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Executive Summary

This report analyses best practice policy case studies for the agriculture sector which may serve as examples for Member States of policies that could be implemented at a national level to meet targets set out within the EU Effort Sharing Decision (ESD).

The agriculture sector differs from other sectors since methane (CH_4) and nitrous oxide (N_2O), not CO_2, are the main greenhouse gasses. In order to limit these emissions, the main abatement measures can be grouped into four main categories, i.e. i) changes in feeding rations for cattle and improved cattle fodder (mainly aimed at lower CH_4 emissions from manure storage and ruminants, respectively, and ii) anaerobic digestion (ruminants versus non ruminants e.g. pigs and poultry), iii) reduced N-application (aimed at less N_2O from soil applications of fertilizer and manure) and iv) application of nitrification inhibitors.

However, there are a number of barriers which limit the take up of these measures currently. The main barrier for farmers is related to higher costs for implementation of the specific measures and application of technologies. Other barriers include a lack of information and awareness among farmers about the possible abatement measures and of the potentials for reducing emissions of greenhouse gases on farm. Policy interventions can help to address these barriers.

The relative strengths and weaknesses of selected policies and measures for mitigating greenhouse gas emissions in the agriculture sector have been explored as case studies. The case studies have considered policies that target emission reduction for CH_4 from manure management, through the promotion of anaerobic digestion, and policies that target N_2O from soils.

Policy incentives to support the adoption of anaerobic digestion (AD) serve two goals: the management of manure and the reduction of methane as well as the production of renewable energy to displace fossil fuel. Financial incentives may target the production of electricity or might target the investment in the production plant. Although no information is available about the effectiveness and efficiency there are signs that incentives that target the electricity production are more powerful than incentives for investments in the plant. However, in terms of environmental effectiveness it can be questioned whether such incentives are desirable.

This principle of stimulating production by means of fixed prices for energy produced has become out dated during the subsequent reforms of the CAP and today steering incentives are more based on (environmental) goals rather than production volume. Moreover, as biogas yields substantially increase by co-digestion, i.e. addition of other digesters to manure, there is a risk that manure is substituted by other substrate. This development is in some way counter-productive as one of the major benefits of biogas plants is its ability to improve manure management and reduce GHG emissions from raw manure storage. Economic policy measures should therefore be a combination of support for investments and a smart regulation for co-digesters that ensures the optimal use of manure as a digester.

In agriculture, farmers would need a more profound change in their management skills and options. There are no specific or general incentives for farmers and land owners to manage their land and select plan activities in order to reduce emissions of greenhouse gases including the emissions from soil carbon or stimulate the carbon removal from the atmosphere (soil carbon sink). Most farmers are not yet aware of their full impact through management practices and implementation of technologies on emissions of greenhouse gases. They cannot (or have no access to a tool to) calculate their farm GHG balance and changes as a result of their specific action. Such knowledge or the availability of a calculation tool would certainly stimulate farmers awareness on the options.

In addition, the implementation of targeted policies might further add to improve the knowledge and management skills to farmers and provide the necessary tools and advice for them to act wise and with impact. It may help if payments and subsidies are in place to reward impact and stimulate activities and measures to be selected and implemented. The primary option would be to get along with the reform of the CAP. Such activities would likely include a farm greenhouse gas balance

(voluntary of mandatory), benchmarks and fees or payments for climate friendly and responsible farm management and some for quality control that would be put in place for the implementation of the CAP anyway.

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1 Introduction

1.1 Background

This report has been prepared by **Alterra**, in collaboration with AEA, as the part of the study *Next phase of the European Climate Change Programme: Analysis of Member States actions to implement the Effort Sharing Decision and options for further community-wide measures.* The project has been funded by DG Climate Action of the European Commission (EC) with the aim of assisting the EC in the identification of policies and measures that enable the Member States to fulfil their national commitments under the Effort Sharing Decision (ESD).

In earlier phases of the project an assessment was made of the projected emissions of greenhouse gases to 2020 in each of the main ESD sectors, the potential gap between the projected emissions and the ESD target, and the abatement measures that could be implemented to reduce the emissions gap. In addition, a high level review was provided of the policies and measures in place at Member State level. Further information on the ESD, on Member State's targets under the ESD, and analysis described above can be found in the report AEA/AlterraEcofys/Fraunhofer ISI (2012).

Building upon the earlier work, this report provides a more detailed examination of the policy options that could be implemented at a national or EU wide basis in order to deliver additional emissions reductions. The focus of the analysis is on additional policies that could be implemented to support and complement existing EU-wide policies.

This report is focused on policies targeting emission reductions in the **agriculture sector.** A series of case studies have been prepared to illustrate examples of existing policies that could be replicated to deliver additional abatement. In each case an assessment has been provided of the relative strengths and weaknesses of the different policies, including the synergies and co-benefits.

The case study policies selected are not intended to be exhaustive. Other policies have been, and could be, implemented to deliver similar objectives. This report therefore presents a sample of the policy available to decision makers looking to mitigate greenhouse gas emissions from the agriculture sector.

1.2 Characteristics of the agriculture sector

The EU agriculture sector provides food, feed and renewable energy. The average contribution of agriculture to the gross domestic product (GDP) is 1.3% for the EU, however among the member states there is a large variation (0.3%-4.7%)[1]. The total agricultural area is about 188 million ha, which is about 45% of the total land area. According to the FSS (farm structure survey) data[2], there were about 13.7 million farms in the EU-27 in 2007. However, almost half of these farms (6.6 million) are considered as subsistence farms, which have only a few animals or relatively small agricultural area to farm.

The agriculture sector differs from other sectors since methane (CH_4) and nitrous oxide (N_2O), not CO_2 are the main greenhouse gasses. In terms of emissions accounting the agriculture sector (IPCC category 4) only includes CH_4 and N_2O emissions, and these emissions are in the scope of the ESD. The main emissions sources are CH_4 from enteric fermentation by ruminants, soil N_2O emissions from mineral fertilizer and manure and manure management. The main drivers for these emissions are the number of livestock, especially ruminants, and the use of mineral fertilizers. Agriculture also affects emissions accounted for in other sectors. The CO_2 emissions from cropland and grazing land management and from land use changes are accounted for in the LULUCF sector, which is not included in the ESD, whereas the emissions from fossil fuel use (e.g. for farm operations and horticulture/greenhouses) are accounted for in the Energy sector, and are partly included in the ESD.

[1] http://ec.europa.eu/agriculture/publi/capexplained/cap_en.pdf
[2] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Farm_structure

1.3 Emissions, policy gaps and abatement potential

1.3.1 Projected emissions

In the EU-27, the agriculture sector (IPCC category 4) has an emission of 476 $MtCO_2$ eq according to the UNFCCC submissions of 2009. This is about 10% of the total EU-wide GHG emissions and about 18% of the GHG emissions within the ESD. Emissions of greenhouse gases have been in gradual decline over the past two decades. From 1990 to 2009, emissions fell by one-fifth. The reductions in the agriculture sector experienced so far have been mostly due to reductions in number of livestock, which decreased especially in the beginning of the nineties in the new member states, due to the economic and structural changes after the collapse of the former Eastern Bloc. In most EU-15 countries the number of livestock also have been reduced due to implementation of animal welfare regulations and the Nitrates Directive, which puts a limit to the amount of animal manure that is allowed to be applied.

According to projections made in 2010 using the GAINS model (Höglund-Isaksson et al., 2010), the baseline emissions scenario only shows a very minor decline, from 471 $MtCO_2$ eq. in 2005 to 463 $MtCO_2$ eq. in 2020, The total number of livestock is projected to remain more or less constant, with a slight decrease in cattle number, but increases in pigs and poultry. The Nitrogen (N) fertilizer consumption in the 2020 baseline scenario is projected to slightly increase (Höglund-Isaksson et al., 2010). However, projections are uncertain, and changes in market prices and human diets have a large impact on the amount and distribution of livestock and crops. Furthermore, the potential agricultural intensification in Central and Eastern Europe depends on the uptake of biomass cultivation for bio-energy and food prices.

The Effort Sharing Decision (ESD) establishes annual binding greenhouse gas emission targets for Member States for the period 2013–2020. These targets concern the emissions from sectors not included in the EU Emissions Trading System (ETS), such as transport, buildings, agriculture and waste. Each Member State will contribute to this effort according to its relative wealth measured as GDP per capita. At the EU level, this will deliver an approximately 10% reduction of emissions from the covered sectors in 2020 compared with 2005 levels. Whilst no sector specific target exist, if the agriculture sector were to make a proportionate contribution to the overall ESD target, in line with the emissions from the sector in 2005, then this would relate to an absolute emission of 431 $MtCO_2$ eq in 2020, based on the ESD targets for each Member State. Compared to the current GAINS baseline projection and the WEM (with existing measures) projections by the Member States, the calculated emission reduction is only small and not sufficient to reach the ESD target. This shows that there is still a large policy gap if Member States want to reduce emissions from agriculture proportionally to the ESD target.

1.3.2 Abatement potential

The abatement measures for agriculture can be grouped into four main categories, i.e. i) changes in feeding rations for cattle and improved cattle fodder (mainly aimed at lower CH_4 emissions from manure storage and ruminants, respectively, and ii) anaerobic digestion (ruminants versus non ruminants e.g. pigs and poultry), iii) reduced N-application (aimed at less N_2O from soil applications of fertilizer and manure) and iv) application of nitrification inhibitors.

Reduced N application is being used as result of implementation of measures to reduce N emissions under the EU Nitrates Directive. For anaerobic digestion several Member States have or are developing policies to stimulate anaerobic digestion of animal manure. For nitrification inhibitors and improved cattle fodder, both measures are currently still at an experimental stage and not applied at large scale.

According to the projected technical mitigation potentials from the SERPEC study (SERPEC, 2009) the total mitigation potential in agriculture could be as high as 122 $MtCO_2$-eq per year by 2020, which is in the same order of magnitude as the GAINS results. This is 26% of the projected 2020 baseline emissions from agriculture. For about 40% of this mitigation potential (50 $MtCO_2$-eq) the costs are estimated to be less than €25 per ton CO_2-eq. These estimates should be treated with some caution as limited testing in practice nor extensive implementation has been recorded across Member States.

For certain measures there are some large differences in the projected emissions savings from the technical potentials in the SERPEC study and those estimated in Member State policy studies. This may indicate that it might be difficult to deliver the potential emission reductions in practice.

1.4 The need for policy intervention

As stated in Section 1.3.1 the projected baseline emissions from the sector agriculture are 463 $MtCO_2$ eq. in 2020, whereas the required emission level to reach the ESD target, assuming a proportional share of the overall ESD target, is 431 $MtCO_2$ eq. This shows that there is still a large policy gap if Member States want to reduce emissions from agriculture proportionally to the ESD target. Consequently, the technical abatement potential (Section 1.3.2) is much larger and measures with a cost of less than € 25 per ton CO_2-eq may be sufficient to reach this illustrative target[3]. However, there are certain barriers and market failures in place which may limit the take up of this abatement potential.

The main barrier for farmers is related to higher costs for implementation of the specific measures and application of technologies. For example, in the case of anaerobic digestion the prices a farmer can receive for the energy produced are not sufficient to cover all cost and as a result - without economic incentives - the uptake will be low. Other barriers are lack of information and awareness among farmers about the possible abatement measures and of the potentials for reducing emissions of greenhouse gases on farm. Many farmers and activities have not been labelled in terms of emissions of (levels of) emissions greenhouse gases nor have target for the sector or farmers been discussed and set in most or all Member States.

For some other measures, e.g. nitrification inhibitors, research is ongoing and the effectiveness of the measure remains rather uncertain. This uncertainty also holds for any positive effect on yield of crops or grassland based on the application of (expensive) nitrification inhibitors to limit nitrogen losses and nitrous oxide emissions. The same holds for improved cattle feed: reduction of methane due to changes in diet are rather certain, but often come at higher cost (buying additional feed or re-structure on farm production of different feed crops) or farmers would not be familiar with technology or reluctant to adapt on-farm feed production strategy. Contrary, the effect of feed additives on the rumen methane production is still uncertain and requiring research to continue.

1.5 Policy options

1.5.1 EU policy landscape

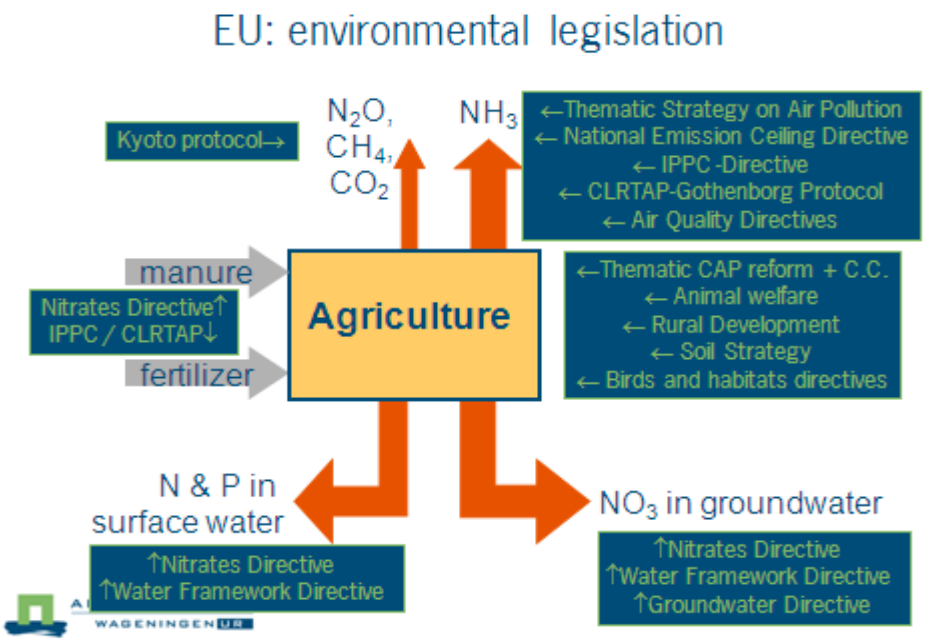
At EU level, many active environmental legislation and policies target the sector agriculture as shown in Figure 1. Several EU environmental policies such as Nitrates Directives, Cross Compliance and Good Agricultural and Environmental Conditions (GAEC) under the Common Agricultural Policy (CAP), as well as the Renewable Energy Directive have the potential to influence greenhouse gas emissions from agriculture.

The CAP reform is in progress and CAP after 2013 may include further incentives for climate related mitigation. On 12 October 2011 the Commission presented a set of legal proposals designed to make the CAP a more effective policy for a more competitive and sustainable agriculture and vibrant rural areas. The aim of the reform of the CAP after 2013 is to strengthen the competitiveness and the sustainability of agriculture and maintain its presence in all regions, in order to guarantee European citizens healthy and quality food production, to preserve the environment and to help develop rural areas. Climate action is one of the three objectives set for the CAP reform. In the proposals for the direct payments (Pillar 1) three greening measures are included, i.e. retaining permanent pasture, crop diversification and establishment of ecological focus areas and these have been defined as GAEC's and are under review and may be transformed in the current process of reforming the CAP. Under Rural Development Regulation (Pillar 2), climate mitigation (and adaptation) are also frequently mentioned and these would include agri-environmental measures.

[3] In practice, Member States are likely to review the abatement potential across all sectors, so as to deliver the target at least cost as a whole, accounting for the different potentials within sub-sectors.

Agri-environmental measures are a key element for the integration of environmental concerns into the Common Agricultural Policy. Agri-environmental measures are designed to encourage farmers to protect and enhance the environment on their farmland by paying them for the provision of environmental services. Farmers commit themselves, for a minimum period of at least five years, to adopt environmentally-friendly farming techniques that go beyond legal obligations. In return, farmers will receive payments that provide compensation for additional costs and income foregone resulting from applying those environmentally friendly farming practices in line with the stipulations of agri-environmental contracts. Examples of commitments covered by national/regional agri-environmental schemes include: i) environmentally favourable extensification of farming, ii) management of low-intensity pasture systems, iii) integrated farm management and organic agriculture, preservation of landscape features such as hedgerows and woods. In addition, in rural development policies, further payments and subsidies might be allocated to adopting innovative technologies including anaerobic digestion. Agri-environmental measures will be designed at the national, regional, or local level so that they can be adapted to particular farming systems and specific environmental conditions (see http://ec.europa.eu/agriculture/envir/measures/index_en.htm).

Figure 1: Active environmental legislation and policies that target the sector agriculture across EU27.



1.5.2 National policies

Based on the EEA database on climate change policies and measures (PAM's)[4], most Member States have defined several policies and measures that target the agriculture sector. However, many of these policies and measures are related to targets set by EU policies on air quality / ammonia (NEC Directive, IPPC, Gothenburg protocol), nitrate (Nitrates Directive) and related to the CAP (cross compliance measures). These are generally not specifically aimed at climate change mitigation and their impact may be uncertain or their impact may not show in the emission calculations or national inventories. However, most do have positive effects on reducing GHG emissions, especially on N_2O, since they lead to reduction of the amount of nitrogen inputs.

Most Member States have thus not yet defined and implemented specific policies to mitigate non-CO_2 greenhouse gases from agriculture. Some are in the process of identifying and planning policies and others have (voluntary) agreements with the agriculture sector to reduce GHG emissions, e.g. Convenant "*Schoon en Zuinig*" in the Netherlands, Green Growth Agreement in Denmark, Comprehensive Rural Environmental Protection Scheme on sustainable farming in Ireland and government-industry partnership in United Kingdom.

[4] http://www.eea.europa.eu/themes/climate/pam

1.6 Selection of case study polices

The case studies aim to summarise the relative strengths and weaknesses of selected policies and measures in member states that target emission reduction for CH_4 from manure management and N_2O from soils.

In the EU methane is primarily from enteric fermentation by ruminants and from manure management. Mitigation of methane from enteric fermentation is possible by all kinds of changes in feed intake and feed additives, and this many options are researched and at an experimental stage. Some options, e.g. the feed additive BsT (bovine somatotropin) has been demonstrated to reduce GHG emissions per litre of milk, and is used in some countries. For reasons of food security and animal welfare and concerns on consumer acceptance and preference this BsT is banned in the EU. No EU or MS policies exist yet, except for supporting further research. Therefore this case study will only focus on mitigation of methane from manure management by anaerobic digestion (AD) of manure for biogas production. AD does not only reduce CH_4 emission from slurry stores, but by capturing that CH_4, and generating more, it produces renewable energy, both electricity and heat, which can displace fossil fuels and generate additional farmers income. This technology has attracted major attention throughout many member states and is relatively well documented. In several Member State the introduction and implementation of this technology has been promoted by specific subsidy programmes.

Nitrous oxide is primarily emitted from soils following the application of manure and mineral and organic fertilizers and grazing with urine and dung deposits. A minor fraction of N_2O is coming from manure management. Currently there are hardly any MS policies that directly focus on N_2O mitigation from agricultural soils, however, many MS have policies that aim at reducing nitrogen inputs to the soil for mitigating NH_3 and NO_3 emissions. In this case study we will present examples of how MS use or extend current environmental policies to include climate mitigation objectives as well, with the focus on N_2O emissions from agricultural soils. We propose to not focus our approach for N_2O on specific technologies as is done for other sectors, for the reason that in the agriculture sector very many specific technologies are available. Many of these technologies would fit some but not all farms and selections by individual farmers would be required to determine best fit. Also, single technologies such as nitrification inhibitors have not been considered at a national and policy level. Finally, the emission sources of N_2O are characterized as being very diffuse and targeting these with specific technologies is difficult. More successful actions would be based on management and managerial decisions taken by groups of or individual farmers. For that reason we have selected the case studies to include a technology based option (CH_4 from manure management and digestion) and a managerial option on management of nitrogen losses and N_2O emissions.

2 Mitigation of CH_4 from manure management by anaerobic digestion to biogas

2.1 Background

Several European member states have implemented policies to stimulate the technology of anaerobic digestion (AD) of manure for biogas production. As AD is a well-proven technology for reducing greenhouse gas emissions by capturing methane from manure and at the same time producing renewable energy, policies supporting the uptake of the AD technology might achieve both goals.

However the driver and primary objective of the policy differs among member states. In some cases, like in Denmark, the main objective is clearly to reduce emissions from manure. While in other cases, like Germany, the main goal is to both increase the share of renewable energy over the use of fossil fuels and reduce the emissions of greenhouse gases by increasing the volume of bio-energy production. In most cases mitigation objectives are considered as a side-condition but not a main objective. This difference in main objective does influence the implementation and eventually the impact the policies have on mitigation goals.

2.2 Barriers to uptake

A recent study for DG Agri (AGRI-2010-EVAL-03) identified, based on 800 farm interviews, the main barriers for uptake of renewable energy on farms, including biogas. The most often identified barriers by farmers in most regions were: high investment costs, low profitability, uncertainty about profitability, long and complicated procedures to get access to subsidies and/or a permit or licence for building and operating an installation.

This suggests that further intervention for AD is needed as both the installation and the use of biogas plants are not yet cost-effective in most current applications. This is reflected in current – low – levels of AD adoption within Member States. In countries where no policy incentive has been given, anaerobic digestion on farms is very limited. In cases where existing policies were being removed, the uptake stagnates. In some cases where progressive long term policies are implemented farmers are willing to adopt the technology (Banks et al 2007).

Policy intervention is also justified in order to internalise the carbon externality i.e. GHG emissions are only partly accounted for in the energy price. Subsidisation of AD effectively puts a price on the carbon saved from using AD both from reduced emissions of CH_4 and from the saved fossil fuel by producing electricity and heat or applying more advance technology and providing natural gas (CH_4) to the grid.

2.3 Policy options to support the uptake of anaerobic digestion

The need for policy support to stimulate farm practices that reduce the emission of methane and at the same time generate renewable energy was acknowledged by the 2008 review of the Common Agricultural Policy (CAP) of the EU (the so-called CAP Health Check). The CAP consists of two pillars: the first pillar which constitutes the direct income support and market regulations and the second pillar which is the rural development plan. The EU determines the budget and strategic lines for the CAP but each member state has the freedom to develop its own Rural development plan.

The CAP Health Check resulted in 2009 in amendments of the Rural Development (RD) plan: financial resources for rural development should be targeted more towards so-called “new challenges” like climate change and renewable energy. For these new challenges an additional budget of approximately 1 billion EUR (almost 20% of the total additional funds) have been made available for Member States (MS). Rural development now offers a range of possibilities to support farming

practices and investments that can contribute to climate change mitigation efforts (including the increase of the use of Renewable Energy (RE) resources)

The RDP 2009 amendments resulted in specific measures for dissemination of knowledge and financial incentives for the installation of biogas plants. Table 1 gives an overview of the different RDP measures and in what way they link with the renewable energy targets.

Table 1: ***Rural Development measures with possibilities for supporting biogas production.***

RDP Axis	Measure	Opportunity to stimulate Anaerobic Digestion of manure
1	111 Vocational training and extension	Specific measure for dissemination of knowledge, e.g. demonstration project concerning renewable energy
	121 Modernisation of agricultural holdings	Support to new environmental technologies, particularly in relation to, renewable energies. Support to investments in new and modern manure and slurry storage and treatment facilities for manures and production of biogas (and electricity to the grid).
	124 Cooperation for innovation.	Contains specific support for concrete innovative activities, like renewable energy.
3	311 Diversification into non-agricultural activities	Investments in biogas production through utilization of manure and slurry (especially in high density livestock areas)
	321 Basic rural services	Support for establishing facilities for biogas production

At a national level, 3 types of policy instruments are implemented: economic, regulatory and information. Economic instruments are needed as financial incentives for investments in the technology and to ensure a fixed price for electricity on the long term. Regulatory instruments are needed to keep the balance between encouraging a growth in the use of anaerobic digestion and the need to ensure protection of the environment. Information instruments are needed to raise awareness and capacity for the operation of the AD technology.

2.4 Application of the measure in EU Member States

Denmark was in 1988 one of the first member states that adopted a policy for stimulation anaerobic digestion (AD). Later on Germany implemented the Law on Renewable Energy in 2000. In both cases the most important policy instruments are economic one, like guaranteed prices on the electricity a biogas plant generates and putting an extra financial bonus in cases a farmer complies with feed-in requirements (e.g. at least 30% manure).

Other member states only adopted specific policies for the stimulation of AD since 2009 initialized by the outcomes of the Health Check. The current implementation of GHG reducing policies, also including incentives for the adoption of AD, within member states is reflected in the table below. Many member states do have policies aimed at reducing methane emissions from agriculture, but only a couple have specific policies on stimulating adoption of AD of manure.

Table 2: Different types of policies within member states

MS	Name	Type	Information	Status
UK	Anaerobic Digestion	Research Information	In February 2009, the Government published Anaerobic Digestion: Shared Goals. This document sets out the shared goals that businesses, regulators, Government and other stakeholders aim to achieve by the cost effective, innovative and beneficial use of anaerobic digestion in England. Government is now working with these actors to develop an Implementation Plan. This will set out the practical measures that each will take individually and collectively to achieve the goals.	adopted
UK	Accelerating the Uptake of Anaerobic Digestion in England	regulatory	Accelerating the Uptake of Anaerobic Digestion in England[5]. This is an Action Plan and the implementation scheme in the action plan includes an economic framework, a regulatory framework, information, capacity building, research and a package of financial measures including subsidies and loans.	adopted
DK	Biogas action programme	Information	Action programme from 1988 – 2002, initializing a global network through research and development activities, construction and monitoring, and information activities. It also included an investment grant for centralised biogas plants (up to 40% of costs) and a loan scheme with low interest rates. The Biogas Action Programme followed a bottom-up approach, constructing one or two centralised biogas plants annually	implemented
DK	Biogas plants	Economic	In order to ensure renewed growth the politically fixed subsidy on the sales price of electricity production based on biogas was adjusted by the Energy Policy Agreement of 21 February 2008. The agreement resulted in the Law on Promotion of Renewable Energy of 27 December 2008. Consequently the latest projection from the Danish Energy Agency expects an increase in the biogas production from 4 PJ in 2007 to 12 PJ in 2020. This is expected to imply a five or six fold increase in the volume of manure digested meaning that close to 30 %of all manure shall be used for biogas generation before 2020.	implemented
AT	Payments for investments in emission reducing animal production	Economic	Investments in and support to new installations of livestock stables and manure storage, e.g. slurry and manure store facilities, slurry hose techniques.	adopted
AT	Biogas production	Economic	Financial support for the digestion of slurry and manure in biogas plants to reduce methane emissions from manure management. Additionally, the reduction potential in the energy sector should be taken into account.	implemented
NL	Manure digestion	Information, economic	Stimulation of manure digestion is part of the 'Schoon en Zuinig' policy. The policy aims at an energy production of 50 PJ from AD by 2020 via agreements and subsidies	implemented

Source: EEA database http://www.eea.europa.eu/themes/climate/pam/introduction)

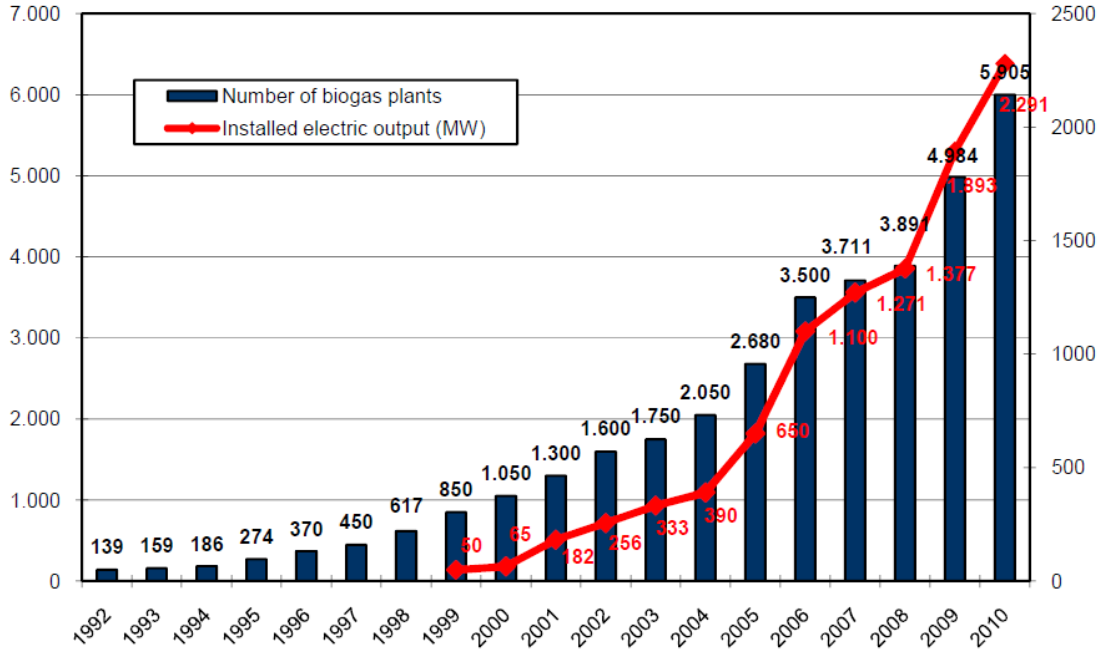
[5] See: http://www.defra.gov.uk/publications/files/anaerobic-digestion-strat-action-plan.pdf. This strategy sets out a vision for AD, whilst the Action Plan sets out the actions in detail that are needed to bring about an increase in energy from waste through anaerobic digestion (DEFRA, 2011).

2.5 Main features of the measure

Germany

In March 2000 the Renewable energy Law (*Erneuerbare Energien-Gesetz EEG*) was introduced in Germany and brought about an unprecedented and rapid increase of biogas plants on German farms within the timeframe of a decade (2000 – 2010), see Figure 2.

Figure 2: ***Development of the number of biogas plants and the total installed electric output in megawatt***



German law covers many types of renewable energy of which energy from biomass is only one type. The law establishes a number of rules concerning technical requirements, distribution and tariffs. It also lists the fixed tariffs and extra bonuses paid for electricity per kW/h for the different types of renewable energy to producers (farmers), the so-called NaWaRo[6] bonus.

As for biogas installations the law states:

- That the payment of the fixed tariff only applies when a certain minimum reduction in greenhouse gases is achieved while generating the electricity from the utilised biomass or manure.
- An extra and conditional NaWaRo-bonus will be paid on top off the fixed tariff in those cases where the share of manure at all times does amount to at least 30 mass per cent of the total mass that is digested.

Table 3 lists the basic electricity prices and bonuses paid for farm-based digestion in Germany. The guaranteed price for electricity over a 20-year period is the most important drivers of the increase in the number of biogas plants (Banks 2007).

Over 30 different organic by-products and wastes from agriculture are permitted for use in biogas plants. The use of energy crops has increased to such extent that they are almost displacing manure as primary substrate, some plants now operate already exclusively on energy crops. This development is in some way counter-productive as one of the major benefits of biogas plants is its ability to improve manure management and reduce GHG emissions from raw manure storage.

[6] NaWaRo = nachwachsenderohstoffe (renewable raw materials)

In this respect regulating the licensing of co-fermentation products in manure fermentation is important. The regulation of this licensing is in Germany advanced and complex. It is based on the type of organic biomass used for the production of biogas. As for manure, there are two important laws: "*Düngegesetz"* and the "*Düngeverordnung"*. The latter law fixes rules for the use of manure, and distinguishes between co-fermentation products as feed stock from own property (and farm) or feedstock imported from outside the own property (and farm).

Table 3: ***Overview of the basic electricity price and bonuses paid for farm-based digestion in Germany (based on EEG 2009)***

Payment/Output capacity	**<150 kW**	**<500 kW**	**<5 MW**	**>5 MW**
Basic electricity price	11.5	9.9	8.9	8.4
Bonus for energy crops	6	6	4	-
Bonus for CHP	2	2	2	2
Technology bonus (only if CHP condition fulfilled	2	2	2	2

The rural development (RD) policy in Germany is organised on federal state level, so 14 different RDP's are implemented. Each RDP is dealing differently with new challenges such as climate change and renewable energy (ENRD 2011). In terms of total additional budget, 19% is spent on climate change and only 2% on renewable energy. The share of the budget spent on these new challenges differs among federal states, but overall support to biogas plants is not a key feature of the RDP's. Only four out of fourteen federal states spent money on renewable energy whereas all spent money on climate change. The specific measures that can be used to support the installation of biogas plants are implemented by only a couple of federal states.

In 2012 the renewable energy act (EEG) will be reformed and includes new requirements to receive feed-in tariff for biogas production. These include a maximum of 60% (mass based) maize and grain and a minimum of 60% heat utilisation or otherwise a minimum use of 60% (mass based) of liquid manure. Furthermore a bonus can be obtained based on the substrate used (Class 0 is waste (no bonus); Class 1 is maize, and Class 2 is grass (higher bonus for landscape maintenance) and also for more manure a higher bonus can be received). No additional bonus on top of the basic feed-in tariff anymore, except for upgrading biogas to bio-methane. The new requirements aim to reduce the negative impacts of the energy crop production and to increase the use of manure.

Wilkinson (2011) reviewed the drivers behind the adoption of on-farm anaerobic digestion in Germany. They concluded that feed-in-tariffs were the main driver for biogas development, while the biophysical and socio-economic character of farming in Germany provided the fertile ground for the financial incentives. For instance, the intensive animal production and the fact that farmers have to comply with the EU Nitrates Directive are drivers for biogas investments. Banks et al. (2007) indicated that in Germany the introduction of biogas plants was successful due to the introduction of the "Renewable Energy Law", which requires grid operators to prioritise RE electricity to get access to the grid above fossil based alternatives.

Denmark

In 1988 a Biogas action programme that aimed to improve farm management and nutrient control was initiated in Denmark (Raven 2010). The programme includes research and development activities, support for the construction and monitoring AD plants, information activities and additional regulations. Initially, the EU nitrates directive drove the need for the setup of the programme: the whole territory of Denmark is designated as nitrate vulnerable zone, therefore all farms in Denmark have to comply with the requirement of a 9-months storage capacity for manure, restrictions on fertilizer application etc. (Banks et al 2007). However, in 2002 the action programme stopped under the new government (Raven 2010). Today, Denmark promotes renewable electricity generation through a premium tariff. In 2008 the Law on Promotion of Renewable Energy was implemented, guaranteeing a support price per kW/h delivered from biogas plants. The Danish government expects that this new law will deliver a five or six fold increase in the volume of manure digested meaning that close to 30 % of all manure shall be used for biogas generation before 2020.

The Danish Rural Development Programme integrates several aspects of further reducing GHG emission and increasing the use of renewable energy sources (ENRD 2011). Specifically, it encourages the reduction of energy use and supports improvements in energy efficiency in most of the available measures. The production of biogas as an energy source is a central element of the RDP strategy in increasing the share of agricultural-derived renewable energy. The key measure for supporting renewable energies under Axis 1 of the Rural Development Policy (improving the competitiveness of the agricultural and forestry sector) is **measure 121** (Modernisation of agricultural holdings). According to the national objective of using up to the 50% of the livestock manure production for generating green energy (tripling of biogas production by 2020), the measure complements the measures for biogas production under measure 311 (Diversification into non-agricultural activities) and measure 321 (Basic services for the economy and rural population) by supporting investment in "green" processes and technologies as well as in manure treatment facilities producing biogas for use on farms. Among the envisaged key actions for Axis 3, is the establishment of biogas plants.

Ravel and Gregersen (2007) reviewed the drivers for biogas plants in Denmark since the 1970s. They mention that some specific Danish circumstances have been beneficial, such as policies for decentralised CHP, existence of district heating systems, implementation of energy taxes in the 1980s and the preference of Danish farmers to cooperate in small communities. They also mention that the current setback in biogas plants is mainly caused by a shift in energy and environmental policies and limited availability of organic waste.

United Kingdom

In march 2010 the UK's government presented an implementation plan for *Accelerating the Uptake of Anaerobic Digestion in England (Defra 2010)* which is a follow up of the 2009 vision document *Anaerobic Digestion: Shared Goals* (Defra 2009). This implementation plan sets out the strategy to stimulate AD by creating an economic framework, a regulatory framework and by capacity building, research and sharing information. As for economic instruments the plan foresees the use of Renewable Obligation Certificates (ROCs), Feed In Tariffs (FITs) or a future Renewable Heat Incentive (RHI) to provide financial incentives for the electricity and heat outputs from anaerobic digestion (Defra 2010).

As for regulatory instruments the plan foresees to introduce revised exemptions from environmental permitting for small scale on-farm anaerobic digestion; introducing new standard permits; publishing Standard and Quality Protocol for digestate; publishing guidance on the regulatory requirements for injecting biomethane into the gas grid; and, identifying the regulatory requirements for the co-digestion of sewage sludge with other feedstocks.

Capacity building, research and sharing information aim at increasing awareness and understanding of the use of the technology and its products among practitioners and researchers.

The RDP plays an important role in the realisation of the AD implementation plan (ENRD 2011). Activities aimed at reducing GHG emissions are an integral part of rural development across the United Kingdom therefore a twin-track approach to mitigation is applied through a) reducing agricultural emissions of GHG and b) off-setting and reducing GHG emissions from the UK as a whole via bioenergy, carbon storage protection and sequestration in soils and forestry. Across the UK, measure 121 (Modernisation of agricultural holdings, Investments for on-farm production and use of biogas) is the key measure for financial incentives for investments in AD technologies.

The Netherlands

The Dutch Government has implemented a specific program for energy and climate "*Schoon & zuinig*". The agricultural sector is specifically mentioned in the program, although the main focus of the program is on the CO_2 emissions from the horticulture (heating greenhouses). Anaerobic digestion of manure is also mentioned by the program. The aim is to have about 400 biogas plants by 2020 with a capacity of 50 PJ of energy. This should be obtained by agreements and energy subsidy (SDE), but there is a lack of translation of the objectives into concrete measures. The current SDE subsidy is by most farmers considered too low to make the biogas production cost-effective.

2.6 Evaluation of the measure

Each of the Member States described above apply a similar mix of policy instruments to stimulate the uptake of anaerobic digestion (AD) of manure. The main types of instruments are:

- Economic: support for investments covered by the measures of the post Health Check RDP's
- Economic: fixed prices and bonuses for the delivery of electricity from biogas plants covered by laws on renewable energy.
- Regulatory: a set of regulating instruments to harmonise production of renewable energy with environmental and safety objectives.

This section evaluates the impacts of the policy in terms of Economic, Environmental and Social factors, indicating if the impacts are positive, neutral or negative and if the impact is High or Low. We focus on those measures that especially aim at encouraging farmers to adopt the AD technology. Only the economic instruments, support for investments and fixed prices and bonuses, are analysed.

(++) High Positive Impact
(+) Low Positive Impact
(n) Neutral
(-) Low Negative Impact
(- -) High Negative Impact

	Economic impacts			
		Fixed prices and bonuses for electricity from biogas		**Financial incentives for installation of biogas plants**
What was the cost to deliver the outcome, was it value for money?	(+)	The increase of bio-energy production in Germany shows that the up take was quite good and as such the measure is considered as a cost-effective option for delivering RE, but there does not exist a cost/benefit analysis of the measure	(-)	Implementation of instrument in Germany was in 2010, which is too recent to draw conclusions. However there are signs that support for investments are less important than the fixed prices for electricity to stimulate the uptake of AD.
	(- -)	With the current low electricity prices based on fossil fuel the amount of subsidy per kWh is high and it is not likely that biogas production will be cost-effective on the short-term		
What wider economic impacts does the policy have?	(+)	Has a positive effect on employment via introducing new jobs, e.g. in Germany about 25000 employment places were created by 2010. It is not known whether this included displacement from other sectors but is unlikely.		

Environmental impacts

		Fixed prices and bonuses for electricity from biogas		Financial incentives for installation of biogas plants
Did the policy deliver the desired outcome?	(++)	Yes guaranteed prices for electricity have proven to be a powerful instrument to stimulate adoption of biogas production, and reduce greenhouse emissions	(n)	Implementation of instrument in Germany was in 2010. Therefore it is too recent to draw conclusions
	(-)	Where biogas production largely depends on energy crops the net GHG savings are lower and might even become negative.		
What other impacts has the policy had?	(+)	The instrument offered farms the possibility to invest in their stables and manure storage facilities, which can also have positive effects on other emissions, e.g. NH_3 and particulate matter		
Are there impacts on emissions from other sectors?	(++)	In addition to the reduction in emissions from fossil fuel use the production of manure-based biogas reduces GHG emissions from manure management		
	(-)	The use of energy crops as feedstock can increase GHG emissions in the agriculture sector		

Social impacts

		Fixed prices and bonuses for electricity from biogas		Financial incentives for installation of biogas plants
Was the policy well received, were there issues in gaining acceptability, what did they relate to?	(+)	Considering the up-take it can be said that the policy was well received. Although some discussion on the sustainability of bio energy crops has emerged.	(+)	Implementation of instrument was in 2010, which is too recent to draw conclusions. However, given the positive effect on employment the policy will probably be accepted
What are the distributional impacts?	(+)	Has created/sustained jobs in rural communities		

Cross-Cutting

		Fixed prices and bonuses for electricity from biogas		Financial incentives for installation of biogas plants
Are there interactions with policies in other sectors?	(n)	The amount of the feed-in tariffs often is linked to the electricity prices, i.e. when prices are higher less subsidies are required	(n)	The distribution of funds under the rural development plans will affect other issues that are addressed in the rural development plans
Timeframe – is there anything to note about the timing of policy implementation and expected impacts?	(+)	A certain lead time is required to develop the market, but impacts can be realised in the short term.		

3 Mitigation of N_2O emission from soils

3.1 Background

There are few Member State policies that specifically focus on N_2O mitigation from agricultural soils from a climate change abatement perspective. However, many MS have policies that aim to reduce nitrogen (N) (synthetic) fertilizer and manure inputs to the soil for mitigating ammonia (NH_3) and nitrate (NO_3) emissions to air and water. In this section we present examples of how MS use or extend current environmental policies to include climate mitigation objectives as well, with the focus on N_2O emissions from agricultural soils. As all policies have been driven by European directives and regulations we first describe briefly the most important ones.

The main drivers for reducing NH_3 emissions are the National Emission Ceiling (NEC) directive, the Gothenburg protocol and the IPPC directive. The main driver for the implementation of agri-environmental policies for mitigating NO_3 is the EU Nitrates directive. This directive aims to protect water quality across Europe by preventing nitrates from leaching from agricultural sources and polluting ground and surface waters, and by promoting the use of good farming practices to encourage and improve nitrogen efficiency in farm operations and prevent losses of nitrogen to air and water.

Member states are required to identify Nitrate Vulnerable Zones (NVZ); several MS e.g. Austria, Denmark, Finland, Germany and the Netherlands declared their whole national territory as NVZ. National Action Programmes with mandatory measures concerning agricultural practices must be implemented in these areas and monitoring of water quality according to specific requirements is required and performed. The policies try to stimulate and achieve changes in farm practices through mandatory reduction of the application of fertilizers, setting rules for the storage of fertilizer and to improve stables for livestock with manure handling and storage to limit losses of Ammonia (Oenema, 2004). A recent study for DG Environment (Velthof et al., 2011) estimated that the total N_2O emission in EU-27 would have been 6.3% higher without the Nitrates Directive than with the Nitrates Directive in 2008. The implementation of the Nitrates Directive has decreased the N fertilizer (both chemical and organic) input and the N excretion of dairy cattle, and because of that the N_2O emission decreased. The largest effects were shown for the Netherlands (19.9%), UK (12.0%), and Denmark (12.3%).

EC regulation 1259/99 establishes Cross Compliance as a requirement for those claiming Single Farm Payments under the Common Agricultural Policy. This obliges farmers to meet a number of Good Agricultural and Environmental Condition (GAEC) standards and Statutory Management Requirements. Statutory Management Requirements (SMRs) are agricultural management standards set out in European Union law. Compliance with these - and the good agricultural and environmental condition (GAEC) land management standards - is called 'cross compliance'. SMRs require farmers to protect habitats, landscape and wildlife, manage and protect their soil and water, control chemical use and prevent animal disease. They also specify rules on animal health, welfare and identification. GAEC applies to soil erosion, soil organic matter, soil structure and how to ensure a minimum level of maintenance to preserve habitats.

The Rural Development Policy (RDP) amendments, resulting from the CAP Health Check, acknowledge also the need to reduce nitrous oxide emissions. Since 2009 the RDP's of some member states include specific measures to reduce these emissions. Table 5 lists the opportunities of each RDP measure for reducing N_2O emissions (ENRD 2011).

Table 5: Rural Development measures with possibilities for reducing nitrous oxide

RDP Axis	Measure	Opportunity to stimulate reduction of N_2O emissions
1	121 Modernisation of agricultural holdings	Support to investments in efficient fertilizer use, improvement of manure storage.
2	214 Agri-environmental measures	Soil management practices: Reduction of nitrous oxide (N_2O),
	216 Non-productive investments	Land use change: Reduction of nitrous oxide emissions (conversion of arable land to pasture)

3.2 Policy options to reduce N_2O emissions from soil

A review by ADAS (2009) identified policies that are likely to be useful in the reduction of nitrous oxide emissions are part of current Nitrate reducing policies. The policies with the greatest potential for reduction of greenhouse gas emission were:

- Regulatory: Cross Compliance and Nitrate Action plans for Nitrate Vulnerable Zone
- Economic (voluntary participation): Agri-environmental payments

The mitigation methods that are covered by cross compliance relate to new actions and are additional to land already in buffer strips or field corners under Cross Compliance and ecosystem services (ES).

3.3 Application of measures in EU Member States

United Kingdom
In the UK, the Nitrate Vulnerable Zone (NVZ) Action Plan applies to 68% of all land. It is based on reducing diffuse nutrient pollution through setting limits to total N applied and closed periods for application of slurries and manures. While the NVZ Action Programme does not target nitrous oxide and other GHGs directly, it does deliver some mitigation for N_2O based on less fertilizer applied and lower N_2O emissions from losses of nitrogen following lower application rates or refrain from nitrogen fertilization on part of the land.

Other options for Environmental Stewardship are based upon payments for income foregone by farmers and land managers but participation to such schemes is on a voluntary basis.

Rural development funds can be allocated to specific measures that target reducing nitrous oxide emissions through a range of actions supported under measure 121 including those relating to efficient fertiliser use, improvement of manure storage and biogas production using organic waste.

Table 6 Summary of (or absence of) policies across EU Member States

MS	Name	Type	Information	Status
UK	Reducing nitrous oxide emissions	information	In January 2009 under the revised Nitrates Action Programme it published Protecting our Water, Soil and Air: A Code of Good Agricultural Practice for farmers, growers and land managers (the CoGAP) which offers advice on minimising risk to pollution while protecting natural resources and allowing economic agriculture to continue.	
Dk	Action Plan for the Aquatic Environment III	Regulatory / economic	The plan contain several measures, where the most import in relation to greenhouse gas emissions are: Establishment of 4000 ha wetlands in 2004 and 2005. Making the rules on catch crops more rigorous. Making the rules on exploitation of N in animal manure more rigorous. Additional environmentally friendly measures in crop farming	implemented
NL	Ammonia and manure policy	regulatory		implemented

Denmark

The Danish measures aimed at reducing NH_3 emissions, which also might reduce N_2O emissions, depending on the type of measure, are since the 1980's combined with measures trying to improve water quality included in Action Plan I and II (Jacobsen et al., 2010). In 2001 the Danish Action Plan II was supplemented by the Action Plan for Reducing Ammonia Volatilization from Agriculture. The aim is to reduce emissions of ammonia from the sector, and the plan introduces the following elements:

- A ban on broad spreading of animal manure
- A reduction in the time until slurry is incorporated into the soil (from 12 to 6 hrs.)

- Cover when storing solid manure is obligatory
- A ban on the use of ammonia in straw

The Ammonia Action Plan is implemented in Denmark by Statutory Order No. 604 of 15 July 2002, which also contains provisions implementing some parts of Directive 91/676/EEC (Jacobsen et al 2002).

In 2007, a new legislation was introduced in Denmark for farmers who wanted to increase the animal production on their farm (Jacobsen, 2011). The aim of the law was to reduce emissions increasingly by 15% in 2007 and 20% in 2008 compared with the best technology in 2005/2006, and later on to increase the requirements to 25% in 2009 and 30% in 2010 based on the same starting point.
In the application for an increase in the animal production, the applicant has to show he complies with the requirements regarding emission of ammonia from stables and storage.

The Danish RDP provides comprehensive support for a range of activities which could contribute to reducing agricultural emissions (ENRD, 2011). These are particularly related to investments in new environmental technologies in agricultural holdings and the promotion of sustainable land management practices. Further support for activities which could help to mitigate climate change is outlined under measure 121 (modernisation of agricultural holdings). Explicit reference is made to supporting investments in new processes and technologies which aim at addressing environmental and climate change challenges. Measure 121 specifically aims to reduce localized ammonia and methane emissions through investments to improve the storage and application of manure and slurry, and this is also likely to help reduce overall GHG emissions at farm level.

The Netherlands

The Netherlands has already since 1984 governmental policies and measures regulating animal manure. The general aim of the manure policy in the Netherlands is to decrease the losses of N and P from agriculture to the environment (atmosphere, groundwater and surface waters) to environmentally acceptable levels. An important constraint is the socio-economic impact; the manure policy should not deteriorate the socio-economic strength of the agricultural sectors. Further, the manure policy must be effective and efficient.

The first phase of the manure policy banned further growth of pig and poultry sectors. The second phase was characterized by (i) lowering of the application limits for animal manure, (ii) restrictions on the timing of manure application and the resulting requirement to take care of sufficient storage capacity for animal manure, (iii) implementation of various measures to decrease NH3 emissions, and (iv) further facilitation of manure distribution and manure processing. The third phase started with the implementation of the nutrient accounting system MINAS at farm level, but in response to the decisions of the European Court and the European Commission, the Netherlands implemented balanced fertilization approach of the Nitrates Directive with crop and soil specific N fertilization standards in 2006. These policies drastically reduced the amount of applied manure and mineral fertilizer, which also reduced the N_2O emissions.

In addition to the ammonia and manure policies, the Dutch government started in 2006 a program for energy and climate "*Schoon & zuinig*", which includes a specific chapter on mitigation of N_2O. As for the agricultural sector the measures focus on precision agriculture and adaptation of stables and fodder. These measures are in the phase of research and development and that is why the effectiveness is still uncertain.

3.4 Evaluation of the policies

The policies in the three member states as reviewed before, apply the same set of policy instruments to reduce the emissions of N_2O. The main types of instruments are:

- Regulatory: action programs with mandatory rules for application and storage of manure as well as the construction of stables.
- Economic: support for investments covered by the measures of the post Health Check RDP's

This section evaluates the impacts of the policy in terms of Economic, Environmental and Social factors, indicating if the impacts are positive, neutral or negative and if the impact is High or Low.

(++) High Positive Impact
(+) Low Positive Impact
(n) Neutral
(-) Low Negative Impact
(- -) High Negative Impact

Economic impacts

		Action programs with mandatory measures for Nitrate Vulnerable Zones		Rural Development Policy measures (pre- and post-Health check)
What was the cost to deliver the outcome, was it value for money?	(+)	Although costs are low for the implementation, there are costs for the farmer to reach the standards (e.g. the construction of manure storage facilities) and also high costs are involved with the control effort	(-)	There are high budgetary cost for premiums and also high costs for administration and control
What wider economic impacts does the policy have?	(-)	Margins within the sector can be low, and additional cost burden can affect the financial sustainability of farms		

Environmental impacts

		Action programs with mandatory measures for nitrate vulnerable zones		Rural Development Policy measures (pre- and post-Health check)
Did the policy deliver the desired outcome?	(++)	Because the measures are generally binding and the standards can be adjusted to local objectives and conditions the action programs have attained considerable reductions in emissions of NO_3 and NH_3	(n)	As it is difficult to fine tune payments, there is no optimal choice of areas from the environmental point of view. Therefore effectiveness and whether standards are secured in the long-term is questionable

Are there impacts on emissions from other sectors?	(++)	The Nitrates Directive reduced nitrogen (NH_3, N_2O, NOx and NO_3) emissions to the environment (Velthof et al., 2011)
	(+)	The reduced use of mineral fertilizer also reduced emissions in the industry sector (i.e. fertiliser manufacture)

Social impacts

		Action programs with mandatory measures for Nitrate Vulnerable Zones		Rural Development Policy measures (pre- and post- Health check)
Was the policy well received, were there issues in gaining acceptability, what did they relate to?	(-)	Problems of acceptance have been detected, especially because of ambitious or unequal (local) standards. Moreover, the regulation does not encourage farmers' initiatives.	(+)	Because of the voluntary character there is a high level of acceptance in many cases, only in case of very ambitious requirements there is a low acceptance. These measures strengthen property rights and initiative of farmers
What are the distributional impacts?	(n)	Measures affect businesses and individuals in rural communities, but distributional impacts likely to be limited.		

Cross-Cutting

	Action programs with mandatory measures for Nitrate Vulnerable Zones	Rural Development Policy measures (pre- and post- Health check)
Are there interactions with policies in other sectors?	Restrictions to the use of mineral fertilizer from nitrate policies and will reduce emissions of N_2O as well[7]; restrictions in ammonia losses may increase emissions of N_2O[8].	

[7] The release of nitrous oxide from the soil is a naturally occurring process, but is exacerbated by the application of additional nitrogen to the soil. In soil, nitrous oxide (N_2O) is produced predominantly by two microbial processes: nitrification, i.e. the oxidation of ammonium (NH_4) to nitrate (NO_3) and denitrification, i.e. the reduction of NO_3 to gaseous forms of N, ultimately N_2. N_2O production is an intermediary by-product of both processes. The magnitude of N_2O emissions relates to the rate of fertiliser

Timeframe – is there anything to note about the timing of policy implementation and expected impacts?	The implementation of the Nitrates Directive differed among MS, starting already with the specification of the NVZ areas. MS should report every four years in Action Plans how water quality is changing and how further improvements will be reached.

applied, which is itself related to the crop type to which the fertiliser is applied, and the soil temperature and soil moisture content (EMEP/CORINAIR, 2006).

[8] For example, certain ammonia control options such as stable adaptations imply a quick removal of the manure from the stable floor to a closed storage system. Manure from pigs and poultry is aerated and dried after removal from the stable. This process causes a large increase in N2O emissions.

4 Conclusions and recommendations

Policy incentives to support the adoption of anaerobic digestion (AD) serve two goals: the management of manure and the reduction of methane as well as the production of renewable energy to displace fossil fuel. Financial incentives may target the production of electricity or might target the investment in the production plant. Although no information is available about the effectiveness and efficiency there are signs that incentives that target the electricity production are more powerful than incentives for investments in the plant. However, in terms of environmental effectiveness it can be questioned whether such incentives are desirable.

The logic of stimulating production by means of fixed prices for energy can be compared with the former agricultural subsidies that were coupled with production volume. This principle has become out dated during the subsequent reforms of the CAP and today steering incentives are more based on (environmental) goals rather than production volume. Moreover, as biogas yields substantially increase by co-digestion, i.e. addition of other digesters to manure, there is a risk that manure is substituted by other substrate. This development is in some way counter-productive as one of the major benefits of biogas plants is its ability to improve manure management and reduce GHG emissions from raw manure storage. Economic policy measures should therefore be a combination of support for investments and a smart regulation for co-digesters that ensures the optimal use of manure as a digester.

In agriculture, farmers would need a more profound change in their management skills and options. There is no specific or general incentive for farmers and land owners to manage their land and select plan activities in order to reduce emissions of greenhouse gases including the emissions from soil carbon or stimulate the carbon removal from the atmosphere (carbon soil sink). Most farmers are not aware of their full impact from management practices and implementation of technologies on emissions of greenhouse gases and cannot (or have no access to a tool to) calculate their farm GHG balance and changes as a result of their specific action. Such knowledge or the availability of a calculation tool would certainly stimulate farmers awareness on the options. Whether engaging farmers in considering activities would be sufficient in the absence of other incentives including financial incentives or is difficult to predict and could be part of targeted trial in specific farmers discussion groups. Such efforts are in place in several Member States and part of on-going EU FP7 research projects.

This situation might further be improved by targeted policies increasing the knowledge and management skills to farmers and provide the necessary tools and advice for them to act wise and with impact. It may help if payments and subsidies are in place to reward impact and stimulate activities and measures to be selected and implemented. The primary option would be to get along with the reform of the CAP. Such activities would likely include a farm greenhouse gas balance (voluntary of mandatory), benchmarks and fees or payments for climate friendly and responsible farm management and some for quality control that would be put in place for the implementation of the CAP anyway.

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