# Monitoring tyre pressures for better economy and safety

Introduction

Tyre Pressure Monitoring Systems (TPMS) are in-vehicle systems that alert the driver to a change in tyre pressure. Simple systems are able to detect changes in pressure for any one tyre and send an alert after a threshold pressure reduction is reached, usually 20% lower than starting point. More sophisticated systems are able to provide monitoring of live tyre pressures and internal temperatures, and issue custom as well as pre-set warnings to the driver.

TPMS is a strong incremental step toward environmental, efficiency and safety targets for Australian vehicles. The United Nations (UN) have developed an international standard UN Regulation No. 141[[1]](#footnote-1) that contains technical requirements designed to achieve those goals for light passenger and goods vehicles as well as heavy vehicles and heavy trailers.

The European Union (EU) mandated that light vehicles must be fitted with TPMS meeting the requirements of UN R141 from 2014. The scope of the EU mandate will be extended to include heavy vehicles and their trailers in 2024. In other markets, the United States requires TPMS be fitted to all vehicles from September 2007 under Federal Motor Vehicle Safety Standard 139. South Korea required TPMS from 2013 for vehicles under 3.5 tonnes and from 2015 for all vehicles. Japan are in the process of considering a mandate.

The Australian Government does not set any technical requirements for TPMS and does not mandate fitment of TPMS to any vehicles. Implementing technical requirements for TPMS, adopting the UN R 141 technical standards or other equivalent standards, could provide complementary efficiency, emissions and safety benefits to existing requirements if we can establish the best way to encourage or regulate installation.

Types of TPMS and modes of operation

There are two major types of TPMS available:

**Direct** –A sensor is installed in each tyre or on the inflation valve stem of the tyre that detects the pressure within the tyre directly and transmits that pressure to a main display unit. These systems are capable of high-resolution detection of the actual pressure in each individual tyre in real time and often perform additional functions like measuring tyre internal temperature. Each sensor unit requires a power source in the form of a battery and therefore has a life in accordance with the battery capacity. Installation and maintenance costs are higher for this type of system but it can be installed aftermarket, can be installed in dual tyre wheel assemblies and gives the best resolution by displaying actual tyre pressure in real time.

**Indirect** – Uses the existing wheel speed sensors on the vehicle with a software implementation that can distinguish differences in the rolling speed of each wheel. If a tyre had differing pressure in comparison with other tyres it will exhibit a change in rolling diameter or erratic rotational velocity and trigger a warning. These systems do not read the pressure in the tyre and are not capable of exact resolution but are developing and are able to detect single or in some case multiple under-inflation events. Due to this type of system using the existing wheel speed hardware and computational systems it is inexpensive for OEMs to implement, but needs to be included as part of the vehicle design. In most cases indirect TPMS does not work on dual tyre wheels. Service life is not limited by any particular factors and is theoretically the same as the rest of the vehicle, excluding unexpected component failure.

**Question** **1**: Have there been or are there expected advancements in TPMS technology that change these categorisations and use cases for Direct and Indirect systems? Have there been advancements in Indirect systems in terms of better resolution or implementations on dual wheels?

The most noticeable benefits of TPMS are achieved by ensuring more consistently optimal tyre pressures. Rapidly deflating tyres are potentially dangerous and at the very least are inconvenient and time consuming to change or repair. While there are certainly safety advantages to warning drivers about rapidly deflating tyres, the best efficiency and safety benefits can be found by making operators aware of deviation from optimal tyre pressures during normal use. This may achieve efficiency and safety benefits for two main reasons:

1. Maintaining recommended pressures allows best average rolling resistance, giving improved fuel efficiency and decreased carbon emissions. For electric vehicles there will be increased power efficiency and in turn increased range and a lower impact on the electricity grid from charging demand.
2. Maintaining recommended pressures allows efficient use of the tyre contact patch, balancing the benefits of load distribution and road grip with tyre wear and preventing tyre structural damage due to excessive sidewall deformation.

Incorrect or under-maintained tyre inflation – why does it matter?

A UNECE TPMS Fitment and Tyre Inflation Pressures Field Study done in 2016/2017[[2]](#footnote-2) suggests that up to 64% of vehicles in service have some level of tyre under-inflation, with up to 25% having under-inflation of more than 10%. The survey found a fitment rate for TPMS of 54% and that those cars fitted with TPMS on average had better tyre inflation pressure. The issue of tyre under-inflation in Australia is likely to be far worse due to TPMS not being mandated at all here.

These factors are influenced by under-inflation:

* Energy efficiency – A vehicle with under-inflated tyres has increased rolling resistance and requires more power to maintain a given speed or accelerate (DG CLIMA TNO Study)[[3]](#footnote-3), resulting in the vehicle using more fuel and emitting more greenhouse and noxious emissions as a result. Similarly, electric vehicles would use more battery charge. Using the available UNECE Field Study figures referred to above, fleet average rolling resistance may be between 1.6% and 2.4% higher due to under-inflated tyres
* Tyre wear – Under inflated tyres lead to increased tyre wear. The result is shorter overall service life of tyres and potential breakdowns due to tyre failure. Based on the UNECE Field Study, an estimated 64% of the Australian fleet, some 12.65 million vehicles, would have some level of accelerated tyre wear due to under-inflated tyres (estimated using DG CLIMA TNO Study modelling).
* Tyre particulate emissions – Additional wear due to under-inflation leads to higher tyre particulate matter emissions. Tyre particulate matter has been an overlooked problem. With a global emphasis on reducing exhaust gas emissions and a shift to electric vehicles, tyre wear particulate will become the greater share of particulate emissions from vehicles. Electric vehicles have no exhaust emissions but continue to emit tyre particulate matter at the same rate as internal combustion engine vehicles[[4]](#footnote-4)
* Road grip changes and dynamic stability – at significant under-inflation, tyres may exhibit decreased levels of grip. Tyres at 20% under-inflation are estimated to cause a 7.5% increase in wet weather stopping distance and contribute to between 0.8% and 4% of accidents involving a loss of vehicle control (estimates from DG CLIMA TNO Study)
* Heat build-up and tyre structural damage – heat generated by excessive sidewall deformation can be a contributing factor to premature wear and unexpected tyre failure (blowout). This kind of damage also reduces the viability of tyre carcases for re-treading and has been noted as a causal factor in sudden tyre failure during maintenance activities. Sudden failures in close proximity to workers can be a source of serious injury and potential loss of life (DG CLIMA TNO Study)

**Question 2:** Has your organisation conducted any evaluation on the effectiveness of tyre pressure monitoring or frequency of corrective measures by drivers/operators when alerted to low pressures by TPMS?

Why regulate?

Introducing a TPMS standard into regulation would be complementary to policies that aim to reduce emissions, increase productivity and improve road safety. Technology that actively monitors tyre inflation could contribute substantially to energy and fuel usage savings, and the reduction of greenhouse gas emissions, as well as reducing tyre wear, particulate emissions and providing improvements to safety and accident prevention. Alerting drivers to rectify under inflated tyres could yield substantial benefits. The following estimates are based on available vehicle statistics from both the Bureau of Infrastructure and Transport Research Economics (BITRE)[[5]](#footnote-5) and the Australian Bureau of Statistics (ABS)[[6]](#footnote-6)

1. Fuel savings for whole of Australia’s vehicle fleet with TPMS fitment: At a nominal fuel cost of $2 per litre, this equates to savings of $85-171 million per year. See **Appendix A**, Figure 1 for detailed fuel figures. Energy savings for electric powered vehicles have not been estimated here. There is likely to be a fleet wide energy consumption saving, that when accumulated, delivers overall benefits to electrical grid consumption.
2. Reduced CO2 emissions. If the whole of Australia’s vehicle fleet had TPMS up to 206,762 tonnes per year (2019 emissions values). See **Appendix A**, Figure 2 for potential CO2 savings for each vehicle type
3. Societal health benefits. The health benefits from the associated reduction in emissions are in the order of $1.4 million, or 6.2 life years saved per annum on average between metro and non-metro locations for carbon emissions alone. Health benefits from reduced particulate matter from tyre wear have not yet been calculated but the unit cost of health effects due to non-exhaust and particulate emissions is approximately 1000 times that of CO2 , and therefore will be significant.
4. Extended tyre life. Reduced tyre wear due to 100% TPMS use and operator response can add an estimated extra service life of 103.22km per 1000km travelled for each tyre and a running cost saving of $0.17 for each tyre per 1000km travelled. See **Appendix A**, Figure 3 for tyre service life and operating costs figures.
5. Safety benefits. Avoiding the effects of reductions in vertical, lateral and longitudinal stiffness of tyres due to under-inflation could have positive results for road safety. Simulations on light commercial vehicles suggest that a tyre fleet with no under-inflation and wear patterns consistent with correct inflation will decrease accident rates by between 0.8% and 4%. This figure includes accidents due to blow-outs causing loss of control (DG CLIMA TNO). Sever under-inflation (20% or more) may increase a vehicle’s propensity to roll in an accident, significantly reduce dynamic stability and greatly increase catastrophic failure or blow-out. The UNECE TPMS Field Study suggested that TPMS reduced the incidence of greater than -20% under-inflation by approximately 75% in practical terms.

Summary of economic benefits and safety effects

TPMS can lead to reductions in operation and societal costs.

* Fuel cost savings due to optimal rolling resistance/tyre contact. See fuel savings at **Appendix A**, figure 1.
* Reduced tyre maintenance costs and extended lifetime of tyres. See **Appendix A**, figure 3
* Fewer service disruptions due to reduced tyre related breakdowns.
* Reduced societal cost by reducing accidents (fatalities, injuries and effects of accidents).
* Reduced costs due to CO2 and particulate emissions.

The European Union applies the international regulation, UN Regulation 141, for TPMS, which was developed by UN Working Party 29 (WP.29) under the 1958 Agreement[[7]](#footnote-7). This would be the primary option to consider for a regulated standard. The US also has a standard for TPMS and this may be considered as an alternative if the technical requirements are consistent with the desired outcomes.

The options available

1. **Business as usual**Allow industry and consumers to continue uptake based on market demands. Fitment rates are likely to continue to rise with market forces, in particular fuel prices and increasing public and private sector desire for cost savings and emissions reduction as long as the cost of fitting TPMS is not prohibitive. As above, an increase in fitment rates will realise a proportional benefit, but rates are unlikely to ever approach 100%. This method involves no associated cost.
2. **Encourage fitment by manufacturers, industry and consumers**
There are a range of non-regulatory options available to encourage higher fitment rates of TPMS in new vehicles. Depending on industry, operators and consumer sentiment and priorities, these methods may result in significantly higher rates of fitment than are current, and may approach 100%. This is a less efficient method to achieve broad uptake as it relies on consumer sentiment. This option would be a lower cost option, with costs depending on the amount and type of engagement to encourage uptake. It would be recommended to complement this option with an ‘if fitted’ regulation for TPMS to set a minimum standard to provide confidence to consumers of the system performance.
3. **Full regulation**
Create new regulation to mandate the fitment of TPMS on new vehicles and to specify technical requirements for the performance of TPMS. This would aim to achieve near 100% fitment rates on new vehicles and realise the greatest benefit for emissions reduction, safety and cost savings to consumers and operators. It would also involve the highest costs for industry.

The vehicle categories and usage cases where greatest benefits can be seen are also the ones where costs are highest, that being the medium to heavy long-haul freight segment. It should be noted that for combination vehicles, best outcomes are achieved when both truck and trailer are fitted with TPMS. BAU or voluntary market uptake may be extremely slow in this segment due to costs, even considering the potential savings. Work will need to be done in those segments if softer policy options are to have good effect.

The objective of Government intervention

* Achieve a rate of TPMS fitment that efficiently reduces issues associated with under inflation.
* Standardise the performance of TPMS through the adoption or recommendation of a set of technical requirements.

Even with 100% fitment rates, there would still be vehicles with under or over-inflated tyres. Results depend on vehicle operators reacting to the system warnings and taking appropriate action to correct tyre pressures. This human element introduces an unknown variable whereby there may be a range of outcomes. For the purposes of the studies on which this discussion is based, there were calculations made using an ideal case with 100% operator response, and a moderate case with 50% operator response. The actual result of full regulation most likely falling somewhere inside this range.

Considerations and further questions

1. The cost of a system may vary significantly for vehicle category and configuration, as well as the type of system required either due to configuration or preference for a direct system over an indirect one. Direct systems have maintenance requirements due to sensors having batteries/power sources with a limited service life and the potential for damage from deflation, road incidents or maintenance procedures. Costings from various studies are quite out of date and are often pre-mandate, meaning that there will have been changes in costs due to economy of scale and availability of technology.

**Question 3**: Are you able to provide OEM costing outlines for installation, including labour and consumables, of a TPMS that is able to satisfy the requirements of UN R 141 (01 series of amendments) using either a Direct or Indirect system as required by vehicle configuration or use case?

1. Market uptake of TPMS may already be at a high level in new vehicles, particularly light vehicles. This could reduce the potential benefits of mandatory TPMS as the gap to fitment on all vehicles will be less than assumed. Percentage savings will be the same for the fleet portion not already voluntarily fitted with TPMS, but the assumed reductions in absolute fuel and energy use, CO2 emissions, tyre wear, maintenance and safety can only be expected for the gap portion of the fleet.

**Question 4**: What are the levels of voluntary uptake in your market segment, or what gap is there to 100% segment installation of TPMS?

1. The success of TPMS is reliant on driver response to correcting tyre pressure when prompted. Drivers ignoring the tyre pressure warnings, being slow to respond to warnings, or tampering with the system to reduce or eliminate warnings will reduce the assumed benefits.

**Question 5**: Is there available data on operator response rates to TPMS warnings in your segment?

1. TPMS is mandated for light passenger and commercial (Australian MA and NA vehicle categories) in many feeder markets and therefore the production and installation cost of TPMS can be assumed to be low for most light vehicle manufacturers. Heavy vehicle TPMS has not yet been fully mandated in feeder markets, although it is being introduced over the next 2 years for heavy vehicles in Europe and is active to safety only based technical standards in the US.

**Question 6**: Are there heavy vehicle (including trailer) manufacturers offering OEM TPMS as either standard or optional equipment to Australian buyers?
**a)** If so, what type of systems are they and what percentage of sales have included voluntary uptake of optional systems?
**c)** Which heavy vehicle fleet operators are using TPMS or Central Tyre Inflation Systems? Would they be willing to share their reasoning and experiences with the department?

Appendix A

|  |  |  |
| --- | --- | --- |
| **Potential fuel savings - whole of fleet TPMS**  |  |  |
| Using data from ABS Survey of Motor Vehicle Use, Australia, 12 months to 30 June 2020 |
| High savings potential is 100% response rate to TPMS warnings. Low is 50% |
|  | **Total fuel** | **High savings potential % rate** | **Low savings potential (half) % rate** | **High savings potential fuel savings** | **Low savings potential fuel savings** |
|  | megalitres | % | % | megalitres | megalitres |
| **Australia** |  |  |  |  |  |
| Passenger vehicles |  18,094  | 0.24 | 0.12 | 43.43 | 21.71 |
| Motor cycles |  102  |  | 0.00 | 0.00 | 0.00 |
| Light commercial vehicles |  6,678  | 0.24 | 0.12 | 16.03 | 8.01 |
| Rigid trucks |  3,138  | 0.25 | 0.13 | 7.94 | 3.97 |
| Articulated trucks |  4,342  | 0.38 | 0.19 | 16.63 | 8.31 |
| Non-freight carrying trucks |  75  | 0.32 | 0.16 | 0.24 | 0.12 |
| Buses |  591  | 0.19 | 0.09 | 1.09 | 0.55 |
| **Total** |  **33,019**  |  |  | **85.36**  | **42.68**  |

Figure 1 – Fuel use potential savings. Figures based on EU study (refer footnote 3, p.2) estimated percentage savings rate with TPMS fitment, as applied to the last available Australian Bureau of Statistics Survey of Motor Vehicle Use figures for Australia – 2020.

**Annual CO2 emissions savings potential**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Vehicle type | % of total | CO2 Emissionsin tonnes | Avg. saving(high) % | High savingspotential (tonnes) | Low savingspotential (tonnes) |
| Cars | 47% | 44,180,000 t | 0.24% | 106,032 t | 53,016 t |
| Light commercials | 17% | 15,980,000 t | 0.24% | 38,352 t | 19,176 t |
| Trucks and busses | 21% | 19,740,000 t | 0.316% | 62,378.4 t | 31,189 t |
|   |   |   | **Totals** | **206,762.4 t** | **103,381 t** |

Figure 2 – CO2 annual savings potential, classed by percentage saving rates.

|  |
| --- |
| **Corrected Tyre service life potential** |
| Results are specific to mandatory implementation of UNECE R141 TPMS requirements. |
| Current estimated tyre service costs - $/1000km |  $ 2.39  |  |  |  |
|  |  |  |  |  |
| Percentage under-inflation  | 0-10% | 10-20% | 20-30% | >30% |
|  Distribution of under-inflation rate/tyre | 39.00% | 19.00% | 4.00% | 2.00% |
| Associated reduction in tyre lifetime | 3.00% | 17.00% | 41.00% | 55.00% |
| Impact of mandated TPMS | 0.00% | 50.00% | 100.00% | 100.00% |
| Percentage of tyres affected by TPMS | 0.00% | 9.50% | 4.00% | 2.00% |
| Cost/1000km for corrected lifetime percentage |  $ 2.32  |  $ 1.98  |  $ 1.41  |  $ 1.08  |
| Cost savings per tyre/1000km |  $ 0.07  |  $ 0.41  |  $ 0.98  |  $ 1.31  |
| Average increased service potential per tyre/1000km | 103.22 | Km |  |  |
| Best case new average cost/1000km |  $ 2.22  |  |  |  |
| Best case saving per tyre/1000km |  $ 0.17  |  |  |  |
| NB - Average savings must take into account the remaining 36% of tyres that are running at optimal pressure and value. |

Figure 3 – Tyre servicing costs and increased service life potential due to mandatory full fleet TPMS fitment.

1. UN Regulation No. 141 - Tyre Pressure Monitoring Systems (TPMS)
<https://unece.org/transport/vehicle-regulations-wp29/standards/addenda-1958-agreement-regulations-141-160> [↑](#footnote-ref-1)
2. TPMS Fitment and Tyre Inflation Pressures - Field Study EU 2016/2017. Study by UNECE.

<https://unece.org/DAM/trans/doc/2018/wp29grrf/GRRF-86-17e.pdf> [↑](#footnote-ref-2)
3. Study commissioned by the European Commission Directorate-General for Climate Action (DG CLIMA) from The Netherlands Organisation (TNO) - 'Study on tyre pressure monitoring systems (TPMS) as a means to reduce light-commercial and heavy-duty vehicles fuel consumption and CO2 emissions'. Chapter 5 on Safety.
[https://repository.tno.nl/islandora/object/uuid:84b183d4-904f-48dc-a2fd-4ee515e24b1a](https://repository.tno.nl/islandora/object/uuid%3A84b183d4-904f-48dc-a2fd-4ee515e24b1a) [↑](#footnote-ref-3)
4. OECD (2020), Non-exhaust Particulate Emissions from Road Transport: An Ignored Environmental Policy Challenge, OECD Publishing, Paris, <https://www.oecd.org/environment/non-exhaust-particulate-emissions-from-road-transport-4a4dc6ca-en.htm> [↑](#footnote-ref-4)
5. Bureau of Infrastructure and Transport Research Economics (BITRE) Road Statistics <https://www.bitre.gov.au/statistics/road> . [↑](#footnote-ref-5)
6. Australian Bureau of Statistics - Survey of Motor Vehicle Use, Australia 12 months to 30 June 2020.

<https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-vehicle-use-australia/latest-release#key-statistics>
Australian Bureau of Statistics (Jun-quarter-2023), Consumer Price Index, Australia

<https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/consumer-price-index-australia> [↑](#footnote-ref-6)
7. Agreement concerning the Adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulations

<https://unece.org/trans/main/wp29/wp29regs> [↑](#footnote-ref-7)