

Smart charging of electric buses

Why smart charging and energy management is vital
for the successful electrification of your bus fleet.





Introduction

On the way to 100% electric public transport

Subway trains and trams have always been electrically powered – and now it's time for bus fleets to be electrified. This is also a major opportunity for your transportation company to operate in a more environmentally friendly way in the future. Electric drive is also clearly superior to the combustion engine when it comes to driving characteristics and ease of maintenance.

However, transitioning to electric buses does pose new challenges for your infrastructure and business processes. With this white paper, our aim is to support you in setting up a future-proof charging infrastructure and making your bus operations ready for the electrical age. In particular, we provide answers to the following questions:

- What specific challenges are there in operating an electric bus fleet?
- How can you ensure that your vehicles are ready for use at all times?
- Why is smart charging and energy management essential for efficient and cost-optimized operations?

The electric bus is the future – wherever you are! We will support you on your route towards 100% electric public transport.

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01 Electric buses – from niche to mainstream

The transition of bus fleets from combustion engine to electric drive is in full swing – in Germany, in Europe, all over the world. Over half a million electric buses are now in use worldwide, 95% of them in China. The metropolitan area of Shenzhen, home to 13 million people, already operates 16,000 electric buses and has correspondingly enormous bus depots, making it the world's largest electric bus operation.

Electrification is also making great strides in Europe: in the last two years, roughly 5,500 electric buses were registered.¹ In 2030 over 60,000 electric buses – one third of the current public transport inventory – could be on the roads providing regular transport in European cities.² The European pioneers of electric buses are currently the Netherlands – in 2025 it will no longer be legal to sell diesel buses and in 2030 it will become illegal to operate them.

Germany's five largest cities, Berlin, Hamburg, Munich, Cologne, and Frankfurt am Main, are also planning to fully electrify their bus fleets by the beginning of the coming decade and are set to purchase several thousand electric buses.

'The trend is clear: Europe is preparing to transition to low-emission bus fleets. The diesel bus is becoming obsolete.'³

Quelle:

¹ Chatrou CME Solutions, electrive.net, February 2022

² All aboard Europe's electric bus revolution, Studie der ING Bank N.V., Sept. 2021

³ Agora Verkehrswende, July 2021

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Many cities worldwide have set themselves ambitious goals for electrifying their bus fleets.



City
Target year for 100% e-buses
Target number e-busses

Driving forces and trends



An increasing range of models to choose from

Both 12-meter standard buses and 18-meter articulated buses are now available in series production from leading European bus manufacturers.



Increasing reach

While the typical reach of the first generation of electric buses was 150 kilometers, the latest models can achieve 300 to 500 kilometers. The possibility of rapid charging also reduces charging times.



Established charging standards

The pilot phase is well and truly over – there is now a broad range of reliable and customizable charging solutions. Standardized socket types and interfaces make solutions from different manufacturers interoperable.



High overall profitability

The total cost of ownership (TCO) of electric buses has further improved in recent years. Positive factors include in particular the longer service life than diesel buses and the lower maintenance costs. In the long term, lower procurement costs can also be expected.



Decision in favor of batteries

While there was originally some uncertainty which technology path would be best for electric mobility, it has since become clear: the electric bus is becoming the standard, with the hydrogen bus remaining a niche.



High funding

The German Federal Government is making a total of 1.25 billion euros available until 2024 for the procurement of vehicles and infrastructure. 100% funding is available for the additional costs for vehicles, along with 50% funding for the additional costs of charging and maintenance infrastructure. Comparable funding programs can be found in other key markets such as Belgium or the UK.



Political requirements

The EU's Clean Vehicles Directive sets binding procurement targets for all member states. In Germany, at least 45% of publicly tendered buses must be procured with low-emission drives from August 2021 onward, and at least 65% from January 2026.

For hydrogen drive with fuel cell, there is some doubt with regard to its profitability, not only because of the complex infrastructure. The city of Montpellier in the south of France recently converted a major order of 51 hydrogen buses to an order for electric buses, as a calculation of total cost of ownership showed them to be several times cheaper.



In conclusion

A political decision has been made to transition from the combustion engine to electric drive, and correspondingly high funding is being provided. Mature technology is available. Take advantage of this favorable time and get started with the electrification of your bus operations!

02 Charging as a success factor

The challenge: charging instead of refueling

In the interest of efficient and cost-effective operation, your future electric bus fleet must be able to meet the same requirements as your existing diesel fleet. As charging is a more complex procedure than refueling, and takes up more time, your operational planning faces new challenges:

Ensuring operational readiness

As a bus operator, you need to run dynamic deployment schedules. Even though charging times last several hours, it is vital for all vehicles to be available at the correct departure time with sufficient charge.

Setting up charging infrastructure

The charging infrastructure must be coordinated to suit the individual profile of your bus operations (route lengths, operating times, location of depots, etc.) and the power supply capacities available on site.

Adjusting timetable and vehicle scheduling

Buses cannot run out of energy during their route. Route lengths and circuits must therefore be analyzed and adjusted in accordance with the available vehicle ranges.

Optimizing investment and operating costs

Electric buses have high energy consumption. For cost-effective electric bus oper-

ations, it is therefore vital to restrict grid extensions while avoiding expensive peak loads when charging.

As a general rule, to charge successfully you always need to consider the individual profile of your bus operations.

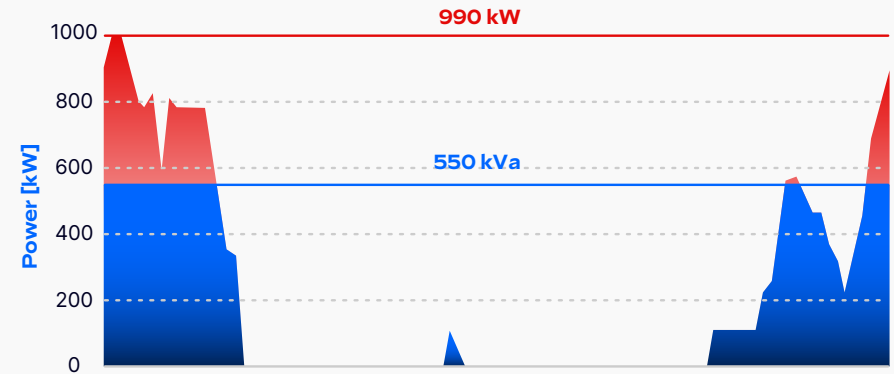
The solution: smart charging

Charging processes should be controlled in terms of the charging time and charging power, rather than being started ad hoc. This is the only way to manage your operational tasks without impacting your fleet's operational readiness or having energy costs spiral out of control. For efficient and cost-optimized operations, smart charging and energy management is therefore essential.

By intelligently controlling the grid loads, charging and energy management can prevent costly peak loads. For optimal balancing of grid load and the fleet's energy requirements, operational parameters can also be taken into account (fleet-based load management).

The following practical example shows how you can use load management in different stages to avoid load peaks and intelligently charge your fleet.

A bus company is planning to electrify its fleet of 30 electric buses. To fulfill the routes, the vehicles are partially charged during the day and fully charged at night. 30 charging stations are installed, each with 150 kW charging power. The grid connection is 550 kVa. This results in three potential scenarios: uncontrolled charging, controlled charging, and (time-table-based) controlled charging:

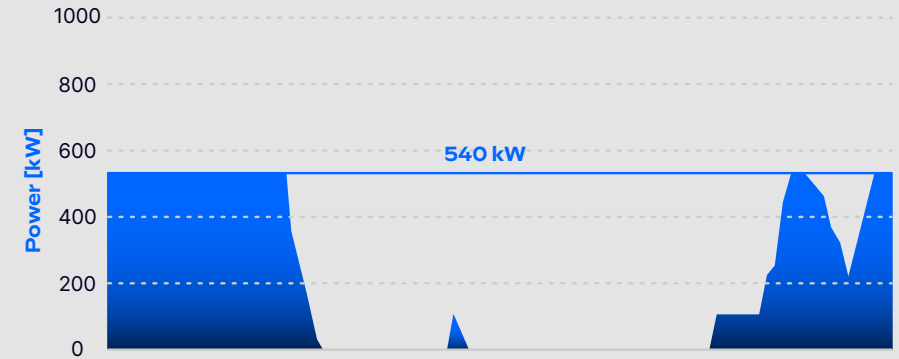
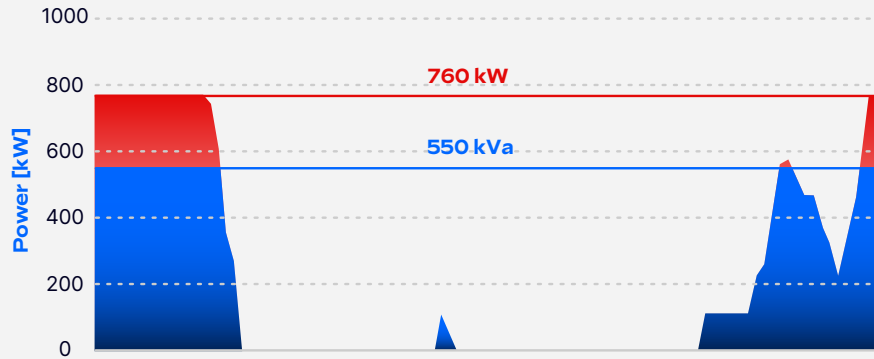


Uncontrolled charging

- **Energy charged: 4.9 MWh/day**
- **Peak load: 990kW**
- The available grid connection is not sufficient for charging more than three buses simultaneously.
- The grid connection must be expanded. This would not only result

in several thousand euros of investment costs but also take much more than one year to plan and implement.

- Even if the grid connection is adequate, without control high peak loads can occur, resulting in operating costs of up to €250 per kW because of peak load tariffs.



Controlled charging

- **Energy charged: 4.9 MWh/day**
- **Peak load: 760kW**
- **Static load management** distributes the available power across the buses being charged within the available grid connection. The available charging times are utilized flexibly, so that vehicles can be charged with a time offset or with reduced power.
- With **dynamic load management** additional energy consumers can be taken into account, such as office buildings, washing facilities, and maintenance hangars. Energy generators such as photovoltaic systems can also be integrated.
- Expensive peak loads are avoided.
- Grid expansion can therefore be kept significantly smaller.
- Compared with uncontrolled charging, there are significant savings of more than €26,000 operating costs per year, and several hundred thousand euros of investment costs. The time period for implementation is also considerably reduced.
- Furthermore, controlled charging processes allow it to make optimal use of favorable energy tariff time windows, when electricity is cheaper – of course always reconciling operational requirements.

(Schedule-based) controlled charging

- **Energy charged: 4,9 MWh/Tag**
- **Peak load: 540kW**
- **Fleet-based load management** is an extension of dynamic load management. It converts the timetables of the bus fleet into charging schedules to ensure that all buses are charged sufficiently, but not excessively, at the right time.
- This makes it possible to further optimize the distribution of the charging cycles and to further lower peak loads.
- Grid expansion can therefore be avoided.
- Compared with uncontrolled charging, there are significant savings in operating costs of over €50,000 per year and additional potential for smaller dimensioning of the grid connection for this phase. The time period for implementation is also considerably reduced.
- The time windows of favorable energy tariffs can also be used optimally here.

In conclusion

Setting up a charging infrastructure for your fully electric bus fleet is a complex process, involving various challenges. The foundation for the setup, and thus the key to success, is smart charging and energy management that ensures that your fleet is ready for operation and also offers extensive ways to optimize profitability.

03 Charging and energy management for optimal charging infrastructure

When you are electrifying your bus fleet, there are a large number of factors to be taken into account: the battery capacity of the vehicles, the selection of charging stations, the available grid power, potential charging locations, and much more. All these factors play an important role. Nevertheless, there is another aspect that should be considered above all else: the right charging and energy management system. This has a major impact on how flexible, efficient, and affordable your future operating processes will be.

This means that if you choose a system that matches your needs from the outset, your charging solution is guaranteed to be flexible and future-proof.

In the following specific examples, we show how charging and energy management influences the setup of charging infrastructure and what characteristics and functionalities you should take into account when choosing a system.



A decision of fundamental importance: The selection of the charging and energy management system affects many other aspects of the transition to an electric bus fleet.

01 Charging hardware

- **Hardware-independence:** Ensure that your charging and energy management has open standards and supports hardware from different vendors. A open, vendor-neutral system makes it possible for you to choose the best charging solutions available on the market, allowing you to combine AC and DC chargers, depot chargers, and pantograph solutions from various vendors, for example.
- **Individual control:** The system should be able to control each charging point individually (not only groups of charging points), even if multiple charging points are connected to one power unit (container). The distribution of charging power and charging times across your vehicles can therefore be controlled more flexibly.
- **Tailored power:** If you have defined an optimized charging strategy involving a charging and energy management system, you can select the matching charging stations with the precisely defined power class. This means your investments are more specifically tailored to suit your particular use case.

02 Planning & configuration

- **Electric infrastructure:** An intelligent charging strategy has a direct impact on your electrical planning. For example, it makes it possible to downsize the transformer and associated cabling, including a reduction in fees associated with a lower power requirement throughout the depot.
- **Controllability of the charging stations:** The charging and energy management system must be able to consider the power limits of all individual charging stations and clusters, regardless of which transformer or which sub-distribution unit they are connected to, with consideration given to the overall site load at all times.
- **Dynamic load management:** The chosen system should be able to integrate not only the charging stations but also all energy consumers and producers of the depot. This enables you to make considerable savings in electricity costs and to highlight carbon-neutral charging.

03 Construction & installation

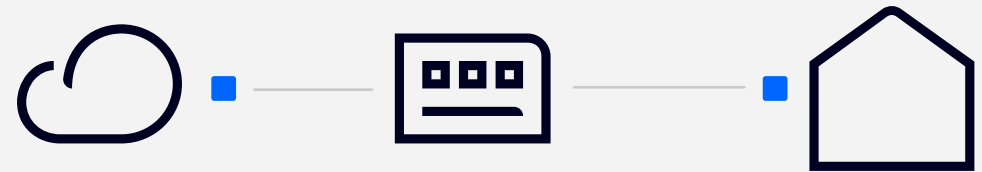
- **Installation costs:** As the smart control makes it possible to configure electric infrastructure with smaller dimensions, savings can be made in infrastructure construction and installation. Project implementation can also be sped up significantly, as potential supply shortages (which are currently very widespread in the electric industry) can be avoided.
- **Conversion costs:** With a thorough planning of investment costs and considering a charging and energy management system, a sustainable conversion of the existing depot is possible. This reduces incremental conversion expenses and project costs.

04 Operation & maintenance

- **Peak Shaving:** Lowering peak loads by spreading charging processes over longer time periods enables considerable savings in electricity costs (in Germany, depending on the region, between 85 and 250 EUR/kW). Experience has shown that up to 70% savings can be realized with controlled load distribution.
- **Utilize variable electricity tariffs:** The charging management should enable priority charging times in accordance with the most inexpensive energy tariff (e.g. at night) or the spot market (EPEX SPOT).
- **Vehicle-grid integration:** Another way to save electricity is vehicle-grid integration (VGI). In the future, VGI technology will enable energy to be fed back into the energy system from the batteries of electric vehicles. This would result in various future applications, such as procuring electricity cheaply and feeding it back into the grid at higher prices during peak periods. With these strategies, leeway can be used economically without limiting operational requirements (e.g. SoC = 94% for departure at 7:15).

- **Carbon-optimized operation:** Charging management can focus not only on cost optimization but also on charging electricity with the lowest possible carbon dioxide impact. For example, vehicles can be charged with higher capacities when electricity is available from the company's own photovoltaic system.
- **Visualization of operating processes, transparent maintenance:** If the energy and charging management system enables clear visualization of all charging processes (in a CPO dashboard), you have a constant overview of all procedures and can take measures to correct faults as needed. This reduces costs for the maintenance of your infrastructure.
- **Software integration:** The support of open, standardized interfaces such as OCPP 1.6 and ISO 15118 is important when it comes to integrating your charging and energy management system into your depot's existing system landscape, e.g. for communication with depot or fleet management. Software integration is also vital for more demanding functions such as fleet-based load management, preconditioning, or vehicle-grid integration.

Note: Detailed technical requirements for a charging and energy management system are given in [this example tendering text](#).

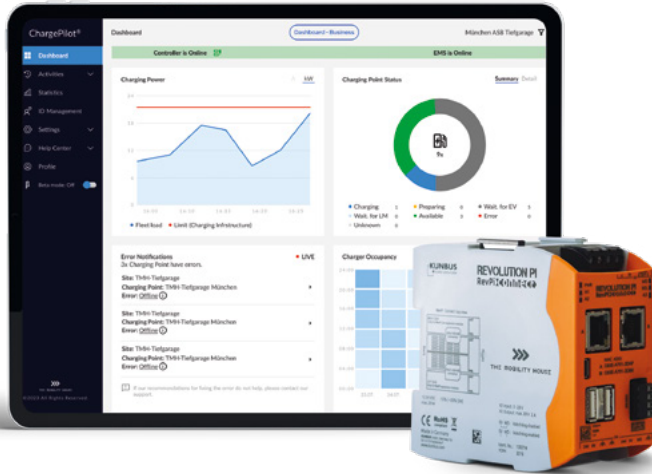


Local or cloud-based?

Systems for charging and energy management are generally offered in these two variants. In the first case, the backend of the control is on your premises, and in the second the data is transferred to an external control center. The advantage of a cloud-based system is that you can access all functions from any location. On the

other hand, it takes longer to respond to changes in load (because of latencies in the Internet connection) and operation is less fail-safe than local systems. Furthermore, with cloud-based systems it is very difficult to realize dynamic load management, i.e. to integrate your depot's other consumers or generators in addition to the charging infrastructure to achieve overall optimization.

04 Smart charging with ChargePilot®



To remain flexible as you work toward your electric future, your charging and energy management system should ideally be a vendor-neutral and scalable solution – such as our system called [ChargePilot®](#). As a central software platform, ChargePilot® integrates your electric bus fleet into day-to-day operations and supports you in controlling and monitoring the charging processes. Experience in electrifying large bus depots with >100 buses has proven the system's performance in practice. [You can find the relevant references here.](#)

Fit for the electric future – with our system ChargePilot®

- Your companion in every scaling phase – from the initial project to large depots with >100 vehicles
- Rapid implementation – quickly installed and immediately ready for operation
- High functional scope – can be used flexibly in line with your specific needs
- Dynamic load management for the integration of buildings, washing facilities, and power generators (photovoltaic systems, stationary storage)
- Fleet-based load management for optimal operational readiness of the fleet
- High system interoperability: Can be connected to existing systems (ITCS, DMS, fleet management) via all relevant interfaces (OCPP, proxy, Modbus, VDV 463). Third-party systems can access ChargePilot® data
- Local installation for high system stability and reliability. The intelligent bus charging remains in place even in the event of an internet failure
- Open, vendor-neutral system – avoids hardware and software lock-ins
- Reduce operating costs with bidirectional charging (V2G/V2G) – very large cost leverage for electric bus depots

In this configuration (standard interfaces, hardware-neutrality, local control, dynamic load management, V2G option) ChargePilot® is unique on the market!



In conclusion

This white paper shows that selecting the right charging and energy management system is the foundation for the successful electrification of your bus fleet. All other factors – from selecting the charging technology, to planning, installation and operation – can build on this. You are then well on your way toward having a fully harmonized, flexible, and future-proof charging infrastructure.

THE MOBILITY HOUSE >>>

Your project partner: That's us!

In the initial phase of your electrification project, there are key decisions you need to make to ensure sustainable success. Seek advice from a specialized service provider like us: with our experience from over 700 electrification projects involving fleets, including the development of charging scenarios for large bus depots, we can skillfully support you in all phases of your project, from the planning to the installation of your charging infrastructure.

Build on knowledge and experience and enter the future of electric mobility with us – we look forward to hearing from you!

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