

Development of Tiers 2 and 3 methane emission factors for enteric fermentation and manure management of cattle and sheep using Hillsborough herd data and calorimetric methane measurements

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Introduction The Intergovernmental Panel on Climate Change (IPCC, 2006) recommends three methods (Tier 1, 2 and 3) to estimate methane (CH₄) emissions from enteric fermentation and manure management for livestock in development of national CH₄ inventories. Tier 1 default emission factors (enteric and manure) provide fixed values for each species of animals in different regions of the World, irrespective of variations in animal physiological state and production level. The objectives of the present study were to develop CH₄ emission factors of Tiers 2 (enteric and manure) and 3 (enteric) using AFBI Hillsborough herd data and calorimeter CH₄ measurements and to identify sources of variations between Tier 1 and Tier 2/3 emission factors.

Materials and methods AFBI Hillsborough herd data used include average live weight, milk yield (7328 kg/year, dairy cows), growth rate (growing animals), birth rates (cows, heifers and ewe), age (growing animals) and dietary GE, ME and ash concentrations for each species. Calorimetric CH₄ and energy metabolism data included measurements undertaken at Hillsborough since 1992 with more than 900 dairy cows, 140 beef and 50 sheep. The life span for lambs was taken as 210 days. Manure was managed under the liquid/slurry system for indoor feeding animals and the pasture management system for grazing animals. Tier 2 CH₄ emission factors from enteric fermentation and manure management were developed using the methodologies proposed by IPCC (2006). Tier 3 enteric CH₄ emission factors were developed from the ratio of CH₄ energy output to ME intake, with ME intake estimated using the FiM models for dairy cows and AFRC systems for beef cattle, heifers and sheep.

Results and discussion The results are presented in Table 1. For enteric CH₄ emissions, Tiers 2 and 3 factors for dairy cows were 10.2 and 7.5 kg/year lower than Tier 1 factor, respectively. This indicates that the increase in Tier 1 default factor for Western Europe from 100 kg/year in the version of IPCC 1996 to the present 117 kg/year (IPCC, 2006) may over-estimate the effect of increased milk production during the period. For sheep, dairy heifer and beef cattle, in general, when compared with Tier 2 and 3 enteric CH₄ factors, Tier 1 enteric CH₄ factors produced a considerable over-prediction of CH₄ emissions for young animals (less than 1 year old), with exception for dairy bulls, for which Tier 1 was similar to Tier 2 (because they were managed under intensive feeding regimes). On the contrary, for animals of over 1 year age, Tier 1 enteric CH₄ factors were smaller than Tier 2/3 enteric CH₄ factors, except for dairy heifers of over 2 years for which Tier 1 was larger than Tier 2/3 (due to low growth rates). Similar results were also obtained for CH₄ emissions from manure management.

Table 1 Tier 1 versus Tiers 2 and 3 methane emission factors for enteric fermentation and manure management

Species	Age	Category	Enteric (kg/y)			As % of Tier 1		Manure (kg/y)		T2/T1 (%)
			Tier 1	Tier 2	Tier 3	Tier 2	Tier 3	Tier 1	Tier 2	
Dairy cow	Milking + dry		117	106.8	109.5	91	94	21	19.4	92
	< 1 year	Dairy steer/heifer	57	34.4	37.0	60	65	6	4.0	66
	< 1 year	Dairy bull	57	57.5	50.2	101	88	6	5.3	89
Beef cattle	< 1 year	Suckler	57	32.0	29.1	56	51	6	4.6	77
	1-2 year	Dairy steer/heifer	57	65.6	66.5	115	117	6	6.8	114
	1-2 year	Suckler	57	63.6	64.0	112	112	6	6.6	110
	> 2 year	Suckler cow	57	56.9	59.1	100	104	6	6.1	101
	< 1 year	Holstein-Friesian	57	29.7	33.3	52	59	6	3.7	61
	< 1 year	Cross breeding	57	27.3	30.2	48	53	6	3.3	55
Dairy heifer	1-2 year	Holstein-Friesian	57	64.5	69.5	113	122	6	7.2	119
	1-2 year	Cross breeding	57	57.5	61.5	101	108	6	6.3	105
	> 2 year	Holstein-Friesian	57	50.3	52.9	88	93	6	5.4	91
	> 2 year	Cross breeding	57	49.7	52.4	87	92	6	5.4	90
	< 1 year	Lamb	8	6.6	4.6	83	58	0.19	0.08	41
Sheep	> 1 year	Ewe	8	8.0	10.5	100	131	0.19	0.16	85
	Replacement		8	7.5	7.5	94	94	0.19	0.13	70

Conclusions For both enteric fermentation and manure management, in comparison with Tier 2/3 emission factors, Tier 1 default factors over-estimated CH₄ emissions for dairy cows, young cattle and sheep, while under-predicted CH₄ emissions for beef cattle, heifers and sheep at age between 1 and 2 years old. This indicates that the development of national CH₄ emission inventories from the Tier 1 method can result in considerable and systematic errors.

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Reference

IPCC. 2006. Guidelines for National Greenhouse Gas Inventories. In: www.ipccnggip.iges.or.jp/public/2006gl/index.html.