# A fuel economy rule for Australia?

The future will probably see the introduction of an Australian fuel economy rule for heavy vehicles. While it may be a few years away, international developments will inevitably be felt in the Australian marketplace. It will be easy for Australian regulators to adopt rules applied overseas – and why not?

Up until recently, emissions rules have been exclusively concerned with gaseous pollutants. These are:

- Carbon Monoxide (CO) which arises from incomplete combustion of fuel;
- Hydrocarbons (HC) which arise from incomplete combustion of fuel;
- Nitrous Oxides (NOx), family of compounds, which arise from combustion conditions; and
- Particulates, carbon and higher organic particles in the exhaust (contributing smoke), which arise from incomplete combustion.

Perfect fuel combustion conditions would result in all fuel being converted to carbon dioxide (CO2), which is non-toxic and is the lowest state of conversion. Nitrous oxides arise naturally because about 70% of the gas in the cylinder is Nitrogen. It is inevitable that Nitrogen will be involved in some combustion reactions.

Whilst CO2 emissions have not been regulated so far, substantial improvements in average fuel economy, and therefore CO2 emissions per kilometre, have resulted from the fine control of fuel combustion that was needed to meet the gaseous emissions limits. The ~25 per cent improvement of fuel economy that has occurred since the late 1980s is a welcome by-product of the early stage emission rules.

By early stage, I mean achievement of improved performance resulting from the application of electronics (ECMs) and unit injectors (which are electrically controlled). Graph 1 (pictured right) shows the Euro emission limits for heavy vehicles. I could have presented US EPA limits with similar introduction dates but will stick with the Euro limits because the Australian emission rules (ADRs 79/00, 80/00, 80/01 and 80/02) are based upon them. Australia has not yet adopted Euro VI.

The Euro limits 0 and 1 could be met with improved fuel pump control. Sensors were added to the engine and the throttle. The ECM worked out how much fuel was needed per stroke. The Euro II and III limits could only be met using fine injection control. That is, the fuel injector contained a solenoid that could be turned on and off at a precise time in the cycle. The injection pressure also needed to be high to create a very fine mist of fuel and improved combustion conditions. So, up until 2005, emission improvements could be achieved coincidentally with improved fuel economy. To meet the Euro IV, V and VI limits, new technologies were needed. These were exhaust gas reticulation (EGR), selective catalytic reactors (SCR with urea) and exhaust particulate traps. All these technologies are detrimental to engine performance and efficiency. Also, EGR increases the cooling load, which has been challenging in Australia.

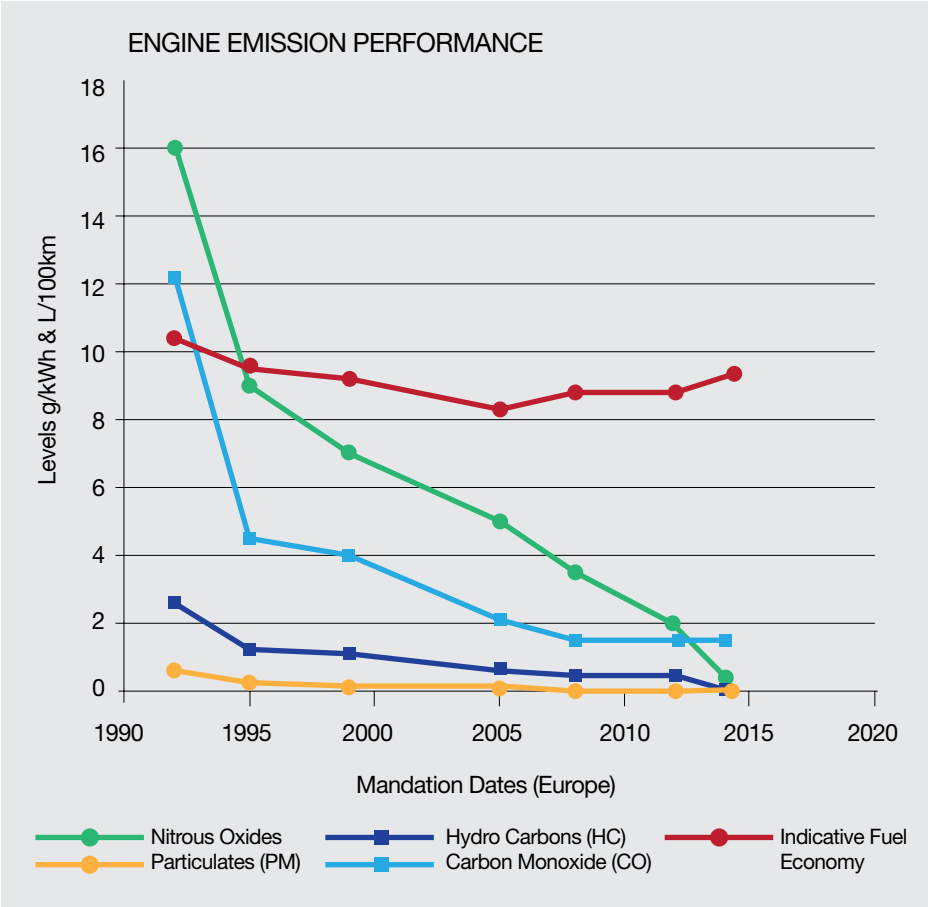
In Graph 1 I have estimated the indicative fuel economy performance of a benchmark laden tractor semi trailer. Best fuel economy performance occurred with year 2005 engine technology.

President Obama recently signed fuel economy improvement requirements into US law. Application in the first instance will occur in 2014 and they will reach full effect in 2018. The rule is applicable to heavy trucks including prime movers. It requires new truck manufacturers to offer fuel efficient models that will, in time, have at least a 20 per cent fuel economy advantage over current benchmarked models. For vocational trucks (such as garbage compactors, etc.), the fuel reduction improvement must reach 9 per cent. The European Union has also foreshadowed introduction of fuel economy targets for heavy trucks. Both the US and EU governments have opted for direct action regulations.

Unlike reduction of gaseous emissions, the onus for compliance with a fuel economy rule will fall on the truck manufacturer. The fuel economy rule will apparently not apply directly to trailer manufacturers, however, the market will demand low drag trailers behind low drag trucks. Australia will benefit from the overseas developments through access to more fuel efficient truck technologies and generally from improved technical knowledge.

Based upon past experience, Australia will eventually have a fuel economy rule for heavy trucks, by about 2020. In preparation, we should not proceed to the Euro VI emission limit stage, instead we should bank some fuel economy advantages. The improvements in city air quality that can be attributed to the introduction of the Euro V and VI level rules are negligible because heavy trucks are very minor contributors. The fuel economy detriment has not been considered. Furthermore, Australia has lost interest in NOx and has become focused on CO2 and other greenhouse gases.

Much of the improvements that will be needed to meet a fuel economy rule will come from drag reduction. The average aerodynamic drag coefficient of a benchmark truck-semitrailer is probably




Graph 1 Euro series emission limits for heavy vehicles. Estimated benchmark fuel economy is also shown.

about 0.7. Reduction to 0.6 is currently feasible representing a ~15 per cent improvement of the single largest drag factor. Advanced designs might lower the aerodynamic drag coefficient to about 0.5. If the truck travels 1,000,000km over its lifetime, a reduction of the drag coefficient by 0.1 will save about 10% of the 900,000 litres of dieseline that the truck would otherwise use. That's about $k135 in today's money. The size of the potential benefit explains why aerodynamic developments will always be on the agenda.

It is interesting to compare fuel economy performance of heavy trucks with cars. The passenger car fuel economy of a Toyota Prius; clearly a benchmark passenger car, is about 6L/100km. The Prius with a family of four passengers weighs about 1.5 tonnes. That is 4L/tonne per 100km.

A benchmark truck-semitrailer weighing 42 tonne when loaded, for example, might achieve 83L/100km. That is about 2L/tonne per 100km. When unloaded, the same truck might weigh 20 tonne and achieve 60L/100km. That is, 3L/tonne per 100km. A benchmark B-double will achieve about 1.6L/tonne per 100km laden. As long as weight is included in the calculation, the benchmark heavy truck is more fuel efficient than the benchmark car.

With an Australian fuel economy rule, a benchmark 2020 model truck semi trailer might achieve 70L/100km. So how can this level be achieved? Here are some examples:

*Application of existing technical knowledge*

- Engine and powertrain matching for vocational applications.
- Engine ECM controls.
- Lowering trailer profiles by reducing trailer floor height.
- Aerodynamic shaping improvements to the front of trucks and rear of trailers.
- Trailer side-skirting.
- Low rolling-resistance tyres and broad-base tyres.
- A real time fuel economy gauge.

*Advanced technologies*

- Supercharged engines to reduce engine size.
- Waste heat capture and use to drive auxiliaries.
- Hybrid technology involving an integrated starter-generator module that contributes peaking torque.
- Electric on board air conditioning.
- Truck-trailer gap reduction using automatically adjusting fifth wheels.
- Air injection into low pressure regions to reduce drag.

A fuel economy rule would favour sleek shaped trucks and penalise COE trucks and to some extent, long bonneted trucks. It seems unlikely that trailers will be explicitly included in a fuel economy rule because of the difficulties involved in regulating particular vehicle combinations. It will, however, be important for Australia to have local engineering expertise to support our innovative vehicle manufacturing industry. ARTSA is proud to be an industry partner of Australia's premier heavy vehicle aerodynamics research group, which is in the mechanical engineering group at Monash University. The team is working on leading edge drag reduction techniques. A 1/3 scale model of a semi trailer is currently under construction. Wind tunnel tests and computer modelling results are being used to identify next generation features and techniques. This work is also being partnered by Kenworth Australia. During 2012, I will keep you informed about this group's progress. I also hope to announce local trailer manufacturers supporting the work.

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