PSIebus.
Depot and Charging Management for Electric Buses.

PSI

Our Vision: Zero Emission

## Integrated depot and charging management system for e-bus fleets

Emission-free local and long-distance transport is now the expressed goal of many municipalities and cities. Besides trams, electric buses are also gaining importance. The ever-increasing number of new vehicles is affecting more than how cities look. Converting to electromobility is also having a dramatic impact on operational processes and requires new systems at depots.

In addition to changes to the demands on employee qualification and service and maintenance technology, dispatching systems also need to be adapted. In the future, new factors like limited battery range, charging infrastructure along routes or at the depot, passenger numbers, the outside temperature, and the connection power capacity will be key to reliable public transport operations.

PSIebus provides transport companies with an integrated software solution that leverages expertise in both public transport processes and energy supplies. The system combines the depot management module PSIeDMS with the charging management system PSIsmartcharging. It takes into account important influences and dependencies relevant for efficiently controlling, charging and dispatching vehicles – both at the depot and along the route. Its modular system architecture and open interfaces make it scalable and future-proof. The system also uses standardized interfaces for data exchange, making it manufacturer independent.

The overall solution PSIebus makes moving to new drive technologies fast, reliable and safe.

PSIebus integrates all tasks associated with electromobility in *one* system.
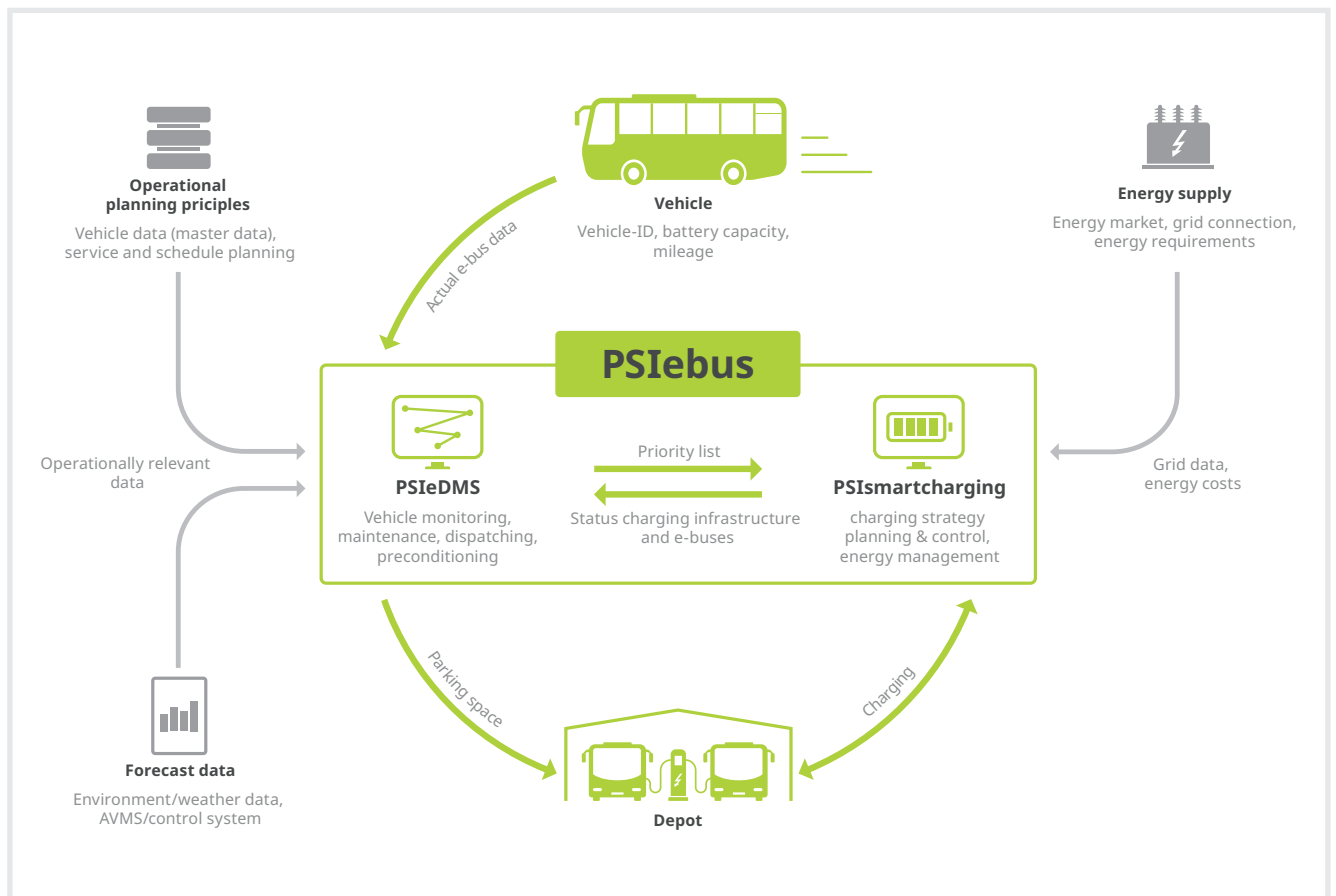
PSIeDMS.
Vehicle monitoring and control 24/7.

Energy consumption during operation varies due to a multitude of factors, such as the number of passengers, the outside temperature, the route profile, and driving behaviour. Additional factors include unique characteristics of vehicles, the manufacturer, and the process of battery ageing.
As a result, the level of charge and the remaining vehicle range change virtually minute-by-minute. Live monitoring is therefore indispensable for reliable operation. Vehicle master data and all variable vehicle and environmental data from daily operation are collected in PSIeDMS, forming the basis for forecast calculations and charge planning. Preconditioning the e-buses is started just-in-time, so that all vehicles are sufficiently charged and at operating temperature when the journey begins.

Functional overview

Vehicle monitoring during operation
PSIeDMS is continuously updated with vehicle data, both on the route and at the depot. It receives this data from the AVMS, CAD, AVL system or via data loggers directly from the e-bus. In this way, battery capacity, mileage and energy consumption are monitored online.

Charging process control and automatic vehicle dispatching
When charging begins, each charging process is assigned a priority that depends on the planned vehicle use. Based on this priority, charging processes throughout the entire depot are balanced without overloading the transformers or the grid connection. While charging, the charge levels are continuously recorded in PSIeDMS and compared with the energy requirements of the planned tour. After the vehicles are sufficiently charged, trickle charging is activated. If for any reason the energy demand cannot be met, a new priority is assigned, or other vehicles are used – automatically. Preconditioning starts just-in-time based on the starting time of the tour. All depot processes, such as maintenance, cleaning and repair, are taken into account when charging.

AI-based forecasting of ranges, energy consumption and demand
PSIeDMS uses the Deep Qualicision optimization algorithm based on Artificial Intelligence (AI) to forecast ranges and energy consumption and demand.

Parking space and charging station allocation
When a bus enters the depot, PSIeDMS identifies the parking space with the correct charging station in seconds – based on the battery's charge level and the vehicle's next tour. If no charging is required, the vehicle can also be assigned to a parking space without charging equipment, meaning that not all parking spaces must be equipped for charging.

Preconditioning
Preconditioning vehicles for the next tour is performed automatically and in a timely manner before the start of the tour. This ensures that trips start on time and that batteries are not subjected to unnecessary stress.

PSIsmartcharging.
Dynamic load and charging management.

PSIsmartcharging communicates directly with PSIeDMS to ensure that electric buses are charged to the optimal level and on time for their intended routes, while also considering safety aspects. All electrical systems in the depot (feed points, transformers, lines, charging stations) are continuously monitored. In the event of imminent overload or limits to the energy supply, the power is redistributed to restabilize the grid. It is possible to integrate additional battery storage or photovoltaic systems at the depot to increase flexibility.
Electricity price fluctuations can be flexibly taken into account in the charge planning. In the future, it will also be possible to generate additional income – where the corresponding technology is available – by offering an operating reserve.

Functional overview

Planning the charging process
PSIsmartcharging creates a charging plan that takes into account the prioritization of the charging processes in PSIeDMS and the limitations of the grid connection capacity and the electrical system at the depot.

Charging control and trickle charging
The system controls charging processes based on the prioritisation of the e-bus and the currently available grid connection capacity. The limits of the electrical system in the depot are also considered. To compensate for self-discharge, charging processes are cyclically monitored and controlled automatically.

Monitoring the electrical system in the depot
The current status of the electrical system at the depot is graphically displayed in real-time. In this way, faults can be detected, analyzed and immediately fixed.

Optimizing the energy supply
The local power grid and the equipment connected to the grid are cyclically monitored automatically by the system and displayed in network diagrams. In case of malfunctions, limit violations or alarms, the electrical control system is notified.

Support of grid-assistive operation
Grid operators may, in special cases or based on grid connection usage contracts, reduce the available grid connection capacity in order to compensate for an imbalance in electricity generation and consumption in the distribution grid. The system receives the grid operator's service specification, calculates the available charging capacity, and takes this into account when creating new charging plans.

# Rethinking mobility. With PSIebus.

PSIeDMS

Vehicle monitoring and route allocation

+ AI-based range forecast
+ 100% availability of the vehicle in daily operation
+ Automatic parking space disposition and dispatching
+ Administration and control of different bus manufacturers in one system
+ VDV 461: Interface to fleet management system (AVMS, CAD-AVL, YMS)
+ VDV 463: Interface and charging management
+ Interface to weather data
+ Consideration of all depot processes (cleaning, workshop, …) during charging
+ All functions also available for diesel, gas or hydrogen buses as well

PSIsmartcharging
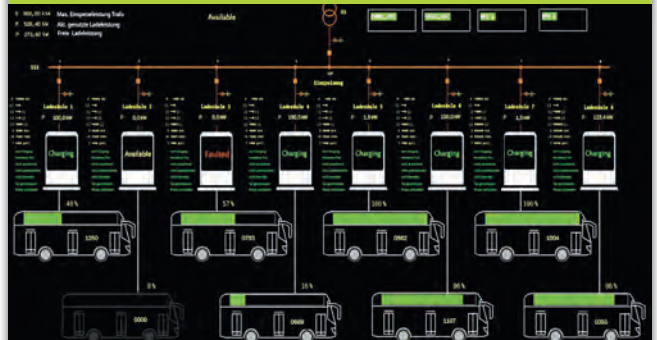
Grid monitoring, control, charging planning

+ Monitoring of all voltage levels
+ Minimization of bottlenecks
+ Automated switchover in case of error
+ KRITIS-certified power supply components
+ Control of different manufacturers' charging stations in one system
+ Fast reaction time in case of faults and failures
+ Support for emergency operation
+ Performance monitoring
+ Charging on demand and grid-assistive charging
+ Connection to existing grid control rooms possible

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Your benefits with PSIebus

+ A modular, combined solution for vehicle disposition and charging management from a single source
+ 100% availability of the vehicle in daily operation
+ Grid fee savings through smart grid operation and grid-assistive charging
+ Reduction and optimized utilization of charging infrastructure
+ Manufacturer independence through support for various charging stations and buses
+ Optimization through many degrees of freedom
+ System operation in the cloud
+ Support for vehicle-to-grid in the future

Project success: Hamburger Hochbahn AG

As part of its introduction of emission-free buses, in April 2019, HOCHBAHN opened the first bus depot in Germany completely designed to support e-mobility. It is planned that it will provide the charging technology and energy supply for 240 buses.

The depot management system PSItraffic/DMS was expanded for this purpose, adding a module for charging and load management of the buses, as well as functions important for vehicle management.

In the future, it will control the processes in the e-bus depots throughout the city. Until the complete switch to e-bus operations, it will ensure that the required number of diesel and electric buses in parallel operation are available for refuelling or charging, also considering drivers including their duty rosters.

The dispatching core used for this is based on PSI's own optimization software Deep Qualicision, which finds solutions in seconds based on operational conditions. The PSIeDMS automatically checks which vehicles at the depot will best match which open routes after how many minutes of charging. This means that not all electric vehicles must be charged simultaneously, constantly or completely.

The PSIsmartcharging management system controls the entire energy requirement and monitors and controls charging performance of individual chargers.

This reduces costs when expanding the power grid and guarantees stable e-bus operation. The system is also designed to permit the mixed operation of electric and hydrogen-powered vehicles.

HOCHBAHN

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