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News

Innovation and Industry

Sustainable mobility | Electrified Mobility | Environmental Analysis of Transport | IC powertrains

Operating through the IFPEN Transports Energie Carnot Institute, IFP Energies Nouvelles (IFPEN) has published the findings of an economic, energy and environmental study into French road transport technologies in the lead-up to 2040, co-funded by the ADEME.

IIFPEN drew on modeling tools to conduct a prospective analysis of the technologies to prioritize in order to cut back on road transport CO_2 emissions by 2040. The E4T 2040* study was co-funded by the ADEME and takes a multidimensional approach to the issue, incorporating economic and environmental criteria for all segments of road transport fleets (light vehicles, light utility vehicles, heavy-duty vehicles, buses, and two-wheelers). While electric cars will become the norm for light vehicles, potential solutions for heavy-duty vehicles are set to be more open-ended.

Shifting towards all-electric solutions for private light vehicles

The study's simulations point to all-electric being the best solution for private cars today — and more so for 2040 — on both an economic and environmental level.

From a total cost of ownership perspective**, **battery electric vehicles** (BEV) are now a competitive option in the light vehicle segment, provided battery capacity is lower than 60 kWh. For these vehicles, help-to-buy funding and low usage costs make it possible to offset the additional cost compared to an internal combustion (IC) vehicle. The time it takes to offset this extra cost will be slashed even further in the future as the technology is honed and the cost and impact of manufacturing the batteries drop. What's more, using limited-capacity batteries will require less energy-hungry vehicles in order to maintain sufficient range, notably a decrease in aerodynamic losses and vehicle mass.

Electric systems are also the most energy efficient due to their components' higher efficiency and the ability to recover a significant proportion of kinetic energy during the deceleration phases. With progress still expected to be made in energy density and battery mass, in 2040 EV energy consumption should show a 30% decrease compared to 2020, across all vehicle types.
EVs' environmental advantage will, however, depend on energy mix: while the situation looks very promising in France due to the proportion of nuclear energy and growing use of renewable energies, this is less the case in light of the average European mix, which is much more high-carbon.

Based on hydrogen station sales prices of €4 to €6 per kilo (electrolysis and low-carbon French electric mix) by 2040, hydrogen **fuel cell technology** will remain uncompetitive for light vehicles within this period of time due to high initial outlay and running costs.

Plug-in hybrid solutions, meanwhile, offer environmental and energy advantages for light vehicles, provided electric usage is maximized to offset battery impact (both in terms of manufacturing emissions and cost). This requires the battery to be charged very regularly to prioritize electric mode. Thus, using plug-in hybrid powertrains and biofuels could be just as beneficial as the all-electric solution.

Finally, for **motorized two-wheelers**, going electric emerges as the best solution both environmentally and economically — today, and all the more so in 2040. Why? Because of two-wheelers' mass- and space-related constraints: by their very nature, these vehicles can only be fitted with small, more competitive and energy-efficient batteries.

Fleet diversification for light utility and heavy-duty vehicles (buses, HGVs)

For passenger transport, electric buses are the most environmentally friendly solution for 2020 and 2040 alike, but are currently costlier than IC engine buses (around 20 to 30% more in terms of total ownership cost). Fuel cell buses, meanwhile, are less environmentally friendly than electric buses, primarily due to high hydrogen consumption levels and the impact of making fuel cells and tanks. However, by 2040 the fuel cell solution will have become more economically competitive. Finally, bioNVG (waste-produced gas) is a very strong contender for buses.

For light utility vehicles (3.5t), natural gas and electric are currently the most economically efficient alternatives to diesel IC vehicles. Battery electric vehicles are already the most environmentally friendly option, and by 2040 they will be the most competitive, too. Fuel cell is also a strong candidate, as is bioNVG, which will have become competitive and viable on a large scale between now and 2040. According to ADEME Transport and Mobility Engineer Bertrand-Olivier Ducreux, "the best route to tackling the wide variety of different usages seen in light vehicles (delivery, trade) could draw on several new powertrain solutions: electric options where they fit with range needs, and fuel cell options

where the vehicle's purpose demands greater range".

Where HGVs are concerned, the total cost of ownership for an IC powertrain and a battery electric powertrain will amount to the same between 2025 and 2035, once again depending on target range and battery capacity. In this segment, battery size is a sticking point due to the range required depending on how a vehicle is used. Finally, in 2040 the hydrogen fuel cell option will be appealing from an environmental impact perspective, but costs will remain high.

"**For transporting goods**, we'll be shifting away from the standard petrol fuel solution and towards a spectrum of different solutions geared towards d**ifferent usages: fuel cell and biofuels for high range needs, and battery electric for transport with fewer constraints**," notes Cyprien Ternel, IFPEN Project Manager.

Hard-to-reach European targets

With the ban on greenhouse gas-emitting IC vehicles due to be ushered in in 2035, plug-in hybrid and electric solutions should soon find themselves leading the pack in the French automobile sector. However, **hitting European targets of slashing CO2 emissions by 55% in under a decade seems out of reach. "The study shows that even in the best-case scenario for electric vehicle sales, the Green Deal objectives (90% cut in fleet CO2 emissions by 2050 compared to 1990) are unattainable**," explains Bertrand-Olivier Ducreux. Technology alone won't cut it: we will also need to make changes in our transport and vehicle-purchasing habits and behaviors, too. Indeed, the study lays out how a drop in demand for new vehicles, without any changes in how we choose to get around and without optimizing vehicle use, will have little impact on decarbonization in the automobile sector.

Working hypothesis: The study's model was based on the assumption that an individual's behavior in relationship to their transport needs remains unchanged.
Factors that were analyzed:
Vehicles assessed:
- Private vehicles, light utility vehicles, HGVs, buses, and two-wheelers
- IC, hybrid, plug-in hybrid, battery all-electric, and fuel cell powertrains
For each vehicle category, evaluation of:
- Energy consumption;
- Economic viability (total cost of ownership),
- Environmental impacts throughout the entire lifecycle (including the energy production required to both manufacture and run the vehicle).

**E4T 2040: Economic, energy and environmental study for French road transport technologies (E4T).*
*** The total cost of ownership refers to the total initial purchase outlay plus running costs.*

Energy, Economic and Environmental analysis for french road transport technologies by 2040 (E4T)

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Press contacts
Anne-Laure de Marignan, IFPEN – +33 (0)1 47 52 62 07 – presse@ifpen.fr
Camille Le Hyaric – Agence EPOKA – 06 60 43 65 02 – clehyaric@epoka.fr

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