Energy efficiency and farm vehicles

Fuel used in tractors and other vehicles currently represents over a third of the energy consumed in the NSW agricultural sector. Significant savings can be achieved through a combination of measures. Key factors include the machinery selection process, training and motivating staff to drive efficiently, tractor set-up and maintenance, and effective planning and record keeping.

Fuel used to run tractors and other vehicles represents over a third of the energy consumed in the NSW agricultural sector and is the dominant input cost for many farms (Energetics, 2013).

There is a wide array of information available about farm vehicles and energy efficiency; however, the majority of this information has been developed with reference to overseas markets and operating environments.

When selecting a new tractor or considering operational measures applicable to Australian farms, it can be difficult to navigate the terrain and gain a clear picture. NSW Farmers has reviewed the literature and consulted industry experts to develop a suite of information that we hope will make the task more manageable. The current paper provides an overview. It is meant to be read in conjunction with the supplementary papers referenced in the text.

Key fuel-saving measures

Opportunities to save fuel are discussed under the following headings:

- Buying efficient machinery
- Efficient vehicle operation
- Vehicle maintenance
- Field operations and design
- Planning and recordkeeping
- Maintaining fuel infrastructure

These matters are interconnected and go hand in hand with running an efficient farm.

Fuel efficiency is strongly linked to effective use of 'time and motion' and to general efficiency. In some cases there may appear to be trade-offs between fuel efficiency and work efficiency. In the net, however, efficient farming is likely also to be more fuel-efficient. To illustrate, front-loading a tractor to enable two operations in one pass uses more fuel in the single pass but saves the fuel that would otherwise have been used on the second pass.

Buying energy-efficient machinery

Perhaps the largest energy savings can be achieved at point of purchase. Buying an unsuitable tractor can lock in fuel wastage for decades. Conversely, a carefully selected machine will need less fuel for the same task and will be easier to operate efficiently. 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, however. Analysis of your particular needs and thorough research is needed to ensure that the machinery you order is truly fit for purpose.

Refer to supplementary paper, *Tractor Purchasing Guidelines*.

Quick wins

- **Make a fuel management plan.** A simple plan that incorporates setting targets and keeping basic records can save your money, especially if it helps you to identify non-production-related losses.
- **Train and motivate staff.** Engage your team in your fuel-efficiency program.
- **Minimise idling times.** Idling motors in break periods are a hidden cost: switch off during longer breaks.
- **Inflate tyres to optimal pressure.** Inflation pressure is an important variable for traction efficiency, tyre life and ride comfort. Improperly inflated tyres can reduce fuel efficiency and tyre life expectancy (refer to supplementary paper, *'Tyre pressure and fuel efficiency'*).
- **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.** Properly matching machinery can minimise excessive power usage, reducing unnecessary fuel consumption. For example, avoid pulling a light load with a high-horsepower tractor (refer to supplementary papers, *Adaptive driving* and *Tractor purchasing guidelines*).
- **Perform routine maintenance.** Routinely replace air filters and oil, and use the proper grade of motor oil in all vehicles, tractors and other equipment to keep them operating at peak efficiency.
- **Minimise discretionary trips.** For example, plan to avoid returning to base during the day.

Efficient vehicle operation

Training and motivating staff

It is essential that your team understands what you are trying to achieve with fuel efficiency, and that they have sufficient skills and motivation to implement the required practices.

Refer to supplementary paper, *Adaptive Driving*.

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Tractor set-up

Correct tractor set-up is central to achieving fuel efficiency. Australian tractors tend to be overballasted. Too little or too much ballast wastes fuel and limits the operator's ability to use tyre pressure to manage traction. A well set-up tractor is easier to operate and having the correct set-up is part of motivating staff to embrace your fuel-efficiency program.

Refer to supplementary paper, *Tractor ballasting.*

Optimising tyre pressure

Whenever practical, tyre pressures should be adjusted according to the axle load and the typical driving speed. Studies have found that having just one tyre underinflated by six psi can increase fuel consumption by three percent and reduce the tyre's useful life (Svejkovsky, 2007).

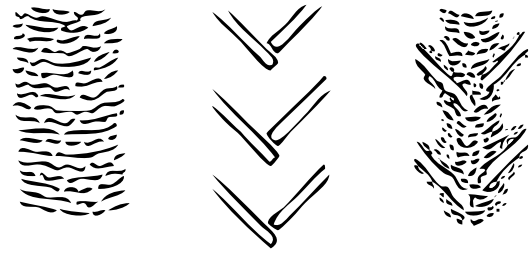
In general, lower tyre pressures in the paddock help to reduce both tractive power demand and soil compaction. On roads and tracks, higher tyre pressures reduce rolling resistance.

Frequent tyre-pressure adjustment may be impractical on older machinery. Coming onto the market, however, are central tyre inflation systems for tractors and trailers that minimise the time and effort required.

Refer to supplementary paper, *Optimising Tyre Pressure*.

Observing wheel slip

Wheel slip is a good indicator of whether your tractor set-up is fuel-efficient. 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, using the following guidelines. 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.



¡ Too little Too much Proper weight

Figure 1: Read your tyre prints. Tread marks provide a rough indicator of correct tyre pressure and tractor set-up. Adapted from (Svejkovsky, 2007).

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.

Refer to supplementary paper, *Wheel slip*.

Gearing

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

A number of field operations, such as light tillage, planting, cultivating, spraying and hay raking, do not require full tractor power. Lowering the engine speed by shifting to a higher gear can save 10 to 20 percent in fuel, depending on the tractor type and load conditions (Intelligent Energy Europe, 2010).

Make sure that your operators understand these principles.

Potential fuel savings are given in Table 1.

Tractor Model No.	Drive style	% fuel saved (75%–55% load)
245	Front-wheel assist	10–20
435	Front-wheel assist	11–14
655	4WD	11–14
8220	Front-wheel assist	15–18
9330	4WD	9–11

Table 1: Fuel savings achievable from correct gearing (University of Nebraska-Lincoln, n.d.).

Vehicle maintenance

Poor vehicle maintenance can have dramatic negative impacts on fuel efficiency. It's recommended that you use the following checklist as part of the regular tune-ups and services you make on all vehicles that use significant quantities of fuel.

- Replace air, oil and fuel filters routinely.
- Change oil as recommended by the manufacturers.
- Use the correct grade of oil.
- Check regularly for leaks, smoke and other signs of improper fuel combustion.
- Clean fuel injectors regularly.
- Have wheels aligned and balanced.

Field operations and design

Planning field operations with energy efficiency in mind can help you 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 European farm study involving detailed modelling and statistical analysis found that a rectangular plot size of 5 ha was optimal for energy efficiency (Intelligent Energy Europe, 2010). While this finding may not be transferable directly to your property, it is worth considering how your current paddock sizing and layout affects energy efficiency.

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

Move stock while you're doing other field work. Where it is practical combine stock relocation with other field work. This, for example, can help minimise the idling time when opening and closing gates as well as the number of field trips made.

Energy efficiency and farm vehicles

'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.

Purchase vehicles that fit the task. Many tractors sold in Australia are more powerful than are needed for their priority duties. The extra weight of the heavier machine will cost you in fuel if its additional power is not essential.

Planning and record keeping

An effective farm fuel efficiency plan starts with documenting the 'when, where and what' of fuel usage.

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 savings areas. Ideally, however, consumption monitoring can become a sustained activity, enabling regular review against targets. Good fuel use records for your major vehicles can pay off in many ways.

Recording 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.

Date	Time		Elapsed time	Description (plot, operation, implements used, operating conditions, working depth)	Area	Diesel consumption		
	From	Until	(h)		(ha)	(L)	(L/h)	(L/ha)
14 Nov 2013	09.30	15.45	6.25	Hill paddock, cutting, front-rear combination, first cut, 6 cm	16	82	13.12	5.125

Table 2: Example data collection table. Adapted from (Handler, et al., 2012).

Monitoring fuel delivery, storage and drawdown

In addition to keeping receipts for fuel deliveries, we recommend that you keep log books for your tanks and ensure that meters are in good working order.

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

Maintaining 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.

We recommend 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 (NSW Farmers 2013).

Painting fuel storage tanks with special reflective products will extend the tanks' life and can help to reduce losses of petrol through evaporation (Alberta Agriculture and Rural Development, 2008). Several products on the market enable you to do this (see *Further information*).

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

Further information

Farm Energy Innovation papers

Adaptive driving
The hidden skill in tractor energy efficiency.

Tyre pressure
The importance of adjusting tyre pressure to surface conditions.

Central tyre inflation (CTI) systems
Taking the labour out of tyre pressure adjustments.

Tractor tyre selection
Bias versus radial tyres and other considerations.

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

Measuring and observing wheel slip
What wheel slip can tell you about energy efficiency.

Tractor purchasing considerations
Vendors, horsepower and efficiency: getting the whole package right.

Energy efficiency and farm vehicles

Other resources

'Conserving Fuel on the Farm'
This paper provides an extensive amount of information relating to farm vehicles and how to improve their efficiency.
njsustainingfarms.rutgers.edu/assets/energy/consfuelfarm.pdf

The EU's 'Efficient 20' program
Efficient 20 is designed to encourage farmers to contribute to reaching the '20 per cent energy savings by 2020' target set by the EU. The focus is put on fuel used in farming machinery.
http://efficient20.eu/

Iowa State University farm energy publications
This site has links to a variety of energy-saving initiatives on farms, including a number of fuel-saving opportunities.
http://farmenergy.exnet.iastate.edu/?page_id=11

Tractor tyre inflation example
This article details the TPG tyre inflation system one farmer implemented to make fuel savings.
www.agweb.com/article/under_pressure

Solacoat heat-reflective paints
Solacoat is an Australia-based company that supplies heat-reflective paints for various types of surfaces. These can be applied to petrol storage tanks to reduce evaporative losses.
www.solacoat.com.au

Ballast information
This article details the specifics regarding ballasts and fuel efficiency for tractors and large equipment.
https://store.extension.iastate.edu/Product/pm2089g-pdf

References

ABARE, 2006. *Farm Costs and Returns – Statistics,* s.l.: Australian Bureau of Statistics.

Alberta Agriculture and Rural Development, 2008. *Farm Fuel Storage and Handling – What are Other Common Issues With on Farm Fuel Storage?* [Online]
Available at:
www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex12367
[Accessed November 2013].

Energetics, 2013. *Tread pattern for different tractor wheel slips,* Sydney: s.n.

Handler, F., Nadlinger, M. & Europe, I. E., 2012. *Strategies for saving fuel with tractors – Trainer Handbook.* [Online]
Available at:
efficient20.eu/files/2011/02/D3-8-Training-Handbook-Fuel-saving-measures.pdf
[Accessed November 2013].

Hanna, M. & Ayres, G., 2011. *Fuel Required for Field Operations.* [Online]
Available at:
www.extension.iastate.edu/Publications/PM709.pdf
[Accessed August 2013].

Intelligent Energy Europe, 2010. *Efficient20.* [Online]
Available at:
efficient20.eu
[Accessed August 2013].

Michigan State University, 2009. *On-farm fuel storage.* [Online]
Available at:
http://www.maeap.org/uploads/files/Farmstead/On-FarmFuelStorageWQ-59.pdf
[Accessed November 2013].

PTG Tyre Pressure Control Systems GmbH, 2014. *RDS Radial CTIS system on a tractor,* Habichtweg: PTG Reifendruckregelsysteme GmbH.

Svejkovsky, C., 2007. *Conserving Fuel on the Farm.* [Online]
Available at:
attra.ncat.org/attra-pub/summaries/summary.php?pub=303
[Accessed 2013].

University of Nebraska-Lincoln, n.d. *Nebraska Tractor Test Laboratory.* [Online]
Available at:
tractortestlab.unl.edu
[Accessed August 2013].

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