

On-farm energy use

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On-farm energy efficiency is becoming increasingly important in the context of rising energy costs and concern over greenhouse gas (GHG) emissions. Energy inputs represent a major cost and one of the fastest growing cost inputs to primary producers. The Australian cotton growing industry is highly

mechanised and heavily reliant on fossil fuels (electricity and diesel). Within highly mechanised farming systems such as those used within the cotton industry, machinery inputs are significant and can represent 40–50% of the cotton farm input costs. Direct energy use is a major component of these costs. Given the major dependence on direct energy inputs and rising energy costs, energy use efficiency is an emerging issue for the Australian cotton industry.

Previous work undertaken by the National Centre for Engineering in Agriculture (NCEA) has studied direct on farm energy use involving a number of case study cotton farms to understand the range, costs and contributions of energy use to cotton production and greenhouse gas emissions. The results from this work showed that

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- Record farm energy usage to identify how efficiently energy is used and where the most energy is consumed.
- Explore ways to reduce energy use by focusing on high energy input areas and investigate opportunities to reduce energy inputs by changing practice or by doing the same operation more efficiently.
- Identifying ways to reduce energy consumption can pay for itself in real dollar terms and is one of the cheapest and fastest ways to reduce greenhouse gas emissions.
- Modifying the operation of machinery and equipment incorrectly (i.e. causing harm to diesel engines; pumping equipment).
- Poorly targeted investment or changes to on farm practices (i.e. on farm improvements need to be informed by an objective assessment of energy savings with sufficient detail to achieve desired outcomes).

For further information and support relating to assessing your energy and greenhouse gas emissions, refer to the energy and greenhouse gas module in *myBMP* (www.mybmp.com.au).

energy use varies depending on the cropping enterprise and the farming system and that there are significant opportunities to reduce energy and costs. In comparison the GHGs from direct energy use can be similar and in fact greater than the GHGs generated by soil/fertiliser/water interactions. Improving on farm energy use would appear to be as important as improving nitrogen efficiency.

In the cropping sector a number of practice changes and technology developments have been, or are being, adopted which can be expected to reduce fuel/energy use or energy use intensity. Examples include minimum/zero tillage, controlled traffic, a range of precision ag technologies, planting of GM crops, some water use efficiency measures and use of legumes in crop rotations.

Within highly mechanised agricultural productions systems such as the Australian cotton industry direct energy inputs (i.e. diesel and electricity) represent a major cost to the grower and potentially a significant proportion of the total GHG emissions. Previous studies have reported significant savings in energy for both a refinement in current practices (i.e. up to 30% for individual operations) and a change in practice (10–20% across the farming system) through energy assessment.

Rational and efficient use of energy is essential for sustainable development in agriculture. At the current market condition, 1 Gigajoule (GJ) of energy would typically cost Australian farmers \$20 to \$25. Previous work including irrigated cotton production has shown that total energy inputs are influenced by management and farming methods, and ranged from 3.7 to 15.2 GJ/ha; at a cost of \$80 to \$310/ha and 275 to 1404 kg CO₂ equivalent/ha greenhouse gas emissions. Dry land cotton production in comparison is expected to be at the lower end of this range.

Assessing on farm energy use

An energy assessment is the systematic examination of a farming enterprise to determine whether, and to what extent, it has used energy efficiently. An energy assessment determines how efficiently energy is being used, identifies energy and cost saving opportunities and highlights potential improvements in productivity and quality.

This may also include potential energy savings through fuel switching, tariff negotiation and managing energy demands. Practically the main purpose of conducting energy assessments and maintaining records is to identify opportunities for significant cost savings which will lead to reduced GHGs.

The concept of energy assessments in the cotton industry is relatively new with ongoing work being continued within the industry and linkages to *myBMP*. Specifically for agriculture, a methodology supported by the software, EnergyCalc (www.kmsi.ncea.biz) has been developed by the National Centre for Engineering in Agriculture to undertake agricultural energy assessments. EnergyCalc also converts direct

energy inputs into greenhouse gas emissions. Both the methodology and software requires some instruction however a record of farming practices and equipment or detailed bowser and electricity meter-box type measurements for all farming operations form the basis of an energy assessment. The methodology and terms used to describe different levels of energy assessments are discussed below. It is noted that the system suggested above for agriculture is similar to that used within the building industry (Australian/New Zealand AS/NZS 3598:2000). However, some differences do occur at the detail in which some measurements are conducted. This is mainly because:

- Agriculture is significantly influenced by seasonal factors and the energy use profile for agriculture may vary on both an annual and daily basis.
- Much more diverse types of machinery are used in agriculture and different machines may be used at different times.
- Fuel use, rather than electricity, is most important for agriculture.

Preliminary assessment

(Overview of the total energy consumption on-site, whole farm approach)

This is the simplest and cheapest form of energy assessment and is referred to as a preliminary assessment or overview of the whole farm. This involves collating all the energy use data from the farm, including the total fuel (diesel, petrol and other fuels) and the total electricity energy consumed. It is generally expected that these figures will be available from the farm receipts. The total energy uses are then divided by the total farm production (e.g., head of cows; bales of cotton; tonnes of wheat) or area. This is done for comparative purposes which assist in identifying the relative significance of opportunities for improvement. In addition this approach also allows for an assessment of the full cropping cycle where multiple crops are grown in rotation. Usually no additional tools are required for this level of assessment. The main purpose of a preliminary assessment is to benchmark overall energy consumption for comparing the relative performance of similar enterprises and identifying high energy use.

Standard/general assessment

(Itemised farm approach, practice based)

A standard/general assessment is effectively a practice based assessment which includes a desktop study of the energy breakdown or itemised account of energy usage across the farm. Energy usage for key farming processes is determined from data easily available from the site (i.e. record of practices, some fuel use data), calculated from machine specifications or based on published data for specific farming practices. A standard/general assessment aims to reach an accuracy of $\pm 20\%$, the purpose of which is to target further investigation. Site specific information including electric motor sizes,

pumping equipment, tractors and vehicles is collated to calculate energy use.

Advanced assessment

(Itemised farm approach, measurement based)

An advanced assessment is a comprehensive measurement based assessment/study of energy usage for different practices across the farm. An advanced assessment utilises site specific data either gained from on-site measurement or through data/records maintained over time. An advanced assessment generally aims to reach an accuracy of $\pm 10\%$ to qualify energy use also leading to further investigation. For an advanced assessment the process is similar to a standard/general assessment. An advanced assessment may include simple record keeping or more sophisticated equipment to extract energy usage for specific items of plant. Measurements would normally include bowser and electricity meter-box type measurements for all farming operations and processes.

Detailed assessment of high energy use farming practices (Specific operation investigation)

The aim of a detailed assessment is to investigate ways to improve the efficiency of a specific operation and most likely require specialised advice. Ideally this would focus on where the greatest energy consumption has been identified from standard or advanced assessments. This will usually involve a range of different sensors to measure the performance (energy efficiency) of different machinery. Examples of sensors used may include pressure (irrigation head pressure), flow rate, engine RPM, tractor travel speed, torque, load and temperature etc. A data logger may be required to record data for a considerable period of time to determine performance and to identify optimised machine settings (i.e. pumping). Detailed assessments of specific tractor based operations have identified potential savings in diesel use of 30% can be achieved depending on how the tractor is operated. Tractor Performance Monitors (TPM) which are standard features in most modern tractors are useful for choosing the appropriate gear and engine speed that maximises fuel efficiency.

Assessing greenhouse gas emissions (GHGs) from direct energy inputs

With the increased community concern on global warming and climate change, the greenhouse gas emissions from the fuel use of agricultural production can be easily determined. This is particularly important in highly mechanised production systems as direct energy use contributes a significant proportion of the total GHGs and may be similar to biologically generated emissions (i.e. soil/water/fertiliser interactions). This may have strategic use to the cotton industry in the future through product labelling or where a price on carbon is established. Conversion of direct energy use (i.e. fuel, electricity etc) to greenhouse gas emissions can

be determined by calculations and factors outlined in the Australian Greenhouse Office (AGO) Factors and Methods workbook (2008) and presented in Table 1.

TABLE 1.
CO₂ Emission factors.

Energy sources	Emission Factor kg CO ₂ equivalent per litre diesel/ petrol/LPG or per kWh electricity
Diesel	2.9
Petrol	2.5
LPG	2.56
Electricity	1.04

These calculations and factors are contained in EnergyCalc (www.kmsi.ncea.biz) and other software available to the cotton industry such as the Cotton Greenhouse Gas Calculator developed by Dr Peter Grace, QUT (<http://www.isr.qut.edu.au/tools/index.jsp>).

On farm energy use & GHGs

Previous work has shown that on farm energy use varies significantly between different farming enterprises, with on farm energy use ranging from 3.7 to 15.2 GJ/ha costing \$80 to \$310/ha. All farms included in the study covered a range of farming regions and farming practices (e.g., conventional tillage, minimum tillage, dryland farming, and irrigation) in both NSW and Queensland. Diesel energy inputs ranged from 95 to 365 litres/ha, with most farms using 120 to 180 litres/ha.

GHGs associated with this direct energy use was estimated to be between 275 and 1404 kgCO₂-e /ha. Dry land cotton production is expected to be at the lower end of this range. It is important to note that these calculations only relate to GHGs from direct energy use, and has not included the (biological) effect due to soil tillage/disturbance and applications of nitrogen fertiliser which can be determined by the Cotton Greenhouse Gas Calculator.

For irrigated cotton, average energy related greenhouse gas emissions can be equivalent to emissions from fertiliser use. A focus on improving on-farm energy use efficiency can be as important in irrigated cropping systems as improving nitrogen use efficiency. For example, data contained in the Australian Government's submission to the UN Framework Convention on Climate Change May 2010 suggests that, in irrigated cotton, average energy related costs and greenhouse gas emissions (0.712 t CO₂-e/ha) appear to be equal to average costs and emissions from fertiliser use (0.67 t CO₂-e/ha).

Energy saving practices

Generally lower energy use on farm is a function of the number and intensity of farming operations and the requirements for pumping irrigation water. In cotton systems, water pumping is often the major energy use

operation (20–70%). Several more detailed examples show that significant efficiency gains (and in some cases crop productivity gains) can be made by optimising pump performance to provide reductions in diesel costs and in some cases improved pump efficiency can lead to increased water flow, more timely irrigation and improved crop yield.

It has been shown that if a farmer moves from conventional tillage to minimum tillage, there is a potential saving of around 10% of the fuel used on the farm, plus other production advantages. It has also been found that energy use associated with picking is also significant and may contribute 20–50% of the total direct energy use (more so in dry land cropping systems).

In 2009 the NCEA conducted a case study to benchmark the energy use reductions resulting in the adoption of reduced tillage systems on the cotton farm 'Keytah' in the Gwydir Valley. The study showed that adoption of a minimum tillage system had reduced energy costs (and greenhouse emissions) by 12% since 2000 and developing a 'near zero till' system had the potential to reduce this to 24% less than 2000 energy costs. The integration of diesel-gas systems to reduce reliance on diesel fuel on this farm also shows considerable promise.

Compared with cotton, the energy use of other rotational (grain) crops is usually lower. Cotton generally has a greater number of farming operations, more intensive energy use associated with harvest (i.e. picking) and higher irrigation demands.

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