Potential cost savings of a charge management system

Reduction of peak loads by way of load shifting

Many operational processes must be redefined or adapted to deploy battery electric buses in daily service: Public transport companies now have to deal with the issues of battery size, range and stricter allocation of vehicles to blocks in the areas of planning, dispatching and monitoring. However, charging vehicles, whether at the depot or en route, is a completely new operational procedure. It presents public transport companies with new challenges, but also offers opportunities, which can be seized using a charge management system.

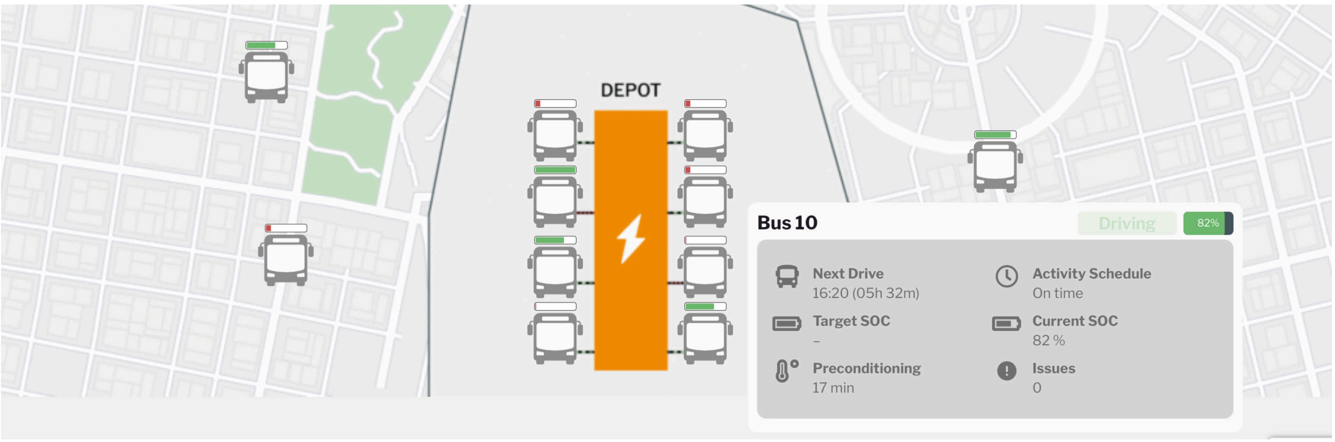

Figure 1: Overview Busdepot

Definition of a charge management system

In terms of business information applications, the Association of German Transport Companies (VDV) sees the charge management system among charging infrastructure, depot management and electricity procurement. In this system architecture, time frame and required state-of-charge of each bus are transmitted from either the fleet management system or depot management system to the charge management system (Figure 1: Overview Busdepot). Such data is utilized to optimize the charging process to ensure that all vehicles are available on schedule (see Figure 2: Architecture of a charge management).

Based on more than 10 years' experience with the charging processes of electric vehicles, INIT has thoroughly analyzed the requirements for an intelligent charge management system when developing MOBILEcharge in order to provide the following functionalities:

- Schedule, control and monitor charging processes
- Parallelize and automate charging processes
- Avoid or reduce peak loads
- Manage disruptions to charging processes and to restart processes
- Alert the dispatchers if charging processes cannot be completed as planned
- Automatically activate vehicle preconditioning
- Provide a clear overview of the entire charging infrastructure of different manufacturers and monitor their functional capabilities
- Provide an optimal and protective charging process to extend battery life

The primary goal of intelligent charge management is to ensure that buses are ready for operation, charged as needed and preconditioned – as cost-effectively as possible. In order to fulfill the aforementioned operational requirements, integration with the depot management system and subsequent systems is required. INIT establishes this networking concept by including charge management in its integrated overall solution eMOBILE for efficient operation of electric buses. But how can a company take care of the charging process in a cost-effective way?

The main objective is to reduce the maximum charging capacity as this is the primary factor when it

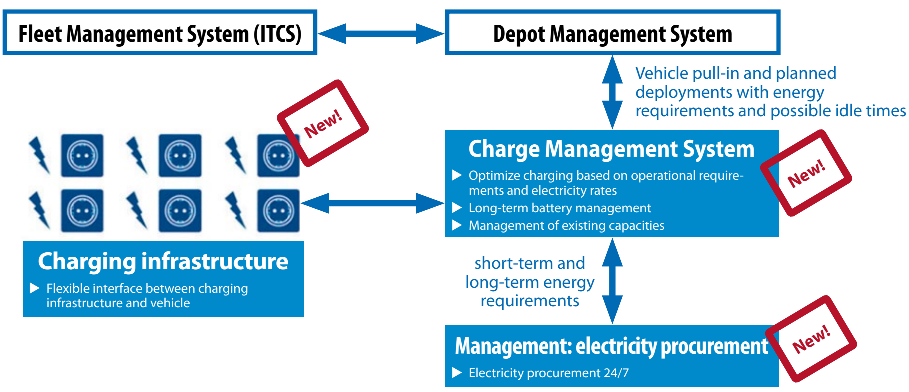

Figure 2: Architecture of a charge management system. Excerpt from VDV230/1

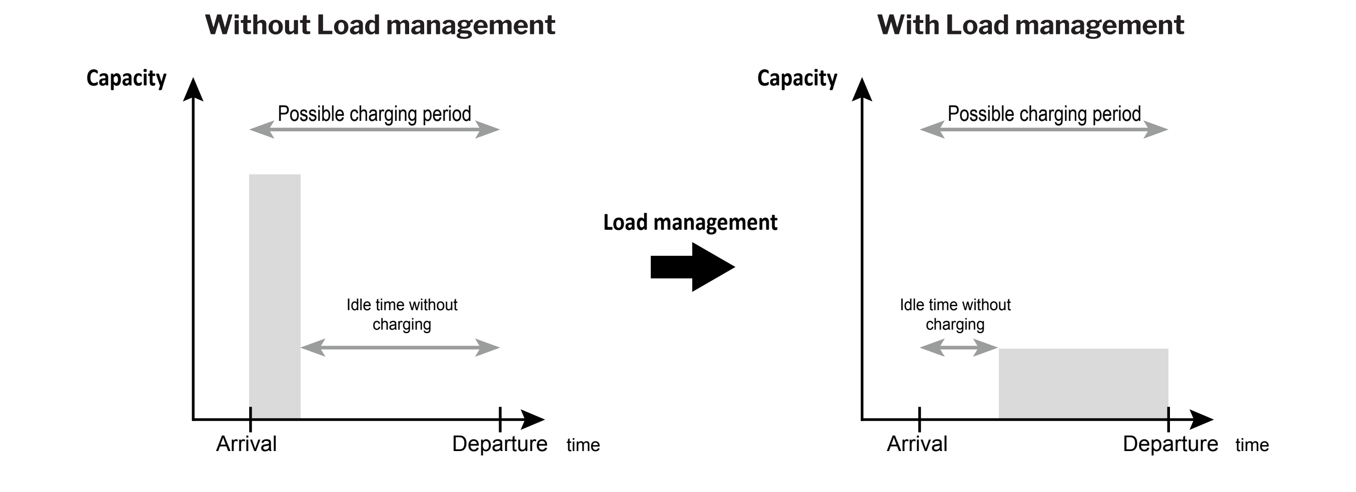

Figure 3: Controlled charge management

comes to the price of electricity to be paid. To this end, unnecessary peak loads must be avoided by means of controlled load shifting, or 'peak shaving' for short. What does this mean specifically?

Load shifting as the main approach for cost-optimized charging

In the simplest case, without intervention, the charging process starts immediately after connecting a vehicle to a charging station. Initially, the charging requirement (vehicle) and availability (charging infrastructure) are synchronized. With no external control, the charging process will be completed as quickly as possible and therefore it is started at maximum charging capacity.

With load shifting, the load is shifted over time. In practice, this means that even though vehicles will be connected to the charging cable when they arrive at the depot, the charge management system may start the charging process later.

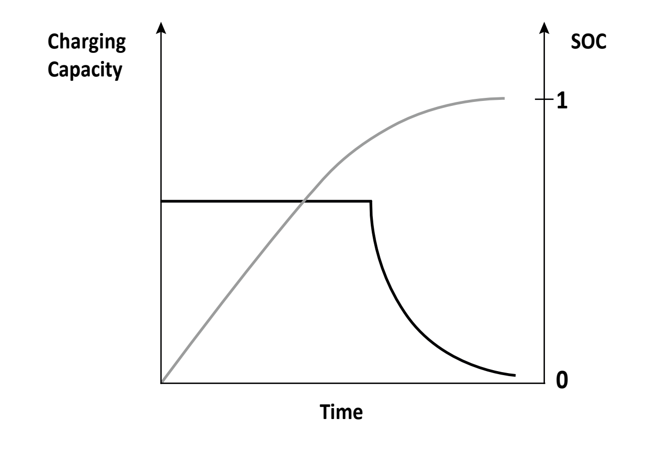

Figure 4: CCCV charging process: Correlation between state-of-charge (SOC) and charging capacity

Charging process, charging curve

For the sake of simplicity, a constant capacity per charging process is shown in the load shifting diagrams (Figure 3). However, with lithium-ion batteries, a correlation exists between the SOC (state-of-charge) and the charging capacity due to the Constant Current Constant Voltage (CCCV) charging process. In this process, the main proportion of the energy is supplied with a constant charging capacity in the initial main charging phase. This is followed by a second phase in which the voltage remains at the end-of-charge voltage and the charging capacity decreases exponentially as a result (Figure 4: CCCV charging process).

This means: to reach a SOC of 70–80 percent, charging will take place at a constantly high level. Once this SOC is met, the charge level will decrease. Thus, the first charging phase to reach the 70-80 percent level will take just as long as the charging phase from 80 to 100 percent.

Electricity procurement, electricity price components

For economic evaluation of the load shifting potential, it is important to take the peak load into account. As this is the main variable having a considerable influence on electricity costs it must be in the focus of public transport companies.

Less known in practice, but worth to look into are variable electricity tariffs. Here, variable prices are fixed in advance throughout the day, for example on a 24-hour basis (see Figure 5).

Charging strategy, load shifting potential

Due to the variable nature of electricity costs and charge demands of vehicles, it becomes obvious that

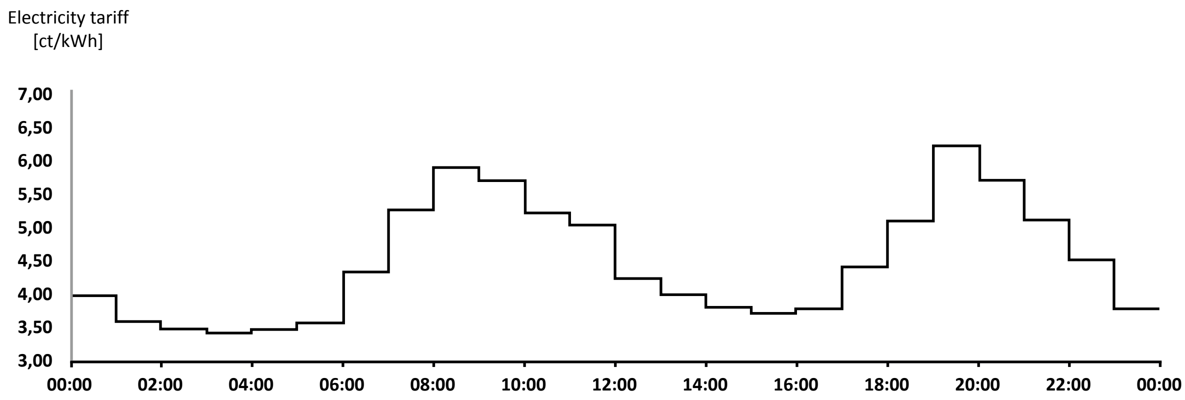

Figure 5: Day-ahead prices

an active charge management system can be leveraged to minimize the total energy costs when:

- The time frame for charging processes and the intended state-of-charge are known
- Charging processes can be controlled in terms of time and capacity
- Individual charging processes are not constant over time in terms of capacity, but decrease significantly at a SOC of 70–80 percent
- The main parameter for pricing is the current electricity rate

On the one hand, it is possible to calculate a charging schedule for all pending charging processes with the aim of minimizing the maximum load. On the other hand, there is further potential for saving if variable electricity price tariffs are considered. However, all these calculations require the support of an intelligent charge management system. The following economic analysis demonstrates that the investment in such a system is useful from an economic point of view.

Case study about optimization potential through load shifting

In order to determine the economic optimization potential of an intelligent charge management system and to find out if a minimum fleet size is necessary to realize this positive effect, various scenarios were taken into account. The case study presented is based on a fleet of 40 electric buses with a battery size of 300 kWh each, which are only charged at the depot. The depot has 40 charging points with a charging capacity of 70 kW each.

In the case of uncontrolled charging (Figure 6, shown in blue), all buses start their charging process directly after entering the depot. Delays therefore only occur due to the buses returning at different times. Some vehicles return during the day, only have short blocks to complete and can therefore be fully recharged during the day. There is a peak of about 1150 kW during the evening and at night due to overlapping of charging processes that have just started and processes that are not yet completed. A peak can also

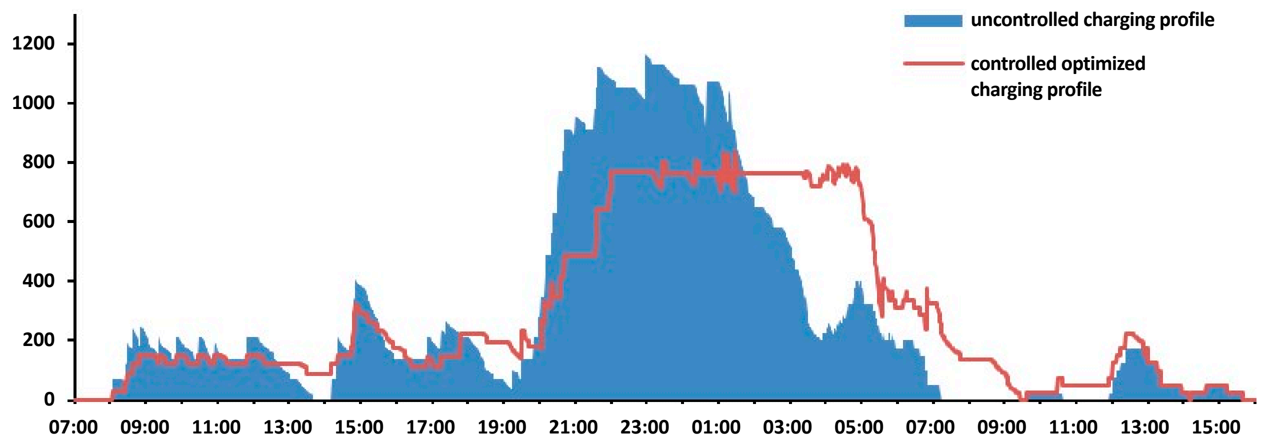

Figure 6: Controlled and uncontrolled charging profiles

be observed in the morning as the vehicles are preconditioned before leaving the depot.

Active control of the charging processes (Figure 5, red line) causes a shift of the loads, reducing peak loads to below 800 kW on the one hand, while still having the preconditioned vehicles ready for leaving the depot on time. A reduction in peak load of more than 30 percent is achieved as a result. **This provides savings of about 15 percent in terms of the overall cost.**

Costs can be reduced even further if variable electricity tariffs are added to the measures for reducing load peaks. High-cost phases, such as between 6 and 8 p.m. in the evening

All in all, the cost reduction potential through load shifting with the aid of an intelligent charge management and variable electricity prices can be as high as 20 percent. Fortunately, these effects can also be realized with a smaller fleet of 10 vehicles.

Future potential for savings

In the future, there will be options that further reduce the cost of energy for charging vehicles. For example, self-generated electricity from photovoltaic systems could be used for charging the busses. This would save costs for the public transport company as it omits or reduces expenses for network charges. However, this type of electricity generation is subject to fluctuations in the weather and the time of day, so that a consistent electricity supply cannot be ensured. In this case, stationary storage batteries could help to compensate for fluctuations and, in turn, reduce load peaks. Some public transport companies such as Verkehrsbetriebe Hamburg-Holstein GmbH (VHH), Germany, are already researching the long-term sustainability of electric bus traction batteries. For example, in the “Second Life Batteries” project, tests are being carried out to ascertain whether decommissioned electric bus batteries can be used as energy storage systems for charging stations at the depots and whether this can improve load management. Finally, another option for reducing costs involves participating in the balancing energy market or providing loads that can be disconnected – assuming that the power input of the depot is 5 MW or more.

Summary

To summarize: an intelligent charge management system offers many functions which can make electric bus operations more efficient and more robust. An essential, quantifiable contribution is made by actively controlling loads, making it possible to reduce energy costs by lowering peak output. Variable price models for energy procurement can lead to further cost savings. Previous calculations have shown optimizations of up to 20 percent, of which about 15 percent results from peak shaving and up to a further 5 percent from utilizing variable tariffs. Decentralized energy generation and storage provide further potential, as well as participating in the balancing energy market.

Contact

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You can find more information on our homepage:
https://www.carmedialab.com/en/produkte/public-transport/charge-management/

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