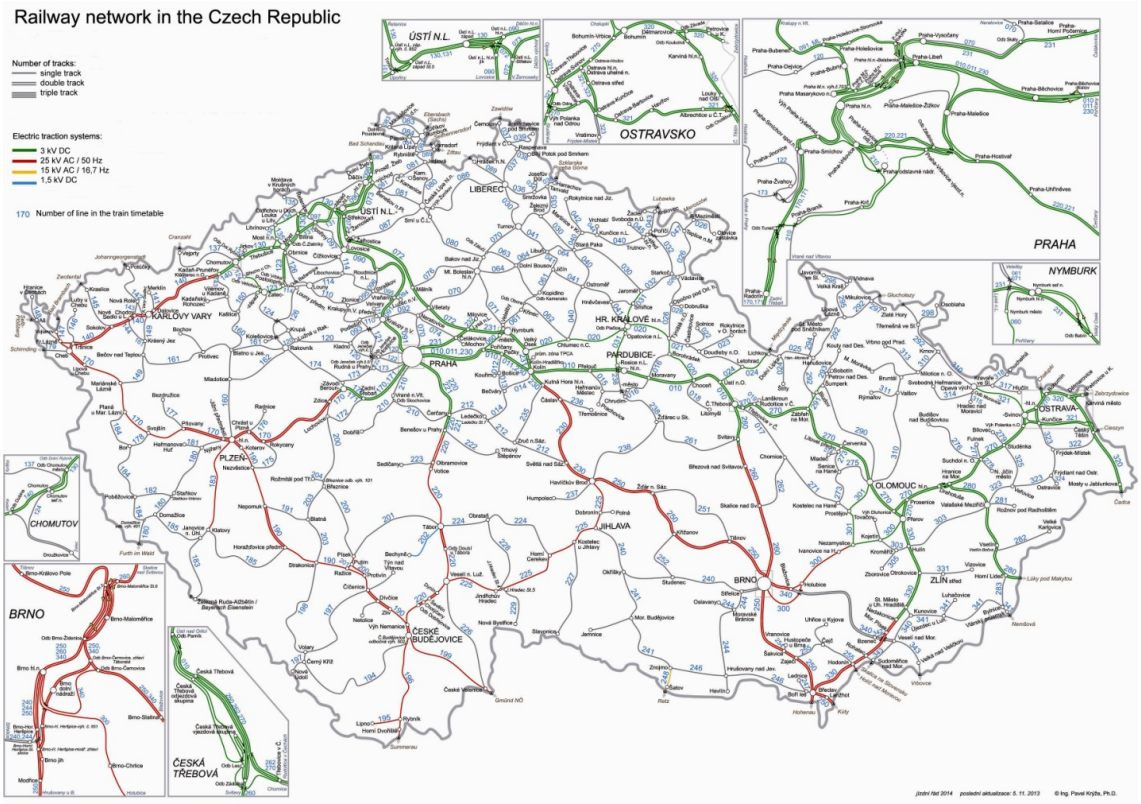

Fig. 1. Railway network in the Czech Republic
Source: SŽDC (Railway Infrastructure Administration of Czech Republic, state organization)

Fig. 2. Public urban transport
Source: Wikimedia Commons

Level of effectiveness and energy saving measures on electric rail traction

Use of multi-system electric locomotives and units

Because the existence of two traction systems in formerly Czechoslovakia caused problems in flexible operation in the year 1974 there were delivered the first dual-system locomotives. Today, Czech Railways (ČD and ČD Cargo) operate the following multi-system electric rail vehicles:

Two-system vehicles 3 kV DC and 25 kV AC/50Hz: 163 locomotives class 340 and 362/363.

Two-system vehicles 3 kV DC and 15 kV AC/16.7Hz: 16 locomotives class 371/372.

Three-system vehicles 3 kV DC, 25 kV AC/50Hz and 15 kV AC/16.7Hz: 20 locomotives class 380, 7 units class 680 („Pendolino“), 7 units class 640/650 („RegioPanter“).

Furthermore, locomotives from ZSSK (Slovakia) class 350 (3 kV DC, 25 kV AC/50Hz) and ÖBB (Austria) class 1116 (15 kV AC/16.7Hz, 25 kV AC/50Hz) and 1216 (3 kV DC, 15 kV AC/16.7Hz, 25 kV AC/50Hz) are running with international trains also in Czech Republic.

Regenerative braking and recovery of electricity

Today regenerative braking and recovery of electricity in the electric railway network in Czech Republic is usual, but often in a limited form. The reasons for these limitations are:

Relatively small amount of electric locomotives and units capable for regenerative braking: Until now, these are 50 locomotives (class 363.5 and 380) as well as 97 units (class 440, 471, 640/650 and 680). Furthermore some locomotives of the ÖBB Taurus class (1116 and 1216) are runnig with international trains from and to Austria.

DC power supply system is a subject to restrictions on the maximum voltage: While European standards allow peak voltage of 3.9 kV, the locomotives of ČD and ČD Cargo have been only designed for a limit voltage of 3.6 kV.

Regarding the AC system the supplier of electricity (company ČEZ – Czech energy plants) initially was not very interested in regenerative braking and recovery of electricity due to the stochastic occurrence of these energy source (in case of older vehicles combined with additional problems like higher harmonics and worse power factors); all these problems increase the requirements on regulation of the entire supply network. Therefore, originally, regenerative braking was banned in the AC railway network. Because of newer technologies regenerative braking and recovery of electricity now continuously is allowed on more and more lines.

It is a goal of SŽDC and ČD to solve these problems and increase the amount of regenerative braking and recovery of electricity in the next years.

A different situation can be found in electric urban rail transport: The Prague Metro with a large number of simultaneously circulating units with frequent acceleration and deceleration has ideal conditions for regenerative braking. Also the Czech tram and trolleybus systems have made significant efforts in the recent years: A wide range of new vehicles put into service have regenerative braking. In addition in older vehicles the expired electromechanical equipment has been replaced by new electronic one which also enables regenerative braking.

Automatic train leading by using magnetic information points

For purposes of automatic train leading (in Czech AVV) are on the track situated installations for identifying position, so-called magnetic information points. Magnetic information points are located in rails designed at the moment mainly for rides of local trains (with many stops). Description of the line (“route map”) must be contained in the vehicle part of AVV (“on-board”). Based on the train position identification, the route map and information transferred though the train control device and/or input by the driver the vehicle part of AVV ensures a continuous and economical train ride. With AVV local trains can achieve savings of 7-9% of traction energy. Currently, about 350 km of tracks and about 250 locomotives and units are completely equipped with ATL.

Planned conversion of 3 kV DC to 25 kV AC/50 Hz

SŽDC, the state owned Railway Infrastructure Administration of Czech Republic, plans the conversion of its lines elctrified with 3 kV DC to 25 kV AC/50 Hz during the next 30-40 years. Traction 25 kV AC/50 Hz is more efficient not only in investment but also operationally, e.g. eliminating damage by stray currents.

Optimized Energy Consumption in Tram and Trolley Bus Network – A project of Brno Public Transport Company (DPMB)

This measure was realized within the EU-project CIVITAS-ELAN in the years 2009/2010. It aimed to reduce the peak usage of energy for trams

and trolley buses in order to limit the contracted reserve capacity and the related costs. Brno Public Transport Company (DPMB) has to contract its annual expected amount of electricity to ensure the electric vehicles operation. To obtain a balanced energy distribution, there is also a requirement for DPMB to book monthly a reserve capacity for each 15-minute interval. The costs related to reserve capacity have a negative influence on the cost of electricity because unused capacity still needs to be paid and exceeding the contracted reserve capacity is heavily penalised.

To achieve these objectives a remote heating control was installed in 380 electric vehicles (240 trams and 140 trolleybuses). This includes also an automatic warning system which in case of reaching the level of reserve capacity will generate the message to be transferred to the on-board computer in the electric vehicle and switch off the heating automatically for 5 minutes.

As final result, in 2012 DPMB contracted 6.24% less of additional reserve capacity due to new system and the total savings due to the operation of the system reached almost 132.000 EUR.

The whole system was certificated by Czech Railways Authority and can now be implemented by all other public operators in Czech Republic.

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Czech Railways currently operate 163 two-system locomotives for 3 kV DC and 25 kV AC/50Hz, 16 two-system locomotives for 3 kV DC and 15 kV AC/16.7Hz, 20 locomotives and 14 units for three-systems (3 kV DC, 25 kV AC/50Hz, 15 kV AC/16.7Hz. Furthermore, some multi-system locomotives from Austria and Slovakia are running with international trains also in Czech Republic.

Regenerative braking and recovery of electricity in the electric railway network in Czech Republic is usual, but often in a limited form. Reasons are relatively small amount of electric locomotives and units capable for regenerative braking, restrictions on the maximum voltage in DC power supply system and restrictions because of requirements for the regulation of the overall network in AC power supply system.

With automatic train leading local trains can achieve savings of 7-9% of traction energy. Currently, about 350 km of tracks and about 250 locomotives and units are completely equipped with this system.

Optimized Energy Consumption in Tram and Trolley Bus Network is a project of Brno Public Transport Company. This measure aims to reduce the peak usage of energy for trams and trolley buses in order to limit the contracted reserve capacity and the related costs.

Keywords: electric traction, effectiveness, energy saving.

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ЕЛЕКТРИЧНА ТЯГА У ЧЕСЬКІЙ РЕСПУБЛІЦІ, РІВЕНЬ ЕФЕКТИВНОСТІ ТА ЗАХОДИ ЕНЕРГОЗБЕРЕЖЕННЯ

Чеські залізниці обслуговуються 163 двосистемними електровозами для систем 3 кВ постійного струму та 25 кВ змінного струму частотою 50 Гц, 16 двосистемними електровозами для систем 3 кВ постійного струму та 15 кВ змінного струму частотою 16.7 Гц, 20 електровозів і 14 одиниць рухомого складу призначені для роботи на трьох системах електропостачання. Крім того, деякі багатосистемні електровози з Австрії та Словаччини також працюють на залізницях Чехії у складі міжнародних поїздів.

Рекуперативне гальмування та відновлення електроенергії в електричних мережах Чехії зазвичай використовується, але досить часто в обмеженому вигляді. Причиною тому є відносно невелика кількість електровозів та одиниць рухомого складу придатних для рекуперативного гальмування, обмеження стосовно максимальної напруги в системі тягового електропостачання постійного струму та обмеження стосовно вимог для регулювання в загальних мережах системи електропостачання змінного струму.

За допомогою технології автоматичного ведення поїзду приміські поїзди досягають економії електроенергії до 7-9 %. На даний час майже 350 км колій та близько 250 електровозів та одиниць рухомого складу обладнані цією системою.

Оптимізоване споживання енергії в мережах трамваїв та тролейбусів – проект компанії громадського транспорту Брно. Цей захід спрямований на зниження пікового навантаження для трамваїв та тролейбусів з метою обмеження договірної резервної потужності та пов'язаних з цим витрат.

Ключові слова: електрична тяга, ефективність, енергозбереження.

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ЭЛЕКТРИЧЕСКАЯ ТЯГА В ЧЕШСКОЙ РЕСПУБЛИКЕ, УРОВЕНЬ ЭФФЕКТИВНОСТИ И ЭНЕРГОСБЕРЕГАЮЩИЕ МЕРОПРИЯТИЯ

Чешские железные дороги обслуживаются 163 двухсистемными электровозами для систем 3 кВ постоянного тока и 25 кВ переменного частотою 50 Гц, 16 двухсистемными электровозами для систем 3 кВ постоянного тока и 15 кВ переменного тока частотою 16.7 Гц, 20 электровозов и 14 единиц подвижного состава предназначены для работы на трех системах электроснабжения. Кроме этого, некоторые многосистемные электровозы из Австрии и Словакии также работают на железных дорогах Чехии в составе международных поездов.

Рекуперативное торможение и возобновление электроэнергии в электрических сетях Чехии обычно используется, но очень часто в ограниченном виде. Причиной этому есть относительно небольшое количество электровозов и единиц подвижного состава способных применять рекуперативное торможение, ограничения относительно максимального напряжения в системе тягового электроснабжения постоянного тока и ограничения в отношении требований для регулирования в общих сетях системы электроснабжения переменного тока.

С помощью технологии автоматического ведения поезда пригородные поезда достигают экономии электроэнергии до 7-9 %. На текущий момент почти 350 км путей и около 250 электровозов и единиц подвижного состава оборудованы этой системой.

Оптимизированное потребление энергии в сетях трамваев и троллейбусов – проект компании общественного транспорта Брно. Это мероприятие направлено на снижение пиковых нагрузок для трамваев и троллейбусов с целью ограничения договорной резервной мощности и связанных с этим затрат.

Ключевые слова: электрическая тяга, эффективность, энергосбережение.

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