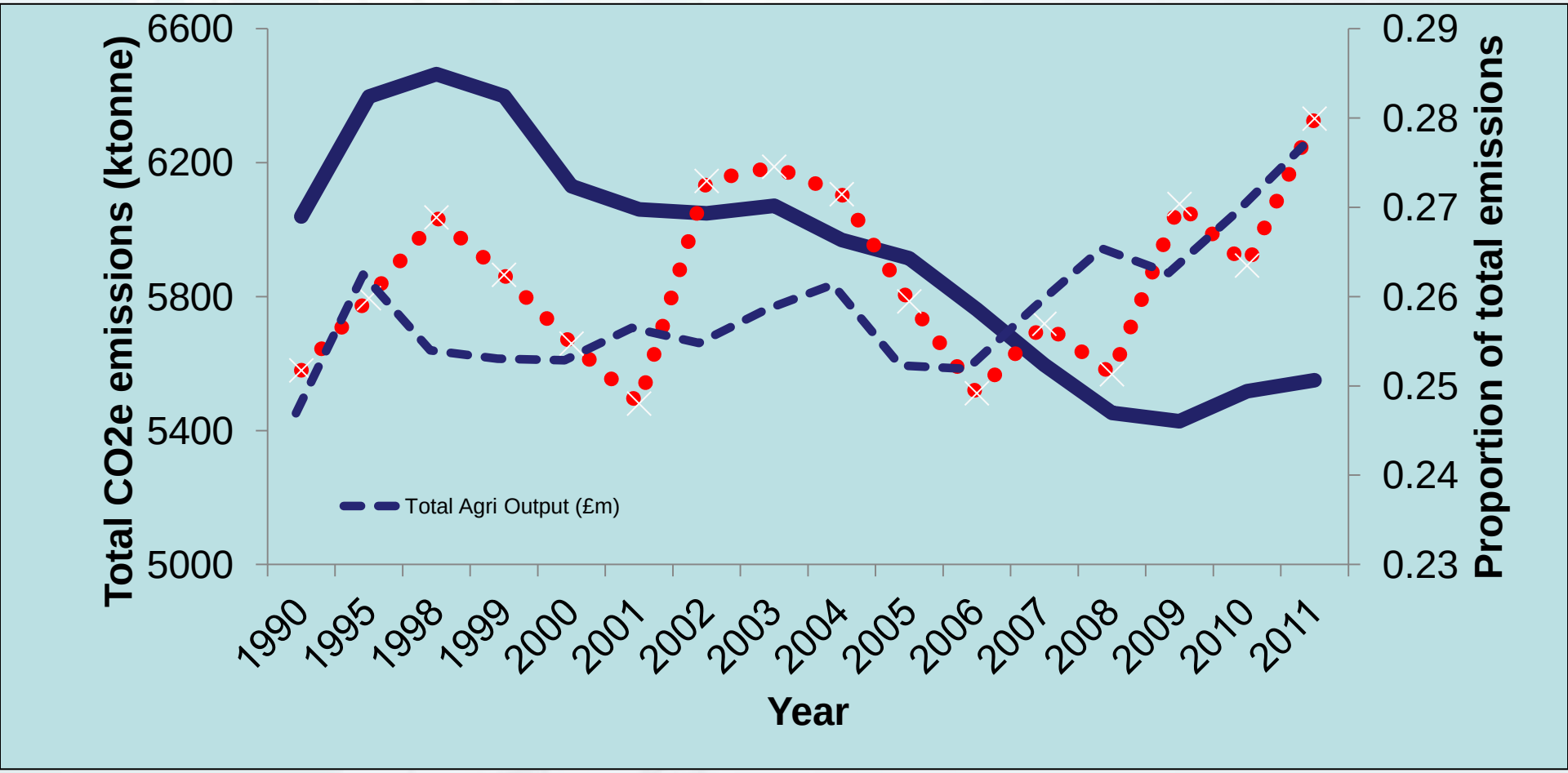
Agri-Food and Biosciences Institute

The Research Challenge Fund

How to calculate the greenhouse gas footprint of milk production

Steven Morrison, Tianhai Yan, Aurelie Aubry, Mark Browne and Wylie McKinty

Trends in agricultural GHG emissions – Northern Ireland



- Overall 8% reduction in GHG emissions from agriculture from 1990 levels
- Total NI GHG emissions have reduced by 17% since 1990

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Greenhouses gas emissions from milk production

Source of Greenhouse Gas emissions from Agriculture in Northern Ireland in 2011

	Emissions ($MtCO_2e$)
Total emissions	5.55
Enteric fermentation	2.07
Manure management	0.56
Agricultural soils	2.40
Agricultural engines and agrochemicals	0.53

32% of the total from dairy cattle

34% of the total from dairy cattle

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BovIS

Bovine Information System

Greenhouse Gas Calculator

AgriSearch NI
Farmer Funded Research

Department of Agriculture and Rural Development
www.dardni.gov.uk

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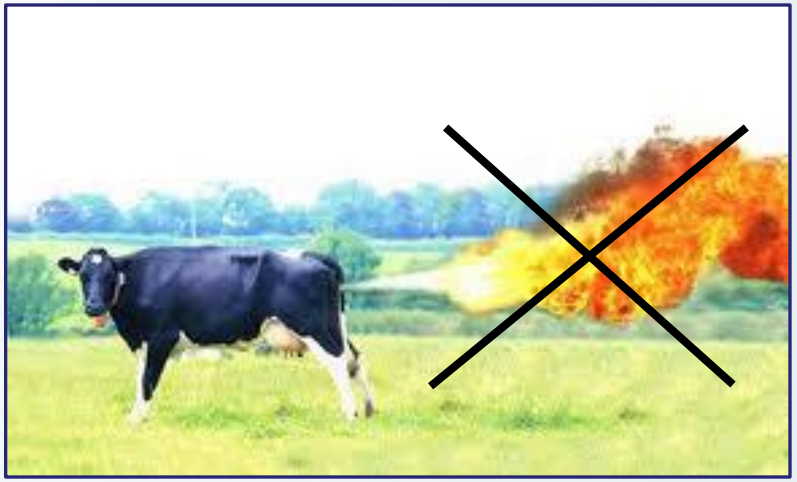
Greenhouse gas calculators

The Research Challenge Fund

Objectives:

The AFBI Greenhouse Gas (GHG) calculators have been developed to:



- enable producers and advisers to calculate the GHG emissions per unit of output
- enable producers and advisers to benchmark emissions against industry recommendations, explore mitigation strategies and monitor the impact of management changes

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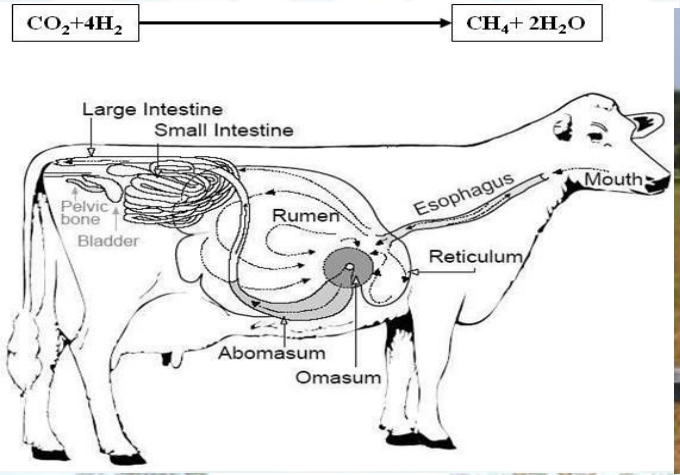
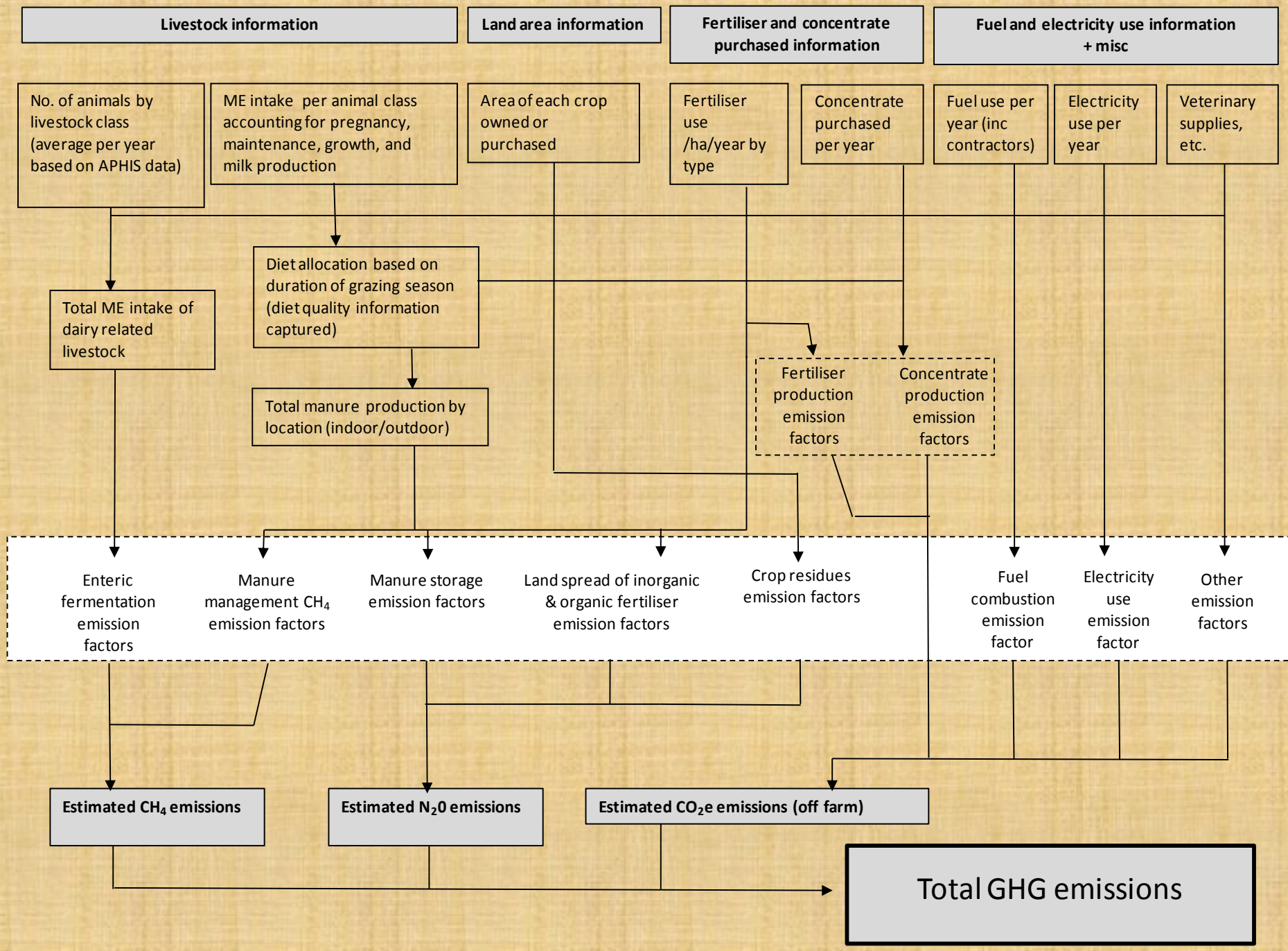
Calculator based on available science - much from Northern Ireland




Livestock information
Land area information
Fertiliser and concentrate purchased information
Fuel and electricity use information + misc
No. of animals by livestock class (average per year based on APHIS data)
ME intake per animal class accounting for pregnancy, maintenance, growth, and milk production
Area of each crop owned or purchased
Fertiliser use /ha/year by type
Concentrate purchased per year
Fuel use per year (inc contractors)
Electricity use per year
Veterinary supplies, etc.
Diet allocation based on duration of grazing season (diet quality information captured)
Total ME intake of dairy related livestock
Total manure production by location (indoor/outdoor)
Fertiliser production emission factors
Concentrate production emission factors
Enteric fermentation emission factors
Manure management CH_4 emission factors
Manure storage emission factors
Land spread of inorganic & organic fertiliser emission factors
Crop residues emission factors
Fuel combustion emission factor
Electricity use emission factor
Other emission factors
Estimated CH_4 emissions
Estimated N_20 emissions
Estimated CO_2e emissions (off farm)
Total GHG emissions

Greenhouse gas calculator

Functional unit:

Emissions are related to intensity of production with total emissions expressed per kilogram of energy corrected milk

Boundary:

Cradle-to-farm-gate although emissions associated with fertiliser manufacture, electricity production and the production of concentrate feeds prior to the farm gate are also included

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Current equations

- Enteric methane production
  - Tier 3
- Methane from manure management
  - Combination of Tier 1 and 3
- N_2O from manure management
  - Combination of Tier 1 and 3
- N_2O from soils
  - Tier 1
- Concentrate manufacture
  - Based on Typical NI diets after consultation with industry
- Fuel and electricity
  - Smyth et al 2009; Iowa state University; Herman et al 2011; Rice and Quinlan 2003; Nielsen (1991), SAC and CAFRE data

Agricultural GHG	GWP (100 years)
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298

- LULUC – currently based on Smith et al., 2010
- Sequestration – NI data (S Laidlaw and C Watson)

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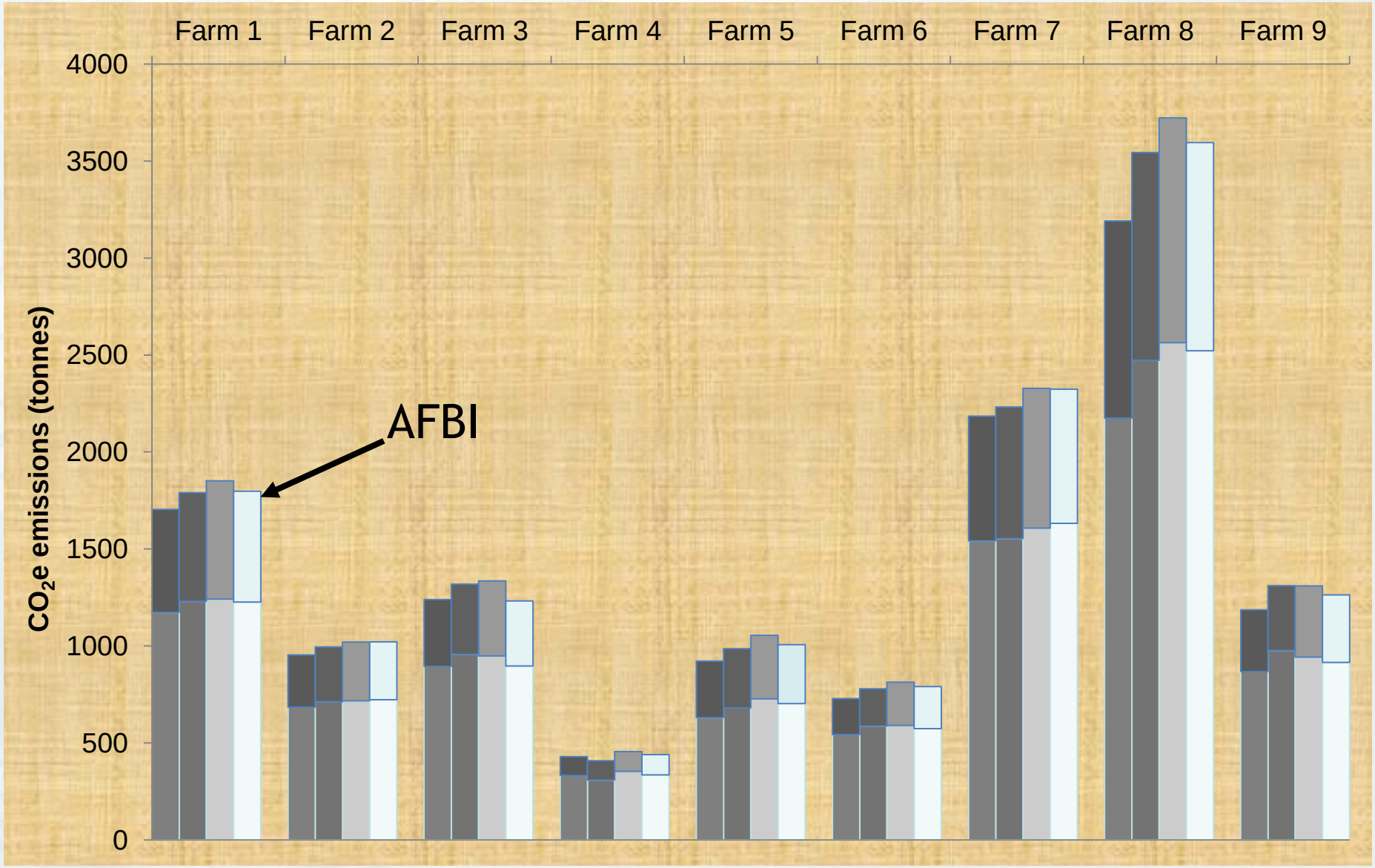
Validation of calculator



Step through guide on how to use the calculator

- Online calculator now available through DARD Online service

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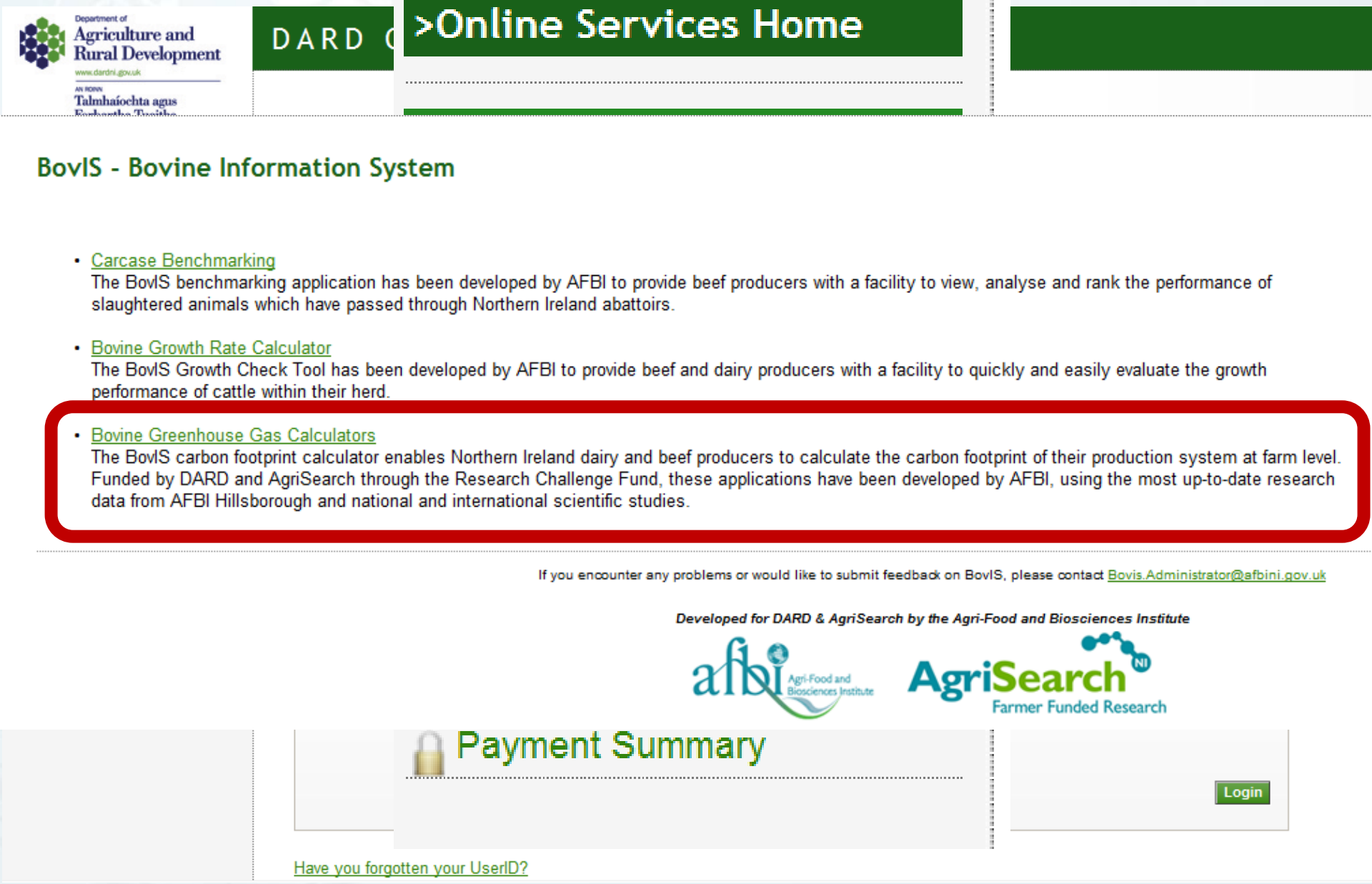
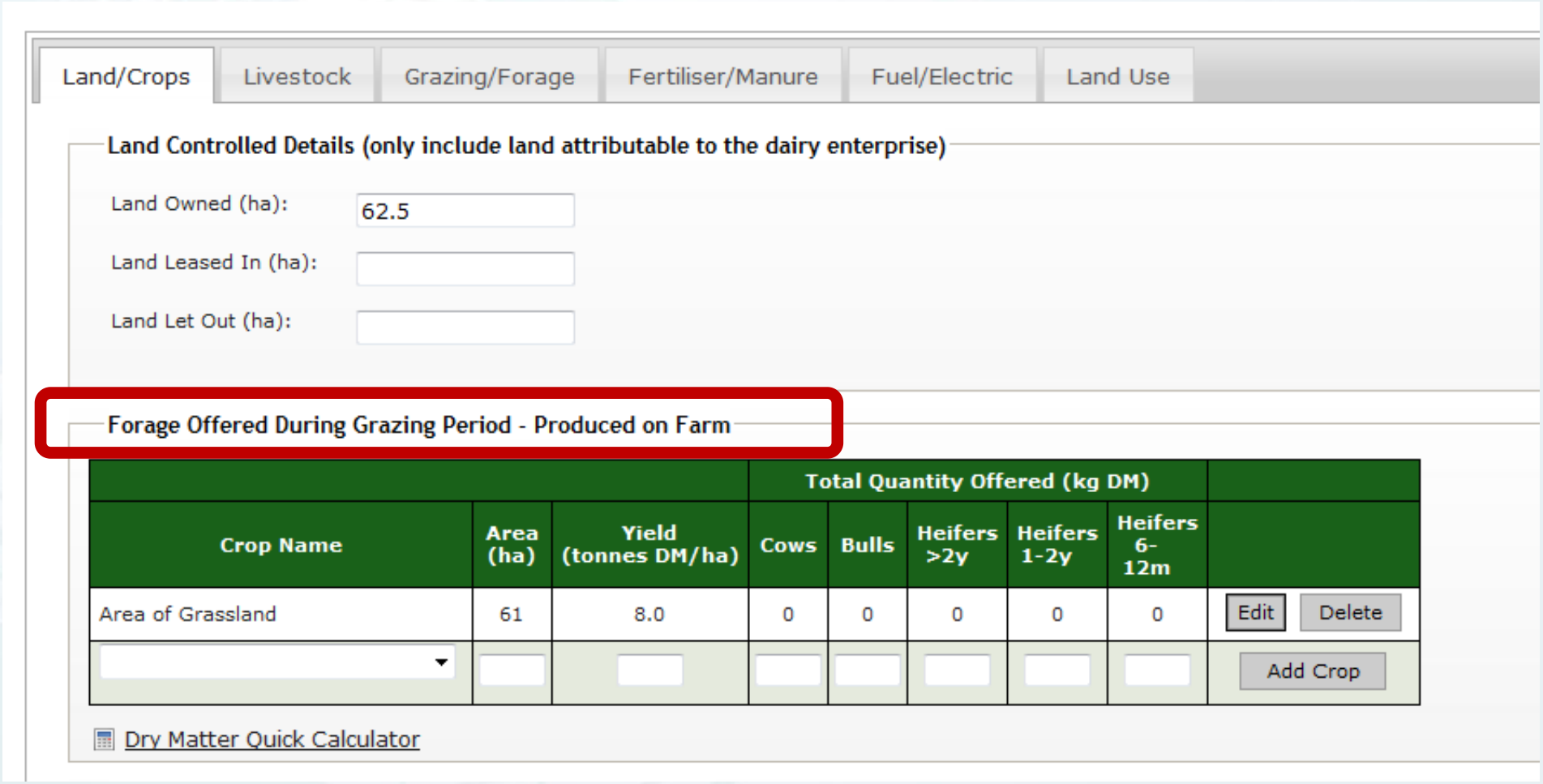
Log in via Government Gateway



Land and crops produced or bought



- Area of grassland does not need to be allocated to animal groups
- Currently only option is for silage buffer feeding
- Must be associated with the dairy enterprise

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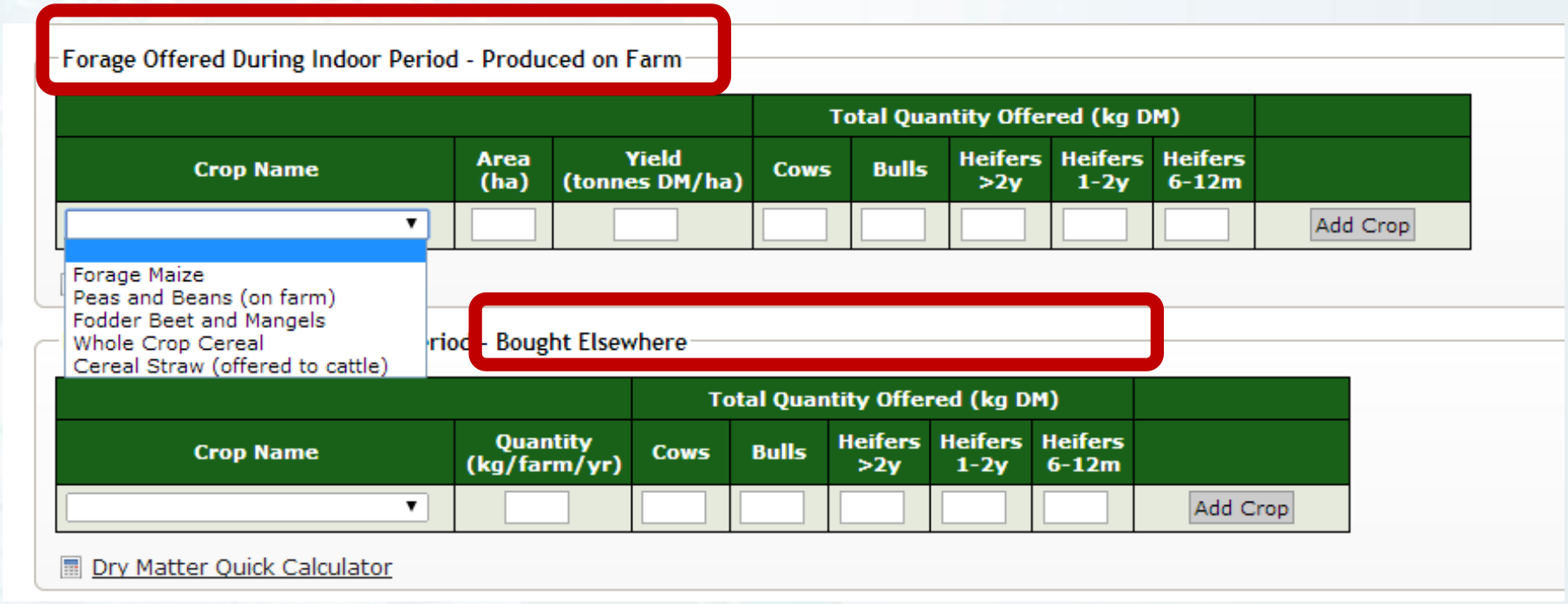
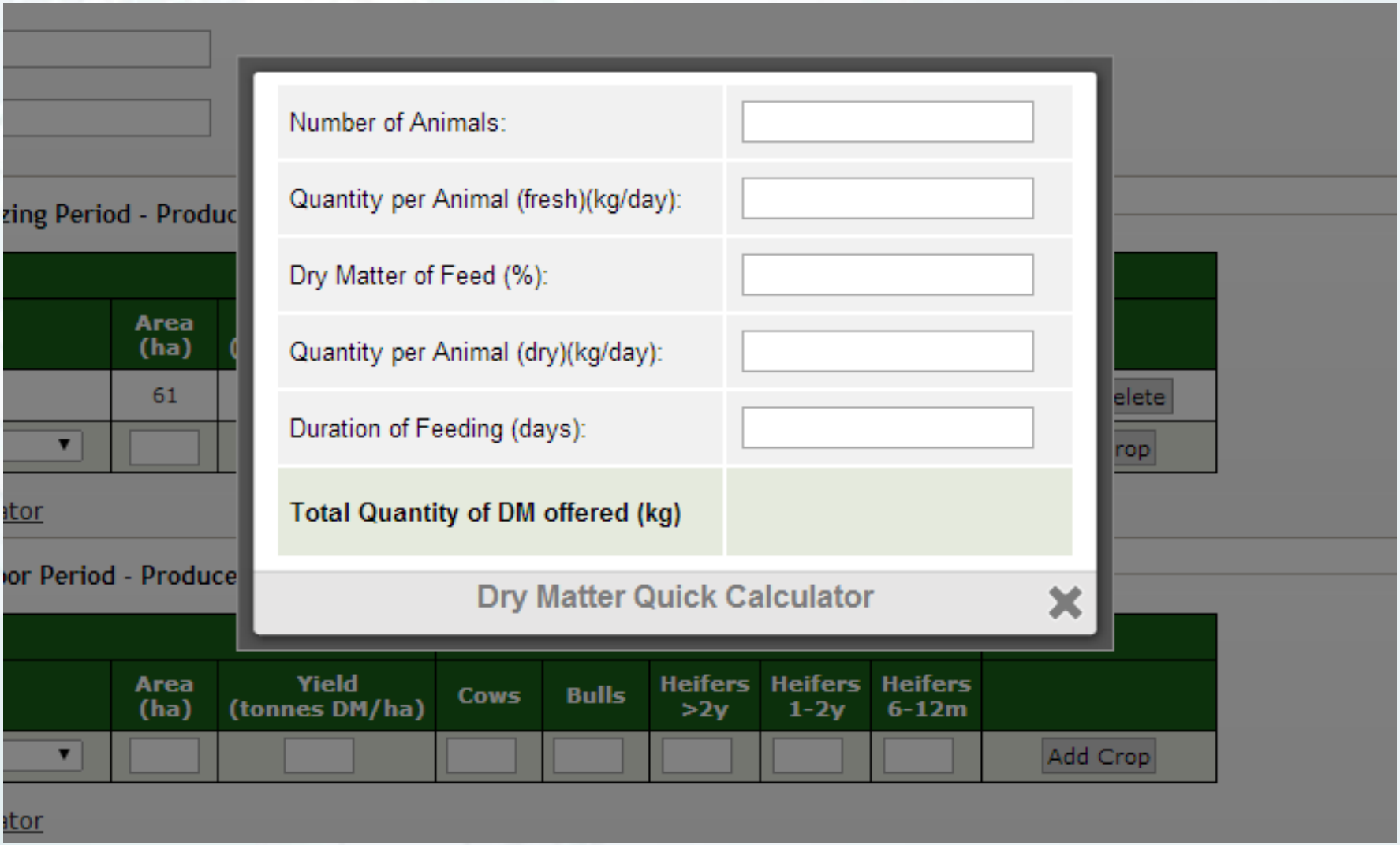
Land and crops produced or bought continued



- Only include the crops used by the dairy enterprise
- Option to include detail on bought in forages
- Allocation of feed is on a group not individual basis but there is a quick calculator to help

Quick dry matter calculator



Livestock numbers

Land/Crops | Livestock | Grazing/Forage | Fertiliser/Manure | Fuel/Electric | Land Use

Dairy Livestock Numbers

Livestock Type	Average Number Per Year
Dairy Cows	87.1 Calculate
Dairy Heifers (2 years +)	9.4 Calculate
Dairy Heifers (1 - 2 years)	7.8
Dairy Heifers (6 - 12 mths)	15.2
Dairy Bulls	0.0

BovIS - Greenhouse Gas Calculator

Please enter livestock numbers on the farm on the 1st day of the months indicated.

Calculate Yearly Average

1st February:	0
1st April:	0
1st June:	0
1st August:	0
1st October:	0
1st December:	0

OK

Livestock performance

Defaults weights

	LWT at beginning (kg)	LWT at end (kg)
Dairy cows	625	
Heifers 2 yrs +	580	620
Heifers 1-2 yrs	310	580
Heifers 0-1 yr	180	310

Dairy Livestock Live W

Dairy Cows and Bulls Li

Livestock Type
Dairy Cows
Dairy Bulls

Dairy Heifers Live Weight

Livestock Type	Live Weight at Beginning (kg)	Live Weight at End (kg)
Dairy Heifers (2 years +)	560	580
Dairy Heifers (1 - 2 years)	280	560
Dairy Heifers (6 - 12 mths)	150	280

Milk Production

Total Annual Milk Sales (L):	634270
Average Milk Fat (%):	4.00
Average Milk Protein (%):	3.20

Calving details and animal exports

Cows Calved

Livestock Type	Number Calved
Dairy Cows	42
Dairy Heifers (2 years +)	8
Dairy Heifers (1 - 2 years)	6

Animal Exports

Animals Exported	No. Animals Exported	Live Weight
Bull calves	41	50
Heifers 0-1 year	0	175
Heifers 1-2 year	0	430
Heifers over 2 year	2	600
Cull Cows	22	620
Cull Mature Breeding Bulls	0	800

Default weights if unknown

Grazing and concentrate information

Ingredient (kg/t)	Growing youngstock
Wheat	150
Rape	50
Hi Pro Soya	
Soya hulls	
Sugar beet pulp	
Molasses	
Min/Vit	
Wheat feed	
Sunflower meal	
maize	
maize distillers	

Ingredient (kg/t)	Lactating dairy cow
Wheat	200
Rape	100
	100
	100
	47
	30
	25
	45
	50
	50
	150
	100
	3

Ingredient	CO2e (kg/kg DM)
Wheat	0.47
Barley	0.46
Rape	0.47
Hi Pro Soya	4.26
Citrus pulp	0.03
Soya hulls	0.1
Sugar beet pulp	0.03
Molasses	0.15
Min/Vit	2
Wheat feed	0.14
Palm Kernal meal	0.1
Sunflower meal	0.47
maize	0.45
maize distillers	0.03
wheat distillers	0.03
oil/fat	1.21

Livestock Type	Am (k					
Dairy Cows	2749					70
Dairy Heifers (2 years +)	0					70
Dairy Heifers (1 - 2 years)	1036					70
Dairy Heifers (6 - 12 mths)	2019					70
Dairy Bulls	0					70

Fresh Concentrate Quick Calculator

Concentrate information and forage quality

Concentrate Offered During Indoor Period (Fresh)

Livestock Type	Amount Fed (kg/year)	DM content (g/kg)	CP content (g/	ME content	Ash content
Dairy Cows	82473	860	18		
Dairy Heifers (2 years +)	0	870	18		
Dairy Heifers (1 - 2 years)	3108	860	18		
Dairy Heifers (6 - 12 mths)	6056	860	18		
Dairy Bulls	0	860	18		

Fresh Concentrate Quick Calculator

Default forage quality values

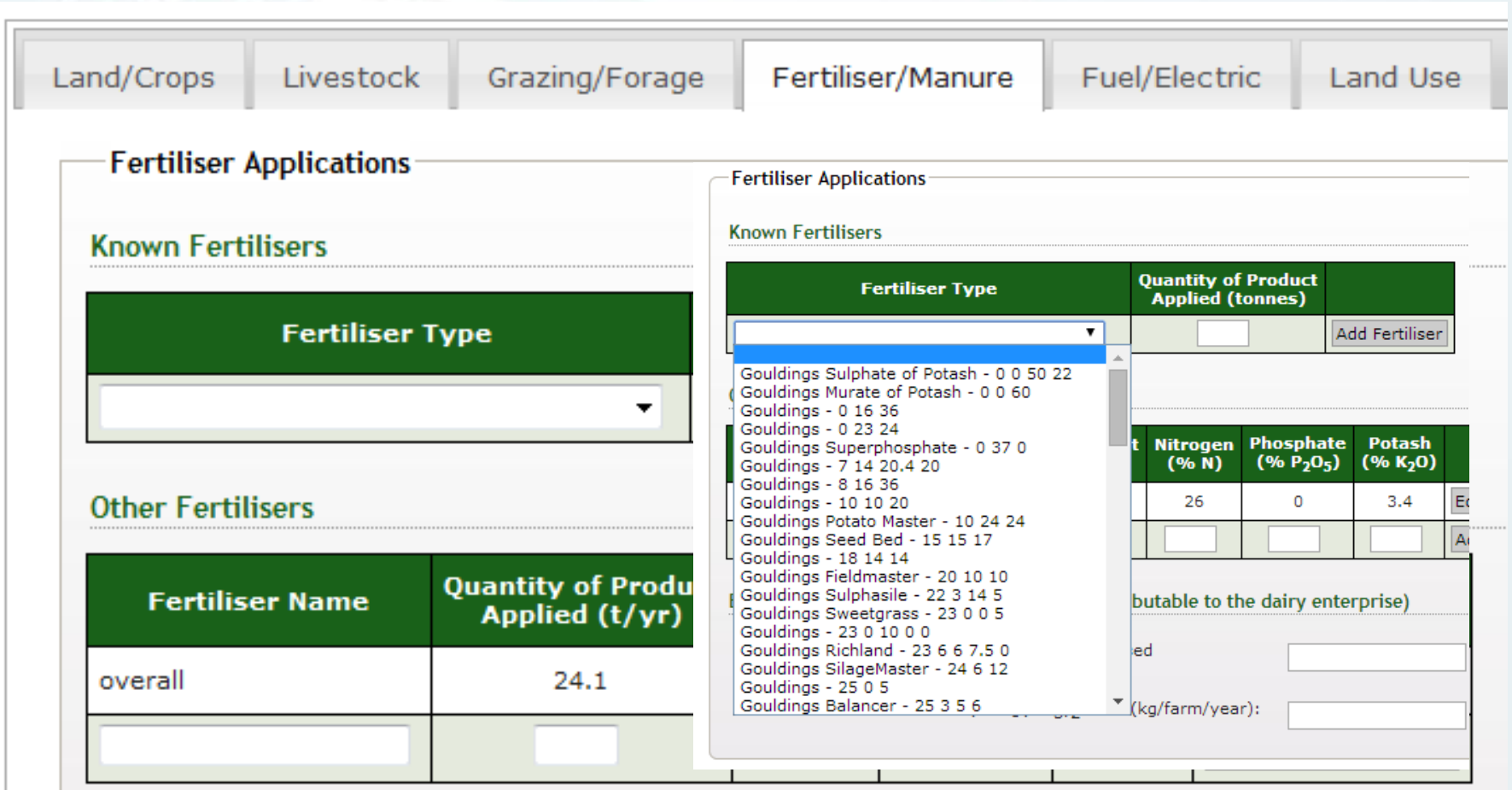
	CP g/kg DM	ME MJ/kg DM	ASH g/kg DM
Grazed grass	160	11.3	85
Grass silage	119	10.9	80
Forage Maize	84	10.7	45
Whole crop cereal	86	9.3	75
Cereal straw (offered to cattle)	40	6.5	70

Forage Nutritive Values - Produced on Farm

	Grazing			Indoor			
Forage Name	CP Content (g/kg DM)	ME Content (MJ/kg DM)	Ash Content (g/kg DM)	CP Content (g/kg DM)	ME Content (MJ/kg DM)	Ash Content (g/kg DM)	
Grazed Grass	175	12.3	80	175	12.3	80	Edit Delete
Grass Silage	148	12.2	83	148	12.2	83	Edit Delete
Forage Maize	84	10.7	45	87	11.0	34	Edit Delete
Whole Crop Cereal	86	9.3	75	90	10.5	75	Edit Delete
							Add forage

(Warning - Please ensure nutritive values have been entered for any any forage offered)

Fertiliser and lime use



Manure management

Organic Manure Management Systems

Organic Manure Type	% of Manure Managed Under Each System	% of Manure Taken Away From Farms
Liquid slurry with natural crust over	0	0
Liquid slurry without natural crust over	0	0
Uncovered lagoon	0	0
Tank storage below slatted floor	100	0
Anaerobic digester	0	0
Farm Yard	0	0

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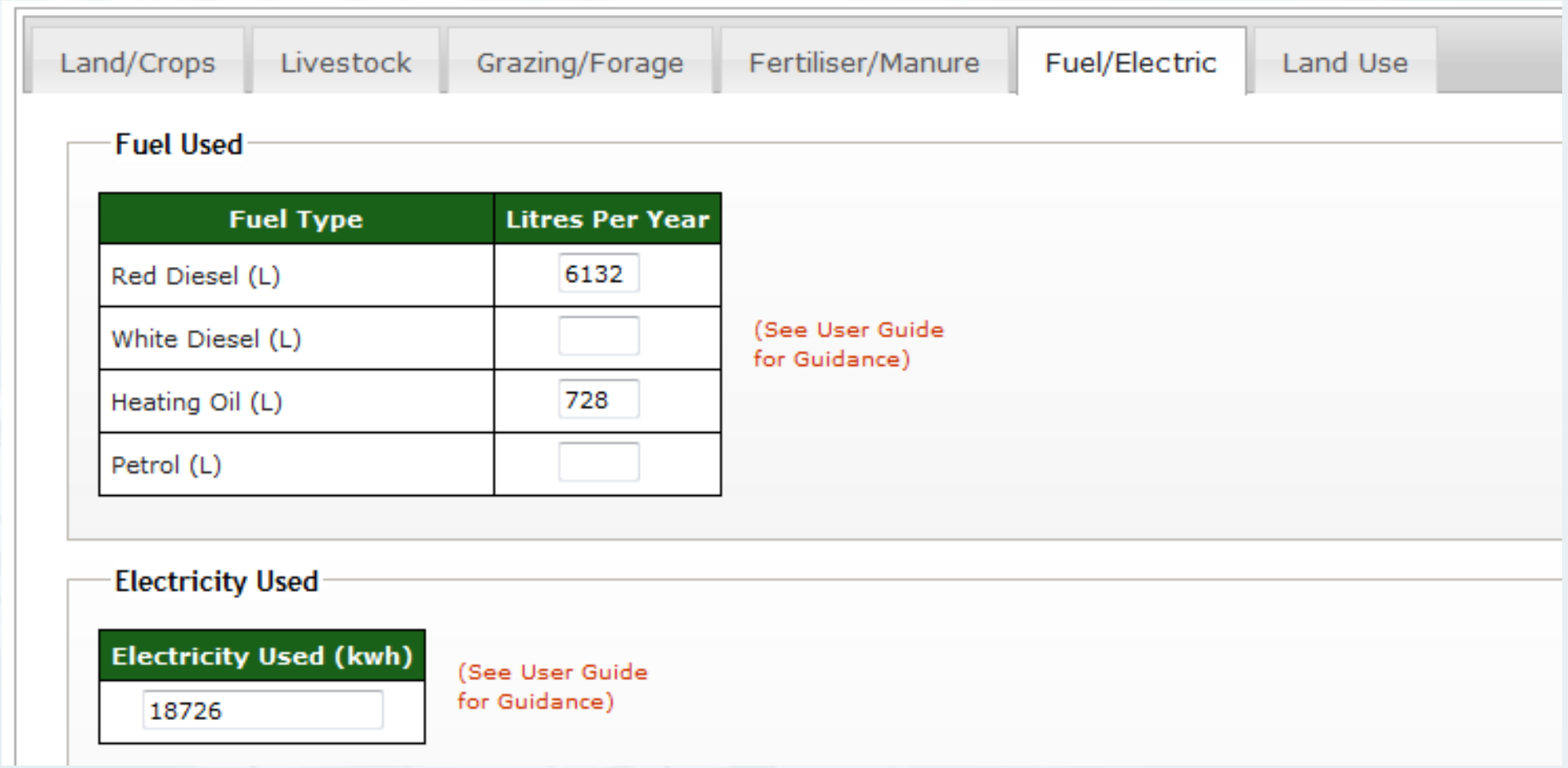
Fuel and electricity use



- If known, input the fuel and electricity use data
- If unknown, leave blank and defaults will be applied
- Operations conducted by contractors who supply their own fuel must be accounted for

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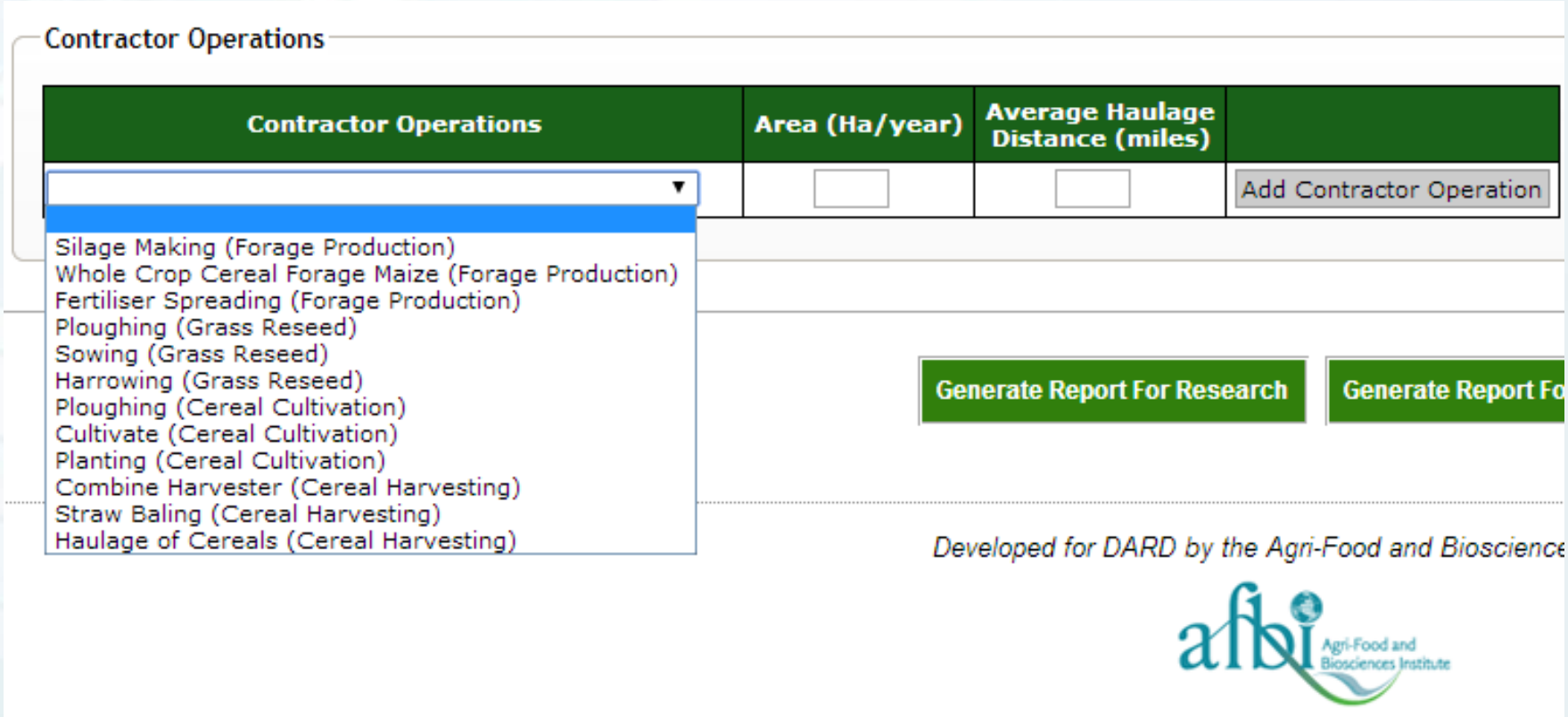
Fuel used by contractors



- Fuel use by contractors based on a range of published values
  Smyth et al 2009; Iowa state University; Herman et al 2011; Rice and Quinlan 2003; Nielsen (1991)
- Further operation types can be added in the future such a slurry spreading

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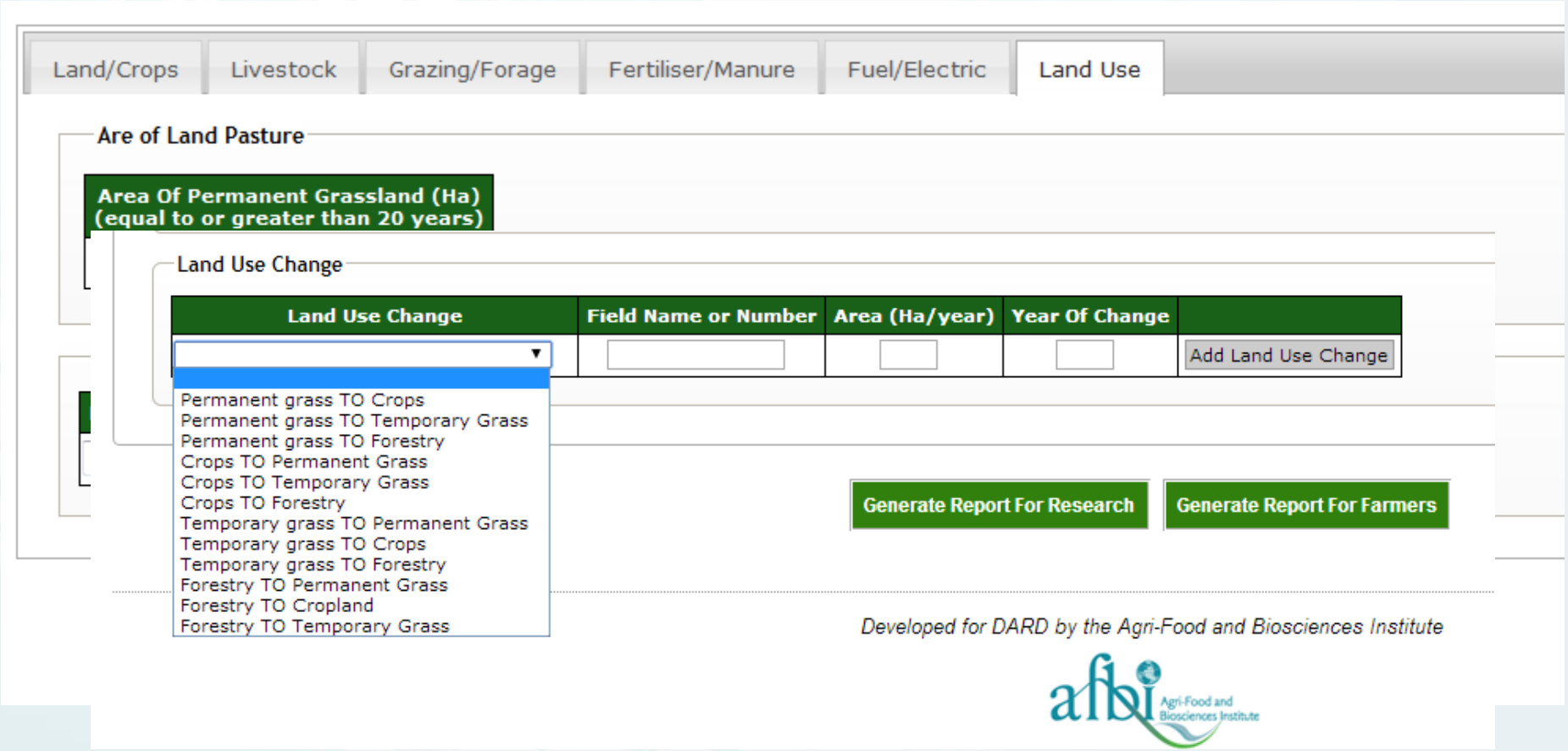
How do we account for changes in land use and sequestration?



- Points to note
  - - 20 year accounting period for land use change
  - - If field use history unknown assume no land use change
  - - Must be fields associated with the dairy enterprise

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Resultant footprint – without sequestration?

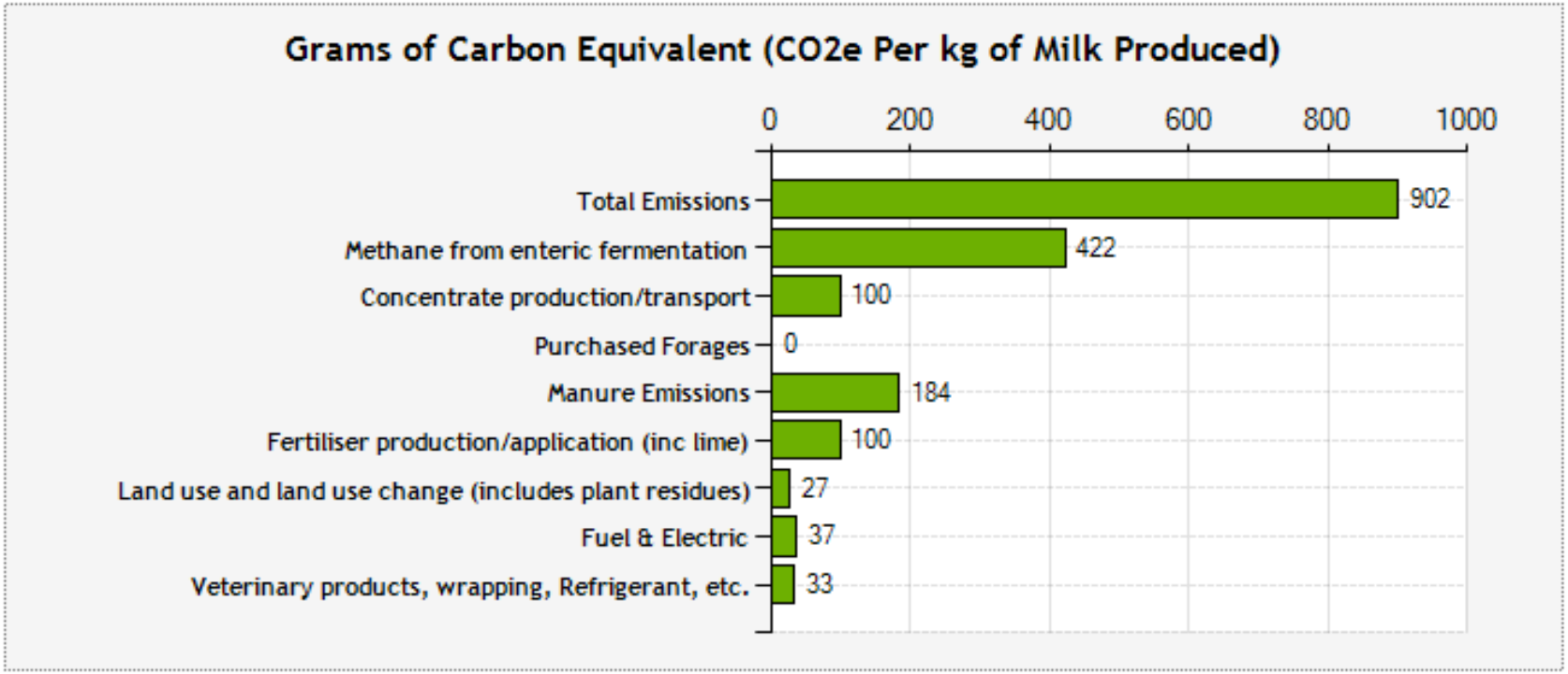
BovIS - Greenhouse Gas Calculator

Dairy Cattle

emissions By Source (Excluding Sequestration)

Carbon Emissions per kg of Milk Produced: 902 g CO_2e per kg of milk

Carbon Emissions per kg of Meat Produced: 14.17 kg CO_2e per kg of meat (14.82% of total CO_2e emissions)

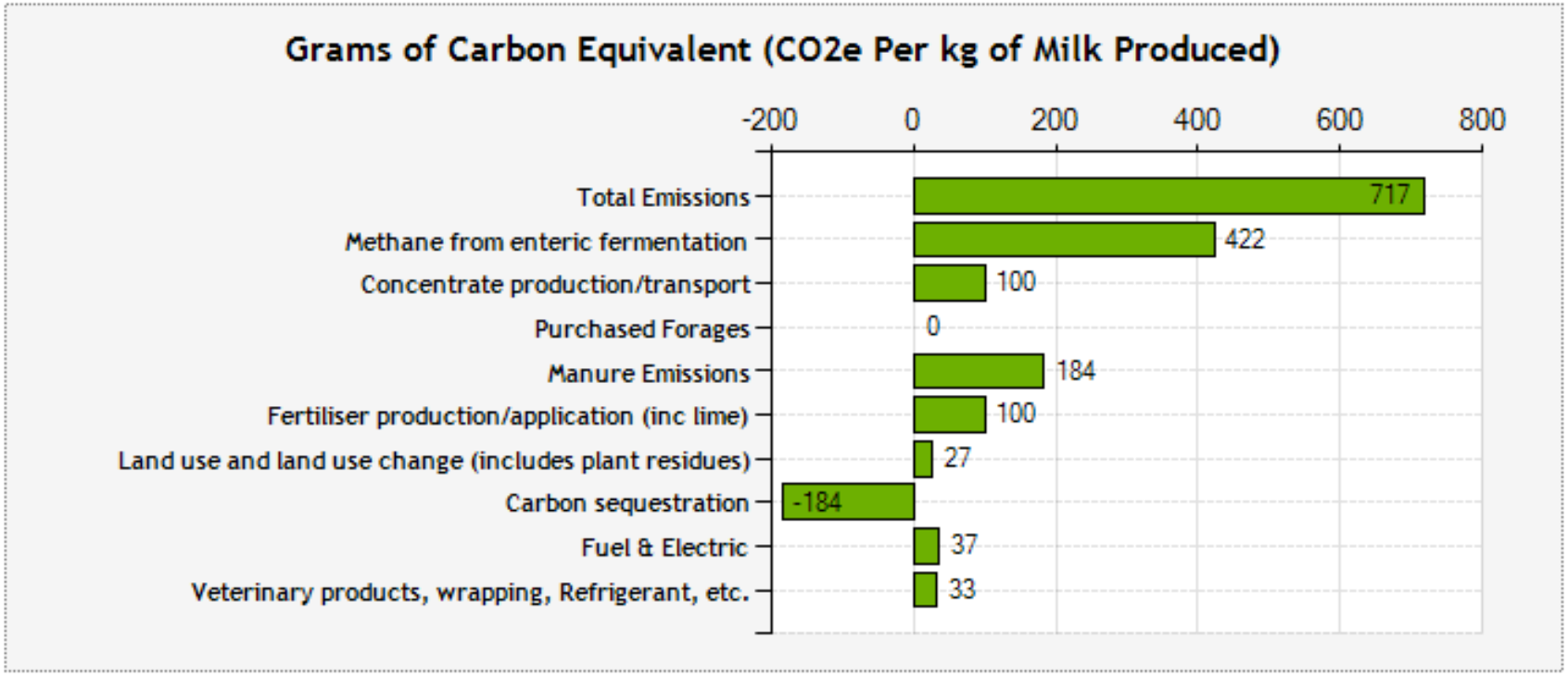


Resultant footprint – with sequestration?

emissions By Source (Including Sequestration)

Carbon Emissions per kg of Milk Produced: 717 g CO_2e per kg of milk

Carbon Emissions per kg of Meat Produced: 11.27 kg CO_2e per kg of meat (14.82% of total CO_2e emissions)



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Summary

Livestock

Other

Milk from Forage:	4602 kg
Fertiliser Use:	24.1 tonnes
	6.3 tonnes N
	100.3 kg N/ha
Efficiency of Grass Utilisation:	6.753 tDM/ha
Liveweight exported:	16890 kg

Carbon Footprint

	CO_2e Emissions (exc Seq)	CO_2e Emissions (inc Seq)
Total emissions:	589.14 tonnes	468.74 tonnes
Total Emissions Relating to Milk Production:	6.764 tonnes per cow	5.382 tonnes per cow
	9.426 tonnes per ha	7.500 tonnes per ha
	902 grams per kg milk	717 grams per kg milk

Return to Your Data

Summary

- Independently verified GHG calculator now available for the NI dairy industry
- Scientifically robust and utilises much of the research generated at AFBI Hillsborough and farms across Northern Ireland
- Calculator will continually evolve as the science develops
- Feedback essential to ensure calculator can cope with the complexities of dairy farming

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