

# Method and Device for Enabling High-Concentration Biodiesel Usage in Diesel Engines: Overcoming Viscosity and Cold-Start Challenges with Advanced Integrated Solutions

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Biodiesel represents a promising sustainable alternative to fossil diesel, significantly reducing greenhouse gas emissions and promoting circular economy through the valorization of organic waste materials. However, the widespread adoption of high-concentration biodiesel blends (above B7) in compression ignition diesel engines faces critical technological barriers. Notably, elevated biodiesel viscosity at lower temperatures impairs fluidity, causing solidification, fuel line blockage, and cold-start difficulties. Additionally, biodiesel compatibility issues with engine materials and the formation of organic residues further restrict its practical use.

To resolve these issues, Refuel Solutions has developed a patented solution (Patent No. 12173663, IT102020000029540A, EP21824698.1A, PCT/IT2021/050375), enabling seamless integration and optimized utilization of biodiesel blends ranging from B7 up to pure biodiesel (B100). The innovative solution, termed BiodieselKit, incorporates a proprietary electronic control unit (ECU), advanced hydraulic fuel management circuits, and dual-tank infrastructure to dynamically regulate biodiesel concentrations during critical operating phases, particularly at cold-start. When starting the engine at low temperatures, the integrated control system automatically reduces biodiesel mitigating viscosity-related issues and ensuring proper ignition and smooth operation. Once optimal engine temperature and operational conditions are achieved, the system seamlessly transitions to higher biodiesel concentrations without user intervention.

The developed BiodieselKit provides extensive backwards compatibility with standard diesel fuels (EN590), facilitating a flexible bi-fuel or bi-flex-fuel approach. Moreover, its intelligent integrated monitoring system with remote data transmission capabilities ensures continuous oversight of fuel quality, emissions, and operational diagnostics, thus complying with stringent legislative and environmental requirements. Experimental validations demonstrate that this approach maintains engine performance, reliability, and longevity comparable to conventional diesel operation, offering a significant economic advantage through reduced fuel costs and enabling immediate decarbonization in sectors where electrification solutions remain impractical.

This technology represents a transformative step towards overcoming biodiesel implementation barriers, significantly enhancing the sustainability profile and operational feasibility of biodiesel in diesel-powered applications across transportation, construction, agriculture, and marine industries.



**Figure 1:** BiodieselKit, truck version.