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Letter from the Guest Editors

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This Commercial Vehicle Engineering Congress (COMVEC) 2025 issue highlights recent advancements in commercial vehicle technologies aimed at improving energy efficiency and reducing emissions. Key innovations include hybrid powertrain designs, hydrogen combustion strategies, and fuel cell energy management systems that leverage predictive control and GPS-based route optimization. Studies demonstrate significant reductions in CO_2 and NOx emissions, cost-effective compliance with EPA regulations using alternative fuels, and improved fuel economy through hotel load management in mild hybrid trucks.

Complementary research applies machine learning and simulation to optimize vehicle specifications, forecast auxiliary energy demands, and enhance aerodynamic performance. A novel pavement monitoring system using reliability-based optimization further showcases the integration of advanced modeling for infrastructure assessment. Collectively, these efforts underscore the transformative potential of hybridization, alternative fuels, and intelligent control in shaping a sustainable future for the commercial vehicle industry. The body of research presented explores various advanced powertrain strategies. This focus issue highlights the utilization of hybridization and alternative fuels as a tool for enhancing efficiency and reducing emissions in heavy-duty vehicles.

In the study on "Optimizing Hybrid Powertrains for Off-Highway Vehicles," Bachu et al. incorporated computer modeling and experimental validation to design a plug-in hybrid electric powertrain for a wheel loader, achieving 48% and 84% reductions in CO_2 and NO_x emissions, respectively, when operated over an 8-hour shift through innovative system integration and active thermal management.

History

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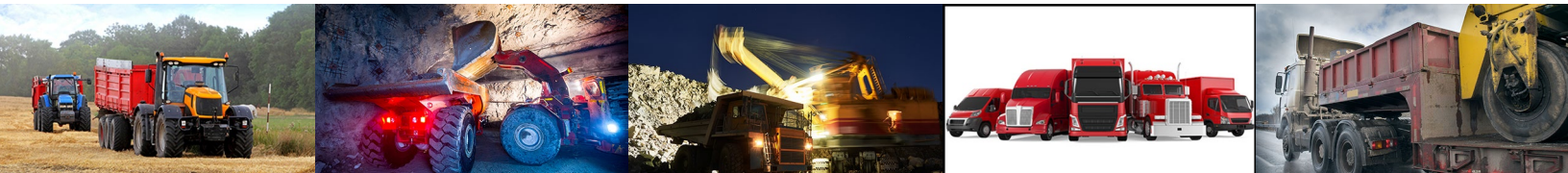

Complementing this, the investigation into "High Lambda Boosting for Hydrogen Internal Combustion Engine" by Gurjar et al. examined different boosting architectures, such as dual-stage turbocharging with superchargers, to enable lean hydrogen combustion with high lambda values. This approach yielded improved brake thermal efficiency and facilitated lower NOx emissions without complex aftertreatment, demonstrating superior transient response and fuel economy.

The next article expands on hybridization and alternative fuels. In "Advanced Energy and Thermal Management Control Strategy for Heavy-Duty Fuel Cell Powertrains," Batool et al. presented an integrated control framework combining adaptive energy management based on equivalent consumption minimization strategy (ECMS) with model-based thermal regulation using linear quadratic regulators (LQR). Employing route prediction via GPS data, the adaptive strategy optimized power split between the fuel cell and battery, while the thermal management minimized cooling system energy consumption, achieving up to 1.8% fuel savings and enhanced component temperature control.

Similarly, in the work titled "Alternative Fuels & Hybridization as Cost-Effective Pathways to Medium-Duty Greenhouse Gas Phase 3 Compliance," Patil et al. provided an in-depth analysis of medium-duty truck powertrains using compressed natural gas (CNG) and liquefied petroleum gas (LPG) combined with hybridization and low rolling resistance tires. This study underscores that such combinations can meet stringent US EPA Phase 3 Greenhouse Gas (GHG) standards cost-effectively, with hybrid configurations offering significant CO_2 reductions and minimal payload penalties.

Finally, Huang et al. focused specifically on managing non-propulsion electrical loads in heavy-duty trucks in the "Optimal Onboard Battery Charging Strategy for Hotel Load Management in Mild Hybrid Truck." The authors addressed the challenge of diesel fuel consumption during idling periods. By utilizing a 48V mild hybrid system with a transmission-mounted electric machine, the authors developed real-time implementable control strategies—including rule-based and adaptive ECMS-inspired methods—to optimize battery charging during driving phases to power hotel loads without engine idling. The adaptive control closely matches benchmark dynamic programming results with a fuel saving of nearly 3%, demonstrating practical feasibility for reducing fuel consumption in real-world scenarios. Collectively, these studies illustrate the promising potential of integrating hybridization, alternative fuels, and advanced predictive control to achieve regulatory compliance, improve energy efficiency, and reduce emissions in heavy-duty vehicle applications.

The next three articles address the critical challenge of reducing energy consumption and emissions in heavy-duty commercial vehicles by leveraging advanced modeling, machine learning, and control strategies.

Khuntia et al. presented an integrated approach combining physics-based HVAC system models with machine learning algorithms to forecast auxiliary power demands during the mandated off-duty (hoteling) periods in their study, "Energy Prediction for Hotel Loads in Mild Hybrid Heavy-Duty Vehicle." The authors developed novel control-oriented cabin temperature models (two-node and three-node) and a vapor compression cycle model that accurately estimated HVAC energy consumption, validated against experimental data with high precision. Complementing these, LSTM (long–short-term memory) a recurrent neural network (RNN) model predicted driver behavior-related energy loads during hoteling. These detailed load predictions feed into a dynamic programming (DP) framework that optimized the battery state of charge (SOC) trajectory, enabling significant fuel savings and CO_2 emission reductions by minimizing engine idling during hotel periods. The framework demonstrated practical viability through a full-day simulation of a Class 8 truck, achieving up to $40 daily fuel savings per truck.

In parallel, Villani et al., in the article, "Data-Driven Vehicle Specification of Conventional and Electric Heavy-Duty Commercial Trucks for Improved Energy Consumption," take a deep dive into data-driven vehicle specifications for conventional and electric heavy-duty trucks developing machine learning models (random forest and neural networks) trained on real-world and simulated datasets to predict energy consumption across vast vehicle configuration design spaces. The framework filters feasible vehicle specs using physics-based constraints and ranks them by predicted energy efficiency for specific routes, driving characteristics helping fleet operators identify optimal configurations.

Shifting gears into utilizing vehicle aerodynamics for efficiency gains in "Validation of Wind Noise for Class-8 Truck Using Lattice Boltzmann Method," Guleria et al. employed high-fidelity lattice Boltzmann CFD simulations incorporating realistic turbulent wind conditions to accurately replicate on-road aeroacoustics measurements. This work advanced aerodynamic and acoustic modeling for heavy vehicles, enabling early stage design optimizations to enhance driver comfort in quieter electric propulsion scenarios. The authors proposed a CFD approach to wind noise prediction at a time when quieter electric powertrains place an emphasis on cabin noise. A validation to experimental tests was performed showing the method to be of high accuracy and a valuable supplement to physical testing. The authors also demonstrated the importance of including upstream turbulence when simulating on-road tests.

Together, these studies provide comprehensive methodologies to enhance heavy-duty truck energy efficiency, environmental performance, and driver experience through integrated simulation, data analytics, and control.

Lastly, in "A Novel Mechanical Model Simulating a Pavement Deflection Measuring System for Non-Invasive Pavement Monitoring Based on a Reliability-Based

Optimization Algorithm," Yarmohammadisatri et al. introduced a novel mechanical model simulating a pavement deflection measuring system (PDMS) mounted on a Ford F-150. Their model integrated high-precision LIDARs, accelerometers, and gyroscopes and incorporated a reliability-based optimization (RBO) algorithm with Monte Carlo simulations and NSGA-II to optimize system parameters under uncertainties such as tire stiffness and vehicle loading. Experimental validation on a Texas road loop demonstrated significant vibration reduction and enhanced measurement accuracy compared to deterministic methods. This study emphasized the importance of integrating advanced computational methods and real-world uncertainties to improve system reliability and performance in vehicle operation and infrastructure monitoring.

In addition to publishing a COMVEC issue with above mentioned valuable technical journal articles, the conference is proud to introduce the inaugural COMVEC Journal Paper Presentation Award, which will be presented at the conference. This award is established to recognize outstanding research papers selected for presentation, recognizing presenters who clearly and confidently communicate complex, journal-quality work. The award commends presenters who skillfully communicate their advanced research effectively engaging a diverse and expert audience. Through this initiative, we strive to inspire researchers to amplify the significance of their findings and extend the reach of their work to a wider conference audience. Simultaneously, it offers attendees an exclusive preview of select articles from this issue, fostering greater engagement and meaningful discussions around cutting-edge research developments.

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