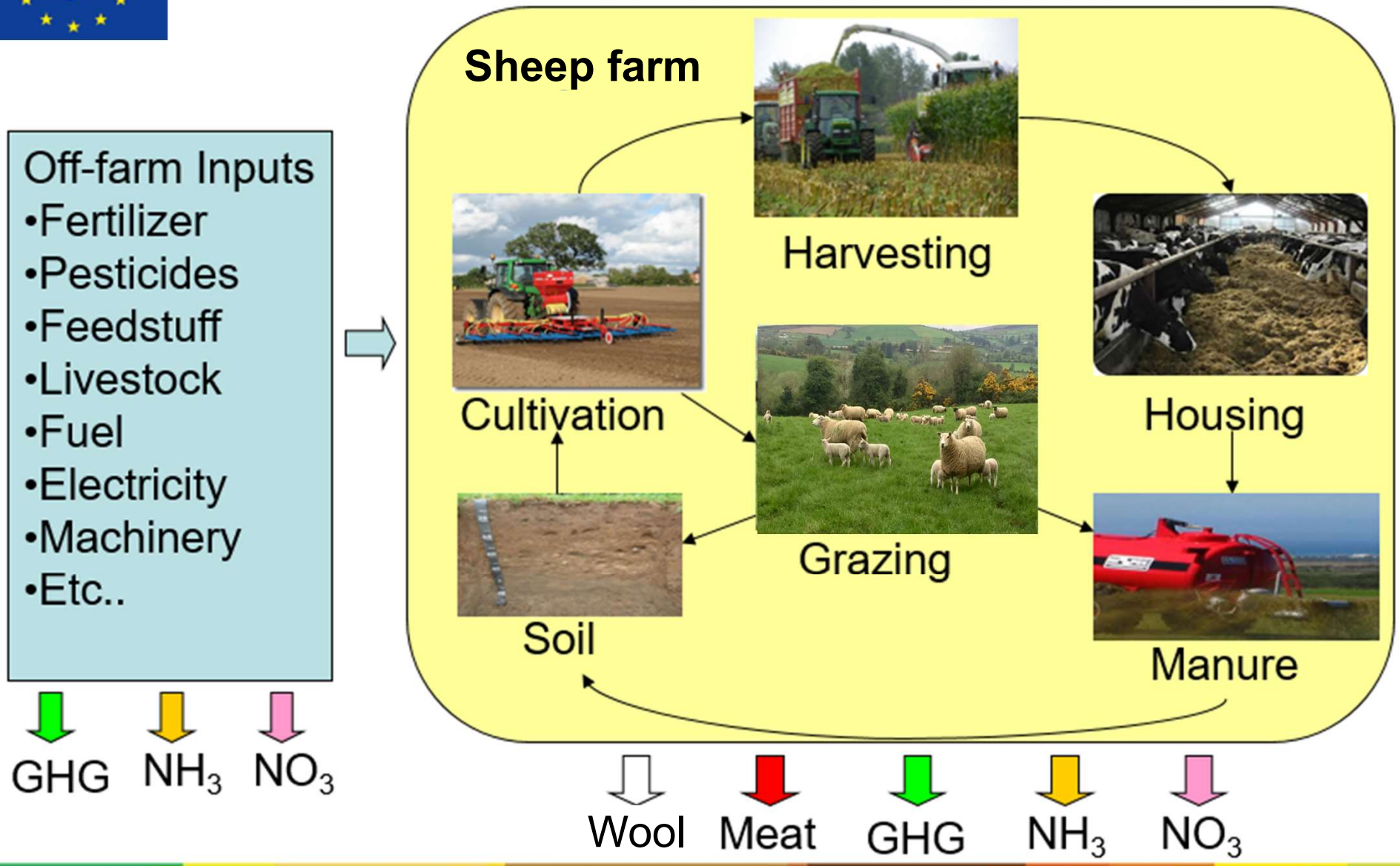
Teagasc sheep life cycle assessment (LCA) model

Teagasc
Agriculture and Food Development Authority

The Irish Agriculture and Food Development Authority

Teagasc Sheep LCA – How it works



Life cycle inventory

Model operates:

- Over one production year
- Monthly time step

5 animal categories

- Mature ewe
- Hogget
- Lambs
- Replacement lambs
- Rams

Life cycle inventory

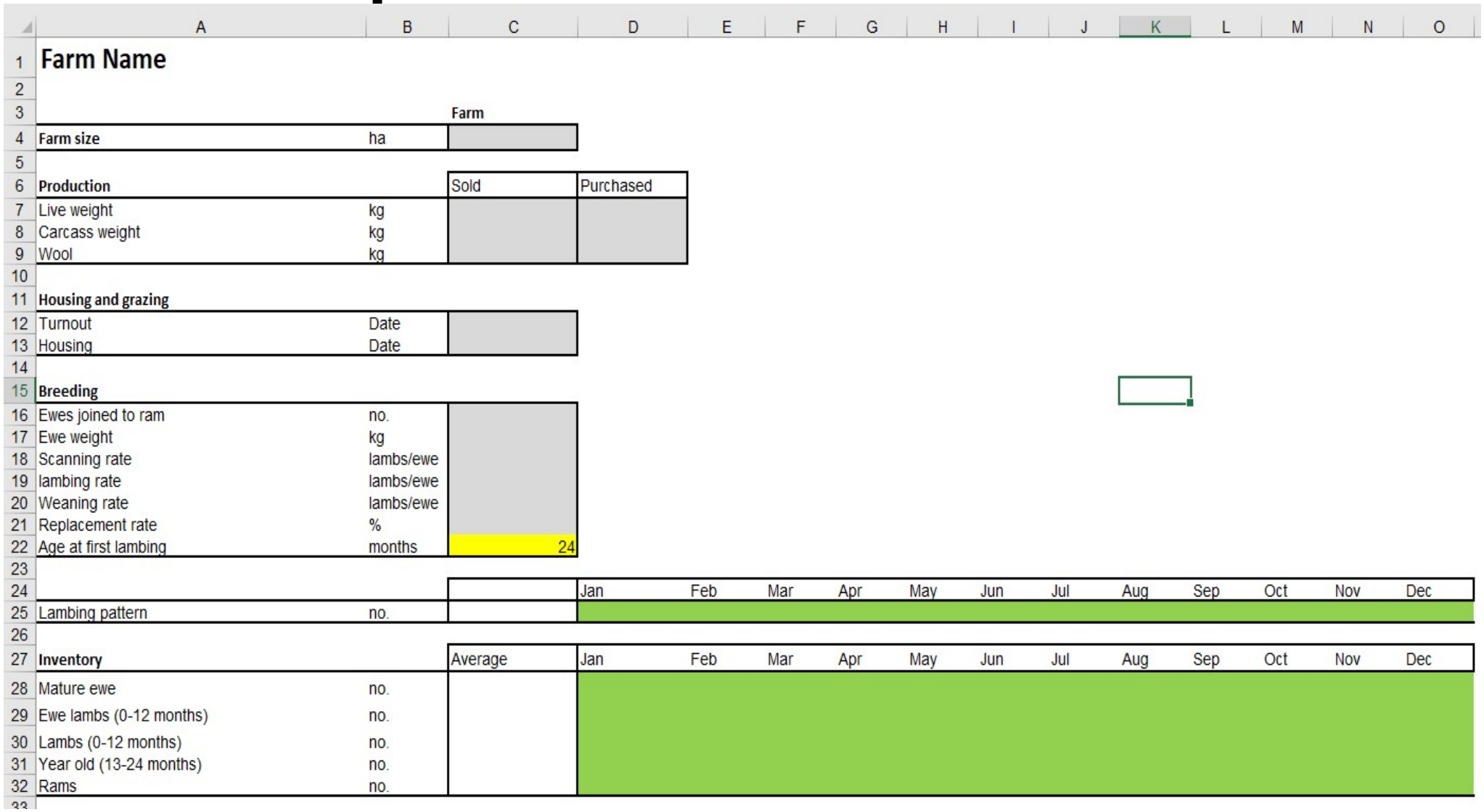
Sheep specific emissions

- Driven by sheep system inputs
- Concentrate feed
- Synthetic fertiliser use

General farm emission sources:

- Agricultural lime
- Fossil fuel use
- Energy consumption
- Chemicals

Model Input Interface – Part 1

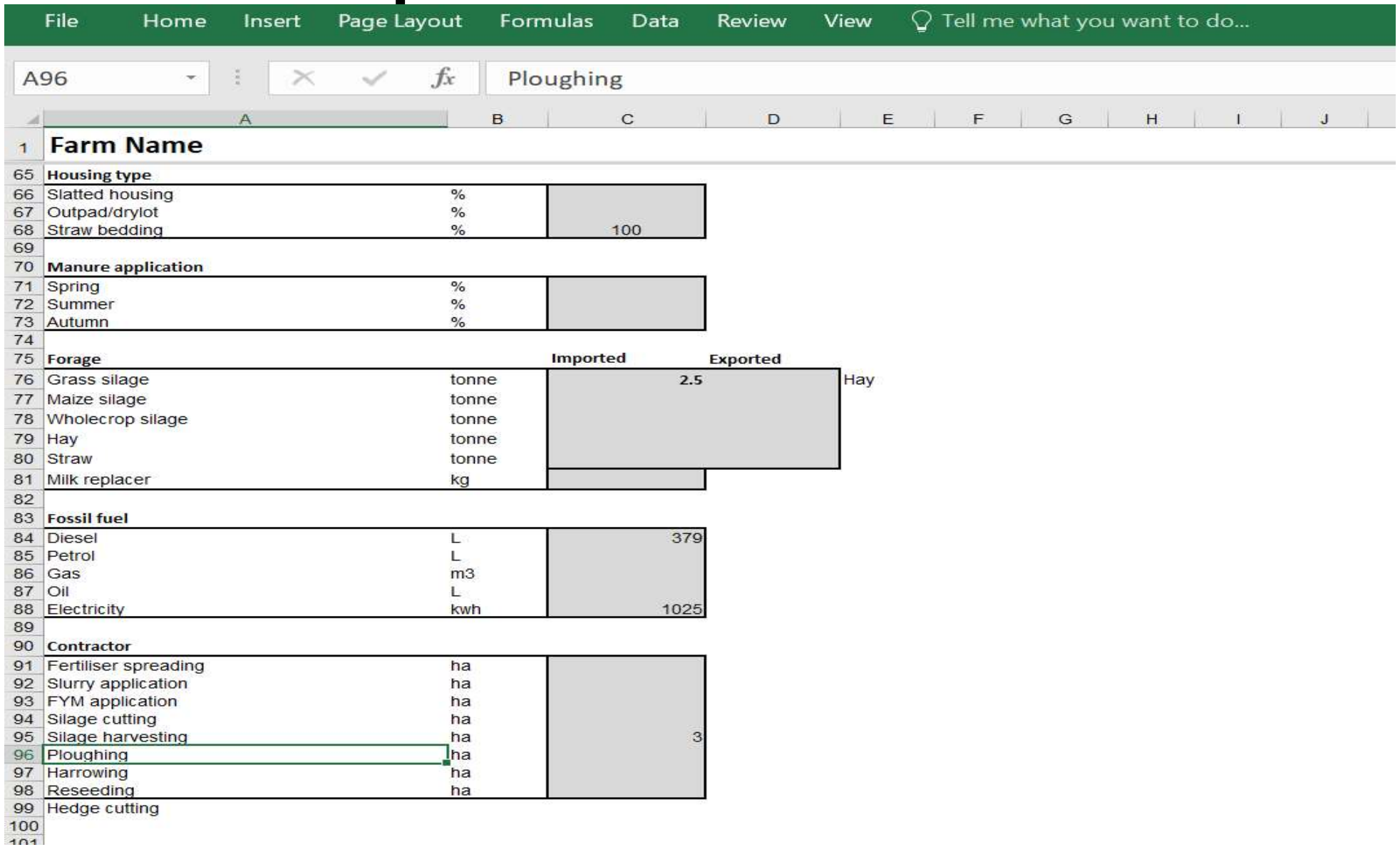


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	**Farm Name**														
2															
3			Farm												
4	**Farm size**	ha													
5															
6	**Production**		Sold	Purchased											
7	Live weight	kg													
8	Carcass weight	kg													
9	Wool	kg													
10															
11	**Housing and grazing**														
12	Turnout	Date													
13	Housing	Date													
14															
15	**Breeding**														
16	Ewes joined to ram	no.													
17	Ewe weight	kg													
18	Scanning rate	lambs/ewe													
19	lambing rate	lambs/ewe													
20	Weaning rate	lambs/ewe													
21	Replacement rate	%													
22	Age at first lambing	months	24												
23															
24				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
25	Lambing pattern	no.													
26															
27	**Inventory**		Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
28	Mature ewe	no.													
29	Ewe lambs (0-12 months)	no.													
30	Lambs (0-12 months)	no.													
31	Year old (13-24 months)	no.													
32	Rams	no.													

Model Input Interface – Part 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	**Farm Name**														
33															
34	**Purchase**		Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
35	Mature ewe	no.		0	0	0	0	0	0	0	0	0	0	0	0
36	Lambs (0-12 months)	no.		0	0	0	0	0	0	0	0	0	0	0	0
37	Year old (13-24 months)	no.	9	0	0	0	0	0	0	0	0	10	0	0	0
38	Rams	no.	1	0	0	0	0	0	0	0	0	1	0	0	0
39															
40	**Sales**		Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
41	Mature ewe	no.	9	0	0	0	0	0	10	0	0	0	0	0	0
42	Lambs (0-12 months)	no.	140	0	0	0	0	0	0	140	0	0	0	0	0
43	Year old (13-24 months)	no.		0	0	0	0	0	0	0	0	0	0	0	0
44	Rams	no.	1	0	0	0	0	0	0	0	0	1	0	0	0
45															
46	**Fertiliser**														
47	Nitrogen	kg N/ha	79.9												
48	CAN	% N	80												
49	Urea	% N	20												
50	Protected urea	% N	0												
51	Phosphorus	kg P/ha	12.1												
52	Potassium	kg K/ha	24.1												
53	Lime	tonnes/ha	0												
54															
55	**Concentrate feed**														
56	Ewe concentrate	kg	7200												
57	Lamb concentrate	kg													
58															
59	**Feeding rate**		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
60	ewe	kg/day													
61	lamb	kg/day													
62	Hogget	kg/day													
63	Ram	kg/day													
64															

Model Input Interface – Part 3



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A96 | Ploughing

	A	B	C	D	E
1	**Farm Name**				
65	**Housing type**				
66	Slatted housing	%			
67	Outpad/drylot	%			
68	Straw bedding	%	100		
69					
70	**Manure application**				
71	Spring	%			
72	Summer	%			
73	Autumn	%			
74					
75	**Forage**		**Imported**	**Exported**	
76	Grass silage	tonne	2.5		Hay
77	Maize silage	tonne			
78	Wholecrop silage	tonne			
79	Hay	tonne			
80	Straw	tonne			
81	Milk replacer	kg			
82					
83	**Fossil fuel**				
84	Diesel	L	379		
85	Petrol	L			
86	Gas	m3			
87	Oil	L			
88	Electricity	kwh	1025		
89					
90	**Contractor**				
91	Fertiliser spreading	ha			
92	Slurry application	ha			
93	FYM application	ha			
94	Silage cutting	ha			
95	Silage harvesting	ha	3		
96	Ploughing	ha			
97	Harrowing	ha			
98	Reseeding	ha			
99	Hedge cutting				
100					

Teagasc LCA Process

Animal emissions are

Driven by feed intake

Computation of monthly net energy requirement for:

Ewe and hogget

Maintenance	(UFL/d) = $(0.033 \times LW^{0.75}) \times AA$
BCS gain	(UFL/d) = LW×0.13×5.6×BCS gain
BCS loss	(UFL/d) = LW×0.13×4.36×BCS gain
Milk production	(UFL/d) = MY×((0.0071×PC)+ (0.0043×FC)+0.2224)

Where MY=milk yield (kg/d); PC=protein content (%); FC=fat content (%); LW=live weight (kg); and AA=activity allowance

Lamb

Maintenance	(UFL/d) = 0.033*(LW^0.75)
Live weight gain	(UFL/d) = 3.42*LWG

Where LW=live weight (kg); and LWG= liveweight gain (kg/day)

Life cycle inventory

Direct methane emissions			
Enteric fermentation	GEI%	7	IPCC (2019)
Enteric fermentation	GEI%	6.7	IPCC (2019)
Enteric fermentation	GEI%	6.3	IPCC (2019)
Manure excreted at pasture	kg CH4/kg VS	Bo 0.19; MCF 0.47%	IPCC (2019)
Solid manure housing	kg CH4/kg VS	Bo 0.19; MCF 2%	IPCC (2019)
Direct nitrous oxide emissions			
Solid manure storage	kg N2O-N/kg N	0.01	IPCC (2019)
Dung at pasture	kg N2O-N/kg N	0.0004	IPCC (2019)
Urine at pasture	kg N2O-N/kg N	0.004	IPCC (2019)
CAN fertiliser application	kg N2O-N/kg N	0.0149	Harty et al (2016)
Urea fertiliser application	kg N2O-N/kg N	0.0025	Harty et al (2016)
Direct carbon dioxide emissions			
Diesel use	kg CO2 / L	2.91	EPA (2019)
Indirect nitrous oxide emissions			
Housing ammonia emissions solid manure system	kg NH3-N/ kg TAN	0.168	EPA (2019)
Solid manure storage	kg NH3-N/ kg TAN	0.35	EPA (2019)
Solid manure spreading	kg NH3-N/ kg TAN	0.68	EPA (2019)
Grazing	kg NH3-N/ kg TAN	0.06	EPA (2019)
CAN fertiliser application	kg NH3-N/ kg N	0.08	EPA (2019)
Urea fertiliser application	kg NH3-N/ kg N	0.159	EPA (2019)
Nitrate leaching	kg NO3-N/ kg N	0.1	EPA (2019)

Life cycle impact assessment - GWP

- Environmental impact of animal production can be measured as global warming potential (GWP), acidification potential, eutrophication potential, photochemical ozone creation potential, ozone depletion potential and energy use and land use.
- Global warming potential shows how much heat trapped in the atmosphere and it is usually reported as carbon dioxide (CO_2) equivalents (CO_2-e).
- It measures accumulative warming over 100 years period of time which resulted from a unit of the gas mass produced at the beginning of a 100 years reference period.
- Greenhouse gas emissions are calculated for biogenic greenhouse gases: CO_2, methane (CH_4) and nitrous oxide (N_2O).

Life cycle impact assessment - GWP

- The GWP of CO_2 is 1, where CH_4 has GWP of 28, while GWP of NO_2 is 265 (IPCC, 2014).

- That means that, each kg of emitted CH_4 absorbs the same quantity of heat as would 28 kg of emitted CO_2, while one kg of N_2O absorb the same amount of heat as would 265 kg of CO_2 over a 100 years period of time.

- Greenhouse gases directly affect overall global temperature and causing climate change. It is predicted that after complete termination of net emissions of CO_2 the effect of global warming will last hundreds if not thousand years, unless a large quantity of net CO_2 is removed over an extended period of time.

Model Outputs - Example

	CO2	CH4	N2O
Enteric fermentation	0	42705.74	0
Manure housing and storage	0	275.0653	1872.245
Manure spreading	0	0	1502.24
Grazing	0	202.4159	1974.361
Fertiliser application	814.104	0	6074.719
Ammonia emissions	0	0	1077.994
Nitrate leaching	0	0	1427.197
Concentrate feed	2123.41	45.70376	632.2698
Fertiliser production	3500.921	143.958	293.9123
Fossil fuel	1764.664	29.2345	97.10418
Purchased animals	1107.415	2730.388	1226.208
Purchased forage/bedding	328.5133	62.37497	360.69
Other	459.5506	9.484869	4.512007
Total	10098.58	46204.37	16543.45
Contribution (%)	0.138628	0.634271	0.2271