European Commission

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TOP GEAR

Gears with top in-service performance developed for hybrid and electric vehicles

Deliverable D6.1 (D10)

Integral Life Cycle Assessment

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Legal Disclaimer

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PUBLISHABLE SUMMARY

Deliverable D6.1 presents an integral Life Cycle Assessment (LCA), Life Cycle Costing (LCC), and Social Life Cycle Assessment (S-LCA) of two production routes: a baseline route using conventional 27MnCr5 steel and a novel route employing 40CrMoBi4 steel.

The study follows ISO 14040/14044 standards and uses the ReCiPe 2016 method with data sourced from Ecoinvent. The system boundary is defined as cradle-to-gate, covering steel production, surface hardening, and gear fabrication. Functional units include 1 ton of steel and one finished gear. Data were provided by project partners SIDENOR, ALD, and WZL.

Results show the novel route achieves a reduction in Global Warming Potential (GWP) during steel production mainly due to the elimination of high-emission heat treatment and the efficiency of quenching and tempering. Surface hardening using nitriding in the novel route has a high reduction in GWP compared to carburizing. Gear fabrication emissions shift from hard machining in the baseline scenario to a second soft machining process step in the novel route. This results in a minimal net effect on GWP, though overall, the novel route still achieves a slight reduction in GWP compared to the baseline solution.

A country-specific analysis demonstrates that Spain offers the most sustainable energy mix for all production phases, outperforming Austria, Italy, and Germany. Austria's impact is comparable to Spain's, while Italy and Germany show significantly higher environmental impacts.

The holistic evaluation of all processes including steel production, surface hardening, and gear fabrication clearly shows that the novel 40CrMoBi4 route delivers significant environmental advantages. The novel route entails slightly higher overall production costs, primarily due to outsourcing. Under identical production conditions, the costs would be comparable (more or less the same). The Social Life Cycle Assessment confirms that the 40CrMoBi4 route achieves meaningful environmental improvements without introducing significant social risks, as all processes are carried out under established conditions without the need for additional qualifications. Notably, enhancements in heat and surface treatment contribute to safer working environments and long-term societal benefits through lower emissions and reduced resource consumption.