# General proposals for the EU to fight against climate change

AgriClimateChange

combating climate change through farming

APPLICATION OF A COMMON EVALUATION SYSTEM IN THE 4 LARGEST AGRICULTURAL ECONOMIES OF THE EU

*LIFE+09 ENV/ES/000441*

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**Partners of the Life+ project**

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# 1. AgriClimateChange project

The AgriClimateChange project is being developed simultaneously in four European countries since October 2010. Its objective is to determine and support the farming practices that better contribute to combating climate change. Curbing greenhouse gases (GHG) emissions on farms and adapting to climate change are major challenges facing European agriculture over the next years. Therefore, promoting farming systems that combat climate change is a powerful tool in improving climate conditions, preserve nature and increase the agriculture sector viability.

A software tool has been designed based on the previous experience of the partners: ACCT (AgriClimateChange Tool). It allows assessing energy balances in farms as well as assessing GHG emissions. This tool is intended to be applicable throughout the European Union and is continuously being improved based on the experiences in the four countries.

Making use of the software, 120 farms have been assessed: 24 in France, 24 in Germany, 24 in Italy and 48 in Spain (given that there are two Spanish partners). Taking into account the results obtained in the assessments, the experts are elaborating Action Plans. These action plans are specifically designed for each farm, considering the results and the characteristics of the farm. Therefore, the experts identify the key elements in the farm management where there is room for improvement in terms of energy consumption and GHG emission, which could also entail money saving in a context of rising energy prices. These action plans include then a list of proposed measures that are agreed with the manager of the farm. These Action Plans are being developed and revised until the end of the project. Their teachings help to draft Global Proposals concerning EU, national and regional measures.

The project also includes communication and awareness-raising activities in order to include key stakeholders such as farmers, Farmer Unions, professional associations or consumers. Next **9th & 10th October 2013**, a European Conference on Farming and Climate Change will be held in Toulouse (France).

In conclusion, the objective of the AgriClimateChange project is to contribute to making the European farming sector an international leader in terms of climate protection.

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# 2. GHG emissions from agriculture

Agriculture contributes to nearly 10% of the total GHG emissions in EU-27 (Figure 1).

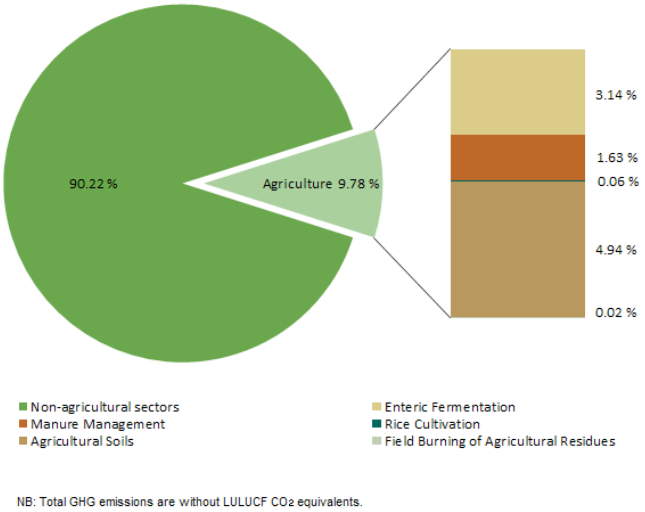



**Figure 1: Contribution of agriculture to total GHG emissions in EU-27**

Agriculture is a main source of emissions of 2 powerful greenhouse gases, which are nitrous oxide ($N_2O$) and methane ($CH_4$).

Nitrous oxide is released into the atmosphere, essentially due to microbial transformation of nitrogen, when it is applied on soil. It concerns nitrogen mineral fertilisers, manure spreading and nitrogen from crops residues incorporated into the soil. The emissions of $N_2O$ represent **more than 50%** of the total GHG emissions from agriculture.

$CH_4$ emissions come mainly from the digestion of animals through enteric fermentation from ruminants. It represents the second source of GHG emissions from agriculture. Both $N_2O$ and $CH_4$ are produced during manure storage and $N_2O$ when manure is applied on soil.

Agriculture emits very little carbon dioxide ($CO_2$)[1]. In contrast, agricultural lands, which occupy more than half the territory of the European Union, contain massive reserves of carbon that contribute to reduce the amount of $CO_2$ in the atmosphere.

[1] In this format of GHG report (Figure 1), direct energies consumed by the agriculture as well as indirect $CO_2$ emissions from processing of inputs are reported in the Energy sector. However, implementing an assessment at the farm scale showed us that direct and indirect $CO_2$ emissions on a farm could represent between 10% and 20% of the total GHG emissions of the farm.

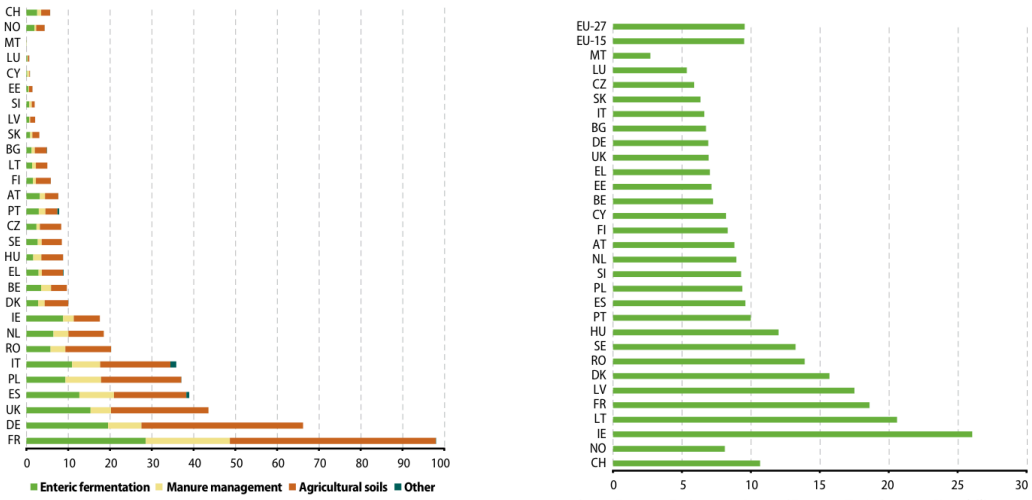



**Figure 2: GHG emissions from agriculture, by source, 2008 (Million tonnes CO2-e), Share of agriculture in total GHG emissions, 2008**

France, Germany, UK, Spain, Poland and Italy represent a significant part of the total GHG emissions from the agricultural sector in the EU-27.

The EU roadmap for moving to a competitive low carbon economy in 2050 has been designed with the objective of 80% of GHG reductions (compared to 1990). Agriculture automatically needs to be part of the solution (Table 1).

**Table 1: Sector milestones, a roadmap for moving to a competitive low carbon economy in 2050**

| GHG reductions compared to 1990 | 2005 | 2030 | 2050 |
|---|---|---|---|
| Power ($CO_2$) | -7% | -54 to -68% | -93 to -99% |
| Industry ($CO_2$) | -20% | -34 to -40% | -83 to -87% |
| Transport (incl. CO2 aviation, excl. maritime) | +30% | +20 to -9% | -54 to -67% |
| Residential and services ($CO_2$) | -12% | -37 to -53% | -88 to-91% |
| Agriculture (non-$CO_2$) | -20% | -36 to -37% | -42 to -49% |
| Other non-$CO_2$ emissions | -30% | -72 to -73% | -70 to -78% |

In the period 1990-2005, non-$CO_2$ emissions from agriculture decreased by almost a quarter, mainly due to the decline of livestock numbers EU wide and the reduction of nitrogen inputs on soils.

In 2050, it is expected a reduction of GHG emissions between 42 and 49%. The majority of these reductions could come from investments in farm scale anaerobic digestion, mixes of feed changes, the reduced and improved timing of fertiliser use and precision farming (UE roadmap for 2050).

# 3. AgriClimateChange proposals

## 3.1. Overview of the proposals

Based on the experiences from the 120 farms assessed in the 4 countries and covering a wide range of farming systems, the partners of the ACC project have selected the most appropriate measures to fight against climate change in agriculture. These measures have been classified in 4 different categories related to the sources of GHG emissions: agronomy, livestock, energy and a specific agro-environmental measure.

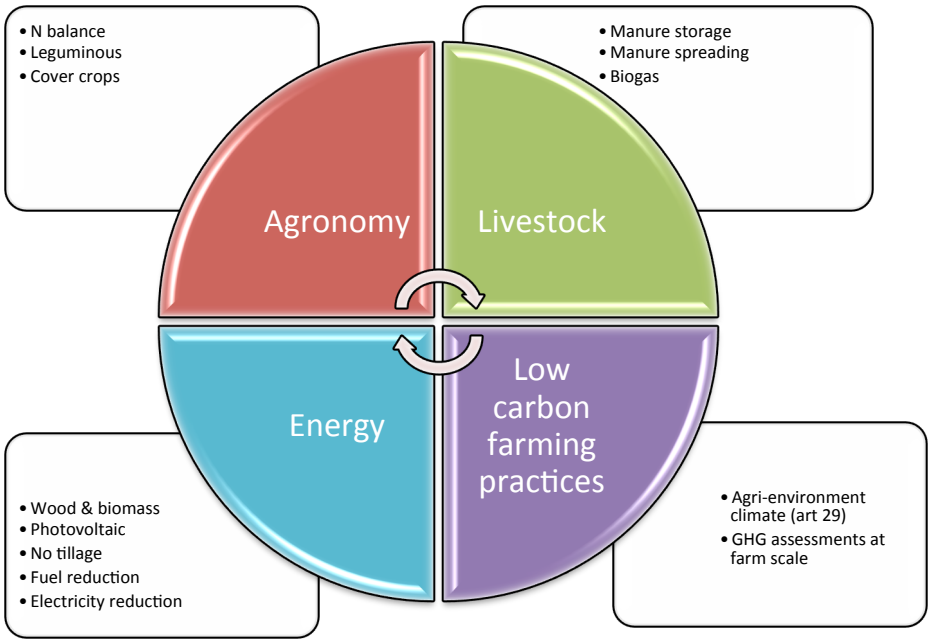



Figure 3: Overview of the proposals per category

A synthetic table (Table 2) is presenting the criteria of analysis of the 12 measures proposed by the AgriClimateChange partners (GHG reduction, target, farming system concerned, implementation costs, other environmental benefits, options for CAP, feasibility for farmers and for monitoring).

The measures whose GHG emissions reduction potential is the most important are agronomic measures (nitrogen balance, leguminous, cover crops) and livestock measures, especially biogas.

The other measures (energy category) also participate in decreasing the GHG emissions from agriculture, but individually, their reduction potential of GHG emissions is lower.

However, it is sometimes not appropriate to divide these measures as their consistency at the end is related to their combination. For example, a cereal farm implementing no-tillage, cover crops and a diversified rotation (including grain legumes) is quite coherent in the systemic approach of the farm.

The same systemic approach could be used for farms with livestock thinking of the fodder system, the manure management system, the presence of leguminous species in grasslands, the origin of the feedstuffs (Figure 4)...

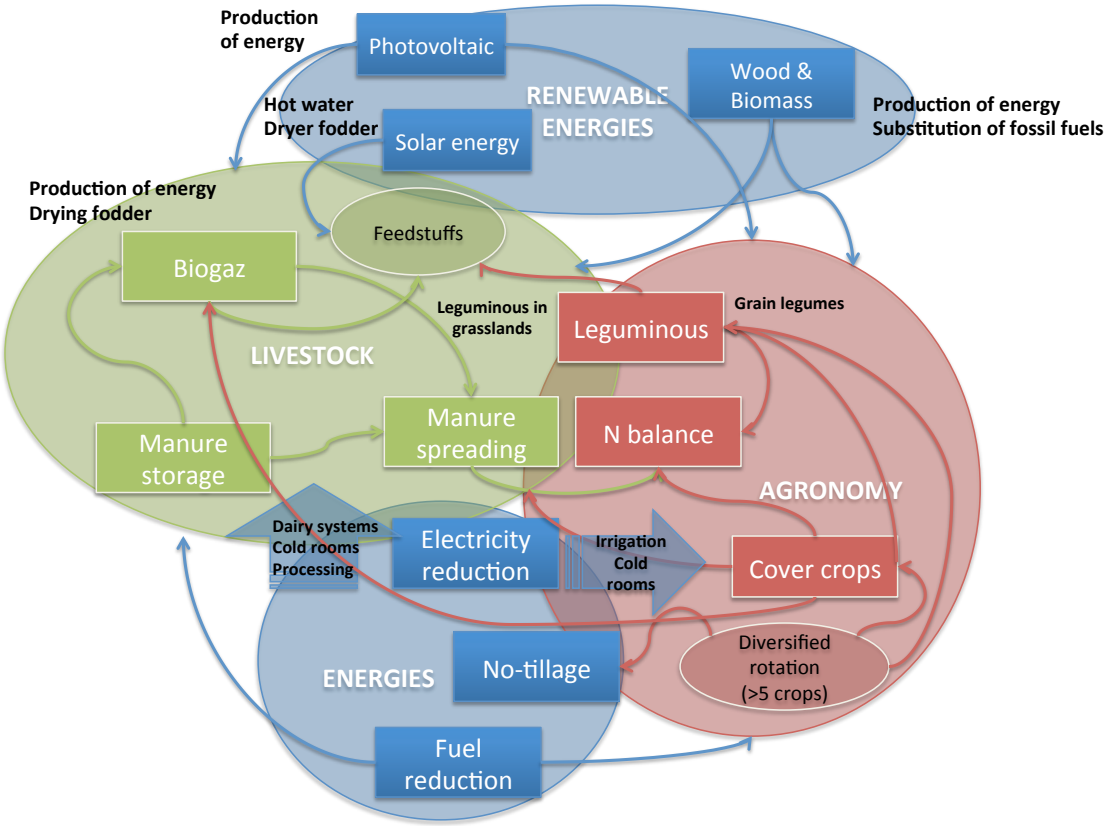



**Figure 4: Connections between Livestock, agronomic and energy measures**

It is obvious that integrating these measures in the CAP would help to fight against climate change and would reduce the GHG emissions in a lot of farms.

From our assessments at the farm scale in the AgriClimateChange project, we can affirm that there is a high diversity of GHG emissions inside a same farming system.

Beyond the CAP measures, some farms that are climate friendly should also be stimulated to maintain the low carbon practices, and CAP could be useful also in this.

The challenge for these farms would be to maintain their low carbon farming practices, for example through an Agri-Environmental Measure in the second pillar (Agri-Environment Climate, art 29).

**Table 2: Analysis criteria for the proposed measures towards GHG reduction, targets, the farming systems concerned, implementation costs, environmental benefits, options for CAP and the feasibility for farmers and for monitoring**

| | Name | GHG reduction | Target | Farming system concerned | Implement ation costs | Other environmental benefits | Options for CAP | Feasibility for farmers | Feasibility for monitoring |
|---|---|---|---|---|---|---|---|---|---|
| **Agronomic measures** | Nitrogen balance | +++ | <50 kg N/ha | All, except vineyards, greenhouse, housed animals | (+) | Nitrates, WFD, 20/20/20 | CC, INF, AS, N2000-WFD | Easy | High |
| | Leguminous | ++ | >10% in cereals & >40% for temporary grassland | Arable land | + | Nitrates, WFD, N2000 | Greening, protein plan, N2000-WFD | Medium | Easy |
| | Cover crops | ++ | 100% of the cropland | Cropland | + | Nitrates, WFD, Soil, Biod | CC in NVZs, greening, N2000-WFD | Medium | High |
| **Livestock measures** | Manure storage | + | Cover slurry pit | Livestock, especially pigs & cattle | + | NEC | CC, Investment | Easy | Easy |
| | Manure spreading | + | Liquid manure | Livestock, especially pigs & cattle | ++ | NEC | CC, Investment | Easy | High |
| | Biogas | ++ | Manure & residues | Livestock | +++ | NEC | Investment | High | Easy |
| **Energy measures** | Wood & biomass | + | Fuel substitution | Farms with heat needs | +(+) | 20/20/20, Biod | Investment, AEM | Medium | Easy |
| | Photovoltaic | + | On farm roofs | All farms | ++ | 20/20/20 | Investment | Easy | Easy |
| | No-tillage | + | 100% of the cropland | Cropland | ++ | Soil, WFD, Biod | QC, AS | High | High |
| | Fuel reduction | + | 10% fuel reduction | All farms | + | 20/20/20 | INF, AS | Easy | Easy |
| | Electricity reduction | + | 5 to 30% electricity reduction | Dairy, cold rooms, irrigation, processing | + | 20/20/20 | Investment | Easy | Medium |
| **AEM** | Low carbon farming practices | + | Maintain farms with low level of GHG emissions | All farms | + | All | Agro-Environment Climate | Easy | Easy |

**Other environmental benefits**
Nitrates: Nitrates Directive WFD: Water Framework Directive N2000: Natura 2000 20/20/20: climate and energy package Soil: Soil Directive Biod: Biodiversity
NEC: National Emission Ceilings

**Options for CAP**
CC: Cross Compliance AS: Advisory Services AF: Agroforestry
INF: Knowledge QS: Quality schemes NVZs: Nitrates Vulnerable Zones

## 3.2. Agronomic measures

### 3.1.1. Nitrogen balance

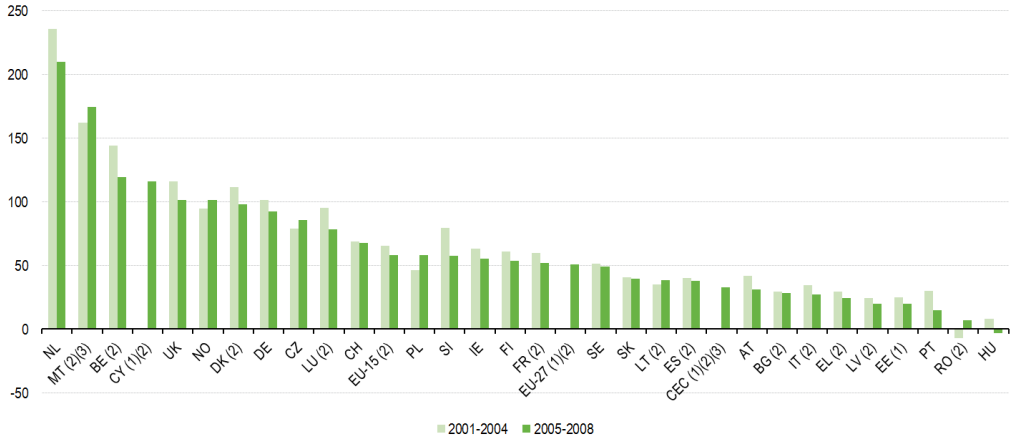
**GHG reduction potential**
High, through direct and indirect emissions of $N_2O$ from soils. Also, processing of mineral nitrogen fertilisers has important consequences on climate change with emissions of $CO_2$ and $N_2O$. Thus, 1 ton of mineral nitrogen corresponds to 14 $teqCO_2$ emissions (processing and field application).

**Energy reduction potential**
High, through savings of mineral nitrogen fertilisers (energy for processing), which is an indirect energy at the farm scale. 1 kg of mineral nitrogen corresponds to 1.5 litres of fuel equivalent. An excess of 30 kg of mineral nitrogen per ha corresponds to 50 litres of fuel equivalent. This amount corresponds to 10% of the total average energy consumption in a grain farm.

**Target**
The surplus of nitrogen at the farm scale should to be less than 50 kg N/ha.

**Description of the action**
An annual nitrogen balance at the farm scale should become a mandatory tool because it helps to highlight the room for progress at the farm scale.
The methodology requires annual data at the farm scale of the nitrogen inputs per category (quantities of mineral fertilisers, quantities of nitrogen through manure and grazing, quantities of nitrogen fixed by leguminous species). Also, yields and surfaces for each crop (cereals, fruits, grasslands…) are needed to calculate the annual output of nitrogen at the farm scale. The annual nitrogen surplus is calculated using the difference between inputs and outputs of nitrogen at the farm scale.

There are huge differences in nitrogen surplus results between farms, even inside a same farming system. Figure 5 illustrates the average nitrogen surplus for each Member State.




(1) Data not available for 2001-2004
(2) Eurostat estimations
(3) PL, RO, BG, CZ, HU, LV, LT, EE, SI, SK
(4) Average 2002-2004

**Figure 5: Nitrogen surplus (kg N per ha), average 2001-2004 vs 2005-2008, EU-27 (Eurostat)**

**Farming systems concerned**
Nearly all the farming systems could be concerned, except vineyards, greenhouse productions (such as vegetables…) and housed animals (when there is no farmland link to the livestock) that are not suitable to the application of a nitrogen balance.

**Implementation costs**
Costs for advisory support to help to optimize fertilization at the farm scale should be assume by farmers, and then compensated. Nevertheless, for farms with a significant surplus of nitrogen, savings of mineral nitrogen fertilisers could be quite significant in the total expenditures of the farm.

**Added value**
The purchases of mineral fertilisers are often a consistent annual expenditure for farmers, especially as prices are increasingly subjected to significant annual fluctuations. Economic forecasts for the coming years predict a continued increase in fertiliser prices in connection with an exponential global demand.
Decreasing the amount of nitrogen per ha can also help to decrease pest diseases pressure in crops as well as avoid lodging for cereals.

**Other environmental benefits**
The main environmental benefits would refer to the Nitrates Directive and the Water Framework Directive. For the 2004-2007 period, a 70% of surface water is moving to the right direction, together with 66% of groundwater. However, agriculture is still a big source of nitrogen in surface waters. Many Member States need to step up their efforts regarding monitoring, identifying pollution hotspots, and tougher action programs.
Also, an indirect benefit would be the energy and GHG emissions savings through less mineral nitrogen fertilisers in relationship with the European climate and energy package.

**Options for the CAP**
Economic instruments such as taxes for nitrogen regulation in agriculture have been experimented in some countries (Norway, Sweden, Denmark and Netherlands). Upstream can be taxed (mineral nitrogen fertilisers purchased) as well as downstream (nitrogen surplus of the farm). The experience of these countries showed that economic instruments alone cannot solve all problems and should be combined to allow any progress. Thus, nitrogen balance at the farm scale should be included in the Cross-Compliance to ensure results.
Other options in the second pillar are available through the knowledge transfer (art 15) and information actions or advisory services (art 16) but their impact will be less.

**Alternative solutions**
Instead of implementing a nitrogen balance to identify the nitrogen surplus at the farm scale, limitations of amount of nitrogen per crops could be defined at national/regional level taking into account the potential of production. This would avoid creating a measure depending on the assessment results.

**Feasibility for farmers**
Easy: data for calculating annual nitrogen inputs and outputs are known by farmers and farming advisors.

**Feasibility for monitoring**
This is a measure based on annual farm assessments and results, that may seem difficult to implement. Several steps should be done in advance, for example to define national or regional level per farming systems, to define the assessment and methodology tools, etc. Nevertheless in some regions, similar farming schemes based on farming assessments and results have been implemented, as in (Switzerland).

### 3.1.2. Leguminous

**GHG reduction potential**
High, through a decrease of direct $N_2O$ emissions from soils (substituted to mineral nitrogen fertilisers) and $CO_2$ emissions from processing and transportation of external feedstuffs of the farms.

**Energy reduction potential**
Indirect energies are concerned through savings of minerals nitrogen fertilisers and feedstuffs purchased on farms.

**Target**
10% minimum of leguminous crops (peas, broad beans, soybean, lupine, lentils, chick peas) in the total surface of cereals of the farm.
40% minimum of leguminous species (clover, alfalfa, sainfoin, vetch) in the total surface of temporary grasslands on the farm.

**Description of the action**
Leguminous species have the ability to fix atmospheric nitrogen (symbiosis with bacteria in nodules on the root system).
Sowing leguminous species on arable lands will improve the fertility of the agro system of the farm.

**Farming systems concerned**
All the farms with arable land in their utilised agricultural area.

**Implementation costs**
Farmers would have to bear the cost of purchasing seeds of leguminous species.
It is clear that grain crops are less profitable than cereals. Moreover, grain legumes are often characterized by a fluctuation in the annual yield due to their sensibility towards climatic conditions (hydric and thermic stress). However, the benefits obtained when sowing legumes (savings in mineral fertilisers and feedstuffs purchased) could balance a part of this loss of profit.

**Added value**
GMO independency in the EU: it would reinforce the traceability of protein crops for breeding farms if more proteins were produced directly on farms.
Nitrogen savings: including legumes benefits the following crops (fertility of the soil). For example, 30 kg of N/ha can be saved on wheat cultivated after peas.
Better quality of fodder produced on the farm: decrease in the need of feedstuffs of the farm.
Grain legumes produced on the farm: decrease in the feedstuffs purchased.

**Other environmental benefits**
Nitrates Directives and Water Framework Directive.
N2000

**Options for the CAP**
Impose leguminous crops through the crop diversity measure of the greening. In pillar I. Other options in the second pillar are available through the knowledge transfer (art 15) and information actions or advisory services (art 16) but their impact will be less significant.

**Feasibility for farmers**
Medium: no specific machinery is required but as legumes are not well developed, improving farmers skills to manage these new crops would be necessary.

**Feasibility for monitoring**
Easy: through the annual CAP declaration of surfaces.

### 3.1.3. Cover crops

**GHG reduction potential**
Decrease in direct and indirect $N_2O$ emissions from soils. Possible reduction of $CO_2$ emissions when cover crops generate less cropland management.

**Energy reduction potential**
Indirect energies at the farm scale (savings of mineral nitrogen fertilisers).

**Target**
Implementation of cover crops and intertillage on 100% of the cropland.

**Description of the action**
Cover crops/ground covers are crops planted primarily to restore soil fertility and quality, contributing simultaneously to a better management of water, weeds, pests, diseases, biodiversity and wildlife in agro-ecosystems. It also includes wild vegetation managed to cover soils as long as possible during the year. This measure is especially suitable for tree crops in all European climates.
Intertillage is an agronomic practice consisting of the use of catch crops (such as beans, clover or peas) that cover the bare soil after other crops. The aim is to prevent nitrogen flushing, to catch atmospheric nitrogen when using leguminous plants, to improve soil conditions, to avoid erosion, etc. The summer intertillage is sown in July or August, mainly after cereals, whereas the winter intertillage is sown in September and October, for example after maize or soya. Another advantage is that these catch crops are an additional forage production, which can be used as fresh matter, hay or silage, thus reducing the need of external inputs.
Regarding climate aspects, cover crops improve the quality of soils in the short/mid - term, reducing the need of using N fertilizers that lead to $N_2O$ emissions. In order to maintain cover crops, tillage and herbicide spraying are abandoned or reduced to the minimum, resulting in the reduction of $CO_2$ emissions. Intertillage practices with legumes replace a significant amount of synthetic nitrogen fertilizer due to the N atmospheric fixation. Finally, both of them contribute to C storage in soils in the long term.

**Farming systems concerned**
All kinds of crops (cereals as well as tree crops).

**Implementation costs**
The implementation of cover crops and intertillage can lead to an increase in machinery operations and seeds purchase in the farm. Nevertheless these practices include a vast diversity of agronomic techniques depending on the crop, climate, farm size, kind of cover plants used, etc.

**Added value**
The main interest for farmers in implementing this measure is related to the improvement of soil structure, which entails a higher content of organic matter, an improvement of the fertility, a decrease in nitrogen needs and a higher resilience to droughts and erosion.

**Other environmental benefits**
Cover crops and intertillage are well-know agronomic measures although insufficiently spread among the farming community. They improve the soil structure, thus having many associated advantages such as avoiding nitrogen leaching to the underground and rivers; creating habitats that benefit the biodiversity and functional connectors between protected areas and/or endangered species; enhancing the potential of biological control of pest and diseases; reducing significantly soil erosion; and with the correct management reducing water consumption on the farm.

**Options for the CAP**
Cover crops and intertillage should be compulsory for Nitrate Vulnerable Zones (Nitrate Directive) due to the fore mentioned benefits concerning the nitrogen use on the farm. For other areas it should be included in the "crop diversity measure" of the Greening (Pillar I) as they improve the crop diversity.
Alternatively this option could be included in the second pillar: both in the knowledge and information transfer measure and in the Farm Advisory System, to ensure the implementation at a large scale.

**Feasibility for farmers**
Medium: as it was mentioned above, the implementation costs of cover crops and intertillage depend on several factors and do not necessarily represent a high cost for the farmer. The most important constraints for the implementation do not refer to economical limitations but probably to other aspects, especially the lack of information among farmers concerning the benefits at the farm scale and insufficient knowledge and transfer of the agronomic techniques.

**Feasibility for monitoring**
High: it requires inspection or farm book control.

## 3.3. Livestock measures

### 3.1.4. Manure storage

**GHG reduction potential**
$NH_3$ ($N_2O$), $CH_4$

**Energy reduction potential**
Indirect energies at the farm scale (savings of mineral nitrogen fertilisers).

**Target**
Cover all the slurry pits.

**Description of the action**
Manure storage of cattle and pig slurry is a source of ammonia ($NH_3$) and methane ($CH_4$). Methane is one of the climate active gases. Ammonia is a precursor gas for nitrous oxide ($N_2O$), which is even a stronger climate active gas than methane. Therefore the reduction of ammonia should be a target in active farming for climate change.

With the relatively simple to handle measure of covering the liquid storage the emission of methane and ammonia during storage can be strongly reduced. There are several possibilities of covering a liquid storage depending on the size and the frequency of the clearance of the storage. The most effective way of reduction of emission is the solid cover such as a concrete or wooden top. Other covers like the floating or the perforated cover, the tent or the natural crust are less effective, but also less expensive.

Cover liquid storage systems with a rigid coverage can decrease $NH_3$ emissions from 70 to 90%; with a flexible coverage can decrease $NH_3$ emissions from 80 to 90%. It also decreases $CH_4$ emissions from manure storage from 20% to 80% (GGELS, JRC).

**Farming systems concerned**
Livestock, especially cattle and pig farms for which liquid manure systems is most frequent.

**Implementation costs**
The implementation costs are related to investment on the farm. Depending on the cover type, the costs can be adapted to the farmer´s budget.

**Added value**
Improvement of the nitrogen content of liquid manure thanks to the avoided nitrogen losses from $NH_3$ volatilization.

**Other environmental benefits**
This measure is directly linked to the NEC Directive implementation. Also, by covering the slurry storage smell emissions can be reduced as well. For farms located in the neighborhood of a village/city the inhabitants would be therefore less disturbed by the smell.

**Options for the CAP**
Cross-Compliance already takes into account measures for manure storage and should include an obligation of coverage of liquid slurry storage for cattle and pig farms to ensure results for climate change mitigation. This measure could also be linked to investment.

**Feasibility for farmers**
Easy: the construction of the slurry storage cover can be guided by a national agricultural adviser. As soon as the type of cover is decided and constructed the handling for the farmer should not be connected with additional work.

**Feasibility for monitoring**
Easy: inspection is required.

### 3.1.5. Manure spreading

**GHG reduction potential**
$NH_3$ ($N_2O$), $CH_4$

**Energy reduction potential**
Indirect energies at the farm scale (savings of mineral nitrogen fertilisers).

**Target**
All the liquid manure.

**Description of the action**
Manure storage of cattle and pig slurry is a source of ammonia ($NH_3$) and methane ($CH_4$). Methane is one of the climate active gas. Ammonia is a precursor gas for nitrous oxide, which is even a stronger climate active gas than methane. Therefore the reduction of ammonia should be a target in active farming for climate change.

The near ground application of slurry reduces the emissions of gases such as methane, ammonia and smell. The state of the art trailing machines such as trailing hose and trailing shoes as well as the application methods with shallow or deep injection can be used therefore. The second improvement for gaseous emission reduction during slurry application, concern the incorporation on soils and the point in time of the application. Slurry should be incorporated as soon as possible after application. The weather during application should be not to hot and not to windy.

For liquid manure, drip hose systems can decrease $NH_3$ emissions around 55%. Also, if liquid manure is injected directly into the soil, 95% to 100% of the $NH_3$ emissions can be reduced.
If solid manure is incorporated 4 hours after spreading, around 80% of $NH_3$ emissions deduction can be observed (60% if incorporation is made 12 hours after spreading).

**Farming systems concerned**
Livestock, especially cattle and pig farms for which liquid manure systems is most frequent.

**Implementation costs**
Specific machinery is needed, thus new investments on the farm.

**Added value**
The ammonia volatilization from liquid slurry is a loss of nitrogen. Therefore the reduction of ammonia emission is a source of nitrogen in the slurry. The farmer needs to add less bought synthetic nitrogen fertilizers.

**Other environmental benefits**
This measure is directly linked to investments measures; Using a ground near application technique the smell emissions can be reduced as well. For farms laying in the neighborhood of a village/city the inhabitants would be therefore less disturbed by the smell.
NEC

**Options for the CAP**
Cross-Compliance already takes into account measures for manure spreading and should include obligations for cattle and pig farms for the spreading of liquid manure to ensure results for climate change mitigation. This measure could also be linked to investment measures.

**Feasibility for farmers**
Easy: at least a new application technique has to be learnt by the farmer. This investment can be quite expensive to be done by a single farmer (if not working with association with others) and can suppose an investment for a five-year budget.

**Feasibility for monitoring**
High: frequent inspection is required.

### 3.1.6. Biogas

**GHG reduction potential**
High: $N_2O$, $CH_4$, $CO_2$.

**Energy reduction potential**
Production of direct energies (in case of heat needs on the farm).

**Target**
Use all manures and residues (crop land and nature protected area) as possible to feed the biogas plants.

**Description of the action**
The fermentation of slurry, residues and other plants generates biogas, which is used in block heating works to produce electricity. Due to this covered process the emission of methane and ammonia from manure storage can be avoided.

**Farming systems concerned**
All livestock farms, especially cattle and pig farms and farms with arable land.

**Implementation costs**
This measure is probably one of the most expensive. Moreover, the planning and construction of a biogas plant are expensive and has to be carried out by professionals.

**Added value**
The production of electricity with block heating works generates heat, which can be used to warm up buildings and water. Another side effect of the biogas production is the reduced smell emission from manure storage, as the fermenter and the post-fermenter are covered and the enhanced efficiency of fertilisers: organic nitrogen is transformed into mineral forms in the digestate, which facilitate balance nitrogen at the farm scale.
The production of electricity and heat with biogas creates new incomes for farmers.

**Other environmental benefits**
This measure is directly linked to the NEC Directive implementation as well as the climate and energy package.

**Options for the CAP**
This measure should be related to investment measures.

**Feasibility for farmers**
High: The installation of the system will be done by experts. To run a biogas plant the farmer needs some month of experience to get to the best working point.

**Feasibility for monitoring**
Easy: inspection is required.

## 3.4. Energy measures

### 3.1.7. Wood & biomass

**GHG reduction potential**
Medium potential of $CO_2$ emission, related to the use of fossil fuel consumed for the heating, usually liquid and gaseous fossil fuel like diesel, LPG, methane, butane.

**Energy reduction potential**
Direct energies at the farm scale (for heating, or drying).

**Target**
100% substitution of the fossil fuel consumed for the boiler with biomass (mainly wood, waste of pruning or other wood by-products).

**Description of the action**
Each farm that requires heat energy for its activities or simply to heat their buildings, can produce the heat from renewable energy like wood or other biomass product.
To implement this action, the conventional boiler needs to be replaced by a new one able to be fed with wood. The raw material could sometimes be obtained on the farm (from the owned forest, using waste from pruning or other by product like the olive stone/pits). If not, it could also be purchased. The boiler technology currently available allows to use both a wide range of materials. In the case of an internal source of biomass, it is necessary to cut, harvest, process and store it in a proper building.
Depending on the case, it could be necessary to adapt the heating system: if the new boiler is positioned in different place, close to the storage of the wood, it is necessary to provide a connector of remote heating to reach the circuit of the heat distribution, which instead is left as it is.

**Farming systems concerned**
The use of the biomass for producing heat is very interesting because it can be applied to all farms that need heat for greenhouses, agricultural product processing, the management of certain animals barns (pigs), or simply for the heating of housing.

**Implementation costs**
Expensive: The main costs for implementing this measure are related to the substitution of the traditional fossil fuelled boiler with another special boiler capable of being fed with wood; the construction, if necessary, of the room used for the wood storage; adapting, if necessary, of the heating system; cutting, harvesting, processing of the raw material if it comes from within the farm.

**Added value**
Reduction of costs related to fuels, independence regarding energy prices.

**Other environmental benefits**
This measure could be linked to the EU climate and energy package as well as biodiversity with the preservation and development of hedgerows on farms.

**Options for the CAP**
This measure should be related to investment measures. Agro Environment Measures through the second pillar are also concerned with hedgerows issues on farms.

**Feasibility for farmers**
Medium: substitution of the biomass boiler; wood supply (purchasing or cutting, harvesting processing and storage); adapting the heating system if needed: creating or adapting the boiler room, organising a storage system for the wood, supplying, implementing with remote heating.

**Feasibility for monitoring**
Easy: brief inspection or bills control for the fuel supply.

### 3.1.8. Photovoltaic

**GHG reduction potential**
Low potential of $CO_2$ emission.

**Energy reduction potential**
Direct energies at the farm scale. Depending on the amount of direct energy consumed in the farm: for some farms, where a lot of electricity is consumed for processing, cooling or irrigation, the potential could be very high.

**Target**
Use the maximum surface of suitable farm roofs.

**Description of the action**
Farm buildings often present significant surfaces. In case of a relevant exposition to solar radiation, photovoltaic panels could be installed for the production of renewable electricity. Sometimes, electricity consumed from the grid could be covered with the local renewable electricity produced (balance between the activity of the farm and the size of the installation).

**Farming systems concerned**
All farms with significant flat surfaces (every 1 kwp installed needs about 7-8 mq for mono or poly crystalline panel), with the right exposure (+/- 20° south directed) and inclination (15°-30°).

**Implementation costs**
Expensive, but depending on the size of the PV plant: each kWp installed costs between 1.500 and 3.000 €.

**Added value**
Income from electricity production, reduction of cost for electricity, energy prices independence.

**Other environmental benefits**
This measure could be linked to the EU climate and energy package. Developing of smart grid in agricultural areas could be very useful from the point of view of environmental monitoring, smart farming management for reducing resources and energy consumption.

**Options for the CAP**
This measure should be linked to investment measures. The "feed in tariff" system to promote the installation of PV in many EU countries has succeeded in developing the market and the technology, thus lowering prices.

**Feasibility for farmers**
Easy: the technology of photovoltaic systems is very mature and allows having the most suitable technical solution for each roof type and PV knowledge is very common among the technicians.

**Feasibility for monitoring**
Easy: to install a PV plant needs an authorization for connecting to the grid.

### 3.1.9. No-tillage

**GHG reduction potential**
Around 50% of fuel reduction for field operations ($CO_2$) compared to conventional systems.

**Energy reduction potential**
Around 50% of fuel reduction (direct energy at the farm scale).

**Target**
100% of the cropland

**Description of the action**
No-tillage is a cultivation technique consisting of a one-pass planting. Soil and residues from the previous crop (mulch or stubble) are minimally disturbed (no plowing). The machines used are normally equipped with coulters, row cleaners, disk openers, in row-chisels or roto-tillers. These penetrate the mulch, opening narrow seeding slots (2-3 cm wide) or small hole, and place the seed and fertilizers into the slots. Weed control is generally achieved by adapted crop rotations (long rotation) and cover crops to avoid bare soil. The entire soil surface remains covered by mulch, or dead sod on more than 50% of the total surface. This technique is different from the one-passage sowing, where reduced tillage is performed with a combined tool (e.g. drill + rotary harrow).

**Farming systems concerned**
All kind of croplands.

**Implementation costs**
This measure requires a specific investment on direct seeding machine.

**Added value**
Other benefits of this measure can be the reduction of cost for fuels, energy prices independence, the increased in organic matter content of the soil (higher fertility) and to reduce the working time per ha as field operations are restricted to sowing.

**Other environmental benefits**
Numerous results reinforce and confirm evidence that no-tillage can diminish springtime run-off and erosion, provided the soil is sufficiently covered (with mulch, green manure, catch crops, etc.) and its biological activity is significant.
The increase in the organic carbon stock is mainly located in the topsoil layer (the first 10 cm). The process continues until a new balance is reached between accumulation and destruction in the topsoil layer. Notice that the alternate use of ploughing and no-tillage techniques can cause the rapid disappearance of all the positive effects of organic carbon in soil, which is why no-tillage has to be maintained over time to store carbon durably in the soil.

**Options for the CAP**
This measure could be included in the second pillar: both in the knowledge and information transfer measure and in the Farm Advisory System, to ensure the implementation at a large scale.

**Feasibility for farmers**
High: to be successful, no-tillage should be combined with cover crops and a diversified rotation. Improvement in agronomics skills is needed for farmers with the help of qualified advisors. A transition period is necessary, especially for farmers that are still using full tillage (reduced tillage should be tried before no-tillage).

**Feasibility for monitoring**
High: only with a certification scheme system.

### 3.1.10. Fuel reduction

**GHG reduction potential**
Reduction of $CO_2$

**Energy reduction potential**
Direct energy at the farm scale.

**Target**
10% reduction in the fuel consumed for mobile machines on farms.

**Description of the action**
The fuel consumed by mobile machines (tractors and other farming vehicles) can be reduced at a farm scale in several ways. In some countries interesting initiatives have been implemented to test the tractors' engines (for example "Banc d'essai tracteur" in France), going beyond the theoretical measures published extensively in most countries and demonstrating that the average amount of fuel saved can be significant (in France, an average of 10-15% reduction in fuel consumption has been achieved after the tests).

Eco-driving training for farmers has also been implemented in several countries showing interesting results. Finally, the reduction of fuel can come as a result of the implementation of other sustainable farming practices that lead to the reduction or optimization of works in the farm. For example, implementing an Integrated Production can suppose a reduction in the number of plant protection treatments and a reduction

in the use of tractors; the implementation of cover crops on tree farms can significantly reduce the tillage and herbicides treatments, and again a reduction in the use of the tractor.

**Farming systems concerned**
All farms.
For farms with livestock, it is quite frequent that half of the total fuel consumption is related to the animals care in buildings (fodder distribution, mulch for animals, cleaning of manure…).

**Implementation costs**
The average cost of engine tests for tractors in the mentioned French experience is 130 €/tractor. The cost of adjusting the tractor after the test results goes from 20 to 1.500€, depending on the equipment, a cost that can be easily compensated with the average fuel reduction of a 10-15% achieved. In the "Banc d'essai tracteur" French experience the testing equipment travels in a truck to different regions of the country to ensure a maximum engagement of farmers. The investment cost for setting up the testing equipment can be significant, but the French initiative has been working for several years under public and public-private management.
For eco-driving training financial limitations should not be a problem. And finally, fuel saving through best sustainable practices can be considered as a parallel benefit of their implementation.

**Added value**
The added value is the reduction of expenditures for the farmer, especially in the current trend of petrol prices increase.

**Other environmental benefits**
Climate and energy package.

**Options for the CAP**
All measures concerning the reduction of fuel consumption could be included in the second pillar: both in the knowledge and information transfer measure and in the Farm Advisory System, to ensure the implementation at a large scale.

**Alternative solutions**
Not envisaged

**Feasibility for farmers**
This measure is very easy to implement for farmers and probably one of the most popular, as fuel is one of the main consumption sources for farmers and its reduction is considered a priority.

**Feasibility for monitoring**
Engine tests are easy to monitor as the farmers receive a document after the engine test. Monitoring could include presenting this document and/or the proof of the tractors modifications to be more efficient.

### 3.1.11. Electricity reduction

**GHG reduction potential**
$CO_2$ reduction from the production of electricity.

**Energy reduction potential**
Direct energy at the farm scale.

**Target**
5 to 30% of the total electricity consumption of the farm.

**Description of the action**
The potential of electricity reduction on dairy farms focuses on the milking process: Installed vacuum pumps reduce the electricity during milking, pre-cooling milk systems reduce the electricity consumption during milking, with an installed heat exchange system the heat can be reused for room heating and water warming.
On irrigated farms, irrigation can represent significant electricity consumption: adjust quantities of water to the hydric needs of the plants with the help of tensiometric probes in the soil is a way to decrease water consumption and therefore electricity consumption.
Farms with processing activities often present issues with electricity optimisation: in case of heat needs, solar panels could be an option. Also, when colds rooms are used on the farm, a potential of heat recovery could be studied.

**Farming systems concerned**
Farms with significant electricity consumptions such as dairy farms, irrigated farms, farms with processing activities or equipped with cold rooms.

**Implementation costs**
Depending on the equipment needed, the type of investment could be very different.

**Added value**
Other benefits far the farmers can be the electricity savings and the decrease in the farm energy dependence.

**Other environmental benefits**
Climate and energy package.

**Options for the CAP**
This measure should be linked to investments measures: electricity efficiency increase should by compulsory for new built farms and replaced machines.

**Feasibility for farmers**
Easy: the installation of the systems will be done by experts but with no significant difficulties.

**Feasibility for monitoring**
Medium: it depends on whether there is an investment or not, and the kind of equipment purchased.

## 3.5. Agro Environmental Measure for climate: low carbon farming practices

**GHG reduction potential**
To encourage and maintain low carbon farming practices.

**Target**
Farmers would receive money through an AEM demonstrating their low climate impact with the help of a GHG assessment at the farm scale.

**Description of the action**
Regarding the results, a great variability in GHG emissions and climate efficiency exists between farming systems and inside a same farming system. These results are linked to both farm practices and farmers' skills and interests. As seen previously, there are often several options on a farm to reduce GHG emissions. Implementing an "AEM climate system", based on GHG results at the farm scale, would allow farmers to be free to organise themselves to reach effective results at the end.

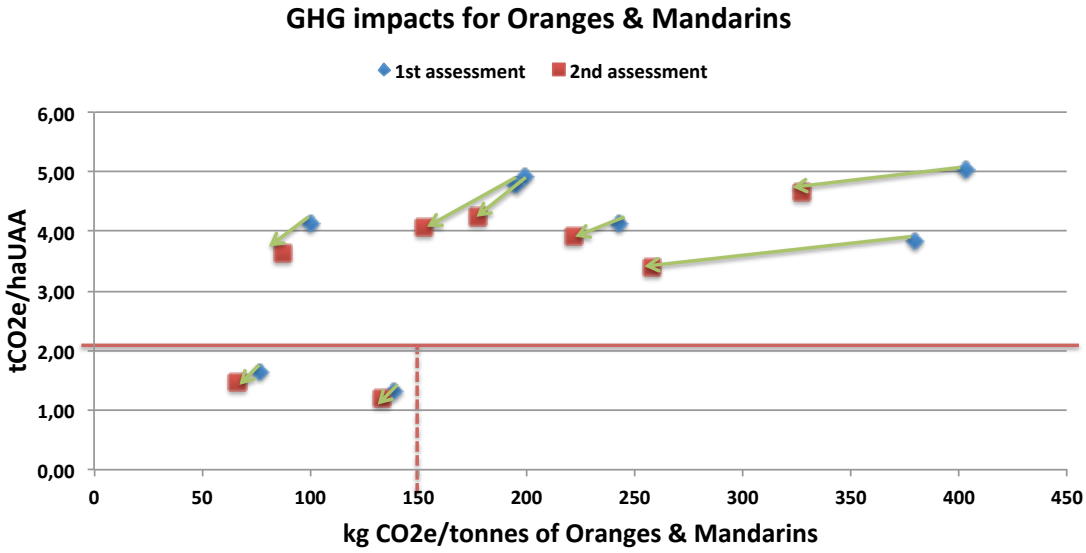



Figure 6: Results from 19 farms producing oranges & mandarins in Valencia (AgriClimateChange project)

For example, Figure 6 shows that for oranges and mandarins farms, GHG emissions per ha of UAA can vary from around 1 tCO2e/ha to 5 tCO2e/ha. These observations would be the same for other agricultural products (dairy milk, cereals, olives…).

An annual GHG assessment at the farm scale could be run by a "certified" external adviser (1 day, divided in ½ day to collect data and ½ day to get results).
The assessment has to be carried out at a farm scale level on a cultivation period (one year). It is the user who defines the beginning and the end of this period based on present agricultural production on the farm and their production cycles.
Most of required data are usually available in various documents of the farm: CAP statement, fertilisation plan, the farm account, invoices input, identification of the herd... Thus, most data could be checked if verification is needed.
The authorities should determine a list of data, stating which ones are mandatory.

Then, in the current context of the availability of numerous "climate tool" for agriculture, it seems necessary to use a recognised tool (for example, Carbon Calculator designed by the JRC for the Parliament). Each tool presents its own methodology, emissions factor and perimeter, which leads at the end to a variability in the final results.

The next step is the central point of the AEM clima: to define national or regional references of climate impacts per farming systems to determine low, medium or high level of emissions.

First of all, GHG emissions that are not linked to the agricultural activities (processing, transportation of products…) should be reported apart from the agricultural sources. Thus, farms that sale their products won't be disadvantage.
Finally, a threshold has to be determined for GHG emissions per ha for the main farming systems (only based on annual gross GHG emissions, not a GHG balance).

**Farming systems concerned**
Farms for which low, average and high level of emissions have been characterized at a national or regional level.

**Implementation costs**
1 day per year to do the assessment at the farm scale.

**Added value**
Support farmers that are "climate friendly".

**Other environmental benefits**
This measure should be linked to the European Union strategy about climate and energy package.

**Options for the CAP**
This measure should be linked to Agro Environment Climate measure (Art 29) and would suppose the optimal development of a climate friendly measure with significant effects at the farm sector.

**Feasibility for farmers**
Easy: data required for the assessment are available in several documents of the farm. Nevertheless, the assistance of an advisor with climate friendly agricultural skills would be necessary.

**Feasibility for monitoring**
Easy: this is a measure based on annual farm assessments and results, that may seem difficult to implement. Several steps should be done in advance, for example to define national or regional level per farming systems, to define the assessment tools, etc. Nevertheless in some regions, similar farming schemes based on farming assessments and results have been implemented.

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