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Automotive Thermoelectric Waste Heat Recovery[1]

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Considerable fuel energy, as much as 70%, is not converted to useful work by internal combustion engines but is instead rejected as waste heat, and more than half of the waste heat, nearly 40% of fuel energy, is contained in vehicle exhaust gas. This provides an opportunity to recover some of the wasted fuel energy and convert it from heat into useful work, subject to the laws of thermodynamics, and thereby improve vehicle energy efficiency. Thermoelectric (TE) materials have been extensively researched and TE devices are now being developed for operation at high temperatures corresponding to automotive exhaust gases for direct solid-state conversion of heat into electricity. This has stimulated substantial progress in the development of practical TE generator (TEG) systems for large-scale commercialization. A significant enabler of this progress has been the US Department of Energy's Vehicle Technologies Program through funding for low cost solutions for automotive TE waste heat recovery to improve fuel economy. Our current project at General Motors has culminated in the identification of the potential supply chain for all components and assembly of an automotive TEG. A significant focus has been to develop integrated and iterative modeling tools for a fully optimized TEG design that includes all components and subsystems (TE modules, heat exchangers, thermal interfaces, electrical interconnects, power conditioning, and vehicle integration for maximal use of TEG power). We have built and tested a new, low-cost Initial TEG prototype based on state-of-the-art production-scale skutterudite TE modules, novel heat exchanger designs, and practical solutions to the many technical challenges for optimum TEG performance. We will use the results for our Initial TEG prototype to refine our modeling and design tools for a Final automotive TEG system prototype. Our recent results will be presented. Thanks to: J.R. Salvador, E.R. Gundlach, D. Thompson, N.K. Bucknor, M.G. Reynolds, K. Rober, F.R. Stabler; Marlow, JPL, Dana, Delphi E&S, Eberspaecher, Molycorp, University of Washington, Purdue University, Michigan State University, ORNL, BNL.

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