Submission to the Garnaut Climate Change Review

Fuel Efficiency of Internal Combustion Engines

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9th April 2008

Abstract

This submission draws attention to the poor fuel efficiency of engines that power private cars and commercial vehicles, diesel and diesel-electric trains and ships as well as earthmoving, farming, mining, marine and industrial machinery. Averaging only 30% fuel efficiency, these engines waste fuel and money, produce avoidable Greenhouse Gas (GHG) emissions and hasten the depletion of precious oil reserves. The submission examines how engines function, and identifies lost heat energy as the main reason for poor fuel efficiency. It is claimed that suitably designed engines can recover waste engine heat and convert this into additional mechanical energy, thereby significantly reducing fuel consumption and GHG emissions. A potential to reduce Australia's GHG emissions by 30 Mt annually is claimed.

Submission - The case for urgent action to improve fuel efficiency of internal combustion engines.

Internal combustion engines provide power for millions of vehicles and machines that Australia and other developed nations have come to depend on. However, these engines are only 30% efficient, on average, in terms of useful work obtained compared with fuel energy consumed. Furthermore, this efficiency applies to engines running under optimum operating conditions for example a car or truck at steady highway speeds. Under urban traffic conditions, fuel efficiency is likely to be even lower.

Internal combustion engines in Australia produce about 100 million tonnes (Mt) GHG each year. Transport alone accounted for over 80 Mt GHG in 2005 (AGO). By improving fuel efficiency to just 50%, GHG emissions in Australia could be reduced by about 30 Mt annually, and internationally by much more. But is this achievable? After over 100 years of research and development to improve engines, is 30% fuel efficiency the best we can manage?

We can do much better. The following brief review of how engines function, points to a promising direction for research and development to maximise fuel efficiency.

In the cylinders of internal combustion engines, combustion of fuel and air produces heat that expands combustion gasses to drive pistons downwards which, in turn, rotate the crankshaft. At the end of each power stroke, combustion gasses at about 900 degrees C pass into the exhaust system and then into the atmosphere. After passing from the combustion chambers, the heat contained in these gasses does no further work and is lost. The combustion process also heats the engine itself, and this heat is removed by the cooling system. Heat energy lost through the exhaust and cooling systems, amounts to about two thirds of the energy contained in the fuel consumed. A demonstration of heat produced by an engine and available for recovery and reuse can be seen on “Youtube” under my name.

Wasted heat energy is the main reason for poor fuel efficiency of internal combustion engines. Since heat can be converted into mechanical energy, and since two thirds of fuel used becomes heat that is wasted, recovery and reuse of engine heat is the only way to achieve fuel efficiency gains of 20% or more. It should be noted that a gain of 30% across the board would double the present average efficiency to 60%, cutting fuel consumption and GHG emissions to approximately half current levels. Until engine designers accept that engine heat must be recovered and reused, the potential to significantly improve fuel efficiency beyond present levels, is severely limited.

For many years, engine designers and vehicle manufacturers have been interested in the recovery and reuse of engine heat, and many patents describe ways to achieve this. And yet there are few, if any commercial examples of engines that do this, so it is tempting to conclude that the technology is too difficult.

While the technology will involve challenges, the explanation for lack of progress in this direction in the past, is likely to be commercial rather than technical. Engines are components of complex products, manufactured as economically as possible in order to compete in highly competitive markets. Internal combustion engines that recover and reuse waste heat will require modification and additional components, and will incur substantial R and D expenditure. Also, manufacturing costs are likely to exceed those for conventional engines. Therefore there was little incentive for manufacturers to develop this technology while fuel costs were low, and while Global Warming was still being denied in some quarters.

However, circumstances have changed dramatically. Global Warming is confirmed and recent data indicate that climate change may be occurring at, and beyond worse-case scenario rates. Crude oil now costs over $110 a barrel with the likelihood of continued price rises for the foreseeable future. Fuel costs are hurting public and commercial consumers and affecting the viability of businesses unable to pass on increasing costs.

Underlying this situation is the inescapable fact that we have become totally dependent on internal combustion engines and the fossil fuel they burn. Fossil fuels are a unique and irreplaceable form of condensed energy. Used wisely they held the possibility to raise living standards for all people. Unfortunately they were mainly used to raise living standards in developed countries to obscene levels while those who really needed the labour-saving benefits of engines got nothing. However, in an ironic twist, the developed world is highly vulnerable to high fuel prices and possible supply shortages.

In spite of hopes for hydrogen and other technologies, internal combustion engines offer unique versatility and convenience and will be the primary power source for vehicles and machinery while fuel supplies can be maintained. However, sensible fuel use, from this point on, is vital to address climate change and extend shrinking oil reserves. Fuel use for non-productive and non-essential purposes should be severely restricted, but the difficulty of implementing this is obvious. The immediate challenge is to push engine fuel efficiency to absolute limits, rather than commercial limits. Heat recovery and reuse is essential to this process and is the direction that offers most potential for improvement.

Recommendations

1. A specific recommendation is for the development of technologies to recover and reuse waste heat produced by internal combustion engines in order to make significant gains in fuel-efficiency.

This presents an opportunity for Australian skills and innovation to make a major impact on GHG emissions, and to revitalise the struggling Australian Automotive Industry with a new focus on fuel efficiency in response to climate change.

It is important, that a working prototype heat-recovering engine be developed rapidly. To familiarise those people interested in how such an engine might look and function, I can present for consideration, a combustion engine/steam turbine hybrid concept. This could serve as a starting point for discussion and for technical and commercial evaluation of feasibility. Rapid progress towards a working prototype could be achieved with Australian Government support and the cooperation of Industry and Research organisations.

An aspect of urgency flows from the possibility that many companies may be retrieving shelved ideas and patents to help them compete in a new economic environment where “clean and green” is rewarded, and old technologies are heavily penalised. Because the R and D process itself usually throws up additional patentable material, early involvement could deliver control and Intellectual Property rights over vital parts of the technology to Australia.

Heat recovering technology developed with the close involvement and support of the Australian Government could be passed on to manufacturers for incorporation into their production lines. This could reduce R and D costs to manufacturers and generate income through licensing agreements.

Previous Government grants to the Australian Automotive Industry, amounting to hundreds of millions of dollars, have been largely useless in delivering a secure future for the Industry. Future support should focus on innovation that helps the Industry compete strongly on the world stage. Technology to reuse engine heat to boost fuel-efficiency meets that requirement.

2. A broader recommendation is that Governments act to reduce the use of fuels generally, and to restrict fuel use to essential and productive purposes. Regardless of how difficult such a policy may seem, it is likely to be critical for survival into the future. Initial responses could include encouraging rail transport over road where feasible, encouraging small, fuel-efficient private vehicles through weight penalties or equivalent means, extending cycling and pedestrian facilities, encouraging food production on urban private and public land.

Conclusion

Current ways we use engines, vehicles and fuel is unsustainable, even with fuel-efficient engines. The lifestyle of most Australians, results in profligate waste of shrinking oil reserves and high levels of per capita GHG emissions. Developing fuel efficient engines is a relatively small step towards changes that will ultimately be needed to address Global Warming, but it is a vital step, and long overdue. Across the many applications of internal combustion engines, improved fuel efficiency could save over 30 Mt GHG emissions each year in Australia and, perhaps more importantly, could provide valuable time for adjustment to a less polluting and wasteful lifestyle and for transition to alternative fuels and technologies.

Declaration: As the holder of an Australian Patent Application describing a heat recovering, hybrid-type engine, I declare an interest in the substance of this submission.

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