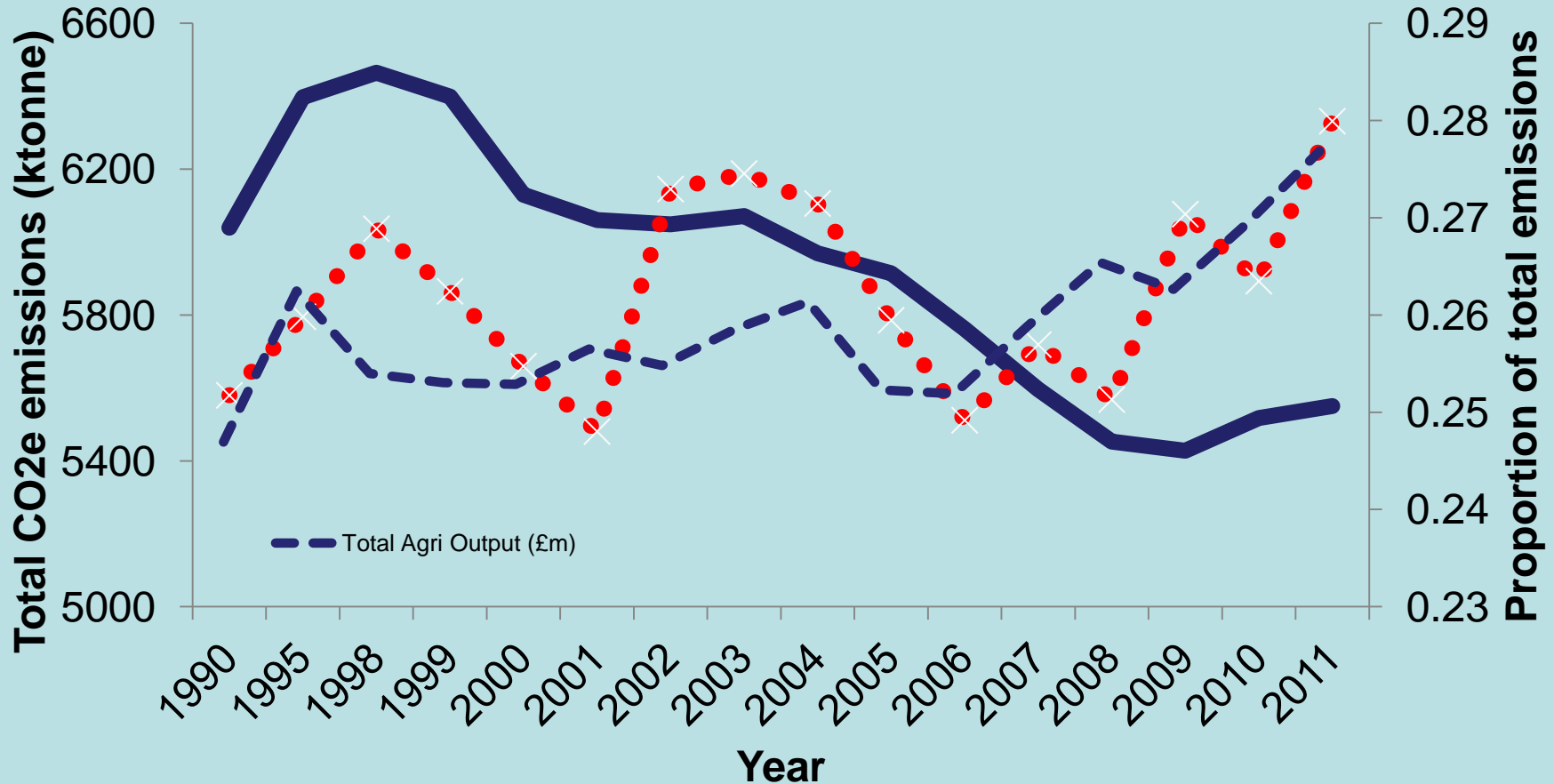


How to calculate the greenhouse gas footprint of milk production

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

Greenhouses gas emissions from milk production

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

	Emissions (MtCO ₂ e)
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

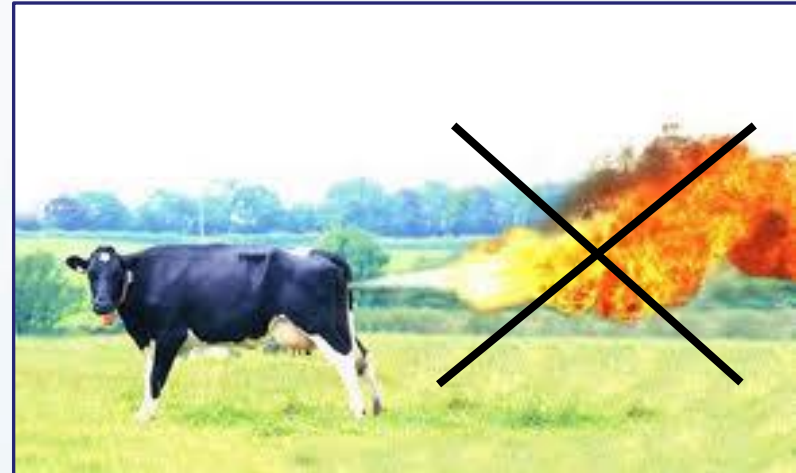
BovIS

Bovine Information System

Greenhouse Gas Calculator

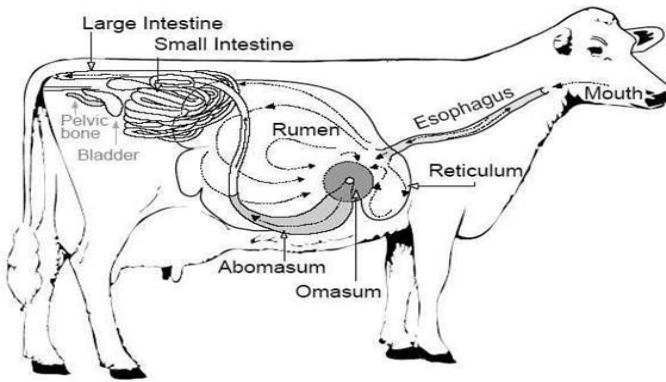
Objectives:

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

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.

Total ME intake of
dairy related
livestock

Diet allocation based on
duration of grazing season
(diet quality information
captured)

Total manure production by
location (indoor/outdoor)

Fertiliser
production
emission
factors

Concentrate
production
emission
factors

Enteric
fermentation
emission
factors

Manure
management CH₄
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 CH₄ emissions

Estimated N₂O emissions

Estimated CO₂e 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

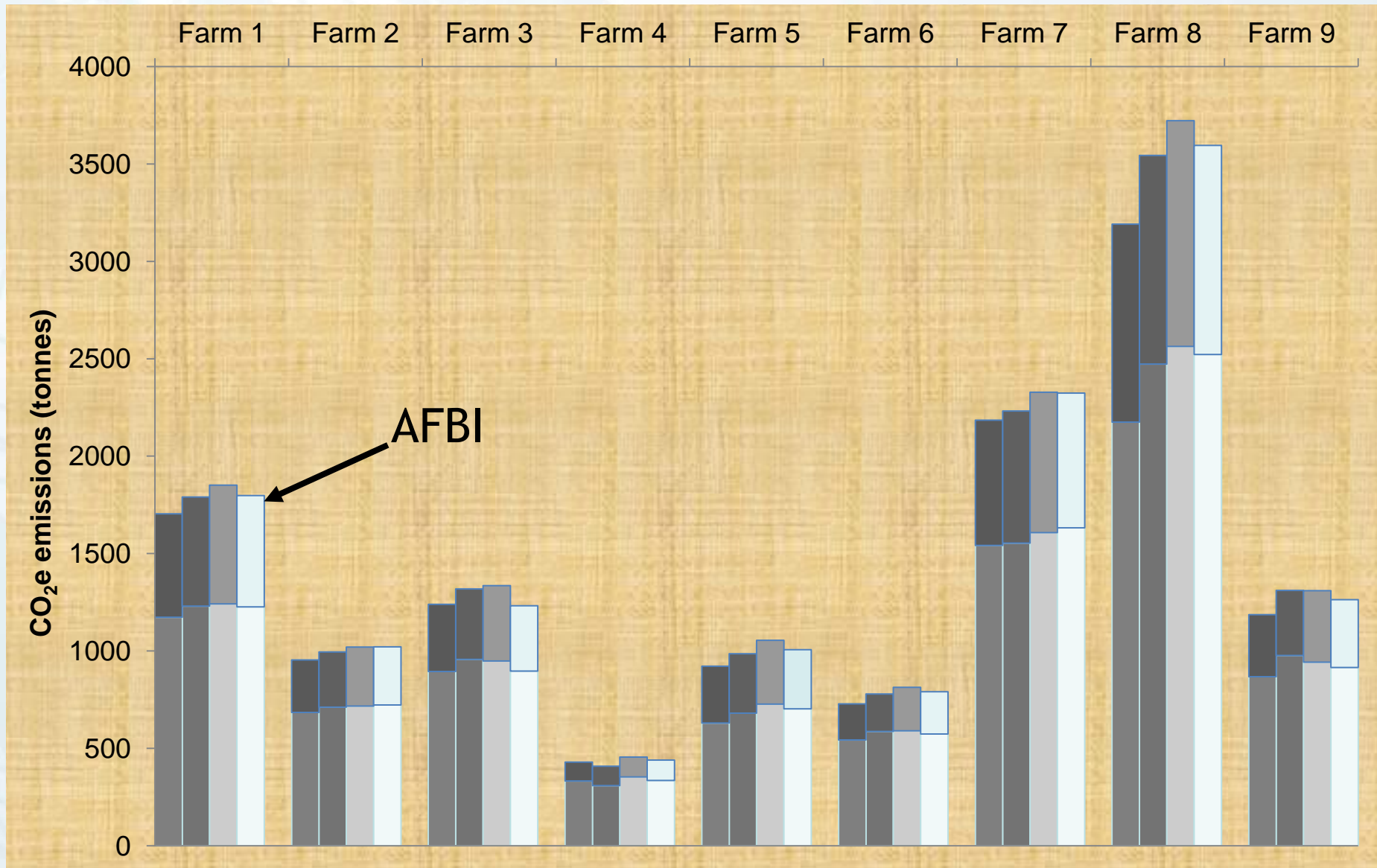


Current equations

- ◆ Enteric methane production
 - Tier 3
- ◆ Methane from manure management
 - Combination of Tier 1 and 3
- ◆ N₂O from manure management
 - Combination of Tier 1 and 3
- ◆ N₂O 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
- ◆ LULUC – currently based on Smith et al., 2010
- ◆ Sequestration – NI data (S Laidlaw and C Watson)

Agricultural GHG	GWP (100 years)
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	25
Nitrous oxide (N ₂ O)	298

Validation of calculator



Step through guide on how to use the calculator

- ◆ Online calculator now available through DARD Online service

PUBLICLY AVAILABLE SPECIFICATION

PAS 2050:2011

Specification for the assessment of life cycle greenhouse gas emissions of goods and services



defra
Department for Environment, Food and Rural Affairs

**GOVERNMENT OF
ENERGY & CLIMATE CHANGE**

BIS
Department for Business, Innovation & Skills

ICS code: 13.020.40
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Gateway Account



Bulletin
of the International Dairy Federation

445/
2010

Non carbon footprint
approach for dairy
OF guide to standard
cycle assessment
dology for the dairy
sector

FIL IDF
International Dairy Federation

afbi Agri-Food and Biosciences Institute

Log in via Government Gateway



DARD >Online Services Home

BovIS - Bovine Information System

- [Carcase Benchmarking](#)

The BovIS benchmarking application has been developed by AFBI to provide beef producers with a facility to view, analyse and rank the performance of slaughtered animals which have passed through Northern Ireland abattoirs.

- [Bovine Growth Rate Calculator](#)

The BovIS Growth Check Tool has been developed by AFBI to provide beef and dairy producers with a facility to quickly and easily evaluate the growth performance of cattle within their herd.

- [Bovine Greenhouse Gas Calculators](#)

The BovIS carbon footprint calculator enables Northern Ireland dairy and beef producers to calculate the carbon footprint of their production system at farm level. Funded by DARD and AgriSearch through the Research Challenge Fund, these applications have been developed by AFBI, using the most up-to-date research data from AFBI Hillsborough and national and international scientific studies.

If you encounter any problems or would like to submit feedback on BovIS, please contact Bovis.Administrator@afbini.gov.uk

Developed for DARD & AgriSearch by the Agri-Food and Biosciences Institute



Payment Summary

Login

[Have you forgotten your UserID?](#)

Land and crops produced or bought

Land/Crops

Livestock

Grazing/Forage

Fertiliser/Manure

Fuel/Electric

Land Use

Land Controlled Details (only include land attributable to the dairy enterprise)

Land Owned (ha):

62.5

Land Leased In (ha):

Land Let Out (ha):

Forage Offered During Grazing Period - Produced on Farm

			Total Quantity Offered (kg DM)						
Crop Name	Area (ha)	Yield (tonnes DM/ha)	Cows	Bulls	Heifers >2y	Heifers 1-2y	Heifers 6-12m		
Area of Grassland	61	8.0	0	0	0	0	0	Edit	Delete
<div></div>								Add Crop	

Dry Matter Quick Calculator

- ◆ 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

Land and crops produced or bought continued


Forage Offered During Indoor Period - Produced on Farm

Crop Name	Area (ha)	Yield (tonnes DM/ha)	Total Quantity Offered (kg DM)					
			Cows	Bulls	Heifers >2y	Heifers 1-2y	Heifers 6-12m	
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	Add Crop

Forage Maize
Peas and Beans (on farm)
Fodder Beet and Mangels
Whole Crop Cereal
Cereal Straw (offered to cattle)

Forage Offered During Indoor Period - Bought Elsewhere

Crop Name	Quantity (kg/farm/yr)	Total Quantity Offered (kg DM)					
		Cows	Bulls	Heifers >2y	Heifers 1-2y	Heifers 6-12m	
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	Add Crop

 [Dry Matter Quick Calculator](#)

- ◆ 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

Number of Animals:		<input type="text"/>
Quantity per Animal (fresh)(kg/day):		<input type="text"/>
Dry Matter of Feed (%):		<input type="text"/>
Quantity per Animal (dry)(kg/day):		<input type="text"/>
Duration of Feeding (days):		<input type="text"/>
Total Quantity of DM offered (kg)		

Dry Matter Quick Calculator ✕

	Area (ha)	Yield (tonnes DM/ha)	Cows	Bulls	Heifers >2y	Heifers 1-2y	Heifers 6-12m	
	61							
								Add Crop

Livestock numbers

Land/Crops

Livestock






Grazing/Forage

Fertiliser/Manure

Fuel/Electric

Land Use

Dairy Livestock Numbers

Livestock Type	Average Number Per Year
Dairy Cows	<input type="text" value="87.1"/>  Calculate
Dairy Heifers (2 years +)	<input type="text" value="9.4"/>  Calculate
Dairy Heifers (1 - 2 years)	<input type="text" value="7.8"/> 
Dairy Heifers (6 - 12 mths)	<input type="text" value="15.2"/> 
Dairy Bulls	<input type="text" value="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:

1st April:

1st June:

1st August:

1st October:

1st December:

OK

Livestock performance

Dairy Livestock Live W

Dairy Cows and Bulls L

Livestock Type
Dairy Cows
Dairy Bulls

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 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):

Average Milk Fat (%):

Average Milk Protein (%):

Calving details and animal exports

Cows Calved

Livestock Type	Number Calved
Dairy Cows	<input type="text" value="42"/>
Dairy Heifers (2 years +)	<input type="text" value="8"/>
Dairy Heifers (1 - 2 years)	<input type="text" value="6"/>

Animal Exports

Animals Exported	No. Animals Exported	Live Weight
Bull calves	<input type="text" value="41"/>	<input type="text" value="50"/>
Heifers 0-1 year	<input type="text" value="0"/>	<input type="text" value="175"/>
Heifers 1-2 year	<input type="text" value="0"/>	<input type="text" value="430"/>
Heifers over 2 year	<input type="text" value="2"/>	<input type="text" value="600"/>
Cull Cows	<input type="text" value="22"/>	<input type="text" value="620"/>
Cull Mature Breeding Bulls	<input type="text" value="0"/>	<input type="text" value="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

ser/Manu

Ingredient (kg/t) Lactating dairy cow

Wheat 200

Rape 100

Hi Pro Soya 100

Soya hulls 100

Sugar beet pulp 47

Molasses 30

Min/Vit 25

Wheat feed 45

Sunflower meal 50

maize 50

maize distillers 150

wheat distillers 100

oil/fat 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

Dairy Heifers (2 years +)

0

Dairy Heifers (1 - 2 years)

1036

Dairy Heifers (6 - 12 mths)

2019

Dairy Bulls

0

70

70

70


70

70

Concentrate information and forage quality

Concentrate Offered During Indoor Period (Fresh)

Livestock Type	Amount Fed (kg/year)	DM content (g/kg)	CP content (g/kg)	ME content (MJ/kg DM)	Ash content (g/kg DM)
Dairy Cows	<input type="text" value="82473"/>	<input type="text" value="860"/>	<input type="text" value="180"/>	<input type="text" value="12.3"/>	<input type="text" value="80"/>
Dairy Heifers (2 years +)	<input type="text" value="0"/>	<input type="text" value="870"/>	<input type="text" value="180"/>	<input type="text" value="12.3"/>	<input type="text" value="80"/>
Dairy Heifers (1 - 2 years)	<input type="text" value="3108"/>	<input type="text" value="860"/>	<input type="text" value="180"/>	<input type="text" value="12.3"/>	<input type="text" value="80"/>
Dairy Heifers (6 - 12 mths)	<input type="text" value="6056"/>	<input type="text" value="860"/>	<input type="text" value="180"/>	<input type="text" value="12.3"/>	<input type="text" value="80"/>
Dairy Bulls	<input type="text" value="0"/>	<input type="text" value="860"/>	<input type="text" value="180"/>	<input type="text" value="12.3"/>	<input type="text" value="80"/>

 [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	<input type="button" value="Edit"/> <input type="button" value="Delete"/>
Grass Silage	148	12.2	83	148	12.2	83	<input type="button" value="Edit"/> <input type="button" value="Delete"/>
Forage Maize	84	10.7	45	87	11.0	34	<input type="button" value="Edit"/> <input type="button" value="Delete"/>
Whole Crop Cereal	86	9.3	75	90	10.5	75	<input type="button" value="Edit"/> <input type="button" value="Delete"/>
<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="button" value="Add forage"/>

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

Fertiliser and lime use

Land/Crops

Livestock

Grazing/Forage

Fertiliser/Manure

Fuel/Electric

Land Use

Fertiliser Applications

Known Fertilisers

Fertiliser Type
<input type="text"/>

Other Fertilisers

Fertiliser Name	Quantity of Product Applied (t/yr)
overall	24.1
<input type="text"/>	<input type="text"/>

Fertiliser Applications

Known Fertilisers

Fertiliser Type	Quantity of Product Applied (tonnes)									
<input type="text"/>	<input type="text"/>									
<input type="button" value="Add Fertiliser"/>										
<ul style="list-style-type: none"> Gouldings Sulphate of Potash - 0 0 50 22 Gouldings Murate of Potash - 0 0 60 Gouldings - 0 16 36 Gouldings - 0 23 24 Gouldings Superphosphate - 0 37 0 Gouldings - 7 14 20.4 20 Gouldings - 8 16 36 Gouldings - 10 10 20 Gouldings Potato Master - 10 24 24 Gouldings Seed Bed - 15 15 17 Gouldings - 18 14 14 Gouldings Fieldmaster - 20 10 10 Gouldings Sulphasile - 22 3 14 5 Gouldings Sweetgrass - 23 0 0 5 Gouldings - 23 0 10 0 0 Gouldings Richland - 23 6 6 7.5 0 Gouldings SilageMaster - 24 6 12 Gouldings - 25 0 5 Gouldings Balancer - 25 3 5 6 	<table border="1"> <thead> <tr> <th>Nitrogen (% N)</th> <th>Phosphate (% P₂O₅)</th> <th>Potash (% K₂O)</th> </tr> </thead> <tbody> <tr> <td>26</td> <td>0</td> <td>3.4</td> </tr> <tr> <td><input type="text"/></td> <td><input type="text"/></td> <td><input type="text"/></td> </tr> </tbody> </table>	Nitrogen (% N)	Phosphate (% P ₂ O ₅)	Potash (% K ₂ O)	26	0	3.4	<input type="text"/>	<input type="text"/>	<input type="text"/>
Nitrogen (% N)	Phosphate (% P ₂ O ₅)	Potash (% K ₂ O)								
26	0	3.4								
<input type="text"/>	<input type="text"/>	<input type="text"/>								

attributable to the dairy enterprise)

ed

(kg/farm/year):

Emissions from Liming (only include land attributable to the dairy enterprise)

Annual Amount of Calcic Limestone (CaCO₃) used (kg/farm/year):

Annual amount of dolomite (CaMg(CO₃)₂) used (kg/farm/year):

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	<input type="text" value="0"/>	<input type="text" value="0"/>
Liquid slurry without natural crust over	<input type="text" value="0"/>	<input type="text" value="0"/>
Uncovered lagoon	<input type="text" value="0"/>	<input type="text" value="0"/>
Tank storage below slatted floor	<input type="text" value="100"/>	<input type="text" value="0"/>
Anaerobic digester	<input type="text" value="0"/>	<input type="text" value="0"/>
Farm Yard	<input type="text" value="0"/>	<input type="text" value="0"/>

Fuel and electricity use

Land/Crops

Livestock

Grazing/Forage

Fertiliser/Manure

Fuel/Electric

Land Use

Fuel Used

Fuel Type	Litres Per Year
Red Diesel (L)	6132
White Diesel (L)	
Heating Oil (L)	728
Petrol (L)	

(See User Guide
for Guidance)

Electricity Used

Electricity Used (kwh)

18726

(See User Guide
for Guidance)


- ◆ 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

Fuel used by contractors

Contractor Operations

Contractor Operations	Area (Ha/year)	Average Haulage Distance (miles)	
<div><div>▼</div><div>Silage Making (Forage Production) Whole Crop Cereal Forage Maize (Forage Production) Fertiliser Spreading (Forage Production) Ploughing (Grass Reseed) Sowing (Grass Reseed) Harrowing (Grass Reseed) Ploughing (Cereal Cultivation) Cultivate (Cereal Cultivation) Planting (Cereal Cultivation) Combine Harvester (Cereal Harvesting) Straw Baling (Cereal Harvesting) Haulage of Cereals (Cereal Harvesting)</div></div>	<input type="text"/>	<input type="text"/>	<input type="button" value="Add Contractor Operation"/>

Developed for DARD by the Agri-Food and Biosciences



- ◆ 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

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

Land/Crops

Livestock

Grazing/Forage

Fertiliser/Manure

Fuel/Electric

Land Use

Are of Land Pasture

Area Of Permanent Grassland (Ha)
(equal to or greater than 20 years)


Land Use Change

Land Use Change	Field Name or Number	Area (Ha/year)	Year Of Change	
<div>Permanent grass TO Crops</div> <div>Permanent grass TO Temporary Grass</div> <div>Permanent grass TO Forestry</div> <div>Crops TO Permanent Grass</div> <div>Crops TO Temporary Grass</div> <div>Crops TO Forestry</div> <div>Temporary grass TO Permanent Grass</div> <div>Temporary grass TO Crops</div> <div>Temporary grass TO Forestry</div> <div>Forestry TO Permanent Grass</div> <div>Forestry TO Cropland</div> <div>Forestry TO Temporary Grass</div>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="button" value="Add Land Use Change"/>

Generate Report For Research

Generate Report For Farmers

Developed for DARD by the Agri-Food and Biosciences Institute



◆ 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

Resultant footprint - without sequestration?

BovIS - Greenhouse Gas Calculator

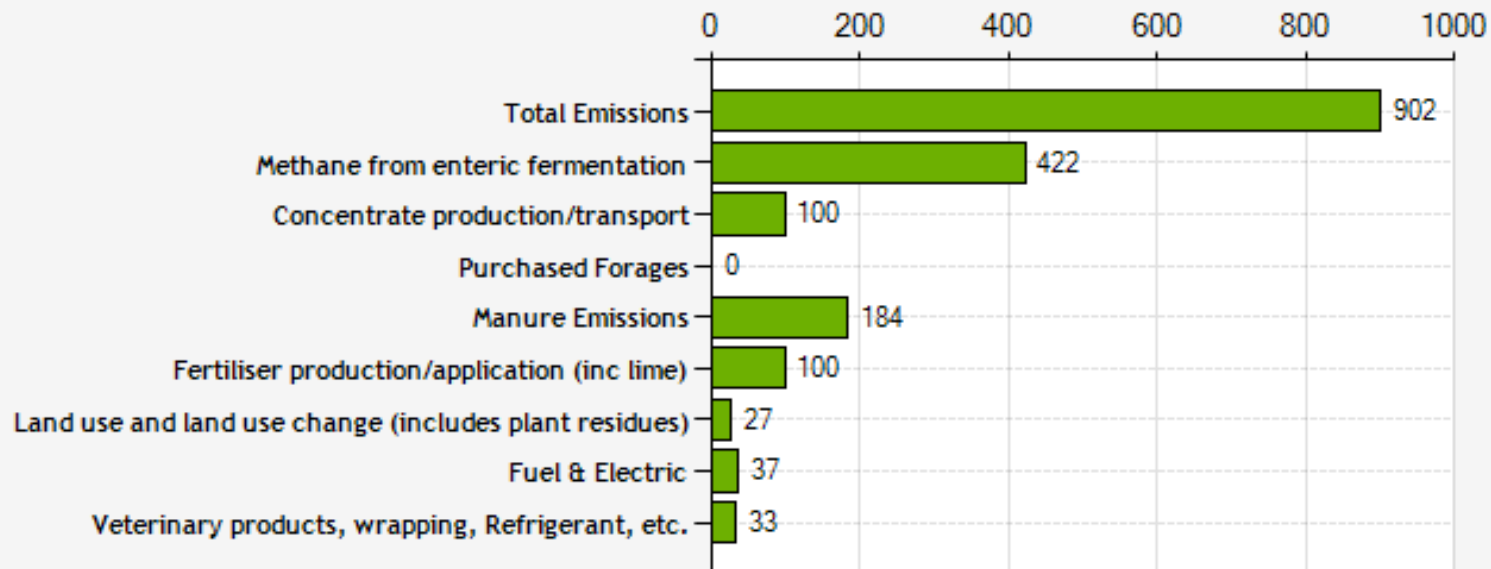
Dairy Cattle

emissions By Source (Excluding Sequestration)

Carbon Emissions per kg of Milk Produced: 902 g CO₂e per kg of milk

Carbon Emissions per kg of Meat Produced: 14.17 kg CO₂e per kg of meat (14.82% of total CO₂e emissions)

Grams of Carbon Equivalent (CO₂e Per kg of Milk Produced)



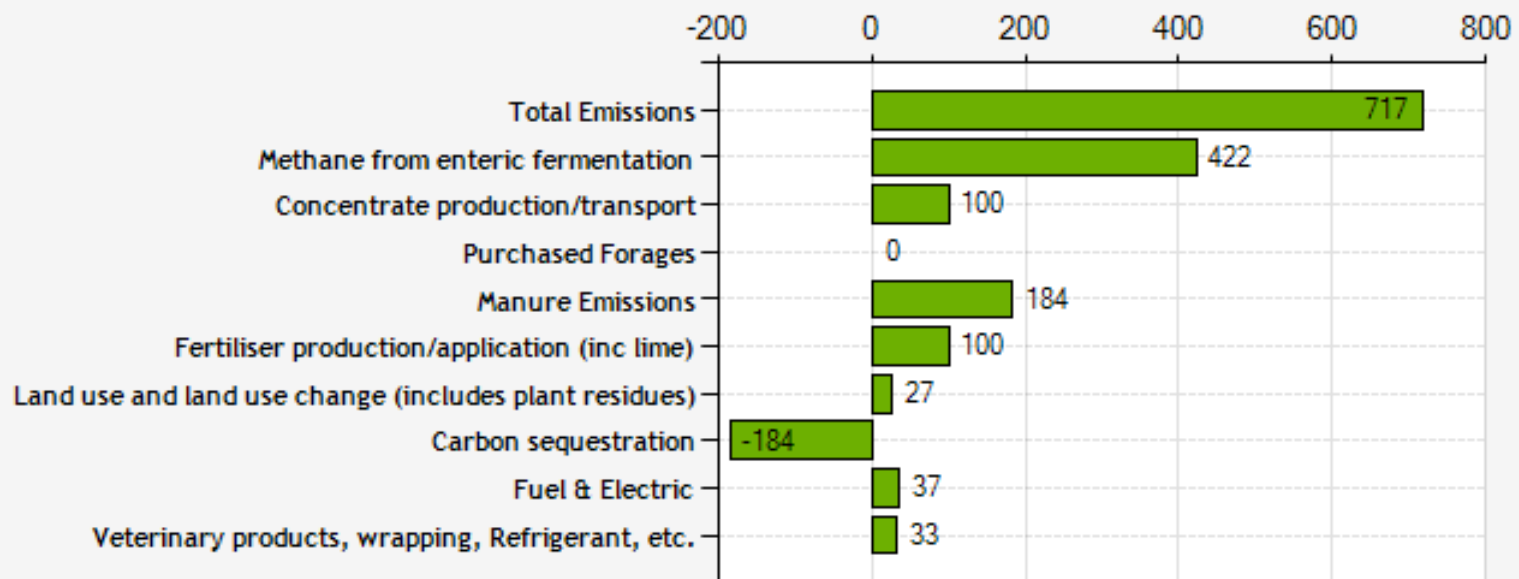
Resultant footprint - with sequestration?

emissions By Source (Including Sequestration)

Carbon Emissions per kg of Milk Produced: 717 g CO₂e per kg of milk

Carbon Emissions per kg of Meat Produced: 11.27 kg CO₂e per kg of meat (14.82% of total CO₂e emissions)

Grams of Carbon Equivalent (CO₂e Per kg of Milk Produced)



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 ₂ e Emissions (exc Seq)	CO ₂ e 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

