INSTITUT MOBILITÉS EN TRANSITION

POLICY BRIEF

N° 01
APRIL 2025

# Decarbonization potential of road haulage through hybridization and improved aerodynamic efficiency of semi-trailers in France

**Louis-Pierre Geffray (IMT) and Roland Schaumann (Ian Motion)**

The year 2025 is set to mark significant progress in the decarbonization of heavy goods vehicles (HGVs). Indeed, 2025 will be a period of technological clarification and the arrival of new, more efficient electric vehicles offering a range of 600 km for a weight of 40 tonnes, without requiring recharging en route. Despite this technological progress—accompanied by ongoing efforts to improve practices, particularly through eco-driving—the emission reductions projected by the French General Secretariat for Ecological Planning (SGPE) for freight transport in France by 2030 are half of what is needed to meet French national targets.[1]

This observation highlights the need to explore additional levers to accelerate the reduction of road transport emissions. This Policy Brief sets out to demonstrate the value of equipping articulated vehicles with aerodynamic deflectors and fitting semi-trailers with non-plug-in hybrid systems to reduce the fuel consumption of tractor units. To this end, this Policy Brief draws on technical and economic analyses and concludes that these measures could yield significant economic and environmental gains.

The analysis is based on a series of consultations with key stakeholders in the sector, as well as on the expertise of Ian Motion, an engineering company specializing in the design and development of electrification solutions.

1 SGPE, Transport: summary of the implementation of the plan. March 2024. Available online: https://www.info.gouv.fr/upload/media/content/5/09/0001dadd629747febad088d92fdc7c990844354914c.pdf

## KEY MESSAGES

Installing side deflectors at the rear of semi-trailers could reduce fuel consumption by at least 0.9 l/100 km. Widespread adoption of such systems on 150,000 French-registered trailers (43% of the fleet) would cut emissions by 0.4 $MtCO_2$, with a payback period of just two to three years. These systems would also improve competitiveness by 0.65 percentage points per semi-trailer fitted with the system.

The development of a non-plug-in, mild hybrid electric system for trailers has the potential to reduce fuel consumption by at least 10% on regional road routes. If deployed on 10% of semi-trailers in circulation in 2030, this technology could deliver a direct emissions reduction of approximately 0.3 $MtCO_2$ for the French-registered fleet, in addition to the gains from deflectors. With an estimated initial cost of €29,000, and state support of €7,000, the system could pay for itself within five years. It also represents an opportunity to foster a French industrial initiative, coordinated across trailer manufacturers, and to serve as a technological foundation for achieving the target of a 10% reduction in $CO_2$ emissions from semi-trailers between 2025 and 2030.

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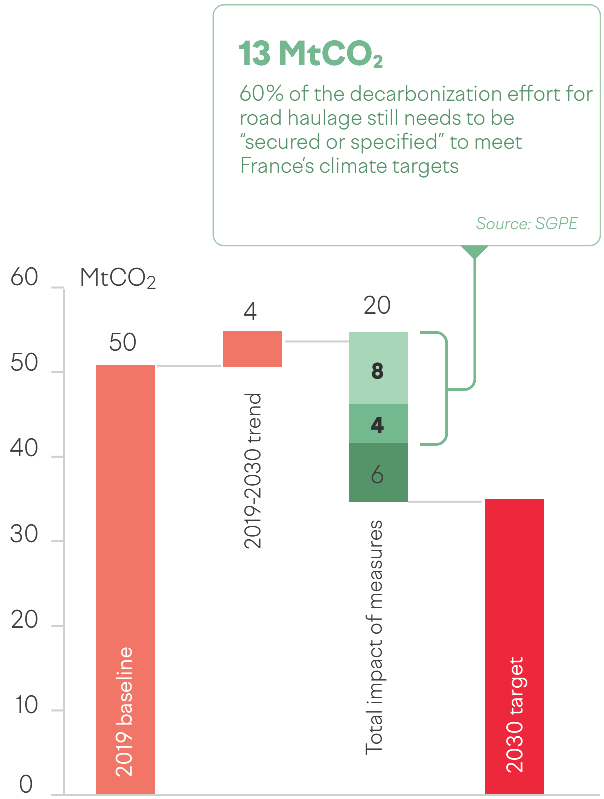
## CONTEXT AND CHALLENGES

In France, the National Low-Carbon Strategy (SNBC) sets sector-specific targets for reducing greenhouse gas (GHG) emissions, with the aim of achieving carbon neutrality by 2050. The transport sector, and freight transport in particular, has been assigned specific objectives to help ensure that the French national 2030 targets are met. According to the SGPE, land-based freight transport must reduce its emissions to 34 Mt$CO_2$ by 2030—a 32% reduction over the decade, compared with the 50 Mt$CO_2$ emitted in 2019.

**FIGURE 1. Road freight transport emissions in France**




Recent data allows to assess the progress in the decarbonization of HGVs in France. IMT compilations based on SDES data indicate that French HGVs consumed 8.65 million $m^3$ of B7 diesel in 2019, compared with 8.16 million $m^3$ in 2023. This represents a decrease of 5.7%, of which one percentage point is attributable to reduced demand (vehicle-kilometres). This figure is conservative as it excludes the rapid growth of B100, which accounted for approximately 0.27 million $m^3$ more in 2023.[2] However, a previous IMT study has indicated that the decarbonization potential of this fuel in France should be viewed cautiously, given its trade-off with B7 diesel.[3]

In this context, and despite a sharp rise in the electrification of new HGV registrations expected in the coming years, it is clear that French decarbonization targets will not be met without additional measures. IMT therefore set out to objectively assess the environmental and economic performance of complementary levers for decarbonizing HGVs. The two levers analysed here focus on semi-trailers.[4] They aim to improve aerodynamic performance and recover energy lost during braking. Specifically, the study proposes fitting aerodynamic deflectors to the rear of compatible trailers and equipping new trailers with a battery-powered electric motor to function as a hybrid system, supporting the tractor unit's propulsion.

While the road transport sector has faced weak demand since mid-2023 due to the broader economic context, this analysis aims to objectively assess the added value of the proposed solutions in helping road hauliers improve their competitiveness. It is worth noting that fuel accounts for approximately 25% of the cost price of a transport service involving a semi-trailer.

A 4% reduction in fuel consumption therefore translates into an additional 1% gain in competitiveness in a sector where operating margins are limited to just a few percentage points. Fuel consumption thus has a direct and significant impact on the financial performance of transport companies.

2 SGPE. Available online: https://www.linkedin.com/

3 IMT. First-generation biofuel in road transport: a better understanding of the dynamics at work and the challenges ahead. Available online: https://institut-mobilites-en-transition.org/en/publications/first-generation-biofuels-in-road-transport-a-better-understanding-of-the-dynamics-at-work-and-the-challenges-ahead/

4 It should be noted that among lorries with French number plates, tractor units account for %86 of tonne-kilometres, %69 of vehicle-kilometres and around %82 of $CO_2$ emissions. IMT, available online: https://institut-mobilites-en-transition.org/wp-content/uploads/01/08/2024_IMT_ST0124_EN_1aout.pdf

## 1. METHODOLOGY AND SUPPORT

For this study, IMT worked in partnership with Ian Motion, a company specializing in the design and production of battery-powered electric systems for a range of applications. Ian Motion's expertise is well aligned with the needs of the study, particularly its in-depth understanding of the technical, economic and regulatory challenges associated with the electrification of off-road vehicles and machinery.

To explore the two decarbonization levers, our approach involved:

- assessing the potential fuel savings for a tractor unit when paired with a semi-trailer fitted with aerodynamic deflectors or a hybrid electric system;
- estimating the additional cost of these technologies and evaluating their potential payback period for operators;
- examining the regulatory context and identifying the measures needed to support the deployment of such systems;
- outlining the conditions for implementation and large-scale rollout in France.

More specifically, the method used to estimate potential fuel savings for tractor units included the following steps:

- defining a so-called "road law" based on aerodynamic drag coefficients and rolling resistance values taken from an ICCT publication that compiles the latest data from major European manufacturers;
- applying various VECTO speed profiles, which reflect the regulatory standard cycles used to quantify energy consumption in HGVs across urban, regional and long-haul routes;
- using these speed profiles and the above-mentioned road law to calculate the fuel consumption of an HGV with an internal combustion engine pulling a standard semi-trailer, without aerodynamic deflectors or electric assistance, and checking that the results align with real-world HGV consumption benchmarks;
- integrating the two proposed technologies into the simulation to estimate their impact on fuel consumption and the associated reductions in $CO_2$ emissions;
- sizing the technical components of each solution to strike a balance between maximizing economic performance and meeting minimum sustainability criteria;
- estimating the cost and sale price of the designed systems;
- developing an economic assessment and calculating the payback period within the French fiscal framework;
- analysing the regulatory constraints that could influence system design or act as barriers to deployment that need to be removed.

The remainder of this report presents the key methodological steps and the results obtained.

## 2. DEFINITION OF A ROAD LAW AND MODEL VALIDATION

The first stage of the analysis involved creating a simulation model to estimate the fuel consumption of HGVs based on their inherent performance, road usage and payload. This work was carried out by Ian Motion, drawing on both in-house expertise and published scientific literature. After several iterations, a representative configuration was selected: a semi-trailer vehicle with a drag area of 5.0 $m^2$ and a specific fuel consumption of 190 g/kWh, corresponding to an average engine efficiency of 44.5%. This level of performance is considered representative of the current generation of road tractors on the market in 2024.

The speed profiles used in the analysis are based on the standards defined in European regulations and correspond to the VECTO[5] cycles for HGVs. These input data are designed to reflect typical vehicle use under varying conditions, providing information on speed and road gradient over time for urban, regional and long-haul routes. Figure 2 shows the speed profile selected for regional operations.

Finally, established road laws were used to simulate and define reference fuel consumption levels for an HGV running entirely on diesel. According to industry experts, the results are sufficiently close to real-world values to validate the model. Table 1 presents the results by route type and load factor.

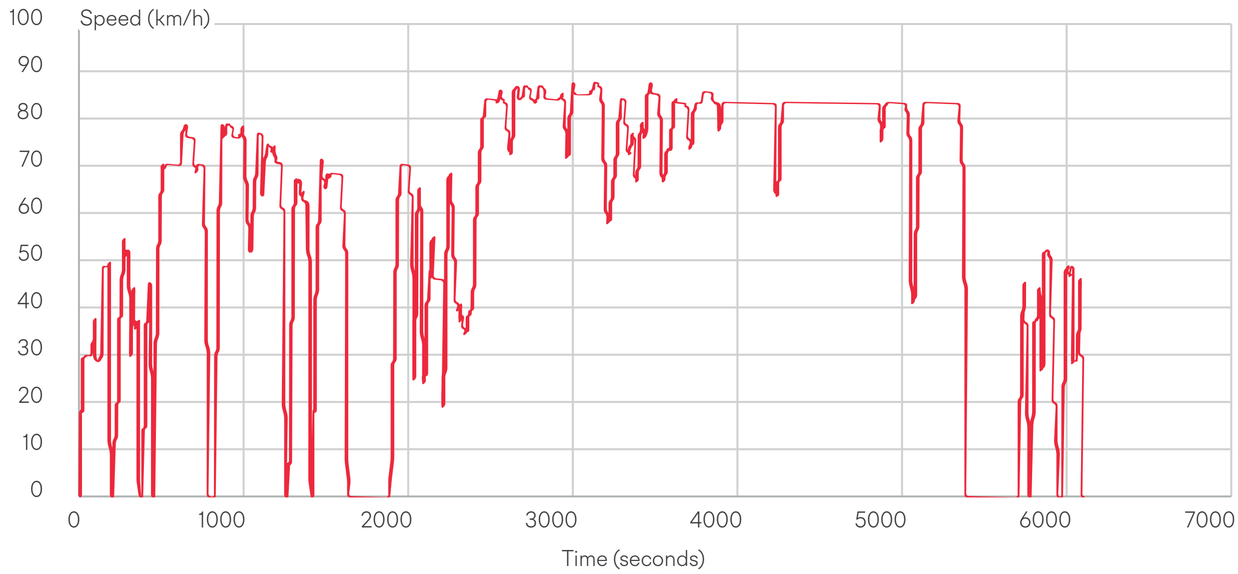
**TABLE 1. Reference fuel consumption levels for a diesel-powered HGV**

| Load factor | 87% | 50% | 10% |
|---|---|---|---|
| Average weight | 40.1 t | 29.0 t | 17.0 t |
| Regional route | 34.4 l/100 km | 26.6 l/100 km | 18.2 l/100 km |
| Long-haul route | 30.1 l/100 km | 24.1 l/100 km | 17.8 l/100 km |

Note: the urban cycle is not included in this analysis, as only a very small proportion of articulated lorries operate exclusively in urban areas.

5 VECTO (Vehicle Energy Consumption Calculation Tool) is the standard simulation tool introduced by the European regulatory framework to model the $CO_2$ emissions and fuel consumption of HGVs and trailers, based on manufacturer-provided data.

**FIGURE 2. VECTO model for HGVs on regional routes**




## 3. FIRST LEVER: AERODYNAMIC DEFLECTORS

The last decade has seen significant improvements in the aerodynamic performance of road tractors sold in Europe and France. Roof spoilers are now widely used across many transport operations, followed more recently by the adoption of side fairings. In addition to this optional equipment, in recent months several HGV manufacturers have introduced major redesigns of their cab architecture, delivering fuel savings of between 3% and 5% compared with 2020 benchmarks. These advances have been made possible by updated vehicle dimension regulations and are exemplified by models such as the Volvo FH Aero[6] and the new cabs of the Mercedes Actros E and Actros L. Such improvements are even more impactful on electric variants, where they significantly extend range.

This body of progress suggests that HGV manufacturers – responding to $CO_2$ regulations – have already made substantial investments, and that the remaining technical potential for improving new road tractors is now limited. The installation of aerodynamic devices on tractor units is already encouraged by the French government, for instance via a standardized CEE (Energy Savings Certificate).[7] As a public policy tool, the remaining lever for road tractors would be to mandate the use of the most aerodynamically efficient models. However, this option is not pursued further here, given the already high market penetration of these improved tractor units. In cases where newer tractors are not yet equipped, this is generally due to operational or terrain-related constraints specific to certain transport applications.

By contrast, aerodynamic optimization of trailers remains limited in both the French and wider European market. As a result, the environmental performance of an articulated vehicle currently depends almost entirely on the tractor unit. However, fitting rear side deflectors to trailers could reduce overall drag area by around 15%. Based on simulations conducted for this policy brief, this would yield a 2.2% reduction in fuel consumption under regional conditions at an average weight of 40.1 tonnes – equivalent to a saving of 0.9 l/100 km. These figures reflect the estimates from companies marketing such systems, such as Pommier, which reports potential reductions of up to 2.5%.[8] The fuel savings are relatively unaffected by HGV load and, unsurprisingly, increase as the route becomes more motorway-oriented. At the maximum authorized motorway speed of 90 km/h, fuel consumption reductions reach as high as 5.9%, or 1.7 l/100 km for a half-loaded HGV (29 tonnes). This type of high-speed, routine use is not uncommon, particularly in refrigerated transport.

6 Volvo Trucks. FH Aero. Available online: https://www.volvotrucks.fr/fr-fr/trucks/models/volvo-fh-aero.html

7 ADEME. Sheet TRA-EQ115 – optimised goods transport vehicle. Available online: https://calculateur-cee.ademe.fr/pdf/display/80/TRA-EQ-115

8 Pommier. Rear aerodynamic deflectors, Airwin. Available online: https://www.pommier.eu/sites/default/files/pim/files/DOCUMENTATIONS/LEAFLETS/FP1000_FR/fp1057_AIRWIN_FR%20BD.pdf

**FIGURE 3. Airwin aerodynamic deflector system developed by Pommier**

**TABLE 2. Projected reductions in fuel consumption from the use of aerodynamic deflectors on semi-trailers**

| Load factor | 87% | 50% | 10% |
|---|---|---|---|
| Average weight | 40.1 t | 29.0 t | 17.0 t |
| Regional route | 0.9 l/100 km | 0.9 l/100 km | 0.1 l/100 km |
| Long-haul route | 1.3 l/100 km | 1.3 l/100 km | 1.3 l/100 km |
| Constant speed – 90 km/h | 1.5 l/100 km | 1.7 l/100 km | 1.7 l/100 km |

Over a distance of 1.2 million kilometres, the direct $CO_2$ emissions avoided through the use of the aerodynamic device tested would range between 30 and 40 $tCO_2$ per semi-trailer running on B7 diesel, depending on whether it is used primarily on regional or long-distance routes. In addition, stakeholder consultations concluded that the unit cost of such devices is ultimately very low: around €3,000 for a pair of rear deflectors. Based on an average annual mileage of 100,000 km, the investment could be recovered within just two to three years. This cost should also be considered in relation to the purchase price of new trailers, which typically ranges from €35,000 for tarpaulin models to €70,000 for temperature-controlled units. These findings raise questions with regards to the lack of wide adoption of such solutions The operational constraints cited do not appear to fully explain this lack of uptake. Some reluctance on the part of stakeholders may relate to maintenance concerns or uncertainty around long-term durability. While this analysis does not provide a definitive answer, it points out the need for an information and awareness campaign, led by public authorities, to promote the adoption of these technologies. Finally, as noted earlier, while most new tractor units are already equipped with aerodynamic deflectors, the existing CEE in France could be revised to prioritize the fitting of such devices on trailers, whether new or already in operation – for example, those under five years old. A genuine effort is needed to support stakeholders and industry federations in managing the transition, especially given that these innovations are not new: Renault Trucks presented a concept incorporating these features more than a decade ago.[9]

Ultimately, these proposals can be seen as a preview of changes aligned with current dynamics and future trends. In the coming years, aerodynamic solutions are expected to become widespread on new trailers, as $CO_2$ standards for HGVs require a 10% reduction in trailer-related $CO_2$ emissions by 2030 compared to 2025.[10] In a relatively proactive scenario in which these innovations are deployed immediately, it is reasonable to expect that aerodynamic deflectors could be fitted to 70% of compatible trailers on French roads by 2030. Taking a conservative assumption that 60% of trailers are compatible—and given SDES data indicating around 350,000 semi-trailers in circulation—the potential rollout over the next five years would involve equipping 150,000 trailers. Assuming an average annual mileage of 100,000 km, this deployment could lead to an annual reduction of around 0.4 $MtCO_2$ by 2030. This saving is roughly equivalent to putting 180,000 electric passenger cars on the road.

## 4. SECOND LEVER: BATTERY-POWERED ELECTRIC HYBRIDIZATION

Modern HGVs are equipped with a range of braking systems designed to maximize safety and reduce mechanical wear. Many vehicles on the road today feature auxiliary braking systems in addition to the mechanical brakes. These include exhaust brakes, electric resistance brakes and hydromechanical brakes, all of which convert kinetic energy into heat, which is then efficiently dissipated. With the exception of electric lorries capable of recharging their batteries during braking, the kinetic energy generated by conventional HGVs (powered by diesel, biodiesel, HVO, natural gas or biogas) is systematically lost. One promising solution involves a trailer-mounted component capable of recovering braking energy and releasing it during acceleration, thereby reducing the fuel consumption of the tractor unit. The system uses a low-capacity electric battery and functions as a mild hybrid solution without the need for external recharging, as illustrated in Figure 4.

9 Renault Trucks. Optifuel Lab 2 Project. Available online: https://www.youtube.com/watch?v=3zh3ccgyU6w

10 Heavy-duty vehicle $CO_2$ standards. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401610 (see page 50)

**FIGURE 4. Schematic diagram of the hybrid solution tested**


To quantify the potential fuel savings enabled by this system, the mechanism was incorporated into the previously defined road law model. Several constraints were applied in the simulation, including:

- the driver's torque demand is shared between the combustion engine and the electric motor;
- the torque delivered by the electric motor cannot exceed its maximum capacity;
- the battery's state of charge must be the same at the beginning and end of the driving cycle.

Once these conditions were defined, the technical configuration of the system was refined to identify the best compromise between minimizing cost and maximizing fuel savings. To achieve this, the analysis sought a technical optimum between the maximum potential for braking energy recovery (which determines battery size and electric motor power) and the resulting fuel savings on the regional route cycle. The system tested in this study had the following characteristics:

- a battery with a gross capacity of 32 kWh;
- an electric powertrain with a power output of 140 kW;
- to minimize cost and complexity, the system had no external recharging capability and operated solely using energy recovered during braking.

The mass of the system is estimated, at first approximation, to be 1,500 kg—representing an additional 1,300 kg compared to a conventional non-electrified axle. While this weight increase is significant, it does not undermine the overall feasibility of the system's deployment. The additional mass would be borne primarily by the trailer axles, with only marginal impact on the load limit of the driver axle of the combustion-powered tractor unit. Moreover, an exemption from the maximum authorized gross vehicle weight could be considered, following the example of existing allowances for supplementary braking systems, which benefit from a 500 kg exemption.[11]

The sensitivity analysis conducted for this study ultimately led to the selection of a net capacity of 29 kWh and a useable SOC[12] range of 20%, centred around a 50% charge level. These sizing choices imply the use of lithium-ion batteries with high durability performance. In practice, the system would need to support several tens of thousands of cycles to ensure a lifespan exceeding one million kilometres. Extensive development and ageing tests will be required to identify battery types capable of meeting these specifications, although no structural limitations have been identified at this stage. The system defined on this basis enables the fuel savings presented in Table 3.

**TABLE 3. Projected reductions in fuel consumption from the use of the hybrid system**

| Load factor | 87% | 50% | 10% |
|---|---|---|---|
| Average weight | 40.1 t | 29.0 t | 17.0 t |
| Regional route | 4 l/100 km | 3 l/100 km | 1.6 l/100 km |
| Long-haul route | 1.9 l/100 km | 1.5 l/100 km | 0.8 l/100 km |

The reduction in fuel consumption is estimated at 11.5% in regional use at 40 tonnes, i.e. equivalent to nearly 130 $tCO_2$ avoided over a distance of 1.2 million kilometres. This performance more than offsets the emissions associated with manufacturing the system (around 6 $tCO_2$).[13]

## 5. ECONOMIC CONSIDERATIONS OF HYBRIDIZATION

Having outlined the potential environmental benefits of mild hybridization of semi-trailers, this section now considers the associated economic implications of its deployment. To this end, Ian Motion and IMT have assessed both the estimated selling price and the potential payback period, based on expected fuel savings within a given usage and tax framework.

### 5.1. Estimated selling price

The estimated retail price of the proposed system was established based on a detailed inventory of its components. Ian Motion then conducted ten interviews with specialized stakeholders at European and international levels to estimate component costs, taking into account sourcing strategies and volume assumptions. Finally, the

11 Article R312-4 of the French Highway Code. Available online: https://www.legifrance.gouv.fr/codes/section_lc/LEGITEXT000006074228/LEGISCTA000006177084/?utm_source=chatgpt.com

12 SOC: State of charge

13 For the carbon footprint calculation, the battery footprint was estimated at 100 kg $CO_2$/kWh.

company drew on its own experience to assess the additional labour time required to manufacture and assemble a hybrid unit on a standard semi-trailer.

The main cost components and the associated assumptions are presented in Table 4.

**TABLE 4. Estimated cost of system components**

| | Unit price (excl. VAT) (€) | Quantity | Price (excluding VAT) (€) | Origin | Notes |
|---|---|---|---|---|---|
| Fitted electrified axle/unit | 9,500 | 1 | 9,500 | CH | For 100 units |
| Fitted battery pack | 200 | 32 | 6,400 | EU | For 3,200 units |
| Energy distribution unit | 1,000 | 1 | 1,000 | EU | For 100 units |
| Power harness | 750 | 1 | 750 | EU | For 100 units |
| Signal harness | 500 | 1 | 500 | EU | For 100 units |
| Project management | 300 | 1 | 300 | EU | For 100 units |
| DC-DC | 400 | 1 | 400 | EU | For 100 units |
| Other | 1,000 | 1 | 1,000 | EU | For 100 units |
| TOTAL | | | 19,850 | EU | |

Note: the "Other" row includes capital costs

In addition to the component purchase cost, labour costs are estimated at €2,250 per vehicle, with a manufacturer's margin set at 30%, equivalent to €6,750. Under these conditions, the cost of the optional system at the time of trailer purchase is estimated at €29,000 excluding VAT. This selling price includes a significant margin, justified by the limited market window for this technology. Since the number of semi-trailers to be equipped is limited over time – due to the electrification of HGVs (which inherently incorporate similar energy recovery systems) – it is considered essential that the stakeholders involved in developing such a system are able to generate a profit margin from the first units sold. It should also be noted that a minimum production volume of several hundred units must be achieved to enable this sale price to be offered.

## 5.2. Economic viability in the context of taxation and energy prices in France

In parallel, a scenario was developed to assess how the future price of road diesel for freight transport in France could affect the return on investment of the system. This scenario incorporates tax measures already enshrined in French law, in particular the planned end of the partial refund of TICPE (domestic consumption tax on energy products) in 2030. Conversely, and following a conservative approach for the purposes of the simulation, the transposition of the ETS2 mechanism is assumed to have a neutral impact on the price of diesel in France, offset by an equivalent reduction in excise duties on diesel.[14] Table 5 presents the projected evolution of the price per litre of diesel under these assumptions, specifically for use in road haulage.

**TABLE 5. Projected diesel price for French road haulage as considered in the study**

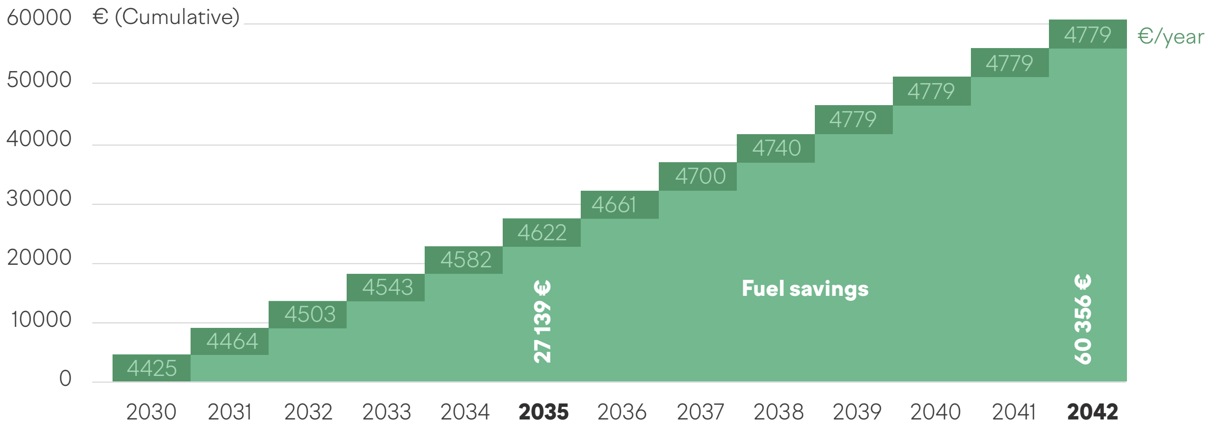
| | €/l | | €/l |
|---|---|---|---|
| 2025 | 1.405 | 2030 | 1.405 |
| 2026 | 1.198 | 2031 | 1.417 |
| 2028 | 1.223 | 2032 | 1.43 |
| 2028 | 1.223 | 2033 | 1.442 |
| 2028 | 1.223 | 2034 | 1.455 |
| 2029 | 1.235 | 2035 | 1.467 |

Note: the pre-tax (HTT) price of diesel is assumed to increase linearly by 1.6% per year, consistent with the average trend observed over the last decade in France. The sharp rise in the price of diesel for road haulage in 2030 reflects the end of the partial TICPE refund in France.

Depending on the assumptions made, it is possible to assess the payback capacity of the hybrid system according to the years of operation. The simulation presented below assumes entry into service in 2030, although the first units could be on the road as early as 2028. This assumption reflects the likely business case for a significant share of deployment volumes (taking into account the expected ramp-up in production). Under the taxation and energy price conditions for 2030, and given the additional cost of the trailer, the payback period is estimated at six years. While this may appear long in the context of tractor units, where fleets are typically renewed every four years, it is relatively short compared to the usual holding period for trailers, which ranges from 10 to 20 years. The economic and environmental rationale therefore appears sound. Achieving payback in under five years, as frequently suggested by the stakeholders interviewed, would require public support at the time of purchase. One possible mechanism for this could be the energy saving certificates scheme. Although the exact form of support remains to be defined, it would likely take the form of a per-unit subsidy of €7,000. If needed,

14 It should be noted that this simulation assumption would also reduce the competitiveness gap between diesel prices for the French fleet and Spanish fleet by 0.04€ per litre. This reflects the application of the ETS2 mechanism in Spain, where a $CO_2$ price of 45€ per tonne is assumed and cannot be fully offset by a corresponding reduction in fuel taxation.

**FIGURE 5. Payback period for hybridization**




hybridization could also be encouraged through favourable accounting depreciation terms.

### 5.3. Regulatory issues

While prototypes of electrified trailers are currently being tested in Europe, regulatory developments are under consideration to support the deployment of these new transport solutions. For example, UN Regulation No. 100 now includes battery safety requirements for category O vehicles—that is, semi-trailers. However, several important issues remain unresolved. In particular, a clear regulatory framework will be needed to define a standardized communication channel between the tractor unit and the trailer. This is essential to prevent unintended acceleration and reduce the risk of jack-knifing[15] in articulated vehicles equipped with hybrid systems. This issue raises important questions about the need to revise UN Regulation No. 13 on braking systems and to introduce clear requirements for coupling and communication with the towing vehicle, within the framework of UN Regulation No. 55. The interviews also identified the existence of ISO 11992-2, a standard governing digital communication between tractors and trailers.[16] Any future regulatory development will need to include a detailed analysis of these different international frameworks and standards.

In view of the issues raised and their relative complexity, discussions between the relevant authorities appear to be moving towards imposing a speed limit of just 25 km/h. ITM notes that such a scenario would render any further development effectively obsolete. At this speed, fuel savings in the regional cycle would be limited to just 0.4%.

Finally, it should be noted that the VECTO-trailer simulation tool, used to assess the environmental performance of trailers, does not include the possibility of traction input from the trailer itself, as trailers are still defined as non-motorized vehicles. If these regulatory constraints are lifted, it will be necessary to revist the VECTO-trailer tool to incorporate the potential for hybridization, and thus stimulate demand on the trailer supply side.

### 5.4. Conditions for successful development in France

This analysis by IMT is set in a context where the German manufacturer Krone has presented a concept for an electrified trailer – this time a rechargeable version – with a battery capacity exceeding 300 kWh. This demonstrator is primarily intended to extend the range of electric tractors, rather than to reduce fuel consumption in diesel-powered tractor units. However, the technological building blocks currently under development in Germany also make it possible to envisage a lighter and more affordable solution, similar to the one presented in this policy brief. From the perspective of technological and industrial expertise, there is now an opportunity to bring together a group of interested stakeholders in France to develop such a hybrid system. The target sale price (€29,000) leaves little margin for the development of a solution based on components from independent distributors. For such a solution to succeed in France, IMT and Ian Motion consider that either:

— a single actor must be capable of vertically integrating as many system elements as possible, or
— a project of common interest should be established, led by a consortium of key actors.

15 For an articulated vehicle, this refers to the formation of an acute angle between the tractor and trailer, which can lead to immobilization or even an accident.

16 ISO 11992-2: Road vehicles – Interchange of digital information on electrical connections between towing and towed vehicles – Part 2: Application layer for brakes and running gear. Available online: https://www.boutique.afnor.org/en-gb/standard/iso1199222023-/road-vehicles-interchange-of-digital-information-on-electrical-connections-/xs343395/141415

The solution proposed represents a genuine industrial project, requiring sequential phases of development, fine-tuning, validation, approval, production and after-sales service. Its deployment thus presents a significant technical, economic and organizational challenge. In either case, these issues must be anticipated through collaborative foresight within the French industrial vehicle and bodywork manufacturing sector. Support and coordination from the French State would also play an important role in securing the project's success.

## CONCLUSION

The distribution of aerodynamic deflectors on semi-trailers represents a major short-term lever for reducing $CO_2$ emissions from road haulage. Given their payback period of just two to three years, these systems can be installed not only on new vehicles but also retrofitted to the existing fleet—multiplying their potential emission reduction impact. IMT believes that targeted awareness-raising among stakeholders in the sector is essential to encourage widespread adoption, both for environmental reasons and because of the significant competitiveness gains available to hauliers.

At the same time, the development of a lightweight non-rechargeable hybrid system for semi-trailers offers a genuine opportunity for industrial growth in France, benefitting the sector as a whole. The timelines outlined in this study, in particular the viability of the solution from 2030 onwards, support the need to establish a joint interest group without delay, with the aim of bringing the system to market within a few years. This approach is positioned as a complementary solution, running in parallel with the broader transition towards electrified road transport. Its success, however, will depend on the continuity of the regulatory framework on $CO_2$ emissions from semi-trailers and the coordinated mobilization of public and private stakeholders. With the right conditions in place, France could take a leading role in this emerging area of innovation.

Geffray, L.-P., and Schaumann, R. (2025). Decarbonization potential of road haulage through hybridization and improved aerodynamic efficiency of semi-trailers in France. *Policy Brief* N°01/25, IMT.

CONTACT
louispierre.geffray@sciencespo.fr

Institut des moblités en transition
41, rue du Four – 75006 Paris – France

institut-mobilites-en-transition.org