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The crucial role of driver training in the deployment of electric buses

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When the transition from diesel to electric buses is considered, a whole new transportation system, not just a new vehicle type only is in question. Because of this, one important part of a successful launch of e-bus operation is driver training.

In practice, a new transportation system includes, in addition to the vehicles, possibly several recharging devices and procedures. Also, in most cases, new arrangements regarding driving schedules and rotation of buses have to be prepared.

The drivers, who are typically used to driving diesel buses only, deserve comprehensive training in both bus operation and recharging procedures. Untrained drivers are more prone to cause traffic accidents. In less severe cases, they may fail in keeping the driving schedule, if they are not completely sure about the recharging procedure of the bus.

The training should make the drivers confident about operating the new vehicle type, recharging, economical driving, and safety issues. This means that the training must be, not about driving only, but also about getting to know the new vehicles. Only thoroughgoing guidance and exercise guarantee the drivers' will and ability to provide safe, reliable and comfortable service to their passengers.

In some cases, the drivers might not be enthusiastic about the switch to e-buses. To make them feel motivated about starting to operate a new vehicle type, they should be given information about the benefits of the e-bus operation and about the reasons for going towards electrification. Additionally, the drivers need some time to cope with and overcome the possible uncertainty and emotional stress related to the change.

"The training really decreased my worriedness about how I will survive with the new vehicle type, charging and everything", was a statement from a driver having attended the training. "Now I know that there is no reason to worry".

Regarding safety, the drivers should be informed that in case of a fire, the most important thing is to let the passengers out immediately. A battery fire in an electric vehicle generates toxic gases. Moreover, the fire is very difficult to extinguish, and after doing so, the fire is prone to burst up again.

In addition to the drivers, usually, also the service personnel of the buses have to be trained. Additionally, the firefighters/rescue people must be informed of at least the location of the batteries and about the positions of the emergency shutdown

switches, as well as the high-voltage components of the vehicles. Moreover, it is important to make sure that the rescue people distinguish the electric buses from the conventional ones.

This article presents suggestions about the implementation of driver training. It gives examples about the possibilities to make the drivers get acquainted with the different aspects related to electric bus operation. Additionally, it discusses specific issues about economical training. The information presented is gathered among the six eBussed project regions during, for example, the international learning events that the project organized in Hungary and Germany.

Charging device maintenance staff and rescue people in training in Turku, Finland. Photo by Markku Ikonen.

Theory and practice in action

When planning the instructions and training procedures for drivers, it would be beneficial to include both a theoretical and a practical part. Theoretical knowledge is important but practicalities are best learned by getting hands-on experience on the topic. One possibility is to give theoretical guidance in the morning and practical training on the same afternoon. By doing this, the theoretical things will stay in mind, and be applied into action right away.

Because there are usually more and less motivated drivers in the company's staff, a question arises, whether all or only a part of the drivers (the most motivated ones) should be trained. Unfortunately, there is no universal answer to this question. Giving training to all drivers will, in most cases, make it easier to plan work shifts and rotation of buses, especially if there are both diesel and electric buses in use, which often is the case. On the other hand, the transition might go through smoother and with less hassle, if only the most motivated drivers are assigned the responsibility to operate e-buses. The latter option might also lead to better passenger experience and feedback.

Also, the number of drivers to be trained depends on the number of e-buses compared to the whole bus fleet of the company. There is no point in training the entire staff if there are not enough buses for them to drive afterwards, as regular practice after the official training.

At the beginning of the regular e-bus service, it is worth considering the so-called "split shifts" for the recently trained e-bus drivers. This means that a driver drives only during peak hours in the morning and again in the afternoon. In between, the driver has a long lunch break. Because the driver is in possession of the vehicle the whole day, there is time and a possibility to self-train on the features of the new bus type.

One possibility to organize the training after the e-bus launch phase is to incorporate economical driving training into the already existing training structure of the company. One of the eBussed project regions utilizes a modular training system, in which one module’s topic is economical driving. E-bus driving is added to that regular module. The other training modules include e.g. first aid, customer service and safe driving. Each driver gets one training module per year, and after all modules are covered, the same sequence is repeated from the beginning. Of course, alterations in the contents are possibly made depending on the recent developments in the buses and/or in the working environment.

Test Driving without Passengers

Before boarding passengers and launching regular service, test-driving is a safe way to familiarize the drivers with the new vehicle. In many cases, the driving technique, operational characteristics, and problem-solving techniques of electric buses may be significantly different from those of conventional diesel buses. Therefore, driving the actual oncoming route without passengers and with the help of a trainer is worth the effort.

In Utrecht, the Netherlands, the bus operator company Qbuzz has delivered comprehensive training for their e-bus drivers. Copyright Qbuzz.

Moreover, based on the experience from the test driving, it is easy to evaluate the performance of the bus. For example, if there are challenging uphill sections in the area, test driving can help to select the routes that the electric bus would be most suitable to be operated on.

If available, a bus manufacturer's representative helps in solving possible technical problems during the test-driving period. A technical expert of the bus supplier can easily identify any problematic issue encountered during the test-driving phase. If technical failures arise, the technical expert can assist the local technicians to resolve the problems. Moreover, if any components get damaged, the supplier can provide access to the necessary spare parts and give guidance to the local technicians on the replacement methods.

Technology as a Helper in Driving

Technical devices exist to help to train the drivers. Some appliances are even designed to help the driver drive sustainably way in regular bus operation. A device for this exact purpose has a display containing small, coloured pilot lamps indicating the sustainability of the bus ride in real-time. The display contains a red, orange and green light. The green light indicates the most fuel-efficient driving style.

It is even possible to connect this kind of device with the navigation system and bus driving schedule. The system detects the position of the bus on the map and calculates, whether the bus is late, on time or ahead of schedule. The system guides the

Electronic instrument cluster of an electric bus.
Photo by Markku Ikonen.

driver to slow down or to speed up, if necessary. The most appropriate way to drive is to keep the driving speed as low as possible while keeping on schedule.

Driving more sustainably can be learned simply by taking a bus ride. A training method worth considering is placing a group of drivers on the passenger seats while a colleague is driving. By doing this, and changing ideas with each other, with the driver and with the trainer, the drivers themselves can gain insight into how comfortable the ride is. Also, in many cases, the drivers find it surprising, how great differences they can feel between the driving styles of different drivers.

Technical devices can help when monitoring driving styles. Riding comfort can be measured during the bus ride. Measurement can be carried out simply with activity trackers that are gaining popularity rapidly. They monitor for example the heart rate and the blood oxygen. These devices give incorruptible feedback from the experience of the passenger. The data on riding comfort and sustainable driving during the trip can be analysed and viewed afterwards to make conclusions.

This information helps the bus driver to understand how well he or she scores on driving comfort and sustainability. An explanation is given about the analysis to the driver, and tips are provided to improve both riding comfort and driving sustainability. To further support the driver in addition to the analysis and tips, also videos can be utilized explaining how to increase driving comfort and improve sustainable driving. This method guarantees better driving behaviour for bus drivers and a better experience for the passengers. It also ensures that the bus company emits less CO2 emissions and that the e-bus battery capacity is used optimally.

Training carried out by the e-bus supplier

The training for drivers can be given also by the bus supplier, in addition to the bus company experienced personnel or third-party experts. If the supplier is responsible for the training, in many cases the training has been negotiated as a part of the e-bus purchasing contract. If the bus supplier is in a foreign country, the training can still be organized in the local language, if the supplier has a representative in the country. In some cases, the training can be financed by European Union grants.

In a typical driver training procedure, the drivers familiarize themselves with the vehicles, learn the locations and precise operation of the various controls, and the emergency protocols associated with them. The training focuses usually on the design of the bus electrical system, including the high-voltage components, the location of the batteries and their impact on the running of the vehicle.

After the theoretical training there usually is a practical part. This consists of a sufficient amount of training to learn how to operate the vehicle economically. The operation of the regenerative braking system is explained and tested.

Bus drivers and stakeholders acquainting themselves with an electric bus in Finland. Photo by Markku Ikonen.

Examples of topics for the theoretical training for bus drivers

1. The general construction, dimensions, and masses of the vehicle
    - Location of batteries and other high voltage components
2. General issues related to the operation
3. Workplace of the bus driver
4. Management of the bus
5. Recharging of the bus
6. Safety and security
    - Safe and economical driving
    - High voltage circuits. High voltage is life-threatening and under any circumstances. The driver should not:
        - touch any of the high-voltage parts of the crashed vehicle of the orange-coloured wires of the high-voltage system
        - touch the damaged components or damaged orange high-voltage wiring
        - remove any protective covering of any high-voltage component marked with a yellow warning sticker
    - When washing the vehicle, the high-voltage equipment on the roof must not be forgotten
        - do not use a high-pressure washing machine
        - do not wash with the roof brush in an automatic washing machine
        - the roof should only be cleaned with compressed air.
    - For the battery mounted on the rear of the vehicle
        - clean with compressed air
        - do not use a high-pressure washing machine,
        - do not use household detergents for washing.
    - Drivers are not allowed to interfere with the high-voltage (HV) system of the vehicle
7. Emergency procedures
    - Emergency towing
    - Switching off high-voltage circuits
        - Positions of emergency switches
        - Disconnecting the high-voltage battery
        - Disconnecting the 24-volt system

Economical Driving of an Electric Bus

The general laws of physics apply to electric buses as well. Any type of energy use involves some sort of energy transformation. In the bus case, this means that the electric energy must be converted to mechanical energy in the electric motor. And with the help of the transmission and driving wheels, the mechanical energy is then converted to the kinetic energy of the mass of the bus.

Typical to energy transformations is that they involve energy losses: no energy transformation process can have 100 % efficiency. One of the main benefits of the electric vehicle powertrain is the much higher energy conversion efficiency than that of the combustion engine-based powertrain. The electric powertrain efficiency is up to 3–4 times that of the conventional powertrain.

However, the energy conversion efficiency is not the only factor that determines vehicle energy consumption. The other key factor is the power needed to accelerate the vehicle and keep it moving. And because energy is power multiplied by time, power need also determines energy need. During acceleration, the power need depends mostly on the mass of the vehicle.

Today's battery technology can provide only fairly heavy batteries, so electric vehicles have here a drawback, especially taking into account that also the rolling resistance of tyres mostly depends on the vehicle mass. At high constant driving speeds, the power need is mostly created by air resistance. However, in city operation, buses travel at quite slow driving speeds, resulting in quite low air resistance.

From these considerations, a conclusion can be drawn that acceleration and rolling resistance are the greatest energy absorbers in city bus operation. If the bus duty cycle consists of very frequent stops and re-accelerations, more than 50 % of the total energy needed is consumed by acceleration.

On the other hand, every acceleration avoided provides savings in the energy bill. In driver training, it should be emphasized that when the vehicle mass is in motion, this has a great value as such. The driver should avoid stopping by anticipating what is far ahead. If the driver sees a stopped line of cars, he/she should immediately release the accelerator pedal and let the vehicle speed slow down gradually. In many cases, the line of cars ahead is not stopped anymore when the bus reaches the stopping point. This has the consequence that the bus speed needs to be re-accelerated only a little, instead of having to accelerate from a standstill.

Of course, the bus has to stop when passengers get on or off the bus. These stops cannot be avoided. But the driver can influence the stopping and re-acceleration needs between the bus stops, and, when stopping is unavoidable, the electric powertrain has the benefit of regenerative braking. This means that the electric motor starts operating as a generator, becomes harder to rotate and slows the vehicle speed. At the same time, it generates electricity, which is then directed back to the battery.

A regenerative braking system, along with the high efficiency, is another important energy-saving feature in the electric powertrain. It must be understood, though, that when kinetic energy is converted to electric energy and back, both transformations

involve energy losses. Thus, the most economical way to drive is to let the vehicle coast without using the motor for decreasing the speed. This method requires starting the deceleration very early.

Of course, there are driving situations when coasting does not reduce the speed quickly enough and regenerative braking should be used. In those cases, the breaking should be kept, if possible, soft enough to avoid activating the conventional friction brakes. They start working if the driver wants stronger deceleration than the regenerative system can provide. In that situation, part of the kinetic energy is converted into heat instead of electric energy in the mechanical brakes.

At least in some electric buses, regeneration based on accelerator pedal release can be switched off. When this option is selected, releasing the accelerator does not activate regeneration, but depressing the brake pedal is needed. This is the recommended operation mode to be used if extremely low electricity consumption values are targeted.

In the city environment, the strongest influencer on energy consumption is the number of bus stops compared to the total length of the line: the greater the number, the higher the energy need. On the other hand, during quiet hours of the day, there usually is no need to stop at every bus stop, which results in lower energy consumption.

Charging device training in Turku, Finland.
Photo by Markku Ikonen.

Another issue worth considering is the way of accelerating the bus. Acceleration can be carried out with high power in a short time or with low power in a long time. Regarding the kinetic energy needed, there is no difference between these two. However, the power plants, also the electric motor, but especially the combustion engine, give in most cases the highest efficiency at high loads. This means that the most economical way to accelerate is to do it relatively quickly. However, before accelerating, the driver has to check that the road is clear. If not, there is no point to accelerate. Quite rapid acceleration also helps keep the driving schedule and makes it possible to use somewhat lower maximum speeds between the bus stops which also saves energy.

There is an idiom saying that you should avoid heavy accelerator foot. However, a better way to think would be to avoid heavy braking foot. When remembering this, also the way of operating the accelerator will indirectly be switched to a more economical way.

Conclusions

- The drivers will feel more motivated to learn about e-buses after getting information about the benefits of e-buses and the reasons for going towards electrification.
- The training should make the drivers confident about operating the new vehicle type, recharging, economical driving, and safety issues.
- The drivers should be informed that the most important thing in case of a fire is to let the passengers out.
- To make the most out of the switch to e-buses, the drivers should be trained to economical driving with the electric powertrain.
- In most cases, also the service personnel should be trained.
- Moreover, the firemen/rescue people and the emergency towing staff should be educated.