Energy efficiency and farm vehicles

April 2021, Primefact DOC21/78402, First edition. Adapted from NSW Farmers factsheet https://www.aginnovators.org.au/initiatives/energy/themes/farm-vehicles

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Diesel accounts for more than 80% of energy consumption in Australian agriculture[1], and is primarily used to fuel tractors, other vehicles and irrigation systems, depending on the type of farming operation.

Significant savings in diesel consumption for tractors and other farm vehicles can be achieved through a combination of measures including the machinery selection process, training and motivating staff to drive efficiently, tractor set-up and maintenance, and effective planning and record keeping. **Each of these measures can result in reductions in diesel consumption of between about 5 and 20 percent.**

This Primefact is intended to be read in conjunction with the Primefacts listed in *Further information*.

Quick tips

- **Make a simple fuel management plan.** Set targets and keeping basic records.
- **Train and motivate staff** in your fuel-efficiency program.
- **Minimise idling times**. Switch off idling motors during longer breaks.
- **Inflate tyres to optimal pressure.** Inflation pressure is an important variable for fuel efficiency, traction efficiency, tyre life and ride comfort.
- **Ensure tractor ballast is in the right ball park.** Too little or too much ballast wastes fuel and limits operators' ability to use tyre pressure to manage traction.
- **Match tractor horsepower to the equipment or loads**. For example, avoid pulling a light load with a high horsepower tractor.
- **Perform routine maintenance**. Routinely replace air filters and oil and use the proper grade of motor oil to keep vehicles operating at peak efficiency.
- **Minimise discretionary trips**. For example, plan to avoid returning to base during the day.

[1] Australian Bureau of Statistics, 46040DO0006 Energy Account, Australia, 2017-18

Buy energy-efficient machinery

Many tractors sold in Australia are more powerful than needed for their priority duties. Buying an unsuitable tractor can lock in fuel wastage for decades.

Modern tractors offer a complex array of functions and options, and can be specified precisely to your operational priorities, enabling you to achieve far higher fuel and operational efficiency than earlier generations of machines could. The range of options and features available can make the selection process more complex.

Analyse your needs and conduct research to ensure that the machinery you order is fit for purpose.

Efficient vehicle operation

Train and motivate staff

Ensure your team understands your fuel efficiency goals and they have sufficient skills and motivation to implement the required practices. Reducing fuel use involves both the tractor set up and gear settings.

Tractor set-up

Correct tractor set-up is central to achieving fuel efficiency and a well set-up tractor is easier to operate.

Australian tractors tend to be overballasted, though both too little or too much ballast wastes fuel and limits the operator's ability to use tyre pressure to manage traction. Correctly setting ballast to match a tractor's main duties can result in fuel savings of five to eight percent.

Optimise tyre pressure

Whenever practical, tyre pressures should be adjusted according to the axle load and the typical driving speed.

In general, lower tyre pressures in the paddock help to reduce both tractive power demand and soil compaction. On roads and tracks, higher tyre pressures reduce rolling resistance.

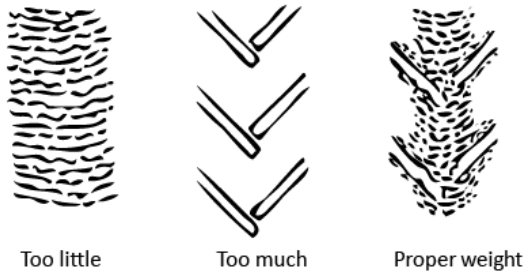
If your machine is particularly heavy, the required tyre inflation may be too high for your tyres or may result in high soil compaction or increased wheel slip. At this point you should consider adding additional wheels so you can operate each tyre at lower pressure, increasing traction and reducing soil compaction.

Observe wheel slip

Overall, wheel slip is a very good single indicator. The tractor always achieves very good efficiency when the wheel slip is between 8-15%. Maximum tractive efficiency will occur when both the rolling resistance and wheel slip are not "excessive" and best "match" with each other. Modern tractors typically include wheel slip monitors, or monitors can be added after market. If this is not an option, an approximate method for observing wheel slip is the tyre tread pattern produced when the tractor is pulling under load.

With correct ballast and tyre pressure, the tread pattern will show that the soil between the cleats in the tyres has shifted but the tread pattern is still visible, as shown in Figure 1.

Figure 1: Tread marks depicting excessive wheel slip (underballasted), insufficient slip (over ballasted) and optimal slip[2]



With too little weight or tyre pressures that are too high, excessive slippage wipes out the tread pattern. If the tractor has high slip levels, tyres will wear excessively and fuel efficiency will be poor. At the other extreme, with too much weight and/or too little pressure, the tread pattern will be sharp and distinct in the soil. The ideal tyre print is one that shows some slippage and some tread pattern.

Gearing

For maximum operating efficiency, an engine should be operated at below or close to its rated capacity. This means using gearing to maintain an optimal engine speed for the desired ground speed.

Vehicle maintenance

Poor vehicle maintenance can have dramatic negative impacts on fuel efficiency. It's recommended you:

- Routinely replace air, oil and fuel filters.
- Change oil as recommended by the manufacturer and use the correct grade of oil.
- Check for leaks, smoke and other signs of improper fuel combustion.
- Clean fuel injectors regularly.
- Have wheels aligned and balanced.

Field operations and design

Plan field operations with energy efficiency in mind to achieve significant savings.

Consider paddock layout. Wherever possible, structure your paddocks so that the number of turns vehicles need to make is minimised and, as far as possible, tracks are on level grades.

A further refinement may include the practice of controlled traffic farming systems (CTF). CTF is a system in which all load-bearing wheels are restricted to permanent "fixed" traffic lanes. This enables the agricultural tyres to work on dry, highly compacted soil for good tractive efficiency, while agricultural crops have access to good moisture, low compaction soil. CTF usually requires the modification of tractor wheel spacing and the use of GPS guidance systems.

Consider the goal of the tillage operation when setting depth. A study found fuel savings with a shallow tillage depth ranged from 10 to 40 percent.[3] Halving the tillage depth will reduce the fuel use by 60%.

A further reduction of fuel use by 25% can also be achieved by the adoption of

[2] Adapted from Svejkovsky, C., 2007. *Conserving Fuel on the Farm.*

[3] https://store.extension.iastate.edu/product/14447

controlled traffic farming (permanent traffic lane for machinery).

Do multiple jobs at once. With smart planning, you can combine working steps and avoid duplication in vehicle use.

'Weed out' unnecessary operations. Consider ways in which you can eliminate jobs or steps, especially those that involve tractors and/or large equipment.

Employ the right tools. Consider undertaking smaller jobs in a light vehicle or on a motorbike or using a phone or radio instead of making an extra trip.

Use GPS effectively. The use of guidance systems has been shown to increase field efficiency, reducing fuel consumption. In addition, consider employing GPS data to help track and refine your use of vehicles and fuel; for example, by giving you comparative distance data between operators and/or seasons.

Planning and record keeping

Good record keeping and accurate fuel input cost data can help to refine cost-benefit calculations around cultivation, agrichemical application and harvesting decisions. A first step is collecting data about the consumption of your vehicles for different operations. This could be a 'one-off' activity to identify priority saving areas. Ideally, however, consumption monitoring can become a sustained activity, enabling regular review against targets.

Record fuel consumption

A table, such as the one below, may help you to keep track of fuel used by your tractors during varying jobs and conditions. Paper records should be backed by additional digital records and supported by telemetry systems, if these are available.

Table 1: Example data collection table

Date	Time	Elapsed time	Description	Area	Diesel use		
		(h)		(ha)	(L)	(l/h)	(L/ha)
4/9	09.30-15.45	6.25	Hill paddock, cutting, front-rear comb., first cut 6cm	16	82	13.1	5.125

Monitor fuel delivery, storage and drawdown

In addition to keeping receipts for fuel deliveries, it is suggested you keep logbooks for your tanks and ensure that meters are in good working order.

Accurate record keeping helps to minimise the risk of theft and aids early identification of leaks and other non-production related losses.

Maintain fuel infrastructure

Fuel wastage resulting from fuel contamination, leakage and evaporation can be significant. Inadequate storage facilities can result in major loss of fuel and serious accidents. It is suggested that you review all fuel storage and dispensing infrastructure: tanks, piping, pumps, valves and meters.

Figure 2: Your records are only as good as your measuring equipment. Faulty gauges and decaying piping and tanks can be a hidden source of fuel wastage

Painting fuel storage tanks with reflective products will extend tank life and reduce losses of petrol through evaporation.

A well-maintained fuel storage system sends a signal to staff that you take fuel wastage seriously and will help underpin your general fuel efficiency program.

Case study

A significant proportion of the fuel bill for dryland cropping operation Garah, near Moree, results from fuel use by contractors who bring in different machines depending on the season. It was difficult to track fuel usage, so the farmer drew up a fuel table to monitor fuel usage for each machine and application so savings opportunities such as driving gears, tractor set-up, and wheel slip monitoring could be trialled and costs savings measured. The farmer established fuel use KPIs per hectare and expects to reduce fuel costs by around 5% per season.[4]

New technology development

Engine and transmission development is focusing on precision control and automation to produce maximum work and efficiency. Continuously variable transmissions (CVT) allow optimal engine speed/gearing combinations at any time and are options on many newer tractors.

Particle trap and other exhaust gas treatments are also appearing on larger machines (such as AdBlue).

Cleaner fuel developments are happening across many areas. Use of lower-emission biofuel is being explored and this presents opportunities for the development of bioenergy resources. It may also allow farms to be transformed from pure energy consumers into energy producers or "prosumers".

Research is being currently carried out to develop advanced biomass and food waste conversion technologies to produce not only biofuels and biopower, but also biochemicals or biomaterials. Each kilogram of crop waste can produce some 0.15-0.3 kg of biofuel, depending on the feedstock properties. Whilst 100% biodiesel (B100) can produce power from diesel engines, the performance limitations have resulted in the maximum proportion of biodiesel in commercial products currently being limited to the order of 20% (B20), meaning 80% is fossil-fuel derived diesel. Methane gas from

[4] https://www.aginnovators.org.au/initiatives/energy/case-studies/switching-grid-and-switching-solar-delivers-big-returns-artesian-trust-bore-near-moree

waste digestion can also be used to power machinery.

Advanced biodiesel fuels are being developed that may be a "drop in" replacement for fossil fuel diesel as they have identical chemical properties.

Electric vehicles/tractors could also play a significant role in the future. Electric motors can achieve efficiency up to 90% efficiency, while diesel engines are around 40%. This technology is particularly suitable for Australia as we are rich in sun, gas and coal reserves, but rely on oil imports from other countries. Currently in agriculture, electric vehicles are being seen in lower-power applications of machinery that return to base regularly for recharging. Technological developments in batteries, and alternate power are in operation that allow heavy machinery such as buses and mining trucks to operate on electricity, so electric tractors in various configurations are likely to become available. Better battery technology is critical and is being developed, that improve battery capacity, charger power and recharge time. The electricity source may come from the grid, a renewable energy source such as solar PV, or a hydrogen fuel cell.

Further information

NSW DPI Primefacts

Tractor purchasing considerations: Vendors, horsepower and efficiency.

Estimating tractor power needs:

Adaptive driving: The hidden skill in tractor energy efficiency.

Tractor ballasting: Don't leave horsepower in the shed – make sure your tractor's not overweight.

Tractor tyre selection: Bias versus radial tyres and other considerations.

Tyre pressure: Adjust tyre pressure to surface conditions.

Monitoring wheel slip: What wheel slip can tell you about energy efficiency.

Acknowledgements

This work has been produced by the NSW Primary Industries Climate Change Research Strategy funded by the NSW Climate Change Fund and reviewed by Prof Craig Baille and A/Prof Guangnan Chen from the *Centre for Agricultural Engineering* at the *University of Southern Queensland.* It is adapted from the NSW Farmers factsheet developed under Farm Energy Innovation program that can be found at:

https://www.aginnovators.org.au/initiatives/energy/themes/farm-vehicles

Please see this factsheet for more information about this topic.

Reference number DOC21/78402