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Greenhouse Gas Emission Projections for UK Agriculture to 2030

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Summary

- The greenhouse gas emission projections for UK agriculture in this paper are an up-date to the previous projections produced by DECC in March 2011.
- Total greenhouse gas emissions from the sector are projected to fall by around 2% by 2020, over 2009 levels. Previously they were projected to rise by 4%.
- Nitrous oxide (N_2O) emissions, which make-up around 55% of total emissions from the sector, are projected to fall by around 2% by 2020, previously they were expected to rise by around 10%.
- Methane (CH_4) emissions, which make-up around 36% of total emissions from the sector, are projected to fall by around 2% by 2020, previously they were expected to rise marginally (less than 1%).
- The latest emission projections are based on activity projections from the AFBI FAPRI model of UK agriculture.

1.0 Background

Greenhouse gas (GhG) emission projections for UK agriculture were previously produced and published by DECC in March 2011. That up-date, although using the most recent outturn emissions data, was based on activity and emission projections produced in the 2007 study, 'Baseline Projections for Agriculture', led by ADAS[1]. The 'Baseline Projections for Agriculture' study used 2004 data for the base year. The projections set out in this paper are based on data from the FAPRI UK agricultural model[2] and replace the original 2007 study and the 2011 DECC projections.

Defra plan to produce up-dated greenhouse gas projections for the agricultural sector annually in future.

2.0 Introduction

Projecting over a 20 year horizon is inherently uncertain in any sector. However, uncertainties in projecting GhG emissions from the agricultural sector are particularly pronounced due to the nature of the sector (CAP support in particular) and the complexity of the natural systems that are the source of emissions. The new projections set out in this paper are based on activity projections produced by the FAPRI model of UK agriculture. Although uncertainties around activity are considered, and reflected in the projections, uncertainties around the measurement of emissions from different agricultural sources are not considered or presented. These uncertainties are large, particularly for nitrous oxide (N_2O), and require a separate assessment that is beyond the scope and purpose of this paper[3]. The prime purpose of this paper is to up-date the previous GhG projections of the sector produced by DECC in March 2011.

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[1] http://archive.defra.gov.uk/evidence/statistics/foodfarm/enviro/observatory/research/documents/SFF0601SID5FINAL.pdf

[2] http://archive.defra.gov.uk/evidence/economics/foodfarm/reports/fapri/

[3] Emission uncertainties and their size from different agricultural sources are discussed in detail in the current UK GhG Inventory Report:
http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php

The current agricultural inventory implements a 'tier 1' approach, with emissions factors derived from an IPCC international literature review multiplied by national statistics of fertiliser use and livestock numbers to generate emission estimates for the sector. This is a relatively simplistic methodology and involves the application of emissions factors which may not be relevant for some UK conditions. Reducing the large uncertainties in point emission estimates within the agricultural sector is being taken forward by the Defra funded GhG inventory Platform Project[4]. The project is expected to be completed by the end of 2016 when it is envisaged that the more sophisticated inventory will become functional, i.e. a tier 2 methodology, implementing nationally derived emissions factors. The current tier 1 methodology will continue to be used until the tier 2 methodology is adopted. A detailed discussion of the current methodology can be found in the current UK Greenhouse Gas Inventory Report[5], the latest of which covers the period 1990-2009.

The projections presented in this paper apply the existing agricultural inventory (tier 1 for the majority of emissions). As such, farmer activities which reduce emissions through improved efficiency are not reflected in the projections unless they are reflected in the current inventory methodology. Emission savings expected to be delivered from the industry action plan (3MtCO_2e by 2020 from English agriculture[6]) are also not reflected in the projections in this paper.

2.1 AFBI FAPRI-UK Model

As set out above, the new projections are based on activity projections produced by the FAPRI model of UK agriculture. The FAPRI-UK modelling system was created, and is maintained, by Agri-Food Biosciences Institute (AFBI) at Queen's University Belfast. The FAPRI-UK model covers the areas governed by the Devolved Administrations (DAs), while endogenously modelling key variables for the following commodities: Dairy, Beef, Sheep, Pigs, Poultry, Wheat, Barley, Oats, Rapeseed and Liquid Biofuels.

The FAPRI-UK model is fully incorporated within the EU GOLD (Grain, Oilseeds, Livestock & Dairy) system which is run by FAPRI-Missouri. Consequently, the UK model yields projections which are consistent with the equilibrium at EU level[7].

2.2 Agricultural Greenhouse Gas Emissions

The agricultural sector accounts for around 9% of total UK GhG emissions. Emissions from the sector were just over 49MtCO_2e in 2009. Of total GhG emissions from the sector around 55% come from nitrous oxide (N_2O), 36% from methane (CH_4) and around 9% from carbon dioxide (CO_2). The main cause of agricultural N_2O emissions is the application of synthetic fertiliser to arable soils. Ninety percent of N_2O emissions are from three sources: direct emissions from soils (42%), indirect emissions from soils (33%) and emissions from pasture range and paddock manures (15%). Eighty-three percent of CH_4 emissions are from three sources: enteric emissions from non-dairy cattle (41%), enteric emissions from dairy cattle (24%), and enteric

[4] www.ghgplatform.org.uk
[5] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php
[6] MtCO_2e- Million tonnes of carbon dioxide equivalent
[7] http://archive.defra.gov.uk/evidence/economics/foodfarm/reports/fapri/

emissions from sheep (17%). Another 10% of CH_4 emissions come from dairy and non-dairy cattle manures. All on-farm CO_2 emissions come from on-farm energy use.

3.0 Greenhouse Gas Emission Projections for UK Agriculture

The new GhG projections for UK agriculture to 2030 are set out in table 1 below. The table included a high and low estimate over which emissions could fall. Given the uncertainty in estimating emissions over such a time period, and the current uncertainties in estimating emissions from the agricultural sector set out above, considering the range over which emissions *could* fall provides a more realistic assessment than simple point estimates.

As noted above these projections do not reflect the savings expected from efficiency improvements due to the industry action plan which is expected to deliver savings of around 3MtCO_2e from English agriculture by 2020. And unlike other sectors of the economy, agricultural emissions are not projected to be affected by the current economic downturn.

Table 1 Up-dated 2011 Central, High and Low Bound GhG Projections for UK Agriculture to 2030 (MtCO_2e)

	2009*	**2010**	**2015**	**2020**	**2025**	**2030**
High	45.0	45.0	45.0	45.0	45.0	45.0
Low	45.0	44.8	43.4	43.4	43.4	43.4
Central	45.0	44.8	43.9	43.8	43.8	43.8

*2009 is outturn data

The new projections do not include N_2O and CH_4 emissions from on-farm energy use. These emissions will in future be projected by DECC using their energy model which should provide more consistency between CO_2 emission projections from on-farm energy use and N_2O and CH_4 emissions from the same sources. N_2O and CH_4 emissions from on-farm energy use accounted for around 1% of total agricultural GhG emissions in 2009.

The new central and previous (March 2011) projections of total GhG emissions from UK agriculture, and the difference between them, are set out in Table 2 below. The new projection has emissions falling by 2% by 2020 over 2009 levels. The previous projection implied an increase of 4% over 2009 levels. We believe the current projection provides a more realistic assessment of emissions from the sector as it is more in keeping with the recent trend.

Table 2 Current and Previous Total GhG Projections (2010-2030) (MtCO_2e)

	2009*	**2010**	**2015**	**2020**	**2025**	**2030**
Latest Defra 2011 projection	45.0	44.8	43.9	43.8	43.8	43.8
March 2011 projection	45.0	47.3	47.8	47.5	47.4	47.4
Difference	0.0	-2.5	-4.0	-3.6	-3.5	-3.5

*2009 is outturn data

The previous projection implied the sector's emissions increased by 5% in 2010, over 2009 levels (see Figure 1 below). This increase is driven by the methodology used to up-date the original 2007 projection when new outturn data becomes available. The methodology for up-dating previous projections simply up-lifted the original 2004 emission estimate to calibrate with the new outturn estimate for 2004 and applied the original 2007 study profile of emissions over the horizon. New post 2004 outturn data was not used to re-profile the projection. Figure 1 illustrates the profile of the new and previous projection (2010-2030) and the historic trend since 1990. Figure 1 clearly illustrates the divergence between the previous projection (red line) and the historic trend. In particular, the projection implied a 5% increase in 2010 emissions over the 2009 level. This is not reflective of the direction of travel and is the main driver for the higher previous projection.

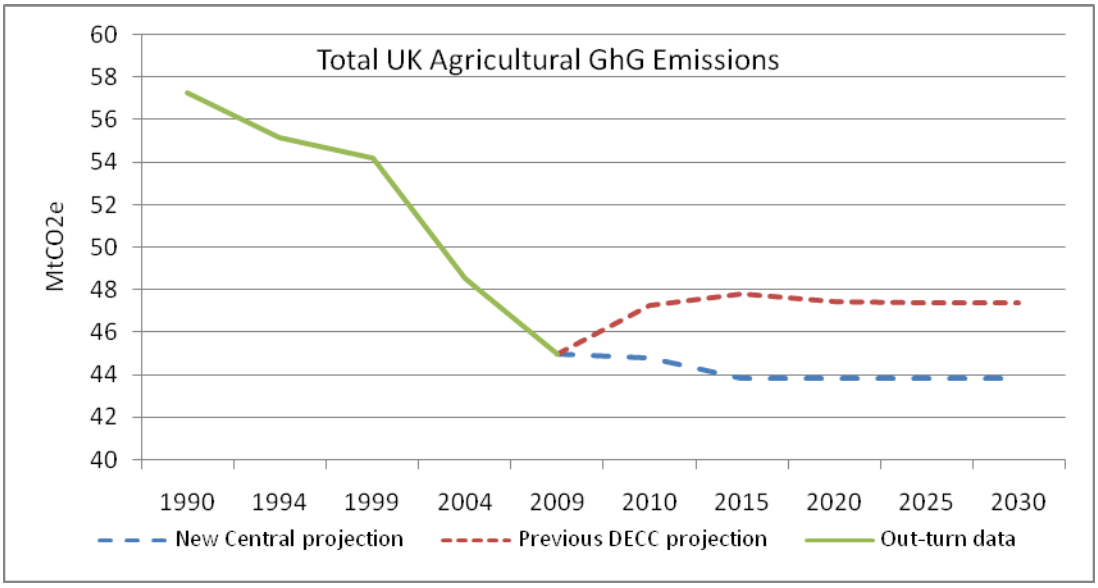

Figure 1: Total GhG Emission Outturn and Projections (2010-2030)

In addition to the 5% increase projected in 2010 there is a further increase to 2015 and then a marginal, decline over the 2015 level, by 2020. Total emissions were expected to be around 4% higher than 2009 by 2020. This profile is significantly different from the historic trend for the sector where emissions have fallen since 1990 and fallen steeply since 1999 (illustrated by the green line to 2009 in Figure 1). An increase in emissions by 5% in 2010 over 2009 levels is strikingly different from the recent trend.

The profile of the new projection is more in keeping with the historic trend. Emissions are projected to continue to decline to 2020, but to do so at a slower rate than historically, resulting in a 2% redcution by 2020. Emissions are set flat from 2020 to 2030 as the model used to project activity within the sector does not extend to 2030[8]. A more detailed assessment of drivers of the decline is set-out in the following two sections.

As noted in the introduction, the new projection does not incorporate the expected savings from the industry GhG action plan.

[8] Defra will develop a more detailed methodology for projecting from 2020 to 2030.

3.1 Nitrous Oxide (N_2O) Emission Projections

This section sets out the projection of nitrous oxide (N_2O) emissions from the sector. As set out above N_2O emissions from on-farm energy use are not included in the current estimates[9].

Around 55% of total agricultural GhG emissions are accounted for by N_2O emissions. N_2O emissions, like total GhG emissions from the sector, have been falling since 1990, 23% by 2009. The main drivers of N_2O emissions are direct emissions from soils (42%), indirect emissions from soils (33%) and emissions from pasture, range and paddock manures (15%). All three sources have seen declines since 1990. However, over recent years direct emissions from soils have been more volatile. Figures 2, 3 and 4 illustrate changes in emissions from these three sources since 1990. The largest decline has been in emissions from pasture, range and paddock manure which have fallen by 28% since 1990. Direct soil N_2O emissions have fallen by 23% over the same period.

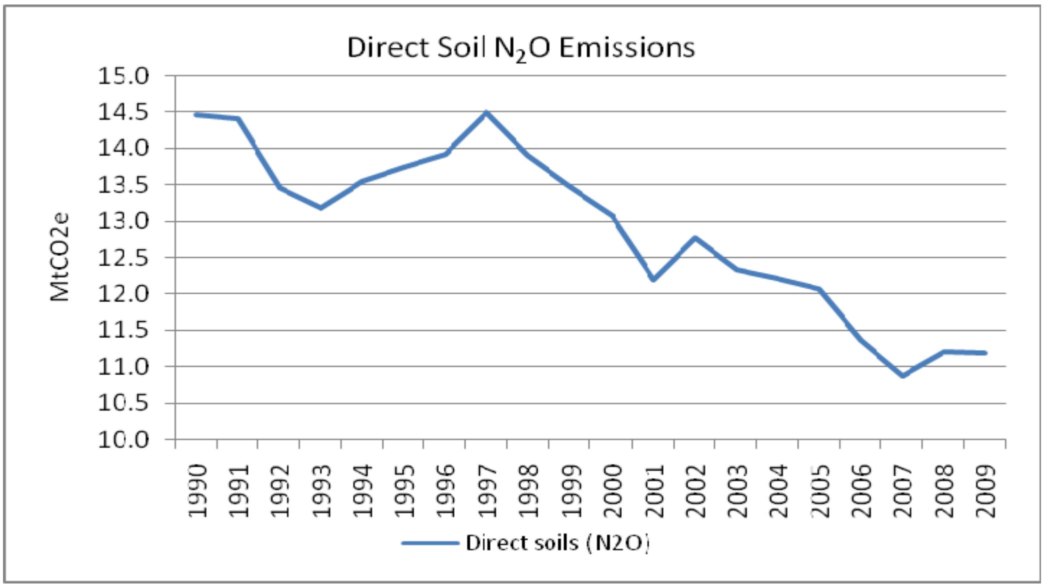

Figure 2: Direct N_2O Emissions from Soils (1990-2009)

[9] N_2O emissions from on-farm energy use account for less than 1% of total agricultural GhG emissions so excluding these from the projections does not have a meaningful impact on the projections.

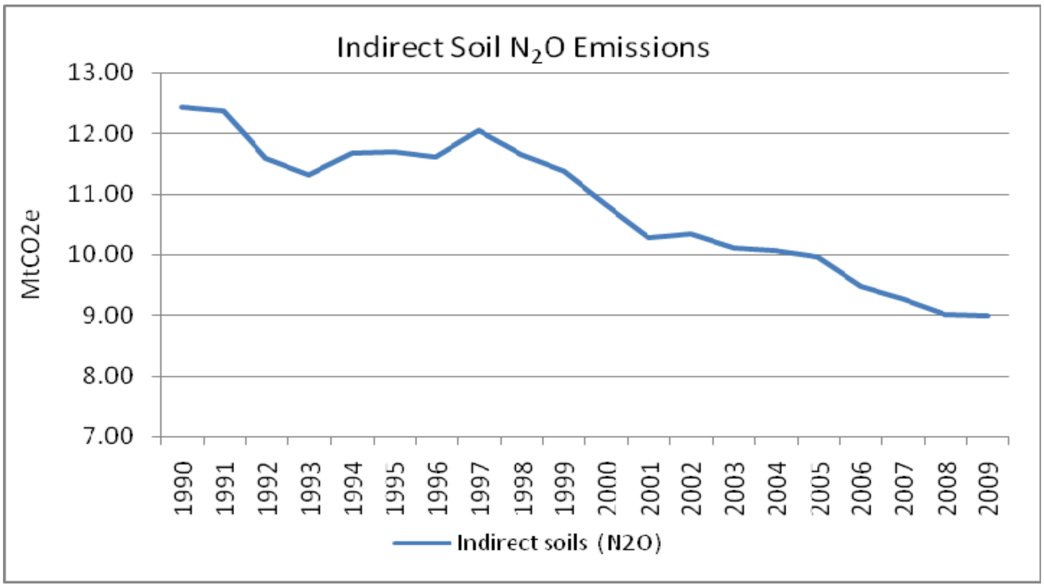

Figure 3: Indirect N_2O Emissions from Soils (1990-2009)

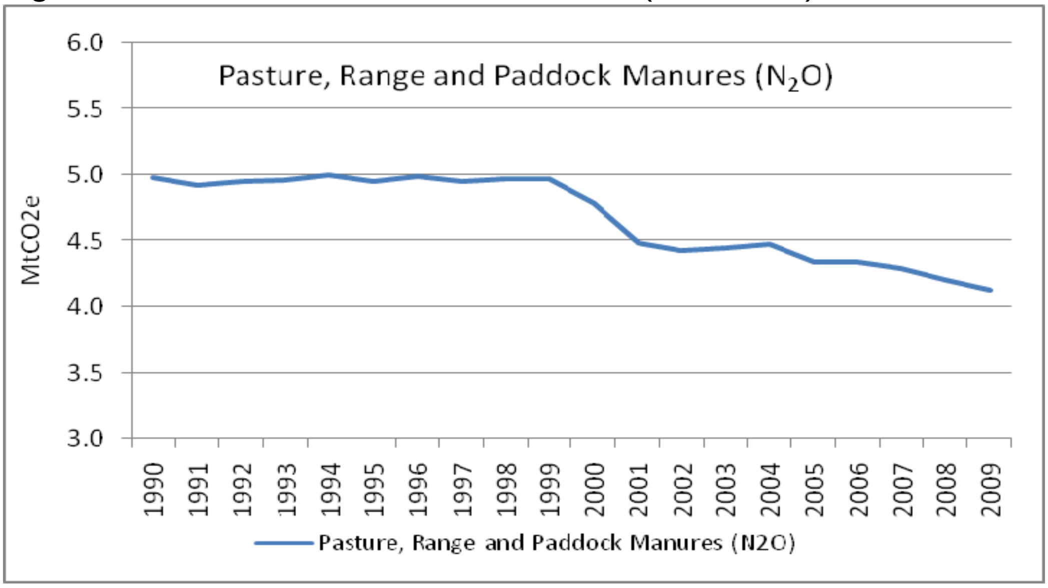

Figure 4: Indirect N_2O Emissions from Soils (1990-2009)

The latest central N_2O emission projection to 2030, along with the previous projection and the difference between them, is set out in table 3 below.

Table 3 Central N_2O Projections to 2030 ($MtCO_2e$)

	2009*	2010	2015	2020	2025	2030
Latest Defra 2011 projection	26.9	26.9	26.5	26.4	26.4	26.4
March 2011 projection	26.9	29.0	29.8	29.5	29.5	29.5
Difference	0.0	-2.1	-3.3	-3.1	-3.1	-3.1

*2009 is outturn data

The current projection has N_2O emissions over $2MtCO_2e$ lower in 2010 than the previous projection. Under the current projection, N_2O emissions fall by around 2% by 2020 over 2009 levels. The previous projection implied N_2O emissions increased by 10% by 2020. N_2O emissions are caused predominately by the application of fertilisers to arable land. If farmers apply more fertiliser per hectare, or more arable land comes into production than has historically been the case, then N_2O emissions under the current inventory methodology would increase. However, as fertiliser prices have increased, farmers have applied fertiliser more efficiently. The current projections assume that this level of efficiency is maintained and no significant additional land is brought into arable production.

Figure 5 profiles the latest and previous N_2O projections along with the historic trend. Again, the previous projection implies a reversal of the historic trend with a noticeable jump of 8% between 2009 and 2010, and an increase of 10% by 2020. In contrast the current projection implies a continuation of the recent trend as N_2O emissions continue to fall, albeit at a slower rate. N_2O emissions are assumed to have fallen by 2% by 2020, over 2009 levels. This is not a significant change and implies relatively similar levels of arable activity as in 2009.

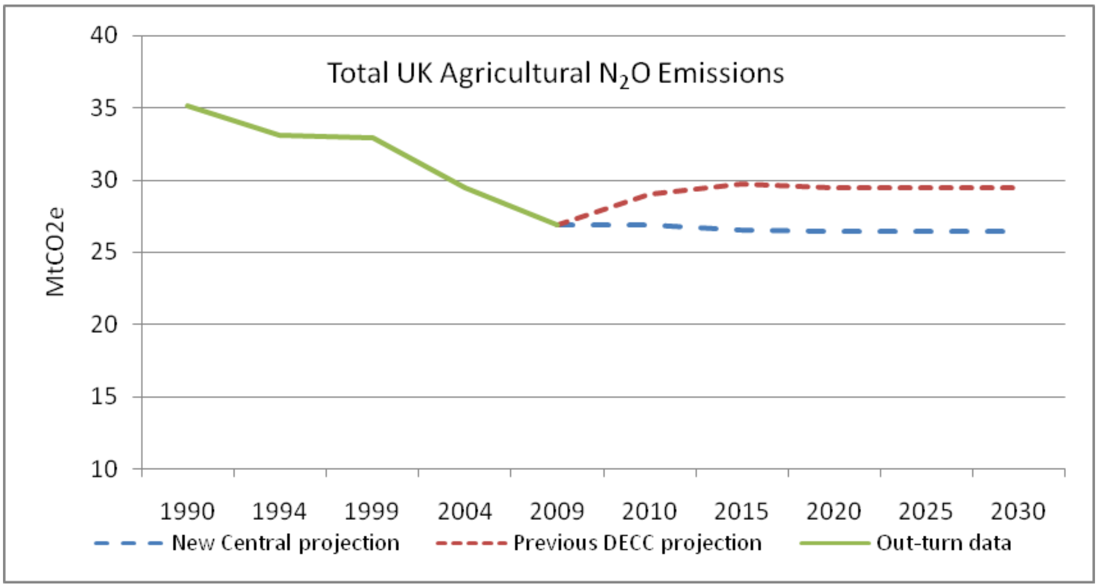

Figure 5: Outturn and Projected total N_2O Emissions to 2030

3.2 Methane (CH_4) Emission Projections

This section sets out the projection of methane (CH_4) emissions from the sector. As set out above CH_4 emissions from on-farm energy use are not included in the current estimates[10].

Around 36% of total agricultural GhG emissions are accounted for by CH_4 emissions[11]. CH_4 emissions, like total GhG emissions from the sector and N_2O emissions, have fallen since 1990, 18% by 2009. The main drivers of CH_4 emissions are enteric emissions from non-dairy cattle (41%), enteric emissions from dairy cattle (24%) and enteric emissions from sheep (17%).

[10] CH_4 emissions from on-farm energy use account for less than 0.01% of total agricultural GhG emissions so excluding these from the projections will not have a meaningful impact on the projections.
[11] Around 9% of agricultural GhG emissions are accounted for by CO_2 from on-farm energy use.

Manures are also a significant source of CH_4 emissions. For example, 10% of the sector's total CH_4 emissions are accounted for by dairy and non-dairy cattle manures. All four sources have seen declines since 1990. The largest decline, however, has been in enteric emissions from sheep (-28%) and dairy cattle (-20%) reflecting the fact that these sectors have seen the largest relative decline in numbers. Figures 6, 7 and 8 illustrate the trend in enteric emissions from non-dairy cattle, dairy cattle and sheep since 1990.

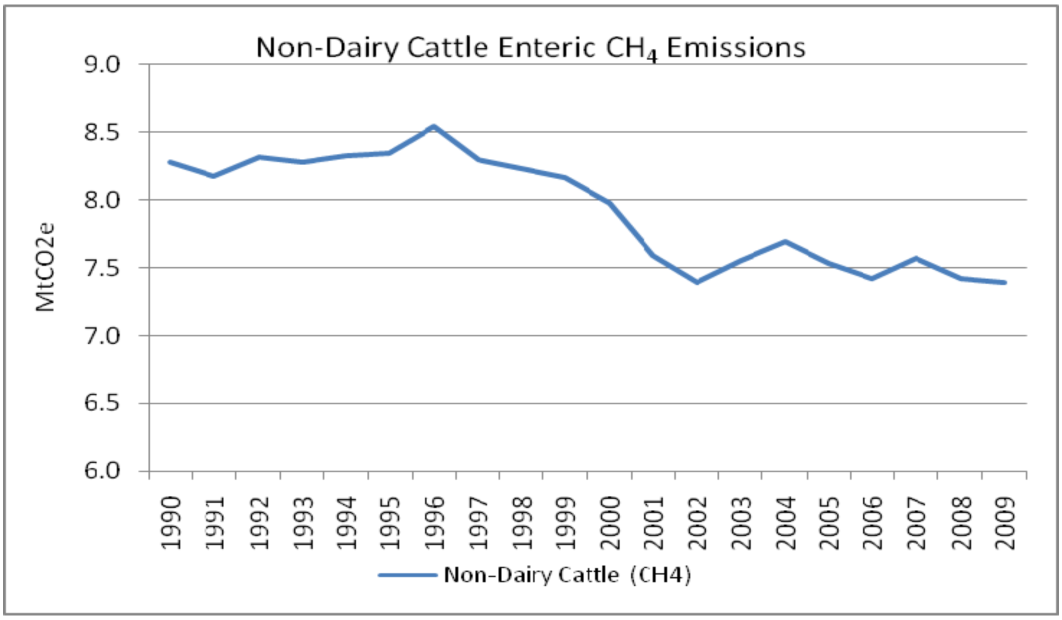

Figure 6: Enteric Non-Dairy CH_4 Emissions (1990-2009)

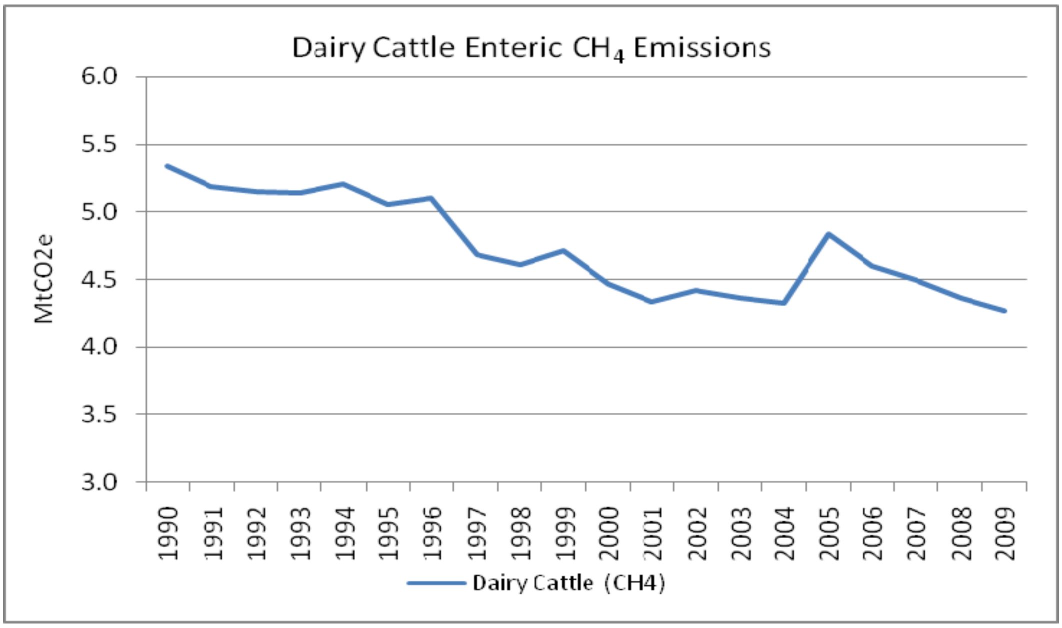

Figure 7: Enteric Dairy CH_4 Emissions (1990-2009)

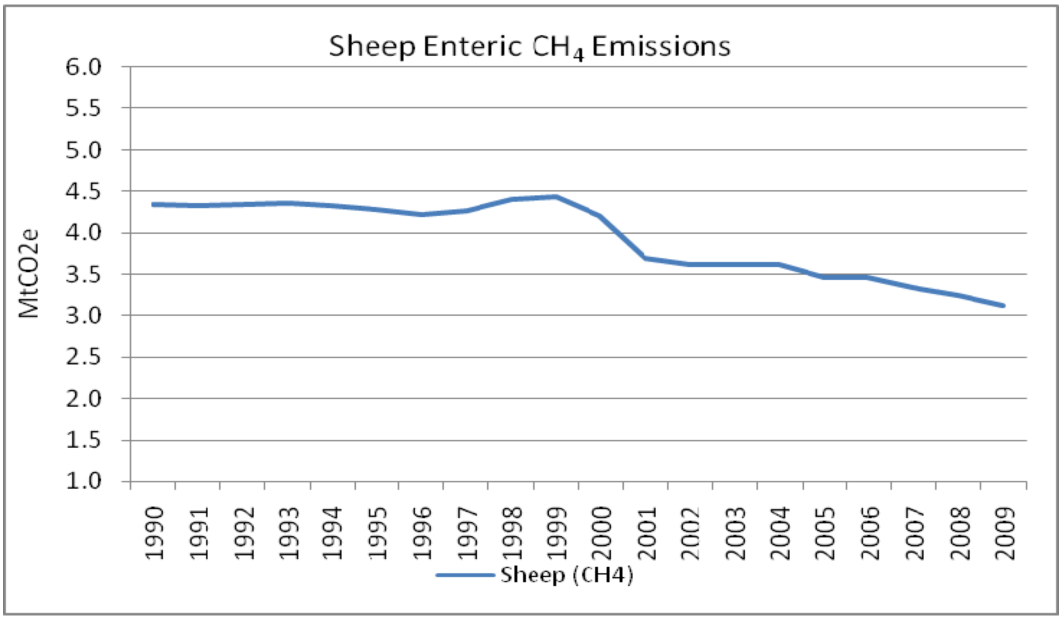

Figure 8: Enteric Sheep CH_4 Emissions (1990-2009)

The latest central CH_4 emission projection to 2030, along with the previous projection and the difference between them, is set out in table 4 below.

Table 4 Central CH_4 Projections to 2030 ($MtCO_2e$)

	2009*	2010	2015	2020	2025	2030
Latest Defra 2011 projection	17.9	17.9	17.5	17.6	17.6	17.6
March 2011 projection	17.9	18.2	18.1	17.9	17.9	17.9
Difference	0.0	-0.4	-0.5	-0.4	-0.4	-0.4

*2009 is outturn data

The latest CH_4 emissions projection is not very different from the previous projection, 0.4$MtCO_2e$ lower in 2010. Over the projection horizon the difference is consistent, the latest projection always being around 0.4$MtCO_2e$ lower over the majority of the horizon. Under the current projection, CH_4 emissions fall by around 2% by 2020 over the 2009 level. The previous projection implied CH_4 emissions were unchanged by 2020, although marginally higher in 2010 and 2015. Given error margins when estimating over the time horizon here (2010-2030), the level of difference between the previous and current projections is minor (just 2%).

CH_4 emissions are determined by livestock numbers. The current projection suggests that overall livestock numbers are not expected to be vastly different from current levels[12]. Note that these projections do not take any account for potential 2013 CAP reforms, or reforms that may occur in 2020. If the returns to farming beef and dairy cattle or sheep were to significantly change as a result of any CAP reform, then CH_4 emissions are likely to be different to those above.

[12] See http://archive.defra.gov.uk/evidence/economics/foodfarm/reports/fapri/ for detail livestock projections by livestock type.

Figure 9 profiles the latest and previous CH_4 projections along with the historic trend. It could be argued that both the latest and previous projections are more or less in keeping with the historic trend, although the previous projection implies CH_4 emissions rise by around 2% from 2009 to 2010 whereas the latest projection implies CH_4 emissions are unchanged over this period. Over the projection horizon the latest projection is about 2% lower than the previous CH_4 projection.

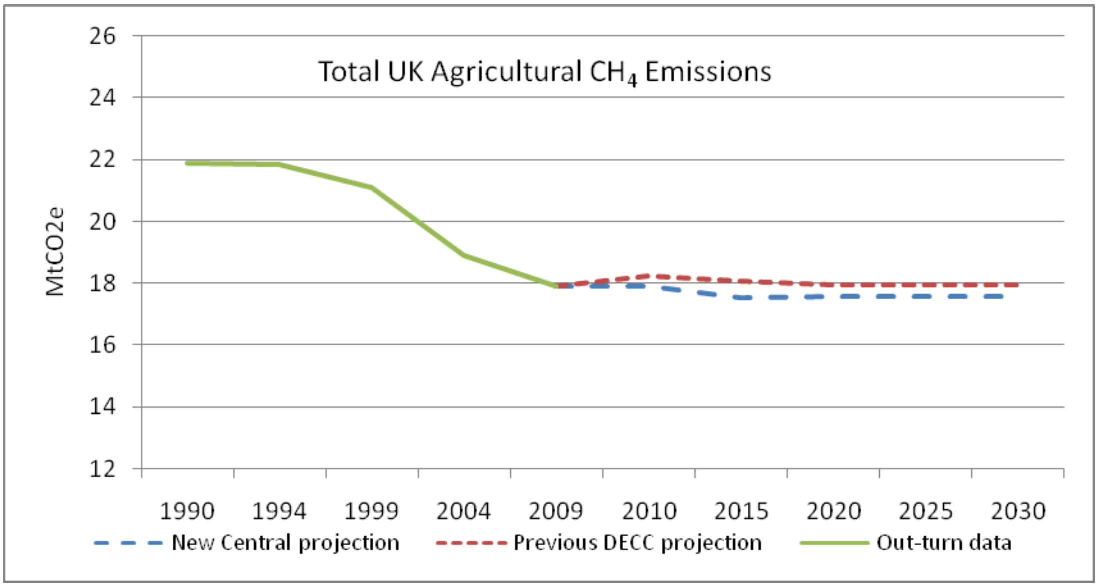

Figure 9: CH_4 Emission Outturn and Projections (2010-2030)

4.0 Summary

This paper sets-out new projections of total GhG emissions, and N_2O and CH_4 emissions, from UK agriculture to 2030. The up-dated projections are based on activity projections from the FAPRI model of UK agriculture and replace the previous emission projections produced by DECC in March 2011.

The new projections imply that total GhG emissions from the sector are around 2% lower in 2020, over 2009 levels. The previous projection implied emissions were 4% higher. The main cause of the difference between the current and previous March 2011 projection is the current expectation that emissions in 2010 do not significantly rise above 2009 levels. More specifically, the current projection implies N_2O emissions in 2010 are similar to the 2009 level. The previous projection implied N_2O emissions increase by 2.1 $MtCO_2e$, or by 8% over the 2009 level. The new CH_4 emission projection is very similar to the previous CH_4 projection, although around 0.4$MtCO_2e$ lower over the projection horizon.

Annex A

Breakdown of UK Agricultural Emission Projections to 2030 by Devolved Administration[13]

Total Greenhouse Gas Emissions

Table A1 Total GhG Emissions from UK Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	45.0	45.0	45.0	45.0	45.0
Low	44.8	43.4	43.4	43.4	43.4
Central	44.8	43.9	43.8	43.8	43.8

Table A2 Total GhG Emissions from English Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	28.4	28.6	28.6	28.6	28.6
Low	28.4	27.6	27.6	27.6	27.6
Central	28.4	28.1	28.1	28.1	28.1

Table A3 Total GhG Emissions from Welsh Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	4.7	4.6	4.6	4.6	4.6
Low	4.7	4.5	4.5	4.5	4.5
Central	4.7	4.6	4.5	4.5	4.5

Table A4 Total GhG Emissions from Scottish Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	6.9	6.8	6.8	6.8	6.8
Low	6.9	6.6	6.5	6.5	6.5
Central	6.9	6.7	6.7	6.7	6.7

Table A5 Total GhG Emissions from Northern Irish Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	4.7	4.7	4.7	4.7	4.7
Low	4.7	4.5	4.6	4.6	4.6
Central	4.7	4.6	4.6	4.6	4.6

[13] Figures may not sum due to rounding

Nitrous Oxide (N_2O) Emissions

Table A6 Total N_2O Emissions from UK Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	26.9	26.9	26.9	26.9	26.9
Low	26.9	26.1	25.9	25.9	25.9
Central	26.9	26.5	26.4	26.4	26.4

Table A7 Total N_2O Emissions from English Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	18.3	18.4	18.5	18.5	18.5
Low	18.3	17.8	17.8	17.8	17.8
Central	18.3	18.1	18.1	18.1	18.1

Table A8 Total N_2O Emissions from Welsh Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	2.3	2.2	2.2	2.2	2.2
Low	2.3	2.2	2.2	2.2	2.2
Central	2.3	2.2	2.2	2.2	2.2

Table A9 Total N_2O Emissions from Scottish Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	4.0	3.9	3.9	3.9	3.9
Low	4.0	3.8	3.8	3.8	3.8
Central	4.0	3.9	3.8	3.8	3.8

Table A10 Total N_2O Emissions from Northern Irish Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	2.3	2.3	2.3	2.3	2.3
Low	2.3	2.2	2.2	2.2	2.2
Central	2.3	2.2	2.3	2.3	2.3

Methane (CH_4) Emissions

Table A11 Total CH_4 Emissions from UK Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	17.9	17.9	17.9	17.9	17.9
Low	17.9	17.2	17.2	17.2	17.2
Central	17.9	17.5	17.6	17.6	17.6

Table A12 Total CH_4 Emissions from English Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	10.1	10.2	10.2	10.2	10.2
Low	10.1	9.8	9.8	9.8	9.8
Central	10.1	10.0	10.0	10.0	10.0

Table A13 Total CH_4 Emissions from Welsh Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	2.4	2.4	2.4	2.4	2.4
Low	2.4	2.3	2.3	2.3	2.3
Central	2.4	2.4	2.4	2.4	2.4

Table A14 Total CH_4 Emissions from Scottish Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	2.9	2.9	2.9	2.9	2.9
Low	2.9	2.8	2.8	2.8	2.8
Central	2.9	2.8	2.8	2.8	2.8

Table A15 Total CH_4 Emissions from Northern Irish Agriculture to 2030 ($MtCO_2e$)					
	2010	**2015**	**2020**	**2025**	**2030**
High	2.4	2.4	2.4	2.4	2.4
Low	2.4	2.3	2.3	2.3	2.3
Central	2.4	2.4	2.4	2.4	2.4