

## **Key Messages from the ETC's *The Road Ahead* Insights Briefing**

*This insights briefing forms part of ETC's analysis of the potential to increase [energy productivity](#) (value created per unit of energy input) across major sectors, including road transport, buildings and heavy industries (coming in 2026), and the policies required to seize this potential. With productivity improvements across all sectors, global GDP could double by 2050 while using a quarter less energy than today.*

**Productivity improvements in cars and trucks can decrease overall energy demand, even whilst overall mobility increases.** By 2050, demand for kilometres travelled could grow by ~75% while energy demand could fall by ~80%. ETC projects that demand for passenger vehicle travel could grow by ~70% by 2050, and commercial vehicles could rise even faster by ~90%. Road transport improvements could deliver a third of total energy productivity potential across the economy by 2050, gaining more economic return or mobility from each unit of energy.

### **Electrification is the dominant driver of energy productivity in road transport.**

Electric vehicle sales are on track to exceed 20 million in 2025 – one in every four new cars worldwide. EVs are already cheaper upfront than ICEs in China, due to rapid cost declines and domestic market competition, and will soon be in several other markets.

Switching from fossil-fuel internal combustion vehicles (ICEs) to EVs delivers around 85% of the energy demand reduction potential in the road transportation sector, as EVs are 3–4 times more efficient than ICEs at turning input energy into movement, achieving the same outcome with less energy. EV motors convert over 75-90% of energy input into motion, while ICE engines convert only 20-30% into useful motion, wasting the rest as heat through the engine or exhaust.

In a technically and economically feasible net-zero by 2050 pathway, final energy demand (energy delivered to the vehicle for driving) could fall by ~80%, from a theoretical 38,800 TWh in an all-ICE 2050 world, to 7,700 TWh, largely due to electrification. The difference is more TWh of electricity than the world generates in a year today, and more than a fifth of current global energy use. This could save 96 GtCO<sub>2</sub> of cumulative emissions between 2023 and 2050 (equivalent to ~2.5 years of today's global emissions).

Other actions to reduce road transport energy demand a further 15% of the opportunity. This includes avoiding and shifting car use (e.g., to cycling, public transport, work from home, etc.), incremental ICE efficiency improvements, design improvements (e.g., lighter vehicles, better tyres/motors, better aerodynamics), driving style, and autonomous vehicles.

### **Electric vehicles are cleaner and more efficient – no matter how the grid is powered.**

Electrification reduces fossil fuel imports and adds flexible electricity demand, aligning with renewables. EVs remain cleaner and more efficient—even on coal and gas powered grids—using two-thirds the primary energy of ICEs. By 2050, EV fleets may need 15,000 TWh vs. 22,600 TWh for ICE fleets (adding the equivalent of 4% of 2024 global primary energy demand).

### **EVs and lighter cars can get even more efficient.**

Today's passenger EVs are only the beginning: by 2050, a combination of lighter materials, better aerodynamics, higher-density batteries, in-wheel motors, and smart tyres could reduce EV energy per km by up to 50%. Use of lightweight materials alone could reduce EV energy use by around 20%. Passenger EV electricity consumption could halve from 0.2 kWh/km today to 0.1 kWh/km by 2035, reducing 2050 electricity demand by 3,200 TWh.

However, there is a buyer trend towards heavier cars (such as SUVs), which require more energy to accelerate. At least part of that energy is recovered in EVs from regenerative braking. ICEs lack this recovery, and therefore, policies to limit ICE weight could lead to significant emissions savings. If all sales of new ICE vehicles weighing over 1.8 tonnes were prohibited (or consumer preferences changed), it could reduce total cumulative emissions by 1.6 GtCO<sub>2</sub> (equivalent to average yearly emissions from ~350 million more cars on the road).

### **Faster fleet turnover to fully-electric is essential**

New ICEs purchased today use 25–40% less fuel than those purchased 15 years ago. Yet slow stock turnover keeps older, less efficient cars on the road for 10–15 years or more.

Hybrid ICE vehicles are more efficient than regular ICEs because they have small electric motors that enhance fuel efficiency at acceleration and low speeds. Plug-in hybrid electric vehicles (PHEV) can run on 100% electric mode, though they also have internal combustion engines. However, hybrid vehicles provide limited long-term energy efficiency gains and emissions reductions compared with full electrification, and are currently losing in cost competition with EVs that have greater policy backing.

### **Most of the efficiency drivers rely on engineering, not behaviour**

Only ~6% of the energy productivity opportunity requires behaviour changes, such as replacing car trips with walking, cycling, public transportation if possible, and replacing truck movements with consolidated delivery systems in urban areas.

Efficient driving styles involving reducing unnecessary acceleration, idling, and high-speed driving contribute a small fraction of road efficiency potential. Modest reductions in speed limits (e.g., 130 km/h to 110 km/h) can cut fuel use in ICE cars by 17% per km driven, and even larger gains for EVs, reducing electricity use by up to 24% per km driven.

### **Truck electrification is accelerating globally and outperforms alternative decarbonisation options.**

Long-haul commercial ICE vehicles can realistically enhance efficiency by 20% by 2030 through incremental engine and aerodynamic upgrades. In contrast, EVs have far greater long-term potential - up to a 50% reduction in energy use per kilometre by 2035 for passenger vehicles - and a similar reduction is expected in commercial vehicles, as they benefit from the same improved battery, motor, lightweighting, in-wheel motors and smart tyre technology.

Battery-electric trucks already use, on average, 70% less energy than diesel trucks.<sup>1</sup> They are also up to 42-65% more efficient than hydrogen fuel-cell trucks (FCEVs) in final-energy terms and up to 52-77% more efficient in primary-energy terms, making them the most energy-efficient and scalable freight solution. Electrification and efficiency savings are likely to lead to lower running costs for businesses. Battery electric truck sales are already soaring in China, capturing 22% market share in H1 2025, up from 9% in H1 2022, and forecast to capture at least 50% of the market by 2028.

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<sup>1</sup> The ICCT (2023), *A total cost of ownership comparison of truck decarbonization pathways in Europe*.

Even by 2040, battery-electric trucks retain a ~40% efficiency advantage over FCEVs.<sup>2</sup> While hydrogen may play a limited role in niche long-distance or high-payload applications, its much lower round-trip efficiency, including losses in electrolysis, compression and fuel-cell conversion, means it cannot match the system-wide energy savings of direct electrification.

**Autonomous vehicles (AVs) offer clear benefits for commercial use, but a mixed picture for passenger travel.**

AVs represent a transformative advancement in transportation technology, enabling navigation and operation without human intervention. Commercial AVs can cut energy use via better routing (fewer empty kilometres, off-peak driving) and reduced idling. We estimate this could reduce final energy demand from commercial vehicles by 3%, without impacting the quality of service.

By contrast, passenger AV demand is more uncertain: it may increase road driving demand based on consumer preferences over walking, cycling and public transport and increase empty driving between pick-ups, reducing much of the potential energy benefits.

**Key policy actions for all road transport (passenger and commercial vehicles):**

- 1. Accelerate the shift to electric vehicles:** set clear phase-out dates for ICE sales, support fleet renewal through incentives and scrappage schemes, and implement fleet purchase mandates (especially for public and corporate fleets). For commercial vehicles, ensure that there are cost parity schemes to bridge the gap in the total cost of ownership between EVs and diesel trucks.
- 2. Build the charging infrastructure:** prioritise rapid-charging corridors for trucks, streamline grid connections, and expand depot, workplace and public charging to ensure reliable access for households and businesses.
- 3. Plan the power system for transport electrification and manage demand smartly:** integrate EV demand into grid investment plans, enable smart and off-peak charging.
- 4. Strengthen vehicle efficiency and design standards:** tighten standards and increase buyer awareness of fuel efficiency, weight and aerodynamics for cars and trucks.
- 5. Develop comprehensive and accessible mobility plans,** including low-emissions zones and reduced speed limits.

**Additional policy actions for commercial vehicles:**

- 6. Improve logistics, operations, and eventually autonomous vehicles:** Support routing optimisation, consolidation centres and measures that reduce empty running. Set early standards for AVs, including energy consumption of software and cybersecurity measures.

Overall, annual reduction in energy use per km (i.e., energy intensity) can accelerate from a historical 1.6% per year between 2010 and 2020 to up to 4% per year between 2024 and 2030. This is in line with COP28/COP30 targets to double global efficiency improvement rates by 2030. The road transport sector offers a third of the potential to increase global energy productivity by 2050 - alongside opportunities across buildings and heavy-industry sectors - which could see global GDP double whilst using 25% less energy overall.

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<sup>2</sup> Ibid.