Developing an adaptable and flexible electric vehicle charging station

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Executive summary

The charging infrastructure for electric vehicles must be able to adapt to changes in a developing market. The adaptability of the terminals is essential to ensure charging regardless of the connected vehicle or the habits of users. This paper discusses the problems related to the adaptability of charging system infrastructure to meet the needs of interoperability between all players in the electric vehicle market.

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Summary

This white paper discusses the problems related to the adaptability of charging system infrastructure to meet the needs of interoperability between all players in the electric vehicle market.

Introduction

Available in many strategic locations, the charging terminals for electric vehicles must provide a service in line with the expectations of drivers.
In fact, several factors impact the use that will be made of the charging system infrastructure:

- the parking location
- its duration
- the technology embedded in the vehicle
- the driver's mileage need.

To address all of the needs and irrespective of their place of installation, the charging terminals are designed to be adaptable and scalable.

Company parking: the electric vehicle is particularly suited for work-home-work commuting. When parking in the day, a standard charge will be performed during office hours. Thus, at the end of the day, the vehicle will have full power to make the return trip.

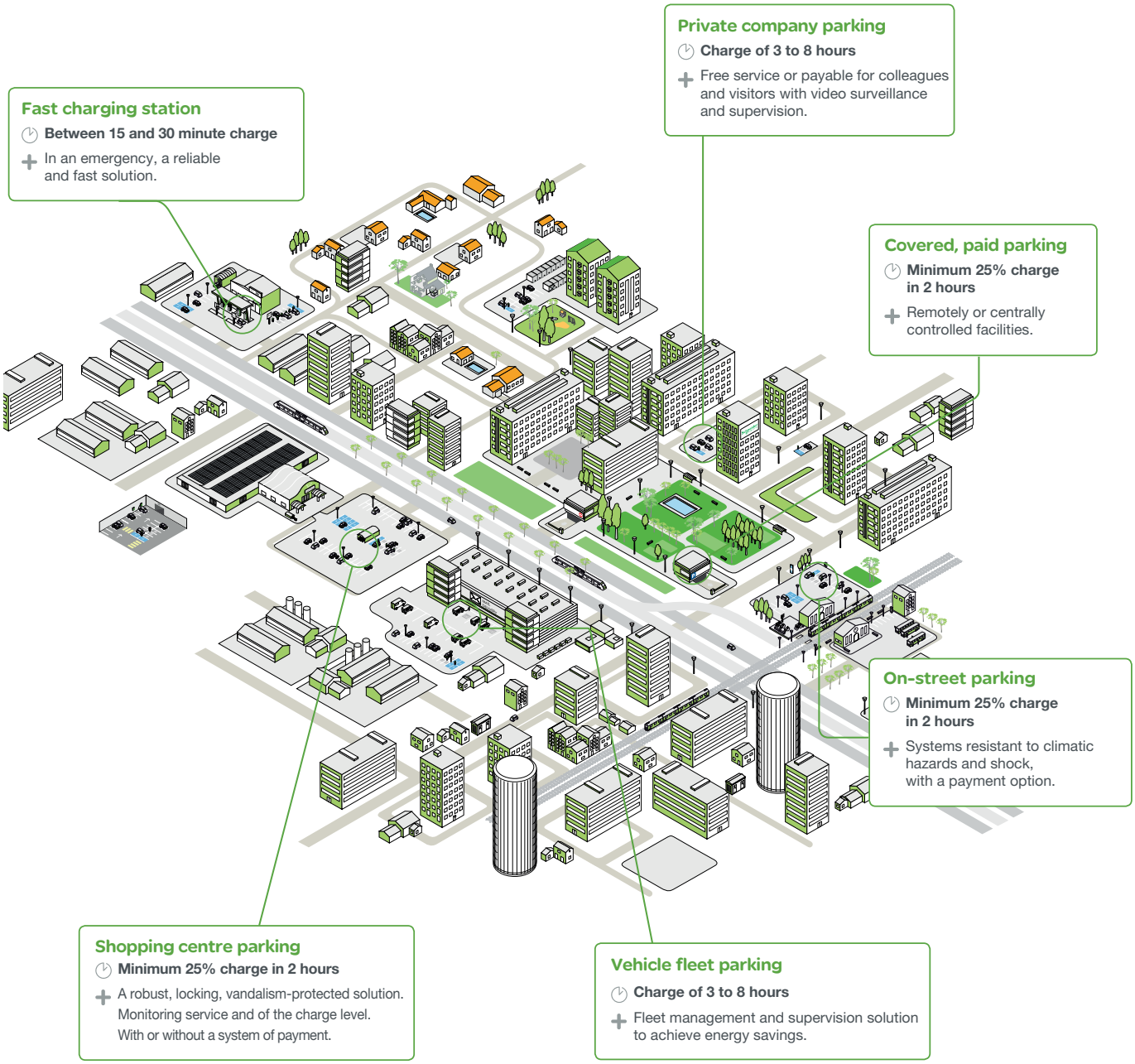
Public or street parking: public charging of the electric car will be the primary charging method for urban dwellers who do not have private parking. It will also be available on trips into town, with varying charging times.

Supermarket, restaurant or cinema parking: a standard or accelerated charge is performed during the ongoing activities. Connecting the vehicle at every extended period ensures the good availability of the vehicle when needed.

Station service: The fast charging system allows an 80% battery charge in minutes. Particularly suitable for long journeys, this solution quickly enables the recovery of a large mileage range.

charging time	range in kilometres				
	standard single-phase charging 3 kW	accelerated single-phase charging 7 kW	standard 3-phase charging 11 kW	accelerated 3-phase charging 22 kW	fast three-phase charging 43 kW
10 min.	4	8	13	26	59
30 min.	11	25	39	78	120
1 hour	21	50	78	150	
2 hours	43	100	150		
4 hours	96				
7 hours	150				

Estimates based on a vehicle having a maximum range of 150 km.


Fast charging station
Between 15 and 30 minute charge
In an emergency, a reliable and fast solution.
Private company parking
Charge of 3 to 8 hours
Free service or payable for colleagues and visitors with video surveillance and supervision.
Covered, paid parking
Minimum 25% charge in 2 hours
Remotely or centrally controlled facilities.
On-street parking
Minimum 25% charge in 2 hours
Systems resistant to climatic hazards and shock, with a payment option.
Shopping centre parking
Minimum 25% charge in 2 hours
A robust, locking, vandalism-protected solution. Monitoring service and of the charge level. With or without a system of payment.
Vehicle fleet parking
Charge of 3 to 8 hours
Fleet management and supervision solution to achieve energy savings.

What is a charging station for electric vehicles?

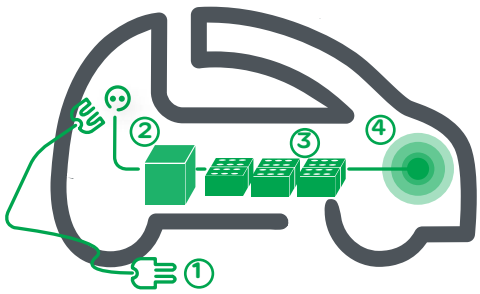
More than just a power outlet, the charging terminal allows for charging electric vehicle safely with maximum efficiency.
Unlike a household outlet, which does not include any specific function, the charging terminal is designed specifically for this operation and that any model of electric vehicle be connected to the terminal (see following page).

The car is normally equipped with one or more electric motors with a total capacity ranging from 15 to 100 kW depending on size, usage and desired performance.
The battery pack provides power either from the charge provided by the cable from an external source or when driving during the deceleration of the vehicle, the engine operating as a generator. The battery capacity ranges from 5 to 40 kWh with a total voltage of 300 to 500 V.

Equipment necessary for the charging of the vehicle

Today, all electric vehicles can be charged with 3 kW (standard charge) AC. Soon, vehicles will be charged with AC up to 43 kW / 63 A (fast charge).

Several manufacturers also allow for a fast DC charge. The charging options depend on the manufacturer's choice regarding the embedded technology in the vehicle.



1. Connection socket for charging
2. Integrated charger
3. Battery pack allows for the storage of energy
4. Inverter and traction motor(s)

In AC, from 3 to 43 kW:

- the charger: it is integrated into the car and adapted to the specific characteristics of the onboard battery. It converts the alternating current of a 230V single-phase station or a three-phase 230V-400V into direct current DC injected into the battery. It incorporates charging safety devices and generates information on the driving range of the battery. For security reasons, the charger will limit its current intake to the maximum level acceptable by the charging station terminal and the car.
- the charging cable: multicore, it is equipped with two sockets:
  - a male type 2 or 3 socket on the side of the charging terminal or a cable attached to a 43kW terminal
  - female socket type 1 (single phase) or 2 on the side of the vehicle.

DC (CHAdeMO), from 10 to 50 kW:

- the charger: is integrated into the charging terminal. It incorporates charging safety devices and generates information and communicates with the user from the screen of the terminal. For security reasons, the charger will limit its current intake to the maximum level acceptable by the car
- the charging cable is secured to the terminal: multicore, it is equipped with a female CHAdeMO specific socket for the vehicle side.

What is *CHAdeMO*?

The DC charge protocol was initially developed by four Japanese automakers. Adopted by 160 companies in over 20 countries, it is fast becoming the global standard.

Different charging modes

Mode 1 and 2:

Connecting the electric vehicle to the household power grid through a regular socket outlet that receives the single-phase or three-phase AC loads with grounding and supply conductors. In mode 2, the cable has a protective device.

A power limit load is being considered for mode 2 to avoid any risk of overheating the electrical installation. Several countries in Europe already have the limit now between 8 and 10A.

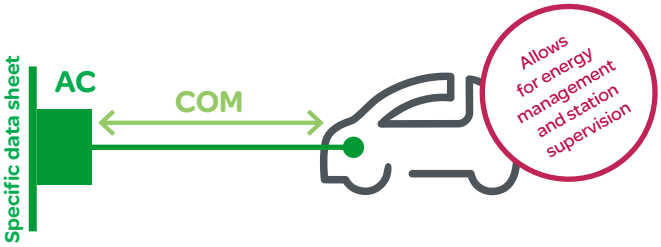
Mode 1:
direct connection to a household outlet

Mode 2:
protective device incorporated in the cable

Mode 3:

Connecting the electric vehicle to the building power grid through a specific socket on a dedicated AC circuit. A charge control function is integrated to the base of the socket.

Mode 3 allows for continuous communication between the vehicle and the charging system. It can only be achieved with a type 2 or 3 socket or a cable attached to the infrastructure side, specifically designed for this use.



Mode 3:
protection device integrated into the installation

Mode 4:

Connecting the electric vehicle to an external charger equipped with a specific fixed cable and delivering DC current. The charger is integrated with control functions and power protection.

Mode 4:
DC charger integrated into the installation

The architecture of the charging terminals

To meet the specific requirements of each installation, there are two types of charging architecture: autonomous terminals and clusters of terminals equipped with energy control boxes.

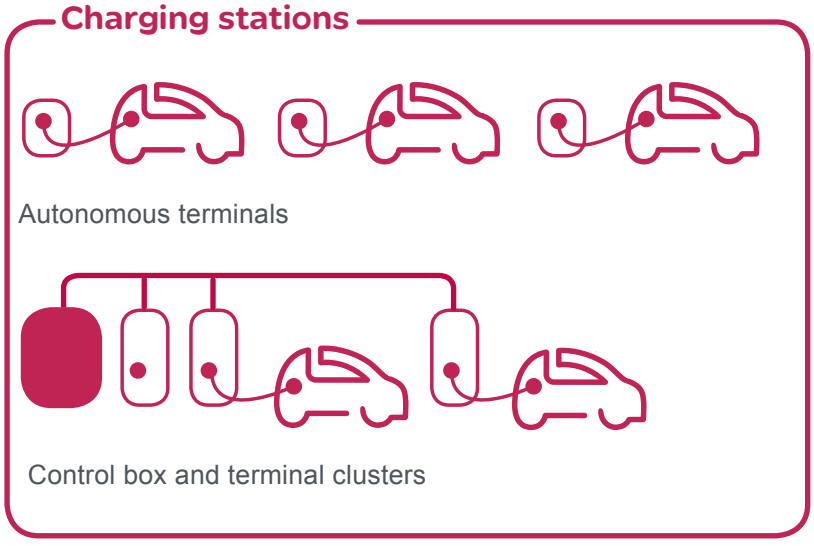
The autonomous terminals provide the charge to electric vehicles in an independent manner. Each terminal is directly connected to an electrical supply and protection panel.

When several terminals are needed, they can either operate independently as autonomous terminals or be associated with a distribution system and centralised management (control box). The system's main functions are to provide power, protection and operational control of the cluster of terminals based on user needs and the available energy in the building. The clusters, by design, facilitate the extension of the existing stock.

Connecting a network of communicating charging terminals to a control system or remote monitoring can improve the use, charging and energy costs of the vehicles.

The fleet management system takes into account the uses and optimises the following:

- the price ranges and the nature of energy (a low-carbon source) of the energy supplier
- the energy management available in the building
- vehicle and charging terminal availability.



How can the flexibility and adaptability of charging station be ensured?

Adapted to needs...

Several criteria are taken into account in shaping and adjusting the charging system infrastructure to user needs:
- to ensure the mobility of goods and people
- optimise energy costs
- minimise environmental impact.

Manufacturers of charging terminals have many support services for the deployment and use of the charging system infrastructure.

The charging terminal itself brings together control equipment and a specific socket. This device enables an electric power supply to the vehicle, and consists of a contactor and a circuit board as well as various equipment depending on the models (surge protection, power supply, etc.).
The user controls the operation of the terminal via an interface consisting of push buttons eventually linked to an information screen or via a touch screen.
The terminals can also benefit from an optional monitoring system through an internet connection.

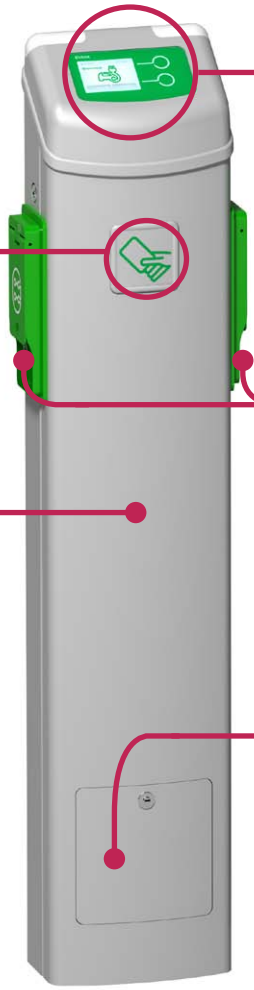
...and for the use

Payment
(Cell phone, automatic payments, payment without contact, etc.)

Identification module
(Key, code, RFID, digital print, video, etc.)

Vandalism protection
(Surface protection, reinforced buttons and screens, etc.)

Personalisation
(Colour, company logo, advertising space, etc.)



Interface screen
(Charge control, information about the state of the charge, advertising, etc.)

Push buttons and indicator lights
(Simple command from the terminal, information, etc.)

Charging point socket
(number of sockets, available power, connectivity, etc.)

Electrical protection
(Colour, company logo, advertising, etc.)

What are the advantages of supervision?

Optimisation of energy costs

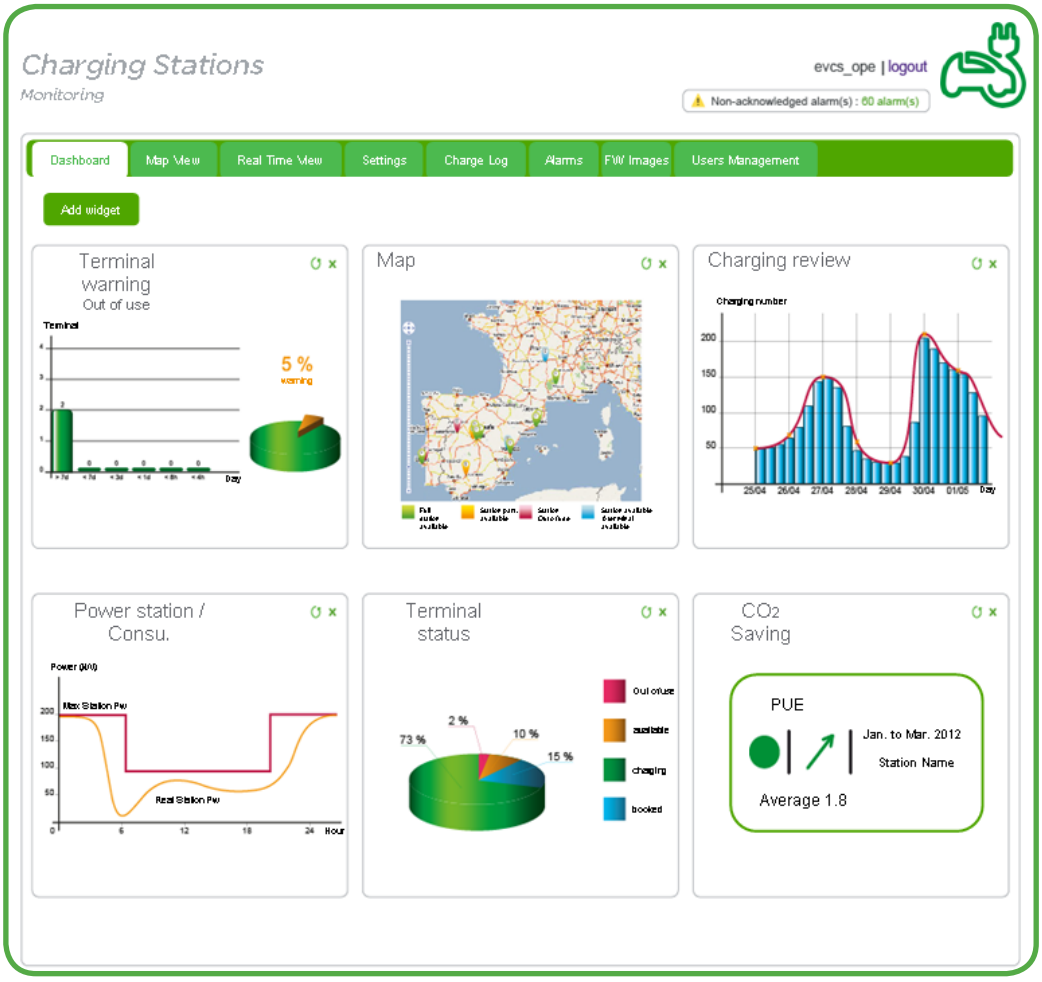
The power of station depends on the number and characteristics of the vehicles being charged. Its automatic management continuously monitors it and can provide modulation orders to the terminals. Optimisation requires the specification of electrical power allocation rules due to variations in building consumption.

Carbon footprint

Consumption during the lowest priced periods is preferred. The management system allows the real-time monitoring of the CO_2 saved.

Control and maintenance

The indicators and counters associated with the processing software provide a continuous view of the station availability. This information allows the optimisation of administration scenarios and efficient maintenance of the station. Centralised management of terminals also ensures the scalability of the system (software updates, hardware, etc.)



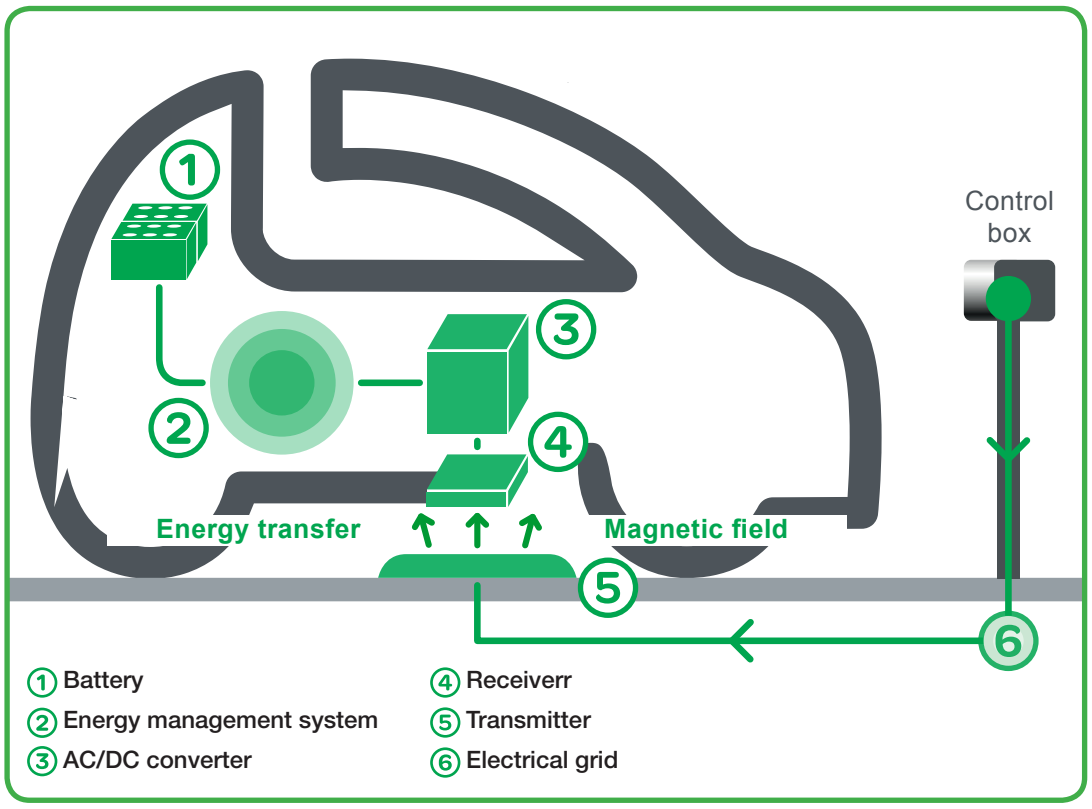
What are the developments in the future?

Charging by induction

Many manufacturers are currently working to propose that local communities and businesses end charging by cable and sockets for a non-contact system of electrical charging for electric vehicles.

The system designed to be installed on the ground can be integrated on a large scale in the asphalt of a road or attached to off-street parking places.

The charging of the battery of a vehicle parked above the system will be done wirelessly by induction.



The battery exchange

A network of stations allowing the exchange discharged batteries for charged batteries is under development.
Some automakers are interested in this technology even though the initial investment is quite significant.
To replace the battery, the vehicle is placed on an automated platform that decouples the battery and replaces it with another fully charged one. The exchange procedure is equivalent to the stoppage time in a classical service station.
The recovered batteries can be charged on site and during off-peak hours when the energy is the most green.

Main conclusions

The charging infrastructure for electric vehicles must be able to adapt to changes in a developing market. Many changes in equipment and technologies are expected. The adaptability of the terminals is essential to ensure charging regardless of the connected vehicle or the habits of users.

Industry standards are still evolving, however, market participants are working to set up labels such as "EV Ready" to ensure the interoperability of the vehicles and charging infrastructure. The goal is to ensure charging in all cases regardless of the vehicle configuration or terminal. This standardisation is an absolute necessity for the future development of the electric vehicle market.

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