Energy use on Arable Farms

Key Points

• Direct energy use is often less than 5% of arable farm expenditure, but on irrigated properties can be 20%.
• There are significant opportunities to save energy. A 15% improvement in diesel and electricity use would boost profits by over $28/ha.
• Total fossil fuel energy use averaged 108 l/ha, most of this from cultivation.
• Electricity use on irrigated farms was 2000kWh/ha and total energy use was 34,200MJ/ha with dryland farms at 20,100MJ/ha.
• Fertiliser accounted for 28% of total energy use (includes extraction, processing and transport) for irrigated properties and 61% for dryland properties.
• Averaged across arable farms total CO₂ and potential taxable CO₂ emissions were 1.6 and 0.7t/ha respectively.
• Carbon tax on NZ produced urea could potentially increase the cost of NZ produced urea by 8%.
• The energy ratio, (output/input), was 3.0 for wheat on both dryland and irrigated properties. The constant ratio reflects the higher yield on irrigated properties. A higher ratio indicates greater energy efficiency.
• There are potentially strong environmental benefits and significant cost savings from greater energy efficiency.

Background

On-farm energy use and opportunities for increasing energy efficiency have been determined for New Zealand in the past. However, with significant changes in inputs and outputs from arable farms the overall energy use needed to be reviewed and benchmarked to:

• provide updated baseline energy use indicators
• develop an overall energy management plan
• identify opportunities for optimising direct energy use.

The project assessed the energy use by Canterbury arable farms as direct energy inputs (fuel & electricity), indirect energy use (fertilisers & agrichemicals) and capital energy (energy associated with vehicles & buildings etc). USDA standard energy contents for crops, on a per tonne basis, were used to calculate energy ratios. Consumer energy values for New Zealand (NZ energy datafile) were used to calculate primary energy values which are directly related to carbon content allowing CO₂ emissions from direct inputs (fossil fuels and electricity) to be calculated. Indirect CO₂ emissions and capital CO₂ emissions were also calculated. This allows the total taxable carbon to be calculated and assigned a value based on the capped 2008 price of $25/t CO₂.

Results

Energy input in dryland farms was 20,100MJ/ha and this was made up of direct (3800), indirect (13,300) and capital (3,000) energy use (Figure 1). The energy output for wheat was 61,300MJ/ha giving an energy ratio of 3.0. Energy input in irrigated farms was 34,200MJ/ha, made up of direct (20,700), indirect (10,700) and capital energy use (2,800)(Figure 2). The energy output for wheat was 103,000MJ/ha giving an energy ratio of 3.0.

The energy ratio for crops will vary in relation to energy inputs and yield. A higher energy ratio indicating efficient energy use. Effective agronomic practices will optimize energy inputs.

These values for energy use on arable farms reflect higher inputs for higher yields so are higher than US but, for dryland properties, similar to those reported for wheat in the UK. NZ irrigated farms are markedly higher reflecting the high energy input to irrigation (Table 1).

<table>
<thead>
<tr>
<th>Table 1: Energy use on arable farms MJ/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
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<tr>
<td>19600</td>
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</table>
Direct energy use within farm varied markedly between farms. Obviously irrigation has a very significant impact, but in field diesel use ranged from 71 to 85 l/ha with total diesel use varying from 86 to 109 l/ha. Indirect energy use varied from 8700MJ/ha to 18300MJ/ha. These differences were largely due to differences in fertiliser inputs and don’t reflect differences in dryland and irrigated but more particularly differences in the individual farm inputs within the limited number of farms studied.

Electricity is the main renewable energy resource, but not all electrical energy is renewable. In New Zealand 63% of electricity is generated with renewable resources. Thus 37% of electrical energy is subject to carbon tax. The high carbon emissions in dryland farms are largely due to high fertiliser inputs, of which a low percentage are subject to carbon tax, thus the higher carbon tax on the irrigated farms in this example.

**Energy savings**
The greatest opportunities for energy savings are around the direct energy inputs. However, obviously optimising indirect energy inputs (fertiliser etc) will help to ensure the energy ratio is as high as possible. Direct energy savings revolve around more efficient operation of machinery and irrigation systems. Some potential areas to reduce energy use are:
- Use of larger than standard tyres and use of radial tyres on field machinery can decrease fuel consumption by 10%.
- Four wheel drive tractors use 10% less fuel than two wheel drive tractors on soft surfaces.
- Better matching the tractor size to the job, particularly where larger horsepower tractors are not operating within their most fuel efficient range, can result in 30% fuel savings.
- Correct ballasting (to optimise wheel slip), improved tractor hydraulic systems and increased driver awareness can result in 30% fuel savings.
- Improved paddock layout and driving patterns can give significant savings.
- Efficient pumping & water application, possibly by auditing to identify areas of poor performance, can give significant savings.

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### Table 2: Energy use in irrigated and dryland farms

<table>
<thead>
<tr>
<th></th>
<th>Irrigated MJ/ha</th>
<th>Dryland MJ/ha</th>
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<tbody>
<tr>
<td>Diesel operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total diesel use</td>
<td>4800</td>
<td>3800</td>
</tr>
<tr>
<td>Total electricity use</td>
<td>15900</td>
<td>0</td>
</tr>
<tr>
<td>Total fertiliser</td>
<td>9500</td>
<td>12200</td>
</tr>
<tr>
<td>Total agrichemicals</td>
<td>1200</td>
<td>1100</td>
</tr>
<tr>
<td>Total capital</td>
<td>2800</td>
<td>3000</td>
</tr>
<tr>
<td><strong>TOTAL ENERGY</strong></td>
<td><strong>35000</strong></td>
<td><strong>20200</strong></td>
</tr>
<tr>
<td>Renewable energy</td>
<td>10020</td>
<td>0</td>
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<tr>
<td>Total energy lost</td>
<td>24980</td>
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</table>

<table>
<thead>
<tr>
<th>Carbon emissions</th>
<th>CO₂ (t)</th>
<th>CO₂tax</th>
<th>CO₂ (t)</th>
<th>CO₂tax</th>
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<tbody>
<tr>
<td>Taxable CO₂</td>
<td>1.5</td>
<td>$30.00</td>
<td>1.8</td>
<td>$6.00</td>
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<td>Carbon tax</td>
<td>1.2</td>
<td></td>
<td>0.2</td>
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</tr>
</tbody>
</table>

1. Capped 2008 level ($25/t CO₂) x taxable carbon emissions using direct energy coefficients (excludes agrichemicals and fertiliser except for 50% of urea which is manufactured in NZ).