ADVANCING PUBLIC TRANSPORT

CLEAN BUS SERIES 1

FACTSHEET

DEPOT ADAPTATIONS FOR CLEAN BUS TECHNOLOGIES

JANUARY | 2023

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INTRODUCTION

Climate change and local air pollution are the main factors driving the transition towards clean- and zero-emission technologies in the transport sector. Around the world, national and local governments have issued transport decarbonisation visions and plans, and set up targets and timelines supporting the transition from fossil-fuelled fleets towards clean and zero-emission technologies.

As key stakeholder in this transition, the bus sector is demonstrating strong commitment to the decarbonisation goals and is embracing clean technologies and innovation whilst investing in substantial fleet renewal in many of our cities. However, while transitioning towards low- and zero-emissions buses can significantly improve quality of life and liveability in our cities, the introduction of a new technology poses several challenges to operators daily business.

When diversifying the technology portfolio, operators need to consider many aspects related to the specificities of each technology and its operational requirements, like the introduction of new equipment, functions and tasks, as well as local regulations and standards. Lack of space, finding a suitable location, energy supply, design for high efficiency of operations, and ensuring compliance to regulations for a specific technology, are usual constraints to cope with when planning for a new depot.

This factsheet series is aimed at providing an overview of the main aspects to consider in the different phases of planning and deploying a new depot, or upgrading an existing one. As public bus fleets are usually made of several technologies, it is not uncommon that depots are shared for different types of buses. The factsheets set the focus on some of the most popular technologies that can be found globally: battery electric, fuel cell hydrogen and natural gas, and its journey starts right after the technology choice has been made, for this reason there are not considerations or comparisons in this regard. The factsheets series is part of the UITP collection of existing documents aiming at shortening the learning curve, such as Bus Tender Structure, released in 2018, or Fleet Renewal Checklist, released in June 2020 by the UITP Bus Committee.

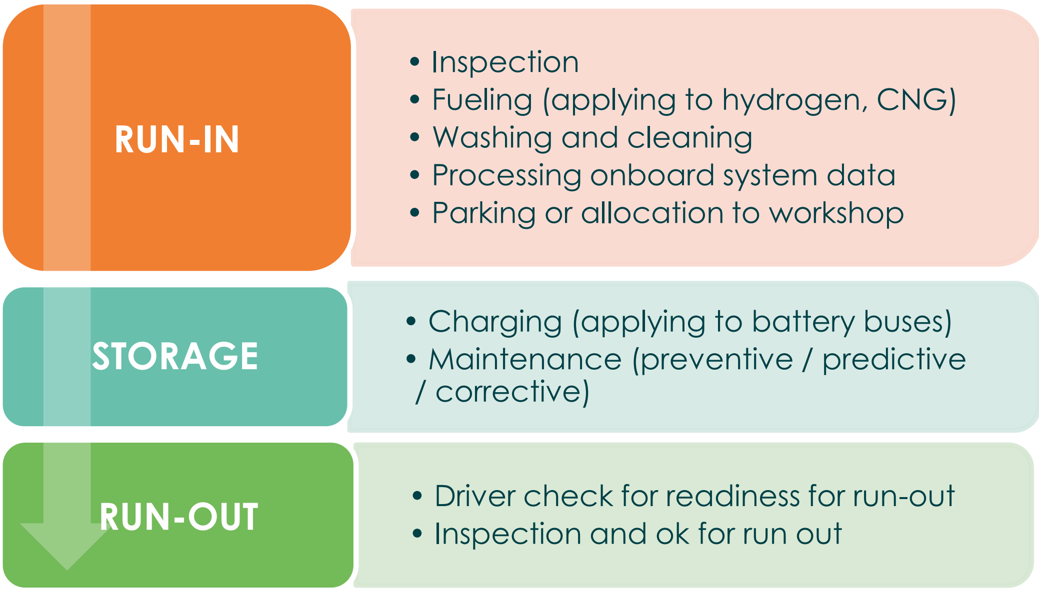
ELEMENTS OF A BUS DEPOT

A bus depot can be defined as the premises where buses are serviced and parked after the daily operation. It entails several facility areas designed to cover the managerial, maintenance and administrative tasks needed to operate a fleet of buses. The main elements of a bus depot can be listed as follows:

- **Entry and exit**
- **Parking bays for buses**
- **Washing and cleaning**
- **Charging and/or fuelling, incl. energy storage (2nd life of batteries)**
- **Maintenance workshops, incl. fire safety systems**
- **Warehouse & storage**
- **Administrative & operational facilities**
    - Operational control centre[1]
    - Facilities for drivers (cloakrooms, personnel rooms, etc.)
- **Parking for staff and externals**

Based on the elements and tasks performed in a depot, this series highlight main considerations and provide tips for the different elements and phases of depot planning, deployment and operation for battery electric, fuel cell hydrogen and natural gas buses.

[1] The Control Centre could also be located outside the depot premises.



► *Source: UITP Field Study Bus Depot, 2013*

FACTSHEET 1. BATTERY ELECTRIC BUS DEPOTS

A battery electric bus is a vehicle that uses electricity to power its driveline via an onboard battery that needs to be charged to fulfil the daily duty cycle. The more demanding the duty cycle, the higher energy consumption, and consequently, the energy needs of the bus. Typical factors affecting energy consumption of a battery electric bus are the topography and type of road, use of HVAC, vehicle weight and passenger load, speed and driving style.

Heavy duty cycles can be covered either by choosing bigger battery size, and charging after the operation when the bus returns to the depot, known as overnight charging; or scheduling a more frequent charging during operation, known as opportunity charging, with smaller battery size.

Choosing the most adequate charging solution and defining the most suitable charging strategy are two fundamental steps in the definition of an e-bus system. Understanding how the charging process works is also important when defining the needs and requirements to either upgrade an existing depot or planning for a new one.

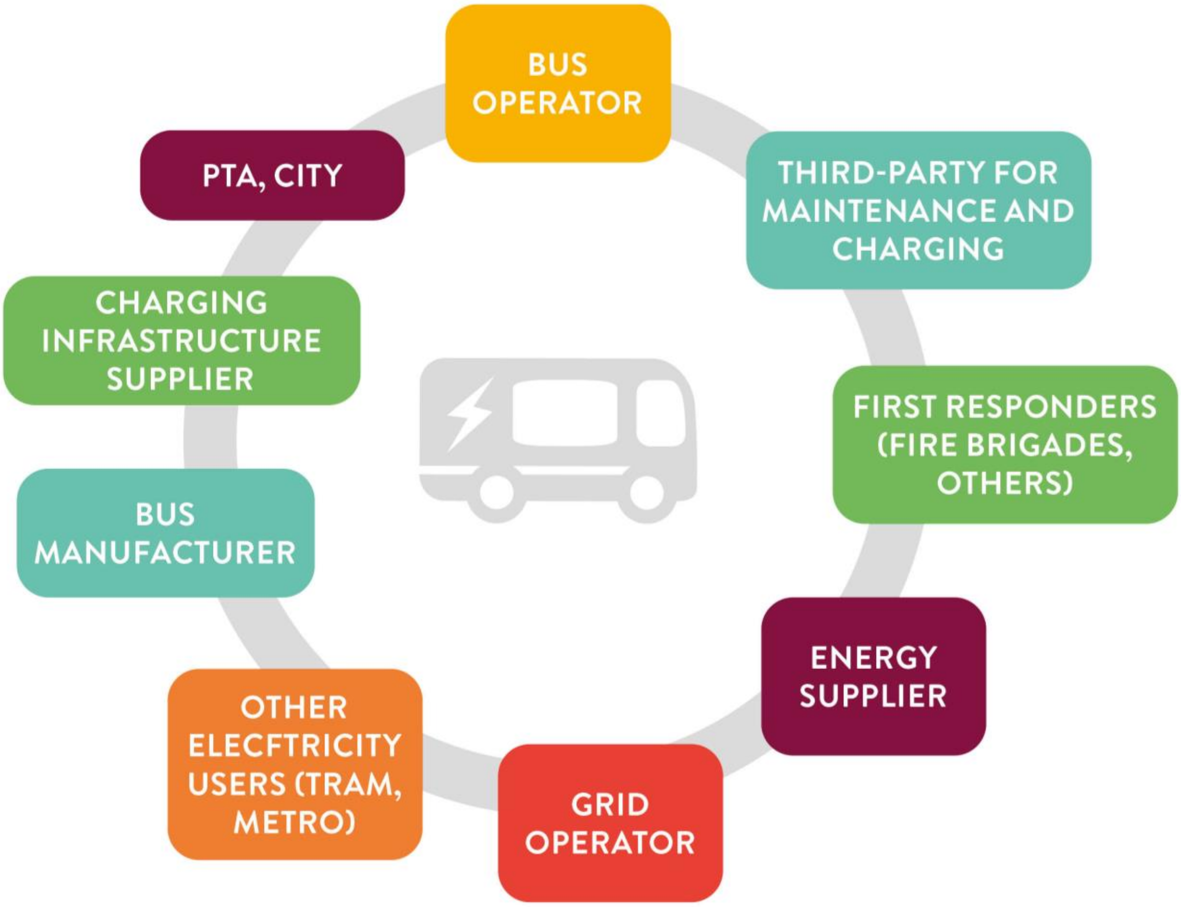
Careful assessment of the complete set of processes and tasks, as well as a deep knowledge of their requirements are essential to ensure the successful planning and deployment of an e-bus depot.

Today, there are several IT depot management solutions available on the market that enable high flexibility and efficiency of bus operations. These solutions are specially interesting when running e-bus fleets, as such tools can help optimise fleet operation and overall depot efficiency, reducing the costs linked to surface needed, power supply or electricity price (smart charging & energy management).

LOCATION AND SIZE

Choosing the right location for a new battery electric bus depot should consider the following criteria:

- Proximity to connection point to the high voltage (HV) grid, considering also future extensions and depot upgrades to ensure future-proof operation, as well as applying regulations and rules of the DSO.
- The cabling costs associated to bring power supply from the right connection point to the final depot location are the most expensive, and thus should be minimized.
- Available surface, enough to accommodate the new infrastructure, i.e. transformers, substations, cabinet, chargers (pantograph-based solutions, plug-based solutions).
- Transformers and substations should be located in a safe area, according to the appliable regulations.
- Question of size: large capacity depots vs medium/small depots. In order to ensure efficient depot management and operation (minimize dead mileage, ensure right ratio of equipment and manpower servicing a bus, as well as the minimum area per bus to perform depot activities), as well as energy supply (based on total capacity to be requested to the energy supplier/DSO) depend on the right sizing for a specific location. It is worth considering if the habilitation of smaller depots, without maintenance facilities, closer to the network would have greater public acceptance.
- Sharing the grid and power infrastructure with other consumers (tram, metro, office facility…) when buses are not charging.
- Accessibility to the depot itself, close to the lines served (network), as well as considerations of potential risks like fire, flooding, etc. Some countries have regulations that do not allow to place bus depot close to residential areas, e.g. Germany.
- A detailed feasibility study and risk assessment of the selected depot is recommended. These are the basis for a collective solution-seeking approach by the stakeholders: bus operator, city administration and transport authority, energy supplier and DSO, etc. Very often, the most challenging issues will be easily addressed by ensuring an early open and frank dialogue among the parties; e.g. overlapping bus network and power supply network maps can help identify connection points at the required voltage and power and in suitable areas.



► *Stakeholders involved in e-bus deployment. Source: UITP*

ENERGY SUPPLY

Power supply is a central element of the planning phase, as it is decisive in terms of a timely execution of the project. Cooperation with the energy supplier and/or DSO is key to ensure that the approval and effective permit for connection to the grid is achieved within the allocated project timeline. As indicated earlier, initial bottlenecks can be successfully addressed by reinforcing cooperation and applying a joint solution-seeking approach.

One aspect worth mentioning is the grid capacity, and how to secure the future energy supply in the case of depot upgrades or new depots. Some years ago, the first bus operators deploying electric depots did not have to face the issue of overloaded grids and limitation of power supply and connection permits. As a leader country in the deployment of battery buses, the Netherlands is already facing the challenges prior to full electrification, and currently, there are energy utilities who have announced that no more connection permits can be issued, as the grid has reached its capacity.[2]

A way to reduce dependency on the grid capacity is to consider the integration of renewable energy power generation onsite, whenever the conditions and the economic feasibility allow it. Photovoltaic installations on depot roofs can be a good backup for peak-time tariff periods, helping reduce the overall energy bill and the carbon footprint of the e-bus fleet.

The main factors to consider when planning the energy demand are daily operational requirements to cover the corresponding duty cycle, the average power demand and the peak power demand.

These are central to dimension the energy needs of the depot (total capacity to be requested) and the charging infrastructure (e.g. size of transformers), as well as for the definition of the charging strategy and the overall feasibility study of the system. For instance, planning for trade-offs between peak and off-peak charging, number of buses vs battery sizing, as well as choice of charging strategy (predominancy of fast charging, or only slow charging), and kWh prices and tariffs. Negotiating grid costs and tariff plans with the energy supplier and DSO is recommended, as these can be highly variable and very unpredictable.

CHARGING INFRASTRUCTURE AND CHARGING STRATEGY

Currently, there are several charging solutions available in the market that can fulfil the needs of bus operators. The most extended solutions in Europe are conductive pantograph-based and plug-based charging.

Although there have been pilots testing inductive charging, results so far are not conclusive enough to be included in this factsheet. Induction charging is less advantageous due to space requirements and important civil works, as well as the lower efficiency of the energy transfer, making this technology less attractive for bus operators.

The charging infrastructure is conceived and installed based on the charging strategy selected by the operator, and considering parameters like energy consumption per bus, available time for charging (e.g. number of hours spent by a given bus at the depot during the night, or number of minutes spent at the terminal stop during operation) number of chargers needed, and location of the chargers. To define the charging strategy and the number of chargers needed per bus, it is recommendable

[2] The Transport Authority of Amsterdam Region, Vervoerregio Amsterdam, is working on a policy framework to define and elaborate contingency plans to secure power supply. Defining priorities of access in the case of energy shortage is one of the questions under discussion.

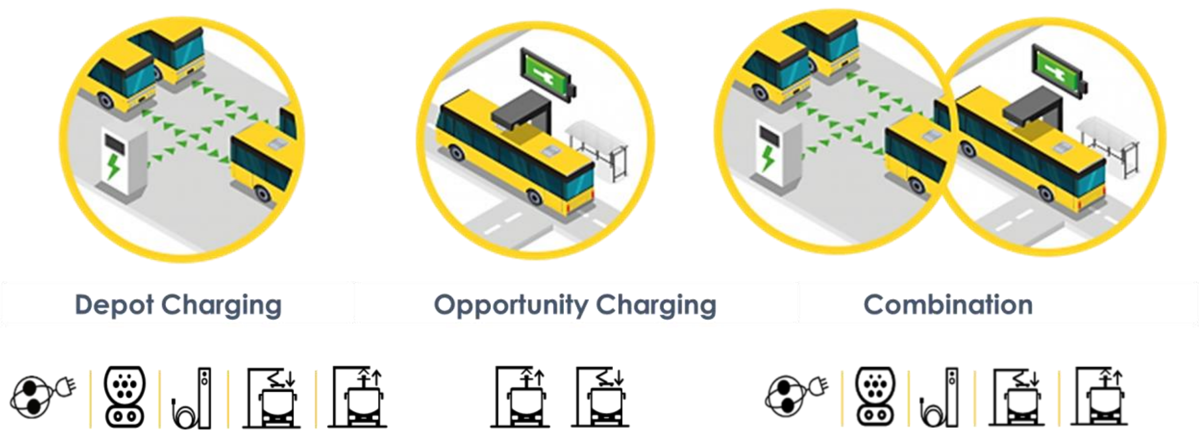
to run iterations with different charging scenarios as well as estimations of one charger by bus vs matrix chargers distribution (availability vs investment).

Other aspects to be considered are:

- Power capacity available by energy supplier on-site
- Availability of external high voltage power supply (redundancy connection point)
- Availability of high voltage power supply system (redundancy)
- Internal high voltage system (redundancy level vs investment)
- Dimension of charger power capacity
- Selection of charging technology and interoperability of charging

Charging strategies are based on the vehicle battery size, the duty cycle and the power supply:

- Depot charging, fast/slow charging, during/off-operation, via either pantograph or plug-based solutions
- Opportunity charging, fast charging, during operation, via pantograph-based solutions, at the depot or in public space, either end of the line or at intermediate stops[3],
- Combination of both, along the line and at the depot, combining fast and slow charging, and including slow overnight charging for battery balancing and pre-conditioning.



► *Charging strategies. Source: Heliox*

[3] The e-BusWay system in Nantes operated by Semitan uses flash-charging in intermediate stops. The buses charge for some seconds while passengers enter in and/or exit the bus.

► *Depot charging with plug solution. Source: RATP Paris*

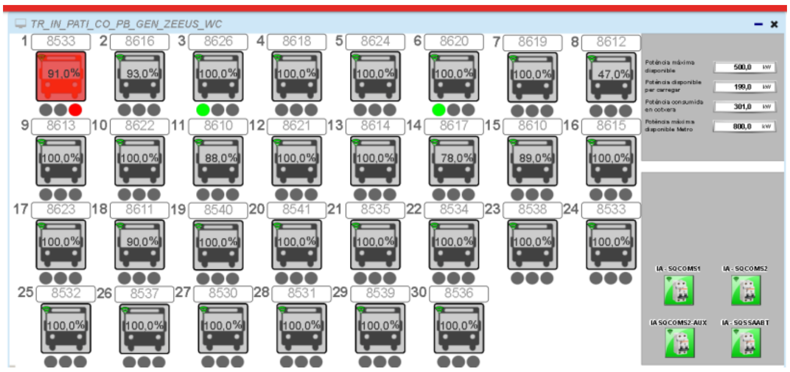
For fleets following mainly opportunity charging, charging during operation requires high power, fast charging to minimize the charging time and ease operations. If the depot is located close to the end/beginning of the line, opportunity charging can take place at the operator's premises. If not, a number of chargers should be installed in public space, along the route, to enable opportunity charging. In this case, planning permit from the local authority is needed to install charging infrastructure on public space (some permissions may also be required for depot based solutions). Additionally, charging during the night is performed to balance the batteries and pre-condition the buses (HVAC requirements and battery pre-warming) before the buses enter into service the next day. Likewise, unplanned charging events should be considered as well in the charging time and windows.

► *Depot charging with pantograph solution (50 kW). Source: TMB Barcelona*

When using pantograph-based solutions, charging takes place automatically by positioning the buses in the corresponding parking slot and giving the command to start the charging event. Generally, this is run by the driver. At the depot, plug-based charging is always available as a backup. In depots with only manual plug-based solutions, charging is performed exclusively by qualified, certified staff, as staff needs to plug and unplug charger and vehicle.

► *Interoperable, high power, opportunity charging (500 kW) at bus stop. Source: TMB Barcelona*

Smart charging or off-peak hours charging should be considered, as could be, on the longer term, use of external batteries (2nd life batteries), increasing storage capacity of energy during valley price hours. This helps reduce pressure on the grid as well as the energy bill.



► *Charging monitoring at depot. Source: TMB Barcelona*

CASE STUDY

Keolis Sweden

Keolis in Sweden has set-up an agreement with the energy provider Vattenfall allowing to manage and adapt electricity delivery to avoid overloading or blackout of the grid. Thanks to additional equipment installed in the depot power delivery cabinet, the energy provider will control energy consumed by Keolis depot. This control will be activated as soon as frequency drop of the grid is detected. The impact for the operator is quite limited with a duration of few minutes but can reduce drastically the risk of local blackout. This win-win solution preserved the full capacity of the grid and provide security for the electricity network manager while the operator is compensated for this flexibility.

CASE STUDY

Waterloo Garage, Go-Ahead

The upfront capital costs for the Waterloo garage conversion to electric amounted to £20,000,000 for 51 buses and the associated infrastructure, including a vehicle servicing regime. The system is powered with overnight charging, as a way to reduce pressure on the grid and benefit from less expensive, off-peak tariff. An island was constructed down the middle of the site with 43 smart charging units. When connected to the bus, the charger calculates how much power is required, based on existing range and the following day’s mileage requirement. This system ensures an even draw across all buses, minimising the likelihood of batteries being over-used. In case of need, the Waterloo garage has some strategically located fast charging units fitted that deliver a 100% SoC in half the time of the standard units (four hours, rather than eight).

► *Plug-based charging at Waterloo Garage. Source: Go-Ahead London*

DESIGN AND LAYOUT

When it comes to the depot design and layout, the use of pantograph-based technology can save space as well as infrastructure and manpower costs[4], as the infrastructure can be installed at height (no chargers and cables per parking slot), and the charging takes place automatically by commanding the vehicle and the charger to start the event (no dedicated staff needed). Also, there is no risk of equipment damage or to staff safety, as there are no cables laying around (damage by driving over, or safety of non-specialised staff).

► *Pantograph-based charging on racks a) openair-rack infrastructure at Harlem depot (Transdev NL); b) indoor-rack on ceiling, at Eindhoven depot (Hermes/Transdev). Source: A. Abdulah, UITP*

[4] Though initially less expensive, plug-based infrastructure is more susceptible to damage and wear, and it can be assumed that cables and chargers will need to be replaced several times over the lifetime of the vehicle (typically 15 years).

This said, there is an inspiring example of plug-based charging infrastructure also at height, with a dedicated first and/or second floor for the chargers, as in Santiago de Chile, at the depot 'El Conquistador" with 200 battery buses (350 in total, diesel EURO VI) operated by STP.

►*Charging infrastructure El Conquistador depot in Santiago de Chile. Source: Red Metropolitana de Movilidad and Revista "En Concreto".*

Additional considerations around depot layout for plug-based charging infrastructure depots to reduce the operational issues or the risk, health and safety concerns are:

- Revised parking bays to maximise the use of any existing surface for buses and infrastructure, ensuring that the charging processes can be made safely and efficiently.
- Revision of traffic flow direction, so that the charging sequence accommodates the bus service needs as in the daily vehicle block plan. This means that run-in and run-out procedures should be reviewed and adapted if necessary.
- Creation of central islands and walkways to locate chargers within reach of the parked buses, and allow safe handling by the staff, also in busy operational environment.
- Fix, clear parking layout with clearly marked bays, ensuring drivers know exactly where and how to park the vehicles, i.e. within reach of allocated chargers, to facilitate the charging. Consider safe parking area for vehicles in quarantine due to battery issues, isolated from the rest of the areal, or in case of tight spaces, the installation of firewalls or other features between groupings of buses.
- Increasing space between parked buses to allow staff safe and comfortable handling for charging.

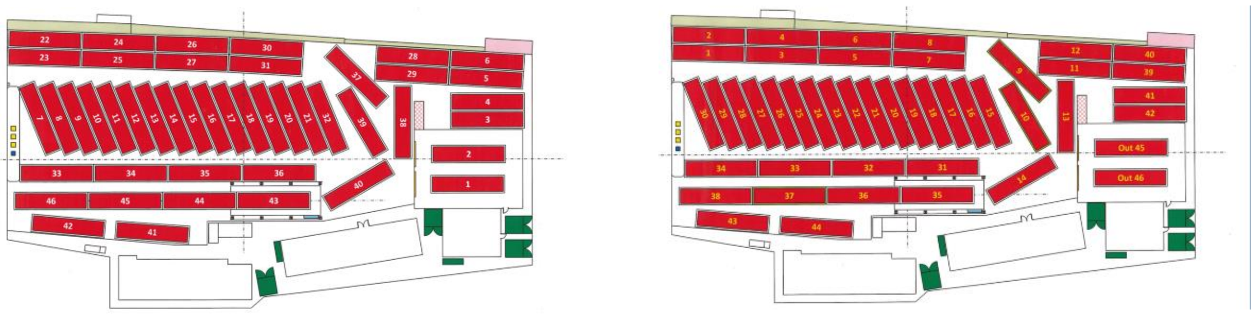
Wheel stops or bumpers to prevent impacts on chargers and cabinets while parking or manoeuvring the bus. Manlifts or other equipment might be required to service the vehicles. Consider to place them in a good location for maintenance activities (proper height, away from other equipment, access, etc),addressing properly safety considerations, for instance, how high is equipment off the ground? Can it be worked on safely? Is the cord a tripping hazard? Is the equipment protected against outside elements (cold, heat, rain, snow, sun, dust, etc.)?Space saving solutions can be applied to both existing and new depots:

- Containerized solutions, placing the equipment in a container that can be moved if necessary.
- Overhead solutions with ceiling racks with pantograph technology; or plug charging reel.
- Dual charging sockets by specifying the requirement for DC CCS2 plug-in charging sockets on both sides of the bus design from the OEM can lead to a much more flexible parking layout and the ability to share charging points between multiple parked buses. This can lead to a reduction in infrastructure points/costs and space needed.
- Angled charging sockets (for plug-based solutions): based on the adaptation of the plug-in angle of the charger to a 45-degree angle with respect to the bus, which can reduce the space between parked buses, by bending and orienting the plug and the socket.

RUN-IN AND RUN-OUT PROCESSES

Operational vehicle blocks, run out times and run in times may need to be adjusted to incorporate longer charging window overnight or several top up charges during the day, also considering the potential need of unforeseen charging events.

Driver first use walkaround checks will need to be modified and adapted to suit the new vehicle technology - inspection areas/points will be different to that of a diesel vehicle.



►*Run-in and run-out schedule at Waterloo Garage, London. Source: Go-Ahead*

DESIGNING OPERATIONS

Adapting operations to the new technology requires making the most of its capabilities. Some considerations below:

- Adapt operational vehicle blocks and charging regimes to the available operational range capability due to battery capacity and weight constraints; consider that battery capacity degrades in time, reducing operational range capability. Considerations to high/low ambient temperatures and other on the environmental factors that impact bus dispatching should be made.

- If possible, vehicle battery capacity should be specified to 120% of the required capacity needed to perform the daily mileage (to account for future battery capacity degradation)
- Energy consumption should be a focus criteria when selecting a vehicle/supplier, vehicle weight, driveline efficiency and regenerative braking capability should be assessed fully
- Designing IT capabilities to match the information needs of staff for running an operation.
- "2nd generation" electric vehicle designs will provide the industry with a critical pivot point - lighter weight, lower energy consumption, smaller capacity battery required
- Special attention has to be given to vehicle height changes - batteries or pantograph on the roof could change the overall height of a single/double deck vehicle (low bridges, maintenance halls, tree branches…)

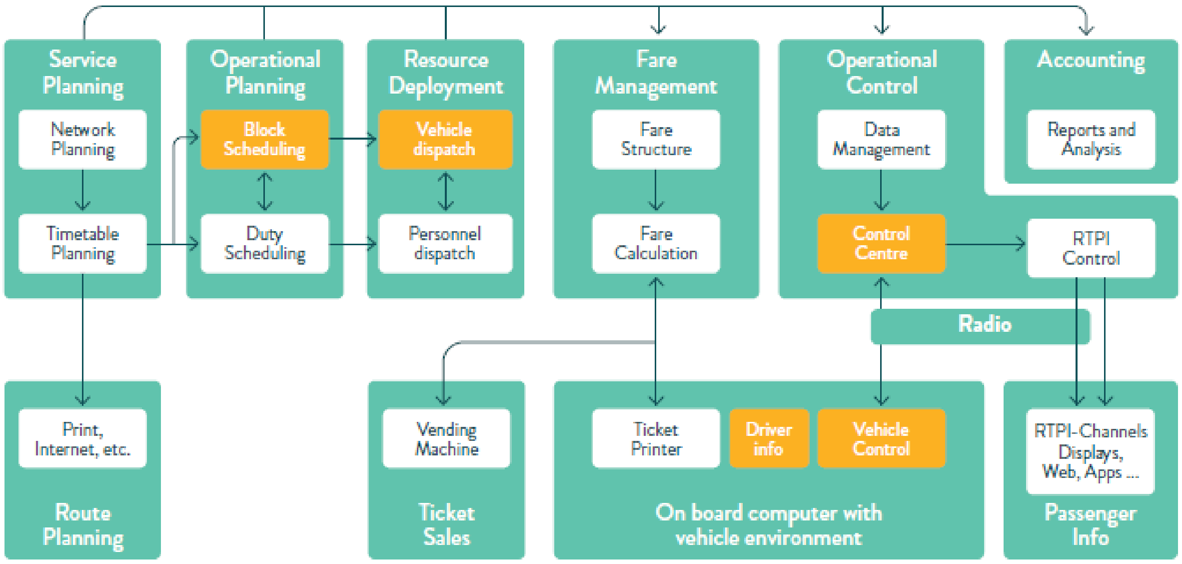
IT TOOLS FOR FLEET OPERATION AND MONITORING

Most steps of e-bus planning and operation are usually managed by IT systems, which need to be adapted to the changing requirements for fleet operation, including bus depots.

From the operation and the integration of sub-systems (scheduling, dispatching, smart charging, energy storage, charging system, high voltage system, CCTV, etc.) to fleet monitoring (mileage, energy consumption, state of charge (SoC), state of health (SoH), etc.), implementing proper background systems is key for a successful fleet conversion.

Thus, investment is likely required to implement hardware/software that will allow real-time monitoring of key assets: infrastructure (during charging), and vehicle (during operation). The latter is especially important to make sure operation remains within the battery warranty conditions and terms of usage.

The typical elements of the IT system environment for bus operation are depicted in the figure below. The graph shows the system support for all main business processes that are directly linked to delivering transport services.



►*Overview IT system for bus operator. Source: Report "Large scale bus electrification: new challenges for IT systems", July 2022, UITP*

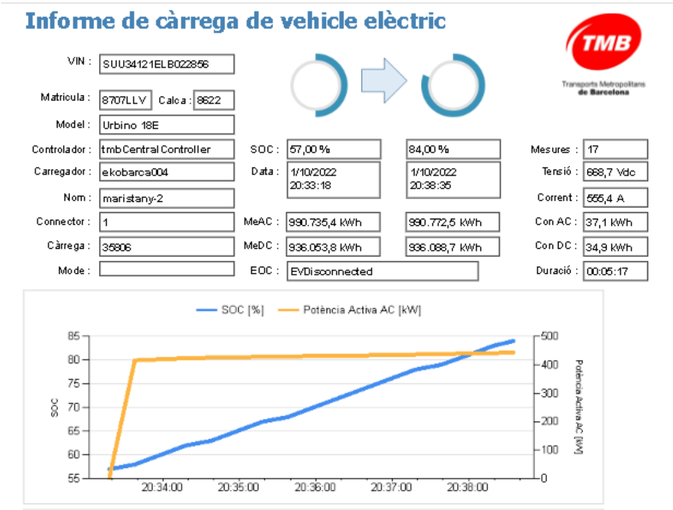
Each white rectangle represents a major functional module, often equivalent to a hardware and/or software system; the green frames group these modules at a higher level. Arrows show the data flows between the modules; arrowheads depict the main data flow direction.

The modules highlighted in orange are those most affected by the introduction of e-buses, of which the Resource Deployment including Vehicle Dispatch and Personnel Dispatch are closely tied to depot management, as well as charge management and operations control, particularly for overnight charging.

Resource Management process is usually divided into two steps, that is also often reflected in the structure of the IT systems: Resource Planning and Dispatching. For vehicles, the dispatching process is closely linked to depot management process, as the availability of vehicles depends heavily on depot activities such as maintenance, washing, fuelling/charging and parking position as discussed in various parts of this report.

The introduction of e-buses constitutes a series of additional requirements for the Resource Management process and thus for the related software systems. This mainly affects the vehicle planning/dispatching and depot management processes, but also has some impact on personnel planning/dispatching. Some IT implications in depot management also include, but are not limited to:

- For pre-conditioning while the vehicle is still connected to the external power supply in the depot, based on the vehicle dispatch, the depot management system has to plan, start on time and control the preconditioning process.
- Between operations, vehicles can be charged at the depot to reach at least minimum SoC needed to cover the next operational need. The assignment of vehicles to charge points in the depot has to be planned and controlled by the depot management system accordingly.
- Information on the actual charge execution and resulting SoC has to be retrieved from the charging infrastructure to update/recalculate range and vehicle assignments accordingly. Hence, the electric depot management and charge management system needs new interfaces to the charging infrastructure
- In duty planning and personnel dispatch, specific skills and qualifications for the handling of electric vehicles and charging infrastructure have to be considered for both drivers and maintenance personnel.



►*Monitoring e-bus charging. Source: TMB*

For a more extensive overview of IT systems, what they entail for bus operation and the future outlook in this domain, please see the recent report issued by UITP IT Committee, LARGE SCALE BUS ELECTRIFICATION: NEW CHALLENGES FOR IT SYSTEMS here.

WASHING AND CLEANING

The vehicle washing and cleaning regime has to be adapted so processes involving volumes of water are not performed whilst the vehicle is connected to the charging infrastructure.

MAINTENANCE

To perform the maintenance tasks, workshops at the depot need to be designed to comply with all necessary requirements in terms of facilities and equipment to operate a certain technology, as well as to ensure safe working conditions for staff. For instance, the engineering workshop may need to be adapted in a way that specialist repair and maintenance activities (high voltage, working at height) are carried out in dedicated area.

Some elements to be considered for the operation and maintenance of battery electric buses are:

- Working at height, to access HVAC system, batteries, etc.
- Electrical equipment tools
- Safety procedures
- Grounding devices, specific tools
- Personal Protection Equipment (PPE)
- Hot work operations like welding, etc.
- Automatic detection and extinction system: smoke detectors and sprinklers, fire alarm
- Quarantine area for vehicles with battery issues / breakdown

Access equipment (facility to access the top of the vehicles, safety harness) and working at height training may be required in scenarios where repair and maintenance on a vehicle roof needs to take place (batteries, pantograph).

Any task related to the electrical maintenance and battery related must be performed by specialized, trained, certified staff. Likewise, workshops and specially the control areas must be duly defined, and identified to perform the corresponding function. This might be not necessary in the case of depots operating only one technology, but certainly in the case of multi-techs depot, the different workshop areas should be well designated and recognizable.

Engineering bays may need to be fitted with additional smaller/lower power charging points to keep the vehicle battery charged during repair and maintenance activities.

Finally, charging infrastructure requires repairing and maintaining by a competent and trained electrician certified in dealing with high voltage - an overhead solution will need access to the ceiling racks.

STAFF TRAININGS

Mechanics and engineering staff

Vehicle maintenance is greatly reduced since battery buses have fewer moving parts, with lowered reliance on lubricants and filters, and although the hub motors require coolant and the air compressor oil, the all-important drivetrain is much less maintenance dependent.

Operational/scheduling personnel need to understand the vehicle range constraint and to monitor battery state of charge and state of health to minimise breakdowns and other inconveniences from depleted batteries. For instance, dispatchers, floor managers, and managers need to understand state of charge for buses on the road or being selected for a pull-out or moved for a pull-in.

Engineering workforce need to be trained from dealing with the traditional internal combustion engine driveline to a high voltage driveline, for instance on safe handling and isolation of high voltage systems before commencing R&M activities and the use of correct/special PPE. High voltage certification is required. Mechanics and engineers need to learn safety procedures as they will likely be the leaders in case of an incident, so they need to be trained for emergency response/procedures for quarantining buses and helping first responders access the site.

Drivers

Battery buses drive, sound and perform differently to diesel buses. Drivers will need to be trained and re-educated for the new tasks and the handling of the vehicle type, for instance, on safety aspects as well as energy efficiency driving training will be required, especially when it comes to acceleration and braking. One of the many benefits of battery buses is that they present very limited brake pad wear as a result of regenerative braking.

Finally, when operating buses with pantograph-based solutions, charging is part of the driver's schedule. The bus driver is charging on the route at the bus stop where he/she has also the break for coffee or lunch.

CASE STUDY

EMT Madrid - Electric Vehicle Training

Level – "Hybrid and Electric Vehicle", 21 h

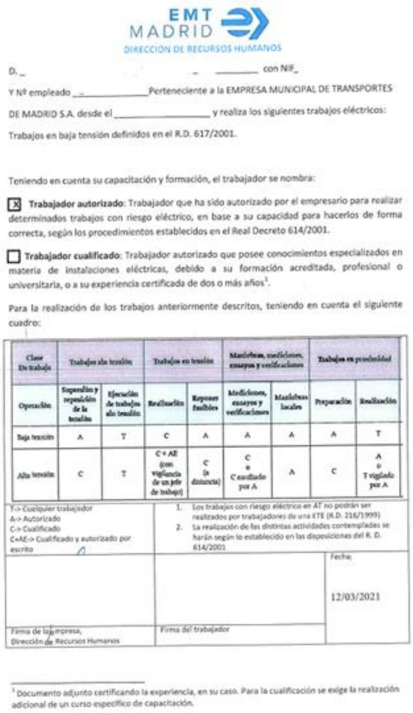
It includes a theoretical section on the traction system and on-board energy, followed up by the praxis session on the vehicle.

Level 2 Authorisation for electric engineering staff, 21 h

Staff with a demonstrable previous training, by work position and experience in the electricity section or by studies completed on a personal basis as a degree in Modules, Vocational Training or other curricular training, which in turn validate the staff's training in this subject. The training is required to work on vehicles and make the security setting; it includes the necessities and requirements depending on the vehicle brand, and it is often conducted by the bus OEMs. The training details and showcases the procedures for all vehicle brands and types in the fleet. Upon successful completion of the training, the staff obtains a certificate that allows to work on vehicles without voltage, i.e. after having set up the vehicle in safe mode and having verified the absence of voltage (with exception of the batteries).

Level 3 – Qualification, 14 hours

To perform work in the batteries or any component with voltage, it is necessary to have the certification as qualified personnel. The training is provided by an authorized organization external to the company. It includes the necessary knowledge to work with voltage in the vehicle and in those components that have not been discharged of voltage, either by failure or because it is not possible to disconnect the voltage with a safety in the vehicle will be given. To obtain the qualification, the staff will successfully run the three levels of training described. The staff who obtains the qualified personnel certification is allowed to perform high voltage work on any vehicle component, as well as cell replacement in the batteries themselves.



EMT MADRID
DIRECCIÓN DE RECURSOS HUMANOS

D. _ _ ________ con NIF_

Y Nº empleado _ ______________ Perteneciente a la EMPRESA MUNICIPAL DE TRANSPORTES DE MADRID S.A. desde el ____________________ y realiza los siguientes trabajos eléctricos:

Trabajos en baja tensión definidos en el R.D. 617/2001.

Teniendo en cuenta su capacitación y formación, el trabajador se nombra:

☒ **Trabajador autorizado**: Trabajador que ha sido autorizado por el empresario para realizar determinados trabajos con riesgo eléctrico, en base a su capacidad para hacerlos de forma correcta, según los procedimientos establecidos en el Real Decreto 614/2001.

☐ **Trabajador cualificado**: Trabajador autorizado que posee conocimientos especializados en materia de instalaciones eléctricas, debido a su formación acreditada, profesional o universitaria, o a su experiencia certificada de dos o más años[1].

Para la realización de los trabajos anteriormente descritos, teniendo en cuenta el siguiente cuadro:

Clase De trabajo	Trabajos sin tensión		Trabajos en tensión		Maniobras, mediciones, ensayos y verificaciones		Trabajos en proximidad	
Operación	Supresión y reposición de la tensión	Ejecución de trabajos sin tensión	Realización	Reponer fusibles	Mediciones, ensayos y verificaciones	Maniobras locales	Preparación	Realización
Baja tensión	A	T	C	A	A	A	A	T
Alta tensión	C	T	C + AE (con vigilancia de un jefe de trabajo)	C (a distancia)	C o C auxiliado por A	A	C	A o T vigilado por A

T-> Cualquier trabajador
A-> Autorizado
C-> Cualificado
C+AE-> Cualificado y autorizado por escrito

1. Los trabajos con riesgo eléctrico en AT no podrán ser realizados por trabajadores de una ETE (R.D. 216/1999)
2. La realización de las distintas actividades contempladas se harán según lo establecido en las disposiciones del R. D. 614/2001

Fecha: 12/03/2021

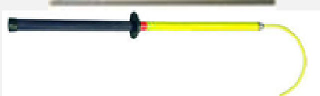
Firma de la empresa, Dirección de Recursos Humanos

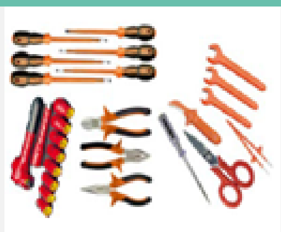
Firma del trabajador

[1] Documento adjunto certificando la experiencia, en su caso. Para la cualificación se exige la realización adicional de un curso específico de capacitación.

►*Training certification. Source: EMT Madrid*

Table 1. Required individual and collective equipment

INDIVIDUAL PROTECTION EQUIPMENT	
Insulating gloves	
Protective screen	
COLLECTIVE SAFETY ELEMENTS	
Protective beacons	
Release poles	

Insulating safety mat	
Steering wheel cover (safety lock)	
Connector locking padlock	
TOOLS FOR CARRYING OUT THE WORKS	
Insulated tool	
Voltage tester	
Insulation tester	

MANUALS AND GUIDES

Identifying and minimising risk potential is one of the main processes to carry out when deploying battery electric fleets.

Operating and handling battery buses requires the introduction of a completely new process to protect staff, passengers or contractors. This will imply the development of a comprehensive safety plan, before, during and after infrastructure works, including an ongoing method of charging and maintaining the buses that is only undertaken by certified personnel (and not drivers).

Operational safety procedures need to be implemented that help staff deal with issues that could be encountered - for instance what to do/who to contact in a vehicle Road and Transport Authority. For instance, in the case of road calls and/or breakdowns, develop proper response and towing.

Fire suppression system will need to be a different specification to the one fitted to a typical diesel vehicle - fire is a hazard due to electrical faults/battery thermal runaway.

Risk assessment should also consider arc flash, fall from height (workers on the platform), and battery end of life and proper disposal. Based on it, update of plans in case of fire, spills, hazardous materials, emergency response and any other facility plan need to be considered.

For staff (inside /outside depot)

Use a lock to shut down the current of the bus while workers are in intervention. It is generally good practices to have "Lock Out Tag Out" ("LoTo") process for safe intervention of workers.

Emergency Responders Guide (inside/outside depot)

Emergency procedures for coordination with external emergency services.

SAFETY REGULATIONS AND STANDARDS

Operating battery electric buses implies compliance with regulations and standards in order to first obtain the necessary permits and approvals to run operations, and second, to do so in a safely and healthy manner that protect staff and the general public from potential risks.

Common risks associated to bus operation are risk of accident, explosion, fire, electric shock/electrocution (staff) and must be minimised and duly mitigated. Risk contingency plans are mostly developed under the company strategy.

ACKNOWLEDGEMENTS

This Factsheets Series is a collective effort by UITP Bus Committee and the members part of the CVT T1 Bus Depot Adaptations Working Group. Thanks to EMT Madrid and TEC Wallonia for their leadership in the elaboration of this work, and all members who provided input.

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ANNEX FOR BEB AND FCHB TECHNOLOGIES

This is available in the Excel document on MyLibrary

ADVANCING PUBLIC TRANSPORT

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