Management of electric vehicle fleet charging

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Introduction

In France, company vehicle fleets represent approximately a third of the overall number of vehicles registered, i.e. 850,000 vehicles in 2010\(^\text{1}\).

With no gas emission, no discharge of particles and silent operation, the electric vehicle offers an effective, concrete solution to reduce the ecological footprint of transport.

It forms the last missing link in the panorama of sustainable urban mobility (train, tramway, bus, bicycle) and perfectly matches the needs of drivers travelling less than 20 km daily, essentially within urban areas. This average distance covered each day corresponds to the needs of private individuals using their vehicles for the home-work run and also to most trips made using vehicles from company fleets.

Using an electric vehicle regularly requires safe, easy-to-use charging systems. These charging infrastructures must also allow the user to charge his vehicle during his usual journeys and not force him to stop specifically to do this. The innovative concept of electric vehicle charging is the possibility to charge it where the user usually parks instead of having to stop specially to charge it as is the case for vehicles with combustion engines which need to stop in service stations.

Environmental initiatives developed on a nation-wide scale are raising the awareness of companies to the importance represented by the arrival of more ecological shared, alternative and multi-mode means of transport.

For this reason several large French companies, the State and the local authorities have undertaken to acquire between 50,000 and 100,000 electric vehicles by 2015. This purchasing process will subsequently be widened to include companies with smaller fleets.

The electric vehicle is more environmentally-friendly than vehicles with combustion engines and provides an effective, concrete solution to reduce the impact of transport on the environment, particularly for short urban or suburban journeys. However, implementing electric vehicles in a company fleet requires the following conditions to be fully met:

- guarantee electric vehicle availability,
- set up a fleet management system or integrate an existing one,
- have an optimised charging infrastructure allowing efficient energy management.

The key factors for successful electric vehicle fleet management are therefore:

- set up efficient vehicle fleet management: journey organisation, rotation and sharing of vehicles, consumption monitoring, battery autonomy, etc.
- availability of a charging infrastructure: the company must ensure that the employee has access to a space and a charging station for his vehicle.
- Include charging station energy management in the management of the overall energy efficiency of the building.

\(\text{(1) source - Ministry for Ecology, Sustainable Development, Transport and Housing}\)
Electric vehicle fleets
What is an electric vehicle?

The motor

The car is generally fitted with one or more electric motors with a total power ranging from 15 to 100 kW depending on the size, usage and desired performance.

E.g. 48 kW (65 hp.) for a small 4-seater saloon.

Batteries and range

The battery bank supplies energy provided:

• either by recharging from an external source via cable
• or by vehicle deceleration, where the engine works as a generator.

The battery capacity is within a range of 5 to 40 kWh, with a total voltage of between 300 and 500V.

The vehicle's range depends directly on the battery's capacity and also on the type of journey (flat, varied, urban, etc.), the driving mode and the accessories used (headlights, heating, air-conditioning, windscreen wipers, other accessories).

The manufacturers announce an average driving range of 150km.
How are electric vehicles charged?

Charging modes

Mode 2: connection to a domestic socket
Connection of the electric vehicle to the building’s electrical distribution system via connector bases which plug into domestic single phase or three phase AC sockets with earth and power supply conductors.
A charging control function is either built into the plug or into a unit fitted to the cable. Charging is restricted to 10A.

Mode 3: connection to a specific socket
Connection of the electric vehicle to the building’s electrical distribution network via connector bases which plug into specific sockets on a dedicated AC circuit. A charging control function is built into the plug base. For reasons of safety, Schneider Electric only offers this solution.

Mode 3 guarantees users the highest level of safety and the best performance. Danger may arise from:
• a faulty system (damaged cable, faulty or aging installation, etc.;)
• mishandling by users (a child putting its fingers into the socket, etc.)
• incorrect usage (the user plugs the connector into the wrong socket, etc.)

In mode 3, the personal protection functions (e.g. differential circuit breaker) are in the fixed part, whereas in mode 2 they are built into the cable. This means that in mode 2, if the cable is damaged, there is no guarantee that these functions will not be affected. In all cases, property protection (e.g. lightning conductor) is not built into the cable.

Mode 4: DC connection
Connection of the electric vehicle to an external charger fitted with a specific cable and delivering direct current.
The charger incorporates the control function and electrical protection.
The time required for optimum charging of the vehicle's battery is directly linked to the electric power injected into the vehicle.

If the vehicle is connected to a domestic socket on the building’s standard electrical distribution network (mode 2), charging will be restricted to 10A, which means a longer time to charge it (around 10 to 12 hours).

If it is connected to a dedicated electrical circuit (mode 3), the time to charge is between 1 hour (three-phase, 63A) and 8 hours (single-phase, 16A).

In addition, quick charging stations (mode 4) delivering 500C/125A in AC allow the battery to be recharged to 80% of its capacity in only 15 minutes.
What to use as a basis for management of an electric vehicle fleet

To be more efficient, management of an electric vehicle fleet must take into account different factors regarding the vehicle (battery autonomy, time to recharge, etc.), the building (available energy, power of the installation, etc.) and the company (vehicle availability, cost of operating the vehicles and the infrastructure, etc.).

To ensure vehicle availability, the fleet manager:

- manages user priority,
- manages the rate of occupation of the charging infrastructure,
- optimises the energy costs.

For this purpose, the fleet manager will need to use a certain number of parameters regarding e.g.

- the charging infrastructure (maximum power, electricity contract subscribed to, etc.),
- the vehicles (type of vehicle, category, registration, maintenance dates, battery autonomy, etc.),
- the charging stations (number of stations, maximum power delivered, charging in progress, vehicle not connected, etc.),
- the drivers (profile, identifier, etc.),
- the reservation system (date and time of departure and arrival of the vehicle, distance travelled, etc.).

In most cases, the daily trips made by employees in a company are less than 100km but have very specific usage constraints:

- the vehicles may be used at set times (home-company run, rounds, deliveries, etc.) or the times may be random (on call, emergencies, etc.),
- the distance travelled by the vehicles may be short (targeted interventions, breakdown assistance) or very long (vehicle used by a sales rep or for rounds),
- the sales rep vehicle departures may be planned in advance or last minute.
How are electric vehicles made available? ...

Different strategies can be adopted by the fleet manager:

1 / first come - first served whatever the charge the vehicle still has left
The employee leaves his vehicle in a free parking space and connects it up. It immediately starts charging if the power available on the infrastructure allows it. If the power is not available, charging will be deferred.

Disadvantages: there is no guarantee that the vehicle will be available when the user wants it as there is no knowing when charging will start and end. Therefore the range of the vehicle is not known when it is taken out.

2 / charging according to the range left in the vehicle.
This strategy involves charging the vehicles with the lowest range first. This means the range each vehicle has left must be fed back to the infrastructure. The vehicle with the lowest range will be charged first.

Advantage: charging of the vehicles with the lowest charge starts as soon as possible.
Disadvantages: there is no guarantee that the vehicle will be available when the user wants it as there is no knowing when charging is supposed to end.

3 / range required for the intervention
The vehicle charging strategy depends on the information in the vehicle reservation system (time slots for use, mission, etc.). The following information is required:
• range remaining on the vehicle,
• range required for the mission,
• the date when the vehicle will be made available.

The automatic system managing the charging station infrastructure will distribute the power of the installation to satisfy the scheduled reservations.

Advantages: the vehicles are guaranteed to be available at all times. The system takes into account the characteristics of the journey (season, type of journey, preconditioning of the vehicle, length).
Disadvantage: a reservation system is required.

4 / group of top priority vehicles
This strategy can be used in addition to the previous ones.
These are vehicles whose battery must always have a minimum charge. The installation must be capable of charging all the top priority vehicles simultaneously.
e.g. utility vehicles intended for urgent interventions or on-call situations.

Implementation

Two technical criteria must be taken into account:
• the power available on the installation to charge the vehicles,
• the maximum charging power of the vehicle (normal charging 3kW, express charging 22kW, quick charging 43kW).

Two approaches can thus be adopted when setting up the infrastructure:
• a charging infrastructure allowing all the vehicles to be charged at the same time.

No system is used to distribute the charging power between the vehicles. The electrical installation is only used for a few hours during the day. This means the infrastructure will be oversized in terms of power and the costs of the electricity contract will be high.

• a charging infrastructure allowing the vehicles to be charged by distributing the charging power over time:
A system is used to manage the available power. The electricity installation and electricity contract are accurately sized.
... whilst at the same time managing your energy bill

Optimising operating costs for an electric vehicle fleet depends on several factors.

1 / tariff bands
The fleet management system takes into account the energy supplier’s tariff bands when charging the vehicles.

Two ways of doing this:

• disabling charging during certain tariff bands on one, several or all the charging stations. Disadvantages: difficult to combine energy savings with vehicle availability.

• spread vehicle charging over the time slots to ensure they are available at the cheapest cost. Advantages: the vehicles will be charged first and foremost during the cheapest time slots.

2 / the source of the energy supplied
The fleet management system takes into account information from the energy supplier with regard to the type of energy (low-carbon electricity) depending on the times of day.

Two ways of doing this:

• disable charging when the energy is not low-carbon on one, several or all the charging stations. Disadvantages: difficult to combine periods of low-carbon energy with vehicle availability.

• distribute vehicle charging, restricting charging when the energy supplied is not low-carbon. Advantages: vehicles will be charged first and foremost during low-carbon periods.

Low-carbon energy is produced in a way which does not generate CO₂.
The charging infrastructure, the key success factor for electric vehicles
Charging vehicles outside the company

Although the vehicle is normally charged on the company car park, the vehicle may require charging outside this location. In this case, the different types of charging infrastructure will allow full charging of the vehicle to fit in with the user’s habits with regard to places and length of stops.

• For long stops (night at home, day at the work place), a full charge of between 6 and 8 hours can be done on a domestic installation or on a car park installation (company).
• For shorter stops of 1 or 2 hours (e.g. during lunch or a meeting), the driver can top up his charge on a car park, a shopping centre or at the roadside.
• Finally for quick charging lasting 15 to 20 minutes, charging will be carried out in a service station (e.g. in case of emergency). It is possible to install a quick charging station on fleet car parks for ambulances or taxis for example.

In this context, the fleet manager will need to have a way of tracing the charges and journeys carried out outside the company to allow him to know the charge of the fleet at any given moment:

• what vehicle has been charged?
• where did this take place?
• what power was delivered?
• how much did the charging cost?
Associated services

The charging stations transfer operating information via a hard-wired connection to the cabinet containing the automatic charging management system. The data is stored on a database to be used by the management system which may be located either:
- locally: if a system is already operational and adapted for electric vehicle management,
- remotely: if operation is off-site or sub-contracted to a service provider.

Services for the electric vehicle fleet manager

Reservations management:
- ensure each vehicle has the necessary range for the type of missions to be carried out.

Vehicle management (administrative, technical and financial management):
- electricity consumption of each vehicle
- state of health of the battery (age, number of charging cycles carried out, level of charge remaining, etc.) and maintenance calendar.

Supervision of stations installed on one or more sites with energy, user and infrastructure management.

Services for the driver

Mobile applications communicating with the system database provide information regarding the state of the batteries and allow the electricity consumption of the vehicle to be remotely consulted, give the remaining charging time, the parking time, the level of CO₂ saved, the cost of the vehicle per km, including the battery rental.

Moreover, the position determination functions available via the vehicle GPS and smartphones allow the range required for the next trip to be calculated, nearby charging stations to be located or the places where the vehicles are parked to be memorised.
Conclusion

The increasing use of electric vehicle fleets is a response to the political commitment to reducing the carbon footprint of the transport sector. Several car manufacturers already produce 100% electric cars but their inclusion in a company fleet means mobility needs to be radically restructured, particularly with regard to the concept of car-sharing.

Suppliers of intelligent charging solutions, aware of the issues linked to the sector, provide their expertise and support companies in the process of integrating electric vehicles into a fleet.

Indeed, for the political aims to be put into practice, it is essential for companies that the cost (TCO) of a fleet of electric vehicles should be close or identical to that of a fleet of combustion vehicles. As the initial cost is greater, intelligent management of the charging infrastructure and vehicle availability is necessary for the company to see a return on the investment.

More than ever, the charging infrastructure is a key success factor for the electric vehicle.
Glossary

• Fleet manager: person managing the company vehicle fleet

• Automatic vehicle fleet charging management: technical measure controlling electric vehicle charging via the charging stations (based on criteria such as tariff bands, available power, vehicle priority and reservation slots booked by the drivers).

• Station or hub: technical device to which the vehicle is connected to charge it.

• Cable: technical device used to connect the vehicle to the station.

• Key cupboard: technical device delivering the keys of the vehicle booked by the driver when he comes to get it

• Server: technical device which recovers, stores and transfers data

• Web service: utility which processes and formats data from the server for a user

• Reservation manager: technical measure allowing the driver to book a vehicle via an interface

• Station manager: technical measure managing the power supply to the stations and energy management