

# **Greenhouse Gas Calculators**

## **Comparison of Three Calculators**

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## ***Executive Summary***

Three greenhouse gas emission calculators were trialled on 2 farms in the Tamar NRM region. Two calculators were trialled on each farm. The results were compared and the merits and deficiencies of each calculator are discussed. A brief discussion on abatement strategies is also included.

The “Decision Support Framework for Greenhouse Accounting on Australian Dairy, Sheep, Beef or Grain Properties” provided the most comprehensive estimate of greenhouse gas emissions and best represented the farming enterprises included. A disadvantage of this model is that each enterprise is treated in a separate calculator thus when combining the calculators for a mixed enterprise farm it is difficult to determine the total emissions.

The “TIAR Dairy Emissions Spreadsheet” is a further development of the Decision Support Framework for Greenhouse Accounting – dairy module, and is a good indicator of greenhouse gas emissions from a dairy farm. It also comes with good explanatory material and the capacity to input various abatement strategy figures. The disadvantage is that it is a single enterprise calculator only.

The Lincoln University, New Zealand based “Agriculture and Horticulture Carbon Calculator” is very user friendly and combines enterprises well, but fails to provide much detail on emission sources or take into account carbon stored in trees on farm. Also, as this is a web based program, it is not possible to save any data or results.

Results from the trial indicate that an average of 76% of the total farm emissions from these two farms is due to enteric methane production from animals. While there are a number of enteric methane reduction strategies being researched, at present the best way of minimising methane production is to feed high quality pasture balanced with high protein supplementary feeding.

There is no information in relation to soil carbon measurement either as released or sequestered carbon dioxide equivalent in any of the calculators. Thus, currently, the most effective method of achieving carbon neutral farms is to store carbon in trees planted on-farm. Both properties involved in the trial can realistically achieve this with little or no reduction in agricultural outputs.

## ***Introduction***

AK Consultants was contracted to undertake a trial of the three currently available greenhouse gas emission audit tools for farming properties with two farms with different enterprises that are part of the ROOFS Property Management Planning system.

The aims were to:

- Test two Greenhouse Gas Emission calculators on each of two properties;
- Report on the three available calculators discussing the merits and deficiencies of each and the implications of the results;
- Provide a brief review of the mitigation / abatement options for the property owners.

The three greenhouse gas emission calculators currently available are:

1. **Agriculture and Horticulture Carbon Calculator** (free online calculator available at [www.lincoln.ac.nz/carboncalculator](http://www.lincoln.ac.nz/carboncalculator)).  
This farm Carbon Calculator will estimate the amount of greenhouse gasses produced by farming activities (in units of CO<sub>2</sub>e) using Life Cycle Assessment. The calculator determines emissions from livestock, farm energy use and the use of fertiliser and feed to arrive at totals for methane, nitrous oxide and carbon dioxide emissions. These are then converted and expressed as total carbon dioxide equivalents.
2. **Decision Support Framework for Greenhouse Accounting on Australian Dairy, Sheep, Beef or Grain Farms** (free online or spreadsheet calculators at [www.greenhouse.unimelb.edu.au/gia.htm](http://www.greenhouse.unimelb.edu.au/gia.htm) follow link to GHG Tools).  
This Framework provides downloadable Excel spreadsheet or web based calculators or accounting tools for dairy, beef, sheep, grain, cotton, wine and tree carbon farms. These tools use the Australian National Greenhouse Gas Inventory method to predict the magnitude and sources of greenhouse gasses emitted from these farms.
3. **TIAR Dairy Emissions Spreadsheet.**  
TIAR (Richard Rawnsley and Karen Christie) and Dairy Tas have developed an Excel based tool for dairy farms that estimates 4 sources of emissions – CO<sub>2</sub>, methane direct from cows and also from the effluent, nitrous oxide, and pre-farm emissions. This tool also includes options for abatement of emissions but does not take into account economics. A prototype has been provided for testing with feedback being sought.

The two farms chosen to be part of the trial provided information representative of the majority of farming enterprises within the Tamar Region. One of the farms (“Elverton” owned by Ian Dickenson) is a mixed sheep, cattle, cropping, and private forestry property in the North Esk Catchment. The other (Graham Arnold’s) is a dairy farm within the Pipers River Catchment in the Lilydale area.

## ***Method***

Each landholder was contacted by phone and letter confirming their voluntary involvement in the trial and outlining the nature of the information required to input into calculators. At Ian Dickenson's farm the Agriculture and Horticulture Carbon Calculator ("Lincoln") and the Decision Support Framework for Greenhouse Accounting on Australian Dairy, Beef or Grain Farms ("Melbourne Uni") were trialled; while at Graeme Arnold's farm the TIAR Dairy Emissions Spreadsheet ("TIAR") and the Melbourne Uni calculator were trialled.

Site visits were then made to each landholder to collect all necessary information in the format required for each calculator. This information was collected on an Excel spreadsheet as different calculators required different information and not all information provided was in a suitable format to be entered directly into the calculators.

Landholders were asked to report how difficult it had been to provide the information in the format required; whether they felt the calculators had required a suitable level of information to accurately assess their farming enterprises; and to provide any feedback on the implications of including greenhouse gas emissions audit results in their overall Property Management Plan.

Information collected was then analysed, converted to suitable formats and entered into each calculator. Where there were gaps in the information supplied, accepted industry standards were applied. Where the information required by the calculators was excessively detailed or ambiguous, reasonable assumptions have been made.

## Results

Results as supplied by each calculator for each farm are listed as Appendices. Below are tables comparing summarised results from each calculator for each farm. Enteric methane produced by animals accounts for an average of 76% of total farm emissions from these two farms (excluding carbon stored in trees).

**Table 1: Graeme Arnold's Farm**

	<b>Melbourne Uni</b>	<b>TIAR</b>
CO <sub>2</sub> – Energy	17.1	20.95
CH <sub>4</sub> – Enteric	820	826
CH <sub>4</sub> – Effluent Ponds	18.0	19.8
N <sub>2</sub> O – Effluent Ponds	0.3	0.32
N <sub>2</sub> O – N Fertilizer	11.6	11.6
N <sub>2</sub> O – Indirect	64.6	59.3
N <sub>2</sub> O – Dung + Urine	45.2	43.5
Tree Plantings	-131	-606
<b>Net Farm Emissions</b>	<b>846</b>	<b>507</b>

All figures expressed as tonnes of CO<sub>2</sub> equivalent

Note; Area of tree plantings included varies between calculators – see discussion for more detail

**Table 2: Ian Dickenson's Farm**

	<b>Melbourne Uni</b>	<b>Lincoln</b>
CO <sub>2</sub> – Energy	172	236
Total Methane	3948	2409
Nitrous Oxide	464	1041
Fertilizer	20	279
Tree Plantings (after 1990)	-3150	-
<b>Net Farm Emissions</b>	<b>1454</b>	<b>3964.52</b>

All figures expressed as tonnes of CO<sub>2</sub> equivalent

Note; Lincoln does not contain calculations for tree plantings

Other discrepancies discussed below

## ***Discussion***

### **Obtaining the Information**

From a farmer perspective, the ease with which the information was gathered depended on the level of detail at which they maintained their farm records. Figures such as rainfall, land usage areas, livestock numbers and weights, and production figures were readily estimated. Information requiring further calculation such as electricity consumption in kilowatt hours, and fuel and fertilizer usage on an enterprise basis required more research. For farmers already involved in activities such as benchmarking programs most of this base enterprise information can be readily obtained.

Additional information concerning feed analysis (crude protein, dry matter availability, digestibility) was more difficult if on-farm pasture testing had not been completed recently or if feed had been purchased without test results included. Some assumptions were also required regarding figures such as quantities of pasture versus supplementary fodder consumed by livestock; seasonal livestock weight gains and dry matter availability. Much of this information was supplied by the consultant using accepted industry standards for the enterprises and locations involved.

### **Using the Calculators**

Inputting the data was a relatively straight forward process, with the Lincoln calculator being the most user-friendly. This calculator is set up as a series of pages covering different aspects of farm production and consumption and the user simply moves in a logical manner through the pages. The disadvantage with this calculator however, is that because it is web based, the information supplied cannot be saved. The results page can be printed but only provides very basic information with no breakdown of the sources of emissions.

The Melbourne Uni calculators were reasonably logical with a more detailed data input sheet sitting behind the main results page. Explanatory notes provided for each set of data helped to clarify what was being sought. All parts of these calculators could be saved and printed with varying levels of detail.

The TIAR calculator is a further development of the Melbourne Uni dairy calculator. While there are no explanatory notes on the input sheets, there is a detailed user manual that includes good information for navigating the calculator; background information on interpreting the results; and a table of typical feed analyses. Unlike the other two calculators, the TIAR program also provides a section to enter either a detailed abatement strategy or various ad hoc changes which can then be compared side by side with the baseline results.

## Comparison of Results

The grain emissions calculator from Melbourne Uni did not include any of the grains grown by Ian Dickenson (namely, barley and oats) and referred only to mainland growing regions, therefore results from this calculator have not been included as they were deemed not applicable. The Melbourne Uni calculators also assume that each farm has one enterprise only; i.e.; all beef or all sheep or all dairy. Thus when combining the calculators for a mixed enterprise farm it is necessary to check carefully which figures come from which source to ensure there is no duplication.

The total emissions calculated for Graeme Arnold's farm vary between the TIAR calculator and the Melbourne Uni calculator because the Melbourne Uni calculator specifies including only trees planted after 1990, while the TIAR calculator does not specify, thus an additional 12.8Ha of remnant bush was included in the TIAR model resulting in an additional 475 tonnes of CO<sub>2</sub> equivalent being sequestered. Excluding this anomaly, the results from each calculator are quite comparable. This is to be expected as the TIAR calculator is modelled very closely on the Melbourne Uni calculator.

The discrepancies between the Lincoln calculator and the Melbourne Uni calculator for Ian Dickenson's farm are due to variations in the base data requested. These are listed below:

- The carbon dioxide produced due to energy inputs is greater using the Lincoln calculator because it includes petrol and diesel consumption whereas the other calculators only include diesel.
- The total methane emissions recorded can be attributed entirely to enteric methane produced by animals. The difference in results is due to different methodologies being used. The Melbourne Uni calculator requests animal numbers, live-weights, weight gains and feed sources to calculate enteric methane production, while the Lincoln calculator uses a process called Lifecycle Assessment to calculate methane production. It is unclear at this stage which of these methodologies, if either, is more accurate.
- The difference in nitrous oxide levels can be attributed in part to the above difference in methodology. Another factor that may influence these results is the way in which nitrogenous fertilizers are dealt with by the two calculators. The Lincoln calculator does not differentiate where on the farm the fertilizer is spread; while the Melbourne Uni calculator requests fertilizer quantities spread on pasture and crops separately. The full explanation for such a large discrepancy, however, is unclear.
- The Lincoln calculator requests information on all fertilizers, while the Melbourne Uni calculator only requests information on nitrogen fertilisers. This accounts for the difference in the carbon dioxide equivalents attributed to fertilizer.

None of the calculators used was able to fully represent the planted and remnant vegetation on either farm. The Lincoln calculator made no allowance for vegetation at all and the other two required choosing a single dominant species from a drop down list of predominantly mainland species. In the introductory information associated with the Melbourne Uni calculator, however, a calculator from the Department of Climate Change called CAMfor is referred to as giving a more accurate estimate of the carbon sequestration associated with a stand of trees. This calculator appears to cover the complexities necessary when dealing with remnant vegetation and a variety of species and further investigation of this calculator is warranted if the net emissions from mixed enterprise farms are to be fully represented.

**Table 3: Summary of Features**

	<b>Melbourne Uni</b>	<b>Lincoln</b>	<b>TIAR</b>
<b>Data input</b>	Logical and detailed	User friendly	Okay; good manual
<b>Data storage</b>	Data can be saved and printed	No Data can be saved only results print out	Data can be saved and printed; good results report
<b>Crop selections</b>	Limited to mainland regions	Not available in this version	Not available
<b>Plantations</b>	Only includes trees planted since 1990. Limited to single species	Not included	Single species only
<b>Fuel</b>	Diesel only	Diesel & petrol	Diesel only
<b>Fertiliser</b>	Nitrogeneous only	All fertilisers	All fertilisers
<b>Native forest</b>	Not included	Not included	Not included

## ***Abatement Strategies***

A basic calculation for the reserves and forestry areas on Ian Dickenson's farm would give levels of carbon dioxide stored in trees far greater than that produced by the remainder of his farming enterprise. For example, using only the forest managed for timber production (359Ha – approximately half of the total area of native forest on the property) and entering this in the TIAR calculator as a hardwood plantation gives a total of 9,937 tonnes of carbon dioxide equivalent. This is around three times the amount of carbon dioxide equivalent contained in enteric methane produced by the animals on the farm.

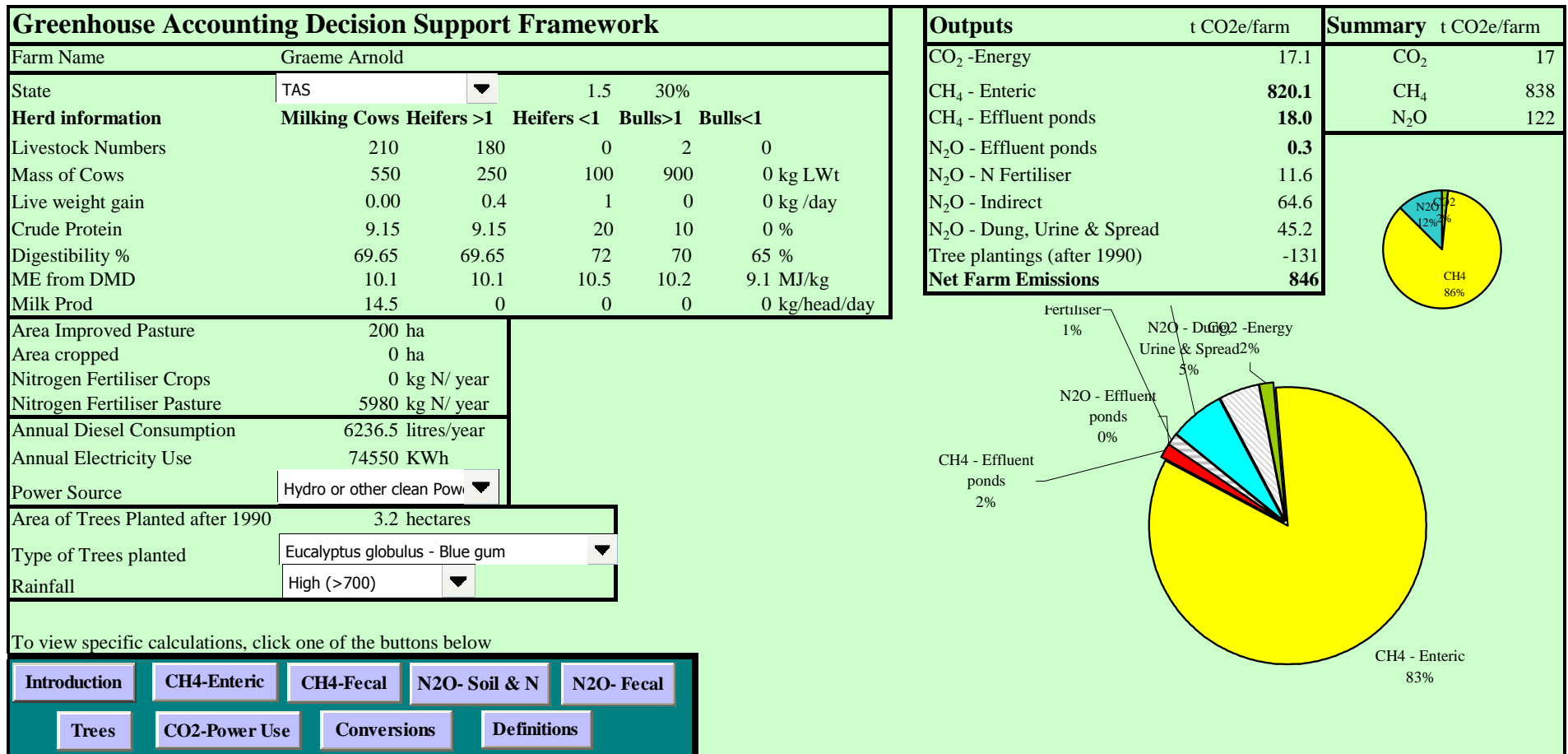
On Graeme Arnold's property, the remnant vegetation, measured as a hardwood plantation on the TIAR calculator gives 606 tonnes of carbon dioxide equivalent which represents over 70% of the amount of carbon dioxide equivalent contained in enteric methane produced by the dairy cows. If the area of vegetation on the farm was doubled to 32Ha (16% of total farm area) the farm would be effectively carbon neutral.

There are a number of strategies to reduce enteric methane production from animals. These include rumen modifiers, feed modifications and alterations to animal gut fauna. Many of these strategies still require further research. However, it is known that enteric methane production is minimised by feeding high quality forages (perennial ryegrass/white clover pasture), particularly where the protein to energy ratio in the ration has been balanced by supplementary feeding.

There is no reference to soil carbon in any of the calculators. The science behind measuring soil carbon is very complex and a workable model is yet to be developed. The farmers in this trial both expressed an interest in including this component of farm carbon in the overall assessment process. While accurate measurement of soil carbon is not yet possible; it is known that increasing the organic matter (or humus) in soil will increase the amount of carbon stored in that soil. Given all the other benefits associated with increased soil organic matter (nutrient availability, moisture retention, improved soil structure etc.) it follows that any greenhouse gas emissions abatement program including increased humus production will provide multiple benefits to the overall farming system.

## Appendix 1. Detailed results

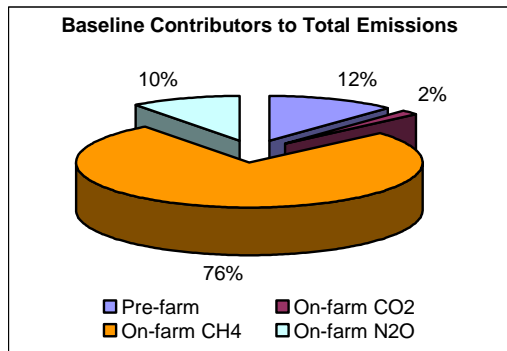
### 1. Results for Graeme Arnold's property from Melbourne Uni calculator



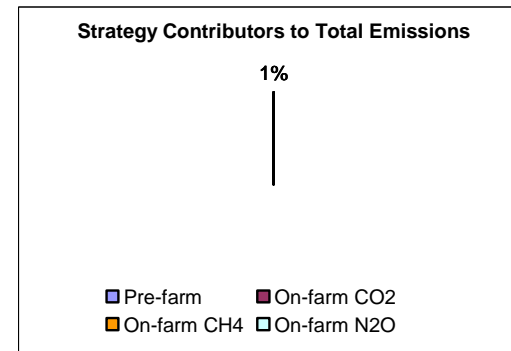
2. Results for Graeme Arnold's property from TIAR calculator. (Baseline results summary page only – note; no abatement strategy data was entered)

## RESULTS

### BASELINE



### STRATEGY



### TOTAL EMISSIONS: Tonnes of CO<sub>2</sub> Equivalent

#### Baseline

Total farm	506.90
Pre-farm	131.76
On-farm CO <sub>2</sub>	20.95
On-farm CH <sub>4</sub>	845.47
On-farm N <sub>2</sub> O	114.77

	Baseline	Strategy
Fertiliser	29.13	0.00
Herbicide	0.25	0.00
Grain	57.38	0.00
Other feed sources	45.00	0.00
CO <sub>2</sub> -Energy	20.95	0.00
CH <sub>4</sub> - Enteric	825.66	0.00
CH <sub>4</sub> - Effluent ponds	19.81	0.00
N <sub>2</sub> O - Effluent ponds	0.32	0.00
N <sub>2</sub> O - N Fertiliser	11.64	0.00
N <sub>2</sub> O - Dung, Urine, Spread	43.51	0.00
N <sub>2</sub> O - Indirect	59.30	0.00
Tree plantings	-606.06	0.00

#### Strategy

Total farm	0.00
Pre-farm	0.00
On-farm CO <sub>2</sub>	0.00
On-farm CH <sub>4</sub>	0.00
On-farm N <sub>2</sub> O	0.00

#### Fixed Strategies

	FALSE	% reduction
Fats	FALSE	
Spring		0
Summer		0
Autumn		0
Winter		0
Tannins	FALSE	
N-Inhibitor	FALSE	0

3. Results for Ian Dickenson's property from Melbourne Uni calculator.

Beef Grazing - Greenhouse Accounting Tool								State: TAS
Farm Name: Ian Dickenson								
<b>Herd Information</b>								
	Bulls >1	Bulls <1	Steers <1	Cows 1 to 2	Cows >2	Cows <1	Steers >1	Units
Livestock Numbers	23	0	0	340	774	0		145
Liveweight	900	195	365	400	650	184		450 kg LWt
Live weight gain	0.00	0.62	0.52	0.52	0.00	0.59		0.52 kg /day
Crude Protein	11.0	11.0	11.0	11.0	11.0	11.0		11.0 %
DMD	68.5	68.5	68.5	68.5	68.5	68.5		68.5 %
<p>Note: Click on the links above to input data</p>								
Area Improved Pasture	1168 ha	Note: Enter the farm areas here						
Area cropped	170 ha							
Nitrogen Fertiliser Pasture	9374							
Nitrogen Fertiliser Crops	1364 kg N/ year							
Annual Diesel Consumption	62404 litres/year	Note: Enter the energy use here						
Annual Electricity Use	42976 KWh							
Power Source	Hydro or other clean Pow							
Area of Trees Planted after 1990	132 hectares							
Type of Trees planted	Pinus Radiata - Pine							
Rainfall	High (>700)							



  

Outputs	t CO2e/farm	Summary	t CO2e/farm
CO <sub>2</sub> -Energy	172	CO <sub>2</sub>	172
CH <sub>4</sub> - Enteric	2,342	CH <sub>4</sub>	2,342
N <sub>2</sub> O - N Fertiliser	20	N <sub>2</sub> O	374
N <sub>2</sub> O - Indirect	190		
N <sub>2</sub> O - Dung, Urine	164		
Tree plantings (after 1990)	-3,150		
<b>Net Farm Emissions</b>	<b>-263</b>		

Gas	Percentage
CH <sub>4</sub> - Enteric	81%
N <sub>2</sub> O - Indirect	7%
N <sub>2</sub> O - N Fertiliser	1%
N <sub>2</sub> O - Dung, Urine	6%
CO <sub>2</sub> -Energy	6%

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Natural Resources  
and Environment

Developed by Richard Eckard, DPI and University of Melbourne

### Sheep Greenhouse Accounting Tool

State: **TAS**

Farm Name: Ian Dickenson

Flock information	Rams	Wethers	Wethers Breeding	Ewes Breeding	Other Ewes	Lambs and Hoggets
Livestock Numbers	30	0	206	2268	0	1106
Liveweight	70	54.25	45	55	50	35 kg LWt
Live weight gain	0.000	0.000	0.030	0.000	0.000	0.030 kg /day
Dry Matter Availability	1.75	1.75	1.75	1.75	1.75	1.75 t/ha
Lambing Rates				31.25		
Crude Protein	11	11	11	11	11	11 %
DMD	68.45	68.45	68.45	68.45	68.45	68.45 %

**Note:** Click on the links above to input sheep data

Area Improved Pasture: 1168 ha **Note:** Enter the farm areas here

Area cropped: 170 ha

Nitrogen Fertiliser Pastures: 9374 kg N/ year

Nitrogen Fertiliser Crops: 1364 kg N/ year

Annual Diesel Consumption: 62404 litres/year **Note:** Enter the energy use here

Annual Electricity Use: 42976 KWh

Power Source: Hydro or other clean Pow

Area of Trees Planted after 1990: 132 hectares

Type of Trees planted: Pinus Radiata - Pine

Rainfall: High (>700)

Carbon content of Wool: 45.2 %

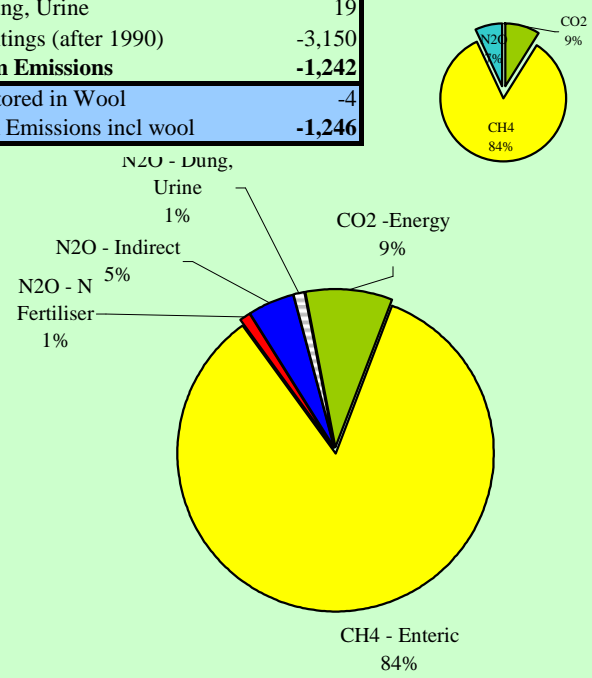
Clean Wool (t/year): 8.2 *Note: Not currently counted.*

To view specific calculations, click one of the buttons below

[Introduction](#)
[CH4-Enteric](#)
[N2O- Soil & N](#)
[N2O- Fecal](#)
[CO2-Power Use](#)

[Trees](#)
[Conversions](#)
[Definitions](#)

Outputs	t CO2e/farm	Summary	t CO2e/farm
CO <sub>2</sub> -Energy	172	CO <sub>2</sub>	172
CH <sub>4</sub> - Enteric	<b>1,606</b>	CH <sub>4</sub>	1,606
N <sub>2</sub> O - N Fertiliser	20	N <sub>2</sub> O	130
N <sub>2</sub> O - Indirect	91		
N <sub>2</sub> O - Dung, Urine	19		
Tree plantings (after 1990)	-3,150		
<b>Net Farm Emissions</b>	<b>-1,242</b>		
Carbon stored in Wool	-4		
<b>Net Farm Emissions incl wool</b>	<b>-1,246</b>		



4. Results for Ian Dickenson's property from Lincoln calculator.

**My Farm Carbon Footprint in kg of CO2 equivalent (Life Cycle Assessment)**

<b>Type</b>	<b>Total CO2eq</b>	<b>per Hectare</b>	<b>per kg Meat</b> ▼
Energy	235,912	176	0.8
Fert/Feed	278,994	209	1.0
Methane	2,409,06	1,800	8.2
Nitrous Oxide	1,040,55	778	3.6
<b>TOTAL</b>	<b>3,964,52</b>	<b>2,963</b>	<b>13.6</b>