

CALCULATION OF METHANE PRODUCTION FROM ENTERIC FERMENTATION IN CATTLE EXCLUDING DAIRY COWS

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1 INTRODUCTION

The methane production in The Netherlands from 1990 to 2002 was calculated via the IPCC-GPG Tier 2 method (Smink et al., 2004). In this calculation no nutritional mechanistic approach can be used to decrease the methane production. Therefore, the calculation of the methane production from enteric fermentation in dairy cows is recently carried out with dynamic modelling (Smink et al., 2005). The model of Mills et al. (2001) including updates (Bannink et al., 2005ab) has been used which is based on the rumen model of Dijkstra et al. (1992). The input for the intake of feed in the model for dairy cows in milk and in calf is based on the intake figures of the VEM system. In order to be in line with the dairy cows, the calculation of methane production of the other cattle categories should be also be based on the VEM system.

The goal of the study is to calculate the methane production from enteric fermentation in all cattle categories excluding dairy cows, based on the VEM system.

2 MATERIAL AND METHODS

The dry matter intake of cattle is the most important factor in the calculation of methane production. The dry matter intake can be estimated from the energy requirement that is used in The Netherlands. The basic data for the calculation of the intake of roughages, wet byproducts and concentrates are collected by the Working Group on Uniform calculations of Manure and Mineral Figures [Werkgroep Uniformering berekening Mest- en Mineralcijfers; WUM] (1994). Since 1990 mineral excretion is calculated on basis of the feed intake of dairy cows. For this purpose, the intake of grass silage, maize silage, wet byproducts and concentrates is estimated from national statistics. Based on the requirement of energy (i.e. VEM or feed unit of lactation), the other part of the ration is estimated to be meadow grass. This means that the calculated intake of feed is suitable to cover the need for VEM. More information about the VEM system is presented in the report of Smink et al. (2005).

The calculation of the methane production via enteric fermentation in dairy cows is carried out with dynamic modelling. The model of Mills et al. (2001) including updates (Bannink et al., 2005ab) has been used which is based on the rumen model of Dijkstra et al. (1992). However, the model is developed for dairy cows and therefore not suitable for all cattle categories. In order to calculate the methane production via enteric fermentation in other cattle categories, the data of roughage, byproducts and concentrates of the WUM are used. The methane production per animal category is calculated via the following steps:

1. Calculation of the dry matter intake per category (based on data from WUM).

Assumptions are:

-90 % dry matter content in concentrates and milk powder

-15 % dry matter content in liquid milk for calves

2. Calculation of the methane production or methane emission factor (EMF) expressed in kg per cattle category.

The formula for calculating the EMF (in kg) is:

$EMF (kg) =$

$(GE \text{ intake (MJ)} * \text{methane conversion factor (MCF)} * 365 \text{ (days/year)}) / 55.65 \text{ MJ/kg}$

Whereby:

$GE \text{ intake} = DM \text{ intake} \times 18.45 \text{ MJ/kg DM (IPCC, 2000)}$

$MCF = 0.04 \text{ for white veal calves and } 0.06 \text{ for the other categories (IPCC, 2000)}$

The basic data needed to calculate the methane production of cattle categories, are the number of animals and the dry matter intake. The number of animals and dry matter intake are presented in Table 1 and 2, respectively.

Table 1 Number of animals per animal category, per year

Year	1990	1991	1992	1993	1994	1995	1996
Cattle for breeding							
Female young cattle < 1 yr	752,658	760,636	720,342	687,326	687,442	696,063	703,237
Male young cattle < 1 yr	53,229	59,044	53,905	49,573	47,841	44,163	57,182
Female young cattle 1 yr – calving	879,726	907,854	892,867	836,109	802,884	807,858	804,949
Male young cattle 1-2 yrs	34,635	37,628	39,297	31,957	33,034	33,118	37,203
Cows in milk and in calf	1,877,684	1,852,165	1,775,259	1,746,733	1,697,868	1,707,875	1,664,648
Bulls for service > 2 yrs	8,762	9,899	8,547	8,551	7,975	8,674	9,229
Cattle for fattening							
Meat calves, rosé veal*	28,876	39,784	51,018	62,996	77,226	85,803	100,394
Meat calves, white veal	572,709	581,834	586,713	593,214	612,290	583,516	577,196
Female young cattle < 1 yr	53,021	65,551	61,436	63,009	63,144	57,218	55,575
Male young cattle + young bullocks < 1 yr	255,375	275,383	244,178	233,479	226,539	188,193	147,553
Female young cattle 1-2 yrs and over	99,489	121,882	127,823	128,765	121,131	115,018	97,145
Male young cattle + young bullocks > 1 yr	190,330	211,036	212,514	198,417	191,875	180,515	150,622
Suckling, fattening and grazing cows > 2yrs	119,529	139,375	145,978	156,459	146,462	146,181	146,384
Total The Netherlands	4,926,023	5,062,071	4,919,877	4,796,588	4,715,711	4,654,195	4,551,317
Year	1997	1998	1999	2000	2001	2002	2003
Cattle for breeding							
Female young cattle < 1 yr	651,019	615,834	596,635	562,563	552,595	529,127	503,703
Male young cattle < 1 yr	46,785	41,830	37,653	37,440	88,001	44,692	31,213
Female young cattle 1 yr – calving	821,891	756,995	714,018	698,733	665,997	648,497	617,295
Male young cattle 1-2 yrs	31,632	27,586	25,331	26,328	26,819	31,543	19,650
Cows in milk and in calf	1,590,571	1,610,630	1,588,489	1,504,097	1,539,180	1,485,531	1,477,766
Bulls for service > 2 yrs	8,198	8,141	10,278	10,410	10,982	14,132	11,755
Cattle for fattening							
Meat calves, rosé veal*	100,948	101,267	118,397	145,828	150,950	152,033	171,501
Meat calves, white veal	603,171	609,724	634,257	636,907	556,780	561,300	560,027
Female young cattle < 1 yr	47,669	42,362	45,977	41,300	42,911	38,887	38,016
Male young cattle + young bullocks < 1 yr	137,053	115,106	97,465	83,447	76,861	62,988	59,682
Female young cattle 1-2 yrs and over	76,482	70,377	63,990	61,724	61,047	58,565	60,676
Male young cattle + young bullocks > 1 yr	150,714	137,870	120,619	98,066	94,902	80,127	63,905
Suckling, fattening and grazing cows > 2yrs	144,502	145,362	152,581	163,397	160,802	150,972	144,004
Total The Netherlands	4,410,635	4,283,084	4,205,690	4,070,40	4,027,827	3,858,394	3,759,193

*: The Agricultural Census provides the numbers of rosé veal calves from 1995. The rosé veal breeding farming started in the second half of the 80-ies. In 1995 the share of rosé veal calves was 12.8% of the total number of veal calves. It is assumed that over the period from 1987 to 1995 the share of rosé veal calves annually increased by 1.6%. Therefore, the share for 1990 was calculated to be 4.8%.

Table 2 Dry matter intake in kg per year of cattle (excluding cows in milk and in calf) according to calculations of WUM.

Year	1990	1991	1992	1993	1994	1995	1996
Cattle for breeding							
Female young cattle < 1 yr	1,561	1,561	1,561	1,593	1,590	1,606	1,569
Male young cattle < 1 yr	1,561	1,561	1,561	1,593	1,590	1,605	1,568
Female young cattle 1 yr – calving	2,812	2,812	2,812	2,863	2,843	2,874	2,798
Male young cattle 1-2 yrs	3,147	3,147	3,147	3,298	3,276	3,361	3,260
Bulls for service > 2 yrs	3,147	3,147	3,147	3,298	3,276	3,361	3,260
Cattle for fattening							
Meat calves, rosé veal	-	-	-	-	-	1,665	1,665
Meat calves, white veal	611	611	611	611	611	648	648
Female young cattle < 1 yr	1,561	1,561	1,561	1,591	1,589	1,604	1,567
Male young cattle + young bullocks < 1 yr	1,710	1,710	1,710	1,644	1,854	1,822	1,780
Female young cattle 1-2 yrs and over	2,814	2,814	2,814	2,861	2,842	2,871	2,796
Male young cattle + young bullocks > 1 yr	3,475	3,475	3,475	4,058	3,340	3,399	3,202
Suckling, fattening and grazing cows > 2yrs	3,344	3,344	3,344	3,384	3,353	3,384	3,297
Year	1997	1998	1999	2000	2001	2002	2003
Cattle for breeding							
Female young cattle < 1 yr	1,583	1,552	1,532	1,505	1,510	1,500	1,539
Male young cattle < 1 yr	1,582	1,550	1,841	1,810	1,819	1,823	1,842
Female young cattle 1 yr – calving	2,842	2,691	2,702	2,659	2,671	2,654	2,951
Male young cattle 1-2 yrs	3,272	3,347	3,353	3,246	3,242	3,192	3,293
Bulls for service > 2 yrs	3,272	3,347	3,353	3,246	3,242	3,192	3,293
Cattle for fattening							
Meat calves, rosé veal	1,633	1,529	2,055	2,055	2,055	1,717	1,717
Meat calves, white veal	647	699	707	707	706	726	726
Female young cattle < 1 yr	1,668	1,548	1,528	1,502	1,506	1,498	1,536
Male young cattle + young bullocks < 1 yr	1,844	1,898	1,898	1,898	1,898	1,884	1,880
Female young cattle 1-2 yrs and over	2,839	2,688	2,698	2,656	2,668	2,652	2,947
Male young cattle + young bullocks > 1 yr	3,289	3,256	3,256	3,256	3,256	3,237	3,231
Suckling, fattening and grazing cows > 2yrs	3,360	3,337	3,434	3,422	3,438	3,444	3,694

3 RESULTS

The calculated methane emission factor is presented in Table 3. The total methane methane production via enteric fermentation is presented in Table 4.

Table 3 Calculated emission factor (EMF) in kg per animal category per year.

Year	1990	1991	1992	1993	1994	1995	1996
Cattle for breeding							
Female young cattle < 1 yr	31.0	31.0	31.0	31.7	31.6	31.9	31.2
Male young cattle < 1 yr	31.0	31.0	31.0	31.7	31.6	31.9	31.2
Female young cattle 1 yr – calving	55.9	55.9	55.9	57.0	56.6	57.2	55.7
Male young cattle 1-2 yrs	62.6	62.6	62.6	65.6	65.2	66.9	64.9
Cows in milk and in calf *	107.7	108.1	108.4	110.8	112.4	112.7	110.7
Bulls for service > 2 yrs	62.6	62.6	62.6	65.6	65.2	66.9	64.9
Cattle for fattening							
Meat calves. rosé veal	33.1	33.1	33.1	33.1	33.1	33.1	33.1
Meat calves. white veal	8.1	8.1	8.1	8.1	8.1	8.6	8.6
Female young cattle < 1 yr	31.0	31.0	31.0	31.7	31.6	31.9	31.2
Male young cattle + young bullocks < 1 yr	34.0	34.0	34.0	32.7	36.9	36.2	35.4
Female young cattle 1-2 yrs and over	55.9	55.9	55.9	56.9	56.5	57.1	55.6
Male young cattle + young bullocks > 1 yr	69.1	69.1	69.1	80.7	66.4	67.6	63.7
Suckling, fattening and grazing cows > 2yrs	66.5	66.5	66.5	67.3	66.7	67.3	65.6
Year	1997	1998	1999	2000	2001	2002	2003
Cattle for breeding							
Female young cattle < 1 yr	31.5	30.9	30.5	29.9	30.0	29.8	30.6
Male young cattle < 1 yr	31.5	30.8	36.6	36.0	36.2	36.3	36.6
Female young cattle 1 yr – calving	56.5	53.5	53.8	52.9	53.1	52.8	58.7
Male young cattle 1-2 yrs	65.1	66.6	66.7	64.6	64.5	63.5	65.5
Cows in milk and in calf	114.0	115.4	117.1	117.9	121.1	118.8	124.6
Bulls for service > 2 yrs	65.1	66.6	66.7	64.6	64.5	63.5	65.5
Cattle for fattening							
Meat calves. rosé veal	32.5	30.4	40.9	40.9	40.9	34.1	34.1
Meat calves. white veal	8.6	9.3	9.4	9.4	9.4	9.6	9.6
Female young cattle < 1 yr	33.2	30.8	30.4	29.9	30.0	29.8	30.6
Male young cattle + young bullocks < 1 yr	36.7	37.8	37.8	37.8	37.8	37.5	37.4
Female young cattle 1-2 yrs and over	56.5	53.5	53.7	52.8	53.1	52.8	58.6
Male young cattle + young bullocks > 1 yr	65.4	64.8	64.8	64.8	64.8	64.4	64.3
Suckling, fattening and grazing cows > 2yrs	66.8	66.4	68.3	68.1	68.4	68.5	73.5

*: EMF calculated from modelling (see report Smink et al., 2005).

Table 4 Calculated enteric methane production (in tonnes per year) of each cattle category in the period 1990-2003.

Year	1990	1991	1992	1993	1994	1995	1996
Cattle for breeding							
Female young cattle < 1 yr	23,332	23,580	22,331	21,788	21,723	22,204	21,941
Male young cattle < 1 yr	1,650	1,830	1,671	1,577	1,512	1,409	1,784
Female young cattle 1 yr – calving	49,177	50,749	49,911	47,658	45,443	46,209	44,836
Male young cattle 1-2 yrs	2,168	2,356	2,460	2,096	2,154	2,216	2,414
Cows in milk and in calf*	202,790	200,034	191,728	193,887	190,161	192,990	184,776
Bulls for service > 2 yrs	549	620	535	561	520	580	599
Cattle for fattening							
Meat calves. rosé veal	956	1,317	1,689	2,085	2,556	2,840	3,323
Meat calves. white veal	4,639	4,713	4,752	4,805	4,960	5,018	4,964
Female young cattle < 1 yr	1,644	2,032	1,905	1,997	1,995	1,825	1,734
Male young cattle + young bullocks < 1 yr	8,683	9,363	8,302	7,635	8,359	6,813	5,223
Female young cattle 1-2 yrs and over	5,561	6,813	7,145	7,327	6,844	6,568	5,401
Male young cattle + young bullocks > 1 yr	13,152	14,583	14,685	16,012	12,741	12,203	9,595
Suckling, fattening and grazing cows > 2yrs	7,949	9,268	9,708	10,530	9,769	9,838	9,603
Total The Netherlands	322,249	327,257	316,821	317,960	308,737	310,713	296,193
Year	1997	1998	1999	2000	2001	2002	2003
Cattle for breeding							
Female young cattle < 1 yr	20,507	19,029	18,197	16,821	16,578	15,768	15,413
Male young cattle < 1 yr	1,474	1,288	1,378	1,348	3,186	1,622	1,142
Female young cattle 1 yr – calving	46,437	40,499	38,414	36,963	35,364	34,241	36,235
Male young cattle 1-2 yrs	2,059	1,837	1,690	1,701	1,730	2,003	1,287
Cows in milk and in calf	181,325	185,222	185,853	177,483	186,241	176,778	184,721
Bulls for service > 2 yrs	534	542	686	672	708	897	770
Cattle for fattening							
Meat calves. rosé veal	3,281	3,079	4,842	5,964	6,174	5,184	5,848
Meat calves. white veal	5,187	5,670	5,962	5,987	5,234	5,388	5,376
Female young cattle < 1 yr	1,583	1,305	1,398	1,235	1,287	1,159	1,163
Male young cattle + young bullocks < 1 yr	5,030	4,351	3,684	3,154	2,905	2,362	2,232
Female young cattle 1-2 yrs and over	4,321	3,765	3,436	3,259	3,242	3,092	3,556
Male young cattle + young bullocks > 1 yr	9,857	8,934	7,816	6,355	6,150	5,160	4,109
Suckling, fattening and grazing cows > 2yrs	9,653	9,652	10,421	11,127	10,999	10,342	10,584
Total The Netherlands	291,247	285,175	283,778	272,070	279,797	263,997	272,438

*: Used EMF in three decimal numbers. This corresponds with the databases of RIVM

About two third of the total methane production from enteric fermentation is from cows in milk and in calf. Other important groups are those of the young female breeding cattle. The total methane production via enteric fermentation is decreased with more than 15% between 1990 en 2003.

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