Developing a “Research Test Bed” to introduce innovative Emission Testing Technology to improve New Zealand’s Vehicle Emission Standards

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Abstract. Vehicle exhaust emissions arise from the combustion of the fuel and air mixture in the engine. Exhaust emission gases generally include carbon monoxide (CO), oxides of nitrogen (NOx), hydrocarbons (HC), particulates, and the greenhouse gas carbon dioxide (CO2).

In New Zealand improvements have occurred in emissions standards over the past 20 years however significant health related issues are now being discovered in Auckland as a direct effect of high vehicle emission levels. Pollution in New Zealand, especially via vehicle emissions are an increasing concern and threatens New Zealand’s “clean and green” image.

Unitec Institute of Technology proposes establishing a Vehicle Emissions Testing Facility, and with an understanding with Auckland University, National Institute of Water &Atmosphere Research Ltd (NIWA) this research group can work collaboratively on vehicle emissions testing.

New Zealand research providers would support an application in the United Kingdom led by the University of Huddersfield to a range of European Union Structural Funds.

New Zealand has an ideal “vehicle emissions research environment” supported by significant expertise in vehicle emission control technology and associated protocols at the University of Auckland, and the effects of high vehicle emissions on health at the National Institutes of Water and Atmosphere (NIWA).

1. Introduction

This paper will detail the need for, technical requirements of, and the potential regulatory benefits of a new approach to Vehicle Emission Testing in New Zealand. A collaborative approach in New Zealand on this subject will also provide the ability to create a transnational partnership - with internationally recognised research capabilities - with the United Kingdom’s University of Huddersfield to establish a “test bed” or “test beds” through their proposed Centre of Excellence that will be the subject of a European Union Structural Funds proposal. Under a technology transfer agreement within such a transnational partnership, it is a sensible proposal that one of these “test beds” should be in New Zealand.

Reducing harmful vehicle emissions is an important New Zealand government objective under the New Zealand National Environmental Standards for Air Quality regulated under the Resource Management Act 1991 and the New Zealand Transport Strategy’s goals of protecting and promoting public health to ensure environmental sustainability.

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If New Zealanders do not make changes to the way we travel and transport freight, or to the technology and fuels we use, transport energy use will grow further. Public transport, biofuels, electric vehicles, rail, cycling and walking, as well as improved vehicle efficiency are all areas to keep in mind. Most forms of travel are fuelled by liquid fossil fuels, such as petrol and diesel, which result in transport and vehicle based emissions of greenhouse gases being released into the atmosphere.

Under New Zealand Land Transport (Road User) Rule 2004, it is an offence to operate a petrol- or diesel-engined vehicle that emits visible smoke for ten seconds or more on the road. The visible smoke check at Warrant of Fitness/Certificate of Fitness inspections is still New Zealand’s only in-service emissions requirement. A new approach to Vehicle Emission Testing in New Zealand is now urgently required with the assistance of new remote and on-board technologies related to measuring vehicle emissions.

This paper describes New Zealand’s desire and capability to further reduce its vehicle emissions and the current legislative environment that is holding back mandatory vehicle emission testing. CO₂ – E emissions from domestic transport per capita have reduced from 3.28 to 3.19 tonnes per capita between 2007 and 2009 and New Zealand aims to, by 2015; reduce the average emission performance of light vehicles entering the fleet to 170g/km of CO₂.

New Zealand research is unravelling the disturbing effects on health, especially in Auckland, of relatively high levels of vehicle emissions. Also, significant technological advances are being made both in vehicle emissions forensics and vehicle emission testing technologies.

This world class research capability embodied in New Zealand’s’ Crown Research Institutes and Universities is briefly reviewed together with the potential to act as a research test bed for the University of Huddersfield and enhance the transnational nature of the proposed University of Huddersfield Centre of Excellence.

2. Emissions Trading Scheme and the “Durban Platform”
New Zealand has recently supported the establishment of the Durban Platform - a comprehensive international approach to combating climate change and not the very patchy coverage the Kyoto deal alone would have secured. The Durban Platform will maintain the legal structure of the existing Kyoto Protocol while improving rules in the treatment of land use and forestry.

The New Zealand Government has reinforced commitments made in principle by all major emitters at Cancun last year for the period beyond 2012 to 2020. New Zealand, therefore will be part of a new single, international agreement beyond 2020 (the “Durban Platform”) that will bring all major emitters, developed and developing, within a legally binding framework.

Dr Nick Smith, Minister for the Environment, 2008-2012, noted that New Zealand has a robust suite of climate change policies in place centred on the NZ Emissions Trading Scheme, described by the OECD in its November 2011 Environmental Outlook as the most developed and most comprehensive trading scheme in the world.

In late 2011 the ETS was reviewed [1] and essentially set the scene for all New Zealand industry sectors to be included. Forestry was the first sector to enter the scheme (on 1 January 2008). Three other sectors joined in July 2010 (liquid fossil fuels, stationary energy and industrial processes). Waste and synthetic greenhouse gas sectors are due to enter the scheme in January 2013 and the agriculture sector in January 2015.
As a result the ETS Review Panel believes it is in New Zealand’s long-term economic interests to continue to change behaviour and that the incentives to do so should continue to increase through a cost on greenhouse gas emissions. Critically, the review panel considers that it is important for the Government to send a clear signal for the future evolution of the ETS, so that businesses and households have greater certainty and confidence in their long-term investment and purchasing decisions.

3. Vehicle Emissions Legislation in New Zealand

Measures currently implemented by Ministry of Transport to manage vehicle emissions are summarised as follows:

i. Improve identification of excessively smoky vehicles being used on the road. This Land Transport Rule, introduced in March 2001 is enforced by the Police,

ii. Introduce progressive emissions standards for vehicles first entering the fleet – including new and used imports,

iii. Monitor the first Land Transport Rule controlling vehicle emissions were introduced in 2003, and are updated regularly to introduce new measures.

Since October 2006, all vehicles must pass a visible smoke test to get a warrant of fitness or certificate of compliance. This was accompanied by a “choke the smoke” publicity campaign. From January 2008, all used imported vehicles must be manufactured to recent emissions standards, and must pass an emission check. Currently there is no legislation or testing protocols that support mandatory vehicle emission testing.

If introduced, mandatory testing for both light and heavy vehicles would support the intentions of the NZ Emissions Trading Scheme. This would also result in wider environmental, social and economic benefits for all New Zealanders.

In 2007 a change of legislation sought to update and revise the New Zealand Land Transport Rule via a Vehicle Exhaust Emissions Revision (2007). The proposed amendment sought to establish tighter emissions standards for imported vehicles that matched international standards.

However, the improvement of emissions testing through mandatory in service testing for used vehicles was not passed despite many submissions and background research suggesting that mandatory testing would improve public health, significantly reduce greenhouse gas emissions, and adhere to a range of National Environmental Standards.

4. New Approach to Vehicle Emissions Testing

In 2009 the NZ Motor Trade Association crudely calculated [2] that if all vehicles were tested, fuel costs could be reduced by $338 million per annum and the cost for the emission testing and required engine tuning work could be up to $285 million per annum.

This is generally regarded by vehicle operators as an unacceptable operating cost by transport providers of mandatory testing. A new approach is needed that reinforces the positive benefits of mandatory vehicle emission testing for both light and heavy vehicles that could lead to reduced fuel costs, reduce greenhouse emissions and most importantly improve health conditions of urban populations in New Zealand.

Early in 2011, the University of Auckland and Unitec Institute of Technology discussed the commercial application of a new approach to vehicle emissions testing with a potential nation-wide user of vehicle emissions. In-service exhaust emissions testing is used in many countries to maintain vehicle fleet emissions quality and whilst New Zealand considered the introduction of this in the mid...
2000’s the concept was rejected due to questions about the accuracy of the test techniques used to support the changes and the likely high cost to consumers.

A business opportunity though exists to develop a more suitable test protocol, and obtain government endorsement for mandatory testing and offer a service nationwide. Developments of innovative testing hardware may also offer research and development opportunities.

The research providers considered that a system involving alternative “Simple Test” protocols would more accurately measure “real driving emissions” and would lower the cost of emissions measurement by rationalising instruments and the measurement techniques used. Unitec and the University of Auckland could also provide a vehicle owner package and test centre protocols and training.

The University of Auckland has a large database of emissions test results and many years of experience of vehicle emissions testing, whereas Unitec has many years experience in educating and training automotive technicians (up to and beyond degree level) and is the biggest education and training provider in New Zealand of automotive mechanics/technicians. Alternative testing protocols for diesel vehicles (automatic transmission) have been prototype tested with positive results and early stage study of petrol emissions (CO and HC) measurements indicates that it may be possible to use current idle/high idle test protocols and manipulate results to give a more accurate assessment of real driving emissions.

Alternative designs for low cost emissions measurement techniques are ongoing at Auckland University based on studying world trends in vehicle emissions testing and the three types of in-service emissions measurement techniques used:

- Chassis dyno based loaded cycle tests, e.g. IM240 (US)
- Unloaded “Simple Tests” - idle, high idle, snap acceleration (Germany, UK, Ireland),
- Roadside measurements - Remote Sensing Devices (Hong Kong).

Table 1. Comparison of Vehicle Emission Testing Techniques.

| Type.                      | Advantages                     | Disadvantages                             |
|----------------------------|--------------------------------|-------------------------------------------|
| Loaded (chassis dyno test  | In accurate measurement of     | High capital and operating costs          |
|                            | “real driving” emissions       |                                           |
| Un Loaded “Simple test”    | Medium capital and operating  | Inaccurate measurement of real driving    |
|                            | costs                          | emissions                                 |
| Roadside remote sensing    | Very low operating cost per    | High capital cost                         |
|                            | vehicle                        | Not “on line”, requires processing of      |
|                            |                                | measurements and advice to vehicle owner   |
|                            |                                | Only a “snap shot” of the vehicle’s emissions |
|                            |                                | performance                               |

Auckland University has concentrated on the measurement of exhaust emissions, performance, and economy of petrol, diesel and biofuel, and gaseous fuelled engines. A commercial study [3] was undertaken for the New Zealand government in preparation for the introduction of exhaust emissions legislation and certification tests were undertaken for importers of vehicles. In the early 1980’s the University was responsible for the development of the NZ fuel consumption Standard NZS5425 and
undertook extensive testing for vehicle suppliers committed to the fuel consumption labeling scheme in place at the time.

Comprehensive studies have also been undertaken for local government assessing the potential impact of biodiesel on emissions from heavy duty vehicles. The University has the most comprehensive test facilities for automotive R&D in New Zealand.

5. Health Related Vehicle Emissions Research

New Zealand’s “Clean and Green” image might suggest that air pollution is not a problem. However, with the relatively high levels of respiratory and cardio-vascular diseases in urban areas, linked with one of the oldest vehicle fleets in the OECD, the importance of vehicle emissions research and testing to New Zealander’s becomes an important issue.

Continuous instrumental ambient air quality monitoring has been performed in the Auckland region since the 1970’s. Auckland Council has data from 1964, which marks the commencement of total suspended particulate (TSP) and lead (Pb) monitoring by the former Department of Health (DoH). In addition to providing information for local and national bodies, three sites in Auckland have contributed data to the World Health Organisation (WHO) Global Environmental Monitoring (GEMS) programme since 1977.

There are 865,000 vehicles in the Auckland region travelling about 12,500,000,000kms [4]. Every year this produces thousands of tonnes of toxic air pollutants - particularly carbon monoxide (CO), nitrogen oxides (NO2) and fine particles (PM10).

The report to the Ministry of Transport, ‘Health effects due to motor vehicle air pollution in New Zealand’ [5] estimates that there are:

- 436 deaths per year in the Auckland region due to PM10, or fine particles
- 58% of these deaths (253) are due to motor vehicle emissions.

Significant improvements have been made in vehicle technology and fuel quality since 2001; however, motor vehicles are still a major contributor to air pollution in most urban areas because of:

- increased number of vehicles on the road and vehicle kilometres travelled
- increasing proportion of diesel vehicles in the fleet
- increase in average engine size.

NIWA’s Air Quality and Health Group have completed research [6] that predicts long term average enhancements in concentrations of PM10, NOx and VOC’s in pre defined road corridors (300 meters wide) and therefore predicts local deterioration in air quality on a long term basis. This is significant as local policies and schemes can be implemented using the data that can respond to a local health threat rather than having to rely on the introduction of nation wide mandatory vehicle emission testing.

Also a vehicle ventilation model predicts the exposure of vehicle occupants to tail pipe emissions as a function of route and vehicle parameters and predicts concentrations of CO2. This research is designed to permit transport schemes and policies, and the options they present for communities.

6. Test Bed Developments

A test bed is defined as a platform for experimentation of large development projects [7]. Test beds allow for rigorous, transparent, and replicable testing of scientific theories, computational tools, and new technologies. A good example of a research test bed being the “Engineering Research Centre for Collaborative Adaptive Sensing of the Atmosphere Test” [8]
A New Zealand research test bed looking at vehicle emissions could be a possibility for the University of Huddersfield Centre of Excellence, if the principle researchers could agree on suitable areas of research. In particular, there are some factors that position New Zealand as a premier research location for emissions prediction, monitoring and control and effects on health.

New Zealand is;

- Geographically isolated; meaning that there is a low impact of long range transport to urban air pollution so that the air quality is predominantly influenced by local circumstances,
- Sparsely populated; with many small, isolated towns with intense domestic wood-burning source but with minimal road traffic pollution which provides strong and distinctive data patterns,
- High vehicle ownership levels. Very high rates of car ownership (second only to the US) with an elderly, non-tested, motor vehicle fleet provides the opportunity to test the impact of emission regulation on ambient air quality.

New Zealand also has a capable research infrastructure in vehicle emissions that has learnt to collaborate in order the make the best use of expertise, equipment and resources. Other areas of health concern both internationally and in New Zealand are the increasing high concentrations of benzene in urban environments. It is probable that the proposed new annual average guideline for benzene in air will be exceeded in Christchurch and perhaps parts of Auckland. Also other air pollutants are being reviewed like the potentially carcinogenic products of combustion such as polycyclic aromatic hydrocarbons (PAHs).

Most of the longitudinal studies have concentrated on the health effects of PM 10. Of increasing concern are the smaller particles especially those less than 2.5 micro (PM 2.5). Until recently, there have been no measurements of particle number or size distributions. Whilst overseas research begun to investigate this danger to health, such studies based in New Zealand are in their infancy. NIWA has recently begun a programme of high resolution measurements of particles to investigate the spatial and temporal distribution of traffic emissions and associated health effects.

Unitec Institute of Technology is proposing a “research bed structure” with which to engage other New Zealand partners. Discussions have already take place with NIWA, University of Auckland and Auckland Council regarding a Vehicle Emissions Research Facility (VERF).

The establishment of a Unitec based Research Centre in New Zealand could therefore be a vital transnational component in an application to the available European Union Structural Funding Programmes by the University of Huddersfield in the UK as long as there were clear governance and operational principles established.

Initially the VERF had the following aims;

i. To develop a research and education package for local transport related companies regarding the NZ Emissions Trading Scheme,
ii. Provide a “testing service”, in particularly for diesel and heavy vehicles, that will ensure that Auckland based transport companies could operate more efficiently,
iii. Contribute to on-going collaborative Government funded and international research projects,
iv. Develop new vehicle emissions testing technology options for New Zealand,
v. Potentially provide a local Auckland solution to relatively high levels of emission based pollution in the Auckland region.
7. International Science Partnerships

Europe is home to some of our major science and innovation partners and over half of New Zealand’s researchers have an active collaboration with a European partner. There are particularly strong links with the United Kingdom.

New Zealand’s S&T relationship with the European Union (cemented by the 2009 Science and Technology Cooperation Agreement) [9] is a critical enabler of developing links with Europe and provides a useful framework for collaboration. New Zealand’s involvement with existing EU research programmes will enable engagement between research providers such as NIWA, Unitec Institute of Technology and University of Auckland.

The European Union Structural Funding Programmes (which support such activities as the transnational partnership envisaged here in principle) include the European Regional Development Fund (ERDF), LIFE+ 2014-2020 and the Framework 7 (FP7) programmes. Initial work in respect of the requirements of each of these funding programmes for the projects that they can support is under way at the time of writing of this paper, and will be brought up to date as appropriate in due course.

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