Agriculture Industry GHG Action Plan: Framework for Action

10th February 2010

This Action Plan has been developed by the joint agricultural Climate Change Task Force (NFU, CLA and AIC) in consultation with the Industry Partnership below. The Action Plan represents a firm statement of intent that the agriculture industry will play its part in ensuring progress towards the reduction of greenhouse gas (GHG) emissions as required by the Climate Change Act (2008). However, the Action Plan acknowledges the rudimentary state of knowledge about the scale of GHG emissions from agricultural systems and the degree to which it is possible to manage the natural processes of denitrification and ruminant enteric fermentation that result in the largest GHG contributions from nitrous oxide and methane.

The plan has yet to be validated and approved by the governing boards of the partners who have been consulted. These include: AHDB and its Sectors (BPEX, Dairy Co, EBLEX, HDC, HGCA, Potato Council); AIC member companies, AICC, TAG, NIAB, LEAF, FWAG, AEA and Farming Futures.

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1. Background

1.1 National climate change policy and agriculture

The National Farmers' Union of England and Wales (NFU), the Country Land and Business Association (CLA), and the Agricultural Industries Confederation (AIC) launched a joint Climate Change Task Force in January 2007 to present a united stance against the serious threat that climate change poses to agricultural production and the rural sector. In December 2007, the Task Force report "Part of the Solution: climate change, agriculture and land management"[1] demonstrated how the agricultural industry was taking the initiative on reducing greenhouse gases from this sector.

As an industry we are firmly of the opinion that climate change poses, on balance, a threat to our interests, social responsibility and duty to future generations. While under UK conditions there may be some gain in plant productivity arising from an increase in temperatures and atmospheric CO_2 concentration, this needs to be weighed against the negative impacts of heat stress on plants and animals, together with more frequent droughts, floods, late frosts, storm events, and disease incursion and spread. This is why we engaged early and positively on the subject of climate change[2], why we support government efforts to secure international agreement on containing global average temperature rise to +2°C, and why we are working to the best of our ability to devise a workable plan for GHG emission reductions in our sector.

However agriculture is different from other sectors of the economy with respect to its emissions of greenhouse gases. The principal greenhouse gas for many industries is carbon dioxide; however for agricultural systems methane and nitrous oxide are of prime concern. The measurement basis for these emissions is much more complex than for CO_2, and their emission factors are subject to significantly larger standard errors. These emissions are bound up into highly complex and imperfectly understood natural soil and animal microbial processes. Mitigation actions will have to be taken and sustained by most if not all farmers, i.e. by a large number of very small businesses. Communicating and motivating these actions is a high order challenge which will require sustained effort, including research and development and then knowledge transfer to get the research results into practice. Because agricultural products are highly tradable and traded, it will be all too easy if this is not handled well merely to displace agricultural production and its associated emissions elsewhere outside the UK.

In the mean time, the policy environment has moved on with the publication of the Climate Change Act of 2008, and the government's Low Carbon Transition Plan White Paper (LCTP)[3], released in July 2009. The Agricultural Industry Greenhouse Gas Action Plan (GHGAP) described here comprises the response to the detailed policy proposals in this White Paper from a partnership of industry representatives and stakeholders, although it has not been debated or agreed more widely within the industry. The LCTP explains how all major UK government departments have been allocated a carbon budget for their respective areas of the UK economy. Each sector is expected to play its part, and each department must produce a plan to help deliver

[1] http://www.nfuonline.com/Our-work/Environment/Climate-change/Climate-change:-Agriculture-is-part-of-the-Solution-says-industry-Climate-Change-Task-Force
[2] Ibid.
[3] http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

nationwide emissions cuts of 18% on 2008 levels by 2020 (equivalent to a 34% reduction on 1990 levels).

Following some initial confusion and clarification about the level of the emissions abatement set for England as opposed to the UK as a whole, **the proposed agricultural emissions reductions are 3 million tonnes CO_2 (equivalent)[4] per year against a 2008 baseline**, to be achieved in England alone by the third Carbon Budget period (2018-2022). The government requested delivery of an outline GHGAP by the end of November 2009, and a plan to be ready by spring 2010, to coincide with Defra's own Climate Change Plan. Defra intends to review voluntary actions taken by the agricultural sector in 2012, looking at relative measures of success and will meanwhile develop its own shortlist of alternative policy options for intervention. It will also introduce an improved agricultural greenhouse gas inventory in 2013. The agriculture industry notes that the independent Committee on Climate Change is presently working on its advice for the 4th UK carbon budget period (2023-27), and that the Committee will address potential emissions reductions within the agriculture, land use and forestry sectors in its Second Progress Report to Parliament in June 2010. We look forward to further interaction with the Committee, considering the long-term agenda for sustainable and competitive agriculture. Proposals for substantial decarbonisation of the UK economy must respect market forces and provide business owners with the confidence to invest, bearing in mind current concerns about food security and world population growth.

The industry is pleased at the acknowledgement in the LCTP that the rural land use sector is already taking significant voluntary action to address climate change issues, and that the government has incorporated some of agriculture's ambitions into its own goals (such as for nutrient management planning and deployment of on-farm anaerobic digesters). We welcome the government's recognition of the physical limits on how far emissions from agriculture can be reduced, due to the complexity of managing natural biological cycles in our industry, and given the proportionality that exists between the scale of food demand and associated emissions.

While we insist upon evidence-based policy, we are also aware that the evidence of the abatement costs in agriculture on which this GHGAP is founded is very thin. The studies by SAC[5] and ADAS[6] were sincere professional efforts to assemble the best that could be done in relatively short and small consultancy projects. However we are aware that they embrace a large amount of judgement and extrapolation from a slender base.

The agricultural industry offers this Plan as a serious statement of intent and a commitment to reduce our sector's GHG emissions.

However, we stress that both the priority actions and results towards the budgeted emission reductions could deviate markedly from those suggested here in the light of circumstances, experience and new evidence. We also attach great importance to Defra's acknowledgement that both the baselines and targets for emission reductions are under review. Increases in agricultural production led by increased demand may require GHG emission targets to be re-aligned, although

[4] CO_2e describes for a particular greenhouse gas the quantity of carbon dioxide that would have the same global warming potential

[5] UK marginal abatement cost curves for the agriculture and land use, land use change and forestry sectors out to 2022, with qualitative analysis of options to 2050. Moran *et al*. Final report to the Committee on Climate Change. Project reference RMP/4950. SAC 20/11/2009.

[6] Analysis of policy instruments for reducing greenhouse gas emissions from agriculture, forestry and land management. Project RMP/5142, ADAS May 2009. 144 pp.

efficiency gains will moderate part of any production-related increases. We expect Government to be conducting considerably more research on abatement potential and costs, and to be prepared to change both baseline and budgets in the light of new evidence and experience.

The industry expects that the bulk of both the short term and longer term reductions in GHG emissions in agriculture will result, not from reductions in agricultural activity and output (indeed these will have to increase in coming decades as population continues to grow), but from further advances in resource use efficiency. This is potentially advantageous in its own right. It means that each kilogram, for example, of wheat, meat and milk solids, will have to be produced with fewer emissions. This requires crop plants that more efficiently use nitrogen (from manures, fertilizers or biological fixation) per unit of harvested crop output, and animals that use less feed per unit of production, coupled with improved agronomy and management. Out of many important considerations which arise from this are, firstly, that there are some difficult trade-offs to be considered between reducing GHG emissions and other environmental and animal welfare issues. Secondly, the greatest potential for efficiency gain may be found amongst those producers who are currently least efficient. This is likely to be the hardest group to reach, and it may easier to motivate not by talking about climate change and greenhouse gases but by linking environmental performance to economic gain for these enterprises.

1.2 International policy

The EU as a signatory to the Kyoto Protocol[7] has committed to reducing its emissions by 8% from 1990 levels by 2008-2012. In order to meet this target, Member States have accepted different emissions reduction rates; the UK is on track to achieve its target of 12.5%. However, the new international framework needed to succeed the Protocol was not put in place at the Copenhagen climate talks in December 2009. Instead the Copenhagen Accord gave international backing to a number of key commitments *e.g.* an overall limit on global warming of 2°C. The talks will continue in 2010 with the aim of building on the Accord and negotiating and ratifying Kyoto's successor. In the mean time, the UN Subsidiary Body for Scientific and Technological Advice has been requested to establish a program of work on agriculture in 2010, and a global research alliance on agricultural GHGs has been established by 20 countries, including the UK.

In 2008, the European Council agreed its energy and climate package, in particular the "20-20-20" objective, which included the commitment to reduce greenhouse gas emissions by 20 % by 2020. The EU has already signalled its intent to go further by offering to cut emissions by 30%, if under the new international agreement, other developed countries commit themselves to comparable emission reductions, and developing countries contribute "adequately" according to their responsibilities and respective capabilities.

World trade agreements need to be linked to international climate change policy. It is also important to consider the part played by the EU Common Agricultural Policy (CAP) in determining what agriculture produces, and how CAP reform must support the minimisation of GHG emissions from agriculture.

[7] The Kyoto Protocol is an international and legally binding agreement to reduce greenhouse gas emissions

1.3 Statement of the Challenge

In the Low Carbon Transition Plan, the Government re-stated its commitment to help farming remain a strong and prosperous industry and acknowledged the potential for carbon 'leakage' from the sector. The agricultural industry agrees that in tackling our emissions here in the UK we should not simply export production and emissions to other countries. It is also fundamental that land use should be at the centre of climate policy, since land-use change, whether in Europe or the developing world, will affect all outcomes. In addition, the mitigation responses required of UK agriculture must recognise the complexity of the economic and public policy goals and expectations placed upon food production now and in the coming decades. The challenge facing the industry is therefore one of addressing relatively intractable GHG emissions without compromising UK agricultural production.

UK agriculture: emissions and their sources

UK agricultural production is directly responsible for about 7% of total UK greenhouse gas emissions (expressed in terms of CO_2 equivalents), which may be broken down as follows:

Emissions	Sources
About 3.5% (half of the 7%) is due to nitrous oxide (N_2O)	mostly from microbial activity in agricultural soils, and an inevitable consequence of using organic or mineral fertilisers and nitrogen fixation by legumes
A further 2.8% is methane (CH_4)	The majority from enteric fermentation in ruminant livestock, plus a minority from manure/slurry handling
Around 0.7% is carbon dioxide (CO_2)	direct energy use in agriculture

Boundary of the emissions calculation for agriculture

- The figures used above for agricultural production are as reported in the UK's official national GHG inventory of emissions. The international guidelines for reporting such information follow the advice of the Intergovernmental Panel on Climate Change.[8]
- Agricultural emissions, as reported in the national inventory, include only N_2O and CH_4 emissions from agricultural production. Emissions resulting from:
    - energy use (and therefore CO_2 emissions) from the sector fall into the 'Energy' category of the inventory, although they are often informally attributed to the sector. Renewable energy generated by agriculture, for on-site needs or for export, is also potentially reported here – it would be good for the agricultural sector to similarly receive 'informal' credit for the contribution of on-farm renewables to decarbonisation of agriculture and other sectors.
    - land use change in the UK (*e.g.* from grass to arable), and carbon storage in vegetation and soils (*e.g.* when arable is converted to permanent grass or woodland) is included in the 'Land-use change and Forestry' category.

[8] This format is followed by all countries that are Parties to the UN Framework Convention on Climate Change and have committed to reducing their GHG emissions by signing the Kyoto Protocol - an international and legally binding agreement to reduce greenhouse gas emissions

- indirect emissions attributed to agriculture *e.g.* energy used and N_2O emitted 'upstream' in fertiliser manufacture, is included under 'Industry'. This would add about another 0.5-0.7% to the agricultural contribution

- However, outside this official reporting system, there are other ways of estimating emissions from the food system. The food chain as a whole is often reported as accounting for between 18% and 22% of UK greenhouse gas emissions, and more recently as much as 30%[9]. These additional emissions actually arise 'downstream' or 'beyond the farm gate', in food processing, distribution, consumption and waste disposal, or (more controversially) indirectly through changes in land use attributed to agricultural inputs produced elsewhere in the world. The PAS 2050 standard, launched in October 2008, provides a carbon footprinting framework that allows the estimation of the life-cycle GHG emissions of goods and services.[10]

Tackling agriculture's GHG emissions

- With current knowledge, reductions in N_2O and CH_4 across the entire industry are most likely to be around the mid-point of the range of technical and economic potentials typically quoted (2-20%). Only the best performing individual 'early adopters' may attain the upper end of this range (around 20% emissions reductions), through efficiency gains and optimal resource management. Measures that can be implemented now to reduce these emissions include improved nutrient use efficiency (for both crops and livestock), improved management of manures and soils, changes to livestock diets, more use of co-products, better animal health and housing, and the deployment of anaerobic digestion. At present, it is both impractical and costly to directly measure N_2O and CH_4 emissions from widely dispersed sources in agriculture, so other indicators of uptake may be required to monitor progress.
- Just like energy-related CO_2 emissions in the rest of the economy, CO_2 from direct energy use in agriculture may be reduced substantially, through energy efficiency and the substitution of low-carbon renewable energy for fossil fuels.
- As the rest of the economy decarbonises, it is certain that agricultural emissions will comprise a larger share of the UK total, due to unavoidable emissions of N_2O and CH_4 which are part of natural processes.

Emissions reductions in England and the devolved administrations

- This GHG Action Plan focuses on emissions for England only, but it is intended to be complemented by similar plans covering the remainder of the UK.
- Chapter 9 of the LCTP describes "Further action in Northern Ireland, Scotland and Wales". A breakdown of GHG emissions by nation within the UK shows that 39% of GHGs are emitted beyond English borders (Appendix 1).
- Detailed targets and agreement between the devolved administrations and their agricultural industry representatives are not as far advanced as in England. The Climate Change Task Force is already consulting with trade associations in Scotland, Wales and Northern Ireland about the GHGAP.

[9] Audsley, E. et al. (2009). How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050. WWF-UK.

[10] Publicly Available Specification (PAS) 2050 estimates the greenhouse gas emissions embedded in goods and services throughout their entire life cycle - from sourcing raw materials, through to manufacture, distribution, use and disposal

- The Scottish Government has set ambitious goals for emissions reductions, and has begun a dialogue with the agricultural sector on its contribution.
- The Welsh Assembly Government has recently (October 2009) closed its consultation on its climate change programme for action[11].
- Discussions between the Northern Ireland Assembly and its agricultural industry are at an early stage.

11 http://wales.gov.uk/consultations/environmentandcountryside/climatechangeaction/;jsessionid=73tdLFsQpSnDry86gvq8MS2Cqg0nhTyh6N1TbgZG0FRL1zmhPdqp!-977831341?lang=en

2. Industry Response and Principles of Engagement

The proposed level of greenhouse gas abatement for the period around 2020 (3 Mt CO_2e/year) is very challenging, and there is a great deal of uncertainty about the current scale of emissions as well as the potential impact of different possible changes in agricultural practice. It appears, on present evidence, that the abatement targets for 2020 will be close to the limits of what is feasible, even with significant advances and investment in anaerobic digestion and genetic improvement of crops and livestock. This is the view of the Climate Change Task Force, expert consultees and other authorities. Meeting this goal is going to require a concerted effort by the entire industry, with a particular focus on those sectors where reductions will be most difficult to achieve at the same time as maintaining or increasing production. All sectors of this industry, all regions and all categories of farmers and growers, as well as Government and its regulators, will need to take shared responsibility for the next steps. The industry looks forward to working with Defra, the Carbon Trust and others to support progress towards resource-efficient, energy-efficient 'low-carbon' farming, where GHG emissions are in balance with carbon storage and CO_2 emissions displaced elsewhere in the economy.

The Industry Partnership's engagement in the process is based on the following principles:

- That production efficiency gains should be the focus of activity, and that domestic production should not be compromised in the face of food security concerns. Potentially, a 'perfect storm' of increasing demand for food, water and energy in the face of a changing climate lies ahead, as described by Government Chief Scientist Prof. John Beddington in March 2009. The fact that many developing countries will be hit harder by climate change may require northern Europe to become a key centre for world agricultural output.

- The need for an improved agricultural inventory that (accurately) reflects changes in agricultural practice. The current GHG accounting methodology utilised by the national inventory estimates and reports emissions at source, and separately accounts for sequestration. At present, this does not recognise abatement potential in terms of improved emissions factors, so agricultural emissions should also be expressed per unit of output to adequately reflect progress made by the industry.

- Ideally, all other GHG costs and benefits associated with the agricultural industry should be recognised, e.g. energy costs and efficiency gains for agricultural inputs, as well as on-farm renewable energy generation.

- Recognition that there are complex trade-offs with animal welfare, food safety and other environmental goals for the industry (such as biodiversity and maintenance of upland heritage landscapes).

The agricultural industry accepts that the complexities of measuring and reducing emissions of the non-CO_2 greenhouse gases nitrous oxide and methane should not delay progress in behavioural change using the best available evidence and that a voluntary approach is the most effective driver of action. In contrast, the measurement and abatement of direct CO_2 emissions through energy efficiency and low-carbon energy technologies is more straightforward, due to the well-understood relationship between fossil energy consumed and carbon emitted. Overall, those factors over which the agricultural sector has a degree of control at present mostly concern efficiencies of resource utilisation, as follows:

- Nitrogen – in animal manures, crop residues, biological fixation, fertilisers and animal feeds - affecting nitrous oxide emissions
- Livestock management systems - where methane emissions are related to production efficiencies
- Energy and fuels (use of which usually results in net carbon dioxide emissions)

There are a number of actions which have contributed to the estimated 20% fall in GHG emissions since 1990 and which, if adopted further and developed, will continue to contribute to the overall improvements in resource use efficiencies (see Table in Section 5). Not all of these actions are possible to capture on a farm-by-farm basis, but analysis of larger-scale trends which are readily available will help to provide relative measures of progress.

3. Structure of the GHGAP

3.1 Aims and Objectives

The GHGAP aims to:

- put the industry on a realistic but ambitious path to reduce its GHG emissions whilst benefiting farm businesses by improving productivity and efficiency of resource use, and by encouraging on-farm renewable energy generation alongside agricultural production
- develop and deliver the industry's measurable, reportable and verifiable contribution to the UK's carbon budget in 2018-2022 and beyond

The GHGAP is intended to be a living document, responsive to changes in policy and knowledge, and requiring regular change and refinement over time. As more data is generated and better understanding of agricultural systems is achieved on the basis of targeted research, it is highly likely that the scale of abatement potential will need to be modified (higher or lower) and the actions that are most feasible and likely to bring about the greatest impact will become more clearly defined.

In order to meet these industry aims, the GHGAP will identify the relative measures of progress (proxy indicators for GHG savings) resulting from the uptake of continuing development in resource efficient farming and land management. It will show how the industry's contribution to existing objectives *e.g.* the nutrient management strategic partnership, and support for the Milk Roadmap and Beef and Sheep Roadmap, is likely to result in a reduction in greenhouse gas emissions. Other voluntary schemes such as the Campaign for the Farmed Environment will work in synergy with the GHGAP. It will also demonstrate how changes in behaviour are promoted through tried and tested routes of influence by existing and established knowledge exchange and advisory services (described in the following sections). Where actions can be enhanced to achieve a more complete level of engagement, there is a role for Defra in allocating resource to complement that which is already in place.

The boundaries of this current version of the GHGAP are defined as being for England alone, and for efficiency gains and changes that take place 'on-farm' only *i.e.* excluding the rest of the supply chain. It is intended that the GHGAP will be publicly available on the websites of the organisations in the Industry Partnership.

3.2 Phased Development and Governance Structure

The development of the GHGAP will take place in two phases:

- Phase I: delivery of the GHGAP Framework to Government in February 2010 as required in the Low Carbon Transition Plan
- Phase II: formulation of a complementary Delivery Plan detailing the activities required to meet the aims of the GHGAP Framework

The development and successful delivery of the GHGAP requires partnership and action by a range of stakeholders involved in communication, advisory and knowledge transfer to farm - the statutory and non-statutory levy bodies, industry initiatives, and communication projects such as

Farming Futures[12]. The establishment of a committed Industry Partnership[13] is integral to meeting these challenges.

3.2.1 Phase I: Framework for Action

This phase will deliver the Framework for Action of the GHGAP to DEFRA in February 2010. and will describe the main aims of and the process whereby the industry intends to deliver the GHG emissions reduction contribution required of agriculture. This phase of the GHGAP will be co-ordinated by the Climate Change Task Force but developed in collaboration with the Industry Partnership (Table 1).

Table 1: Phased development and delivery of the GHGAP

Timetable	Phase	Co-ordination	Other information
10th Feb 2010	I: Framework for action	CCTF	DEFRA alternative policy shortlist also published in Spring 2010
Mid-Autumn 2010	II: Delivery	Industry Partnership	CCC special report on agriculture in June 2010 CCC advises on 4th C budget (2023-2027) in Dec 2010
2012	III: First Report to DEFRA and DEFRA review of progress	Industry Partnership	DEFRA low-carbon advisory service in place by 2011(?)
2015	IV: Proposed industry interim review	Industry Partnership	
2018	V: Budgetary period begins	Industry Partnership	

It was the Industry Partnership's view that a clear understanding of the range of its current activities, their potential for mitigation and gaps in delivery would be necessary before it could commit to developing robust relative measures of progress and their associated abatement potential. Phase II is intended to contribute towards filling this knowledge gap. However in order to demonstrate its commitment to putting in place measurable, reportable and verifiable emissions reductions, the Partnership has developed its best assessment of relative measures of progress combined with existing estimates of associated abatement potentials during Phase I.

3.2.2 Phase II: GHGAP Delivery

During the period February to September 2010 (timescale to be agreed with Government), the Partnership will assess its current initiatives and their mitigation potential and commit to developing a detailed Delivery plan(s) to implement the activities outlined in the Framework. The Delivery plan (or plans if the partnership decides that a sectoral approach is required) will:

[12] http://www.farmingfutures.org.uk

[13] ADAS, AEA, AHDB and its Sectors: BPEX, Dairy Co, EBLEX, HDC, HGCA, Potato Council; also AIC member companies, AICC, FWAG, LEAF, Farming Futures, FWAG, NIAB, Poultry representative, TAG and CCTF

- build upon the actions laid out in the Framework
- identify the appropriate delivery channels
- agree common key messages across all sectors
- utilise existing initiatives where possible, to deliver emissions reductions
- identify potential barriers to uptake of mitigation measures
- suggest mechanisms to facilitate uptake
- identify the need for government advisory support funding where gaps in advice and information provision cannot be met solely by industry's income streams
- refine where required, the relative measures of progress set out in the Framework

The Government is funding an analysis of existing 'low-carbon' agricultural advisory services which is due for completion in March/April 2010. The outputs of this project will be critical in informing the development of the Delivery plan(s) and in assessing the demand for Government support funding.

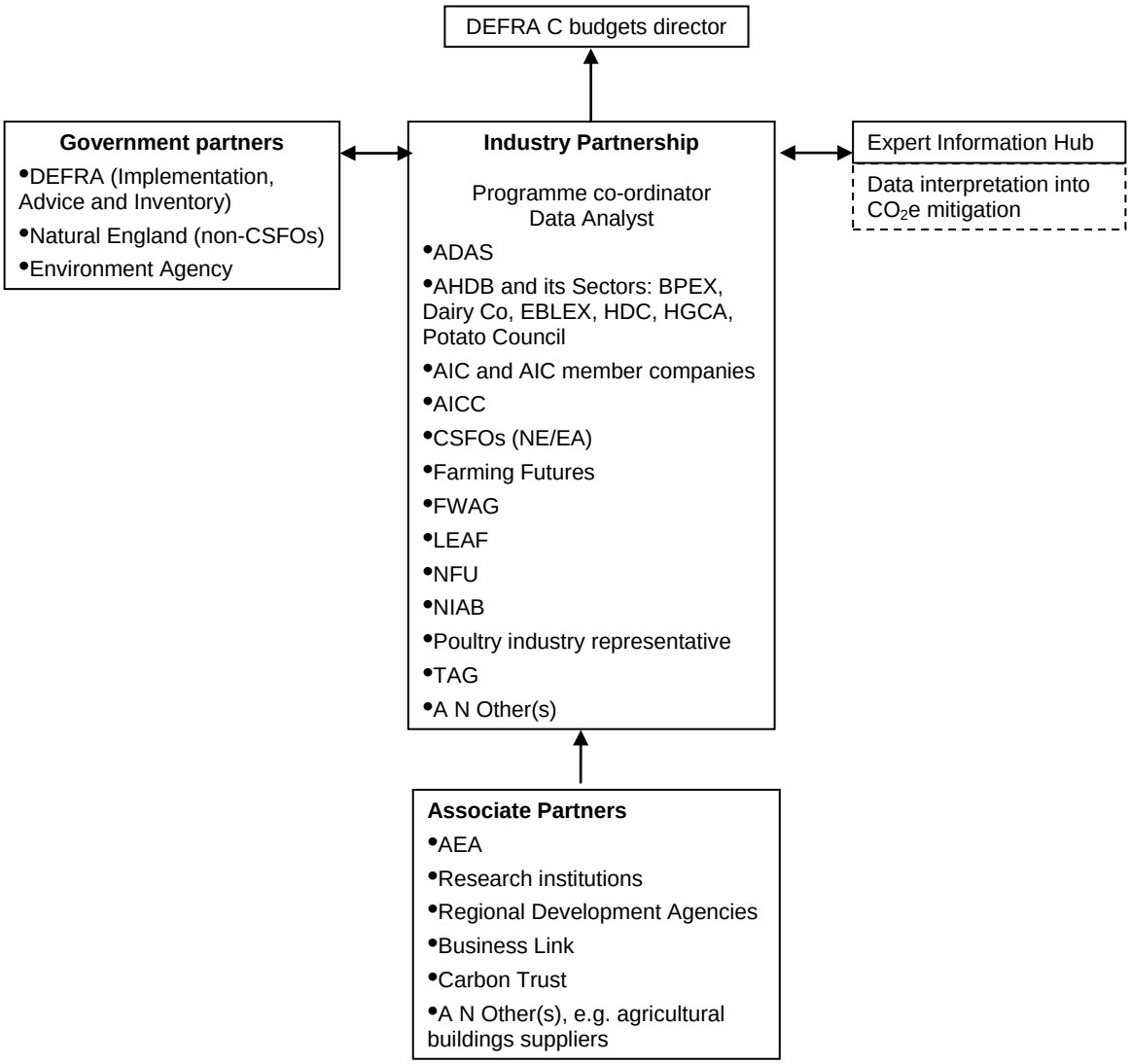
The Industry Partnership will meet in March to agree a governance structure for the Delivery phase of the GHGAP. A proposed structure is presented in Figure 1 (refer also to the following table of acronyms). It is envisaged that a Project Manager/ Co-ordinator will be required to manage the activities and outputs of the Partnership and a Data Analyst/ Reporter to interrogate all available data sources and report these in a suitable format. The industry requires support in meeting the costs of the Project Co-ordinator, and the total costs of the long-term contract for the Data Analyst's role, which would be put to open tender. The criteria for membership of the Industry Partnership and Associate Partners will be agreed during Phase II.[14]

Table of Selected Acronyms

AEA	Agricultural Engineers Association
AHDB	Agriculture and Horticulture Development Board
AIC	Agricultural Industries Confederation
AICC	Association of Independent Crop Consultants
CCC	Committee on Climate Change
CCTF	Climate Change Task Force
CSFO	Catchment Sensitive Farming Officer
CLA	Country Land and Business Association
FWAG	Farming and Wildlife Advisory Group
GHGAP	Greenhouse Gas Action Plan
LEAF	Linking Environment and Farming
NFU	National Farmers' Union (England and Wales)
NIAB	National Institute of Agricultural Botany
RDPE	Rural Development Programme for England
SAC	Scottish Agricultural College
TAG	The Arable Group

[14] Possible criteria include *e.g.* for the Industry Partnership – organisations with established routes of communication with farmers and on-farm visits

Figure 1: Possible Governance structure for Phase II of the GHGAP



This phase of the programme will ensure the collaboration and communication necessary to co-ordinate and link action which can help to reduce GHG emissions.

3.3 Data Analysis and Reporting Progress

The formulation of a delivery strategy represents only one aspect of the Partnership's work. In order to satisfy the Government's need for measureable, reportable and verifiable emission reductions, reporting progress made by the industry will be an important component of the Partnership's role.

Progress will be monitored against baseline assumptions. Assumptions made by the SAC in their 2008 marginal abatement cost curve study[15] will be included in the baselines together with information collected from other robust data sources (from relevant surveys – see Appendix 2, supporting campaigns and initiatives) *e.g.*

- Campaign for the Farmed Environment
- Catchment Sensitive Farming projects in priority catchments (benefiting air as well as water quality)
- Sector Roadmaps of AHDB
- Industry's nutrient management group[16]
- Analysis of relevant ELS and HLS options
- Farm Practices Survey – to evaluate actions in robust farming groups
- British Survey of Fertiliser Practice
- Census data (e.g. as reported in Agriculture in the UK)
- Continuing Professional Development programmes
- Farming sector benchmarking studies (e.g. the Dairy Roadmap *et al* under development)[17]
- Other relevant Government or agency funded programmes
- Farming Futures[18]
- LEAF Audit and Green Box data
- RDPE

All data, both quantitative and qualitative will be provided by the relevant members of the Industry Partnership, and made accessible, under a confidentiality agreement, to the Project Data Analyst. It is envisaged that specialist data analysis skills will be required to advise on data collection methods, to collate and interrogate collected data, to avoid double-counting and to prepare reports of progress[19]. Data will be submitted to the analyst on an annual basis and will be used in conjunction with public funded data sources (Surveys and Projects) to produce reports, demonstrating contributions to the relative measures of progress outlined in the Plan Reports generated by the data analyst will be reviewed by the Partnership in advance of their publication, at intervals of 18 months from January 2012. The proposed Government review in 2012 will need to audit whether this process has been adequately established.

Many of the actions outlined in the GHGAP are already known but are being adopted to a varying extent. The aim is to monitor the continual improvements in uptake and to report the farm efficiencies that are relevant for each farming type. The Partnership believes that the report of its work will paint a national picture of farm management improvements in fertiliser efficiency, manure management, soil management and livestock feeding and breeding, and their potential for reducing GHG emissions based on a comprehensive understanding of what is happening within farm groups and in geographical areas.

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[15] UK marginal abatement cost curves for the agriculture and land use, land use change and forestry sectors out to 2022, with qualitative analysis of options to 2050. Moran *et al*. Final report to the Committee on Climate Change. Project reference RMP/4950. SAC 20/11/2009.

[16] 13,800 copies of Tried & Tested Nutrient Management Plan already distributed, upon request

[17] Existing sector-based activities e.g. EPDF and Milk Roadmap have existing targets and figures which GHGAP could re-audit, ascribing estimated savings

[18] Qualitative data, behavioural change, relative measures of progress

[19] It is proposed that the data analyst be contracted by Government to provide both itself and the Partnership with a robust data analysis and reporting system. It would be advantageous if the data analyst were in place during Phase II of the GHAP to inform the development of such a system.

3.4 Data Interpretation

The Industry Partnership proposes the establishment of an Expert Information Hub in order to meet the combined needs of Government and the industry, for the independent analysis of a robust dataset of relative measures of progress which can be converted into estimates of GHG emissions savings. It is envisaged that the contractor (Project Data Analyst) responsible for producing the industry progress reports on behalf of the Delivery and Reporting Group would be one of the 'hub' of independent experts capable of undertaking the necessary interpretation of the reported datasets into estimated CO_2e mitigation. We propose that the Data Analyst has a key role in the development of the Defra surveys and other reporting mechanisms.

3.5 Realistic emissions reduction potential

Not all farming sectors have the same potential or opportunity for improvement, so it is important to understand the realistic potential for efficiency savings in each robust farming group. For example, a low uptake of advanced in-field 'precision farming' technologies in an area characterised by grassland should not be viewed as failure to implement improvement; neither should it be assumed that such technologies are fundamental to achieving efficiencies. Uptake of simple management tools and use of the recommended equipment or components (e.g. soil, manure analysis and trailing shoes) may offer relatively low-technology, affordable solutions to achieve the desired outcome. By comparison, a farmer with a high standard of management capability and the latest in-field technologies available may have little scope to make additional improvements, and will almost totally rely on improvements in genetics to make further progress (taking correspondingly longer for such improvements to be detectable).

Realistic expectations should be made for each farming group and the extent of action and uptake of appropriate tools measured against these. For example, only 7% of arable area has a 'high' or 'very high' potential for variable application of nitrogen, whereas a greater area has potential for variable rates of phosphate and potash – nutrients that are important determinants of nitrogen use efficiency.

The Industry Partnership looks forward to working with Government to identify the remaining potential for basic efficiency improvements through a more thorough analysis of market segmentation, and to support the adoption of new technologies and scientific advances, as they are made available through the proposed Information Hub.

4. Government's contribution to addressing gaps in communications

4.1 Knowledge transfer

Efforts will be made to reach all sectors of the farming community by the many and varied routes of communication using established channels. Inevitably the levels of successful communication resulting in positive change will also vary and there will be gaps in success. We propose that those who have the experience in working with farmers on a sector by sector basis are asked to identify where (within their current level of activities) actions could be enhanced to capture a more complete level of interest in improving farming efficiencies. Each AHDB sector and/or industry body will be asked to propose a plan as to how complementary government funding could be dovetailed into existing work programmes. A consortium approach to developing these plans could be desirable. These plans would address the gaps identified by this process and by the Government's agricultural advisory services analysis project.

We strongly recommend that these trusted routes of advice and information exchange provide the vehicles for the N_2O and CH_4 aspects of the government's proposed Low-Carbon Advisory Service[20]. Therefore, the remit of this service would i) cover CO_2 emissions by delivering advice on energy efficiency and renewables, and ii) enhance the advice on N_2O and CH_4 delivered through existing services.

In summary, apart from specific energy advice, we believe Government's partnership role in the GHGAP should be directed in two ways:

i) To fill the gaps in advice and knowledge via the levy bodies and existing industry services or to enhance these services as described above, to provide any additional technical advisory support to farm that is required.
ii) by providing long-term core support for Farming Futures or a similar project in a complementary communications role through a range of media activities.

Both of these corresponding functions are necessary. One of the biggest threats to the success of the GHGAP is the quantity of competing communications to farm. Many organisations focused on co-ordinating their activities to achieve the common aims of the Plan will help stream-line activities but the role of good communication professionals in our industry, such as that offered by Farming Futures, should not be under-estimated. Both technical and communications experts have joint roles in this Plan, providing consistent messages without duplicating effort. The role of agricultural suppliers and distributors will also be important in reaching the less efficient 'late adopter' producers.

[20] Such an advice forum might include AHDB, land agents, Regional Development Agencies, the Carbon Trust, FWAG, Business Link, etc. – organisations that can identify gaps in existing low-carbon advice, and develop more comprehensive services to fill these gaps.

4.2 Research and Development

The Industry Partnership is aware that the GHGAP should be viewed against the Government's longer term trajectory for GHG reductions through to 2050, and examined in the context of a range of possible scenarios associated with this timescale.

Beyond 2020, possible future actions may be adopted into the Plan as new scientific evidence, technologies and products emerge. Furthermore, as the ability to account for changes in farm practice and spatial variability within the UK GHG Inventory become more sophisticated, it is likely that the level of uncertainty in estimating agriculture's GHG emissions can be reduced.

5. Framework of the GHG Action Plan

For each targeted improvement in farm practice, *e.g.* improving fertiliser utilisation efficiency, manure management, it is envisaged that associated actions, delivery channels and relative measures of progress will be identified and refined. The Industry Partnership has attempted to map these proposed Aims and Actions against the Mitigation Method codes in the analyses by SAC[21] and ADAS[22]. Actions under each Aim are mostly Voluntary Policy Instruments (ADAS, p. iv) although there is scope for some GHG savings from existing Regulatory PIs (e.g. NVZ regulations) and Economic PIs (Agri-Environment Schemes).

The table that follows is divided into two parts:

- A: lists the aims and actions covered by the national inventory **so that the desired GHG reduction target (3 Mt CO_2e)** has been satisfied through abatement of N_2O and CH_4, for conformity with IPCC reporting standards.
- B: covers other abatement potential offered by the industry

5.1 Limitations, risks and other issues

The following tables should be regarded as indicative of the type of activities and scale of benefit the Industry Partnership seeks to implement. However, we anticipate that additional activities beyond the scope of the SAC and ADAS analyses will be included in the final delivery plan. This being the case, these tables do not represent an exclusive or indeed finalised statement of action.

Note also that some of the abatement potentials identified here go beyond the bounds of the SAC and ADAS analyses. These abatement potentials are based on the best available estimates at the time of writing, and they will be subject to refinement as further evidence and analysis becomes available. It is likely that individual sectors of the agriculture and horticulture industries will wish to examine in detail these potential abatement opportunities, having been presented with the framework outlined in this Action Plan. The proportion of abatement allocated to particular actions in particular sectors may therefore change, as sectoral analyses are refined and the validity of particular assumptions is challenged.

The relative measures of progress towards achieving the abatement potentials are considered realistic at the time of writing. However, it must be borne in mind that externalities such as animal disease outbreaks or extreme weather conditions may impede progress towards these goals.

[21] UK marginal abatement cost curves for the agriculture and land use, land use change and forestry sectors out to 2022, with qualitative analysis of options to 2050. Moran *et al*. Final report to the Committee on Climate Change. Project reference RMP/4950. SAC 20/11/2009.

[22] Analysis of policy instruments for reducing greenhouse gas emissions from agriculture, forestry and land management. Project RMP/5142, ADAS May 2009. 144 pp.

A: GHGAP aims and actions to deliver N_2O and CH_4 emissions reductions recognised by the national inventory for the 2018-2022 budgetary period (Mt CO2e/year)

Aim	Action	Possible abatement potential 2020 Mt CO_2e/year	SAC report code	Relative measures of progress[23]			Delivery channel
				2012	2015	2020	
Nutrients							
Reduce N_2O per unit of N applied (optimise N per tonne marketable crop)	Nutrient Management Planning and application practice (inc timing)[24]	0.6Mt	AG, AJ, AE, AD, AB, AL, AM, AH	Plan of suitable standard[25] used on an additional 30% of ag land.[26]	Plan of suitable standard used on an additional 40% of ag land. Potential new advice on N timing.[27]	Improved timing of N applications realise a further 5% in N utilisation efficiencies.	Industry Advice[28]; NVZ Action Programme; Cross compliance; RTFO
	Differential application of fertiliser (variable rate technologies)			Cost savings or improved output from an additional 5% of tilled land	Cost savings or improved output from an additional 10% of tilled land	Cost savings or improved output from an additional 15% of tilled land	Fertiliser suppliers; Specialist services; Industry advice
	Manure management[29]- based on manure management plans	0.1Mt	AJ, AE, AO, AB	Improved nutrient utilisation efficiencies of	Improved utilisation efficiencies of	Possible further efficiencies of 10-20% through	NVZ Action Programme; Cross compliance;

[23] Extracted from datasets referenced in section 3.3 and Appendix 2
[24] Manures, fertilisers and other organic sources (inc. recycled nutrients/ co products) both individually and in combination. Possible areas of focus: machinery calibration and accurate application of recommended rates
[25] Industry's Tried & Tested Nutrient Management Plan is the standard
[26] RTFO (Renewable Transport Fuels Obligation) on crops grown for biofuels promotes similar 'sustainability approach' for other crops on the farm
[27] New advice available to farmers giving added % efficiency
[28] Including Fertiliser Advisers Certification and Training Scheme (FACTS) http://www.factsinfo.org.uk/facts/ ; Tried & Tested; MANNER and PLANET
[29] Application to land of manures and slurries only.

				manures achieved on an additional 20% of grassland 2% of tilled land	manures achieved on an additional 30% of grassland, 5% of tilled land Potential new advice available	nitrification inhibition[30]. Further 5% in manure N utilisation from latest guidelines	Government advice support; EA; CSF
	Soil and manure testing[31]		AG, AJ, AE, AL AD		Cost savings/ improved output from an additional 20% of grassland 15% of tilled land	Cost savings/ improved output from an additional 30% of grassland	Industry advice
	Participation in local resource protection initiatives[32]				Reduced pressure of nutrient loadings to water by additional 5%[33]	Reduced pressure of nutrient loadings to water by additional 10%	CSF – i) national strategic actions and ii) priority actions plus CFE
Soil and land management[34]	Uptake of Soil Management Plans. Continue and enhance training and education in soil management[35]				Soil structure improvements to additional 20% of farmed area	Potential for adoption of new guidance based on research adds to %	Industry advice; Environmental Stewardship; CSF
Selection of crop varieties with traits which favour reduced N_2O emissions		0.2Mt				Selection and generation of enhanced varieties.[36] High starch varieties may improve N utilisation 10-	NIAB; AIC seed suppliers Qualified advisers and agronomists

[30] Cost/benefit of inhibitors is a constraint. Government to address cost issues associated with this opportunity.
[31] Generally farms ordering fertiliser and feeds without in-house knowledge or advice
[32] Farms in areas without strong co-ordination activities (e.g. Catchment Sensitive Farming) in the region. To improve soil protection & nutrient management planning & resource (input) efficiencies.
[33] Improving crop recovery and risk of loss as N_2O
[34] Climate (soil temperature and wetness) and soil type are the most significant determinant of nitrous oxide emissions
[35] This includes knowledge of cultivation techniques, benefits of drainage and reduced compaction from wheelings/animals. The declining numbers of soil scientists is of concern in this area.
[36] This includes nutrient efficient varieties. Potential for high starch varieties for biofuels to improve actual nitrogen utilisation.

						15+%	
Reduce NH_3 emissions[37]	Manure management and urea N- increased risk of loss from AD digestate[38]		AJ, AE, AO, AD, AM		Changes to livestock housing reduce emissions by additional 10%[39] Manure and slurry handling storage and spreading reduce emissions by additional 10%[40]	Changes to livestock housing reduce emissions by additional 15% Manure and slurry handling storage and spreading reduce emissions by additional 15%	Levy bodies; Government advisory support; Industry advice

[37] Although not a GHG, ammonia (NH3) is included here, because of the strong linkage between existing actions focused on NH3 and beneficial nutrient and livestock management.
[38] Application to land of manures and slurries only
[39] Housing improvements and management
[40] Includes in-house handling and spreading using low NH3emission application equipment

Aim	Action	Possible abatement potential 2020 Mt CO_2e/year	SAC report code	Relative measures of progress			Delivery channel
				2012	2015	2020	
Livestock							
Reduce CH_4 and N_2O from manures and slurries	Overall manure and slurry management[41]		FA, FB, FC, FD, GA, GB, GC, GD, IA, IB, IC, ID	Additional 5% of land (i.e. that outside NVZs adopting parallel good application practice) Additional 5% of land in NVZs adopting improved manure/slurry handling and application	Additional 10% of land (i.e. that outside NVZs adopting parallel good application practice) Additional 10% of land in NVZs adopting improved manure/slurry handling and application	Additional 15% of land (i.e. that outside NVZs adopting parallel good application practice) Additional 15% of land in NVZs adopting improved manure/slurry handling and application	
	Deployment of on-farm AD systems	0.55 Mt[42]	EB, EC, EE, EF, EH, EI	1-2% of manures, or ~1-2 M tonnes[43]	8% of manures	20% of manures	Private sector sales; AD Implementation Plan; AD Portal web site
Manipulation of ruminant diets to	Dietary changes and beneficial additives[44]	0.5			Potential for estimated 5%[45]	Potential adoption of more efficient	Levy bodies; Industry advice

[41] Storage and handling of manures and slurries only.
[42] Based on 1000 plants processing and abating emissions from 20% of all manures. Uncertainty (as of February 2010) about level of uptake of smaller-scale on-farm AD, given proposed levels of Feed-in Tariffs. Larger AD projects more likely supported by both Renewables Obligation and Feed-in Tariffs
[43] Mostly pig, beef and dairy, processed by >50 AD plants and applied to land as digestate.
[44] Conflicting legislation and evidence base for change
[45] Through application of existing knowledge and new R&D

reduce CH_4						dietary formulations may reduce emissions by a further 10-15%	
Overall feed efficiencies[46] - reducing N_2O and CH_4 per animal	Optimal livestock feeding[47]	1.1	CG, BF, BI, BB		Numbers fed to a recognised feeding plan/regime An additional 20% of livestock[48]	Added benefits of animals bred with improved conversion efficiencies –more likely post 2020[49]	Nutritionists; Levy boards; Vets; Industry advice Government advice support
Increased productivity, lower CH_4 per animal	Improved health and welfare of livestock[50]						

[46] Optimise N per Kg meat/ N per litre milk
[47] N in feed; animal nutrition efficiency. Need to look at available information and advice on feed management systems on farm
[48] Potential for co products of biofuels to displace a % of imported feed (increased demand for domestic wheat a constraint.)
[49] Measures likely to be superceded by units of performance by species type – converted into CO_2e and results from actual farm benchmarking studies - provided by for example: Dairy Co, EBLEX & BPEX.
[50] The Industry Partnership is aware that there may be potential benefits of improved livestock health in reducing emissions but feels there is insufficient evidence at this stage to clearly identify measures of progress

B: GHGAP aims and actions to deliver emissions reductions associated with agriculture in England but currently not recognised by the national inventory for the 2018-2022 budgetary period

Aim	Action	Possible abatement potential 2020 Mt CO_2e/year	SAC report code	Relative measures of progress			Delivery channel
				2012	2015	2020	
Nutrients							
N_2O abatement in N fertiliser manufacture [51] - European and global production	Investment in abatement to realise 50% reduction of current N_2O levels in Europe by 2015[52]	> 3 Mt abatement from total wheat area[53]	Indirect emissions from farm products		More than 75 % of AN-based fertiliser consumed on England's farmed from abated facilities	More than 85 % of AN-based fertiliser consumed on England's farmed from abated facilities	
Livestock							
Compound feed energy savings (CO_2) – domestic production only			Indirect emissions from farm products		CC Agreements commit animal feed mills (UK) to reduce CO_2 emissions by an additional 7%		

[51] Indirect emissions, not counted as part of the agricultural inventory but an important upstream area for mitigation
[52] Calculations based on Ammonium nitrate (AN). Future work may include understanding amount of fertiliser imported from non abated facilities
[53] Indirect emissions, not counted as part of the agricultural inventory but an important upstream area for mitigation. Additional mitigation for other crops to be calculated

Aim	Action	Possible abatement potential 2020 Mt CO_2e/year	SAC report code	Relative measures of progress			Delivery channel
				2012	2015	2020	
Energy efficiency and renewables[54]							
Energy	Improved fuel efficiency of farm machinery but also fuel alternatives inc. hybrid, hydrogen, electric and self propelled options[55] Reduced fuel consumption due to variable rate technologies[56]				The aim is for an additional 5% reduction in overall fuel consumption[57]	Further savings to be advised in time	Accelerated vehicle replacement?; Government advice support; 'Seed Financing'
	Improve energy efficiency of farm buildings and on-farm processing[58] Improve building design and management	0.03 Mt[59]		Successful applications to CT loan scheme			Government advice support; C Trust; RDPE support; Climate Change Levy Agreements[60]
	Renewable energy supply (vehicles, buildings, on-	19.2 Mt [62]		Uptake of local and regional grant	also data from UK National Action		Government advice support; CT loans;

[54] Not included in SAC report
[55] As discussed with AEA
[56] ~50% reduction resulting from fewer passed and advances in crop protection
[57] Confirmed by AEA
[58] Eligible for proposed Carbon Trust (CT) interest-free loans for energy efficiency and low-carbon energy, savings easily measurable – could CT support be extended to include non-CO_2 GHG savings such as precision fertiliser spreaders?
[59] Based on 1000 x £12k loans @ 2.5 t CO2/£1000
[60] Climate Change Agreements for specific sectors

	farm processing, exported energy and fuels)[61]			support; data from FIT, RHI and RO;	Plan for Renewable Energy Directive		RDPE support

[62] Electricity, heat, solid biomass fuels and transport. 3.3 MtCO2 displaced as direct electricity (6 TWh from 500 MW AD + 1.75 TWh from 1000 MW wind, hydro and PV, displacing UK grid average electricity at 0.43 tCO2/MWh); 1.6 Mt as heat based on 6 TWh from AD/CHP, displacing oil at 73 tCO2/PJ; 11.5 Mt as solid fuels (4 Mt straw + 3.5 Mt perennial energy crops, displacing coal at 93 tCO2/PJ; 2.75 Mt as transport fuels (5% of 110 MtCO2 from transport, assuming 50% net GHG saving). FIT = Feed-in Tariff scheme, RHI = Renewable Heat incentive scheme, RO = Renewables Obligation for electricity generation

[61] Some technologies potentially eligible for CTloans

Aim	Action	Possible abatement potential 2020 Mt CO_2e/year	SAC report code	Relative measures of progress			Delivery channel
				2012	2015	2020	
Carbon storage							
	New woodland planting[63]	1.25 Mt				A 3 fold increase in current planting rates could increase sequestration by 1.1Mt/year by 2020	
	Peat (slowing degradation)	1.47 Mt[64]					
	Management of hedges/ buffer strips[65]						Environmental Stewardship
	Soil carbon enhancement under perennial energy crops	0.31 Mt[66]		Data from energy crops scheme and energy users[67]			NE

[63] Forestry Commission England proposal of 10,000 ha/year for 40 years to 2050
[64] Byrne et al 2004
[65] Modest contribution expected. This is already in the baseline
[66] Based on 350 kha in England alone @ 0.24 t C/ha/year net soil C storage. Assuming average soil carbon increase from 2.0% to 2.5% SOM to depth of 0.3m (1.5 kg/m2) over 25 years. Note that this is independent of the offset contribution from export of biomass fuel.
[67] Presently poor uptake of establishment grants needs to be addressed. Likely modest impact on food production area. Data needed on permanence of C storage under long rotation

Aim	Action	Possible abatement potential 2020 Mt CO2e/year	SAC report code	Relative measures of progress			Delivery channel
				2012	2015	2020	
Communication and training							
Raising awareness of GHG emissions and related actions	Coordinate communications through partnerships Support the development of carbon accounting at a farm/estate level[68]						Farming Futures; Industry; Levy bodies
Improve skills and proficiency of land-based sector[69]	Content of training updated to include GHG mitigation						BASIS; Industry CPD; LANTRA[70]
FACTS Qualified Advisers updated	FQAs to lose their status without additional CPD Training in Nutrient Management Planning				Cut-off date for additional training to be completed		FACTS Scheme; Peer pressure
Education of next generation of farmers and advisers	Integrate GHG mitigation and adaptation into new qualifications						Schools, colleges, universities,

[68] For example, by using CALM, C-Plan
[69] NPTC, farmers taking FACTS courses, FACTS Qualified Advisers required
[70] New training initiatives

Appendix 1: UK GHG emissions breakdown

Wales, England, Scotland and Northern Ireland emissions breakdown (2007)

	Emissions (Mt CO_2e)[71]	% of UK agricultural emissions
England	27	61
Scotland	7	16
Wales	5	11
N.Ireland	5	11

Appendix 2: Examples of DEFRA datasets relevant to GHG Action Plan reporting

Farm Practices survey https://statistics.defra.gov.uk/esg/publications/fps/default.asp
Results are given according to farm size (small, medium, large), by region and by farm type.
Information available:

- Soils advice – mostly cross compliance
- Precision farming – use of
- Nutrient management - % with nutrient management plan, method of creating plan, source of recommendation, seeking professional advice, source of advice, frequency of updating, seeing financial benefits, nutrient testing of soil, nutrient testing of manures + assessing nutrient content, manure management plan
- Financial risk management – includes question on numbers willing to increase collaboration if it reduced their carbon footprint
- IFM – water management plan, LEAF, farm energy efficiency policy, record of GHGs, ES
- Recycling
- Farm health – monitoring animal performance and health, farm health plan
- Also Uncropped land; Farm assurance; Responsibility and Cost sharing

British Survey of fertiliser practice https://statistics.defra.gov.uk/esg/bsfp/2008.pdf
Information available includes:
Fertiliser use by crop and for grass by cutting and grazing management

- Timing of application
- Product type by crop group and month of application
- Average practice on livestock farms

[71] Million tonnes CO_2 equivalent

- Manures
    - % farms using each type of manure
    - Application method
    - % incorporation by timing and manure type
    - Dm and nutrient content
    - Estimated average rates of total N to crops and grassland
    - Fertiliser application +/- manure
    - Spread pattern checks
    - Record keeping

Farm Business Survey
Cropping, stocking, labour, outputs, inputs and income by size and performance band

Agriculture in the UK
Details acreage, livestock numbers (from CTS), training, input prices, vet expenses, ag services, (including contractors), animal feed, food chain, payments, animal health and welfare (including bTB), environment (including emission from inputs; NH_3, CH_4, N_2O; renewables generation; ecosystem valuation, comparisons with other member states.

Cattle Book
Numbers, breeds, age, births, mortality