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Sustainable Pavement Design: LCA perspective & biogenic - A comprehensive analysis of environmental impact in infrastructure construction

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26 November 2026

# Sustainable Pavement Design

## LCA Perspective & Biogenic: A Comprehensive Analysis of Environmental Impact in Infrastructure Construction

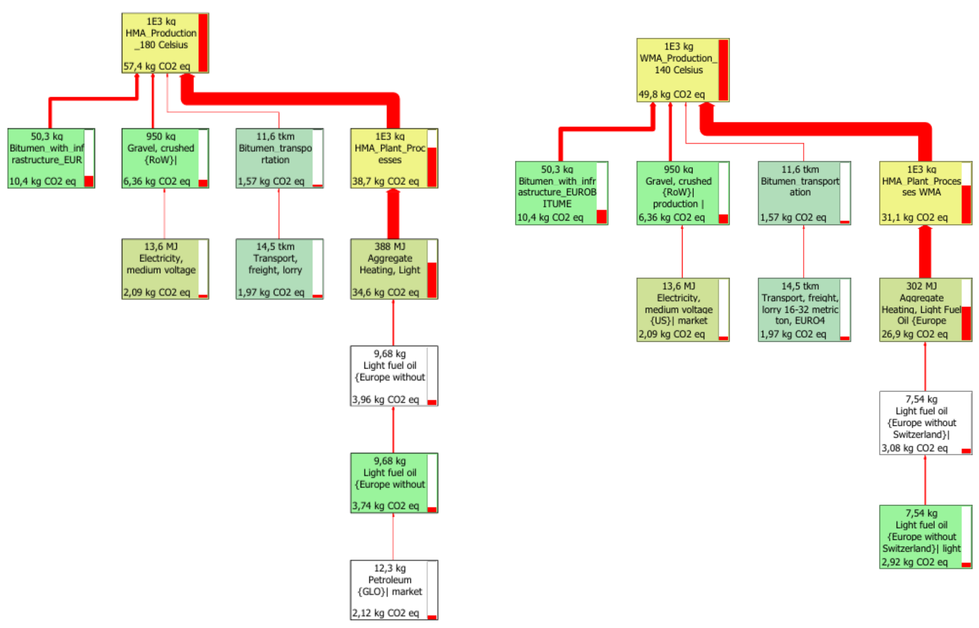
Authors: Eng. Rajab Ali Mehraban, Prof. Lucia Tsantilis, Prof. Pier Paolo Riviera, Prof. Ezio Santagata.

This study examines the environmental impacts of Hot Mix Asphalt (HMA) and Warm Mix Asphalt (WMA), produced at 180 °C at 140 °C, respectively. A Life Cycle Assessment (LCA) was performed with a cradle-to-gate approach. The findings of this study revealed a notable advantage of WMA, with $CO_2$ equivalent emissions being 14% lower compared to HMA. This stems from a reduced production temperature, which allows a significant enhancement of the environmental sustainability of pavements containing WMA.

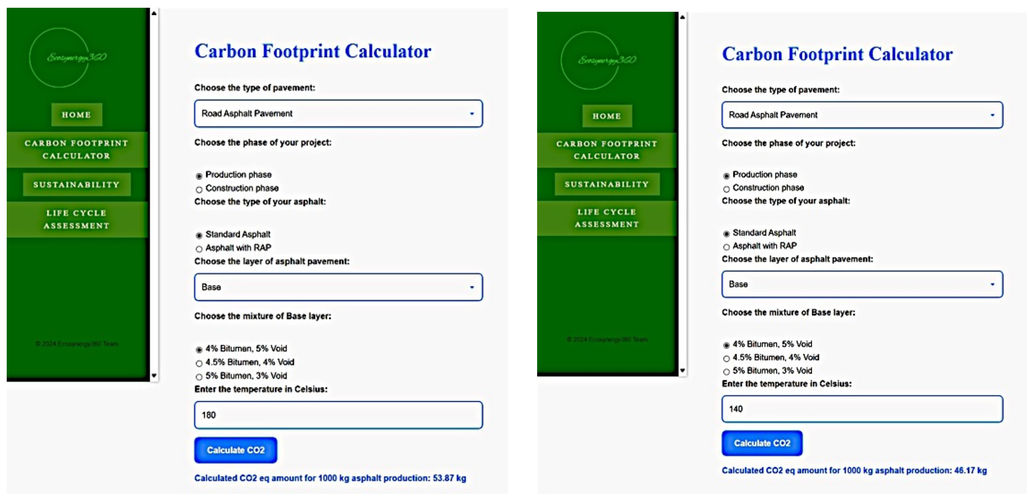
Furthermore, the research investigated the environmental implications of integrating biogenic materials (such as biodiesel) into infrastructure construction practices, with the specific purpose of mitigating ecological impacts. By employing the LCA methodology, this study thoroughly evaluates the benefits of employing biodiesel in the plant-production of asphalt mixtures, highlighting substantial reductions in $CO_2$ equivalent emissions, which were found to be of the order of 50%.

## LCA Perspective (HMA & WMA)

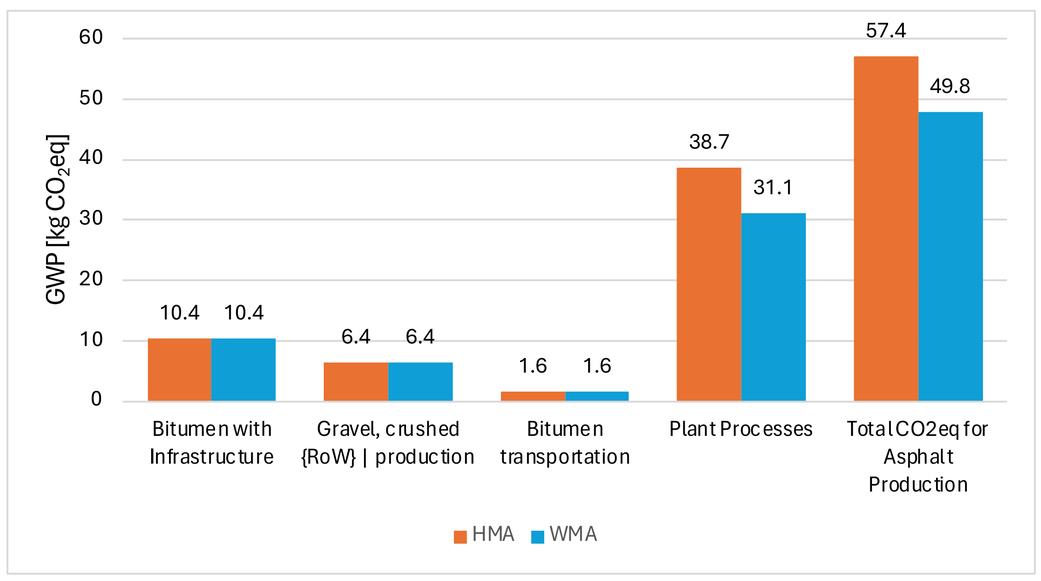
Environmental LCA for the production phase of HMA & WMA (SimaPro impact assessment results)



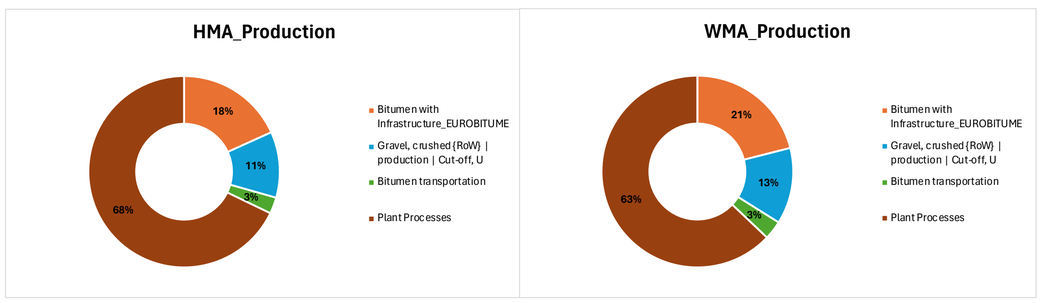

Carbon Footprint ($CO_2$eq) for the production phase of HMA & WMA (Ecosynergy*360* results)




Carbon Footprint ($CO_2$eq) results for the production of 1 ton of HMA and WMA

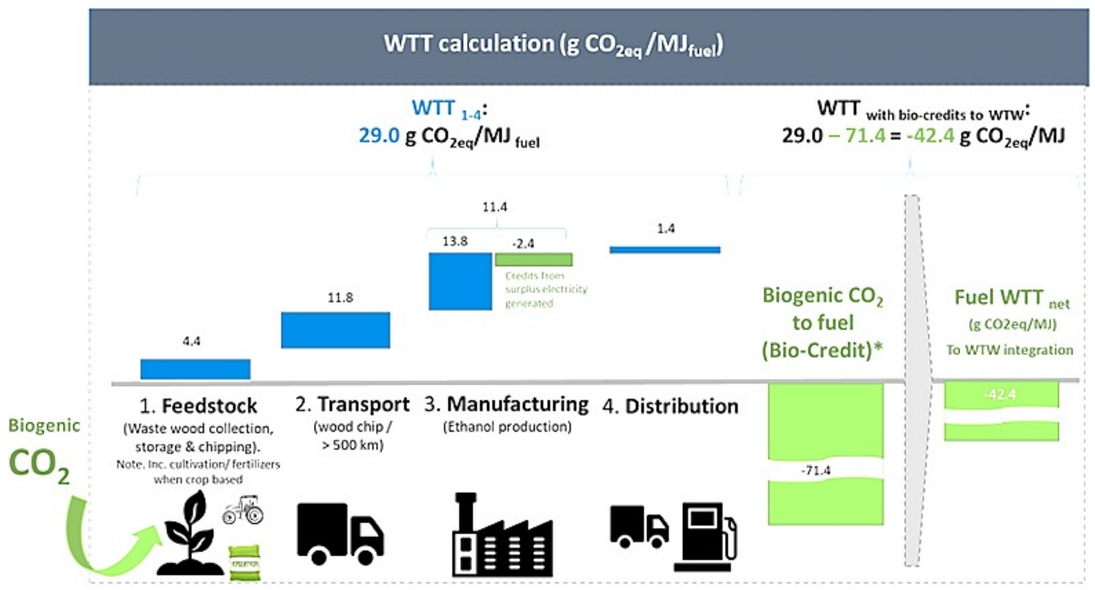



Carbon Footprint ($CO_2$eq) relative results for HMA and WMA production



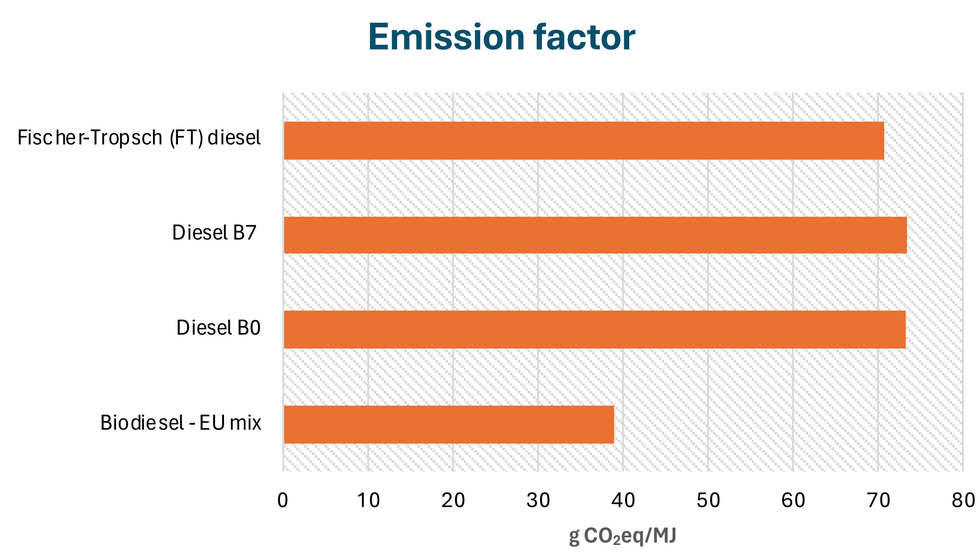

## LCA Carbon-Credit (Biogenic material)

Carbon-Credit calculation for Biodiesel in Wheel-To-Wheel method (g $CO_2$eq/MJ)

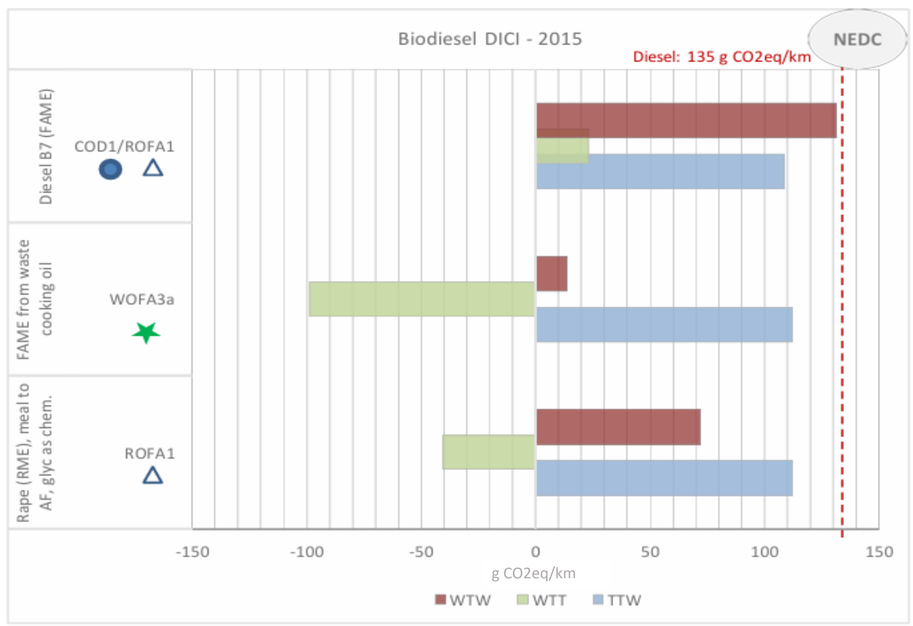



Bio-Credit: $CO_2$ is released back into the atmosphere when 1 MJ of the fuel is fully combusted. Equivalent to the amount of $CO_2$ initially captured by the tree during the photosynthesis process (zero net effect).
Source: JRC - JEC WTW report v5

Carbon Footprint (CO2eq) results for full combustion of different diesel products




Bio-credit for biodiesel DICI (Direct Injection Compression Ignition) with different sources compared to fossil diesel without bio-credit




Source: Adapted from JRC - JEC WTW report v5



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VTRC Virginia Transportation Research Council
U.S. Department of Transportation Federal Highway Administration