COMMENTARY

How PLM is Decarbonizing Automotive Transport—Amid Political Uncertainty

Why PLM Matters More than Ever

Takeaways

PLM is a strategic enabler of the transportation industry's decarbonization through electrification, circularity, sustainable materials, and emission compliance. It supports vehicle and powertrain innovation throughout the product lifecycle—from eco-design concepts and simulation, to supply chain transparency and digital product passport enablement.

US governmental policy uncertainty underscores the need for resilient strategies. With the potential rollbacks of federal emission rules, incentives, and agency capabilities, the US market is facing regulatory volatility. PLM empowers OEMs to decouple innovation from policy shifts, maintaining momentum regardless of current political direction.

Global momentum is driving decarbonization. The EU, China, and countries across Asia and Latin America are tightening emissions, sustainability, and electrification mandates. PLM enables multinational coordination, allowing OEMs to harmonize efforts across jurisdictions, allowing them to stay ahead of compliance demands.

For automotive and heavy-duty trucking companies to thrive, they must view decarbonization as a competitive imperative. While regulatory shifts may slow US domestic enforcement, the business case for decarbonization—driven by global targets, investor pressure, and consumer demand will only grow. OEMs that invest in PLM-led sustainability will be best positioned for 2030 and beyond.

Transportation Emissions & The Urgency for Decarbonization

The transportation sector is a major contributor to global greenhouse gas (GHG) emissions and air pollution. Road transport alone was responsible for 6.3 gigatons (Gt) of CO_2 emissions in 2023, accounting for approximately 17% of total global energy-related CO_2 emissions (IEA, 2024). Among these, passenger cars and vans contributed the most—approximately 3.8 Gt, or over 60% of road transport emissions. Freight trucks added another 30%, while buses and two- and three-wheelers made up the remaining 5%. This underscores the dominance of automotive transport as a source of climate-impacting emissions.[1]

[1] https://www.iea.org/energy-system/transport/cars-and-vans

In addition to carbon emissions, the transport sector is also the leading contributor to urban air pollutants like Nitrogen Oxides (NOx) and Fine Particulate Matter (PM2.5), both of which are harmful to human health. Tailpipe emissions from internal combustion engine (ICE) vehicles, as well as non-exhaust sources like brake and tire wear (even for electric vehicles), are significant contributors. In densely populated urban areas, vehicles can account for up to 50% of NOx and over 30% of PM2.5 pollution.[2]

The urgency to act is growing. In 2024, the average global surface temperature reached a staggering 1.55°C, the warmest year on record above the pre-industrial baseline (1850–1900).[3] This surpasses the Paris Agreement's ideal goal of limiting global warming to 1.5°C and puts the long-term goal of 2.0°C by the end of the century at risk. The U.N. projects the planet could warm by 3.1°C by the end of the century unless significant decarbonization occurs.[4]

To address these needs of improving air quality and lowering GHG emissions, most major automotive markets have set fuel economy or CO_2 emission standards and stringent limits on tailpipe pollutant emissions. There is significant societal pressure on the transport sector, including light- and heavy-duty on-road vehicles, as well as off-road machinery, to further reduce their carbon footprint. This is driving another round of regulatory tightening, starting in the 2027–2028 timeframe, in Europe, the US, China, and India. The US has recently proposed pulling back on some of these regulations, which we highlight in the next section. Nevertheless, the upcoming standards are approaching "near-zero" tailpipe emissions and will require the adoption of advanced engine and powertrain technologies, electrification, and a shift to non-conventional and renewable fuels. A wide range of technologies are being developed, and global OEMs are making strategic choices in pursuing select pathways that enable global harmonization and leverage limited resources.

During the past few decades, the transport industry has made continuous technological advancements and has been able to meet ever-tightening emission standards. However, recent geopolitical changes in Europe and the US are drawing attention to the need to balance further regulations with the increasing complexity of managing a diverse set of powertrain technologies, as well as their supply chain and infrastructure needs. OEMs are seeking resilient, long-term strategies to navigate regulatory uncertainty and overcome challenges to adopting new technology.

The Shifting US Policy Landscape: A Decarbonization Setback?

In March 2024, the US EPA published a "Multi-Pollutant Emissions" rule for light-duty vehicles sold in model year (MY) 2027 and beyond. This effectively required a 50% reduction in fleet-averaged CO_2 emissions from MY 2027 through 2032, a similar reduction in combined hydrocarbon and NOx emissions in that period, and a tightening of tailpipe particulate emission standard from 3 mg/mile to 0.5 mg/mile, over a broader range of driving conditions. While OEMs are free to choose any technology/powertrain pathway to meet the standards (supporting a "technology neutral" approach), the EPA estimated CO_2 reductions would be met primarily through an increasing share of battery electric vehicles (BEVs), reaching 55% of new vehicles sold by 2032.

For heavy-duty vehicles, the EPA announced the "Clean Trucks Plan," which required an 82.5% reduction in tailpipe NOx from heavy-duty trucks starting MY 2027, and Phase 3 Greenhouse Gas standards, which require a 25 to 40% reduction in CO_2 emissions for Class 8 tractors.

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[2] https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

[3] https://wmo.int/news/media-centre/wmo-confirms-2024-warmest-year-record-about-155degc-above-pre-industrial-level

[4] https://www.reuters.com/business/environment/climate-set-warm-by-31-c-without-greater-action-un-report-warns-2024-10-24/

While the EPA does not set electric vehicle sales mandates, California has chosen to do so. The state has been granted waivers to set its own emission standards, provided they are tighter than the federal level. Its latest Advanced Clean Cars (ACC) II regulation set a 100% zero-emitting vehicle (ZEV) sales target by 2035. These standards have been adopted by 15 other ("Section 177") states, which cumulatively represent over a third of the US light-duty vehicle market. For heavy-duty vehicles, it has published a "Low NOx Omnibus" regulation, which requires a reduction in tailpipe NOx by 75% starting MY 2024, and the Advanced Clean Trucks (ACT) regulation, which sets ZEV sales mandates for heavy-duty trucks.

The Trump administration initiated a series of rapid deregulatory actions intended to dilute or rescind numerous previously established standards. Among the most significant, and with direct consequences for the transport sector, these include:

- Proposal to rescind the Greenhouse Gas (GHG) Endangerment Finding, which provides EPA with the legal basis for setting GHG limiting standards for vehicles.[5] If implemented, this will nullify the current and proposed CO_2 standards for heavy-duty and light-duty CO_2 vehicles. It has implications for electric vehicle strategies at OEMs that were relying on the zero tailpipe emission certifications and the generated credits for meeting regulatory requirements.
- The use of the Congressional Review Act (CRA) to revoke waivers previously granted to California for the ACC II, Advanced Clean Trucks, and the Omnibus Low NOx regulation.[6]
- A review of the criteria pollutant standards[7] included in the MY2027+ Light- and Medium-Duty vehicle regulation, and the low NOx Clean Trucks Plan.[8]
- Passage of the One Big Beautiful Bill[9,] which included the following key provisions:
  - Elimination of Corporate Average Fuel Economy (CAFE) Civil Penalties
  - Modification of the Clean Fuel Production Credit (45Z), and provisions to promote domestic production of bio/renewable fuels
  - Termination of Clean Vehicle Credits Up to $7,500 for passenger EVs and Commercial Clean Vehicle credits (45W)
  - Termination of Clean Hydrogen Fuel Credit (45V)

According to Mr. Ameya Joshi, CEO & Founder of MobilityNotes and a coauthor of this commentary, "US governmental policy uncertainty underscores the need for automotive OEMs to decouple innovation from policy shifts, maintaining momentum regardless of the current political direction."

Why PLM Matters More Than Ever

PLM-enabling solutions have become indispensable for automotive manufacturers as they face rapid shifts in regulations, customer expectations, and technology development timelines. Amid the uncertainty caused by shifting US emissions policy, PLM acts as a stabilizing force, providing manufacturers with the ability to continue strategic innovation even when regulatory clarity is lacking. Rather than delaying development while awaiting new policies, OEMs can leverage PLM solutions to model multiple

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5 EPA Releases Proposal to Rescind Obama-Era Endangerment Finding, Regulations that Paved the Way for Electric Vehicle Mandates | US EPA

6 https://www.epa.gov/newsreleases/epa-hails-congressional-disapproval-biden-epas-california-ev-mandate-rule

7 Criteria air pollutants are six commonly found air pollutants for which the Clean Air Act requires US EPA to set National Ambient Air Quality Standards (NAAQS). These include ozone, particulate matter, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide.

8 https://www.epa.gov/newsreleases/epa-announces-action-implement-potuss-termination-biden-harris-electric-vehicle

9 The One Big Beautiful Bill – The White House

compliance scenarios simultaneously, allowing them to stay on track regardless of how regulations evolve.

PLM supports the full management of vehicle electrification programs by enabling synchronized collaboration across mechanical, electrical, and software domains. This is particularly crucial as vehicle platforms evolve to integrate electric drivetrains, energy storage systems, and thermal management technologies. Through PLM, engineering teams across continents can collaborate in real time, ensuring accelerated program timelines and robust, compliant product launches.

Real-time emissions tracking becomes essential as regulatory pressure mounts to reduce product carbon footprints throughout a vehicle's lifecycle. PLM connects data across materials, components, and suppliers, making it possible to track embedded emissions early in the design process and throughout the supply chain. This visibility empowers OEMs to design out carbon and make better sourcing decisions up front that align with their sustainability goals.

As OEMs are increasingly expected to measure and reduce the environmental impact of their products, PLM plays a key role in supplier transparency. Companies must now monitor not just their own operations but those of Tier 1, 2, and 3 suppliers to meet Scope 3 emissions targets.[10] PLM systems provide a central platform for collecting and validating supplier declarations, integrating sustainability metrics directly into the BOM and product development workflow.

PLM also helps optimize energy resource use during both product development and manufacturing. Simulations can model energy demands across systems such as HVAC, lighting, and drivetrains to determine optimal efficiency under real-world conditions. Additionally, PLM allows scenario modeling in manufacturing plants, enabling optimization of factory energy use and reduced operational carbon footprints.

The shift toward circular economy practices and regulatory frameworks like the EU's Ecodesign for Sustainable Products Regulation (ESPR) requires vehicles to be designed with recycling, reuse, and material recovery in mind. PLM supports this transition by allowing OEMs to embed circularity KPIs—such as recyclability, disassembly costs, and secondary material content—into early-stage vehicle designs. This not only prepares OEMs for compliance but also supports new business models based on reuse and refurbishment.

As part of the ESPR, the implementation of Digital Product Passports (DPP) will also place new demands on OEMs to track materials across their supply chain throughout a vehicle's lifecycle. PLM enables DPP integration by organizing and linking all relevant product data—from chemistry to component sourcing to performance—making it easily shareable across the value chain.

Digital Thread and Digital Twin data constructs supported by modern PLM solutions are particularly transformative. A Digital Thread creates traceable, bidirectional links among all stages of product development and usage, ensuring consistency and auditability. Digital Twins—a digital replica of physical products, processes, and simulations—enables advanced simulations of EV range, emissions behavior, and degradation over time, reducing costly physical prototypes and enabling quicker, more confident design iterations.

Emerging technologies such as Generative AI and Agentic AI are further amplifying PLM's value. These tools help engineers automate design validation, simulate regulatory scenarios, and explore novel materials, materials with less carbon dioxide equivalent (CO_2e), and new architectures with less human

[10] https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-are-scope-1-2-and-3-emissions

input. In an industry under pressure to innovate rapidly while meeting aggressive decarbonization goals, this AI-enhanced PLM capability may prove to be a key differentiator.

How PLM Accelerates Decarbonization Across the Automotive Lifecycle

PLM enables a comprehensive, end-to-end lifecycle approach to decarbonization by embedding sustainability into each phase of automotive development—from concept through end-of-life recycling. During the product design phase, PLM tools facilitate sustainable and eco-design strategies, such as lightweighting, modularity, energy-efficient architectures, and embedding sustainability into product structures such as including the CO_2e and other sustainability metadata related to parts and materials. By simulating performance with lighter materials and modular vehicle platforms, engineers can develop vehicles that require less energy to manufacture and operate. This results in a lower total product carbon footprint (PCF) and supports compliance with global fleet emissions targets.

Digital Twins offer powerful capabilities for simulating performance attributes critical to sustainability, such as range optimization in electric vehicles, energy consumption under varying driving conditions, and thermal system efficiency. These digital models allow OEMs to evaluate thousands of configurations quickly and cost-effectively, accelerating innovation and reducing physical testing. For example, improving thermal management through simulation can significantly boost battery efficiency, extending range and reducing charging needs.

Materials innovation is another key enabler of decarbonization. PLM platforms help R&D teams identify and validate low-carbon materials, track their source, and ensure they meet structural, regulatory, and environmental requirements. Integrations with databases like Ecoinvent or tools such as GaBi allow companies to lower their PCF for the materials and components that make up their product. This enables informed decision-making on trade-offs between performance, cost, and environmental impact.

In battery and powertrain R&D, PLM ensures data continuity among disciplines such as battery chemistry, control software, and mechanical packaging. As OEMs develop next-generation battery systems with greater energy density and recyclability, maintaining a unified development environment is essential. PLM provides the infrastructure to track development from lab-scale tests through production, ensuring safety, performance, and regulatory readiness.

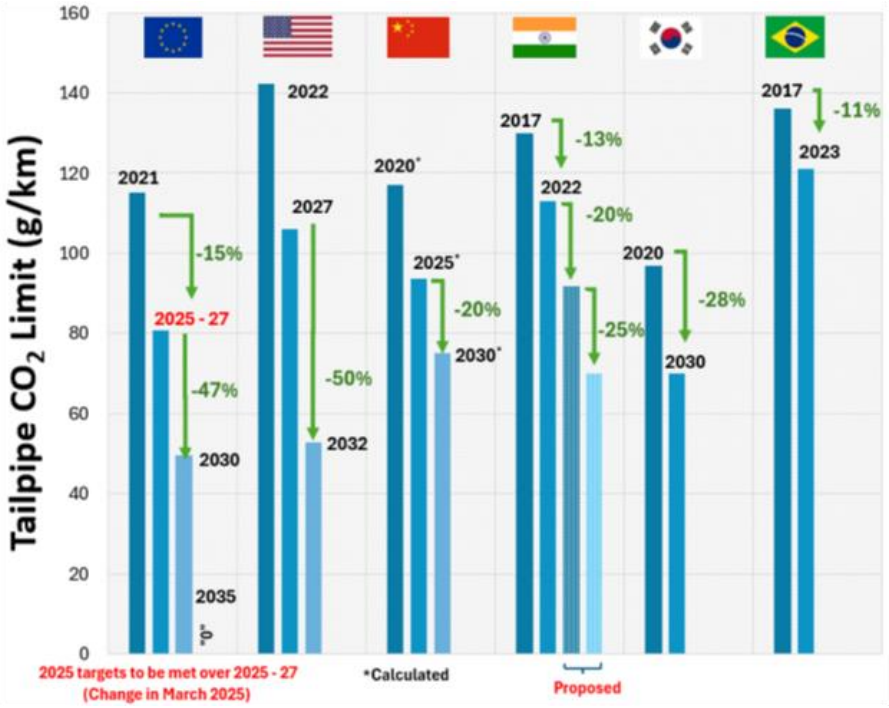
With the use of various Bill of Materials, PLM allows for precise modeling of Scope 1, 2, and 3 emissions. This not only reduces the environmental impact during design but enables manufacturers to evaluate the carbon intensity of production techniques, logistics routes, and even packaging options. PLM helps identify hotspots in the supply chain and supports scenario analysis to optimize for lower-carbon pathways, such as sourcing components regionally or shifting to greener suppliers.

Compliance and traceability are also enhanced through PLM. Whether facing Europe's battery regulations, China's NEV mandates, or India's fuel efficiency targets, OEMs must demonstrate compliance with an increasing number of detailed and dynamic requirements. PLM provides the digital backbone to document, track, and audit compliance throughout the vehicle's lifecycle. This proactive approach not only avoids regulatory penalties but also builds trust with consumers and investors alike.

Global Momentum

Companies are adjusting their strategies and reallocating resources to a slower-than-anticipated decarbonizing market. Any shift in direction, however, must be tempered with a broader global view given the emphasis on decarbonization in other parts of the world.

As shown in the following chart, CO_2 limits for light-duty vehicles continue to tighten in major markets across the world. In Europe, the limit reduces to "0 g/km" by 2035, which will require phasing out new passenger cars with internal combustion engines (there is a provision to allow some vehicles to continue using synthetic fuels). In recent years, this has been driving a rapid increase in the market share of conventional and plug-in hybrids. China is the undisputed leader in electrification, with over 14 million EVs expected to be sold domestically in 2025, representing 70% of the world's EV share. China also owns much of the battery manufacturing and raw material supply chain.



CO2 Limits for Light-Duty Vehicles Tighten Across the World
(Courtesy of MobilityNotes)

Criteria pollutant emission standards are moving to their next and likely last stage. After much debate, Europe has finalized the Euro 7 norms, which effectively kept all gas emission standards the same as Euro 6. Tailpipe fine particulate standards are tightened to include sub-23 nm particles in the overall count, based on health concerns. There is greater emphasis on lowering emissions under real-world driving conditions and regulating non-tailpipe emissions, such as those from brakes and tires. A new "Batteries Regulation" has been published, which introduces targets on battery recycling and material recovery. For the first time, a lifecycle-based approach is adopted to evaluate the carbon footprint of batteries and their use with electric vehicles.

China and India are expected to publish their next criteria standards in the coming months and could exceed Europe in stringency for tailpipe limits. Other regions of the world—e.g., Japan, Korea, and Brazil—typically follow European standards, so that by the end of this decade, the tightest regulatory standards will likely propagate to most of the advanced automotive markets.

Meeting these standards will require the adoption of several advanced engine and emission control technologies, hybridization, renewable fuels, and ZEV technologies, including electric and hydrogen-powered vehicles. Each of these has its strengths and challenges, and countries are promoting a regional

strategy based on their available resources. This is further highlighted in the heavy-duty sector, where decarbonization requires higher levels of infrastructure development, alternative powertrains, and more expensive solutions, and there is a greater need for cost parity with conventional fuels to support the business case. Meeting the low NOx standards in the US and Europe is already driving the adoption of innovative emission control systems. PLM will serve as a critical element for coordinating product strategy across such a diverse regulatory and policy framework across the world.

Conclusion

PLM has emerged as a strategic enabler of transport decarbonization, embedding sustainability into every phase of the automotive lifecycle—through electrification, circularity, sustainable materials, and compliance with ever-tightening global regulations. By integrating eco-design, simulation, digital threads and digital twins, supply chain transparency, and the advent of digital product passports, PLM provides the transport sector with the tools to innovate decisively, even amid regulatory uncertainty.

While US policy volatility presents real risks, PLM enables manufacturers to decouple innovation from political cycles and maintain long-term momentum. The global trajectory is clear: Europe, China, and markets across Asia and Latin America are driving toward stricter emissions and sustainability mandates, creating a regulatory baseline that OEMs cannot afford to ignore.

For automotive and heavy-duty trucking companies, decarbonization is no longer just a regulatory obligation—it is a competitive necessity shaped by investor expectations, consumer demand, and global climate targets. Ironically, isolationist shifts in US policy may accelerate corporate and regional commitments to sustainability, as businesses and communities turn to clean energy, circular economies, and resilient supply chains to manage risks and costs.

CIMdata believes that ultimately, OEMs that embrace PLM as the backbone of their decarbonization strategies will be best positioned to thrive in this complex landscape—balancing compliance, competitiveness, and innovation on the road to 2030 and beyond.

About CIMdata

CIMdata, a global strategic management consulting firm, provides services designed to maximize an enterprise's ability to design, deliver, and support innovative products and services. For more than forty years, CIMdata has provided industrial organizations, providers of digital technologies and services, and investment firms with world-class insight, expertise, and best-practice methods on a broad set of product lifecycle management (PLM) topics and the digital transformation they enable. CIMdata also offers research, subscription services, publications, and education through certificate programs and international conferences. To learn more, visit www.CIMdata.com or email info@CIMdata.com.