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Electrification of Heavy-Duty Mobility in France

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The transport sector in France accounts for one third of the nation's final energy consumption and greenhouse gas emissions, with heavy-duty vehicles contributing a significant portion. While only 0.2 % of trucks in France are electric, transitioning to electric mobility is a crucial strategy for decarbonization, particularly given France's low-carbon electricity mix dominated by nuclear and renewables. Regulatory frameworks in France and Europe are driving this shift, although the heavy-duty electrification rate remains low.

Truck manufacturers are aligning with these goals by developing diverse electrification strategies, including short-haul electric vehicles using AC charging and long-haul solutions incorporating MCS charging. Despite progress, challenges like high TCO and grid adaptation issues remain. EDF Group is actively preparing to support the transition through increasing its low-carbon electricity production, deploying different kinds of charging infrastructure, and proposing innovative smart charging solutions via its subsidiaries, positioning itself as a key player in the electric mobility ecosystem.

Introduction

In France, the transport sector accounts for 34 % of the nation's 1,532 TWh final energy consumption and contributes to 32 % of the greenhouse gas emissions. Notably, 25 % of these emissions are attributed to heavy-duty mobility. Among motorized vehicles in France, 3.5 % light vehicles are battery electric (BEV, hybrid vehicles not included) as opposed to only 0.2 % for trucks.

In addition to being a more efficient energy source, French electricity is particularly low in carbon, as more than 90% of the country's mix is from nuclear and renewable sources. Given the sector's considerable energy consumption and emission share, electrification of transport emerges as a major lever for reducing CO_2 emissions.

As a key player in the ecosystem at many levels, EDF Group is actively promoting electric heavy-duty mobility and preparing for its widespread adoption by adapting its short and medium-term strategies.

1 Current trends in heavy-duty mobility

1.1 Policies in Europe and in France

To address the decarbonization of the transport sector, both the European Union and the French government have introduced a range of legislative measures.

In April 2024, the EU tightened existing CO_2 emission regulations, establishing a new target of 45 % reduction by 2030, in replacement of the previously planned 30 % reduction. The tracking of emissions is carried out by using on-board systems installed in each vehicle and approved by the European Union.

At the same time, the European Parliament and EU Council adopted at the beginning of 2024 the Euro 7 regulations, more restrictive towards diesel trucks than Euro 6. Notably, it will regulate the emission of NOx particles and fine particles with a diameter greater than 10 mm (instead of 23 mm in Euro 6) to further reduce harmful emissions and improve air quality in urban and peri-urban areas. The European Automobile Manufacturers' Association (ACEA) estimates the extra cost of ICE trucks caused by the application of Euro 7 at around 12,000 €.

Another policy that benefits electric mobility is the extension of the European Emission Trading System Phase 2 (ETS-2) to the mobility sector. Set to begin in 2027, it will apply a carbon price to road transport fuels like gasoline and diesel, therefore encourage a shift to low-emission, including electric mobility.

Moreover, to deal with the well-known problem of reduced payload capacity due to the significant weight of the battery, the European Union's Weights and Dimensions Directive is currently being revised to allow at least a 4-ton increase in the maximum authorized weight. Height and weight limits have also been raised for intermodal transport. Weight limits is a key issue in Europe. If some countries allow, for example, 44-ton heavy-duty trucks, the European limits remains 40-ton, even if the trip is exclusively across these countries. Note that in France, the weight limit is 44 tons and there is no height limit.

In France, the National Low Carbon Strategy (SNBC) aims to achieve carbon neutrality by 2050, and it sets out the emission reduction trajectory for all sectors of activity. For the transport sector, CO_2 emissions should be 28 % lower in 2030 than in 2015.

Table 1: CO_2 emission trajectory for the transport sector according to SNBC

	2015	**2030**	**2035**	**2050**
CO_2 Emissions	137 $MtCO_2eq$	90 $MtCO_2eq$	60 $MtCO_2eq$	4 $MtCO_2eq$

The SNBC associates the use of biofuels and hydrogen with electricity to accelerate the decarbonization of the heavy-duty transport sector. The latest iteration of this policy outlines key projections for implementation.

Table 2: Energy usage for transport recommended by the SNBC

SNBC3 (target of the fleet according to the energy used)	**2020**	**2025**	**2030**	**2035**	**2040**
Fuel	**97%**	**73%**	**50%**	**34%**	**2%**
NGV / Bio-NGV	**3%**	**20%**	**25%**	**30%**	**39%**
Electricity	**-**	**7%**	**22%**	**27%**	**45%**
Hydrogen	**-**	**-**	**3%**	**9%**	**14%**

These regulatory measures have driven an increase in electric truck sales across France. However, the market share remains relatively low.

1.2 World vs France

In 2023, China accounted for 89 % of new electric truck sales, maintaining its position as the leading market, as in previous years. However, electric truck sales in Europe have shown significant growth, as they tripled since 2022. Despite these advancements, the market share of electric trucks remains low in both regions, at 1.6 % in Europe and 2.8 % in China.

In the second quarter of 2024, the market share of electric trucks in Europe remained roughly equivalent to that of 2023. Germany accounted for the largest share of sales at 37 %, followed by the Netherlands at 17 % and France at 16 %.

In 2023, there was 39,3 million light vehicles, 6,5 million light commercial vehicles and 625 000 trucks in France, with the last two categories accounting for less than 15 % of the total. However, they travel more distance per year and consume more energy as they are heavier and larger than light vehicles. By considering their average consumption, we can calculate the total CO_2 emitted by each category and observe that commercial and heavy-duty vehicles are responsible for almost 40 % of the CO_2 emissions of the transport sector. These figures show that the electrification of the heavy-duty mobility segment is a crucial lever for decarbonizing the transport sector in France.

Table 3: Total yearly emissions for each vehicle category

2023 data	Cars	LCV	Trucks	Buses
Total vehicles	39.3 M	**6.5 M**	**625 000**	93 900
Average km/year	11 700	13 400	75 000	32 300
- petrol	6.8 L/100 km	9.0 L/100 km	-	-
- diesel	5.9 L/100 km	7.7 L/100 km	33.0 L/100 km	30.4 L/100 km
Yearly emissions	80 Mt CO_2eq	**24 Mt CO_2eq**	**30 Mt CO_2eq**	5 Mt CO_2eq

By the end of 2024, the total fleet of electric trucks in France counts 1,396 vehicles. Among these, over 942 are Renault Trucks-branded vehicles, followed by 168 from IVECO, 96 from FUSO, and 72 from VOLVO. In addition to this currently low number of electrified trucks, its growth rate is also slowing down, decreasing from 210 % in 2023 to 86 % in 2024. This trend highlights the significant challenges ahead in electrifying the rest of the fleet and in developing the necessary charging infrastructures to support it.

1.3 What strategies and developments are truck manufacturers planning to implement in the coming years?

To meet European CO_2 reduction regulations, European truck manufacturers have committed to ensuring that 40–50 % of their new sales by 2030 are zero-emission vehicles, with this proportion set to increase further in subsequent years. While they are also developing hydrogen-powered solutions and leveraging biofuels, their decarbonization strategy mainly focus on BE vehicles as the primary solution. For instance, Renault Trucks has announced that 100 % of its sales will be zero-emission vehicles by 2040. Of these, 70–80 % are expected to be BEV, with the remainder powered by hydrogen or biofuels.

Truck manufacturers plan to implement different charging strategies based on the type of vehicle and its intended use. Vehicles designed for short and medium-distance operations, such as urban delivery, are typically equipped with batteries ranging from 200 to 300 kWh and support both AC and DC CCS2 charging. For long-haul transport, current battery usable capacities reach 400 to 700 kWh, and will charge exclusively via DC CCS2 and an optional DC MCS system.

Figure 1: Renault Trucks E-Tech exposed at EDF R&D during a technical visit
Renault Trucks courtesy – @EDF 2024: J-M. Fourmigué

Figure 2: MAN eTGX trucks arriving at EDF R&D lab for test campaign
MAN courtesy - @EDF 2025: V. Murin

2 Strategic positioning and emerging opportunities

2.1 Challenges and prerequisites for the development of electric trucks

Currently, the primary challenge for the development of electric heavy-duty mobility is the disadvantaging total cost of ownership (TCO) compared to thermal vehicles. While cost parity has nearly been achieved for light and commercial vehicles, it remains significantly more distant for heavy trucks. Although electric trucks benefit from lower maintenance and energy costs, their substantially higher upfront purchase costs can discourage logistics operators and fleet managers from making the transition.

To address this challenge and encourage this transition, major companies such as IKEA have introduced requirements for their transport providers to incorporate a certain proportion of electric vehicles into their fleets.

Another challenge lies in adapting the electrical grid to accommodate high-speed charging infrastructure connections and enhance its flexibility through solutions such as energy storage and demand management systems. In France, this represents a significant focus area for grid operators like Enedis.

2.2 Leading electricity supplier, EDF is prepared to support a charging network with a reliable supply of low carbon electricity

By 2035, EDF anticipates an important electrification of energy usage by the substitution of energy fossils to electricity, leading to an additional electricity demand of more than 100 TWh, part of which will be driven by electric mobility. Notably, EDF expects a large number of charging stations for heavy-duty mobility to be deployed in France, and more generally in Europe to support the growing adoption of BEVs.

In a scenario where all vehicles are electric, by assuming that the average consumption of an electric car is 20 kWh / 100 km[1] and that its average mileage is around 13,000 km, we multiply these two figures by the forecast number of light vehicles in 2035 and obtain a total electricity consumption of 39 TWh per year. For heavy-duty mobility, trucks currently consume an average of 150 kWh of electricity per 100 km[1], but with the development of more aerodynamic and more efficient models, we have already seen that the new models developed reduce this consumption to 100 kWh / 100 km[1]. Multiplying this figure by the average distance travelled by a truck and by the forecast number of trucks on the road in 2035 gives us a total consumption of 12 TWh / year. In conclusion, these two segments combined will consume 51 TWh of electricity in 2035. The 2023-2035 projection of the French Transmission Network Operator, RTE, forecasts total consumption of 580 TWh to 640 TWh[2] in the country. Thus, even in the ambitious case of all vehicles being electrified by 2035, the sector's electricity consumption would represent less than 10 % of total consumption, which is largely acceptable.

[1] It should be noted that these consumptions are very conservative because they are measured currently and not those that will exist in 2035, which will be greatly reduced.
[2] In 2024, the French **Energy** consumption is around 1,700 TWh including 565 TWh for the Transport sector. 3% of these 565 TWh are electric, the rest is from fossil energy.

Table 4: Electricity Consumption Forecast in the transport sector by 2035

Electric vehicle	Cars*	Trucks (current technology)	Trucks **
Average consumption	20 kWh / 100 km	150 kWh / 100 km	100 kWh / 100 km
Average mileage	13 000 km / year	75 000 km / year	75 000 km / year
EV fleet by 2035	15 000 000	162 000	162 000
Unit consumption	2.6 MWh / year	112 MWh / year	75 MWh / year
Fleet consumption ***	39 TWh / year	18 TWh / year	12 TWh / year

* Light road vehicles ** "2024 New Technology" Trucks

*** France Electricity Consumption: 445 TWh in 2023 –RTE (the French Transmission Network Operator)
2023-2035 projection: between 580 and 640 TWh in 2035

To meet electricity demand for all new uses, including electric mobility, EDF plans to increase its low-carbon electricity production capacity, targeting for an annual output of 550 TWh to 600 TWh by 2035, compared with 445 TWh in 2023. As a result of this policy, the carbon intensity of electricity is projected to decrease from 37 g CO_2 per kWh in 2023 to 22 g CO_2 per kWh by 2035.

As of April 2025, the French electricity generation capacity is composed by 41 % nuclear, 17 % hydraulic, 16 % wind, 13 % solar, 9 % gas, 2 % oil, 1 % biomass and 1 % coal. In reality, low-carbon production methods are prioritized, and fossil fuels are used as a reserve in the event of special situations such as high demands or breakdowns. Generally speaking, around 70 % of electricity is generated by nuclear power plants and only 1% by fossil fuels.

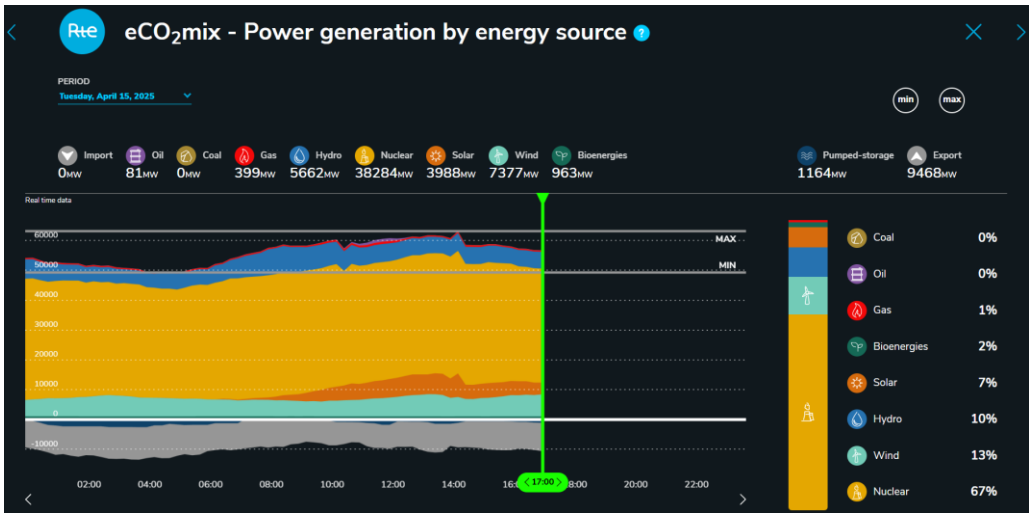

Figure 3: Real-Time Electricity Mix, 15th of April, 2025, 5 pm

2.3 EDF joins the electric mobility ecosystem as a mobility operator and offers smart charging solutions

Through its subsidiaries Izivia and Dreev, the EDF Group aims to establish itself as a key player in the electric mobility ecosystem and especially in heavy duty mobility.

Izivia is a Charge Point Operator primarily targeting large corporate clients. They have notably recently partnered with McDonald's to equip all their restaurants' parking lots across France with 150 kW DC chargers.

Figure 4: McDonald's charger operated by Izivia

Although, until now, Izivia's business focused mainly on light vehicles, Izivia is developing a new offer "Izivia Trucks" to meet the specific needs of shippers and logistics providers. It is composed of several packages allowing customers, for example, to monitor the charge of their fleet in real time, to manage it smartly and to track their consumption to optimise costs and performance. For instance, Izivia signed with France Boissons a contract adapted to their needs which can vary significantly from one client to another. The possibilities of this offer include a new 43 kW AC charger and several DC fast chargers specially designed for trucks with power ranging from 50 to 400 kW. One of these chargers has got a 'satellite' architecture in order to answer to specific issues.

Figure 5: Modular and mixed installation with DC fast chargers

Depending on the type of electric truck chosen, which in turn depends on its use, Izivia needs to propose various solutions, all designed specifically for charging heavy duty trucks. Recharging for long periods at high currents generates, as a matter of fact, heat that is not compatible with the classical charging points for light vehicles; reliability and longevity will be no longer guaranteed.

For the moment, Izivia Trucks is limited to depot charging but the company is currently exploring the possibility of expanding into on-route charging.

Dreev specializes in Smart Charging solutions and works closely with Izivia to offer their customers an adapted charge optimization solution in addition to their basic mobility contract. This technology represents a significant advantage for intelligently managing the charging of vehicle fleets. They use an algorithm developed by EDF R&D to integrate both the fleet's mobility needs and fluctuating electricity prices. In particular, they are deploying a smart charging contract for all RATP (state-owned transport operator of Paris Region) electric buses, giving them an economic advantage estimated at a 20 % bill reduction and 'with a strict guarantee of operating performance', as communicated by RATP group. In the logistics field, DREEV is currently working with Izivia on their offer for France Boissons to develop a smart charging contract like that of RATP, but adapted to the use of trucks, which is different from buses.

Dreev is also actively researching Vehicle-to-Grid (V2G) solutions which may also be of interest for fleet management in the future.

All these entities and their projects are supported by the expertise of EDF R&D division. All equipment undergoes rigorous testing under diverse conditions to ensure reliability and performance. In some cases, collaborative efforts with manufacturers allow for further refinement and optimization, ensuring the final commercialized products deliver the highest possible performance.

3 Different charging solutions designed to address specific requirements of different use cases

3.1 Up to 43 kW AC charging for depot or destination charging

Originally developed around 2013 to support the first Renault Zoe electric vehicles capable of charging at 43 kW in AC, this charging mode was soon discontinued in favour of 22 kW AC charging. The unique architecture required to receive such power levels without overheating introduced additional technical challenges and has not been replicated in other vehicles. The widespread adoption of DC fast charging has also made high-power AC charging less relevant.

More recently, 43 kW AC charging has regained interest, particularly for depot-based truck charging. In depot environments, where charging speed is less critical compared to on-route charging, the lower cost of AC chargers offers substantial financial advantages for logistics operators and fleet managers. Compared to 22 kW charging for light vehicles, larger truck batteries can benefit from this higher power level, reducing charging times to practical durations.

For instance, a Renault Trucks E-Tech D equipped with a 280-kWh battery can be charged in 6 hours and 30 minutes. Depending on the specific use case, this charging duration can be comparable to the typical time spent at a depot at night. In this configuration, it is suitable for the logistician to have a 1:1 charge point/truck ratio as all trucks need to be charged at the same time.

Between 2024 and 2025, the electric mobility lab of EDF R&D tested two versions of a 43 kW AC charger designed for heavy-duty trucks. The first version was a modified version of a 2*22 kW charger for light vehicles. We tested it under real conditions for trucks, i.e. for more than 8 hours and at different atmospheric temperatures. Although it was fully functional and capable of delivering the power required, there were a few areas for improvement, in particular overheating issues. Indeed, as some components are not suitable for prolonged use at 43 kW, they quickly exceed the maximum temperatures recommended in the standards. This was particularly the case for cables which were too small in diameter. After taking our comments on the first prototype into account, the charger manufacturer came up with a second improved version. As well as solving the issue of overheating, the charger has been completely redesigned for heavy duty truck use. The new prototype is higher, features a larger light indicator on top for better visibility and a 10 m cable to reach the vehicle socket regardless of the truck’s position.

This experience was very instructive and informative regarding the difference of requirements between light-duty and heavy-duty vehicle applications.

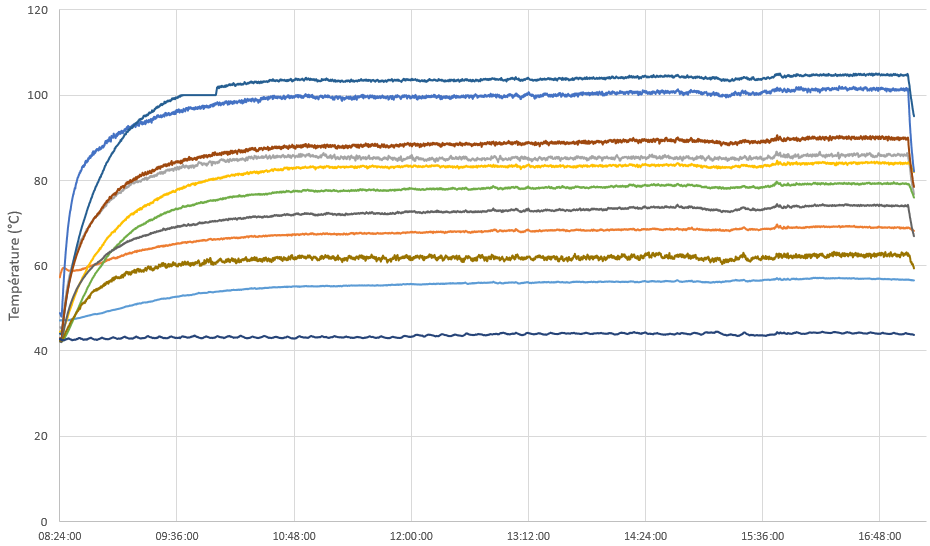

Figure 6: Temperature evolution of different components during test campaign (first prototype)

3.2 CCS2 for medium-speed charging

CCS2, the European standard for DC charging, is currently the most widely used standard for light vehicles at highway charging stations and destinations such as supermarkets and restaurants. This same charging mode is expected to become the predominant DC standard for heavy-duty trucks, more particularly for short and medium haul.

Electric trucks entering the market will leverage the existing charging infrastructure for light vehicles, supplemented by new networks dedicated to heavy-duty. Notably, the Milence network aims to establish 1,700 charging points across Europe, specifically designed to answer the needs of electric trucks.

With maximum charging powers ranging from 20 to 500 kW, CCS2 is well suited for charging trucks on-route, but also in depots, with shorter downtimes than in AC.

With the highest charging powers available with CCS2, a 280 kWh Renault Trucks E-Tech can be fully charged in less than an hour. In reality, as most CCS charging stations have a maximum power lower than 300 kW, charging times may extend beyond an hour and, in some cases, take several hours depending on the battery capacity and state of charge.

In a context of rapid growth of the electric mobility ecosystem, the EDF R&D e-mobility laboratory had the opportunity to test several chargers to support our subsidiaries in the deployment of charging infrastructure and to deepen our expertise in this area. Indeed, it is crucial to test all equipment under all possible real-world conditions as it is not uncommon to observe differences between the performance claimed by manufacturers and the reality. Operating and load-balancing strategies can also vary from one charger to another and must be studied in detail. Among the key tests addressed in our programs, we notably assess charging efficiency across various voltage and current levels, thermal performance and long-duration charging sessions. As with AC charging, the latter is particularly critical for heavy-duty vehicle usage.

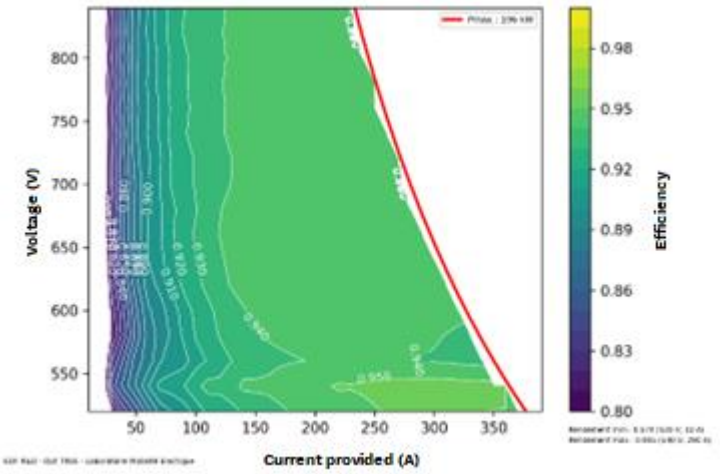

Figure 7: Example of efficiency map

3.3 MCS for high-speed roaming charging

Under development since 2020, the Megawatt Charging System (MCS) standard will allow charging at power levels up to 3.75 MW once its standardization is finalized, expected by 2025. This technology promises to significantly reduce charging times, allowing a MAN eTGX truck to charge in less than 20 minutes, or potentially as little as a few minutes. However, this remains theoretical, as 3.75 MW MCS is primarily designed to charge much larger batteries, particularly for long-haul trucks with substantial energy storage requirements.

Based on standards distinct from CCS2, both in terms of physical architecture and communication protocols, MCS will offer enhanced functionality and improved safety features. However, the increased complexity of new components, such as a potential cooling system both in the charger and the vehicle socket, possibly introduces reliability uncertainties.

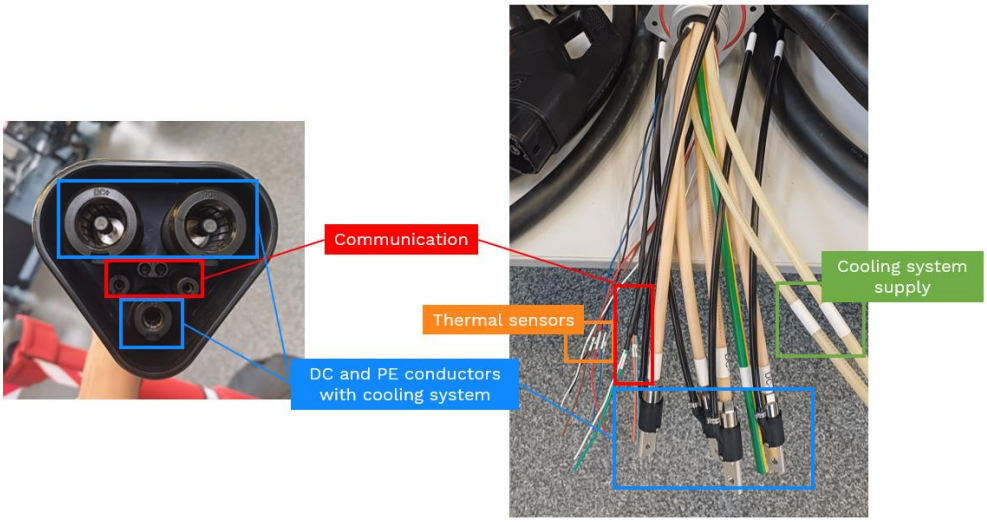

Figure 8: Prototype MCS plug with components

In preparation for the expected adoption of MCS technology in a near future, the e-mobility laboratory is currently undertaking work to achieve a testing power capacity of 1.2 MW by end of 2026. This scale-up represents a major shift in the scope of our facilities: the size of electronic loads and testing equipment increases significantly, and a dedicated ventilation system becomes necessary for cooling. However, our main

challenge lies in the laboratory's safety, particularly in terms of fire prevention. It is indeed well known that the behaviour of an ignited battery is challenging to control and can be devastating if not. Although the probability of fire is not necessarily increased with MCS, the associated consequences in case of fire are substantially greater compared to CCS due to the higher power and current levels involved. As a result, we are currently assessing different fire protection strategies and emergency evacuation procedures.

Conclusion

It is now clear that the electrification of heavy-duty mobility has a major role to play for decarbonising the transport sector, especially in France where electricity is low carbon. Despite the increased interest and the policies being implemented to promote electrification, France is not the most advanced country on this subject. But the situation is changing, and different trends are emerging for both truck manufacturers and logistics providers. In particular, 43 kW AC will gain popularity for depot charging, given that Renault Trucks has chosen to be able to charge using AC and that it accounts for over 70% of the French market. CCS2 and MCS will of course complete the other uses. Other major manufacturers chose therefore not to include on-board chargers in their vehicles to reduce the associated cost in their trucks. In this context, EDF Group, thanks to its subsidiary IZIVIA, is able to provide both solutions in order to meet the specific needs of the clients according to their own constraints and to offer different smart charging solutions through DREEV offers.

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Presenter Biography

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