Life Cycle Assessment for greenhouse gas footprinting: clover-fixed-N *vs.* fertiliser-N

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Te Ahuwhenua, Te Kai me te Whai Ora. Tuatahi

Outline of talk

1. What is Life Cycle Assessment (LCA)?
2. Importance of including whole life cycle
3. Clover fixed N *versus* fertiliser N
   - ♣ energy use
   - ♣ nitrogen leaching
   - ♣ nitrous oxide
   - ♣ LCA & GHGs – farmlet study

1. What is Life Cycle Assessment?

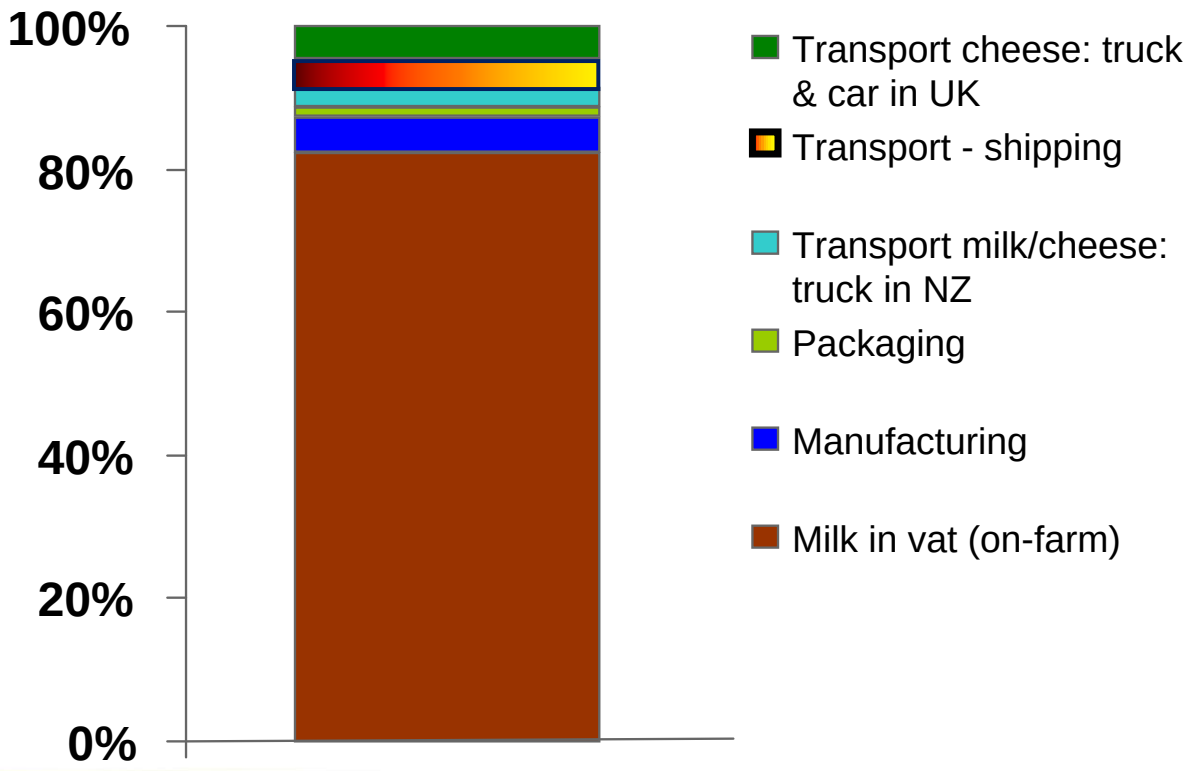
Total resource use or environmental emissions (e.g. GHG) of a product or system from "cradle-to-grave"

(uses ISO 14040s norms; PAS 2050)

Contributors to the NZ dairy GHG footprint

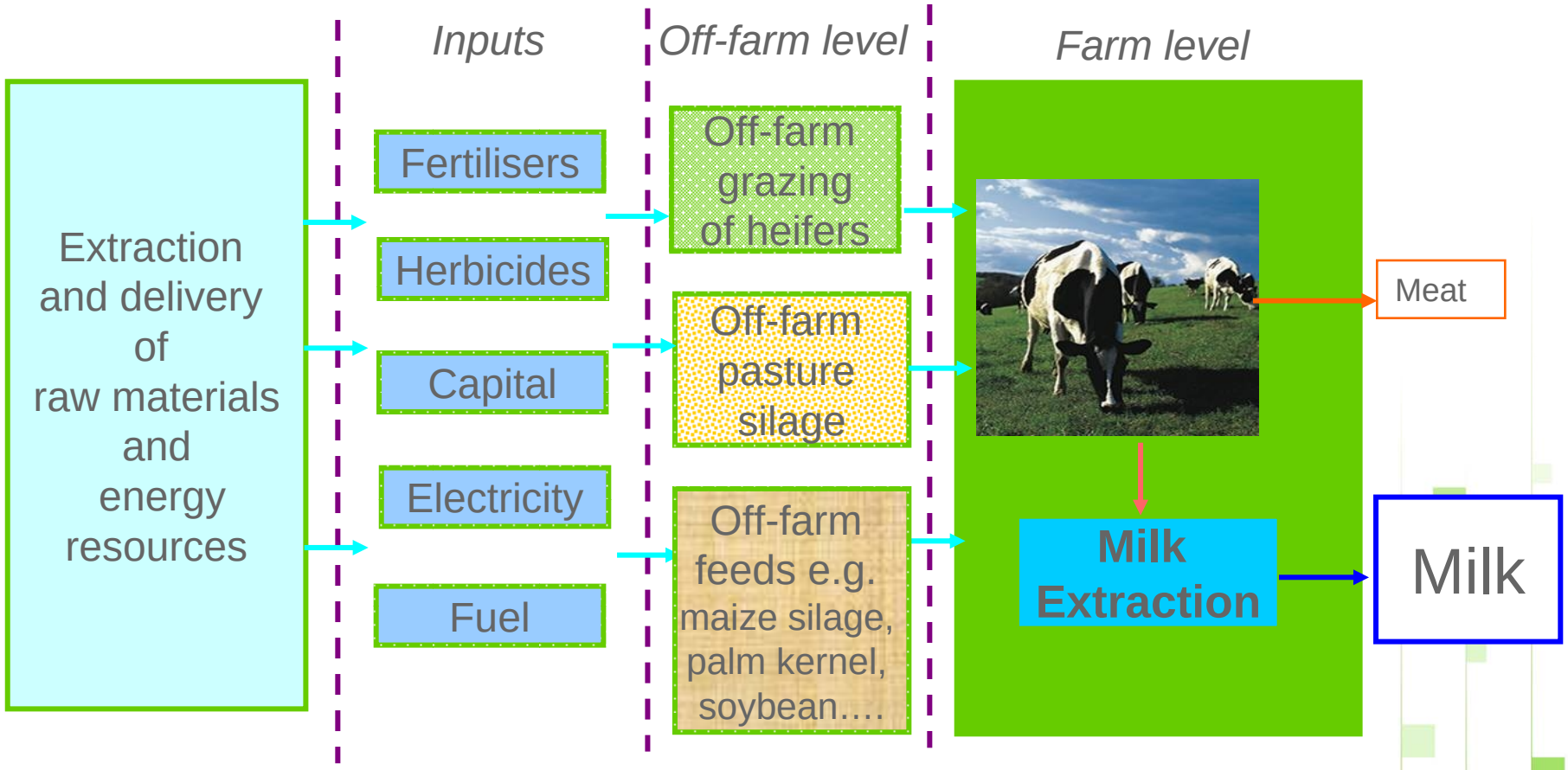
Preliminary "Cradle-to-plate" life cycle of NZ cheese to the UK: GHG emissions

Ledgard et al. (2005)



Life Cycle Assessment (LCA) methodology

("cradle-to-farm-gate" stage)

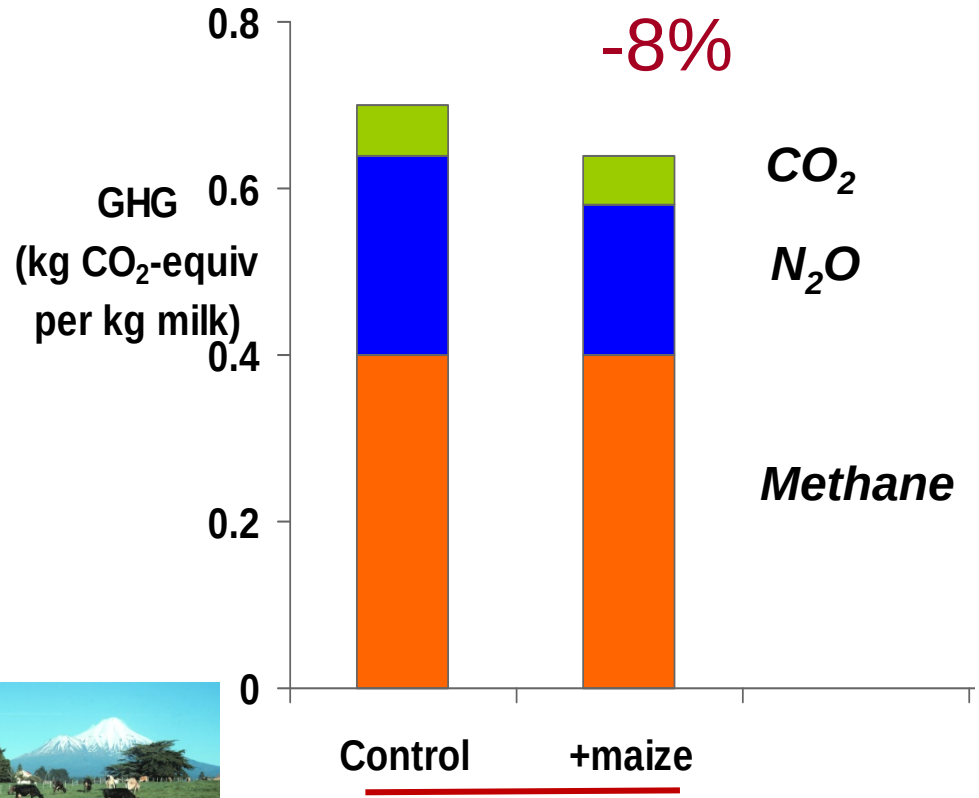


2. Importance of including whole life cycle

DairyNZ RED trial:

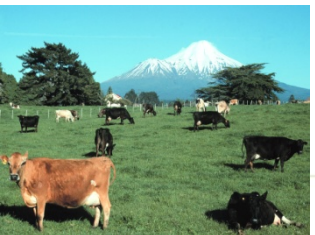
Control	**3.0 cows/ha**	**1150 kg milksolids/ha**
+maize (+5 t DM/ha)	**3.8 cows/ha**	**1490 kg milksolids/ha**

Effect of maize silage use on GHG emissions from dairy farm systems (to farm-gate stage)



On-farm

Effect of maize silage use on GHG emissions from dairy farm systems (to farm-gate stage)



3. Clover *versus* N fertiliser

i. Energy requirements & GHG

ii. N leaching risk

iii. N_2O emissions

iv. LCA – farmlet study

i. Energy requirements & GHG

Clover:

- energy from photosynthesis used to fix atmospheric N_2 (~ 6 g C / g N fixed)
- "greenhouse gas neutral" N source

Fertiliser N:

- ammonia production has high energy requirement (~ 60 MJ / kg N)
- total GHG emissions (production, cartage and use) ~ 3.5-4.0 kg CO_2-equiv/kg N

ii. Measured N leaching from clover/grass *versus* N-fertilised grass pastures

		White clover/ ryegrass	Ryegrass +150-200N
		kg N/ha/year	
Sheep	(Cuttle et al. 1992; Wales)	15	11
Dairy cows	(Sprosen et al. 1997; NZ)	25	27
Dairy cows	(Shils et al. 2000; Netherlands)	22	20

iii. Nitrous oxide emissions from clover/grass *versus* N-fertilised grass pastures

- At the same excreta N inputs, N_2O emissions are expected to be similar for clover or N-fertilised pastures
- Direct N_2O emissions:

	IPCC (2006)	Corre & Kasper (2002)
clover-N	= nil	~ 0.2%[1]
fertiliser-N	= 1%	~ 1.3%[1]

[1]high uncertainty

- Therefore, total N_2O emissions are higher from N-fertilised grass systems than clover-based systems

iv. LCA : Farmlets of 0 and 207 kg fertiliser-N/ha/yr

Data is an average of 5 years measurements

	0N	207N
Cows ha^{-1}	3.3	3.3
Milk production (kg/ha/yr)	13210	15460
Fertiliser N (kg N/ha/yr)	0	207
N_2 fixation (kg N/ha/yr)	160	100
N leaching (kg N/ha/yr)	30	63

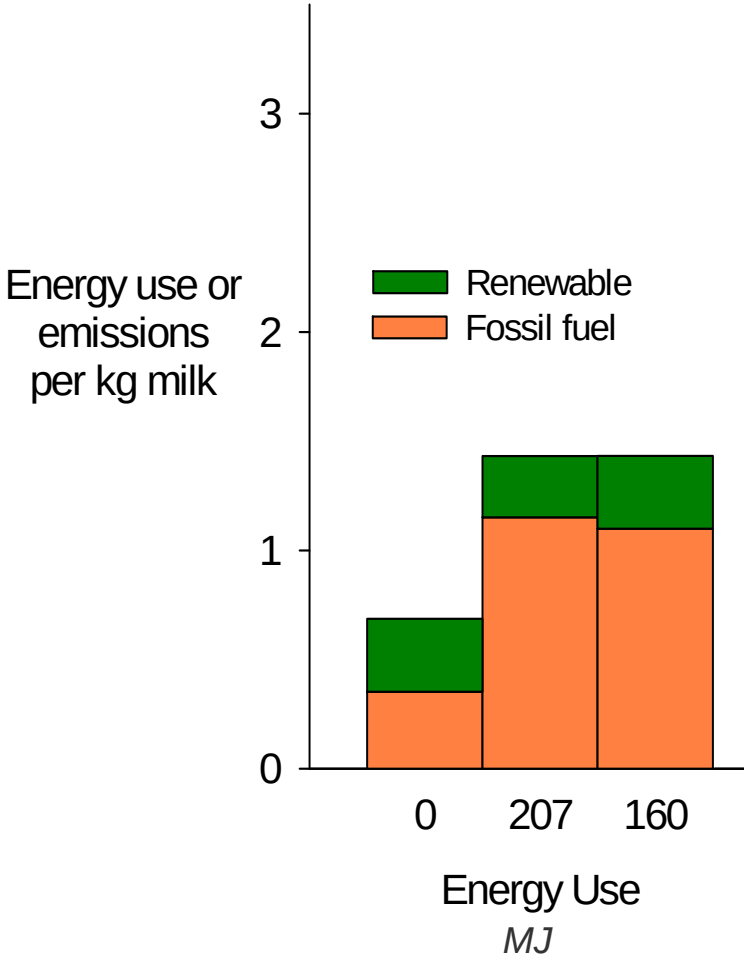
iv. LCA : Farmlets of 0 and 207 kg fertiliser-N/ha/yr and a hypothetical grass-only N system

Data is an average of 5 years measurements

	0N	207N	160N grass-only
Cows ha^{-1}	3.3	3.3	3.3[1]
Milk production (kg/ha/yr)	13210	15460	13210[1]
Fertiliser N (kg N/ha/yr)	0	207	160
N_2 fixation (kg N/ha/yr)	160	100	0
N leaching (kg N/ha/yr)	30	63	30[1]

[1]*assumed to be the same as for the 0 N farmlet*

iv. LCA: Farmlets of 0 and 207 kg fertiliser-N/ha/yr, and a hypothetical grass-only N system



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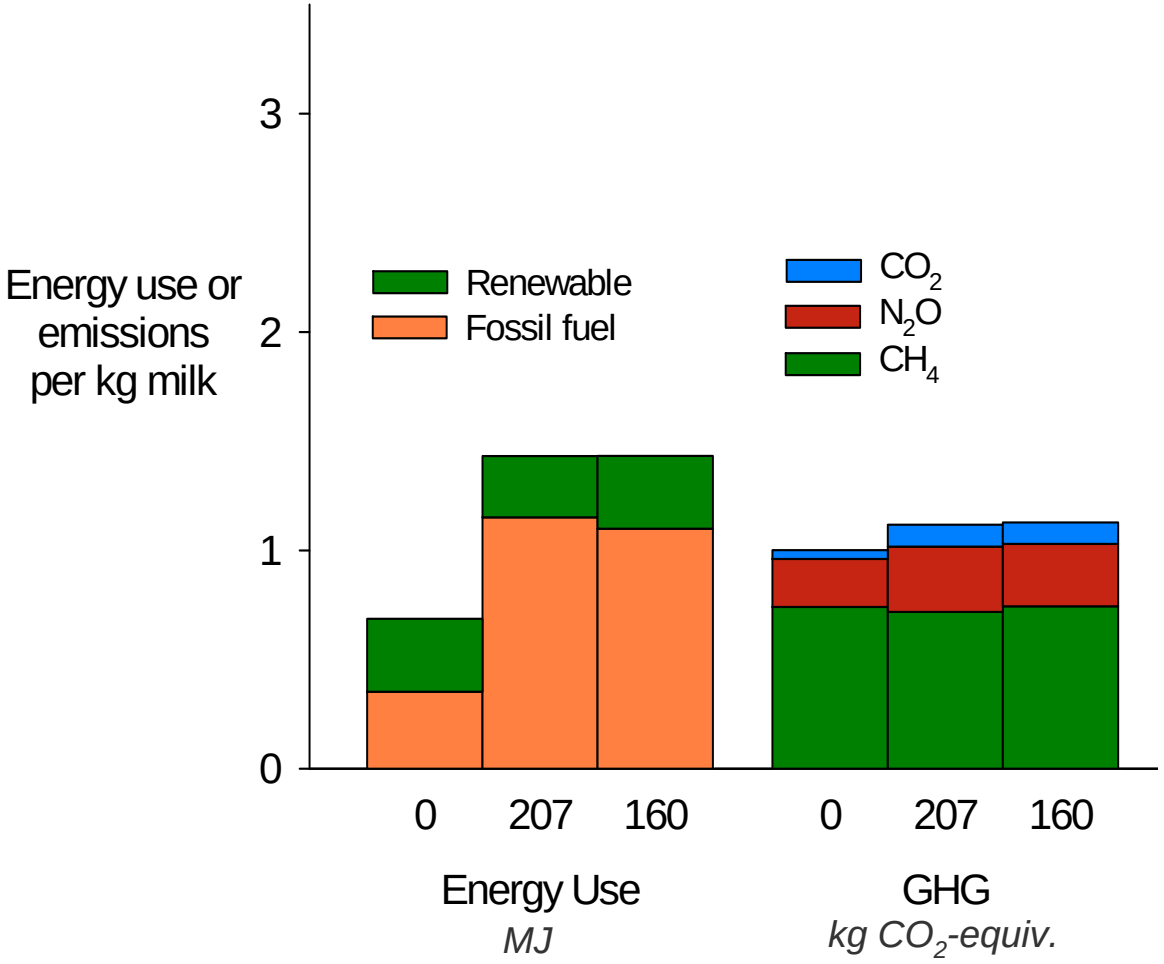


Summary

- Life Cycle Assessment (LCA) includes all contributors to GHG emissions

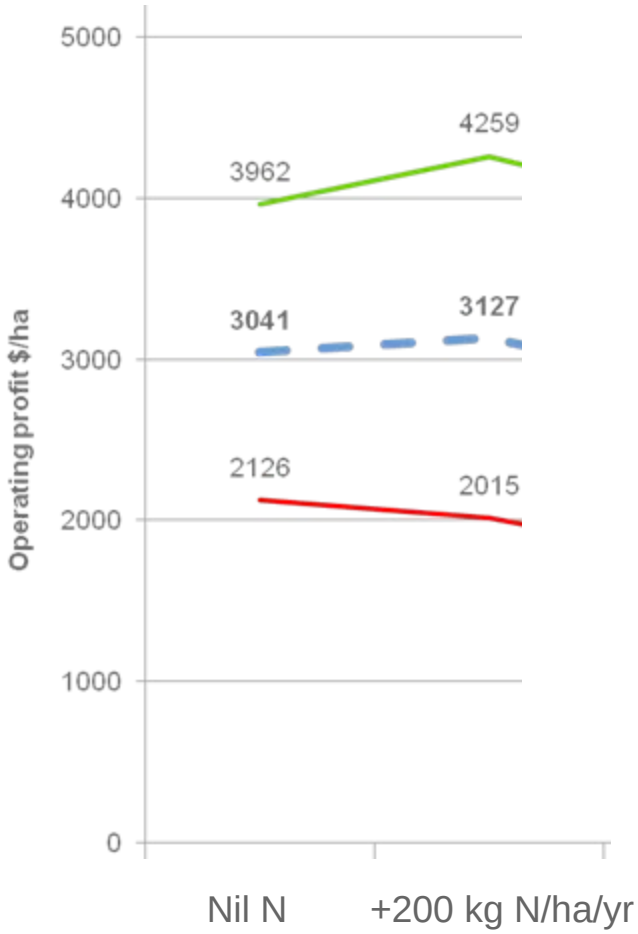
- LCA should be used to fully evaluate a system or mitigation technology to account for total GHG emissions

- Clover fixed N *versus* fertiliser N

  - ***Energy use***: clover much more efficient (especially for fossil fuel use)

  - ***GHG***: clover was 12-15% more efficient

Operating Profit $ per ha: Red Trial 2002-2006
Assumptions: N applied $1.60/kgN



$6.50/kg milksolids

$5.50/kg milksolids

$4.50/kg milksolids