“Waste” grass co-substrate for dairy farm digesters: concept and greenhouse gas and energy balances

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agresearch Farming, Food and Health. First

Te Ahuwhenua, Te Kai me te Whai Ora. Tuatahi

-Five years ago: using grasses to produce biofuels: climate change mitigation

- 2013: small rural energy supply niche e.g. East Coast; Chatham Islands as model community: proposals to FRST, SFF – failed – “not nationally important”

- exploring the concept of using grass feedstocks to make anaerobic digestion for effluent treatment viable for “average” diary farm

- fits in well with Agresearch’s strengths of forage and farm system research

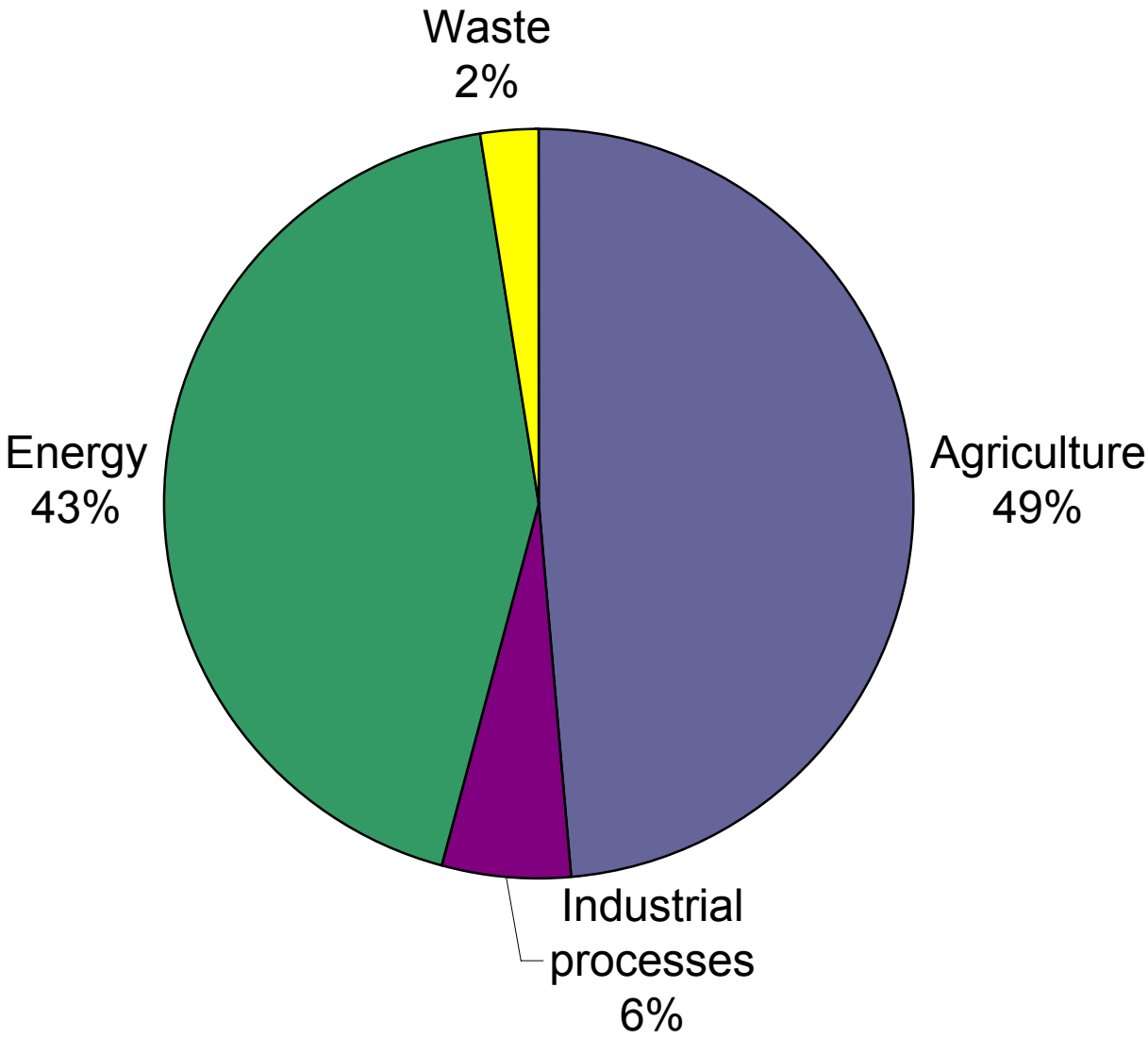
Presentation outline:

-Dairying and GHG emissions

-Concept of using “waste forage”

-Energy and GHG balance

Sources of GHG emissions:



from New Zealand Greenhouse Gas Inventory 1990 – 2005

- dairying in N.Z.: 20% of exports by value and 10% of GDP

- **however……..**

	%
Dairy	36
Beef	22
Sheep	38
Other	4

Total 37,445 kt CO_2e

dairy farms are also the source of other emissions, most importantly
ed pads: anaerobic lagoon system

- anaerobic digestion for biogas and electricity production to deal with dairy effluent, farm energy supply and GHG and other emissions

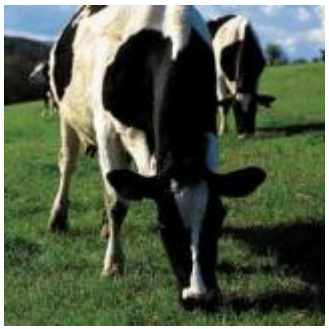
images from http://www.powerbase.com/biopower/index.html

- average 300 cow farm uses 40,000 kWh per year
- only about 10% of the manure is collected (at milking times) = 16,000 kWh
- currently not economically viable for the average N.Z. dairy farm
- solution: co-digest forage to increase biogas output ?

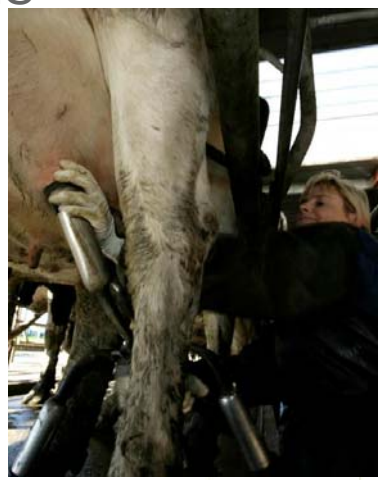
- **option 1**: grow dedicated areas of bioenergy feedstock for digestor

However:

conversion efficiency of N.Z. dairy cows:



15 kg DM (grown) = 1 kg MS @ \$7.5 kg MS^{-1}



$\therefore$ 1 t DM = **\$500** in revenue from milk

in contrast:

1 t DM = 200 m^3 CH_4 = 7500 MJ

@25% conversion = 520 kWh_e

worth ≈ **\$80** @\$0.15 kWh^{-1}

Option 2: topping pastures

- especially in spring/summer pasture supply outstrips cow demand: lax grazing
- grazing at 2800 kg DM ha^{-1} – down to 1800 kg DM ha^{-1} – should be 1600 kg DM ha^{-1}

"Harder" grazing = more leaf, less stem, higher legume content, less weeds = better pasture quality

- topping: useful management tool to ~~increase pasture quality~~:

spring/summer topping has been shown to increase MS production 14%

-usually toppings left in paddock

pick up the toppings and supplement the digestor, increase biogas output to enable economic viability

Topper-picker-upper™

Super-duper-pooper-scooper-topper-picker-upper

Does it make sense???

-Energetics

-GHG

-management

Energy Balance

- 300 cow, 100 hectare farm; topping 4 x yr^{-1} from 1800 to 1600 kg DM ha^{-1}

Effluent:

- 0.4 kg manure volatile solids (VS) cow^{-1} day^{-1}; 250 day milking period; digested @0.22 m^3 CH_4 kg VS^{-1}, @25% conversion = **60 GJ electricity**

Toppings:

- 80 tonnes DM = 1400 GJ gross energy

- @ 200 m^3 CH_4 t DM^{-1} = 600 GJ CH_4 @25% conversion = **150 GJ electricity**

Energy Out = 210 GJ electricity

(plus 336 GJ process heat)

Energy In

-diesel use: topping 200 kg DM ha^{-1}

@ 2 ha hr^{-1}; 50 kW tractor @ 75% power

= 6 litres/ha

4 x yr^{-1} x 100 ha

= 2400 litres diesel yr^{-1} = **90 GJ**

Simplified energy ratio:

210:90 = **2.3:1**(electricity only)

or

546:90 ≈ **6:1** (electricity+heat)

- if topping increases pasture energy value by 0.6 MJ ME kg DM^{-1} then for the 3 month spring-summer period 7 t DM x 100 ha = extra **420 GJ** pasture energy would be grown

Simplified GHG Balance

- replacement of anaerobic lagoon: **0.60 t CO_{2e} ha^{-1}**

- grid electricity offset 66 MWh x 0.2: **0.14 t CO_{2e} ha^{-1}**

Total offset/avoided GHG = 0.74 t CO_{2e} ha^{-1}

- emissions from diesel for topping = **0.06 t CO_{2e} ha^{-1}**

Net GHG savings: 0.68 t CO_{2e} ha^{-1}

-cf. enteric CH_4 = 4 t CO_{2e} ha^{-1}

The bigger picture: GHG at the national level

- 2.1 million ha of dairy farms replace anaerobic lagoons (or same)

- @savings of **0.68 t CO_{2e} ha^{-1} = 1.4 million t CO_{2e}**

- N.Z Kyoto Protocol obligations = reduction of 15 million tonnes CO_{2e}

- increases from agriculture 1990 - 2005 = 5 million tonnes CO_{2e}

The bigger picture: Energy at the national level

- 2.1 million ha of dairy farms
- @generation of **0.66 MWh ha^{-1}** ≈ **1400 GWh**

electricity used to harvest milk: **600 GWh**

net electricity purchased by Fonterra: **560 GWh**

Total **1160 GWh**

Conclusion

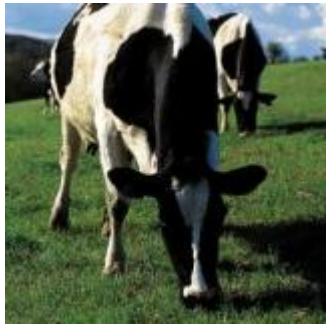
potentially a sensible method

a) to reduce GHG emissions associated with dairy farming

b) in a way that is profitable for the farmers

c) while at the same time dealing with effluent disposal and on-farm and national energy issues

Lieffering M., Newton P.C.D. and Thiele J., 2008 Greenhouse gas and energy balance of dairy farms using unutilised pasture co-digested with effluent for biogas production. **Australian Journal of Experimental Agriculture 48: 104 -108**



Thank you

- grid electricity GHG offset: 66 MWh x electricity gen. emission factor

which emission factor to use?

- current: 0.21 t CO_{2e} MWh^{-1}
- marginal: anticipated future generation mix

  new generation based on
  - a) fossil fuels: 0.625 t CO_{2e} MWh^{-1}
  - b) renewable: 0 – 0.085 t CO_{2e} MWh^{-1}

But is there more????

- topping increases pasture quality:

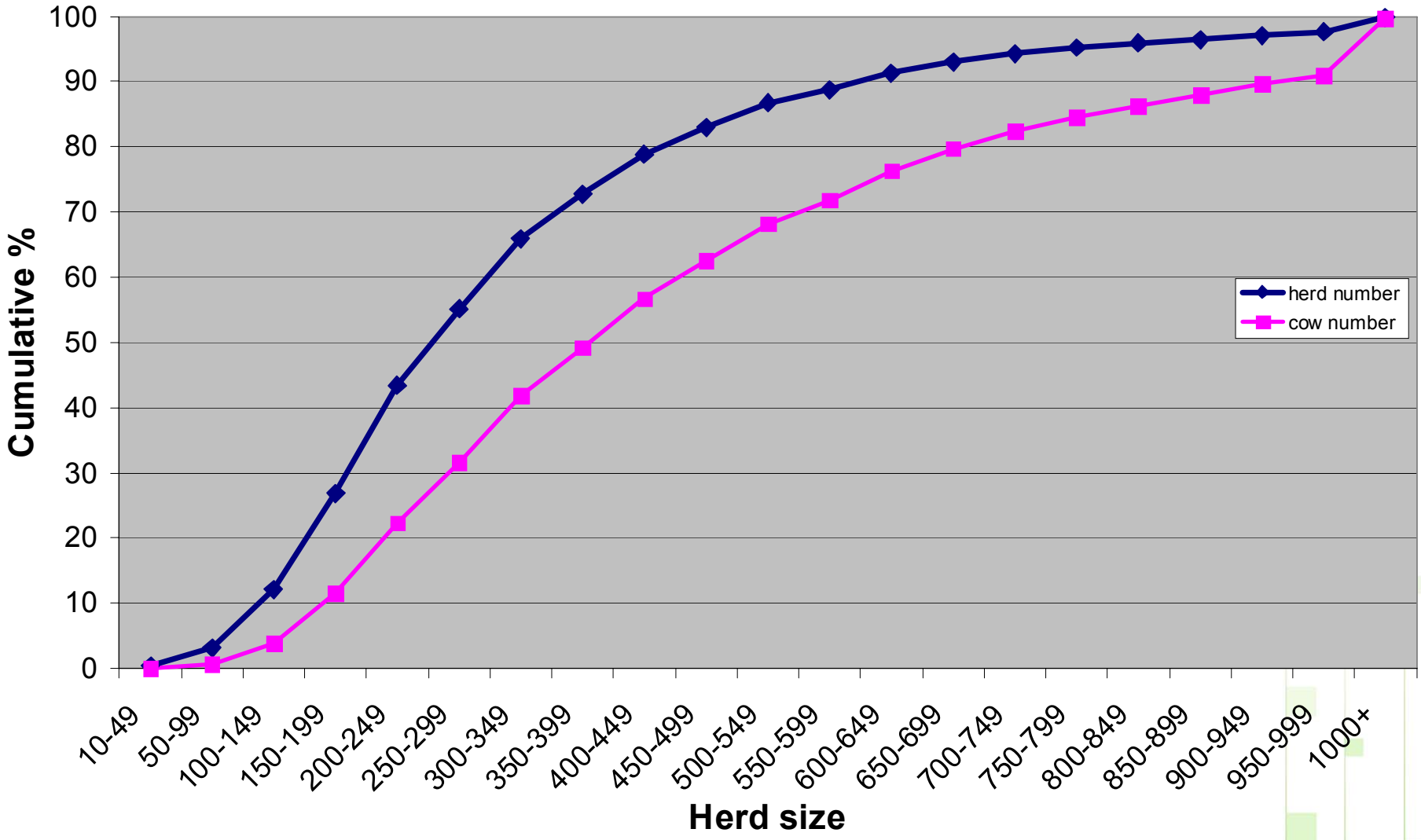
+ 0.6 MJ ME kg DM^{-1}

= decrease of 2% NDF

= decrease of 2.4 g CH_4 kg $milk^{-1}$

but change in pasture quality will also increase milk yield so

- for a 100 ha farm topping over spring summer = decrease **0.15 t CO_{2e} ha^{-1}**


Cumulative %
100
90
80
70
60
50
40
30
20
10
0
herd number
cow number
10-49
50-99
100-149
150-199
200-249
250-299
300-349
350-399
400-449
450-499
500-549
550-599
600-649
650-699
700-749
750-799
800-849
850-899
900-949
950-999
1000+
Herd size