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Topic Insights

# Prospects of Reciprocating Engines and Fuels

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Reciprocating engines and their fuels are largely associated with road transport. This isn't surprising. About 70% of transport-sector greenhouse gas emissions today are from road vehicles [1], and these vehicles are overwhelmingly propelled by reciprocating engines. However, reciprocating engines are also widely used in other sectors, particularly off-road land transport, sea transport, and electrical power generation.

Various forms of gasoline and diesel are the dominant transport fuels for several reasons. These include the scale of their primary resource, their affordability, and their high volumetric and gravimetric energy densities. However, natural gas, liquefied petroleum gas, methanol, ethanol, and electricity also play a part in transport. Natural gas and diesel also play important roles in reciprocating engine-driven electrical power generation.

The global scale of reciprocating engine use can be grasped to some extent by considering road transport alone. Road travel has roughly doubled in the last 40 years in terms of both the total distance traveled per annum and the total number of vehicles [2], with roughly one billion vehicles on the world's roads today. Road travel is thought likely to roughly double again by 2050, with most of this growth occurring in low- to middle-income countries via greater use of light-duty passenger vehicles [2]. Given the enormous volume of road transport occurring today, it is not surprising that reciprocating engines already contribute significantly to global emissions of greenhouse gases and other pollutants, and their adverse impact on urban air quality and mortality is featured regularly in the press.

In most system-level studies [2], the use of more fuel-efficient vehicles and alternative fuels are the primary projected means to achieve road transport sector abatement. Modal shift and more productive vehicles are also important. Although full vehicle electrification and fuel cell vehicles are efficient vehicle options, Kalghatgi rightly points out in this volume that these technologies only constitute a very small fraction of the current global fleet, and that both face significant challenges to their rapid adoption.

Therefore, more effective use of increasingly efficient and cleaner reciprocating engine-driven vehicles is the dominant means by which we will reduce vehicle emissions over the next one or two decades, at least. Similar arguments hold for other transport sectors in which reciprocating engines are used. As this volume attests, many opportunities remain to improve engine and fuel performance. These include new engine concepts and the use of more advanced engine subsystems, with fuel injection and after-treatment as two active areas of current research.

Modal shift and more productive vehicle use should also be transformative. Our working, learning, and socializing are increasingly taking place online, and innovation in mass transit continues apace. Information and communication technologies have also already disrupted the transport sector, directly not only via Uber and similar, but through less obvious, yet major, innovations such as freight path optimization, real-time vehicle and network monitoring, and improved data-driven planning, to name a few.

The uptake of greater vehicle autonomy is a logical part of this transition. In order to offset the higher upfront costs of the technologies required to achieve substantial autonomy, it is expected that these vehicles will first appear in commercial applications in which reduced need for or complete removal of a paid driver is the major economic benefit for the business and its customers. Such examples include the displacement of conventional taxis and public transport with ride-sharing autonomous vehicles, and the displacement of freight vehicles with their autonomous equivalents.

Like any capital-intensive asset, further economic benefits are then likely to be achieved by maximizing vehicle use, as is the case with conventional taxis, public transport, and freight today. Thus, heavy autonomous vehicle use over relatively long distances is likely to prove economically beneficial. In such cases, it is not obvious that full vehicle electrification will follow, given range and recharging/refuelling time requirements. Rather, greater vehicle hybridization may result, with advanced reciprocating engines and cleaner fuels then continuing to play an important role.

At the same time, we should not be too focused on using technology alone to achieve our goals. For example, several studies have found substantially greater public health benefits from active travel (e.g., walking, running, and cycling) displacing vehicle use, in comparison with the health benefits that arise from the increased use of lower emission vehicles for the same travel task [1]. Such findings will hopefully lead to significant abatement of greenhouse gas emissions from transport as a co-benefit of improved public health—particularly when governments consider the reduced public health costs from active travel relative to investment in public transport, and dedicate routes for walking, running, and cycling.

A broad perspective of the plethora of different options available makes it clear that we need to take a more system-level

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approach to the important, dual challenges of decarbonization and improved human health. Numerous technological and non-technological options can help to achieve both goals, and there are risks in ignoring potentially poor environmental or economic performance by technologies that are commonly assumed to be always beneficial or benign.

Ideally, therefore, we should regulate the life-cycle emissions of greenhouse gases and other pollutants from vehicles and their fuels while integrating non-vehicle options into such analyses. Should such regulation be achieved, it is then expected to result in the continued use of reciprocating engines for several decades, while engines, fuels, vehicles, cities, and our attitudes continue to evolve.

## References

[1] Sims R, Schaeffer R, Creutzig F, Cruz-Núñez X, D'Agosto M, Dimitriu D, et al. Transport. In: Edenhofer O, Pichs-Madruga R, Sokona Y, Farahani E, Kadner S, Seyboth K, et al., editors. Climate change 2014: mitigation of climate change. Contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change. New York: Cambridge University Press; 2014. p. 599–670.

[2] International Energy Agency (IEA). Energy technology perspectives 2014. Report. Paris: IEA; 2014 May.