The art of managing e-bus fleets

Your road to the successful operation of e-buses

init
The Future of Mobility

Many cities have made the decision to implement electric buses in their public transport networks, but the road to smooth implementation is still unclear. Find out how to implement and how to deploy and operate electric buses efficiently.

1. Deployment concept
2. Charging concept
3. Charge management
4. Depot concept
5. Block optimization
6. Range monitoring and prediction
7. Continuous optimization

7 steps to run an e-bus fleet

Many aspects have to be considered and the overall strategy must be defined before electric buses can be successfully incorporated into your fleet. E-bus integration has an impact on numerous operational processes – from planning and scheduling to operations control. Electromobility is nothing short of a complete paradigm shift – but it can be mastered successfully in 7 steps.

Step 1

Deployment concept

The first step towards e-mobility is often the use of one or more test vehicles. These are typically deployed on morning and afternoon peak blocks, where their shorter and more volatile range is unlikely to have negative effects. This meets the initial political requirements while minimizing the impact on ongoing operations. At least by the time additional buses are being procured, public transport operators must ask themselves the question: How can we efficiently operate an entire fleet of electric buses?

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Numerous factors affect energy consumption

From an economic point of view, it is not enough just to put e-buses on shorter blocks. Rather, they need to be used as much as possible in order to hit their break-even point. It is therefore important to find ways to deploy these vehicles on longer or additional blocks as well. Various factors have an impact on energy consumption and consequently the range of the vehicles. The topology of the route, the number of stops and starts, individual driving styles, the size of the battery, and the outside temperature on that given day are some of the essential parameters to consider.

Comparing scenarios is key

This is where the support of a powerful planning and simulation system such as eMOBILE-PLAN proves essential. Such a tool allows the user to simulate and optimize numerous deployment scenarios or block variations, while considering additional vehicles or drivers that may be required. Comparing all conceivable scenarios ultimately makes it possible to make a sound decision for the right deployment strategy based on reliable economic data.

Additionally, assistance facilitating and comparing different vehicles and battery types during the procurement process is critical. eMOBILE-PLAN can provide this valuable insight.

Deployment scenarios ++ resources ++ costs

Step 2

Charging concept

Having determined the optimal new blocks for your fleet, the next task is to determine the most efficient charging strategy: charging in the depot, charging en route (opportunity charging), or a combination of both?

Balancing investment and operating costs

Being able to compare different scenarios gives you a valuable overview of investment and operating costs to guide you as you make critical strategic decisions.

The aim is to determine how many charging stations are required for each strategy and locate the best position to place them. The investment costs for the associated charging infrastructure can be calculated for each scenario and be reliably compared.

Depot charging reduces infrastructure-related investment costs, although it limits how flexible the e-buses can be used. On the other hand, it increases the amount of electricity that has to be made available in a shorter time frame, usually overnight. This aspect is not to be taken lightly, as peak consumption has a direct impact on electricity costs and therefore on operating costs.

Once both the investment and operating costs have been determined for the respective scenarios, the total cost for each option can be compared in a subsequent step.

This makes it possible to determine not just the most appropriate charging strategy, but also the approximate future energy consumption and the correct layout for the electrical supply – even for a rapidly growing fleet of electric buses. The most decisive factor for the actual energy demand is the outside temperature – as heating and cooling in different weather conditions can double total energy consumption.

MENDEL

MENDEL research project

Research and product development come hand in hand at INIT. This project is a shining example of our approach. We defined the key features we would find in an optimal charging infrastructure, then identified the precise planning and operational requirements of public transport operators. The overall objective of the project was to find ways to keep investment and operating costs low. INIT gained a competitive edge through this project in the form of advanced knowledge that has since been incorporated into the development of our complete suite of e-mobility products.

Find the right strategy ++ depot charging, charging en route, a combination of both

Step 3

Charge management

Once the charging strategy has been determined, the charging processes have to be managed smartly in order to keep ongoing energy costs as low as possible.

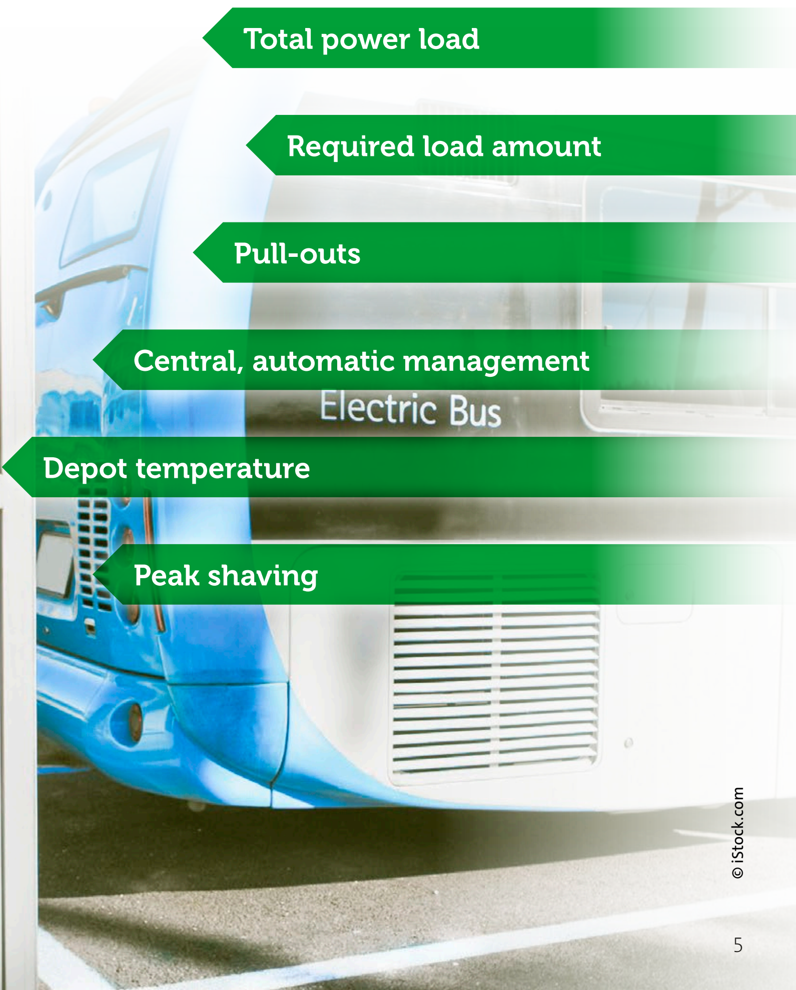
Requirements for efficient charging

- **The buses must be available for pull-out on time and be at a comfortable temperature for passengers.**
- **Charging stations must be available for all vehicles so that charging can be centrally controlled and occur in parallel.**
- **There must be sufficient power to charge the entire fleet.**
- **The total power load must be balanced in order to avoid expensive load peaks (peak shaving).**
- **Charging should be as easy on the battery as possible.**

The duration of the charging process is not only determined by the maximum connected load, but also by the individual vehicle and the ambient temperature. When assigning charging slots to any specific vehicle, it must also be noted that other work has to be carried out on vehicles while they are in the depot, which means that they will not be available for charging the entire time they are there.

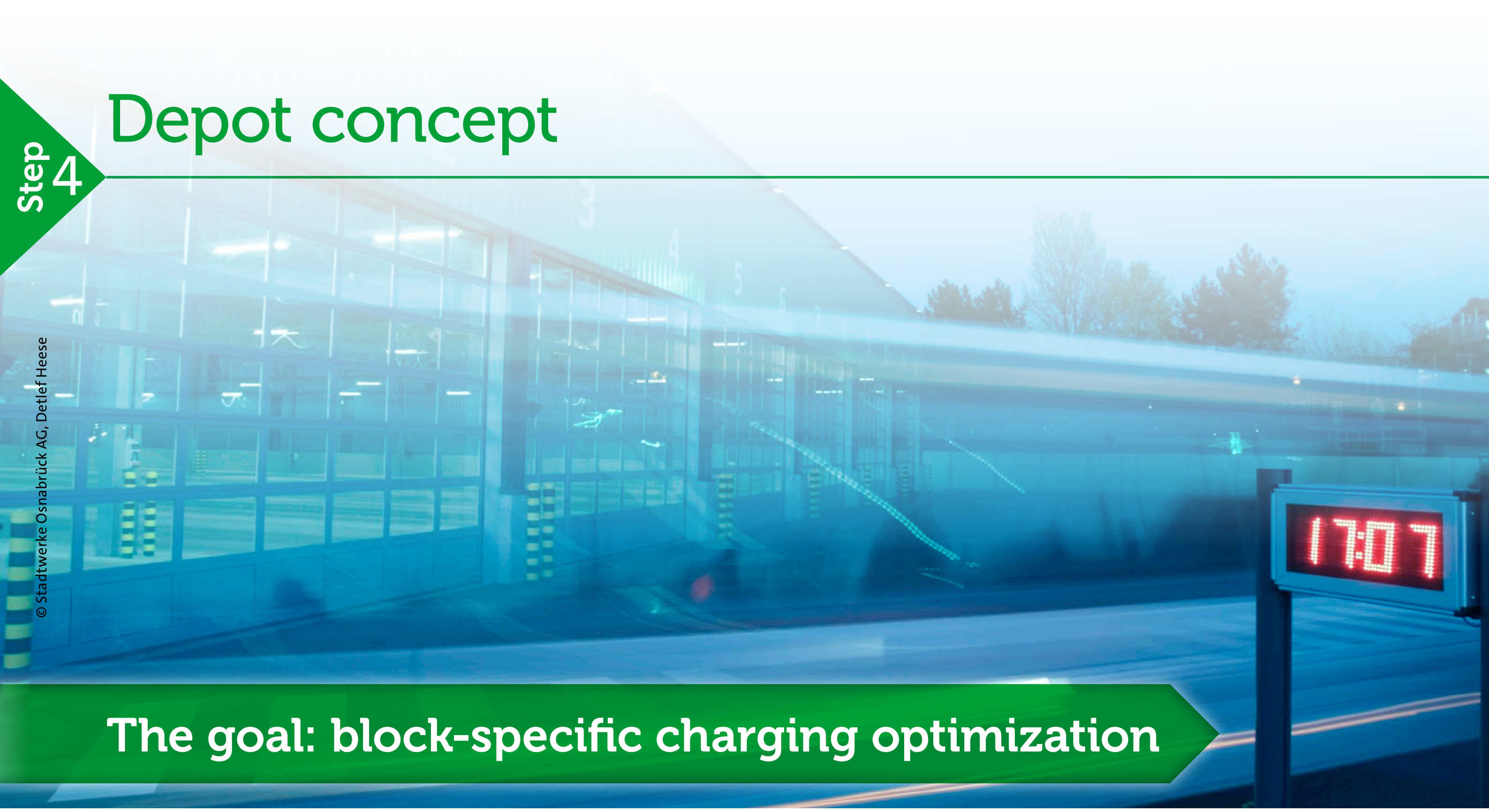
Objective: peak shaving

To avoid unnecessary charging peaks an intelligent charge management system, such as MOBILEcharge, is essential. MOBILEcharge controls all charging processes centrally and automatically. This is the only way to calculate the optimal charging schedule for the entire fleet to ensure balanced charging by intelligently allotting charging times and amounts to avoid expensive peaks. MOBILEcharge also monitors the charging processes and restarts them in the event of an unexpected interruption to ensure all vehicles hold sufficient charges at the required time.



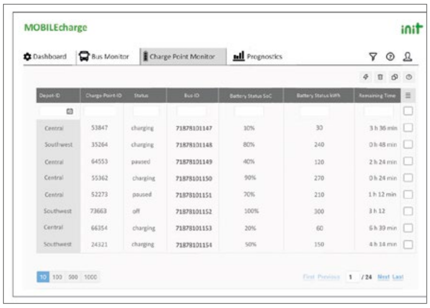
Step 4

Depot concept



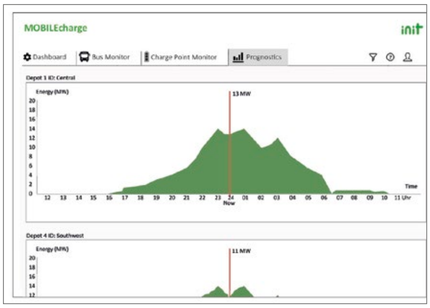
The goal: block-specific charging optimization

The depot plays a central role in a public transport company. Depot workers ensure that vehicles are ready in good time for operation the following day. Obviously, this applies also to electric buses.



Charging can therefore only be controlled in a smart way if the charge management system is connected to the depot management system. This is because it is the depot management system that holds the required information on the blocks scheduled for the following day.

To effectively ensure all vehicles are charged to their capacity, the charge management system requires information on energy demands and pull-out times. This helps staff to assign the charging slots and times, avoiding expensive peak loads. It is not reasonable to transfer this data manually, and once you have an e-fleet of any significant size, it is not even doable.



Feedback into block and duty building

If the interaction between depot and charge management systems reveals that not all blocks can be completed as planned, MOBILE-DMS will adjust the blocks and even generate additional blocks and duties for the next operating day, which are subsequently transmitted to the Intermodal Transport Control System.

Step 5

Block optimization

From an economic point of view, the operating times of e-buses should be as long as possible. For this reason, careful consideration must be given to how they can be appropriately put into operation on longer blocks.

The focus here should be on those aspects that have the biggest influence on energy consumption and consequently the vehicle's range. The topology of the route, the number of stops and starts, the individual driving style, the size of the battery and the outside temperature on that given day are some of the essential factors to consider.

A suitable planning tool must take all these parameters and many more into account, e.g. the locations of the charging stations. It should also feature powerful optimization algorithms which allow to play through different scenarios to help determine the most appropriate variant at the end of the optimization process.

The specific range

The bus type specific range can be calculated based on battery capacity and energy consumption per kilometer and minute, with due consideration to other influencing factors. Aside from the factors already mentioned, the time of year has a strong impact on energy consumption. A reduced need for air conditioning and heating means vehicles can cover greater distances on a full charge in spring and autumn, which indicates that seasonal planning is essential. It is the only way to ensure the stability of the blocks and services.

Factors that influence the blocks

- Location of charging points
- Outside temperature
- Topology of the route
- Driving style
- Bus type

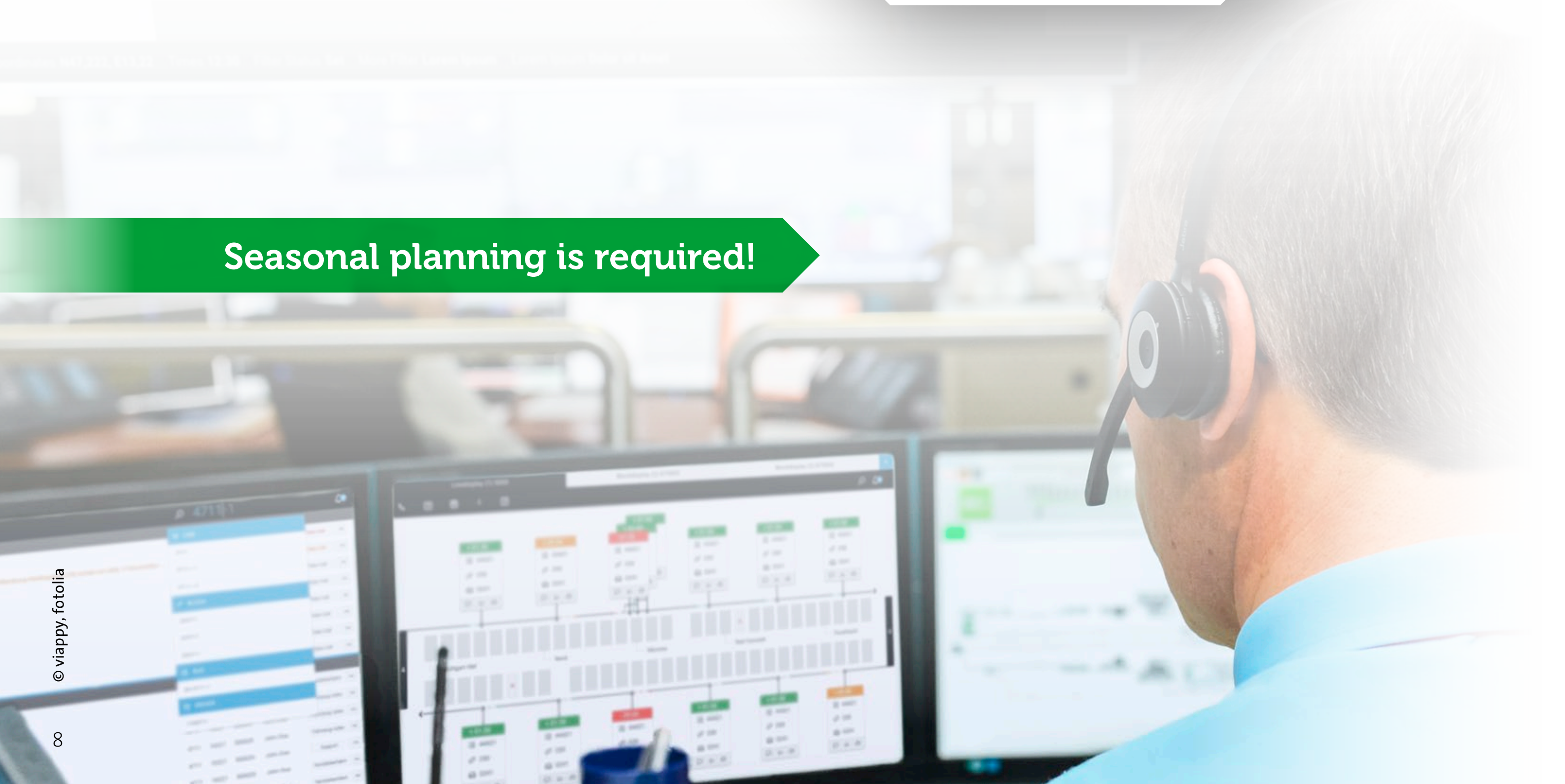
Conflict of objectives: Top-up charges and duties

From an economic point of view, an electric bus should be operational for as long as possible. However, if electric buses are assigned to blocks that exceed the range of the battery, top-up charges will become necessary. As a result, it may be necessary to increase the number of vehicles and corresponding number of personnel. The optimal times for these top-up charges will need to be determined, taking the impact on duties into account. This is because the requirements in terms of the driver (the driver needs a break) and the requirements in terms of the vehicle (the vehicle must be recharged) can be in conflict.

MOBILEopti^2's superior algorithms for an integrated optimization of blocks and duties reconcile the goals and generate economically efficient blocks and duties that are as robust as possible. After all, when dealing with e-buses, very close attention must be paid to the robustness of your plans. This is because a delay can lead to a reduction in the allotted charging time, which can cause problems if the bus then runs out of power en route.

A paradigm shift

Electromobility sometimes contradicts previous best practice ideals. After all, fewer breaks, fewer dead runs, less time lost around connections, a reduction in the fleet size and the efficient use of drivers' working time used to be key objectives to reducing costs. This is why it is necessary to rethink the way schedules, blocks, and duties are planned. This can be achieved with the MOBILE-PLAN planning system, which is fully adapted to the new requirements of electromobility.

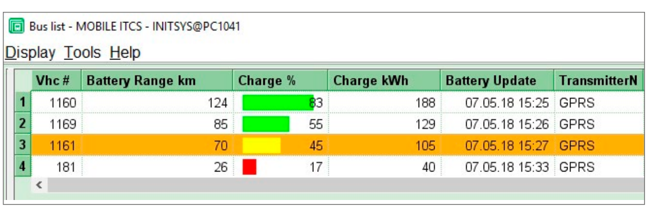


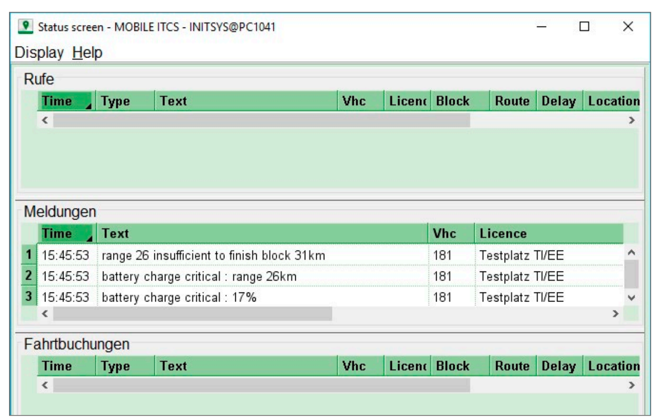
Seasonal planning is required!

Range monitoring and prediction

The blocks meet the requirements of e-buses, while intelligent charge management and integration with the depot management system ensure that the buses are available on time and have been sufficiently charged. Now the only thing left to do is to prevent high volatility from disturbing your operations.

For this reason, the battery's current state of charge needs to be monitored not just by the driver, but also by the control center. This means that electromobility needs to be integrated into the public transport provider's most important management tool – the Intermodal Transport Control System (ITCS). A sophisticated ITCS supports your dispatchers, helping them to keep operations as smooth as possible and enabling them to quickly respond to incidents. To ensure maximum working efficiency, the e-bus fleet also needs to be monitored via the same tool.





Keeping an eye on the range

MOBILE-ITCS provides dispatchers with a quick overview of the vehicle's current state of charge (SoC). The SoC is seen as red (low), yellow (running low) or green (fully charged) on the dispatcher's screen, as well as the operator's driver terminal. Thresholds can be defined and alerts triggered when any vehicle's SoC falls below the defined threshold. The system also checks whether the vehicle can manage the additional distance when executing dispatching measures like an unplanned detour. This provides the dispatchers with all information and the full support needed to perfectly control even fleets of e-buses.

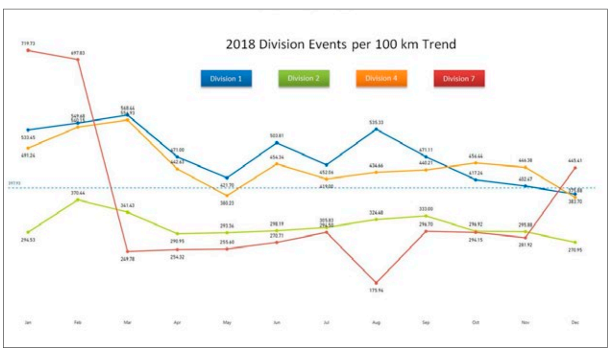
Range prediction: vital for reliability

Variable factors, as well as static ones such as the typical battery consumption and the topology of the planned route, need to be taken into consideration when calculating the vehicle's remaining range. The temperature on the particular day should once again be taken into account, and the driver's individual driving style can also have a considerable influence. Based on all these factors, MOBILErange, INIT's tool for range prediction, uses appropriate statistical analyzes and state-of-the-art machine learning to generate a model for each vehicle's individual battery consumption for specific route sections. MOBILErange functions as a central service for all INIT applications that require range information.

Step 7

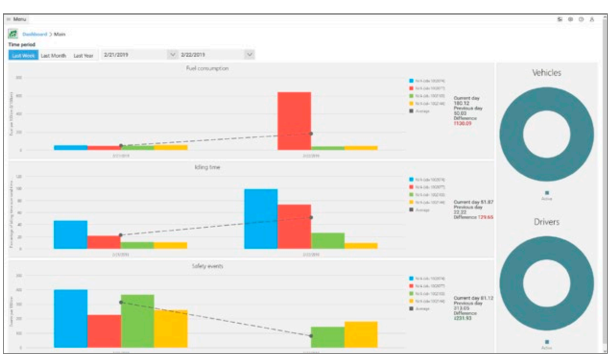
Continuous optimization

It is clear that the secret to operating e-buses most efficiently lies in being able to reliably predict the specific charging amount needed for the particular day as the bus travels on a particular route within a particular range of outside temperatures. This means it is necessary to predict not just a general range, but a specific range based on individual factors. The more precisely ranges can be determined, the more efficiently vehicles and drivers can be deployed, and the more energy costs can be reduced through intelligent charge management, while also ensuring smoother operations with fewer service disruptions.



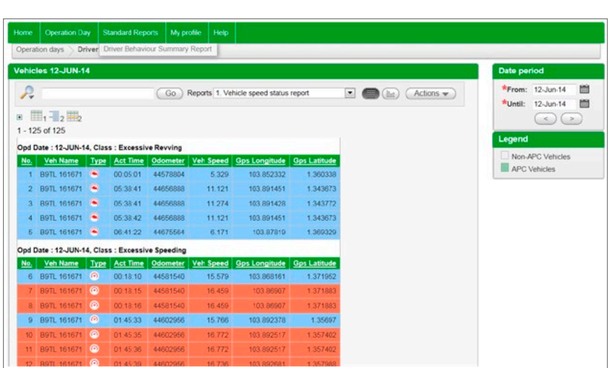
Historical operational data

It is imperative to use historical operational data to improve the quality of results when calculating the range or the actual remaining range of a given vehicle. This historical data must be logged during everyday operations, evaluated in an appropriate manner and then provided to the central range prediction tool to ensure that improved predictions can be provided consequently to all other operational information systems.



Actual energy consumption

MOBILE-ECO² tracks actual energy consumption and driving situations along with influencing factors such as the vehicle, the driver, topology, route, and even weather conditions, and provides the range prediction tool with this information. The tool can also give the driver helpful pointers, e.g. when braking or accelerating too hard, to encourage a more energy-efficient driving style and open up further potential for improvements.



Vehicle health management

Proactive maintenance of e-buses also plays a significant role in ensuring profitable operations. The workshop has little empirical data to refer to when it comes to electric vehicles, which makes the support of vehicle health software particularly valuable. MOBILE-ECO² does more than simply track error messages – it also offers comprehensive vehicle monitoring while the vehicle is in operation, which improves efficiency in planning maintenance and repair work.

Conclusion

These seven steps – applied consistently – are the key to a successful implementation of e-mobility in public transport. All the forementioned considerations must be taken into account, and new processes and parameters must be introduced. But it is also mandatory to get adequate support from operational information systems. So far, they often have been neglected, in spite of their crucial role in ensuring efficient operation.

eMOBILE: 7 information systems,

From providing the basis for strategic decisions to charge management, depot management, planning, vehicle dispatch, range prediction and managing an entire e-bus fleet – INIT combines all of these functionalities into one integrated solution.

eMOBILE-PLAN

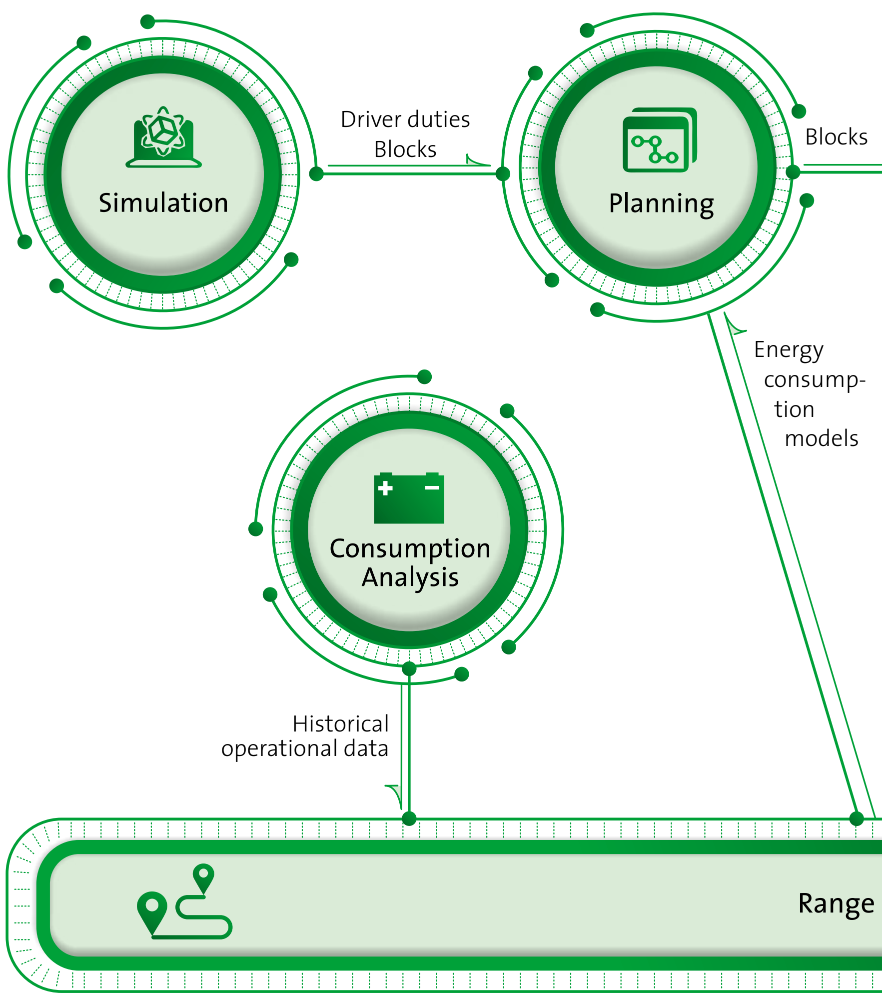
The simulation tool, which is also available on a rental basis, allows you to simulate how e-buses might be used in your transport company, allowing you to identify the best strategies and make sound economic decisions.

MOBILEopti²

Extensive optimization algorithms and electromobility-specific parameters are available to support everyday building of blocks and duties.

MOBILE-ECO²

The system promotes energy-efficient driving and tracks actual energy consumption along with influencing factors such as the vehicle used, the driver, topology, route, as well as even weather conditions, and reports this historical information to the range prediction module. The tool can also give the driver immediate feedback, e.g. when braking or accelerating too hard, which moreover encourages a more energy-efficient driving style.



one integrated product suite

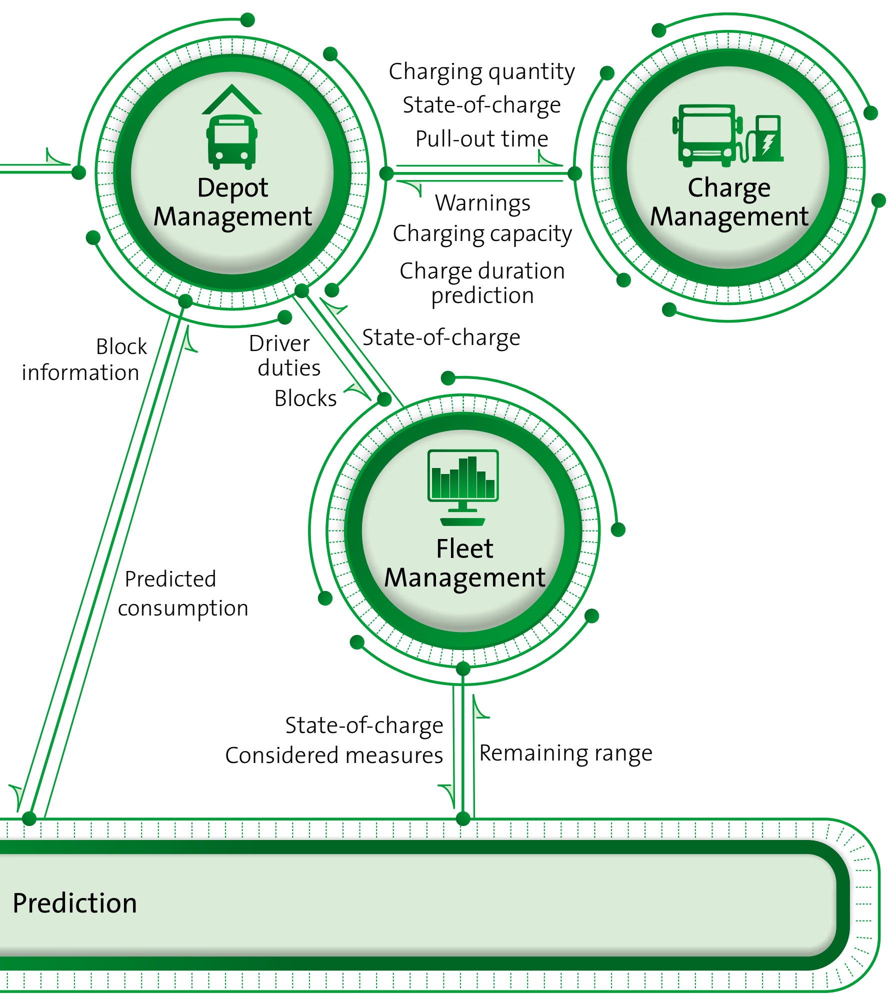
This allows you to benefit from a coordinate process, a continuous data flow, synergy effects and an efficient work-flow when implementing e-mobility in public transport.

MOBILE-DMS

The depot management systems interacts with the charge management system on the blocks of the next day, charging requirements and pull-out times. It even will adjust block and driver duties should this become necessary due to insufficient vehicle charges or as a result of dispatching measures.

MOBILEcharge

The smart charge management system centrally controls all charging processes and generates optimized charging plans for the entire fleet. It helps you avoid expensive load peaks through a sophisticated assignment of loading slots and charge amounts.



MOBILE-ITCS

The Intermodal Transport Control System allows continuous monitoring of all vehicles' current state of charge. This means your dispatchers will be informed when they need to intervene and also receive a warning if there is a range conflict when executing dispatching measures.

MOBILErange

The central service in the INIT e-mobility product suite calculates the range of a vehicle based on vehicle-specific models, taking into account numerous other static and variable factors along with historical operational data.

What you can achieve with eMOBILE

Financial decisions

Predicted financial impact

Acquiring suitable e-buses

Determining the most efficient charging concept

Optimal planning

Optimizing blocks while taking weather, topology etc. into account

Assigning the right buses to individual blocks

Assigning the right driver (e.g. for energy-efficient driving)

Continuous optimization

Continuous optimization of planning

Vehicle-specific models of battery consumption to facilitate more precise range predictions

Cost savings

Peak shaving

Optimized calculation of the required charge

Energy-efficient driving

Optimized maintenance

Operational support

Monitoring the state of charge in the ITCS

Reliable information on the remaining range

Supporting dispatchers in executing dispatching measures

Integrated solution

Perfectly adapted to the requirements of electric vehicles, INIT systems provide a comprehensive solution that carefully considers all operational aspects of e-mobility in public transport. This provides an integrated solution allowing public transport companies to implement e-mobility in a way that is safe, controlled and predictable, and over all, ensures efficient and successful operation of e-bus fleets.

Go directly to the video about eMOBILE:

If you would like to know more about eMOBILE, please contact Heiko Bauer: heiko.bauer@carmedialab.com.

We look forward to hearing from you.

More than 1,100 transport providers worldwide rely on our integrated solutions to support them with their daily tasks

- *Planning & Dispatching*
- *Ticketing & Fare Management*
- *Operations Control & Real-Time Passenger Information*
- *Analyzing & Optimizing*

Moreover, transport companies can also master all requirements of electromobility and set up a single sign-on mobility platform using our integrated solutions. A robust package of operational services completes the INIT offer.

INIT is the worldwide leading supplier of integrated planning, dispatching, telematics and ticketing systems for buses and trains. For more than 40 years, we have been assisting transport companies in making public transport more attractive, reliable and more efficient.

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