WORK PACKAGE 3

CCCfarming Book: FARM PLANS

CCCfarming book: Farm plans

Project: CCCfarming

Workpackage 3 'Mitigation practices and techniques'

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Content

Introduction to farm plans

Formulation of farm mitigation plan

The base situation of the on-farm nutrient balance in the year 2020 of the 60 field study farms have been prepared as part of the project CCCfarming. The nutrient inventory has been performed with three Nutrient Management Tools, i.e AgreCalc from Scotland, ANCA from the Netherlands and Cap'er2 tool from France.

The goal was that a one-page development plus emission mitigation plan would be drawn up of each of the 60 CCCfarming field study farms. This would be executed by the local research team in discussion with the farm family on basis of the following work performed in this project:

- Description of farm (Task 1.1 of project plan)
- NPC balance of farm (Task 1.4 of project plan)
- Emission measurements with simplified method (Task 1.5 of project plan)
- Outcome of Kitchen Table interview performed with survey (Task 1.6 of project plan)
- Additional input of farmer

As a key part of composing the Farm Plan, the farmer could choose a small set of mitigation practices of which the effect on the nutrient balance and emissions was assessed through calculations. For this purpose, a list of mitigation practices was prepared based on an extensive inventory in the partner countries of interesting practices thought to reduce the GHG and ammonia emissions on dairy farm level. Also, results of the Kitchen Table interviews contributed to the composition of that list. Next, the most suitable practices were selected that fitted to be simulated by the Nutrient tools.

To present the list of the 17 chosen practices to the CCCfarming study farmers, the description of practices was translated into the local language. The project partners provided supporting farm data and information to make the tool simulations possible, as well as supporting data for the economic (MACC) calculations. These data were based on in depth conversations with the farmer and on expert knowledge.

Those study farms were selected that had fully completed data for either the ANCA or the AgreCalc tool. In discussion and agreement of the local project team with the farm family, 2 to 4 alternative mitigation practices were chosen for each farm. Next, the chosen practices were simulated by re-running the Agrecalc or ANCA nutrient accounting tool. The ANCA tool deals with GHG and NH_3 practices, while the AgreCalc tool focusses on GHG. But in the list of practices for the AgreCalc tool, nitrogen reducing practices were also listed. For these N-practices, the indirect positive (or negative) effect on GHG is taken into account by the tool. In fact, the repeated calculations that took place can be defined as a simulation of various practices, while the outcomes / environmental impacts were compared with the base calculations of each particular farm as done before.

- **Agrecalc**: a carbon footprint tool developed in the United Kingdom for agricultural production systems (link to website) designed to identify the main sources of GHG emissions and benchmark key performance indicators.
- **ANCA**: the Annual Nutrient Cycling Assessment tool, developed in the Netherlands for dairy production systems (link to website).

Per country, the ANCA tool was used to re-run the chosen practices for two farms, and the AgreCalc tool for the other farms. The obtained simulation results were compared with the base situation, i.e. farm data collected for the reference year 2020. As explained, the nutrient management calculation tools provide

technical output. The framework for economic aspects of the alternative practices / mitigation measures was generated by applying a Marginal Abatement Cost Curve (MACC) approach. Based on these results "Farm plans" were prepared for each study field farm separately.

The framework of the Farm Plan contains the following information:

1. Description of farmers' future strategy on development of farm and reduction of emissions
2. Which mitigation measures / practices were already taken?
3. Which mitigation measures are planned to be implemented and how?
4. Expected effects on emissions (based on tool calculations)
5. Equipment involved, investment and economics
6. Attention points when implementing measures
7. Quote of farmer

Overview of simulated mitigation practices

A description of the mitigation practices, including some indication of the benefits and costs of implementing such a practice, are presented in below Table 1. Next, each of the project farms chose 2 to 4 preferable emission mitigation measures from this list, which practices were related to the needs of the individual farm and the local situation, for calculating, in fact simulating and the effects on the farm business.

Table 1: Scheme of presented sixteen mitigation measures

Measures	NH3	GHG	Explanation
I	II	III	IV
Increase feed efficiency	x	x	The aim of the measure is to improve the feed conversion rate (reduce required DM per kg FPCM). In this example we assume feed efficiency is improved through improved feeding, causing less feed is needed. We assume the feed ration composition is not changed and milk yield remains the same. **Mitigation practices include:** feed ration calculation; feeding plan preparation; precision feed distribution. **Farm benefits**: lower feed consumption. **Farm expenses***:* application of precision farming.
Low protein diets	x	x	The aim of the measure is to reduce the N content of feed ration ingredients, e.g. by reducing N content of concentrates. We assume milk yield and milk composition remain the same, the feed ration composition is not changed, and there are no changes in grass or crop management. **Mitigation practice include:** purchase/production of low protein feed; feed ration calculation; feeding plan preparation; precision feed distribution**.** **Farm benefits**: Less N in manure effects - less NH_3. **Farm expenses**: application of precision feeding.
High digestible diet and change in crops		x	The aim of the measure is to reduce methane production by increasing the digestibility of rations. **Mitigation practice include**: purchase or production of high digestible feed; feed ration calculation; feeding / cropping plan preparation incl. land use; precision feed distribution. **Farm benefits**: the amount of fodder required decreases, thus alternative use of land possible. **Farm expenses**: change in work input for farmer (less or more work dependant on choices made in cropping and land use plan).
Use of probiotics in the barn		x	The aim of the measure is to use Probiotics for adult ruminants to improve fibre digestion by rumen microorganisms and reduce ruminant CH_4. **Mitigation practice include:** purchase/production of probiotics; precision probiotics distribution. **Farm benefits**: perhaps effect on growth and feed efficiency. **Farm expenses**: probiotic cost, increased additional work through precision feeding for farmers.

I	II	III	IV
Methane blocker as feed additive		x	Effect on reduction CH_4 depends on ration daily. Milk yield and milk composition remains the same, assumed that the feed ration composition is not changed, and there are no changes in grass or crop management. **Mitigation practice include:** enteric methane inhibitor purchase; precision inhibitor distribution**.** **Farm benefits**: Use of 3-NOP reduces methane from 5 to 30%; a slight increase in fat% may be expected. **Farm expenses**: methane blocker cost; precision feeding.
Use of nitrification inhibitor for crops	x		The aim of the measure is to decrease nitrogen loses with nitrification inhibitors use to retard or prevent the conversion of ammonium-nitrogen to nitrate-nitrogen by nitrifying bacteria in soil. **Mitigation practice include:** nitrogen fertiliser with inhibitors use. **Farm benefits**: increased yield and recovery of fertilizer nitrogen by a crop, less nitrogen fertiliser demand. **Farm expenses**: additional expenses for the purchase of fertilizer with inhibitor.
Low emission floors	x		The aim of the measure is to separate the faeces and urine flows in the barn. **Mitigation practice include:** reconstruction of the barn floor by installing the appropriate type of floor**.** **Farm benefits**: animal welfare improves. **Farm expenses**: capital investment: floor type; extra storage; field application
Mechanical manure separation	x		The aim of the measure is to divide liquid manure into solid and liquid fractions by using techniques of manure separation. **Mitigation practice include**: purchase and installation of separation equipment; construction of production facilities. **Farm benefits**: possibility of two manure products: liquid and solid **Farm expenses**: capital investment: separator, electricity, field application (slurry, liquids, solids)
Manure acidification	x	x	Reduce N losses during manure management at field application. **Mitigation practice include**: purchase and installation of acidification equipment. **Farm benefits**: reduction in N losses **Farm expenses**: costs for equipment in barn and application in field; acid costs; possible additional equipment / fertilizer needed for liming the soil
Adding straw to slurry for covering the manure storage	x		The aim of the measure is to reduce N losses during manure management in the outdoor storage. Assumed is sealing the outdoor storage with straw cover. **Mitigation practice include:** straw cover installation**.** **Farm benefits**: reduce nitrogen losses, inorganic fertiliser saved. **Farm expenses**: additional work/equipment for adding straw to manure
Conversion of manure lagoon to cylindrical storage (from open to tanks without covering)	x		Decrease is realized in surface m^2. The aim of the measure is to reduce N losses during manure management in the outdoor storage. **Mitigation practice include:** new construction of the cylindrical manure storage**.** **Farm benefits**: reduced manure management costs, and reduced fertilizer use. **Farm expenses**: investment in cylindrical manure storage

I	II	III	IV
Covering manure storage	x		The aim of the measure is to reduce N losses during manure management in the outdoor storage. Assumed is sealing with outdoor storage impermeable cover. **Mitigation practice include**: purchase and installation of storage impermeable cover. **Farm benefits**: reduction in N losses **Farm expenses**: investment in manure storage cover; manure management somewhat more complicated
Low emission slurry spreading techniques	x		The aim of the measure is to reduce N losses during manure management at field application incorporate slurry directly into soil. **Mitigation practice include**: purchase and installation of application equipment; **Farm benefits**: reduction in N losses **Farm expenses**: investment in drain system + injector or in tank + injector; additional manure management efforts compared to traditional management, like mixing and spreading of the slurry
Anaerobic digester	x	x	The aim of manure fermentation in a biogas reactor is to ensure efficient manure management and production of valuable fertilizers for agricultural crops, as well as to reduce GHG emissions to a minimum in cattle farms. **Mitigation practice include**: purchase and installation of anaerobic digester equipment; mono (manure) and Co (other bioresources) use. **Farm benefits**: reduction in N losses; production of fertilizers; production of renewable energy sources (methane and heat) **Farm expenses**: capital investment in biogas installation; maintenance
Renewable energy sources on farm (RES)		x	The aim of the measure is the production of renewable energy on the farm. The following resources are used: solar, wind, ground heat or biomass (wood and agricultural by-products). **Mitigation practice include**: purchase and installation of RES equipment. **Farm benefits**: substitution of supplied energy consumption with that produced on the farm. **Farm expenses**: capital investment in RES equipment; maintenance
Energy saving equipment			The aim of the measure is to install energy-saving technology and equipment on the farm. **Mitigation practice include**: purchase and installation of energy-saving equipment. **Farm benefits**: used energy saving on the farm. **Farm expenses**: changing the technology used; capital investment in energy saving equipment; maintenance

The farmers' preferences of mitigation measures accumulated over all farmers in the CCCfarming project are shown in Figure 1.

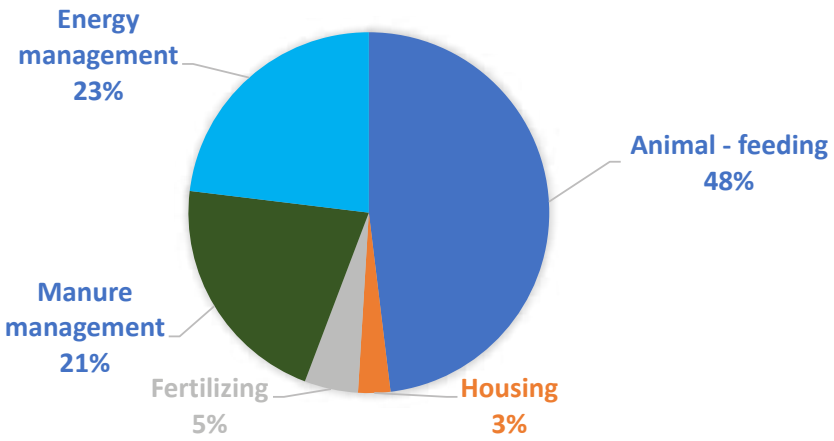

Figure 1. Farmers choice of mitigation measures

There are significant variations in the chosen practices for simulation between the farms in the eight countries. The choices were determined by farmers and their consultants based on the practical needs and characteristics of the farm. The choices per country are listed in below table 2.

Table 2: Farmers choice of mitigation measures in eight countries

Mitigation measures	Country							
	LV	LT	PL	DE	NL	UK	FR	IT
Increase feed efficiency	7	2	6	1	2	1	2	2
Low protein diets					4			2
High digestible diet and change in crops						1		
Use of probiotics in the barn			1	1		1		1
Methane blocker as feed additive	2	1	4		3	5		1
Use of nitrification inhibitor for crops	2			1				
Low emission floors	2				1			
Mechanical manure separation						2		
Adding straw to slurry for covering the manure storage				2				
Covering manure storage	1	2	3	2		1	2	2
Manure acidification		1		1				1
Low emission slurry spreading techniques	2							
Renewable energy sources on farm (RES)	4	1	4		3	4		1
Energy saving equipment		2		1		1		

As shown in table 2, the farmers most often selected "Increase in feed efficiency", "Use of probiotics in barn", "Methane blocker as feed additive", "Covering manure storage", and Renewable energy sources" as preferred mitigation strategy from the 14 practices available.

Principle of the technical evaluation of the mitigation practices

The output of the simulation calculation results with tools were prepared separately and dedicated for greenhouse gases from AgreCalc tool and for ammonia from ANCA tool.

The following emissions criteria were estimated with the Agrecalc tool:

- Reduction of total farm emissions in kg CO_2e per hectare, compared to original, i.e. base situation
- Reduction of total farm emissions in kg CO_2e per livestock unit (LU), compared to original, i.e. base situation
- Emissions' reduction from whole farm production output in kg CO_2e, compared to original, i.e. base situation
- Total CO_2e emission from farming in kg CO_2e, compared to original, i.e. base situation

Criteria calculation with the ANCA tool:

- Ammonia emission reduction from farm in kg NH_3, compared to original, i.e. base situation
- Reduction of ammonia emissions in kg NH_3 per Dutch livestock unit (LSU), compared to original, i.e. base situation
- Emissions' reduction from production of 1 ton of milk in kg NH_3, compared to original, i.e. base situation
- Reduction of total farm emissions in kg NH_3 per hectare, compared to original, i.e. base situation

Principle of economical evaluation of the mitigation practices

MACC (Marginal Abatement Cost Curve) calculations are used in France (Pellerin S. et al., 2013), Ireland (Schulte R. et al., 2012), Great Britain (Spadavecchia L., 2014) as well as in other countries. Overall, one can find that the approaches and solutions are diverse (Eory V. et al., 2018). Latvia also constructs MAC curves for its agriculture (Popluga, D., et.al, 2017). In general, a MACC is a very useful instrument for an analysis of GHG emission abatement measures, yet it has limited opportunities to give a comprehensive insight into the effects on economic activity as a whole, as it does not have parameters of the social, economic as well as natural environments.

Method. In order to evaluate the economic efficiency of the measures, it is not necessary to calculate all the management costs, but only those costs or incomes that change because of the implementation of the measures, i.e. the marginal costs or benefits (returns) should be calculated. The MACC approach with the additional costs or benefits is illustrated in Figure 2.

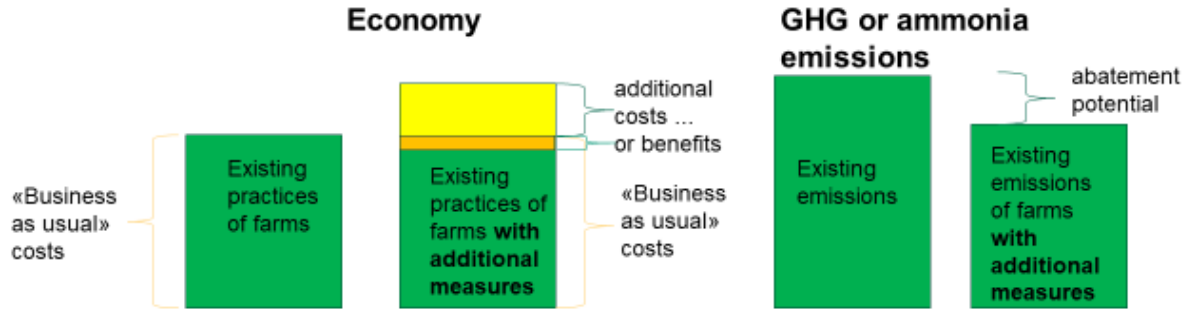

Figure 2. Scheme of Marginal Abatement Cost Curve (MACC) calculation

Data. Explanation of measures mainly describe the purpose, benefits and costs. There are significant variations in the simulation of farms in the application of each individual measure. They were determined by farmers and consultants based on the practical needs and characteristics of the farm. The data were offered by farmers and representatives of the countries, this applies both to data characterizing the activity, as well as prices, investments and others. If farmers or state representatives were unable to provide information, then statistical data and surveys were used, and these data were coordinated with country representatives.

The result. The information obtained in the calculations was used to create a Farm Plan, which describes the effectiveness of GHG and Ammonia reduction measures for each farm of the project. The aggregated MACC describes the total effect of all GHG mitigation measures applied to the farms (Figure 3).

In these figures the X-axis characterizes the GHG or ammonia emission reduction potential of each measure (in t CO_{2e}, kg NH_3) resulting from the implementation of the measure. The Y-axis characterizes the costs or benefits of each measure. These are calculated per kg of reduced GHG or ammonia emissions.

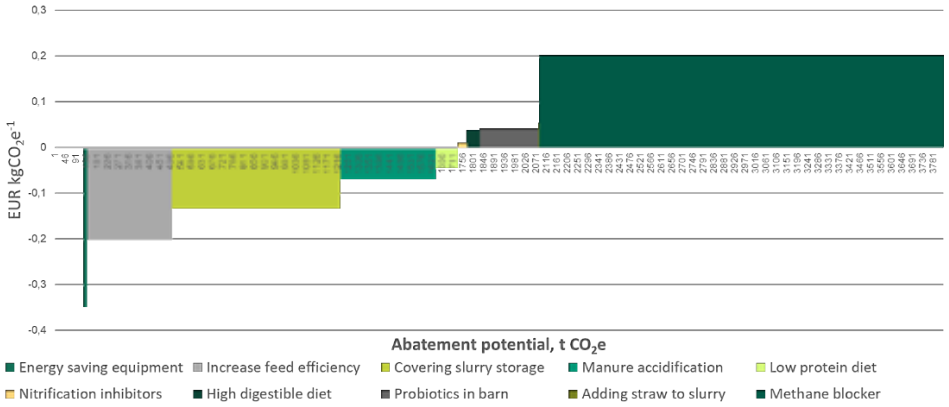

Figure 3. MACC on basis of the simulated application of mitigation measures (practices) on the field study farms*, expressed in total reduction potential and cost / benefit per 1 kg reduction in emission compared to the base situation in 2020.

*For the measure "Renewable energy production", the cost (EUR - 11.84) is not shown, which is done for better visualization.

A number of measures has negative costs. This indicates that the measure creates not only a reduction in emissions, but also additional financial benefits. The opposite is the case with measures that have positive costs, when implementing the measures additional costs must be expected in order to achieve GHG emission savings. For example, the "Methane blocker" measure is very popular, which provides a large part of the GHG emission savings, but it generates 0.2 EUR in additional costs for each reduced ton of CO_{2e}.

List of references

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Farm plans

Latvia

1. Description of farmers' future strategy on development of farm and reduction of emissions

Farm LV_1 has made changes in farm practices and strategies to reduce greenhouse gas emissions and increase carbon sequestration. These practices and strategies are: Extending pastures and improving animal welfare.

For the reduction of emissions, farmers consider important would be to change the following farming activities: animal health; Livestock sheds and manure storage; Fertilizer and manure use and soil management; Machinery and Fuel Use and Technology and Automation.

For the economic development of the farm farmers consider important the following farming activities:Increase milk production per cow; Increase longevity of stock; Use grass clover mix in pastures; Increase fertilisation efficiency; Increase roughage production per ha; Add feed additives to ration and Increase soil organic matter.

To reduce an ammonia emissions farmer made changes on the following farming practices: fast application of manure and retain nitrogen. In the future, the farm does not plan to implement additional measures to reduce an amonia emissions.

2. Which mitigation measures / practices were already taken?

- **Extending pastures**
- **Improving animal welfare**
- **Fast application of manure**
- **Retain nitrogen**

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Renewable energy production (RES) at farm.
The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Renewable energy production (RES) at farm.
The measure envisages placing 12.8 kW solar panels on the farm, which will produce 10,432 kWh of electricity.

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, which provide for the preparation of feed plans (377 EUR per year), additional work for the distribution of feed to workers (105 EUR per year).

Renewable energy production (RES) at farm.
The investment for the purchase and assembly of the panels is EUR 17,920 and the service life is 20 years. The value of the produced electricity (price 0.11 EUR kWh-1) is 1,148 EUR per year.

6. Attention points when implementing measures

Increase feed efficiency.
It is difficult to express the expected effect financially

Renewable energy production (RES) at farm.
The solar panels service life.

7. Quote of farmer:

"while increasing milk production per cow, it is important to maintain the longevity of the herd"

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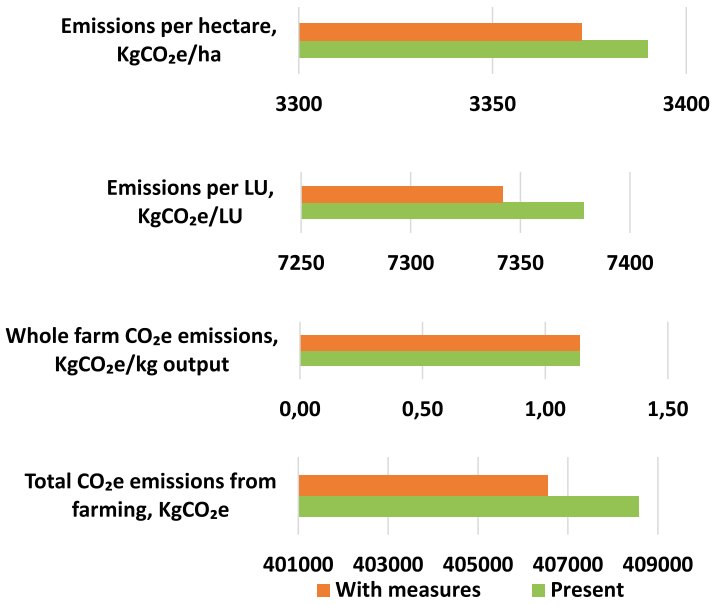
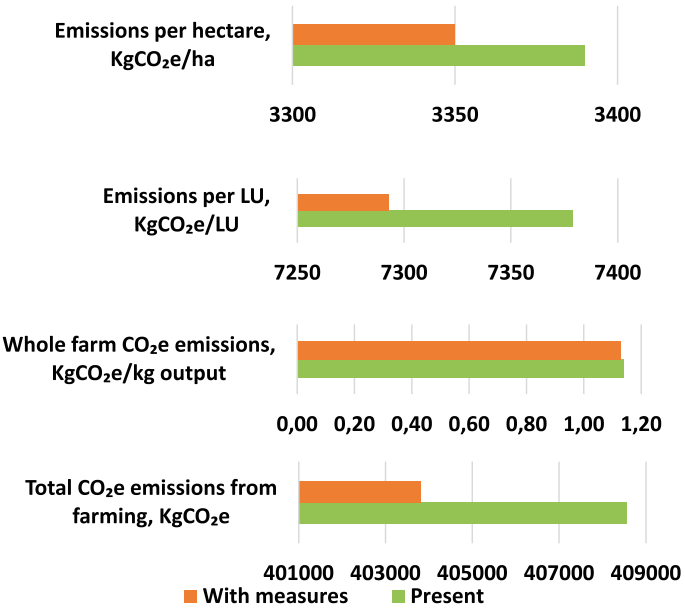
8. Table: Farm LV_1 emissions calculations results with Agrecalc tool

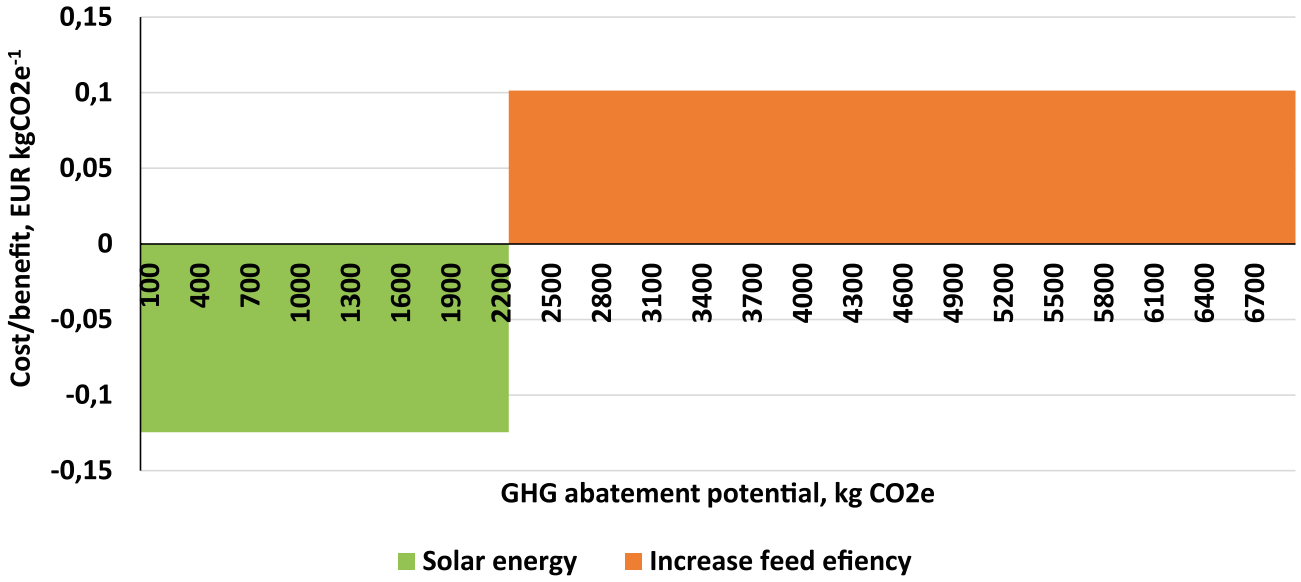
GHG emissions reduction with RES use



GHG emissions reduction with feed efficiency



9. Economics: MACC curve LV_1 with all simulated measures



Picture resource: https://cometrenewables.ie/solar-pv-for-dairy-farms/

1. Description of farmers' future strategy on development of farm and reduction of emissions

Farm LV_2 has made changes in farm practices and strategies to reduce greenhouse gas emissions and increase carbon sequestration. These practices and strategies are manure storage cover, silage coating and manure plowing.

In order to reduce emissions, the farmer believes that it is important to change the following agricultural activities: Improve animal feeding and health; Improve fertilizer and manure application and soil management; modernization of the barn by introducing technologies and automation.

For the economic development of the farm farmers consider important the following farming activities: Animal feeding; Animal breeding; Animal health; Livestock housing and manure storage; Fertilizer and manure application and soil management; Irrigation and/or drainage and Business management (contracts and labour) .

In the future, the farm plans to implement the use of inhibitors and introduction no till measures to reduce ammonia emissions.

2. Which mitigation measures / practices were already taken?

Improving animal feeding

Improving animal welfare

Manure storage cover

Manure plowing to retain nitrogen

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.

Feed efficiency is improved through improved animal management (incl. health).

Renewable energy production (RES) at farm.

The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.

Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Renewable energy production (RES) at farm.

The measure envisages placing 10 kW solar panels on the farm, which will produce 8,150 kWh of electricity.

5. Equipment involved, investment and economic

Increase feed efficiency.

Significant changes in farming, which provide for the preparation of feed plans (81 EUR per year), additional work for the distribution of feed to workers (23 EUR per year).

Renewable energy production (RES) at farm.

The investment for the purchase and assembly of the panels is EUR 14,000 and the service life is 20 years. The value of the produced electricity (price 0.11 EUR kWh-1) is 896 EUR per year.

7. Quote of farmer:

"The future growth of the farm will be determined by the introduction of robotization"

6. Attention points when implementing measures

Increase feed efficiency.

It is difficult to express the expected effect financially

Renewable energy production (RES) at farm.

The solar panels service life.

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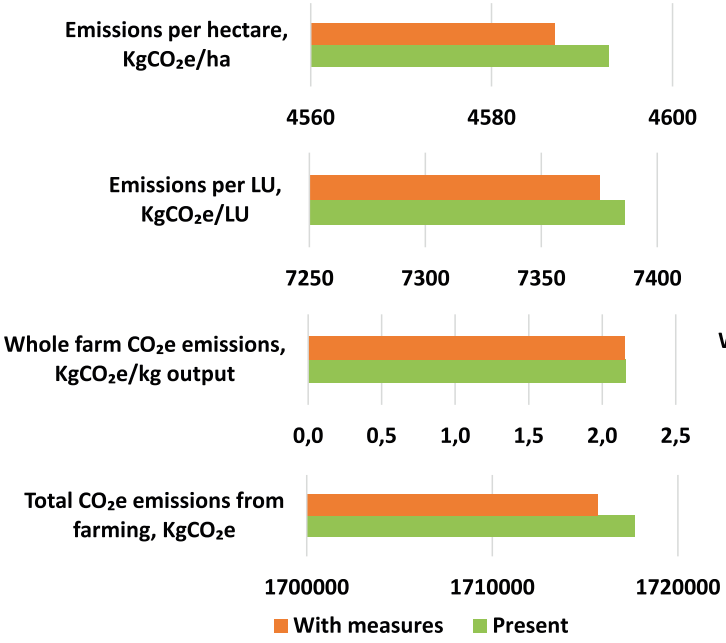
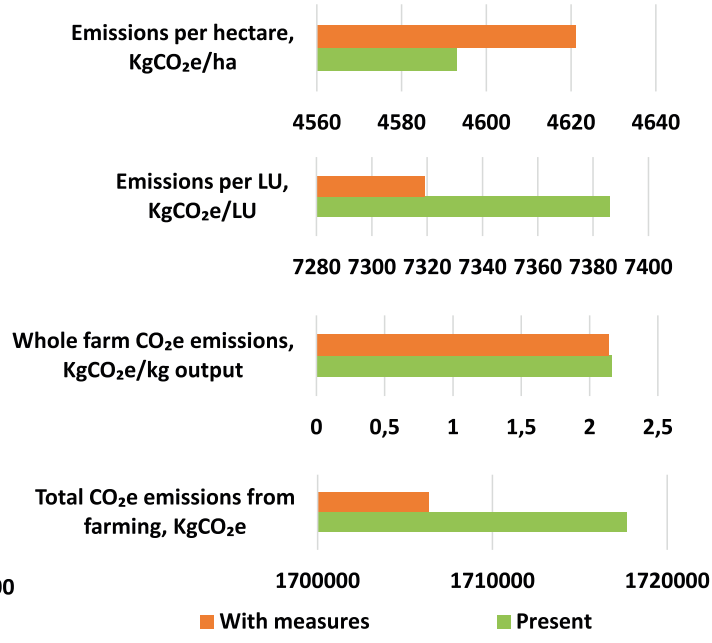
8. Table: Farm LV_2 emissions calculations results with Agrecalc tool

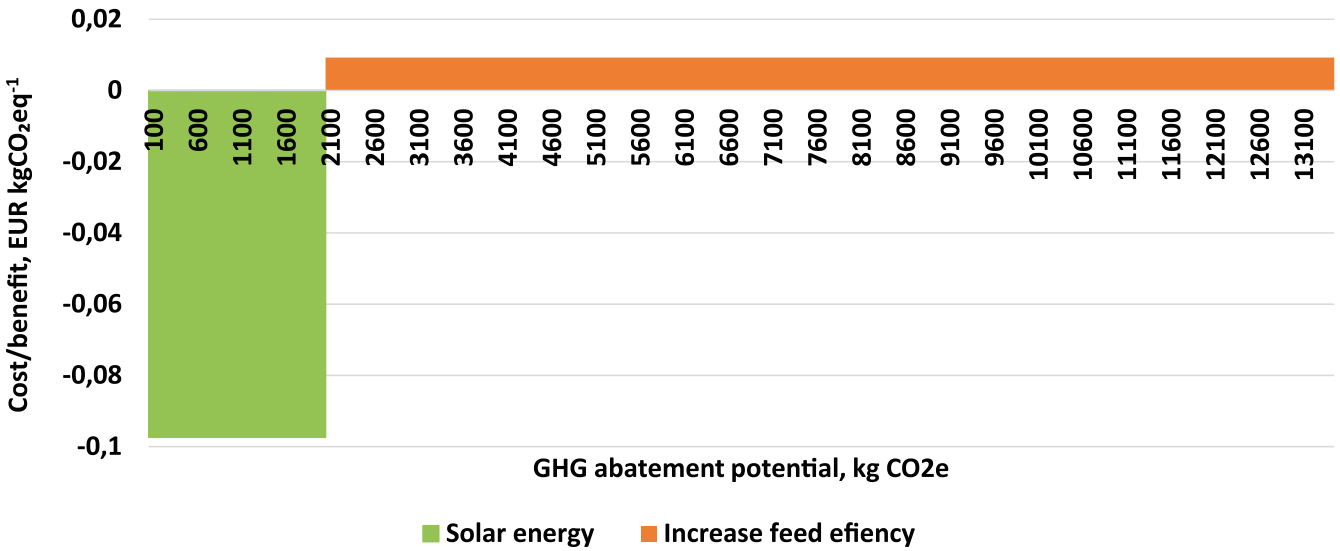
GHG emissions reduction with RES use



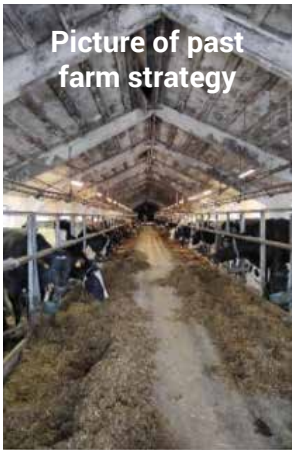
GHG emissions reduction with feed efficiency



9. Economics: MACC curve LV_2 with all simulated measures



Picture resource: https://cometrenewables.ie/solar-pv-for-dairy-farms/



1. Description of farmers' future strategy on development of farm and reduction of emissions

Farm LV_3 has not yet made any changes to farm practices and strategies to reduce greenhouse gas emissions and increase carbon sequestration.

In order to reduce the greenhouse gas emissions of the farm, it would be important to change such agricultural activities: improve animal feeding health; livestock housing and manure storage; fertilizer and manure application and soil management; grassland and grazing management (e.g., reseeding, cutting regime) and technology and automation.

For the economic development of the farm farmers consider important the following farming activities: improve animal feeding health.

Farm has not yet made any changes to farm practices and strategies to reduce an ammonia emissions.

2. Which mitigation measures / practices were already taken?

- **Extending pastures**
- **Improving animal welfare**
- **Fast application of manure**
- **Retain nitrogen**

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Use of nitrification inhibitor for crops.
For which crops a nitrification inhibitor was used, the expected N2O reduction range is 10 to 20% of the amount of fertilizer and slurry used.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Use of nitrification inhibitor for crops.
The measure envisages the use of urea with an inhibitor on an area of 13.5 ha.

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, which provide for the preparation of feed plans (291 EUR per year), additional work for the distribution of feed to workers (81 EUR per year).

Use of nitrification inhibitor for crops.
The implementation results in an additional cost of EUR 150, while ensuring a more efficient use of N and providing a saving of EUR 138.

6. Attention points when implementing measures

Increase feed efficiency.
It is difficult to express the expected effect financially

Use of nitrification inhibitor for crops.
An increase in the price of nitrification inhibitor is expected.

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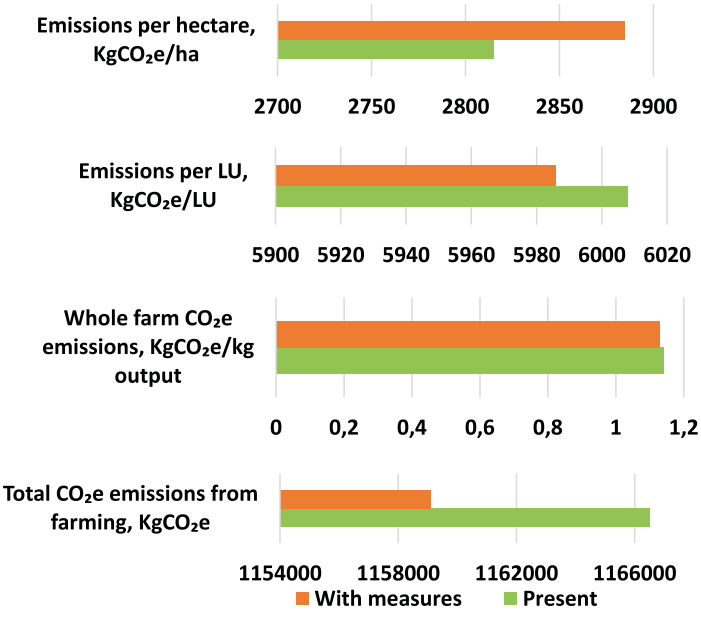
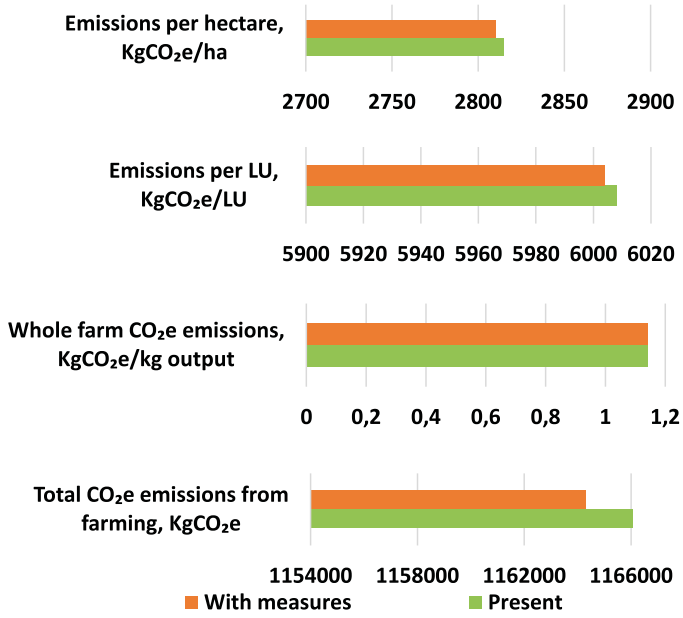
8. Table: Farm LV_3 emissions calculations results with Agrecalc tool

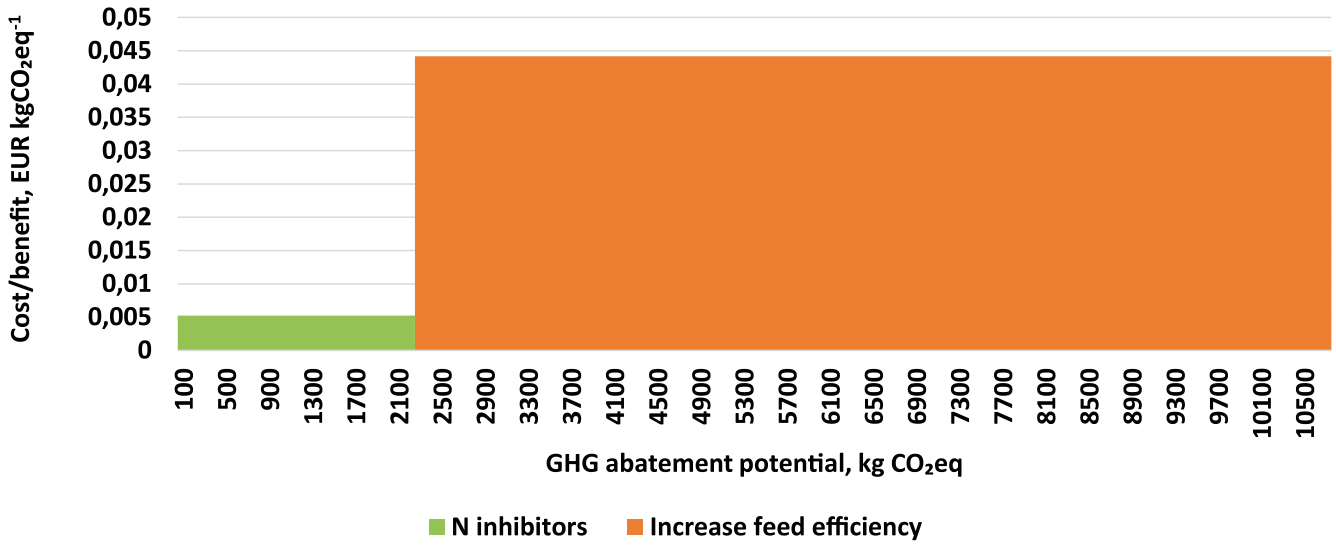
GHG emissions reduction with feed efficiency



GHG emisions reduction with inhibitors use



9. Economics: MACC curve LV_3 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Farm LV_4 has not yet made any changes to farm practices and strategies to reduce greenhouse gas emissions and increase carbon sequestration.

To reduce the greenhouse gas emissions of the farm, the farmer considers changes in the following farming activities: practices according to the policy (under financial support); improve soil fertility and increase productivity, thereby increasing income and product quality.

Improvement of livestock housing and manure storage, use of fertilizers and manure, as well as soil management and employee qualification are considered very important measures for reducing GHG in agriculture.

For the economic development of the farm farmers consider important the following farming activities: animal feeding; grassland and grazing management (e.g. reseeding, cutting regime) and business management (contracts and labor).

Farm has not yet made any changes to farm practices and strategies to reduce an ammonia emissions.

2. Which mitigation measures / practices were already taken?

- **Improve soil fertility**
- **Grassland management**
- **Improving animal feeding**
- **Grazing management**

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Use of nitrification inhibitor for crops.
For which crops a nitrification inhibitor was used, the expected N2O reduction range is 10 to 20% of the amount of fertilizer and slurry used.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Use of nitrification inhibitor for crops.
The measure envisages the use of urea with an inhibitor on an area of 165 ha.

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, which provide for the preparation of feed plans (112 EUR per year), additional work for the distribution of feed to workers (31 EUR per year).

Use of nitrification inhibitor for crops.
The implementation results in an additional cost of EUR 2022, while ensuring a more efficient use of N and providing a saving of EUR 1870.

7. Quote of farmer:

"By cooperating and doing things together, the impact on the climate can be reduced"

6. Attention points when implementing measures

Increase feed efficiency.
It is difficult to express the expected effect financially

Use of nitrification inhibitor for crops.
An increase in the price of nitrification inhibitor is expected.

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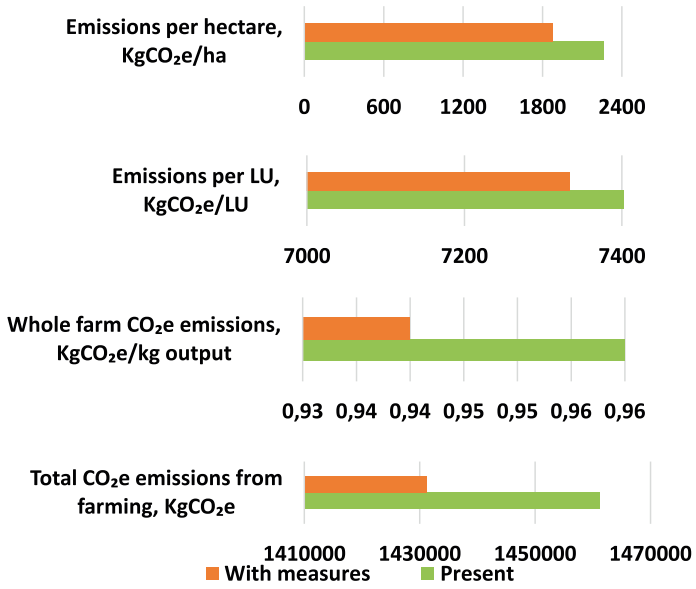
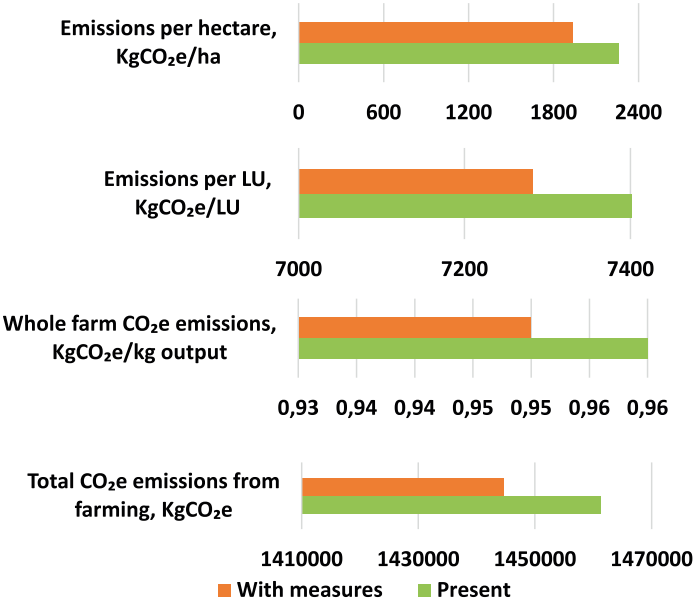
8. Table: Farm LV_4 emissions calculations results with Agrecalc tool

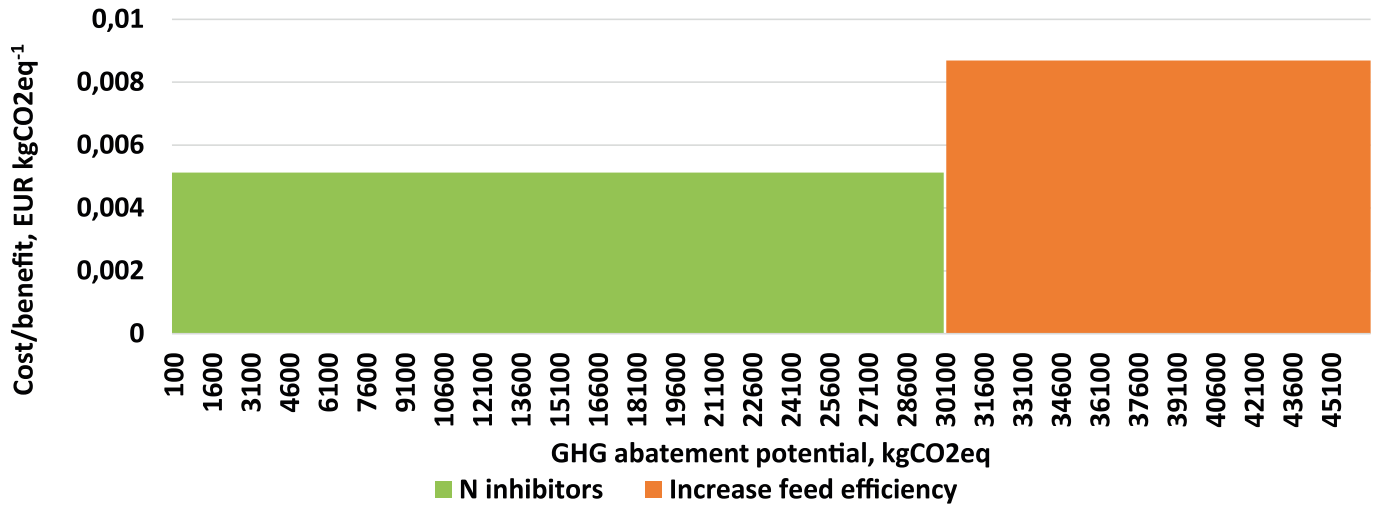
GHG emissions reduction with inhibitor use



GHG emissions reduction with feed efficiency



9. Economics: MACC curve LV_4 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Farm LV_5 is a family farm in which the new generation starts to take the lead. New farmers have put a lot of work into it – they have built a new barn that they run themselves. The milking system on the farm is fully automated.

For the reduction of emissions, farmers consider important would be to change the following farming activities: to introduce improved animal management (including health) and provide feed with a lower crude protein content, separate feces from urine and cool the manure storage, as well as install a low-emission slurry spreading technique.

2. Which mitigation measures / practices were already taken?

Use grass clover mix in pastures

Increase fertilisation efficiency

Improving manure storage
(easier management, work optimization, cost reduction)

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health) and provide lower crude protein content feed.

Use of nitrification inhibitor for crops.
The purpose of the measure is the add feed additives to ration.

Use of nitrification inhibitor for crops.
Separate faeces from urine and cool the manure store.

Use of nitrification inhibitor for crops.
Manure direct incorporation.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Use of nitrification inhibitor for crops.
The construction of low-emission floors in the barn involves large investments for rebuilding the barn (EUR 50,382).

Use of nitrification inhibitor for crops.
It is planned to buy a manure spreading injector from a transport barrel, investment EUR 161,000.

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, which provide for the preparation of feed plans (223 EUR per year), additional work for the distribution of feed to workers (62 EUR per year).

Use of nitrification inhibitor for crops.
These costs can be relatively compensated by the reduction of N mineral fertilizers (EUR 388 per year) due to the higher N content of manure. The measure does affect also the reduction of GHG emissions (752 kg CO2eq).

Use of nitrification inhibitor for crops.
It ensures less evaporation of N and saving of fertilizers (EUR 1,682 per year).

6. Attention points when implementing measures

Increase feed efficiency.
It is difficult to express the expected effect financially

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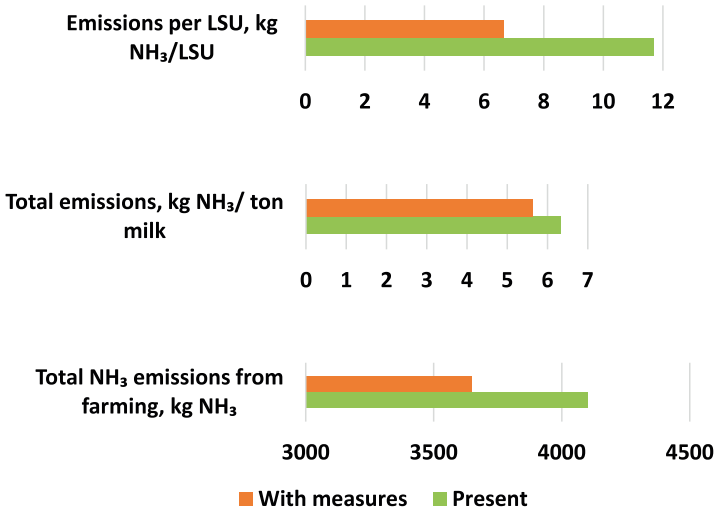
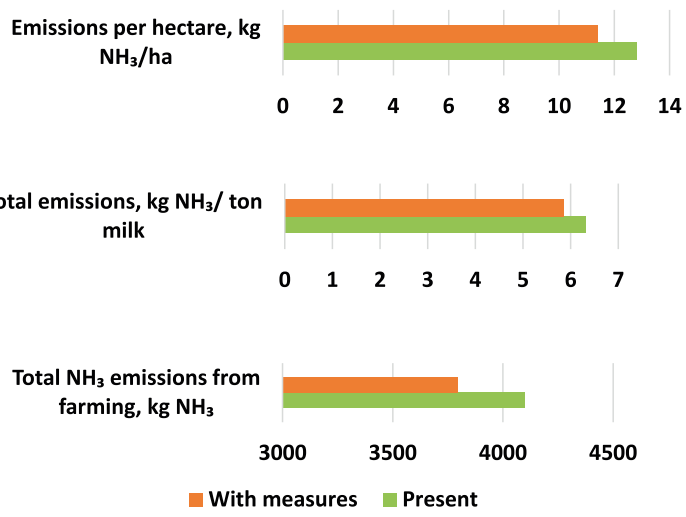
8. Table: Farm LV_5 emissions calculations results with ANCA tool

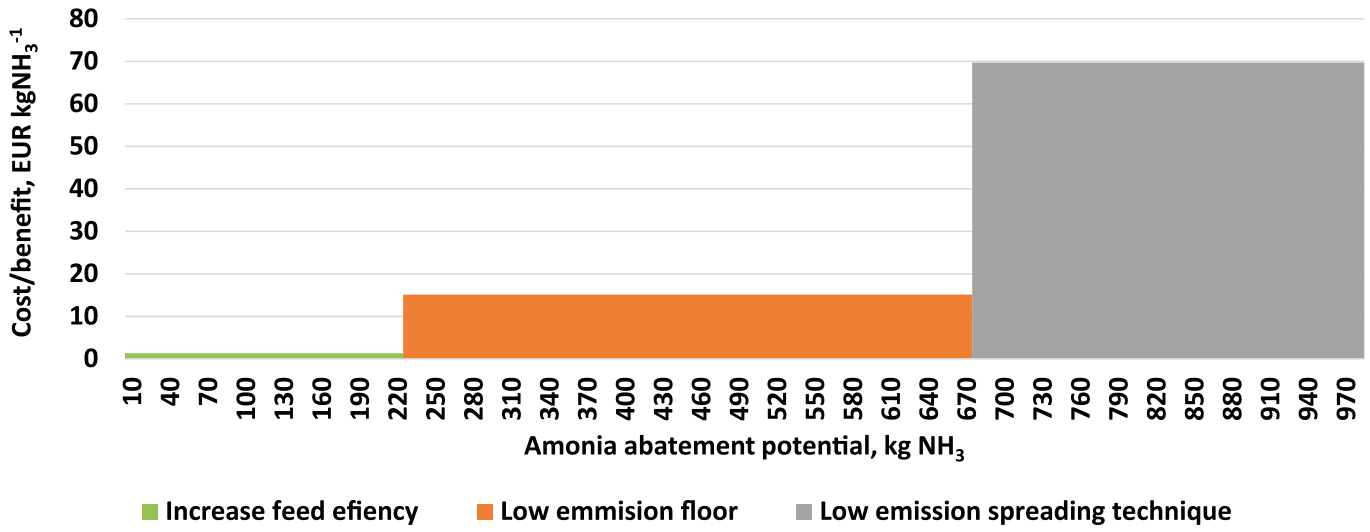
Emission reduction with install low emissin floor



Emission reduction with impruve slurry spreading



9. Economics: MACC curve LV_5 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Farm LV_6 has made changes in farm practices and strategies to reduce greenhouse gas emissions and increase carbon sequestration. These practices and strategies are built barn, manure management robot – scraper; improving manure storage.

In order to reduce emissions, the farmer believes that it is important to change the following agricultural activities: animal feeding, breeding and health; livestock housing and manure storage; improve fertilizer and manure application; soil management and crop cultivation (e.g. rotation, cover crops, varieties).

For the economic development of the farm farmers consider important the following farming activities: animal feeding; animal breeding; animal health; livestock housing and manure storage; fertilizer and manure application and soil management; grassland and grazing management and technology and automation .

In the future, the farm plans to implement protein production and the use manure for biogas production, use of solar panels.

2. Which mitigation measures / practices were already taken?

- **Improving animal feeding**
- **Improving animal welfare built new barn**
- **Improving manure storage and capture of N**
- **Manure management robot – scraper**

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Renewable energy production (RES) at farm.
The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Renewable energy production (RES) at farm.
The measure envisages placing 10 kW solar panels on the farm, which will produce 8,150 kWh of electricity.

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, which provide for the preparation of feed plans (151 EUR per year), additional work for the distribution of feed to workers (42 EUR per year).

Renewable energy production (RES) at farm.
The investment for the purchase and assembly of the panels is EUR 14,000 and the service life is 20 years. The value of the produced electricity (price 0.11 EUR kWh-1) is 896 EUR per year.

6. Attention points when implementing measures

Increase feed efficiency.
It is difficult to express the expected effect financially

Renewable energy production (RES) at farm.
The solar panels service life.

7. Quote of farmer:

"In the future, we will move from intensive to extensive farming in accordance with Latvian historical traditions"

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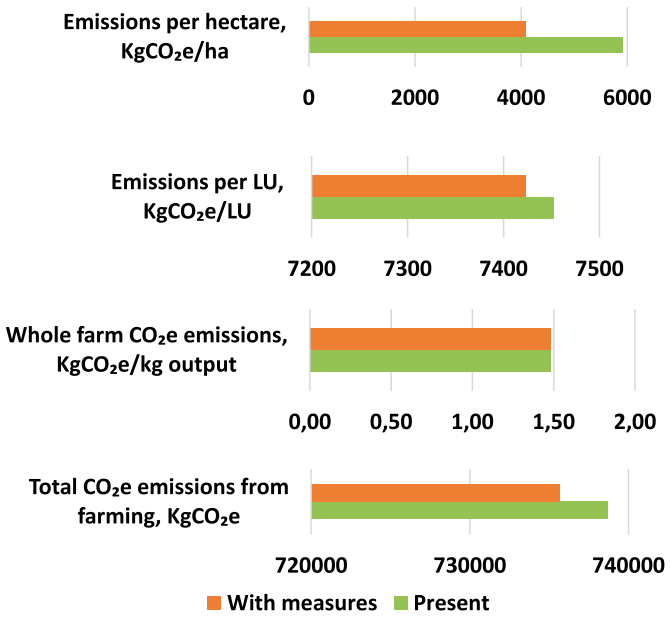
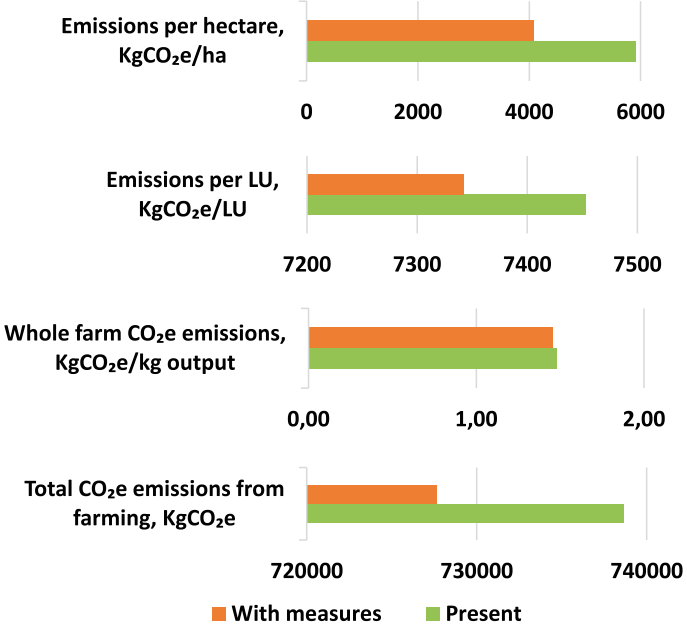
8. Table: Farm LV_6 emissions calculations results with Agrecalc tool

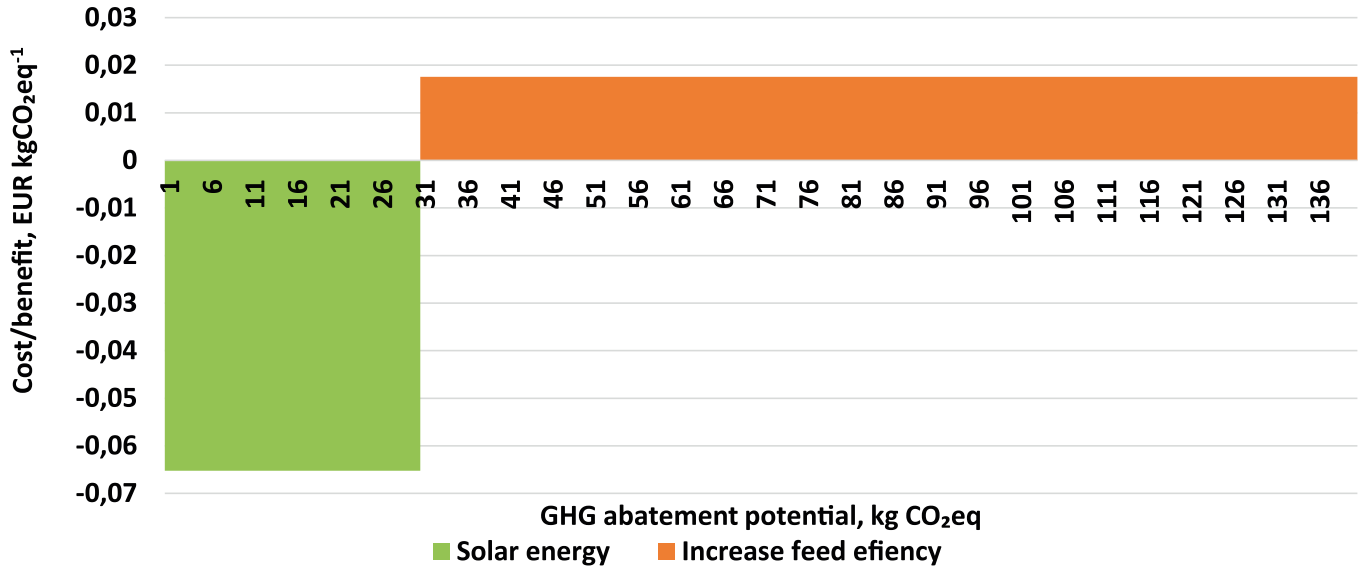
GHG emissions reduction with RES use



GHG emissions reduction with feed efficiency



9. Economics: MACC curve LV_6 with all simulated measures



Picture resource: https://cometrenewables.ie/solar-pv-for-dairy-farms/

1. Description of farmers' future strategy on development of farm and reduction of emissions

Farm LV_7 is a family farm. They support exact farming, the milking system on the farm is fully automated and they are using feeding robot. The farm is one of the first in Latvia which started to make silage from corn cobs. Farm's members are opened for innovation and are ready to try manure acidification.

For the reduction of emissions, farmers consider important would be to change the following farming practices: increase milk production per cow, icrease longevity of stock, use grass clover mix in pastures, provide lower crude protein content feed, provide higher fat content feed, compost the manure and increase soil organic matter.

2. Which mitigation measures / practices were already taken?

Precise feeding

Improving animal welfare

Improving animal longevity

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health) and provide lower crude protein content feed.

Methane blocker as feed additive.
The purpose of the measure is the add feed additives to ration.

Install low emission floor.
To compost the manure.

Low emission slurry spreading technique.
To increase soil organic matter.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Use of nitrification inhibitor for crops.
The costs can be relatively compensated by the reduction of N mineral fertilizers (EUR 384 per year) due to the higher N content of manure.

Use of nitrification inhibitor for crops.
Measure ensures less evaporation of N and saving of fertilizers (EUR 1,261 per year).

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, which provide for the preparation of feed plans (249 EUR per year), additional work for the distribution of feed to workers (69 EUR per year). The measure does affect also the reduction of GHG emissions (78,101 kg CO2eq).

Install low emission floor.
The construction of low-emission floors in the barn involves large investments for rebuilding the barn (EUR 55,640). The measure does affect also the reduction of GHG emissions (2604 kg CO2eq).

Low emission slurry spreading technique.
It is planned to buy a manure spreading injector from a transport barrel, which is a significant investment (EUR 161,000).

6. Attention points when implementing measures

Increase feed efficiency.
It is difficult to express the expected effect financially

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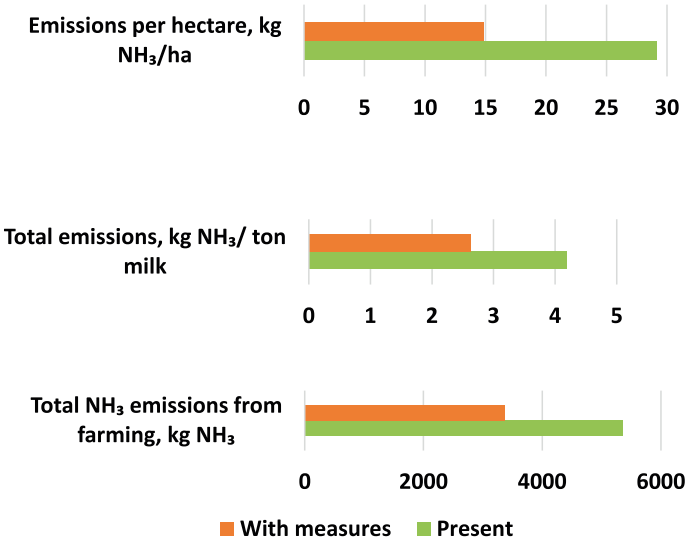
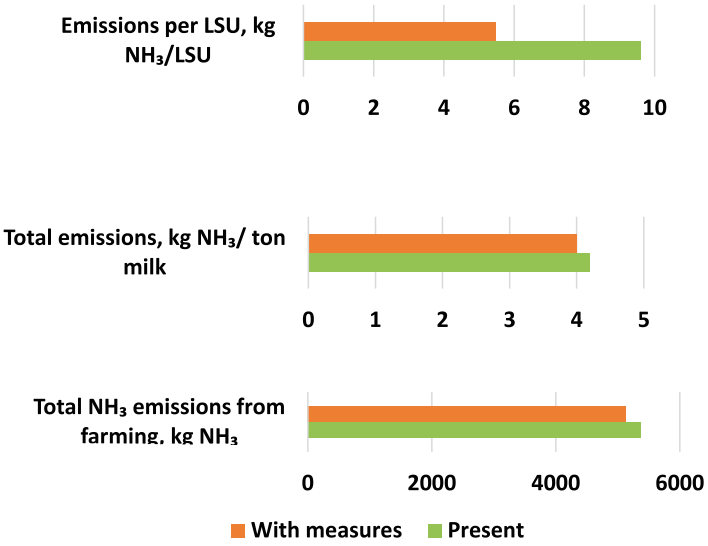
8. Table: Farm LV_7 emissions calculations results with ANCA tool

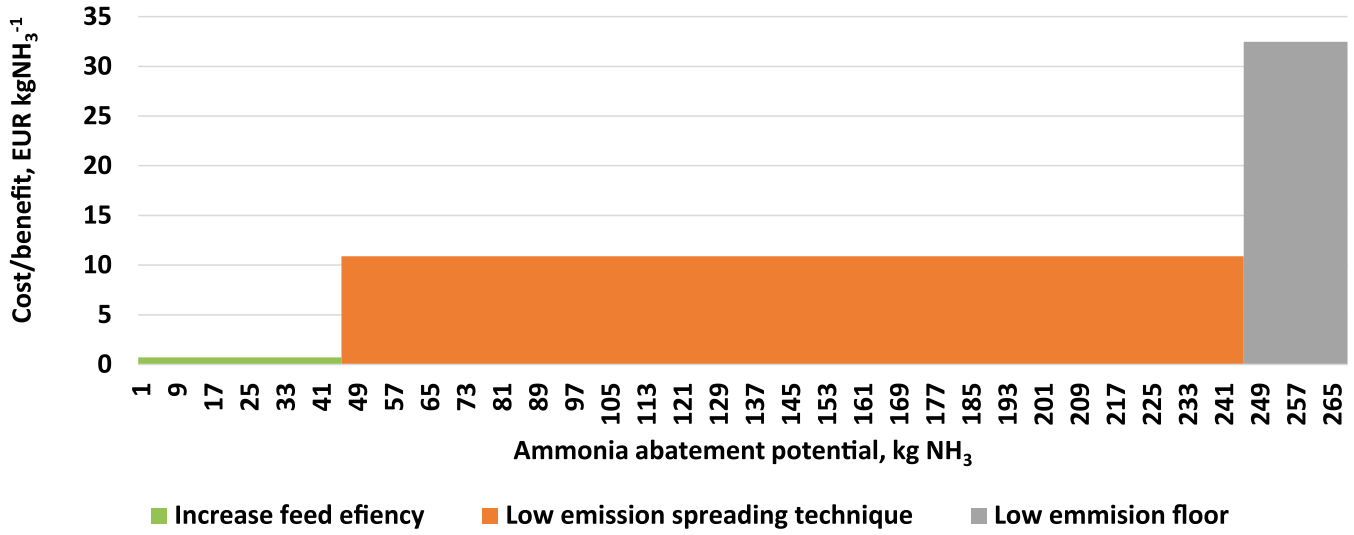
Emission reduction with impruve slurry spreading



Emission reduction with low emission floor



9. Economics: MACC curve LV_7 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Farm LV_8 has made changes in farm practices and strategies to reduce greenhouse gas emissions and increase carbon sequestration. These practices and strategies are new manure storage.

In order to reduce emissions, the farmer believes that it is important to change the following agricultural activities: fertiliser and manure application and soil management.

For the economic development of the farm farmers consider important the following farming activities: animal feeding; animal breeding; machinery and fuel use and health of farmer.

In the future, the farm plans to Installing a solod slurry tank cover and use of solar panels.

2. Which mitigation measures / practices were already taken?

Improving animal feeding

Improving animal welfare

New manure storage and capture of N

3. Which mitigation measures are planned to be implemented and how?

Covering solid slurry storage.
Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

Renewable energy production (RES) at farm.
The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

4. Expected effects on emissions (based on tool calculations)

Covering solid slurry storage.
Reduction of methane is expected to be 47% and reduction of ammonia 80%.

Renewable energy production (RES) at farm.
The measure envisages placing 10 kW solar panels on the farm, which will produce 8,150 kWh of electricity.

5. Equipment involved, investment and economic

Covering solid slurry storage.
Covering 4,625 t of solid manure ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 1,143 per year. The burning of solid manure costs EUR 1472.

Renewable energy production (RES) at farm.
The investment for the purchase and assembly of the panels is EUR 14,000 and the service life is 20 years. The value of the produced electricity (price 0.11 EUR kWh-1) is 896 EUR per year.

6. Attention points when implementing measures

Covering solid slurry storage.
Need direct injection or band spreading to be used with slurry application to maximize effects.

Renewable energy production (RES) at farm.
The solar panels service life.

7. Quote of farmer:

"Caring for the well-being of the neighbors, we had to build a manure storage and reduce the impact on nature"

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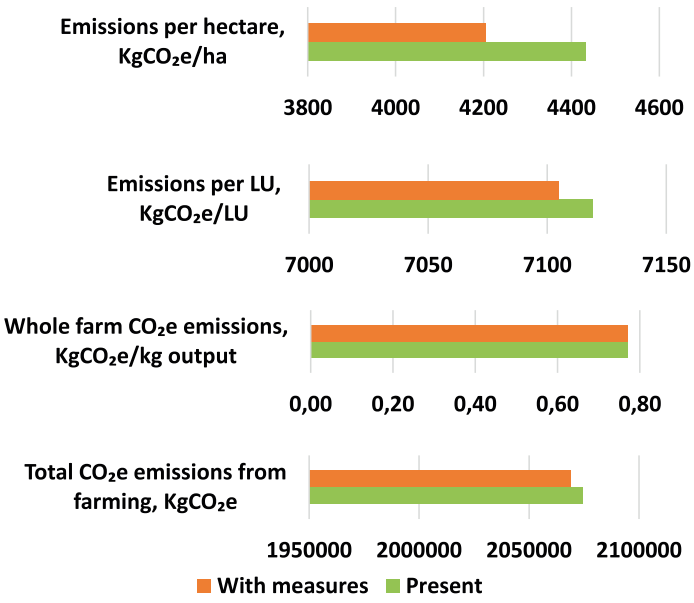
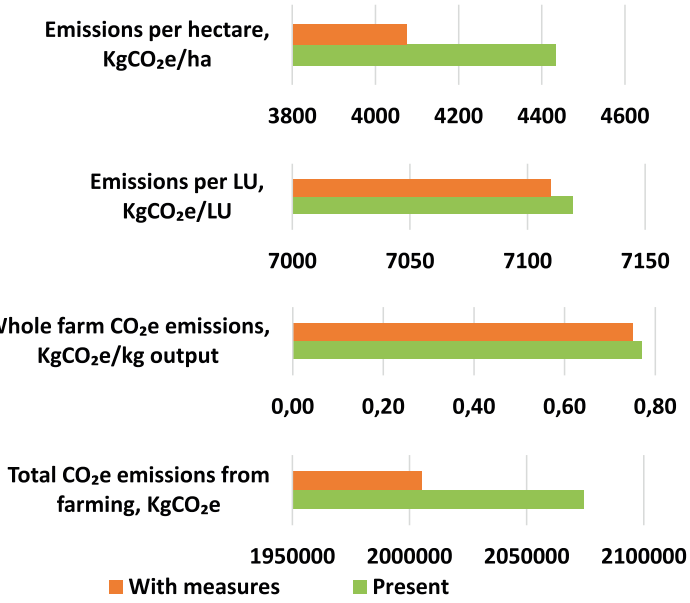
8. Table: Farm LV_8 emissions calculations results with Agrecalc tool

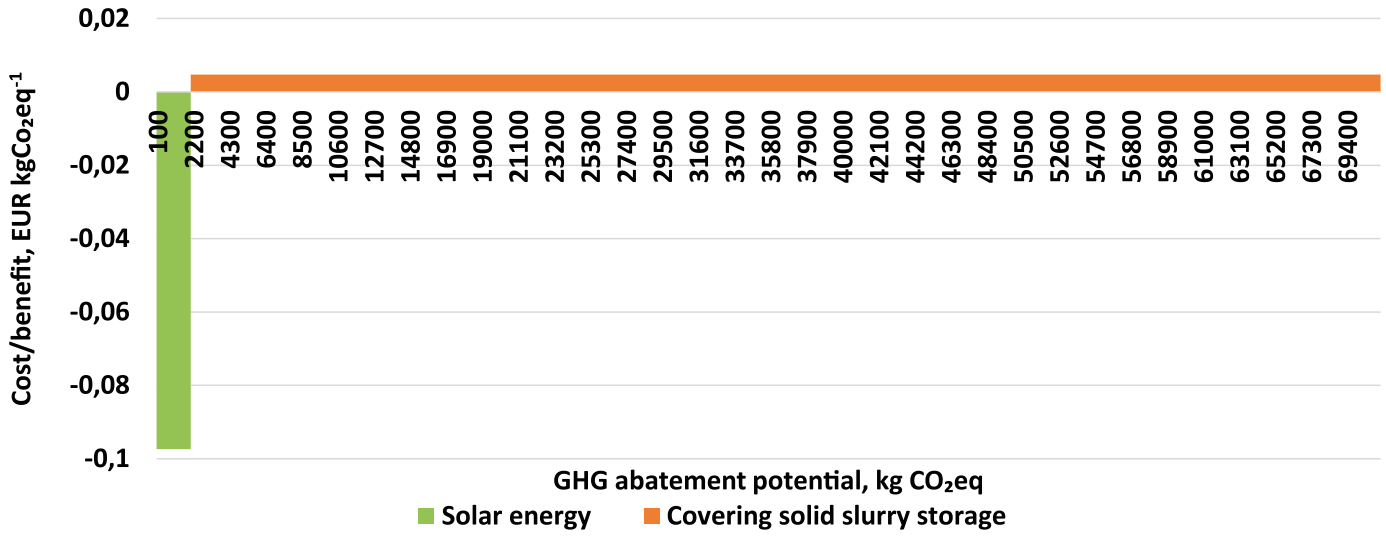
GHG emissions reduction with RES use



GHG emissions reduction with covering slurry storage



9. Economics: MACC curve LV_8 with all simulated measures



Picture resource: https://cometrenewables.ie/solar-pv-for-dairy-farms/

Lithuania

1. Description of farmers' future strategy on development of farm and reduction of emissions

The farmer is interested in technological development and tries to introduce available innovations on his farm. To solve the manure storage problems, the farmer adopted manure separation technology, bought a smart equipment for soil fertilization.

In the comming year the farmer plan to have solar panels.

2. Which mitigation measures / practices were already taken?

Extending pastures

Improving animal welfare

Retain nitrogen

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.

Feed efficiency is improved through improved animal management (incl. health).

Renewable energy production (RES) at farm.

The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.

Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Renewable energy production (RES) at farm.

The measure envisages placing 12.8 kW solar panels on the farm, which will produce 10,432 kWh of electricity.

5. Equipment involved, investment and economic

Increase feed efficiency.

Significant changes in farming, which provide for the preparation of feed plans (377 EUR per year), additional work for the distribution of feed to workers (105 EUR per year).

Renewable energy production (RES) at farm.

The investment for the purchase and assembly of the panels is EUR 17,920 and the service life is 20 years. The value of the produced electricity (price 0.11 EUR kWh-1) is 1,148 EUR per year.

6. Attention points when implementing measures

Increase feed efficiency.

It is difficult to express the expected effect financially

Renewable energy production (RES) at farm.

The solar panels service life.

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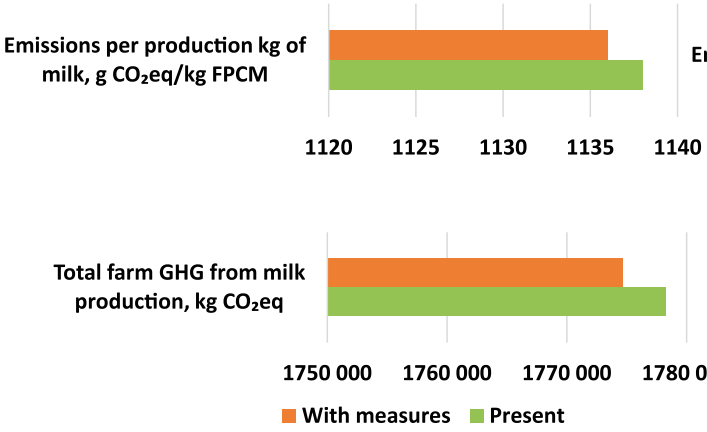
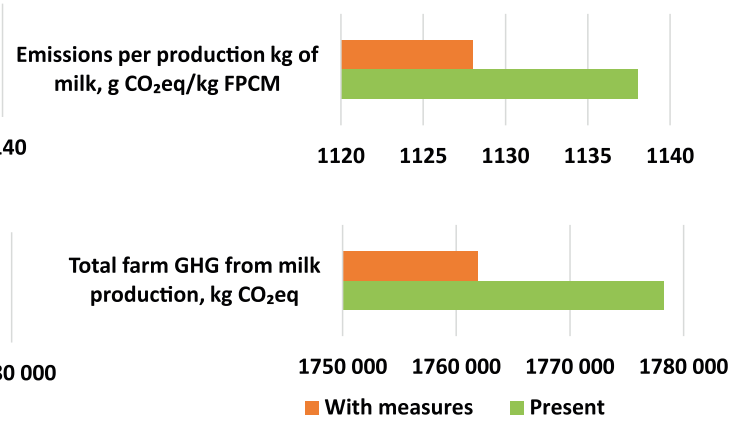
8. Table: Farm LT_1 emissions calculations results with ANCA tool

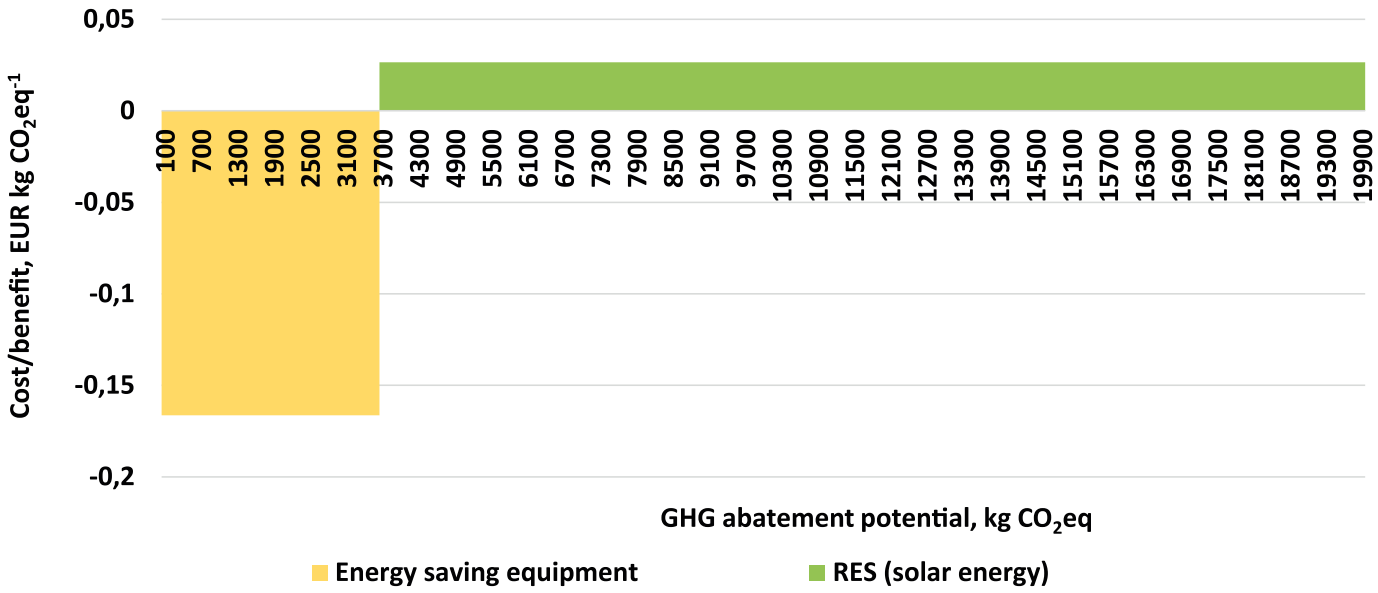
Emission reduction with energy saving equipment



Emissions reduction with RES use



9. Economics: MACC curve LT_1 with all simulated measures



Picture resource: https://cometrenewables.ie/solar-pv-for-dairy-farms/

1. Description of farmers' future strategy on development of farm and reduction of emissions

The farmer is interested in innovations and tries to implement them on his farm. He has purchased and use on his farm milking and feeding robots, manure separation to solid and liquid fractions. In this year the farmer began to use solar energy.

2. Which mitigation measures / practices were already taken?

Milking robots

Feeding robots

Separation of feces and urine

Solar panels

3. Which mitigation measures are planned to be implemented and how?

Methane blocker as feed additive.

The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

Acidification of manure.

The main goal is to reduce nitrogen losses during manure storage and application to the soil.

Covering solid slurry storage.

Reducing methane losses and using them for energy production can be a profitable.

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.

Enteric methane blocker purchase and precision distribution to reduction CH_4. Number of used inhibitors per cow – 20g/cow/day; 130 cows.

Acidification of manure.

The measure is relatively complex but provides a significant GHG reduction effect. The amount of manure to be processed -1520m^3.

Covering solid slurry storage.

Area of the storage – 380 m^2; amount of manure – 2100m^3.

5. Equipment involved, investment and economic

Methane blocker as feed additive.

The measure is easy to implement but requires the purchase of a methane blocker EUR 9,490. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself.

Acidification of manure.

Manure acidification requires equipment EUR 10,000 (for 7 years), as well as sulphury acid EUR 1,322. Generally, soil liming requires EUR 991. At the same time, the N stored in manure results in a benefit of EUR 4,086, which makes the measure cost-neutral.

Covering solid slurry storage.

Covering 2,100 m^3 of manure with covering material cost EUR 6,350, that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 4,657 per year. Lifetime of covering material 7 years.

6. Attention points when implementing measures

It is difficult to express the expected effects financially.

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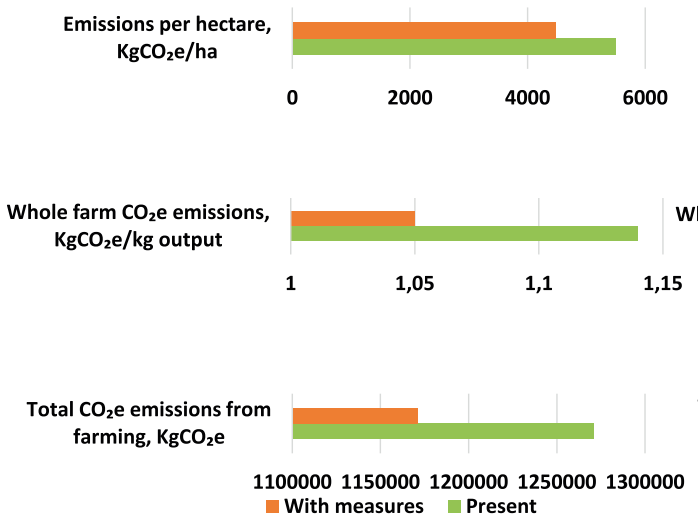
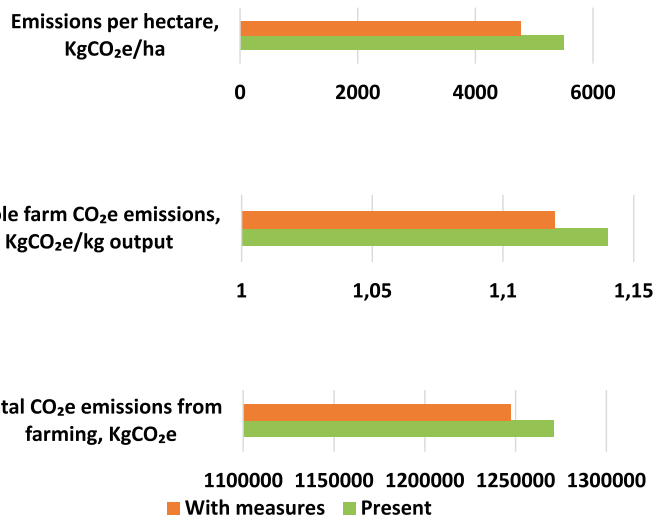
8. Table: Farm LT_2 emissions calculations results with Agrecalc tool

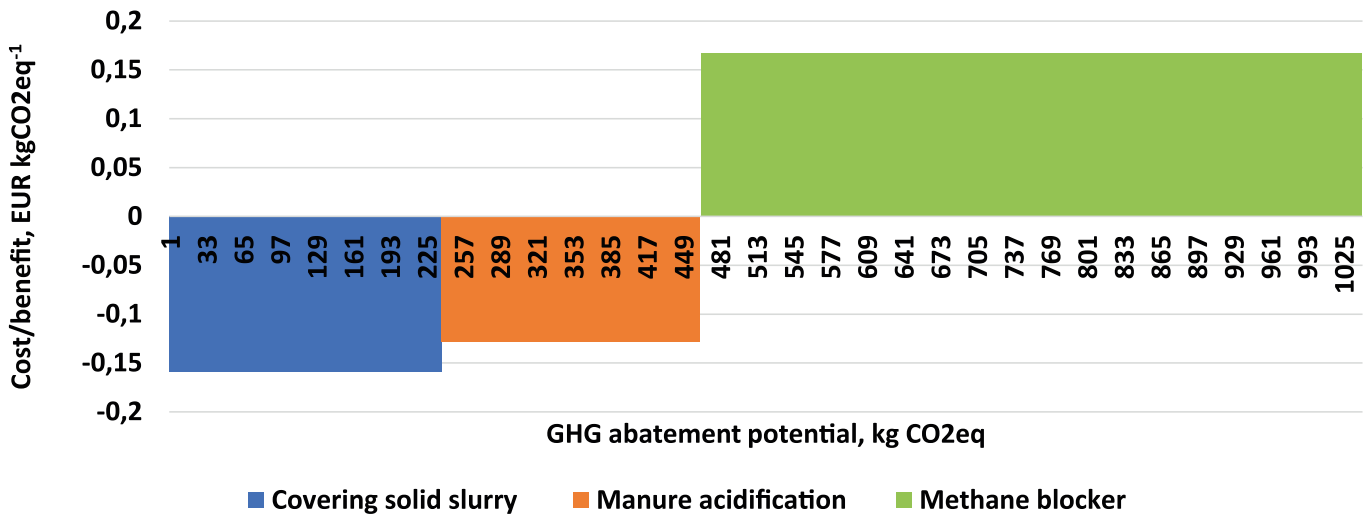
GHG emissions reduction with CH_4 blosker use



GHG emissions reduction with slurry storage cover



9. Economics: MACC curve LT_2 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

The farmer is participating in several projects aimed at solving environmental problems, although he does not pay much attention to it later. He is satisfied with his participation and the results but, after project completion date, he does not contemplate about using innovative products due to financial reasons.

2. Which mitigation measures / practices were already taken?

Improving animal feeding with use of probiotics

Grazing in summer

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Energy saving equipment.
The goal is to save energy.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Energy saving equipment.
The amount of energy saved – 1800 kWh.

5. Equipment involved, investment and economic

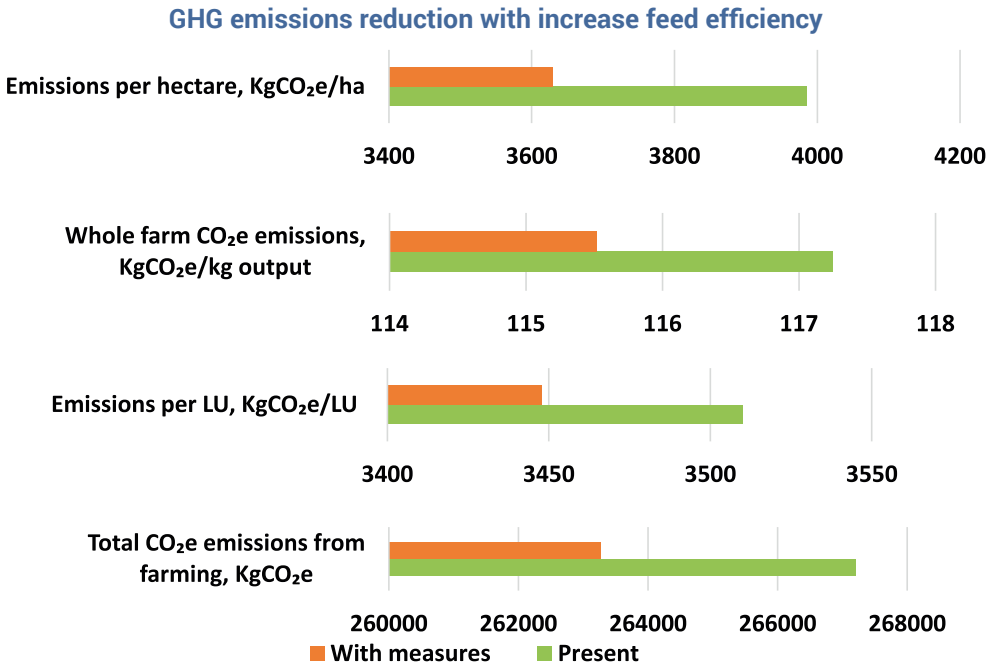
Increase feed efficiency.
Significant changes in farming, which provide for the preparation of feed plans (112 EUR per year), additional work for the distribution of feed to workers (18 EUR per year). At the same time, changes in feed quality will improve cow welfare. The feed saving provides a benefit of EUR 2,862 and veterinary costs are reduced by EUR 450.

Energy saving equipment.
The measure envisages replacing various electricity-consuming devices with more energy-efficient ones. It is planned to invest EUR 450 to save 1,800 kwh of electricity.

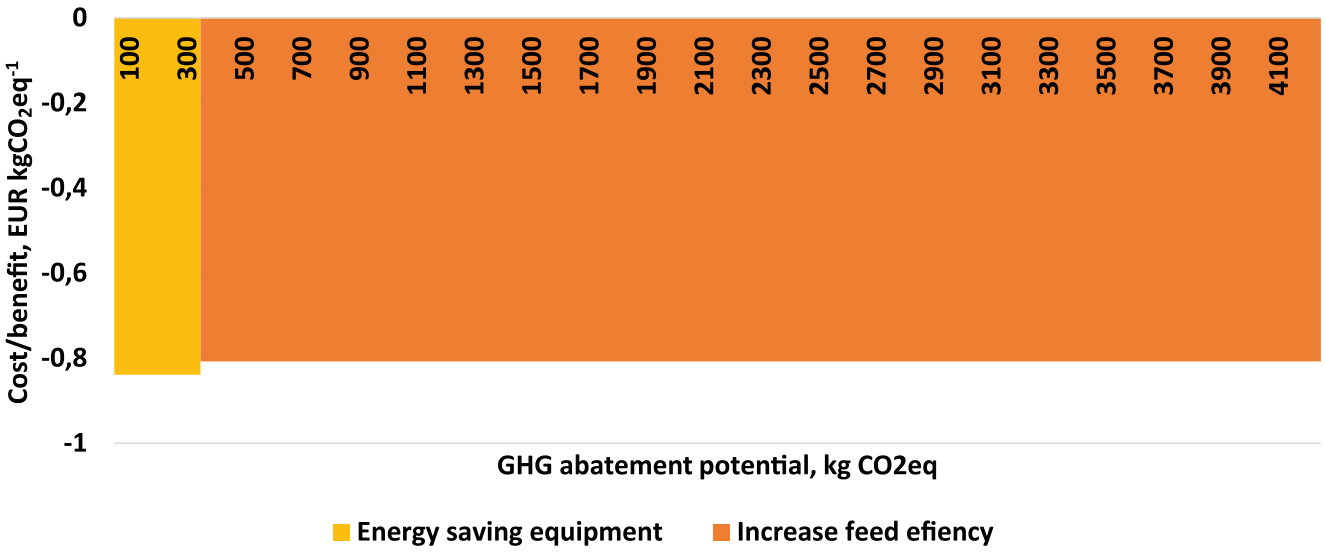
6. Attention points when implementing measures

Increase feed efficiency.
It is difficult to express the expected effect financially.

8. Table: Farm LT_3 emissions calculations results with Agrecalc tool



9. Economics: MACC curve LT_3 with all simulated measures




Picture of mitigation practice


Picture of present farm strategy

1. Description of farmers' future strategy on development of farm and reduction of emissions

The farm is an experimental farm of the Animal Science Institute which serves as a basis for scientific research and participate in conservation of local rare cattle breeds. Tiestall housing system is applied for dairy cows, therefore, the important goal is to renovate the cows housing facilities in near future. The farm give an attention to develop environmentally friendly systems. Participation in INTEREG project allowed to acquire a modern slurry acidification equipment to reduce ammonia emission and unpleasant odours. The equipment allows to reduce harmful emissions during slurry application to the soil and now farm is trying to find the best options, not only to reduce emissions, but also to obtain the most suitable fertilization properties, which would be optimal for the crop yield.

2. Which mitigation measures / practices were already taken?

Own production of concentrates, buying only feed additives

Grazing in summer

Slurry acidification in the field

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
The realization of the event does not require significant investments. The goal is to increase the feed digestability and to reduce unfed feed losses.

Covering manure storage.
The farm is planning to do a reconstruction of dairy cows housing facilities and to cover the manure tank .

Anaerobic digester.
The tool was chosen due to willingness to save very expensive energy resources and opportunity to solve manure management issues.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Covering manure storage.
Reduction of methane is expected to be 47% and reduction of ammonia 80%.

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, but saved feed costs (17,520 EUR per year), in the same time, measure provide additional work for the distribution of feed to workers (120 EUR per year). The measure does affect also the reduction of GHG emissions (60,304 kg CO_2eq).

Covering manure storage.
Covering 5,000 m^3 of manure with covering material cost EUR 60,000 that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 11,088 per year. Lifetime of covering material 7 years. The measure does affect also the reduction of GHG emissions (48 kg CO_2eq).

6. Attention points when implementing measures

No matter how much you want to update the farm facilities, it may be difficult to implement all plans if you fail to get support from the development program.

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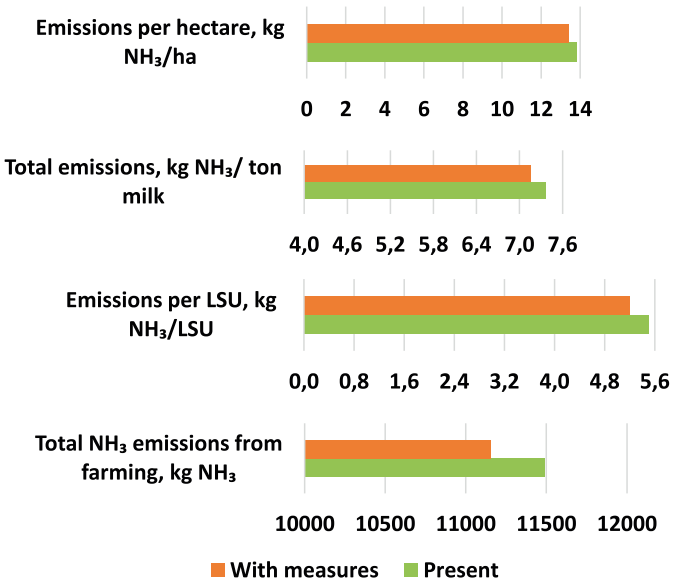
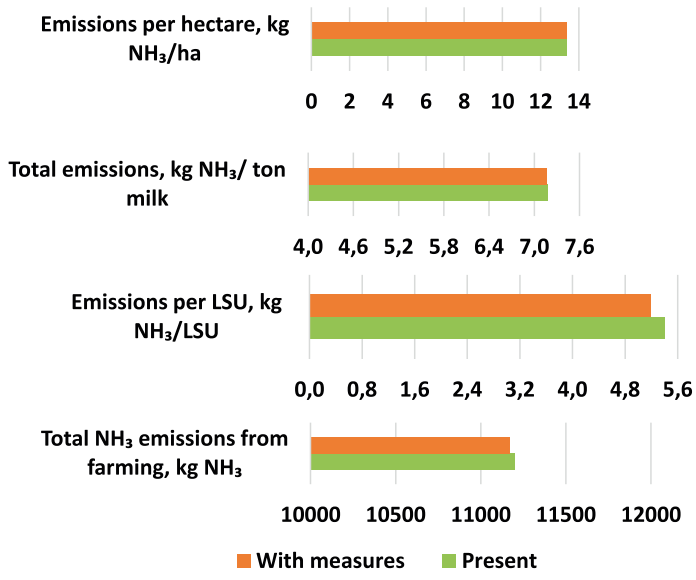
8. Table: Farm LT_4 emissions calculations results with ANCA tool

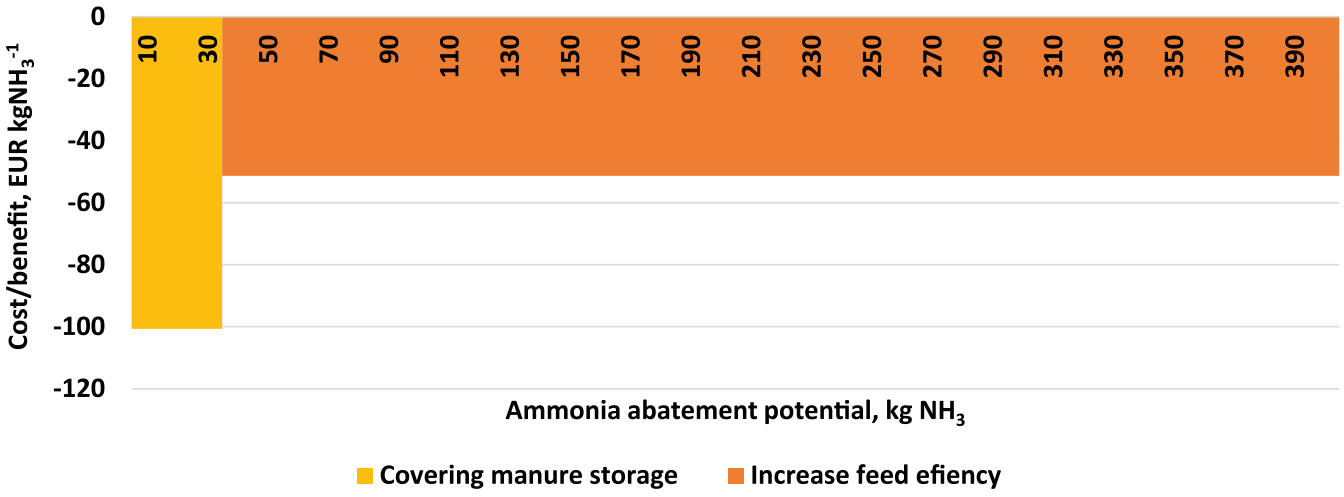
Emission reduction with improve feed efficiency



Emission reduction with cover manure storage



9. Economics: MACC curve LT_4 with all simulated measures




Picture of present farm


Picture of farm practice

Italy

1. Description of farmers' future strategy on development of farm and reduction of emissions

The farmer's focus is to become self-sufficient for the heat and electricity requirements of the dairy farm by using renewable energy.

Further, a goal is to reduce the amount of stocked slurry by covering manure storage. The farmer is considering joining a consortium biogas plant.

2. Which mitigation measures / practices were already taken?

Increase milk production per cow

Increase longevity of cows

Minimum tillage

Installation of solar panels (the farm is not still self-sufficient)

3. Which mitigation measures are planned to be implemented and how?

Provide coverage to slurry storage, by using a conic PVC cover.

Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

Installing 70 kWh solar panel, providing electricity and heat for self-supply.

Interested in joining a consortium biogas plant.

4. Expected effects on emissions (based on tool calculations)

Covering manure storage.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

Install further solar panels to be self-sufficient.

The measure envisages placing 70 kW solar panels on the farm, which will produce 25,550 kWh of electricity.

5. Equipment involved, investment and economic

Covering manure storage.

Covering 272 m^2 of manure with covering material costs EUR 19,564 which ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 776 per year. The lifetime of covering material is 7 years. The measure does affect also the reduction of GHG emissions (763 kg CO2eq).

Install further solar panels to be self-sufficient.

The investment for the purchase and assembly of the panels is EUR 56,000 and the service life is 20 years. The value of the produced electricity (price 0.05 EUR kWh^{-1}) is 1,252 EUR per year. The measure does not affect ammonia emissions, but ensures the reduction of GHG emissions (11,419 kg CO2eq).

7. Quote of farmer:

"Providing technical information for farmers and financial support would represent a good incentive for the adoption of mitigation practices"

6. Attention points when implementing measures

How high will be the costs for these additives, measures should generate a profit.

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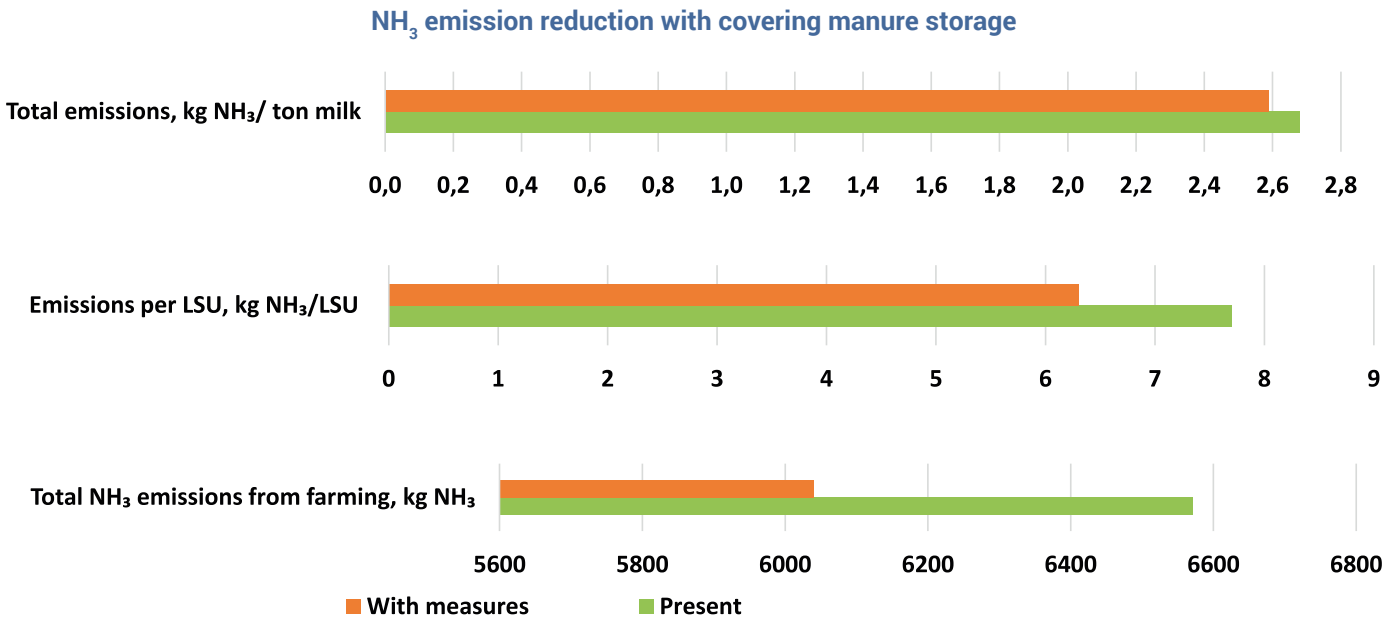
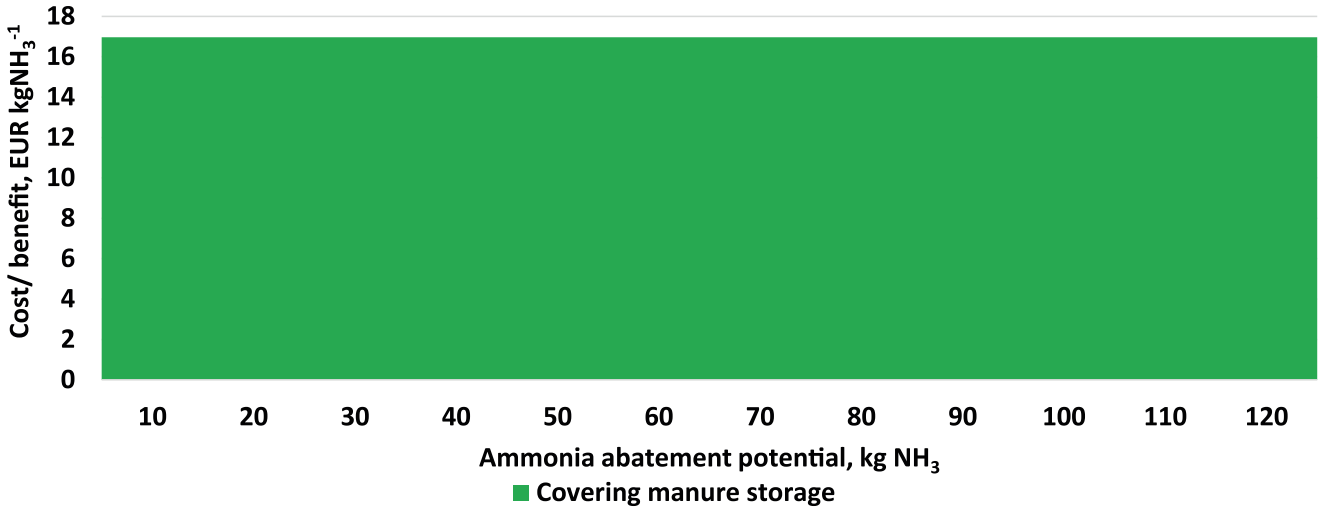
8. Table: Farm IT_1 emissions calculations results with ANCA tool



9. Economics: MACC curve IT_1 with simulated measure




Picture of farm strategy


Picture of farm practice

1. Description of farmers' future strategy on development of farm and reduction of emissions

The strategy of the farmer focuses mainly on improving rations and feed efficiency and is already putting effort and attention into cows' feeding. In particular, the effort is focused on the reduction of crude protein from concentrates by enhancing the use of amino acids.

The farmer is also oriented towards increasing the use of renewable sources, e.g. by expanding the photovoltaic plant.

2. Which mitigation measures / practices were already taken?

- **Increasing fertilization efficiency**
- **Increase roughage production per hectare**
- **Increase milk production per cow**
- **Installation of a grooved concrete floor for lowering emissions**
- **Renewable energy from solar panels**

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Reduce the amount of crude protein in the diet.
The essence of the measure is to enrich the cows' ration with amino acids while decreasing the amount of fed crude protein.

Interested in joining a consortium biogas plant.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency (Low protein diet).
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

5. Equipment involved, investment and economic

Increase feed efficiency (Low protein diet).
The realization of the event does not require significant investments. At the same time, changes in feed quality will improve cow welfare. There are no peculiarities of the farm (The vet is part of the family that manages the farm, and the farmers receive feed consulting services from the association), there are no costs for the implementation of the measure. Despite this, there is a significant reduction in feed costs. The measure also reduces GHG emissions – 163,926 kgCO2eq.

6. Attention points when implementing measures

It is difficult to express the expected effect financially.

How high will be the costs for these additives, measures should generate a profit.

7. Quote of farmer:

"Environmental protection should start with the single"

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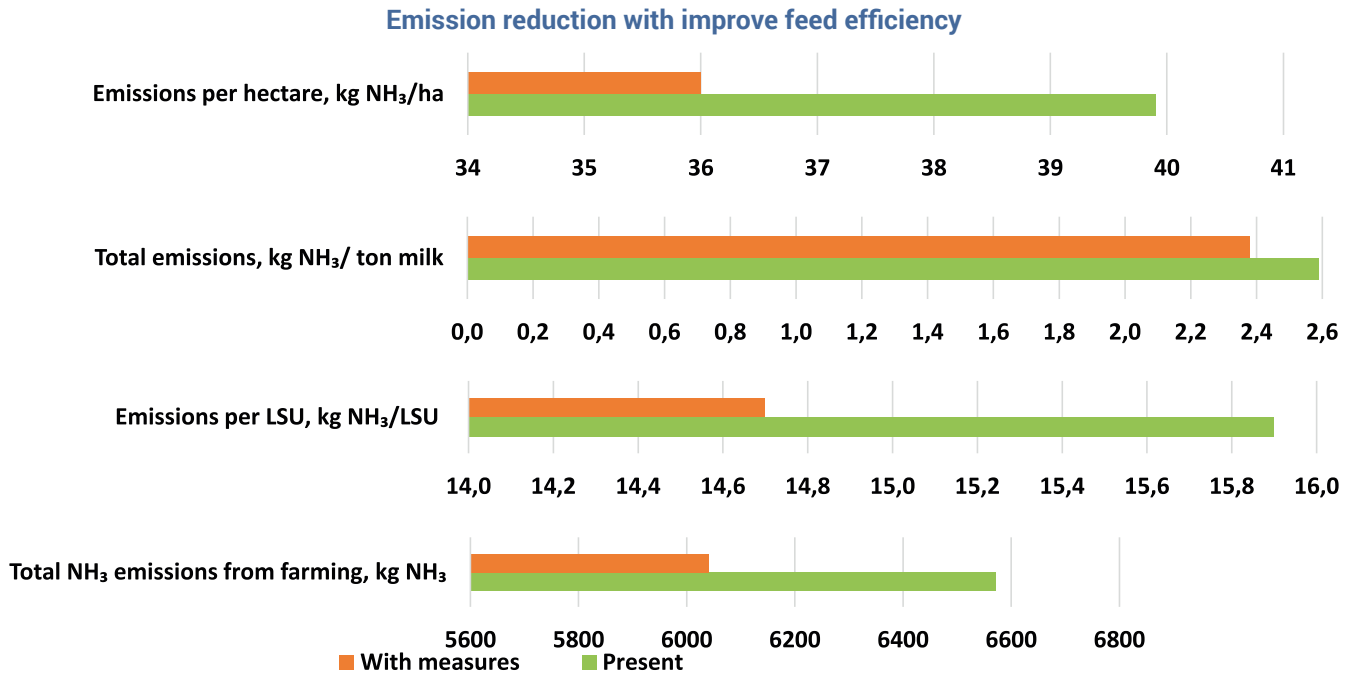
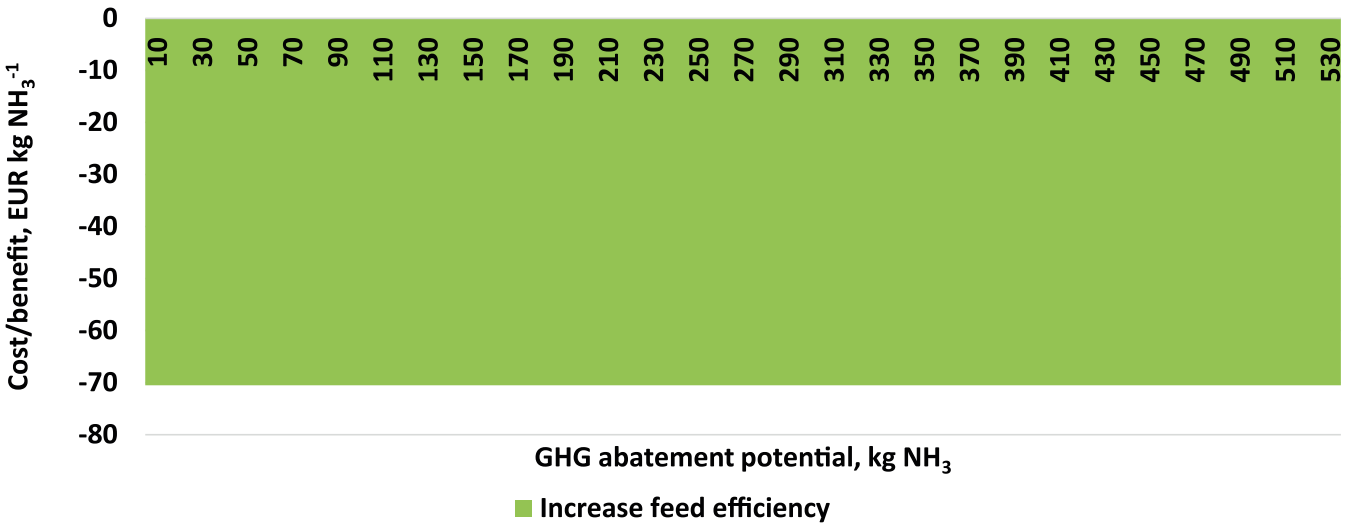
8. Table: Farm IT_2 emissions results calculations results with ANCA tool



9. Economics: MACC curve IT_2 with simulated measure




Picture of farm strategy


Picture of farm strategy

1. Description of farmers' future strategy on development of farm and reduction of emissions

The farmers are currently using multiple strategies related to animal feeding (improve feed efficiency and reduce crude protein in the ration), manure management and energy use. Their future perspectives on reducing GHG and ammonia emissions are driven by concern for farm sustainability and consumers' acceptance. They look with interest towards new strategies such as using feed additives to reduce animals' methane emissions or implementing practices related to slurry storage.

2. Which mitigation measures / practices were already taken?

Increasing feed efficiency and reducing the nitrogen content in the diet

Using energy-saving equipment

Producing renewable energies at the farm

3. Which mitigation measures are planned to be implemented and how?

Methane blocker as feed additive.

The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

Covering solid slurry storage.

Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.

Enteric methane blocker purchase and precision distribution to reduction CH_4.

Covering solid slurry storage.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

5. Equipment involved, investment and economic

Methane blocker as feed additive.

The measure is easy to implement, but requires the purchase of a methane blocker EUR 8,760. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself.

Covering solid slurry storage.

Covering of manure with covering material costs EUR 27,504, which ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 1,089 per year.

7. Quote of farmer:

"We are trying our best towards environmental protection by following regulations and aiming not to receive critiques"

6. Attention points when implementing measures

How high will be the costs for these additives, measures should generate a profit.

"A single farmer can do little. However, it is necessary that everyone involved takes action to have concrete effects"

"It's hard work following such practices, but when a certification is provided the products increase their value on the market"

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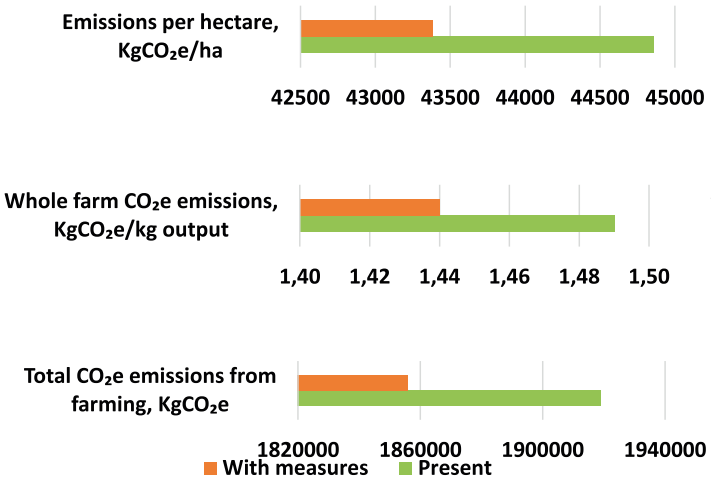
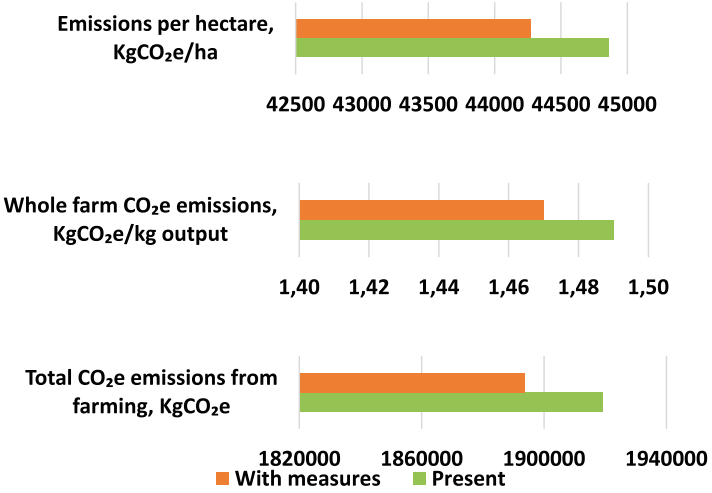
8. Table: Farm IT_3 emissions results calculations results with Agrecalc tool

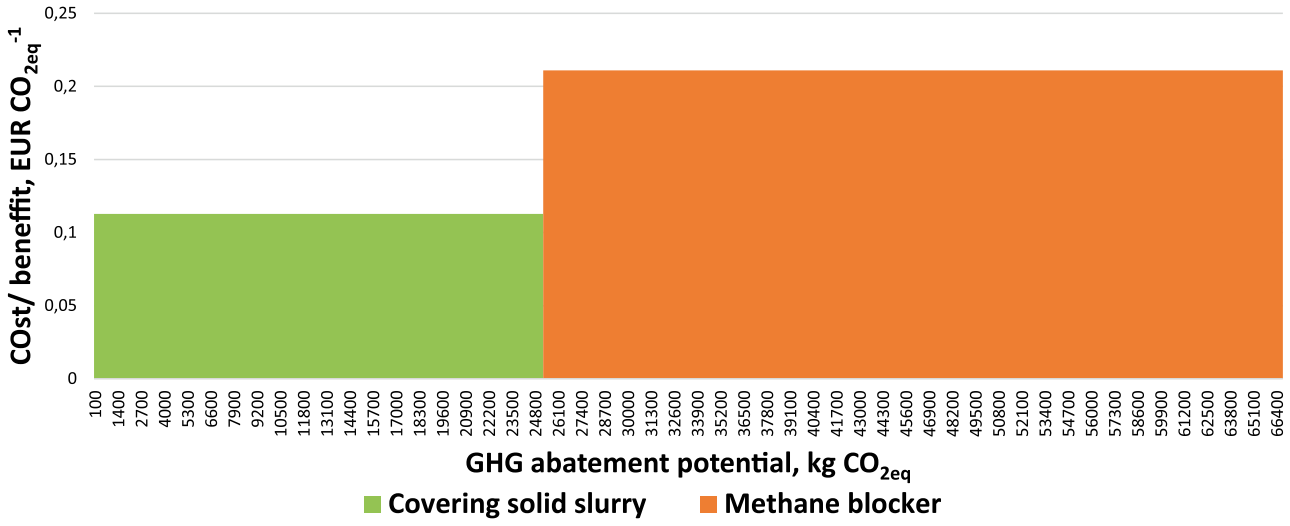
Emission reduction with methan blocker use



Emission reduction with covering slurry storage



9. Economics: MACC curve IT_3 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

The farmer seeks animal welfare and pays attention to the farm's environmental impact. His current strategy is oriented towards increasing the use of renewable energies and decreasing energy consumption. The farmer's perspectives on future mitigation practices are mainly related to animal feeding.

2. Which mitigation measures / practices were already taken?

- **Increasing fertilization efficiency**
- **Increasing the longevity of the dairy stock**
- **Mechanical separation of slurry**
- **Using energy-saving equipment, as illumination for the barn**
- **Producing renewable energy at the farms with photovoltaic panels**

3. Which mitigation measures are planned to be implemented and how?

Provide coverage to slurry storage, by using a conic PVC cover.

Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

Installing 70 kWh solar panel, providing electricity and heat for self-supply.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.

Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Use of probiotics in barn.

Enteric methane inhibitor purchase and precision inhibitor distribution to reduction CH_4.

5. Equipment involved, investment and economic

Increase feed efficiency.

The measure saves EUR 18,104 in feed, improving cow welfare reduces veterinary costs by EUR 2,000. At the same time, additional costs include feed additives EUR 8,760, as well as a little extra work. In general, the measure is cost-effective, which is mainly determined by the saved feed. It is assumed that milk yield does not change.

Use of probiotics in barn.

In this event, cow feed is supplemented with probiotics that improve enteric processes. The most significant costs are the purchase of probiotics for EUR 8,760 and a little additional work. The measure does not provide additional income, as it is assumed that milk yield will not change, nor will other costs of additional farming decrease.

6. Attention points when implementing measures

It is difficult to express the expected effect financially.

How high will be the costs for these additives, measures should generate a profit

7. Quote of farmer:

"Providing the farmer a free consultancy service to help make the best choices for the farm in terms of practices for the reduction of GHGs and ammonia would be of great help for the adoption of mitigation strategies"

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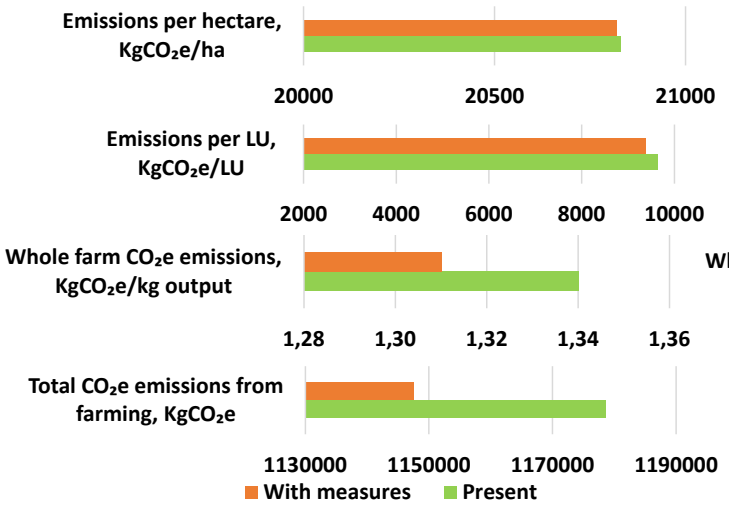
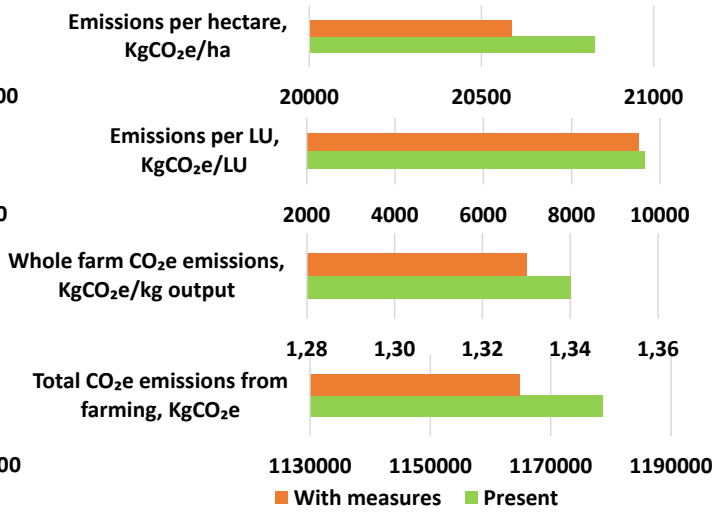
8. Table: Farm IT_5 emissions results calculations results with Agrecalc tool

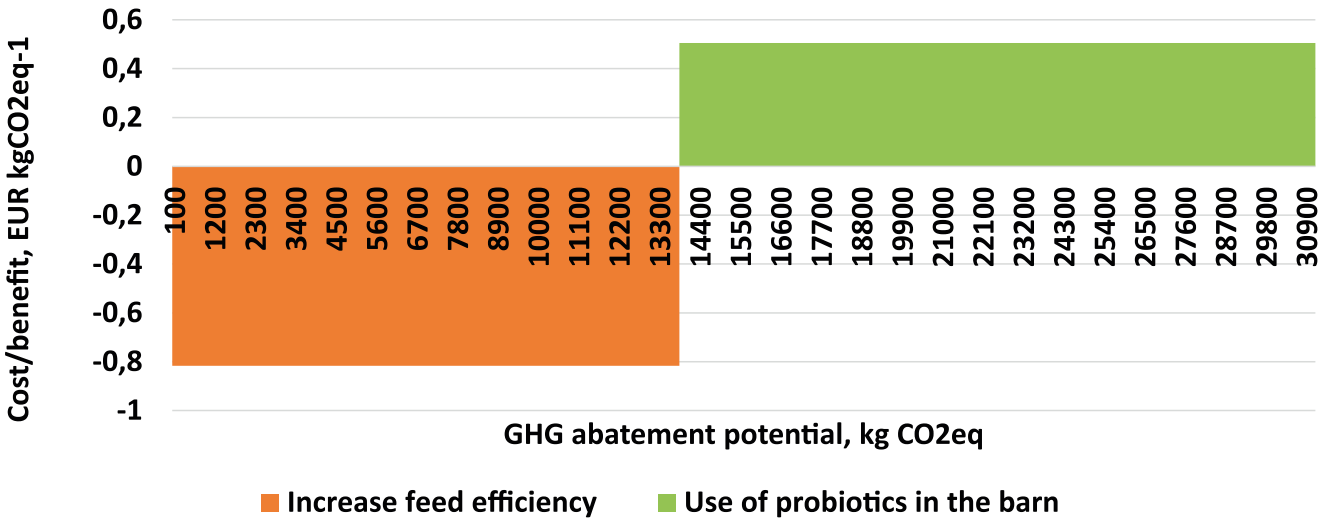
GHG emissions reduction with use of probiotics



GHG emissions reduction by feed efficiency



9. Economics: MACC curve IT_5 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

The farmers are working on the improvement of the cows' rations, thus their strategy is focused on increasing feed efficiency and reducing the N-content of the feed. They also are interested in increasing fertilization efficiency.

2. Which mitigation measures / practices were already taken?

Providing probiotics in the ration

Increasing the longevity of cows

Increasing milk production per cow

Adopting mechanical separation of slurry

3. Which mitigation measures are planned to be implemented and how?

Low protein diet.

The aim of the measure is to change the rations of feed. The N content of feed ration ingredients is reduced, e.g. by reducing N content of concentrates.

Acidification of manure.

The aim of the measure is to reduce N losses during manure management in barn and / or at field application. Mitigation practice include: purchase and installation of acidification equipment.

4. Expected effects on emissions (based on tool calculations)

Low protein diet.

Reduced protein in the diet (140) compared to higher protein in the diet (155) to redact CH_4 and N_2O emissions.

Acidification of manure.

To reduce N losses during manure management at field application.

5. Equipment involved, investment and economic

Low protein diet.

The measure reduces the amount of protein available to cows, which provides a 20,928 EUR cost reduction. It is assumed that milk yield does not change.

Acidification of manure.

The measure is relatively complex, but provides a significant GHG reduction effect. Manure acidification requires equipment EUR 10,000 (for 7 years), as well as sulphuric acid EUR 1,440. Generally, soil liming requires EUR 429. At the same time, the N stored in manure results in a benefit of EUR 15,327.

6. Attention points when implementing measures

How high will be the costs for these additives, measures should generate a profit. Farm expenses: soil acidification; additional expenses for liming the soil.

7. Quote of farmer:

"Farmers have a pivotal role that should be further acknowledged and rewarded"

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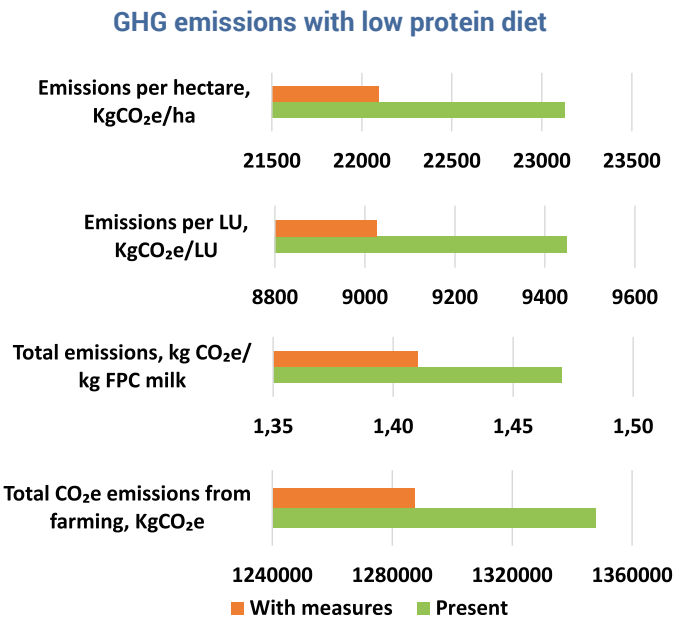
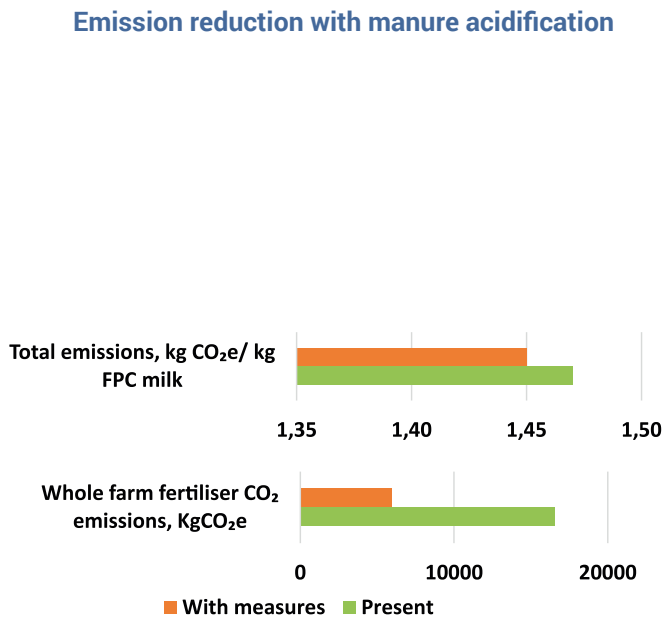
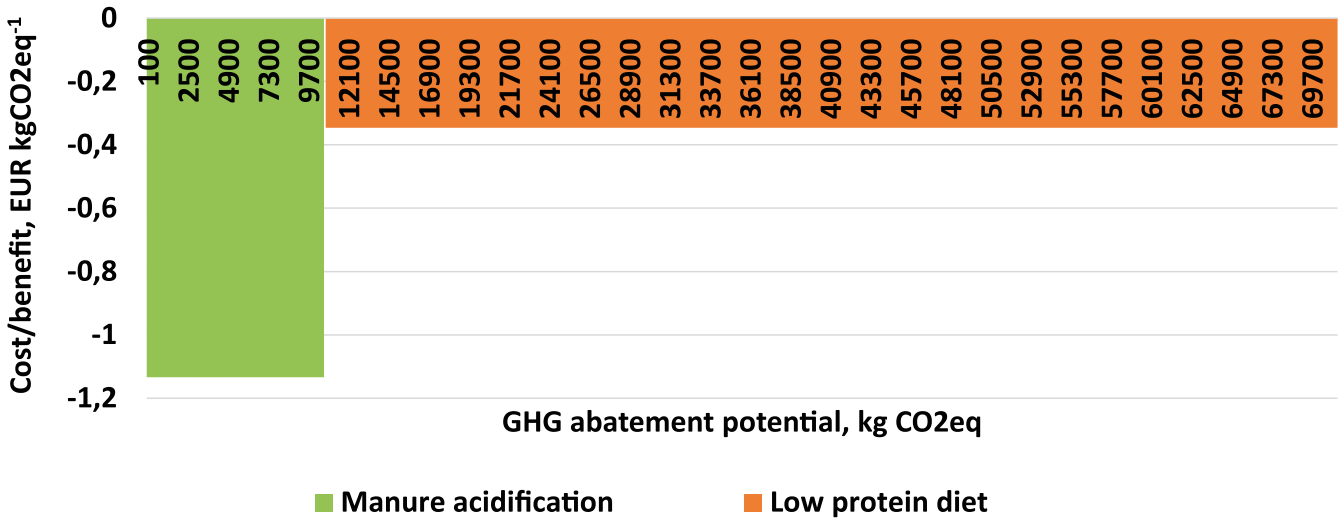
8. Table: Farm IT_8 emissions calculations results with Agrecalc tool





9. Economics: MACC curve IT_8 with all simulated measures



Picture resource: https://www.environmental-expert.com/products/syren-mobile-acidification-system-for-slurry-552824

Deutschland

1. Description of farmers' future strategy on development of farm and reduction of emissions

This farm is an organic experimental farm of our university (Justus-Liebig-University, Giessen). Its task is the production of seeds of important cereals, seed potato production and animal feed in a way that is as environmentally and resource-friendly as possible. This requires management that is more strongly based on the internal nutrient cycles on the farm and uses self-regulating forces on the farm as far as possible. This includes the preservation and creation of a richly structured cultural landscape with its ecologically valuable animal and plant communities. Their breeding goal is the longevity of the animals. As well as own calf and heifer rearing is pursued. The female calves are reared for breeding and fattening and the males are sold to the mast. Among other things, the scientists deal with issues of crop rotation and soil cultivation, the availability of phosphorus in the soil, the effect of biogas manure on soil, plant and environment, and the health and performance of dairy cows in organic farming. They have an own farm shop, where you can buy a.o. eggs from their hens and potatoes from their fields and milk and meat from the cows. The farm manager is very well educated and very interested in new techniques, especially to reduce GHG emissions. They build a new barn with a focus on good environmental sustainability and a good ecological balance sheet.

2. Which mitigation measures / practices were already taken?

Green roof (old barn)

Individual cow feeding and feeding ratio for each performance group

New barn (100% automatic feeding system)

Focus on longevity

3. Which mitigation measures are planned to be implemented and how?

Adding straw to slurry for covering the manure storage.

Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

Covering solid slurry storage.

Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

4. Expected effects on emissions (based on tool calculations)

Adding straw to slurry for covering the manure storage.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

Covering solid slurry storage.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

5. Equipment involved, investment and economic

Adding straw to slurry for covering the manure storage.

During the event, it is planned to purchase a straw blower for EUR 20,000, it is expected to last for 7 years. Straw EUR 365 per year is also required. This will ensure a saving of N mineral fertilizers worth EUR 3,326.

Covering solid slurry storage.

Covering 1,500 m3 of manure with covering material cost EUR 6,075, that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 3,326 per year. Lifetime of covering material 7 years.

6. Attention points when implementing measures

Costs for covering the slurry tank shouldn't be to high.

Covering the manure storage only with a simple cover fleece maybe not practicable, because of removing when adding new manure to it. For covering the manure with a roof, not enough space.

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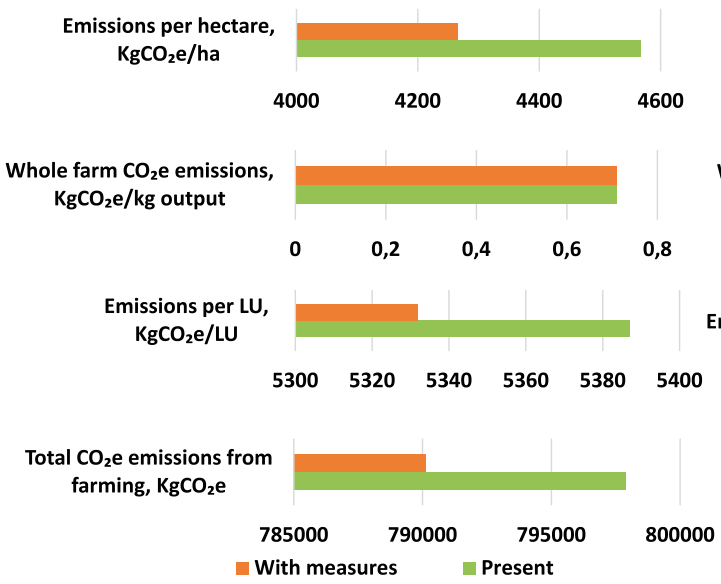
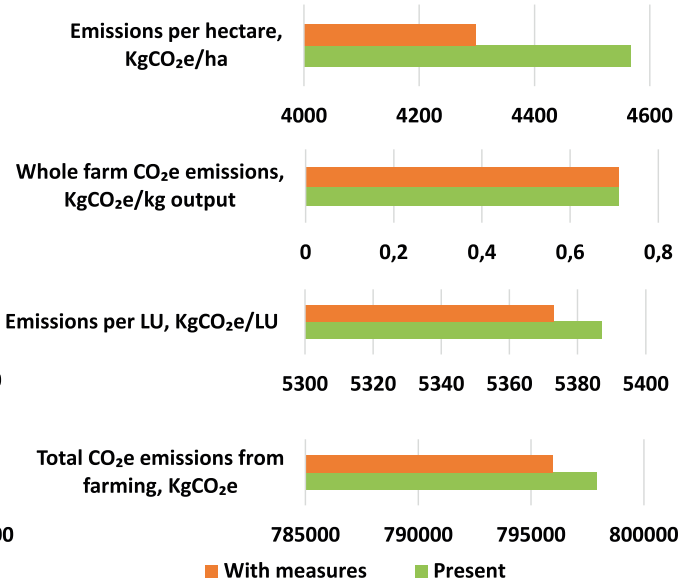
8. Table: Farm DE_2 emissions calculations results with Agrecalc tool

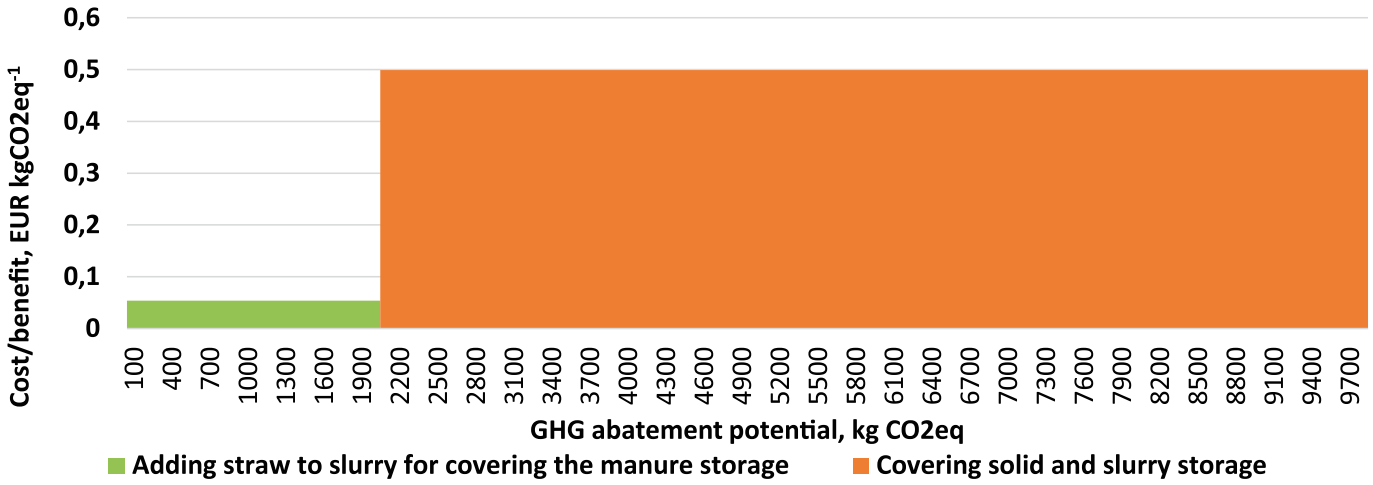
GHG emissions reduction with covering slurry storage



GHG emissins reduction wiht straw cover



9. Economics: MACC curve DE_2 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

The farm is located in the north of Hesse. Central Germany. It is an organic producing farm. Their main business is milk production. They sell the milk to a local company and produce their own cheese. They have also some pigs, breed "Bunte Bentheimer" and some laying hens and they keep the bull calves and fatten them up to market the meat regionally and directly. All these animal products are organic and selling in a local shop at the farm. This ecologically holistic and regional approach means that this farm produces less emissions than comparable conventional farms.

2. Which mitigation measures / practices were already taken?

Producing and using self cultivated forage

Pasture access

Renewable energies at the roof of lactating cow barn

3. Which mitigation measures are planned to be implemented and how?

Covering the outdoor slurry tank with hardcover.

Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

4. Expected effects on emissions (based on tool calculations)

Covering the outdoor slurry tank with hardcover.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

5. Equipment involved, investment and economic

Covering the outdoor slurry tank with hardcover.

Covering 12 000m^3 of slurry manure with tent roof cost EUR 23 625, that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 2 661 per year. Lifetime of tent roof 7 years.

6. Attention points when implementing measures

Costs for covering the slurry tank shouldn't be to high.

7. Quote of farmer:

"Regionality is the best"

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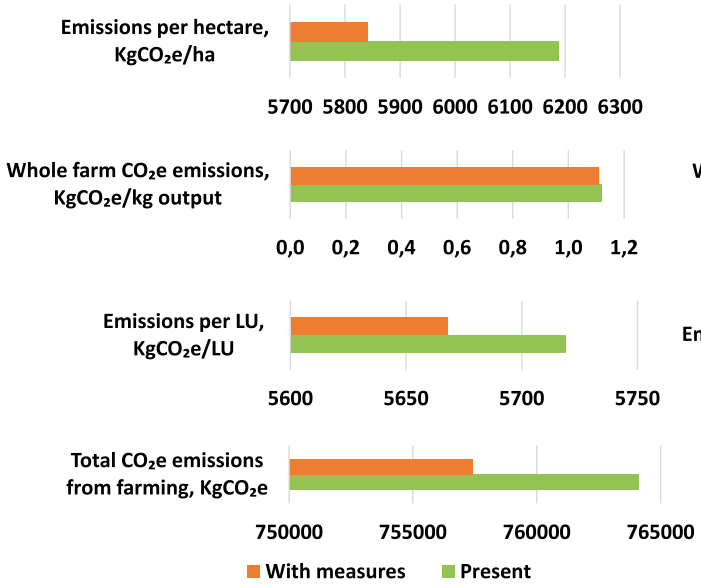
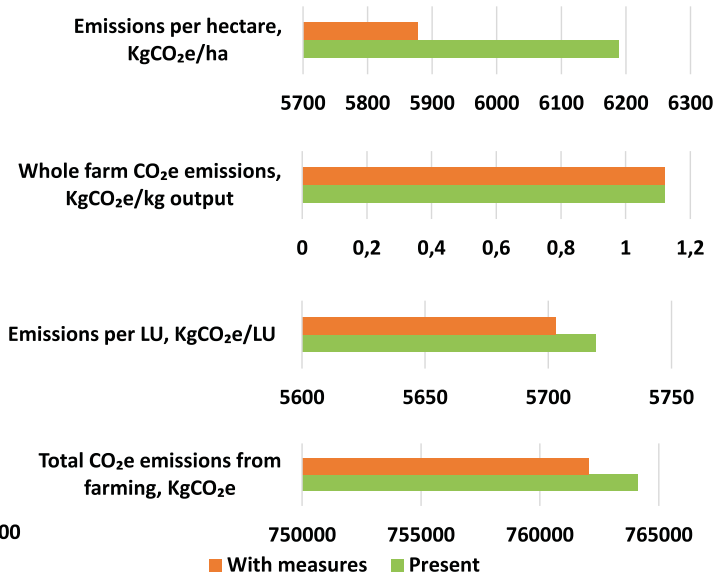
8. Table: Farm DE_7 emissions calculations results with Agrecalc tool

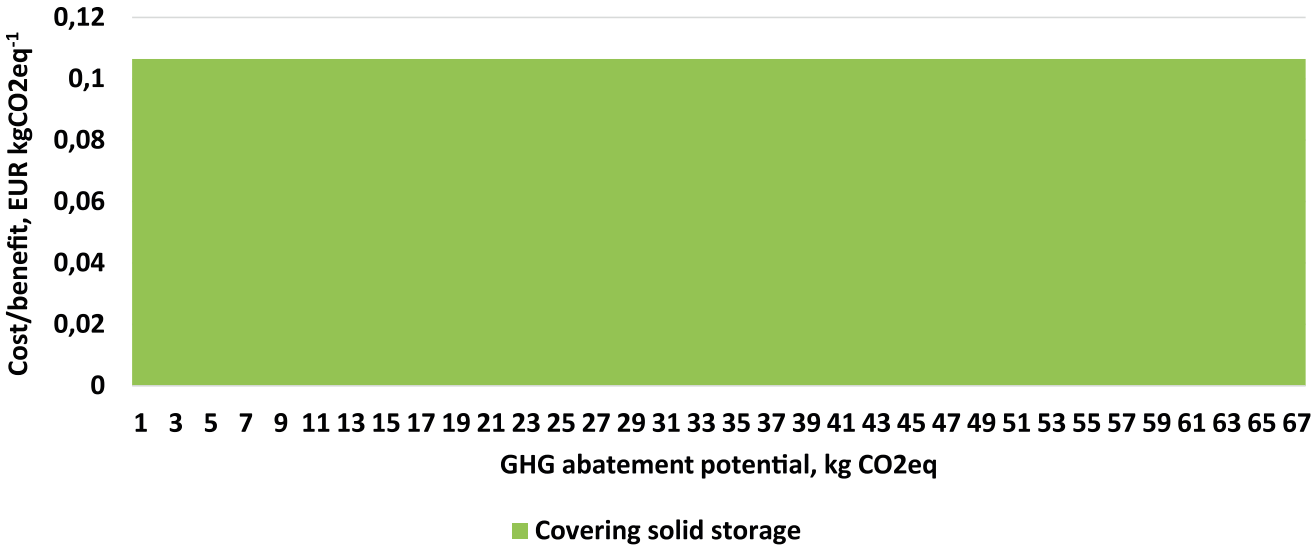
GHG emissions reduction with covering slurry tank



GHG emission reduction with straw slurry cover



9. Economics: MACC curve DE_7 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

This farm is located in the north of Hesse. It produces organic and has built a new composted bedded pack barn. Sustainability and environmental friendliness are very important on this farm. Through constant investments and the purchase of more efficient equipment, the farmer is trying to further reduce his emissions in the future while maintaining or increasing comfort for the animals. Because healthy animals are also a good contribution to climate protection.

2. Which mitigation measures / practices were already taken?

Built a new barn (composted bedded pack barn)

Renewable energy (photovoltaic system)

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Buying a new manure application system.
less manure, smaller manure storage, less gas emission because of feces will be composted in the barn, new milking parlor -> more efficient (less energy, water use).

Energy saving equipment.
Buying a new tractor.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
The realization of the event does not require significant investments. Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Energy saving equipment.
The measure envisages changing the obsolete tractor to a modern and more efficient tractor.

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, which provide for the new diet, (saved feed cost – 10,693 EUR per year), additional components of diet (additional costs – 1,800 EUR per year). At the same time, changes in feed quality will improve cow welfare. However, it is difficult to express the expected effect financially.

Energy saving equipment.
Investments in technology are EUR 109,000. The measure makes it possible to significantly reduce fuel costs (EUR 3,170 per year). Financial leasing rate 4%.

6. Attention points when implementing measures

Costs are the main point, how high will the savings potential of the new equipment actually be?
- Saving fuel and manure.

7. Quote of farmer:

"Healthy animals are good for climate protection"

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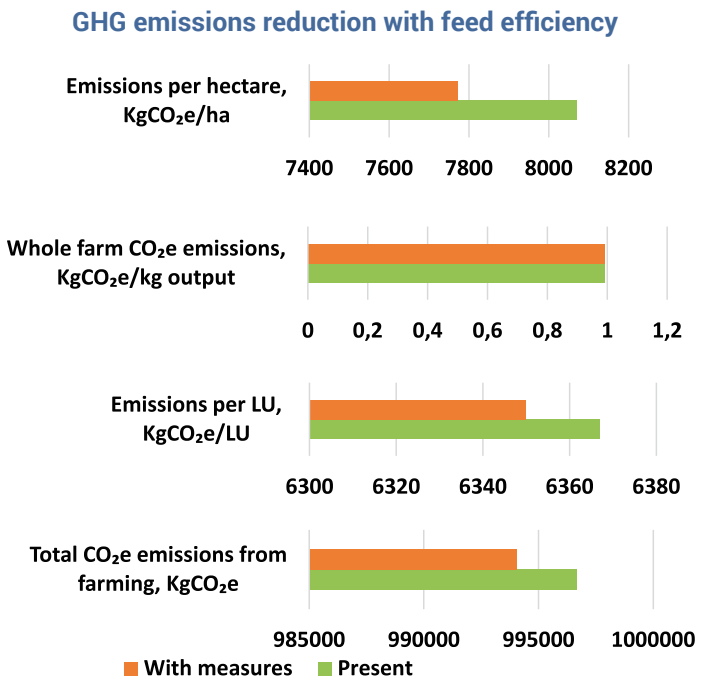
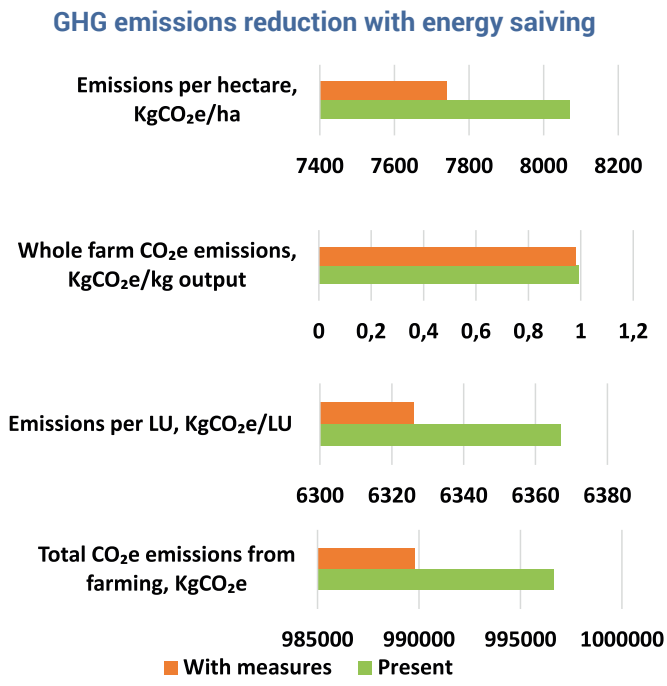
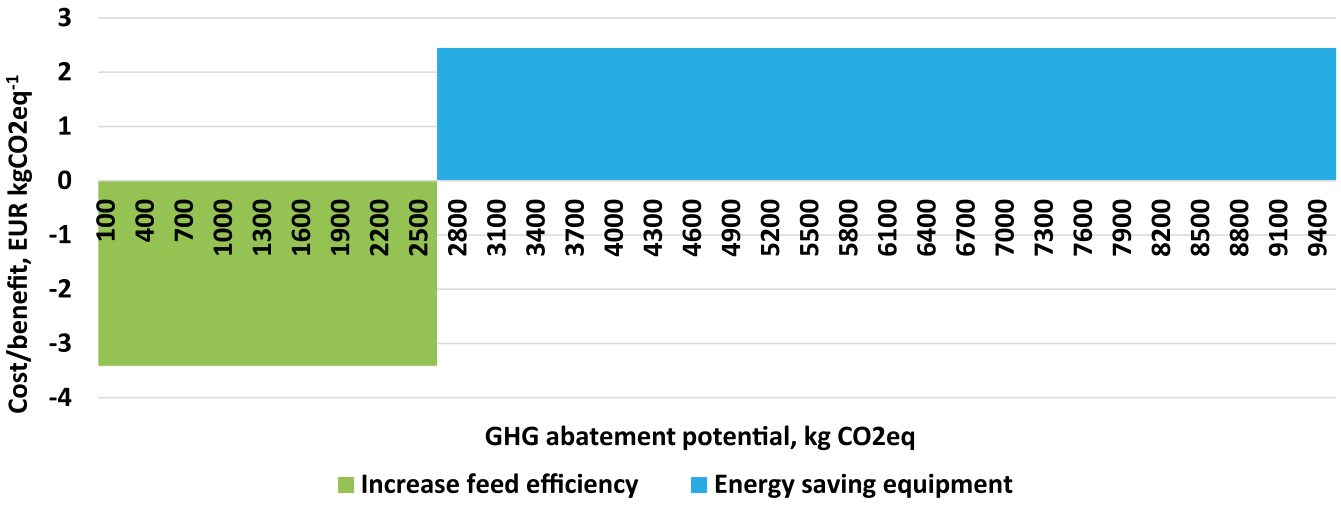
8. Table: Farm DE_8 emissions calculations results with Agrecalc tool





9. Economics: MACC curve DE_8 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

This farm has a composted bedded pack barn for the dry cows and transit (first 100 lactation days) cows. It's a conventional milk production farm with a biogas system. The transit cows have been kept in a composted bedded pack barn since 2013. The cow comfort is impressively high in the two-room free-walk housing system with a flat feed alley (slider manure removal) and the free lying area, which is strewn with a mixture of grain and horse manure with wood shavings at intervals of 9 days to 9 weeks. The performance parameters have developed very positively with this barn, e.g. 305-day performance averages 11,400 kg ECM per cow and the remount rate is 26.9%. The farmer focuses on longevity and improving the fitness of the cows in order to reduce the number of offspring and to keep fewer unimportant animals in total, thus producing fewer emissions and less manure. He wants to achieve/maintain high performance through high animal comfort, so that the farm is as efficient as possible. The conversion of manure into energy with the help of the biogas system and the upgrading of the soil with the help of the composting material (humus enrichment) are also positive aspects.

2. Which mitigation measures / practices were already taken?

- **Providing probiotics in the ration**
- **Increasing the longevity of cows**
- **Increasing milk production per cow**
- **Adopting mechanical separation of slurry**

3. Which mitigation measures are planned to be implemented and how?

Low protein diet.
The aim of the measure is to change the rations of feed. The N content of feed ration ingredients is reduced, e.g. by reducing N content of concentrates.

Low protein diet.
The aim of the measure is to change the rations of feed. The N content of feed ration ingredients is reduced, e.g. by reducing N content of concentrates.

Acidification of manure.
The aim of the measure is to reduce N losses during manure management in barn and / or at field application. Mitigation practice include: purchase and installation of acidification equipment.

4. Expected effects on emissions (based on tool calculations)

Adding probiotics to the feeding ration.
Enteric methane inhibitor purchase and precision inhibitor distribution to reduction CH_4.

Add nitrification inhibitor to improve organic fertilizer.
The use of urea with an inhibitor on an area of 34 ha to reduce N losses.

Use manure acidification supplements.
To reduce N losses during manure management at field application.

5. Equipment involved, investment and economic

Adding probiotics to the feeding ration.
The cost of probiotic supplements is EUR 6,935.

Add nitrification inhibitor to improve organic fertilizer.
Additional cost of EUR 716, while ensuring a more efficient use of N, ensuring savings. EUR 491.

Use manure acidification supplements.
Manure acidification requires equipment EUR 10,000 (for 7 years), as well as sulphuric acid EUR 2,880. Generally, soil liming requires EUR 14,100. At the same time, the N stored in manure results in a benefit of EUR 32,256.

6. Attention points when implementing measures

How high will be the costs for these additives, measures should generate a profit.

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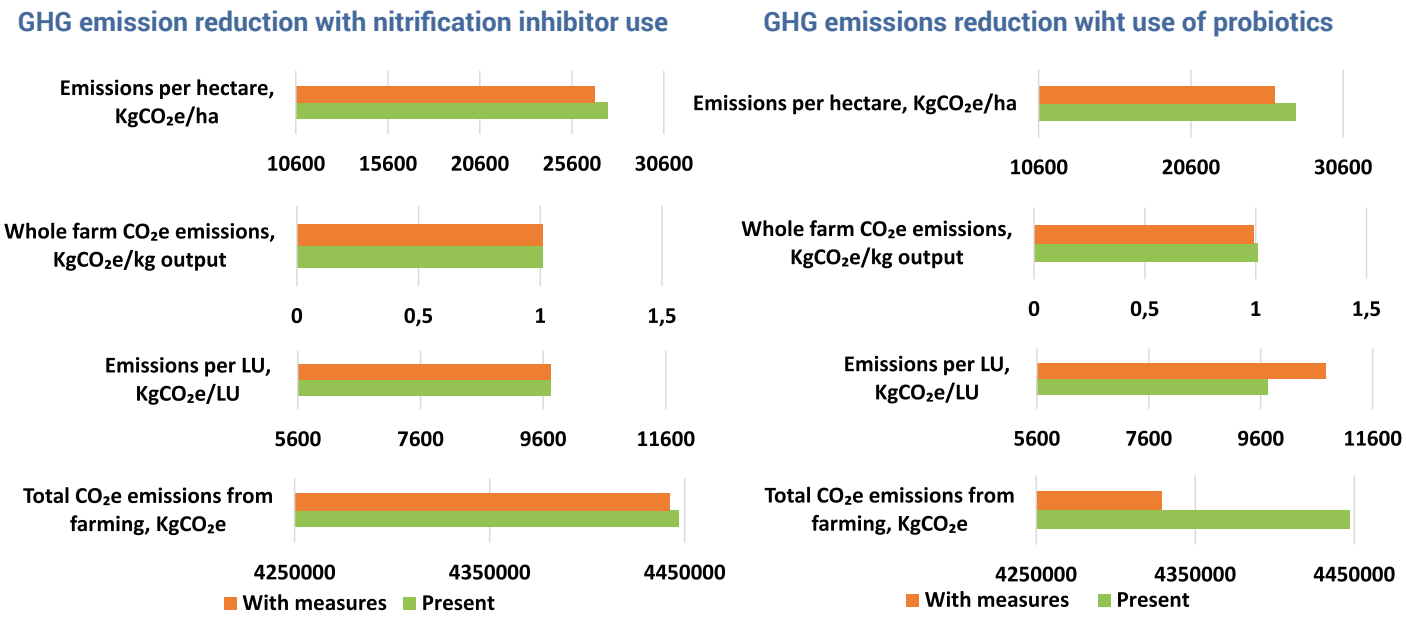
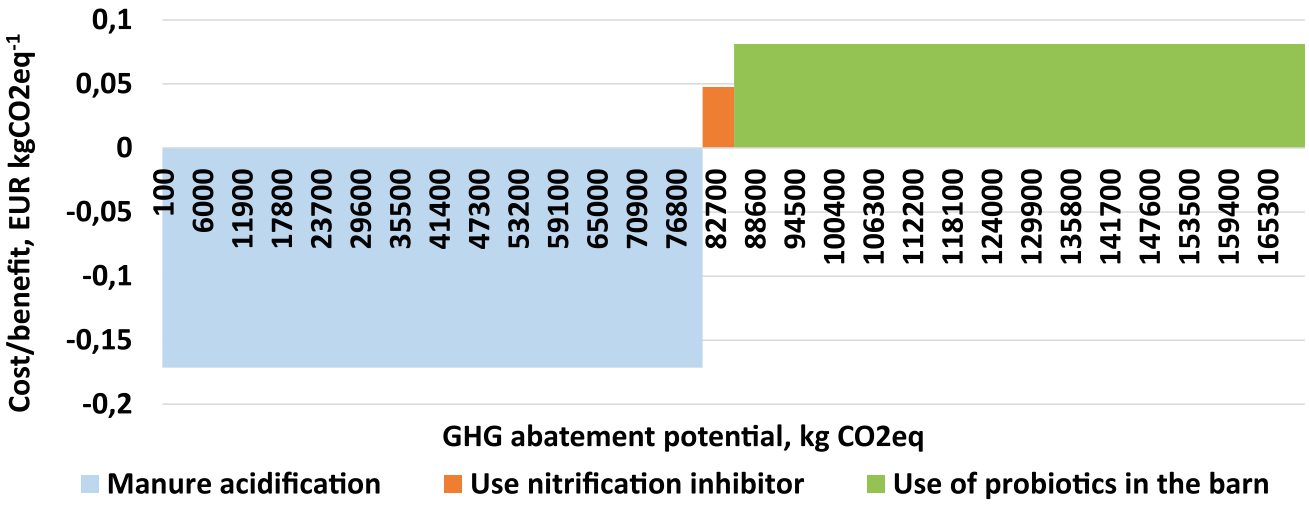
8. Table: Farm DE_10 emissions calculations results with Agrecalc tool



9. Economics: MACC curve DE_10 with all simulated measures



Picture resource: https://www.environmental-expert.com/products/syren-mobile-acidification-system-for-slurry-552824

France

1. Description of farmers' future strategy on development of farm and reduction of emissions

It is an experimental farm involved in various research works and groups of breeders, particularly on the environmental themes. Motivated by a rationalization of the workforce (retirement) and by an innovative collective project optimizing manure management, the choice of methanization was made in 2019. It reduced the working time (minus 1.5 FTE) and generated an annual gain of 7,000 €. Also, the farm changed its spreading method, to maximize the manure fertilizer value by mitigating gas volatilizations. Reduced tillage practices were implemented too for economic (high fuel costs) and environmental reasons. The no-till practice has been considered but not yet implemented due to a lack of suitable equipment. Nevertheless, the wish is to keep reducing ploughing, given the good technical results obtained. The farm has also reduced its first energy expenditure item: the milk tank. In the future, they would like to plant hedges because of limited costs with important benefits in terms of biodiversity, landscape maintenance, animal welfare (shade for heifers) and for the good image brought in livestock farming in the society.

2. Which mitigation measures / practices were already taken?

Reduced tillage (1 / 2 years instead of 1 / year)

Methanization

Manure spreading method
(minimizing burial time of manure and use of drop-pipes for spreading)

Reduction of the energy consumption of the milk tank
(layout of the tank to have a minimal consumption, use of the calories of the milk to generate hot water)

3. Which mitigation measures are planned to be implemented and how?

Continue the reduction of ploughing.
More thorough way.

Planting hedges.

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Covering solid slurry storage.

4. Expected effects on emissions (based on tool calculations)

Covering solid slurry storage.
Reduction of methane is expected to be 47% and reduction of ammonia 80%.

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

5. Equipment involved, investment and economic

Covering solid slurry storage.
Covering 197 m^3 of manure with covering material cost EUR 14,400, that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 250 per year. Lifetime of covering material 7 years.

Increase feed efficiency.
Significant changes in farming, which provide for the reduced rations – 36,932 EUR per year. At the same time, changes in feed quality will improve cow welfare. The cost of rescheduling feed rations is 1,491 EUR per year.

6. Attention points when implementing measures

Increase feed efficiency.
It is difficult to express the expected effect financially.

7. Quote of farmer:

"With the societal evolutions, I am not comfortable with the spreading... I choose the time to do it depending on climate but also … without neighbors around"

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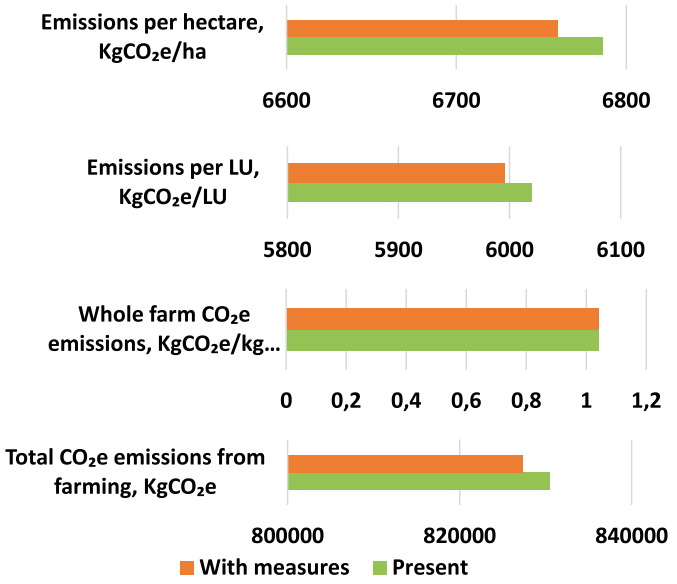
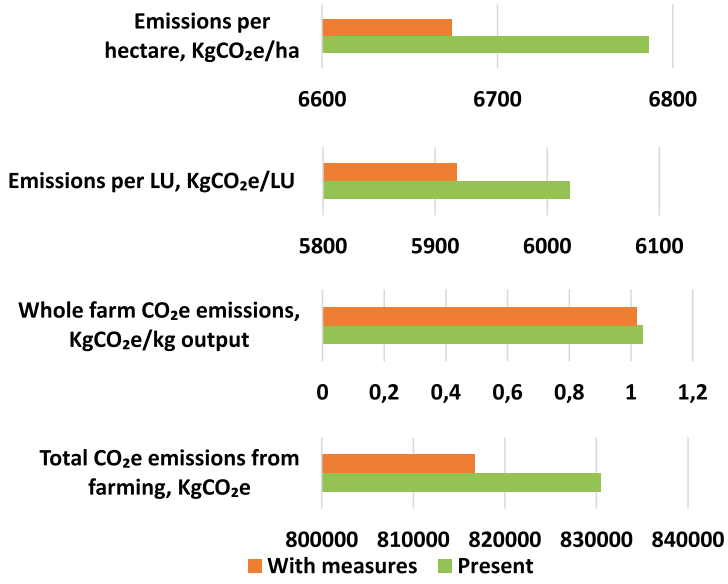
8. Table: Farm FR_1 emissions calculations results with Agrecalc tool

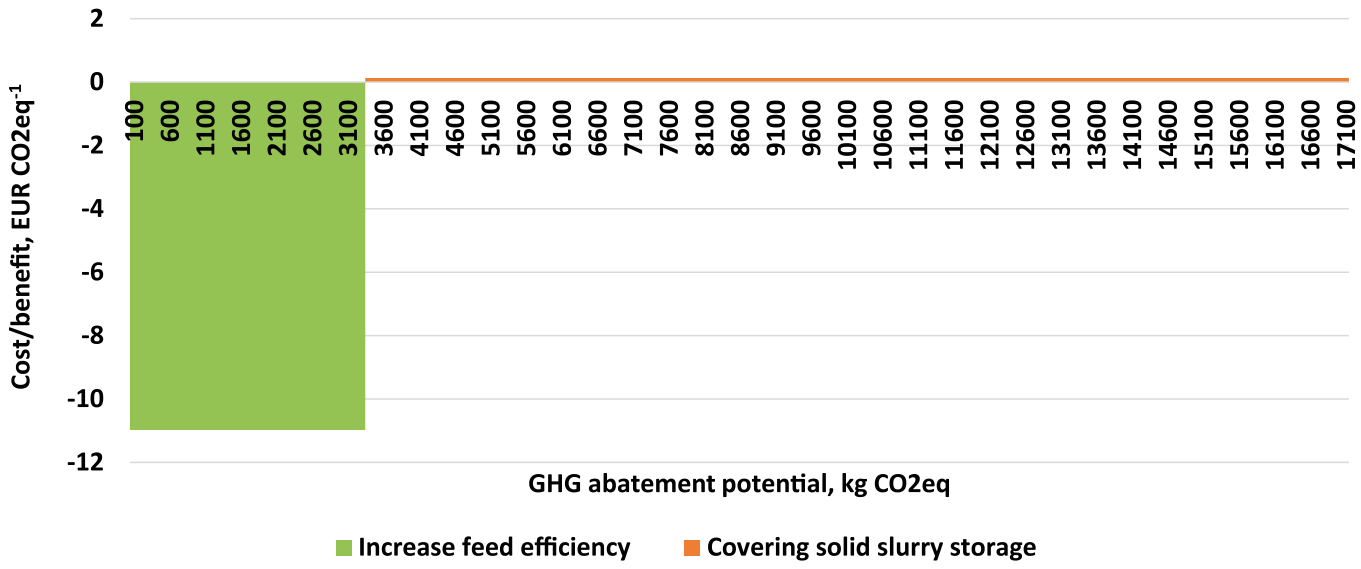
GHG emissions reduction wiht feed efficiency



GHG emissions reduction with covering slurry



9. Economics: MACC curve FR_1 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

It is an experimental farm, including organic productions for part of it. It carries out various tests, in particular on GHG emissions and leguminous grazing. In this perspective, it is equipped with GreenFeed® for methane emission measurements related to the animals' feeding. The farm has recently expanded (30 ha additional). Several renovation works have been carried out (white water treatment, spreading area, …). There are also plans to make the mobile milking robot available for GHG measurement trials on conventional batches. In the future, one of the important way which is planed will be to reduce the number of unproductive animals on the farm, in particular through crossbreeding and the fattening of culled cows.

2. Which mitigation measures / practices were already taken?

Use of GreenFeed® to measure emissions related to animal feeding

Reduction of unproductive animals through crossbreeding

Renovation of the white water treatment system
(planted lagoon for natural purification)

3. Which mitigation measures are planned to be implemented and how?

Fattening culled cows.

Increase feed efficiency.
Work on the feed value of forages to reduce the use of concentrates.

Covering solid slurry storage.
Construction of a new building with a covered slurry pit.

4. Expected effects on emissions (based on tool calculations)

Covering solid slurry storage.
Reduction of methane is expected to be 47% and reduction of ammonia 80%.

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

5. Equipment involved, investment and economic

Covering solid slurry storage.
Covering 237 m^3 of manure with covering material cost EUR 17,280, that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 300 per year. Lifetime of covering material 7 years.

Increase feed efficiency.
Significant changes in farming, which provide for the reduced rations – 16,198 EUR per year. At the same time, changes in feed quality will improve cow welfare. The cost of rescheduling feed rations is 1,479 EUR per year. The realization of the event does not require significant investments.

6. Attention points when implementing measures

Covering solid slurry storage.
Need direct injection or band spreading to be used with slurry application to maximize effects.

7. Quote of farmer:

"When there are many people on the farm, we don't all have the same conviction about environmental management"

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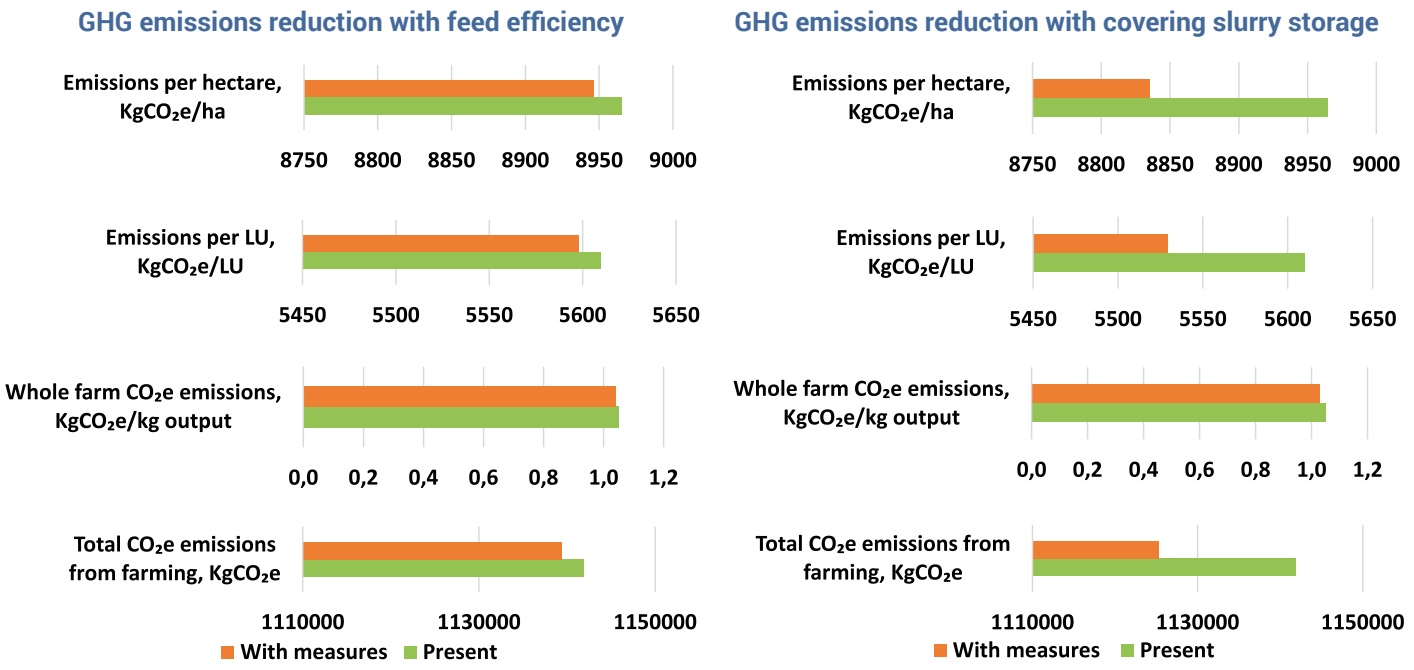
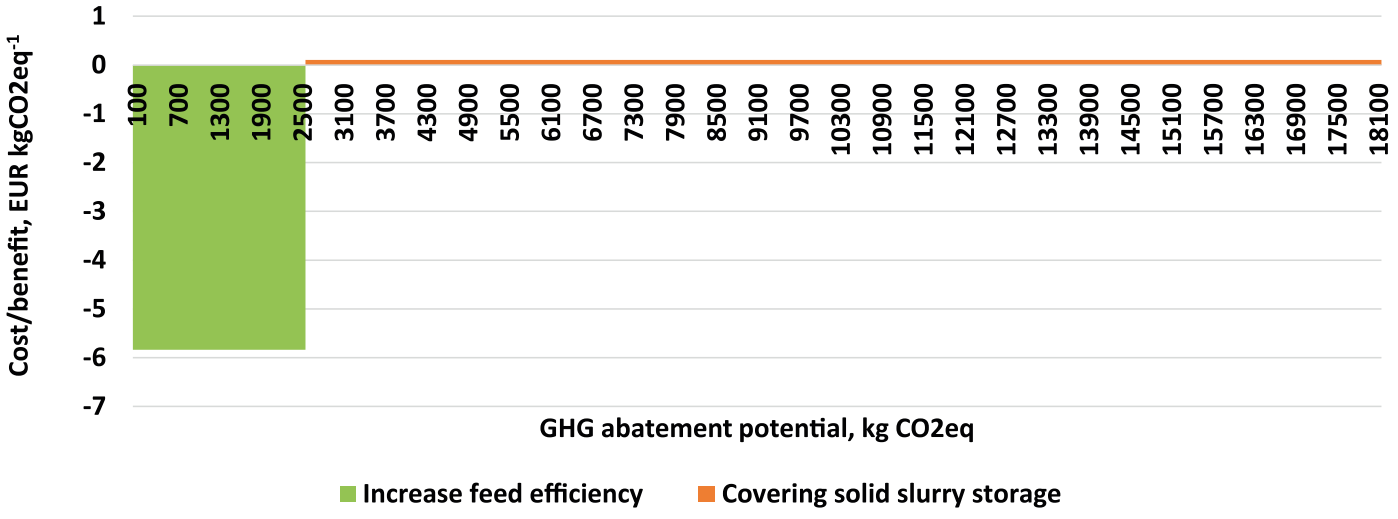
8. Table: Farm FR_3 emissions calculations results with Agrecalc tool



9. Economics: MACC curve FR_3 with all simulated measures



Netherlands

1. Description of farmers' future strategy on development of farm and reduction of emissions

There is already lots of attention on soil quality, (reduced) young stock management and increased true waste/by-product feeding. De Marke is trying to transition to circular farming: more attention to clean air and soil and more focus on being nature inclusive and climate. Important aspects are carbon sequestration and reduction of chemical agents. For this, a complete plan is being drafted, but this is dependent on how agriculture develops. Targets for this have been defined, but how to execute this exactly, is in discussion.

2. Which mitigation measures / practices were already taken?

- **Focus on longevity**
- **Optimal management of cows on pasture vs barn**

- **Summer feeding**
- **Reduced protein feeding (145gr RE)**

- **Increased frequency of mowing to decrease NDF value of the grass silage**

- **Biogas**
- **Reduction of input and increase/aimed to the use of solely by-products that cannot be used for human consumption**

3. Which mitigation measures are planned to be implemented and how?

Methane blocker as feed additive.
The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows

Low protein diet.
The aim of the measure is to change the rations of feed.

RES (solar energy) at farm.
The purpose of the measure is the production of renewable energy on the farm by installing solar panels. Idea is a solar roof for new barn.

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.
Enteric methane blocker purchase and precision distribution to reduction CH_4.

Low protein diet.
The N content of feed ration ingredients is reduced, e.g. by reducing N content of concentrates.

RES (solar energy) at farm.
The measure envisages placing 1705 kW solar panels on the farm, which will produce 1,449,675 kWh of electricity.

5. Equipment involved, investment and economic

Methane blocker as feed additive.
The measure is easy to implement but requires the purchase of a methane blocker EUR 9,490. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself

Low protein diet.
Low protein diet effect is achieved by replacing forage bread (EUR 17,816) with winter barley grain (EUR 42,457).

RES (solar energy) at farm.
The investment for the purchase and assembly of the panels is EUR 2,507,085 and the service life is 20 years. The value of the produced electricity (price 0.54 EUR kWh-1) is 785,825 EUR per year.

6. Attention points when implementing measures

Solar panels should be placed on a roof

Plant heat stress is more important than drought

7. Quote of farmer:

"When it comes to herb rich grasslands, biodiversity is more present in the soil than above"
"We can contribute more to providing food for human consumptions and use by-products for animal feed"

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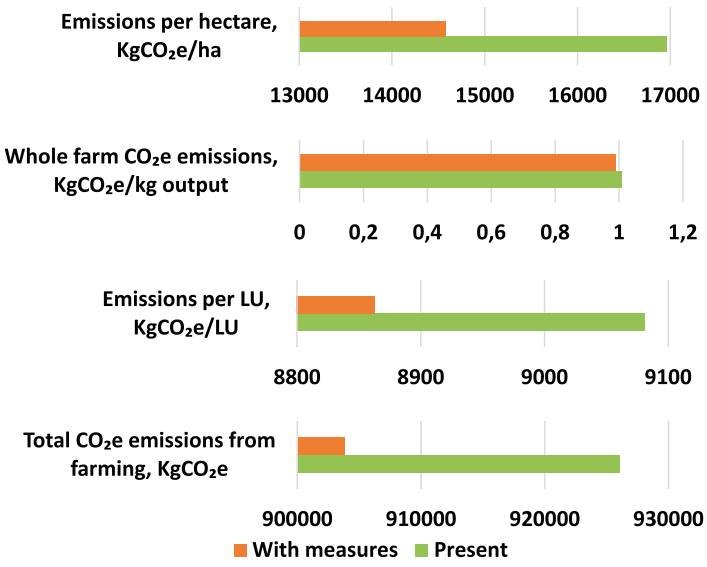
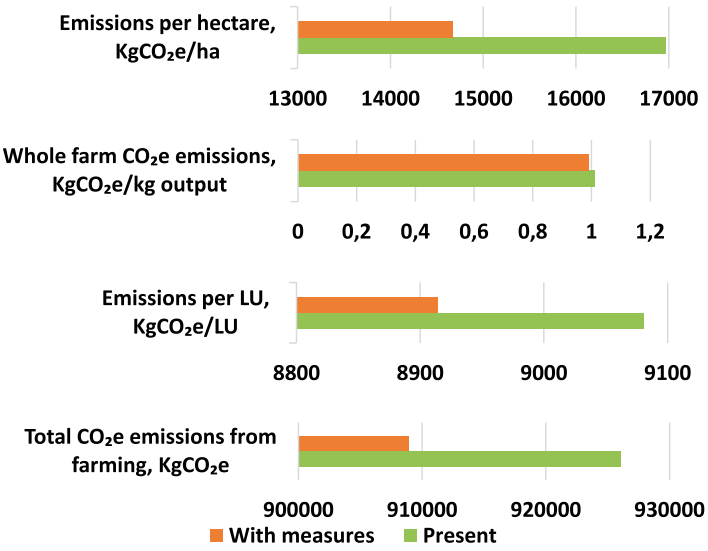
8. Table: Farm NL_1 emissions calculations results with Agrecalc tool

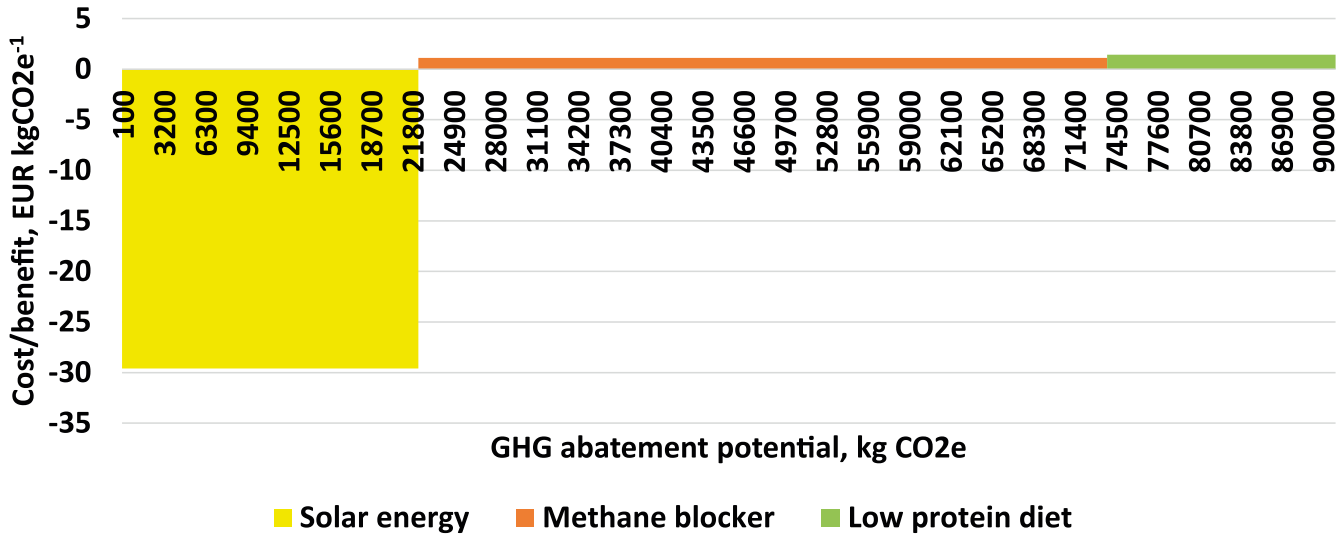
GHG emissions reduction with RES use



GHG emissions reduction with low protein diets



9. Economics: MACC curve NL_1 with all simulated measures




Farm practice (biogas)


Picture of farm practice

1. Description of farmers' future strategy on development of farm and reduction of emissions

Becoming completely self sufficient, trying to achieve circularity. Input of minerals via wood chips to correct for output of milk and meat. This strategy has led to 1% higher organic matter in the soil. No input of concentrates; grow own sugar beets. Low fertilizer use

2. Which mitigation measures / practices were already taken?

- **Own concentrate production that support soil health (fodder beets, MKS) and also improve feed and nutrient quality by combined silaging.**
- **Wood chips also add organic matter in the soil.**

- **Free walk barn, to reduce N loss (ammonia emission), inside the barn as it will get fixed by high C:N.**
- **Sieving of wood chips to reduce amount new bedding material**

- **Drip system over the floor to wet the manure, reduce concentration to lower ammonia emission and prevent slippery**
- **Low emission floor**

- **Use of heat produced by floor to use other buildings.**

3. Which mitigation measures are planned to be implemented and how?

Increase grazing time from 8/9 hours to for 180 days to 3000 hours.

- **Idea to combine low emission floor to a air scrubber/filter based on wood chips ('biobed')**
- **Oxygenation of slurry to increase its quality and reduce emission**

«Compost tea» to boost soil with nutrients and warmth

Wind turbines to save ventilator working time

4. Expected effects on emissions (based on tool calculations)

Low protein diet.

Reduced protein in the diet (140) compared to higher protein in the diet (155).

5. Equipment involved, investment and economic

Low protein diet.

Low protein diet effect is achieved by reducing dairy nuts 20cp (EUR 3,321), it reduces both GHG emissions and production costs.

6. Attention points when implementing measures

It is difficult to express the expected effect financially

7. Quote of farmer:

"Rules kill creativity"
"Freewalk is a total farm system, not a housing system"
"Dierzaam" (Dutch word joke combining animal and sustainability)

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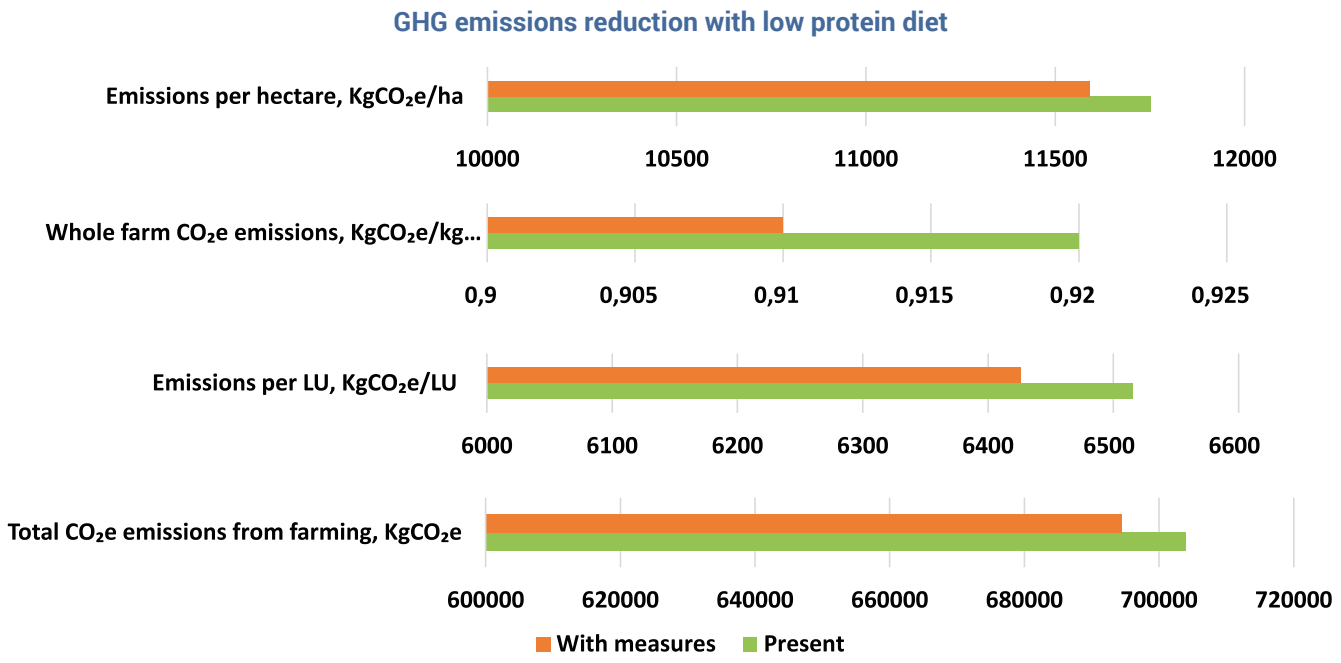
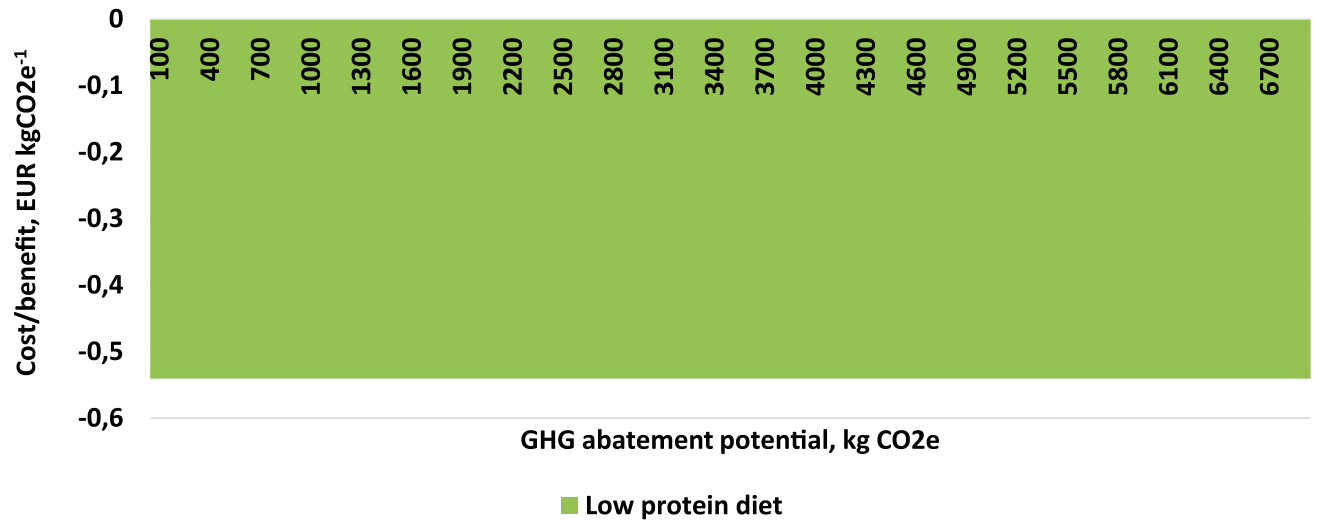
8. Table: Farm NL_2 emissions calculations results with Agrecalc tool



9. Economics: MACC curve NL_2 with simulated measure




Picture of farm practice


Picture of farm practice

1. Description of farmers' future strategy on development of farm and reduction of emissions

Improve management – comfort dairy cows, feeding dry cows, grazing management
Good farming practice regarding longevity cows and land use.
Aim is to be as independent and self-sufficient as possible.
Sustainable position of farms in society (as an example, providing energy via H2 Converters).

2. Which mitigation measures / practices were already taken?

- **Rotating crops, herb rich grass**
- **Limited use of soy - rape is preferred as well as pressed pulp**
- **Own production of concentrates an purchasing strategies – wheat vs rape vs field beans cultivation and purchase**
- **(Small) windmills and solar panels (self sufficient already)**

3. Which mitigation measures are planned to be implemented and how?

Increase grazing (currently at 2500 hours).

- **ZeraFlex permeable floor**
- **Use of runoff water to reduce NH3 emissions**

- **Improve drying grass for pellets using self produced heat**
- **Additional windmills and solar panels**

Electrolyser (H2-energy hybrid converter) instead of gas for local use.
Reduces the load on the energy network, by using sustainable energy to convert to storable energy.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.
Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced
(For 130 cows, from 25kg to 20kg concentrate / 100 kg milk and 3000 hours grazing).

Install low emission floor.
ZeraFlex floor, primary separation of manure.

5. Equipment involved, investment and economic

Increase feed efficiency.
Significant changes in farming, which provide for the preparation of feed plans (1,631 EUR per year), additional work for the distribution of feed to workers (455 EUR per year). At the same time, changes in feed quality will improve cow welfare and reduce cost of feed (EUR 2,835). However, it is difficult to express the expected effect financially. The measure does affect also the reduction of GHG emissions (5,630 kg CO2eq).

Install low emission floor.
The construction of low-emission floors in the barn involves large investments for rebuilding the barn (EUR 364,000). These costs can be partly compensated by the reduction of N mineral fertilizers (EUR 601 per year) due to the higher N content of manure. The measure does affect also the reduction of GHG emissions (6,350 kg CO2eq).

6. Attention points when implementing measures

Energy from extra windmill and solar panels will be used to produce H2. Storage of energy is necessary because in winter period extra need for energy while most is produced in summer (solar panels).

7. Quote of farmer:

"When it comes to herb rich grasslands, biodiversity is more present in the soil than above"
"We can contribute more to providing food for human consumptions and use by-products for animal feed"

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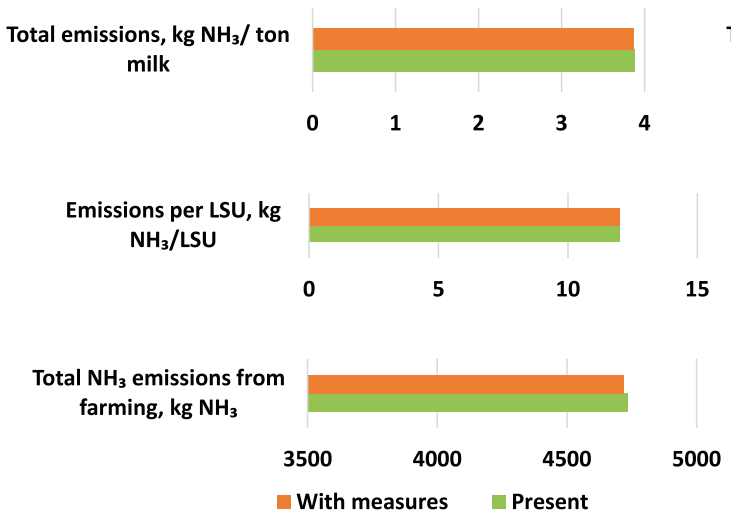
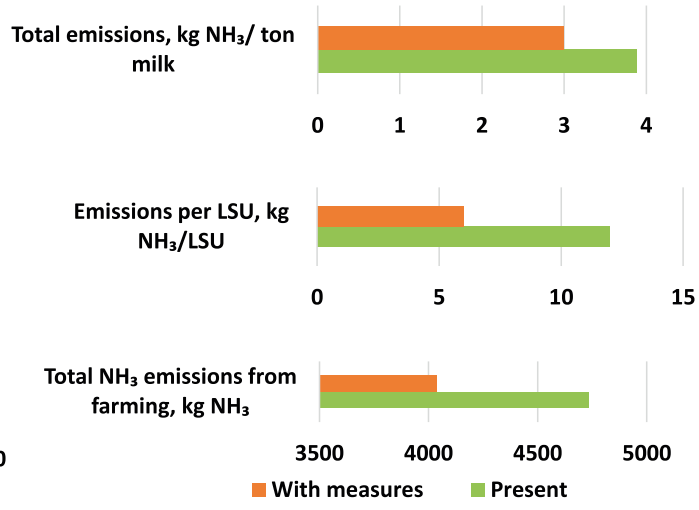
8. Table: Farm NL_3 emissions calculations results with ANCA tool

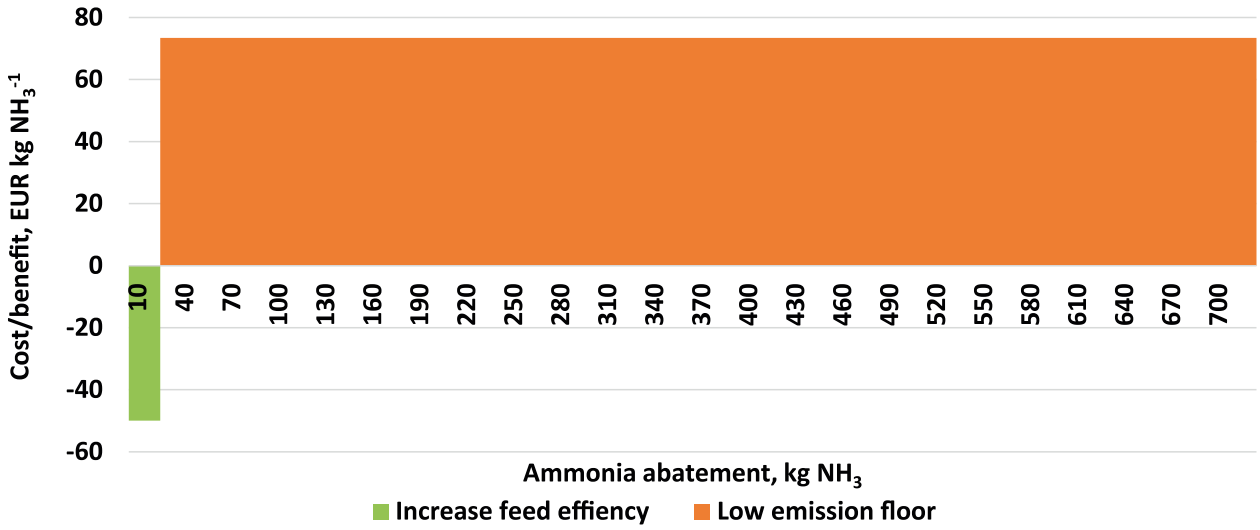
Reduce emission with reduction concentrate per cow



Emissions reduction with instal low emission floor



9. Economics: MACC curve NL_3 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Soil health (roots, funghi) leading to healthy feed, leads to healthy cows. Focus on realistic numbers/values. Regional feeding, local products and maintain circularity (grain mixture, alfalfa pellets). Freewalk housing system with woodchips bedding is important to create a manure product with high organic matter.

2. Which mitigation measures / practices were already taken?

- **Kensey-methode representative soil analysis (Ca:Mg, K, P)**
- **Herb rich grassland (mixture with clover and 20 types of herbs**
- **Field beans as cover crop (protein retention crop for rewarding)**

Drying of hay (to increase protein utilization)

Free walking barn to reduce slurry production

- **Liquid, urea based and acidified fertilizer on first cut**
- **MgCl to bind N from ammonia**
- **Dilute manure with rain water (50% H2O in slurry)**

- **Solar panels on full roof**
- **Solar thermal heating with a boiler**

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.

Feed efficiency is improved through improved animal management (incl. health).

Renewable energy production (RES) at farm.

The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.

Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced
(For 130 cows, from 25kg to 20kg concentrate / 100 kg milk and 3000 hours grazing).

Install low emission floor.

ZeraFlex floor, primary separation of manure.

5. Equipment involved, investment and economic

Increase feed efficiency.

Significant changes in farming, which provide for the preparation of feed plans (1,631 EUR per year), additional work for the distribution of feed to workers (455 EUR per year). At the same time, changes in feed quality will improve cow welfare and reduce cost of feed (EUR 2,835). However, it is difficult to express the expected effect financially. The measure does affect also the reduction of GHG emissions (5,630 kg CO2eq).

Install low emission floor.

The construction of low-emission floors in the barn involves large investments for rebuilding the barn (EUR 364,000). These costs can be partly compensated by the reduction of N mineral fertilizers (EUR 601 per year) due to the higher N content of manure. The measure does affect also the reduction of GHG emissions (6,350 kg CO2eq).

6. Attention points when implementing measures

Energy from extra windmill and solar panels will be used to produce H2. Storage of energy is necessary because in winter period extra need for energy while most is produced in summer (solar panels).

7. Quote of farmer:

"I want a 100K L milk cow every year"
"Slurry is not a natural product"

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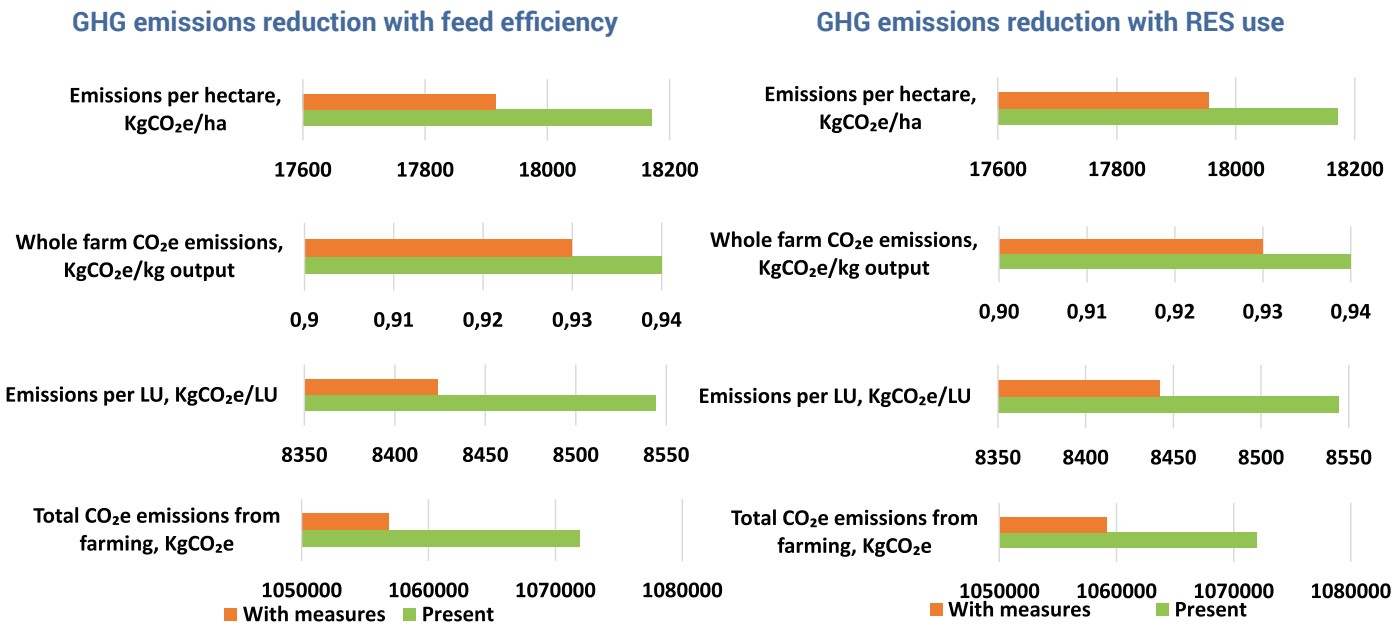
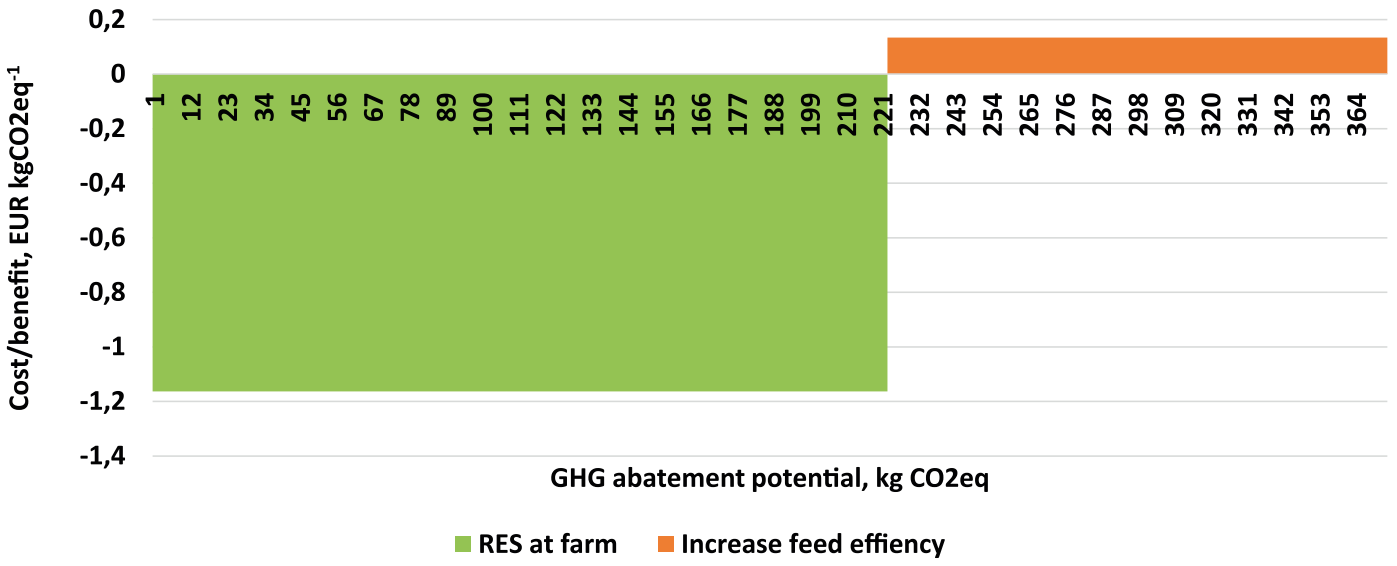
8. Table: Farm NL_4 emissions calculations results with Agrecalc tool



9. Economics: MACC curve NL_4 with all simulated measures



Picture resource: https://cometrenewables.ie/solar-pv-for-dairy-farms/

1. Description of farmers' future strategy on development of farm and reduction of emissions

Focus on low energy and energy savings and stay on top of developments with regards the energy market providing fresh grass via summer-grass feeding and grazing (with proper monitoring and steering based on Farm Walk) vs ensiling

Focus on cow comfort and on preventive animal health. Premium rewarding via Ben & Jerry's

2. Which mitigation measures / practices were already taken?

- **Arable farm has been changed to dairy farm with grassland**
- **Additional grass feeding (pasture/summer-grass feeding)**

- **Additional grazing from 750 to 1350 hours**
- **Provide more energy rich feed to utilize protein**
- **Sand bedding in cubicles**

- **New low emission floor with rubber**
- **Sand filtering leading to manure/urine filtration**

- **Energy saving – frequency converter, newest equipment**
- **Solar panels (close to self sufficient)**

3. Which mitigation measures are planned to be implemented and how?

Methane blockers

Low protein diet

Combination of energy saving measurements (energy/gas)

4. Expected effects on emissions (based on tool calculations)

Low protein diet.
Protein reduction from 160 to 150 CP for 220 cows.

5. Equipment involved, investment and economic

Low protein diet.
Low protein diet effect is achieved by reduction crude protein compound concentrate feed by 91 t, that's give EUR 40,950 feed economy and EUR 1,241 fertilizer economy.

6. Attention points when implementing measures

It is difficult to express the expected effect financially

7. Quote of farmer:

"Rules kill creativity"
"Working with Ben & Jerry's makes me proud"
"Cow comfort and working preventively leads to less hassle and annoyances"
"The first step is to stop needlessly wasting energy and be more energy aware"
"Start with the small things; like changing lights and turning on milk pumping systems at the right time"

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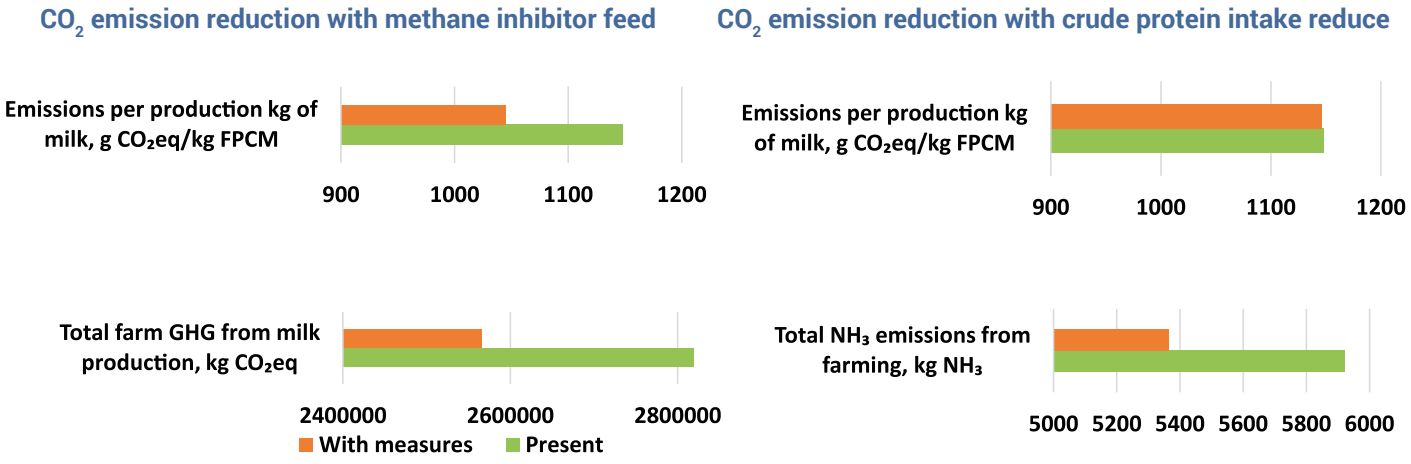
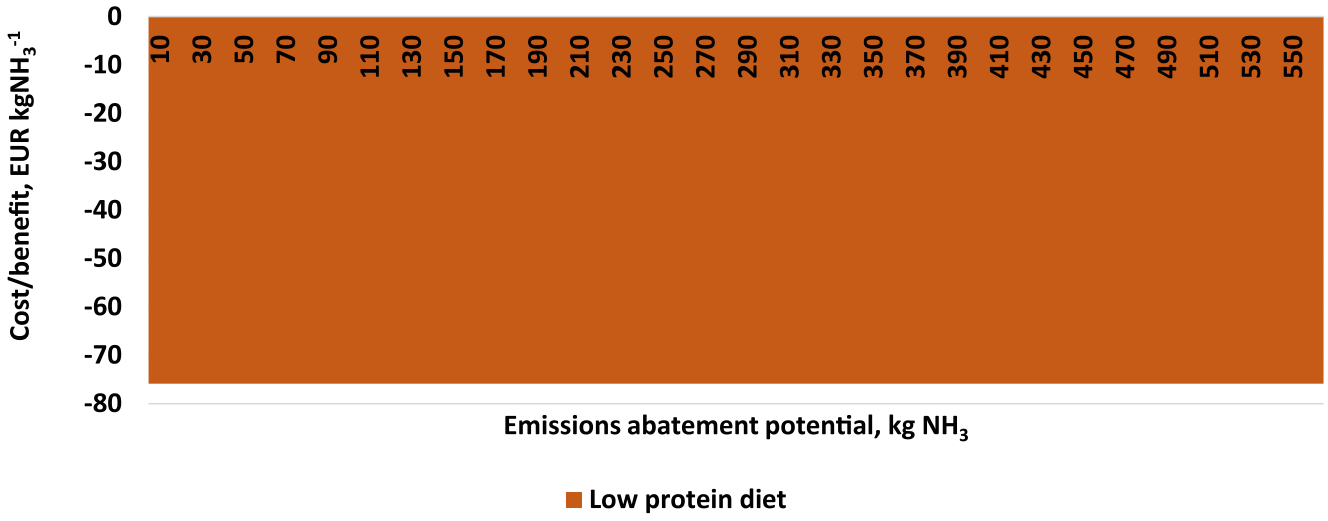
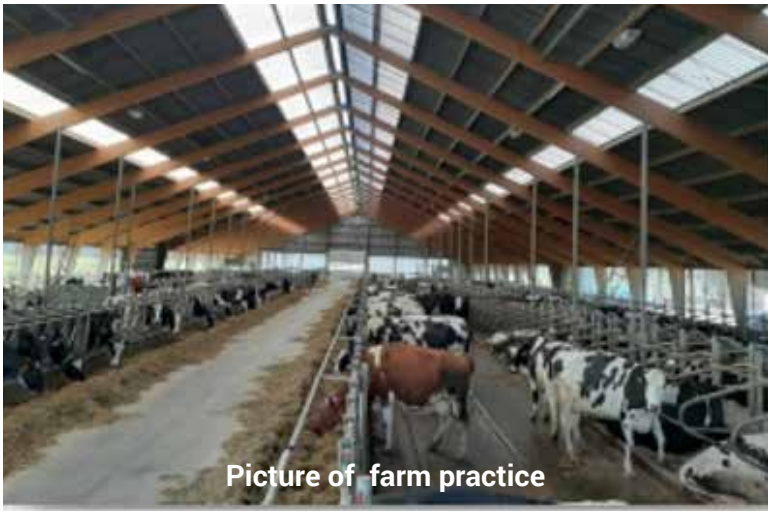
8. Table: Farm NL_5 emissions calculations results with ANCA tool



9. Economics: MACC curve NL_5 with all simulated measures



Picture of farm


Picture of farm practice

1. Description of farmers' future strategy on development of farm and reduction of emissions

Increase earnings, efforts and professionalisation of the (social) care farm and (passive) biogas production. Always trying to optimise farm with technical innovations.

2. Which mitigation measures / practices were already taken?

Low emission floor which separates feces and urine

Dilution of urine / liquid fraction during field application

Passive biogas production (small scale)

Urine and liquid from mechanical separator are stored in manure bag. With a mobile installation the gas is compromised, cleaned and stored in gas pipes.

3. Which mitigation measures are planned to be implemented and how?

Low protein diet.

The aim of the measure is to change the rations of feed. The N content of feed ration ingredients is reduced, e.g. by reducing N content of concentrates.

Just started with passive gas collection from urine/liquid storage.

Just started with passive gas collection from urine/liquid storage.

4. Expected effects on emissions (based on tool calculations)

Low protein diet.

Reduced protein in the diet (140) compared to higher protein in the diet (155) to redact CH_4 and N_2O emissions.

5. Equipment involved, investment and economic

Low protein diet.

Low protein diet effect is achieved by reducing dairy nuts 20cp (EUR 2,784), it reduces both GHG emissions and production costs.

6. Attention points when implementing measures

How to collect gas from liquid fraction or with other floor in barn to collect gas from slurry.

7. Quote of farmer:

"It's going to happen, and it's one way or another!"

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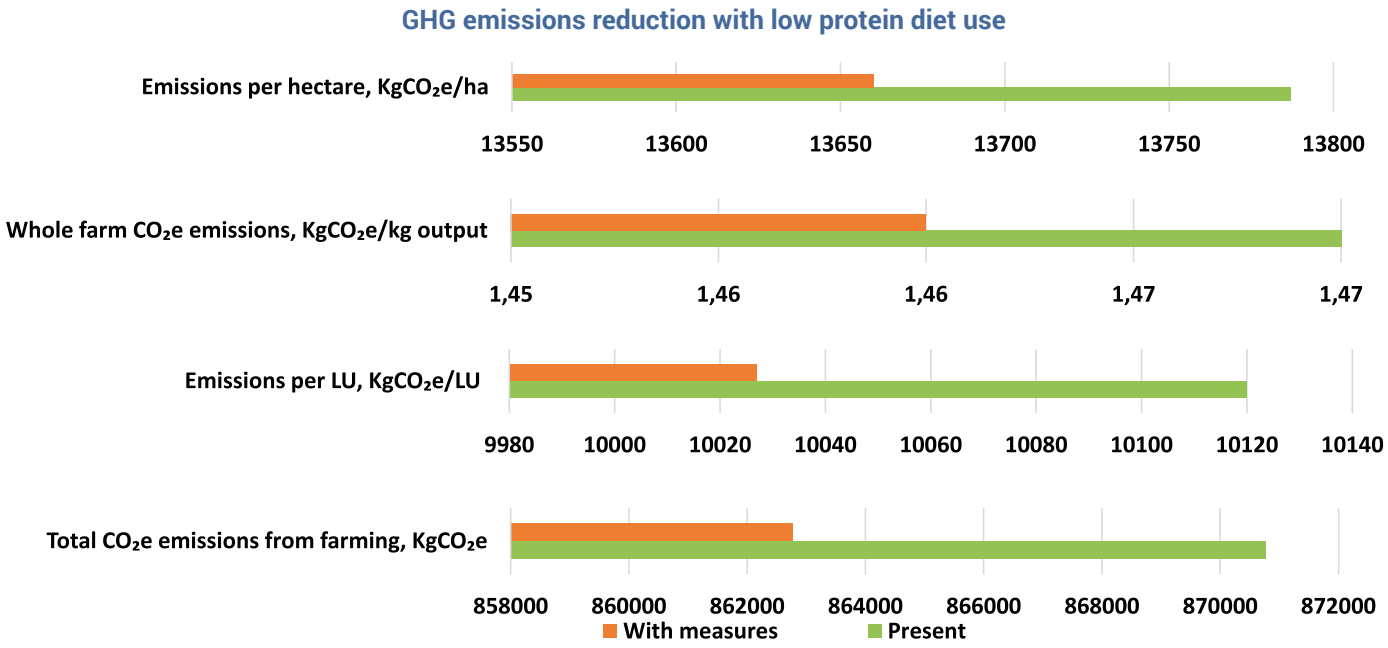
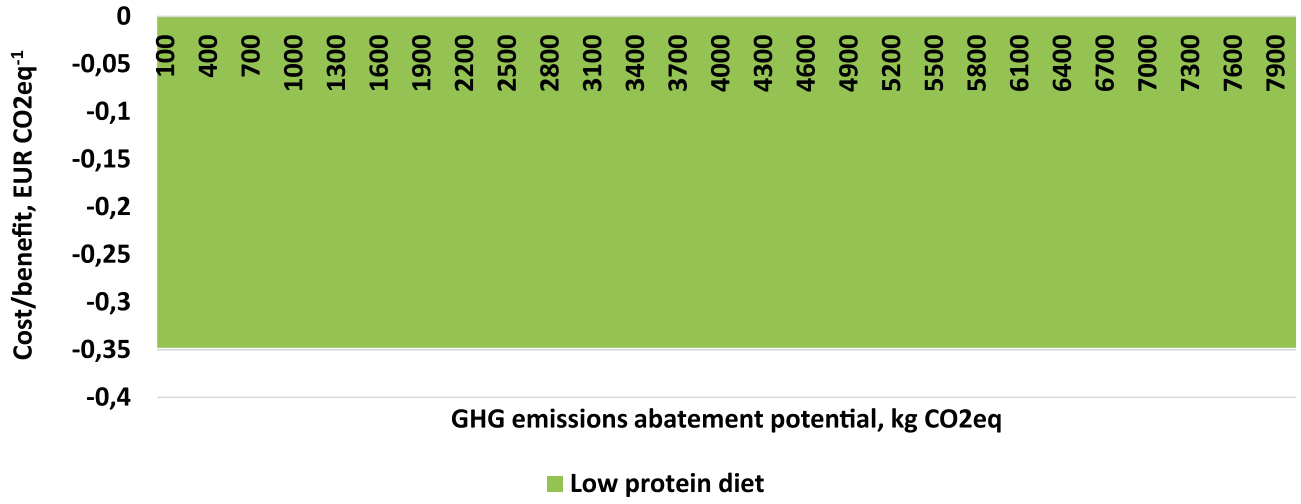
8. Table: Farm NL_6 emissions calculations results with Agrecalc tool



9. Economics: MACC curve NL_6 with simulated measure



Picture of farm practice

Picture gass collection from manure storage

1. Description of farmers' future strategy on development of farm and reduction of emissions

Focus on circular farming by local cooperation with arable farmers – use of local wheat, straw, and provision of manure. And focus on longevity of cows.

2. Which mitigation measures / practices were already taken?

More grazing to 120 days

No more maize production

Manure dilution

- **Solar panels/wind mill – for general use**
- **New LED lightning**

3. Which mitigation measures are planned to be implemented and how?

Methane blocker as feed additive.

The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.

Enteric methane blocker purchase and precision distribution to reduction CH_4. Number of used inhibitors per cow – 20g/cow/day; 130 cows.

5. Equipment involved, investment and economic

Methane blocker as feed additive.

The measure is easy to implement but requires the purchase of a methane blocker EUR 55,250. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself.

6. Attention points when implementing measures

It is difficult to express the expected effects financially

7. Quote of farmer:

"A country that forgets its history is doomed to fail"

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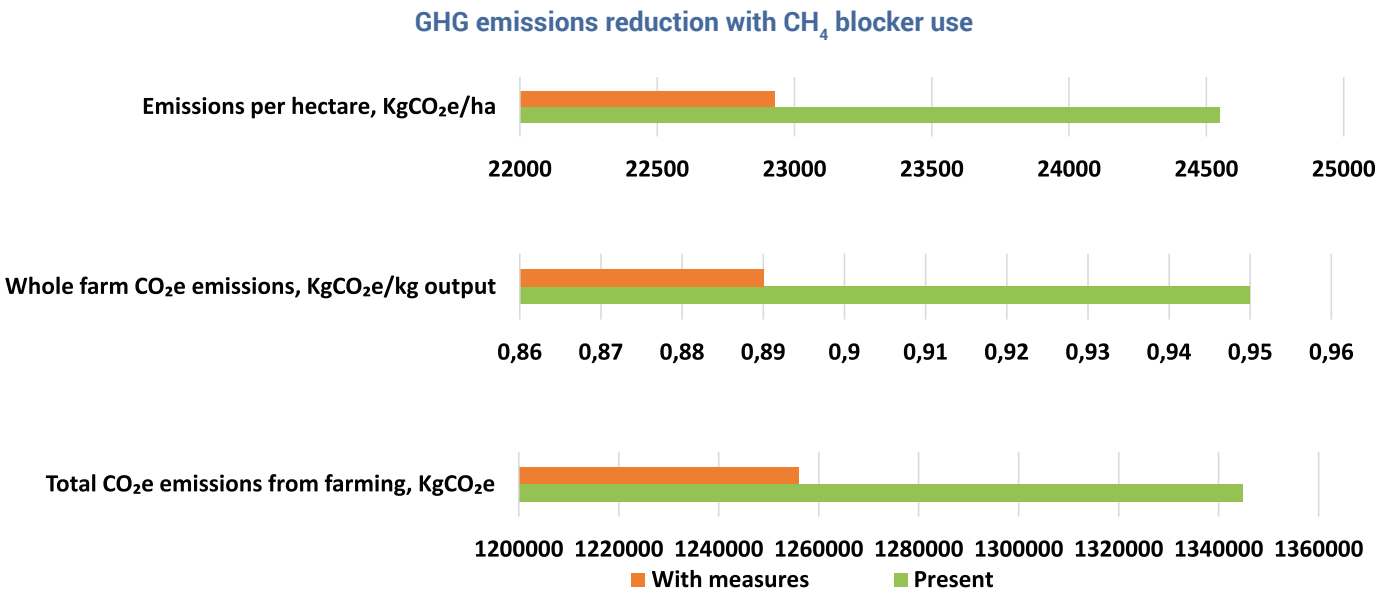
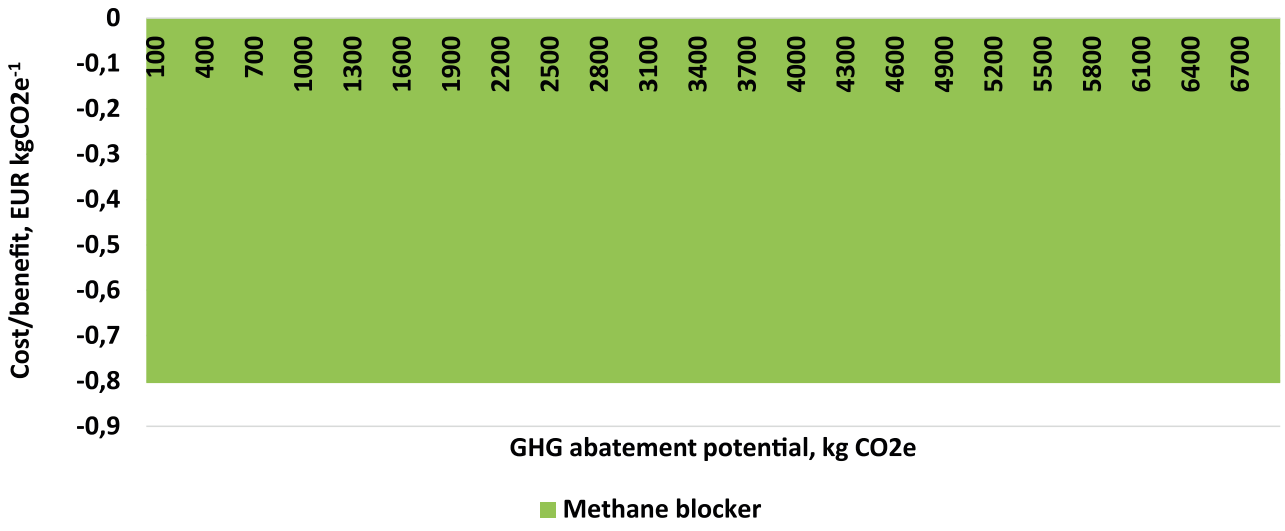
8. Table: Farm NL_8 emissions calculations results with Agrecalc tool



9. Economics: MACC curve NL_8 with simulated measure




Farm practice


Longevity cows: all > 100.000 kg milk

Scotland

1. Description of farmers' future strategy on development of farm and reduction of emissions

Timings of manures and fertiliser.
More precision in breeding – a more elite milking animal.
More sustainable less susceptible to disease more efficiency.

2. Which mitigation measures / practices were already taken?

Reduce inorganic fertiliser use

Growing of crops to reduce concentrate purchases

Increased use of organic fertilisers with cereals (Whole crop and maize)

Less losses from the herd

3. Which mitigation measures are planned to be implemented and how?

Covering solid slurry storage.
Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

Renewable energy production (RES) at farm.
The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

4. Expected effects on emissions (based on tool calculations)

Covering solid slurry storage.
Reduction of methane is expected to be 47% and reduction of ammonia 80%.

Renewable energy production (RES) at farm.
The measure envisages placing 50 kW solar panels on the farm, which will produce 40,753 kWh of electricity.

5. Equipment involved, investment and economic

Covering solid slurry storage.
Covering solid manure ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 222 per year. The burning of solid manure costs EUR 607.

Renewable energy production (RES) at farm.
The investment for the purchase and assembly of the panels is EUR 50,000 and the service life is 20 years. The value of the produced electricity (price 0.08 EUR kWh-1) is 3260 EUR per year.

6. Attention points when implementing measures

Covering solid slurry storage.
Need direct injection or band spreading to be used with slurry application to maximize effects.

Renewable energy production (RES) at farm.
The solar panels service life.

7. Quote of farmer:

"useful – to think about other matters and the bigger picture"

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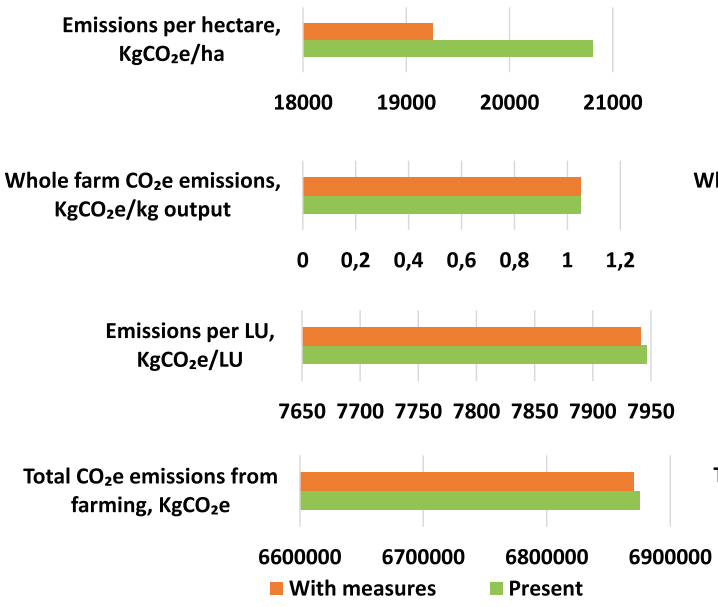
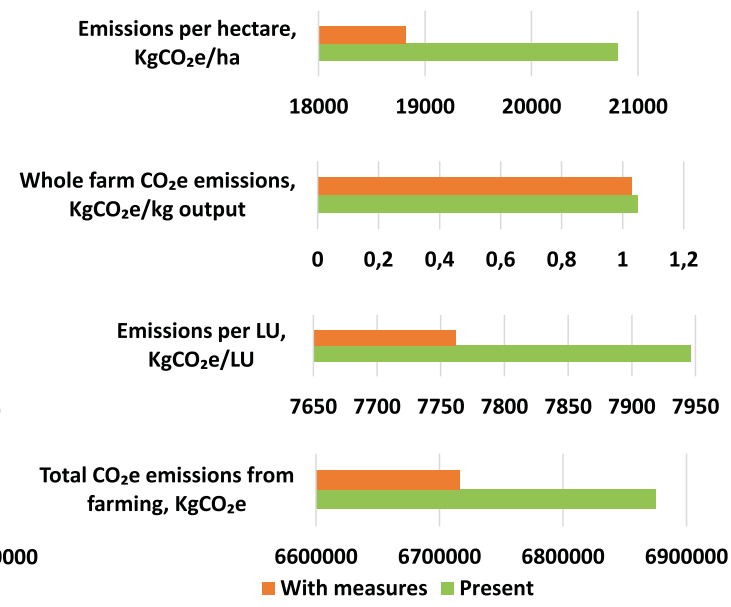
8. Table: Farm GB_1 emissions calculations results with Agrecalc tool

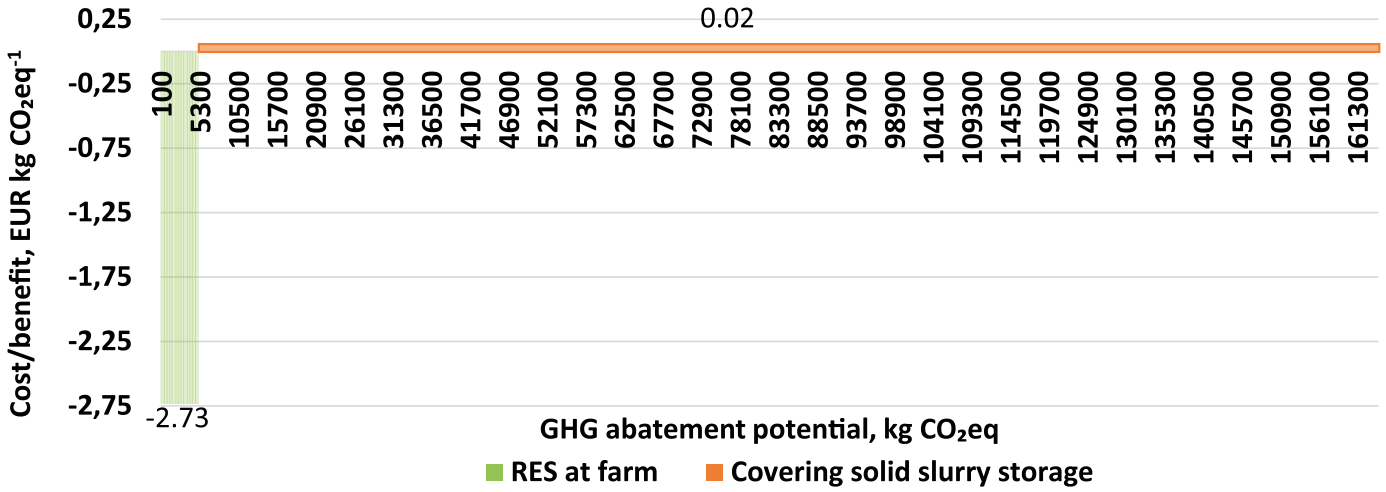
GHG emissions reduction with RES use



GHG emissions reduction with covering slurry



9. Economics: MACC curve SC_1 with all simulated measures



Picture resource: https://cometrenewables.ie/solar-pv-for-dairy-farms/

1. Description of farmers' future strategy on development of farm and reduction of emissions

Other alternative crops – beans (protein) home grown feeds to minimise concentrates.
Looking at better use of organic manure to reduce C footprint.

2. Which mitigation measures / practices were already taken?

- **Reduce herd mortality**
- **More precision in breeding**
- **Reduce inorganic fertiliser use**
- **Reduce fuel consumption**

3. Which mitigation measures are planned to be implemented and how?

- **Growing more on farm protein i.e. beans and legumes.**
- **Increase feed efficiency.**
- **Use of N2 plant to capture GHG losses and enhance N content of slurry.**
- **Introduction of an AD plant.**

4. Expected effects on emissions (based on tool calculations)

Use of probiotics in the barn.
The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

Methane blocker as feed additive.
Enteric methane blocker purchase and precision distribution to reduction CH_4.

5. Equipment involved, investment and economic

Use of probiotics in the barn.
The cost of probiotic supplements is EUR 889. Additional work for the workers and the preparation of feeding plan 512 EUR per year. At the same time, feed quality improvements provide EUR 11,870 feed cost savings.

Methane blocker as feed additive.
The measure is easy to implement, but requires the purchase of a methane blocker EUR 18,834. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself.

6. Attention points when implementing measures

It is difficult to express the expected effects financially

7. Quote of farmer:

"collectively working together and benchmarking ideas and emission reductions would help overall"

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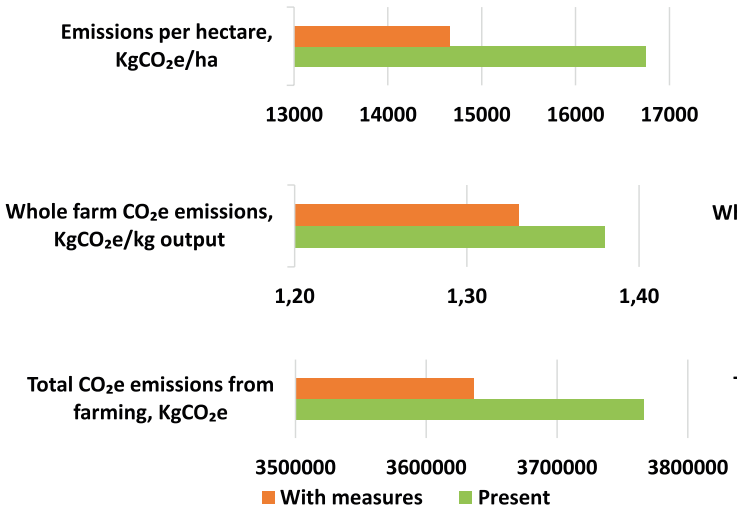
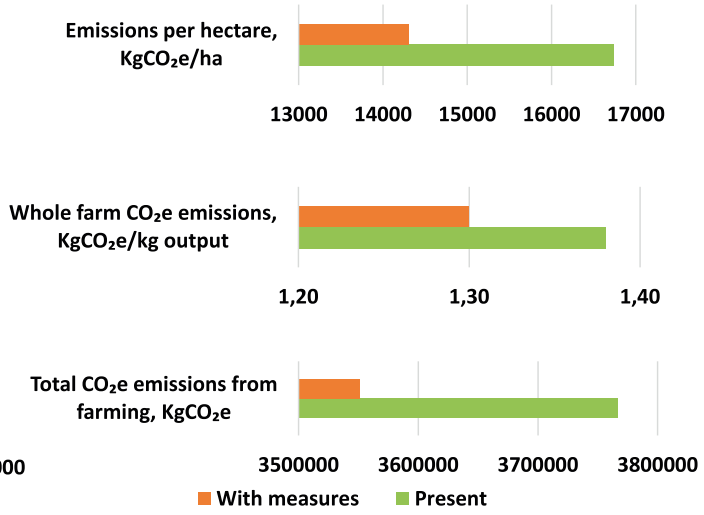
8. Table: Farm GB_2 emissions calculations results with Agrecalc tool

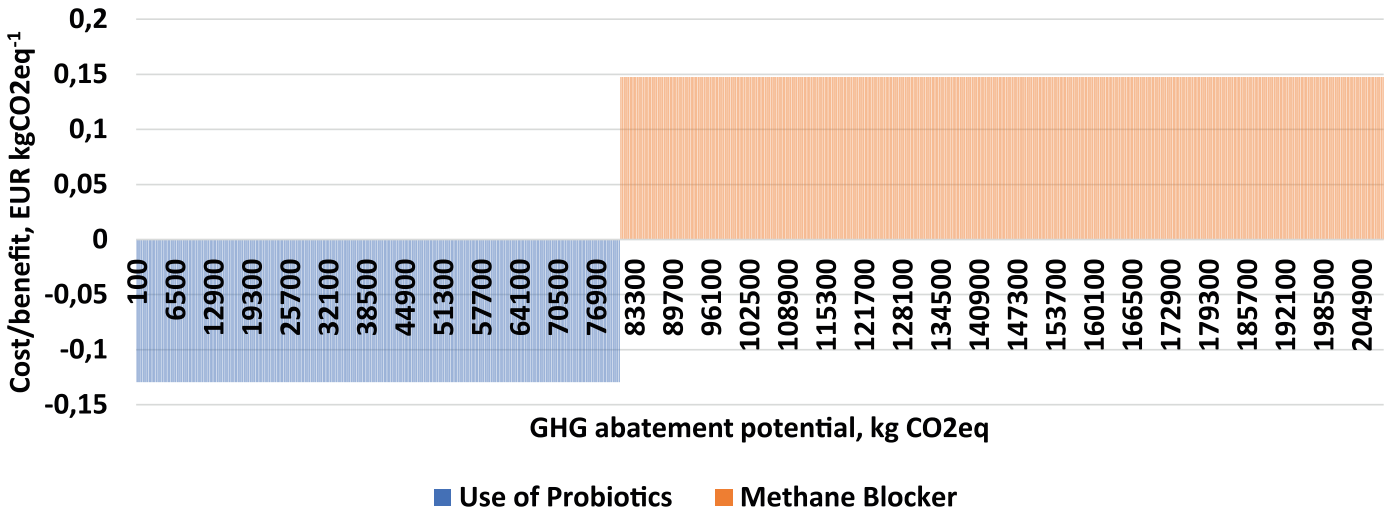
GHG emissions reduction with probiotics use



GHG emissions reduction with methane blocker use



9. Economics: MACC curve GB_2 with all simulated measures




Farm practice

1. Description of farmers' future strategy on development of farm and reduction of emissions

Changes to be more efficient and hence more profitable as:

– Buying a slurry separator to use more efficient the slurry and manure, for example, dried manure material for bedding

– More sensor tags implemented to the herd to monitor and better control of animal health

2. Which mitigation measures / practices were already taken?

Use of sex-semen heifers to control unwanted dairy herd/ male calves

Changed the slurry spraying system to tube/bar and injection systems

Adopted a brassica-forage system to feed the heifer herd outside during the winter

Reduced use of soya

3. Which mitigation measures are planned to be implemented and how?

Methane blocker as feed additive.

The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

Use of probiotics in the barn.

Reduce imported concentrates and produce more on farm.

Covered slurry tanks to reduce losses.

Renewable energy production (RES) at farm.

Use of more renewable energy to reduce overall farm costs.

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.

Enteric methane blocker purchase and precision distribution to reduction CH.

Mechanical manure separation.

The saved N in manure allows to reduce the use of urea by 5,663 EUR per year. The measure does affect also the reduction of GHG emissions (241,445 kg CO2eq).

5. Equipment involved, investment and economic

Methane blocker as feed additive.

The measure is easy to implement but requires the purchase of a methane blocker EUR 40,807. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself. The measure does not affect ammonia emissions but ensures the reduction of GHG emissions (796,141 kg CO2eq).

Mechanical manure seperation.

For mechanical manure separation, a separator (EUR 43,320) is required, as well as the construction of an additional pool for liquid (EUR 20,000). Electricity required for the operation of the separator (EUR 7048 per year), as well as maintenance and operating costs (EUR 866 per year).

7. Quote of farmer:

"Research needs to address efficiency that allows farmers to be financially stronger…able to implement changes… use innovating technologies to reduce the greenhouse gas or ammonia emissions"

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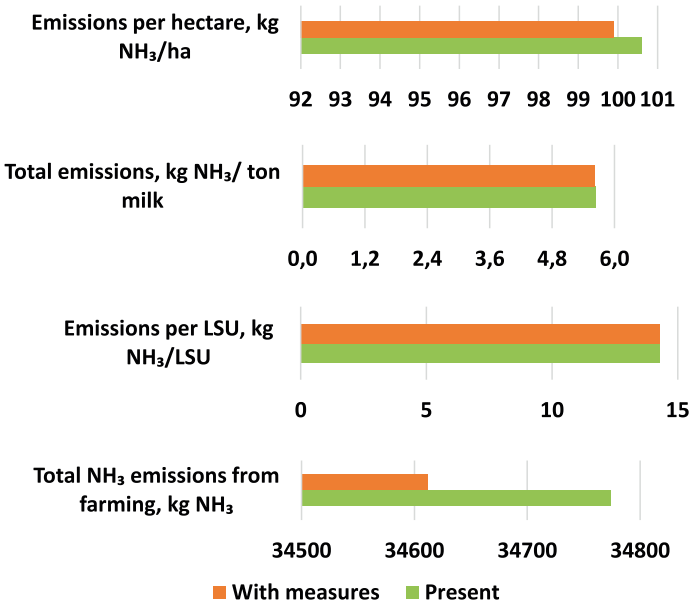
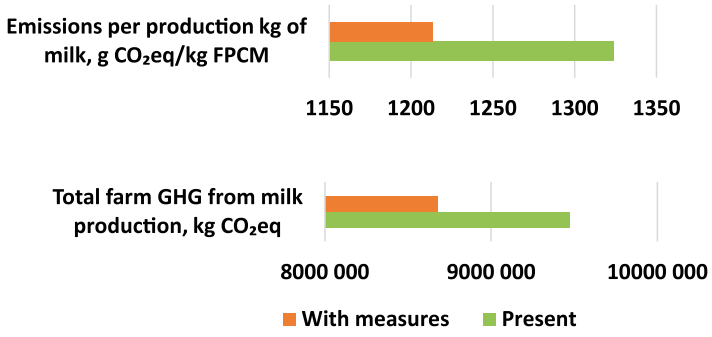
8. Table: Farm GB_3 emissions results calculations results with ANCA tool

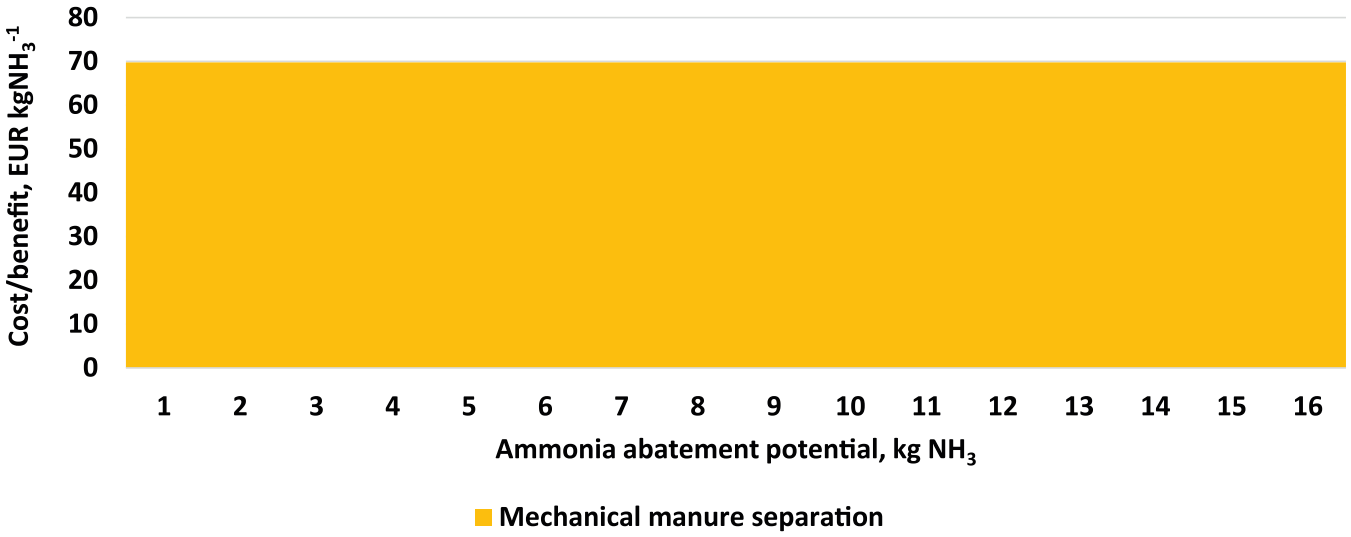
NH_3 emission reduction with manure separation



CO_2e emissions reduction with methane inhibitor use



9. Economics: MACC curve GB_3 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

We are considering having a Carbon audit/carbon footprint for the farm that will allow us to take the decisions about what needs to be changed in order to reduce the greenhouse gas emissions from the farm. Use of anaerobic digestion (AD) on the farm.

2. Which mitigation measures / practices were already taken?

More efficient feeding

Installation of a biomass boiler

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.

Feed efficiency is improved through improved animal management (incl. health).

Renewable Energy use on farm.

The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

Energy saving equipment.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.

The realization of the event does not require significant investments.

Energy saving equipment.

The measure envisages changing the tiller tractor to a methane tractor, as well as reducing tillage.

5. Equipment involved, investment and economic

Increase feed efficiency.

Significant changes in farming, which provide for the preparation of feed plans (88 EUR per year), additional work for the distribution of feed to workers (358 EUR per year). At the same time, changes in feed quality will improve cow welfare. However, it is difficult to express the expected effect financially.

Energy saving equipment.

Investments in technology are EUR 205,000. The measure makes it possible to significantly reduce fuel costs (EUR 16,204 per year), while pesticide costs increase (EUR 1,597) per year. Financial leasing rate 4%.

6. Attention points when implementing measures

Increase feed efficiency.

It is difficult to express the expected effect financially.

7. Quote of farmer:

"Very useful…to think about things related with greenhouses gases emission and the farm sustainability"

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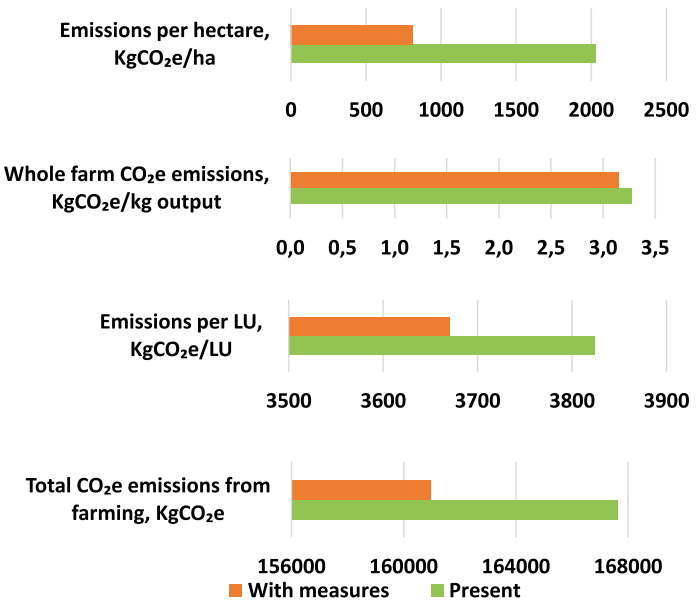
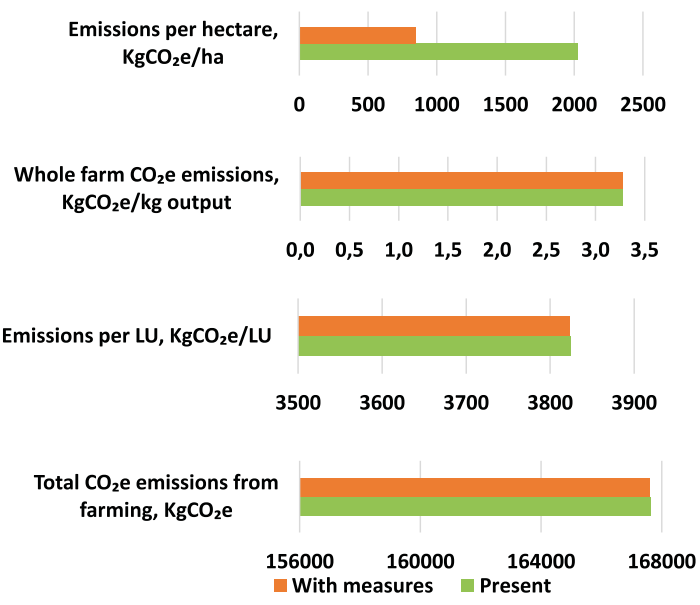
8. Table: Farm GB_4 emissions calculations results with Agrecalc tool

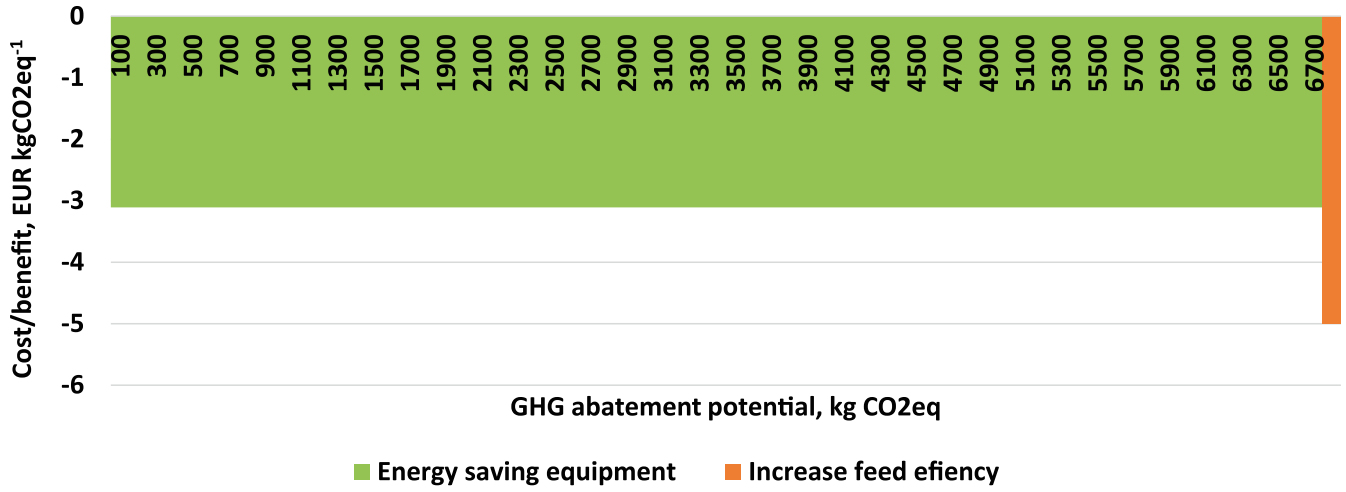
GHG emissions reduction with energy saving

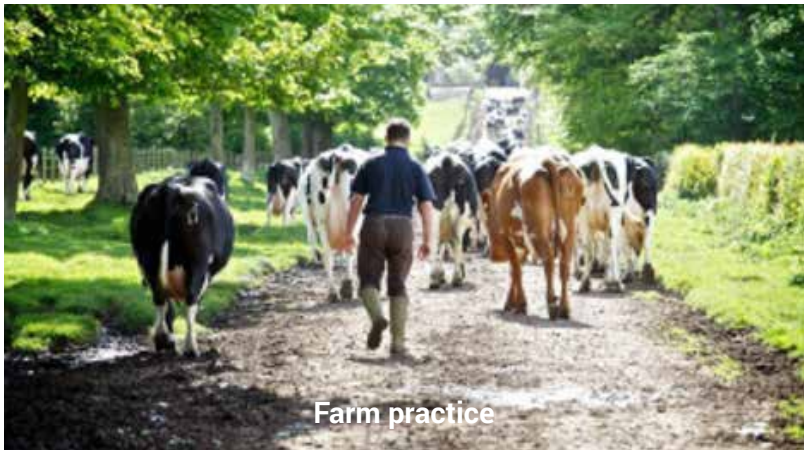


GHG emissions reduction with feed efficiency



9. Economics: MACC curve GB_4 with all simulated measures





1. Description of farmers' future strategy on development of farm and reduction of emissions

Investing in milk vending machines, to help supply local needs directly.

Opening of farm shop selling ice cream, yogurt and eggs to locals and visitors to reduce food miles.

Extension to the farm shop to sell more produce (bread and cheese, coffee, home baking) again to sustain local economy and reduce food miles.

2. Which mitigation measures / practices were already taken?

Reduce herd size

More efficient feeding

More clover in the swards

Reducing fuel use

3. Which mitigation measures are planned to be implemented and how?

Increased efficiency – grow more protein on farm.

High digestible diet.

Cover slurry tank to reduce losses.

Use more renewable energy.

4. Expected effects on emissions (based on tool calculations)

High digestible diet.

Measure suggest 4.25 ha moved to beans for protein increased reduce grass silage growing area.

RES at farm.

The measure envisages placing 50 kW solar panels and 50 kW wind turbines on the farm, which will produce 180,753 kWh of electricity.

5. Equipment involved, investment and economic

High digestible diet.

Measure suggest 4.25 ha moved to beans for protein increased reduce grass silage growing area. That mean additional costs of fuel and fertilisers – EUR 2280 per year. There are several strategies for using unused land sustainably, such as afforestation, which is supported by the UK government.

RES at farm.

The investment for the purchase and assembly of the panels and turbines is EUR 240,000 and the service life is 20 years for solar photovoltaic and 25 years for wind turbines. Operational costs are EAR 4,000 per year. The value of the produced electricity is 28,460 EUR per year.

7. Quote of farmer:

"Move forward by communicating different ideas or what works best and what doesn't work so well"

6. Attention points when implementing measures

It is difficult to express the expected effects financially.

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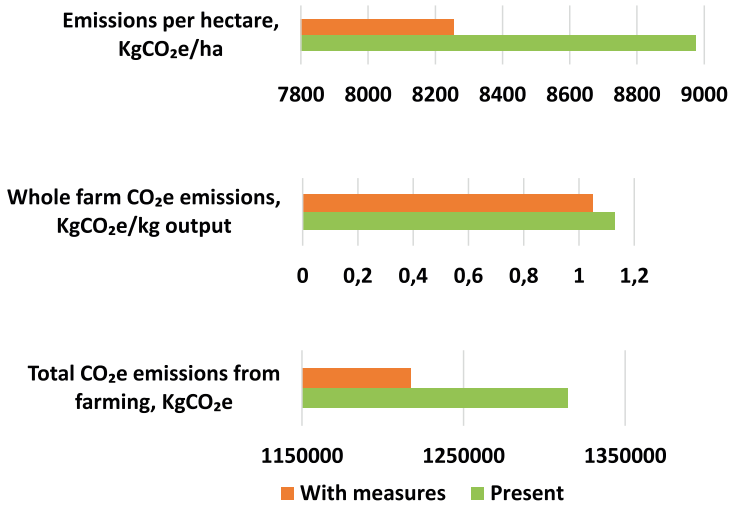
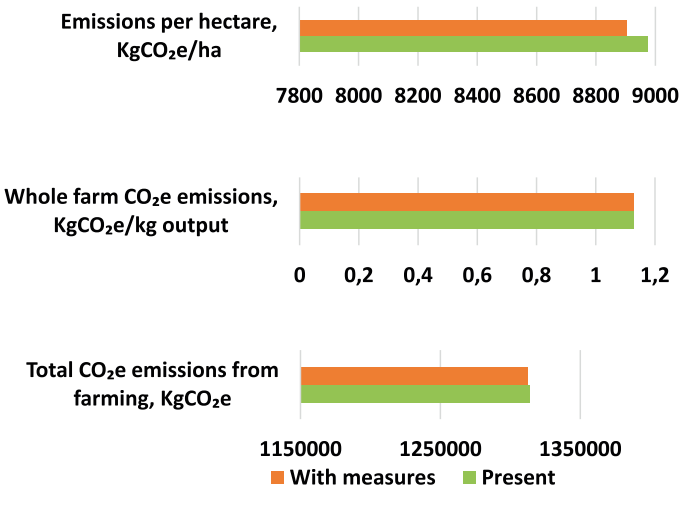
8. Table: Farm GB_5 emissions calculations results with Agrecalc tool

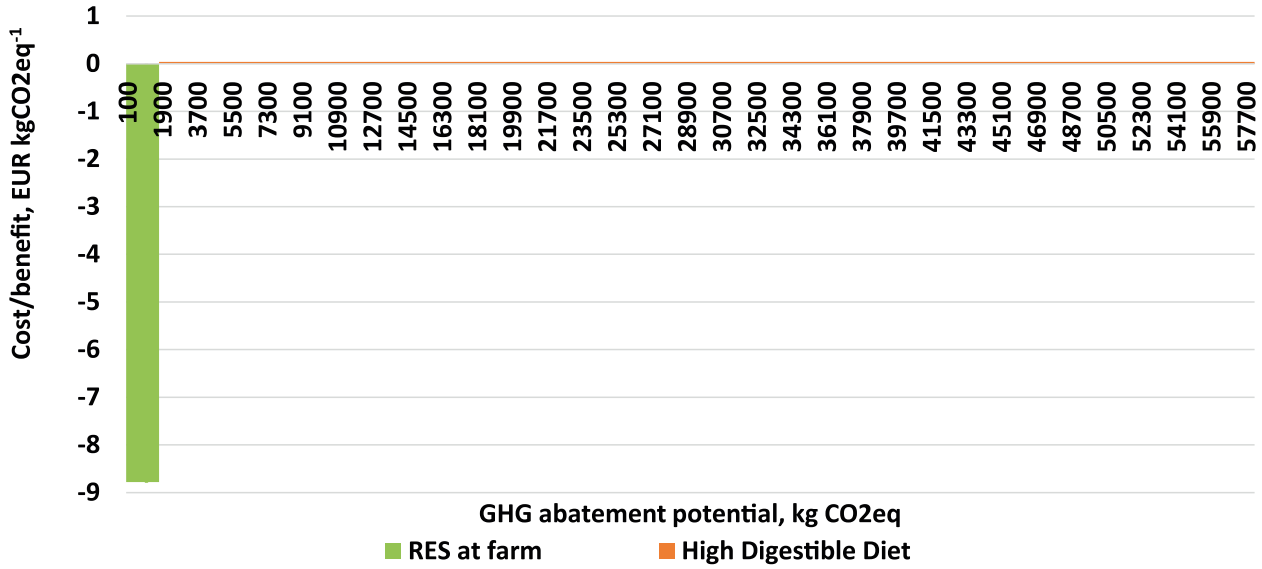
Emission reduction with high digestible diet use



GHG emission reduction with RES use



9. Economics: MACC curve GB_5 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Increase grass productivity.

Improve both the quantity and quality of the grass to improve feed conversion.

2. Which mitigation measures / practices were already taken?

More clover in grass swards and herbal lays

More precision application of fertilisers

Energy saving equipment

Invested in solar and wind generation

3. Which mitigation measures are planned to be implemented and how?

Use of methane blocker (additive).

The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

Covering solid slurry storage.

Use of renewable energy – methane from covered slurry tanks. Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.

Enteric methane blocker purchase and precision distribution to reduction CH_4.

Covering solid slurry storage.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

5. Equipment involved, investment and economic

Methane blocker as feed additive.

The measure is easy to implement, but requires the purchase of a methane blocker EUR 74,825. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself.

Covering solid slurry storage.

Covering 51,410 t of manure with covering material cost EUR 15,500, that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 118,449 per year. Lifetime of covering material 7 years.

6. Attention points when implementing measures

It is difficult to express the expected effects financially

7. Quote of farmer:

"Role for environmental co-op for collaboration between farmers to introduce climate change reduction locally"

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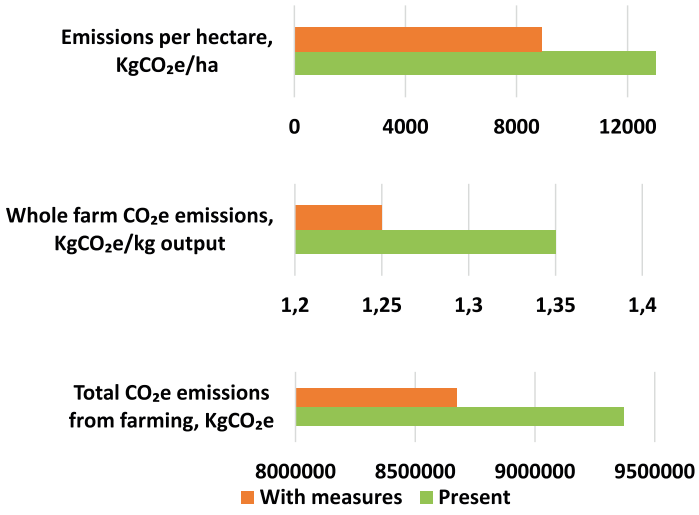
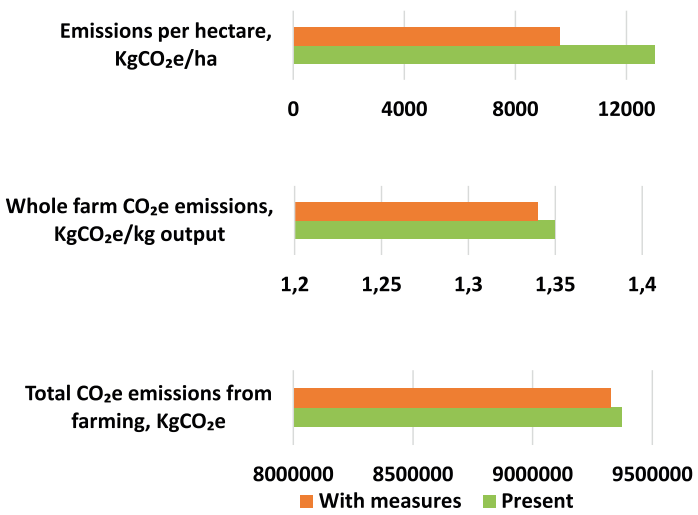
8. Table: Farm GB_6 emissions calculations results with Agrecalc tool

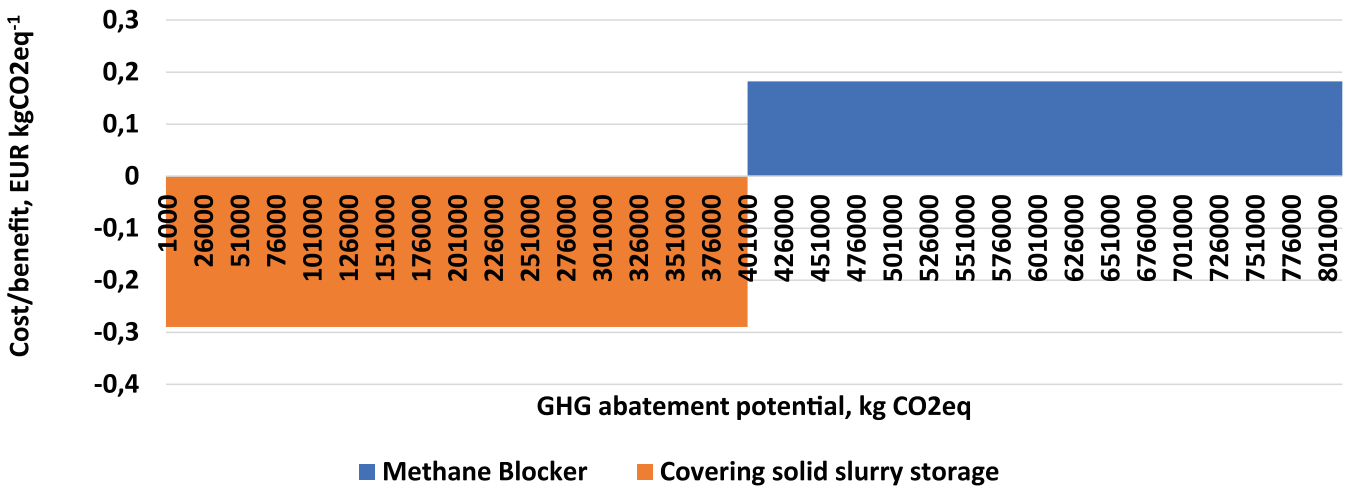
GHG emissions reduction with methane blocker use



GHG emissions reduction with covering slurry storage



9. Economics: MACC curve GB_6 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Moved to cheese production, Small volume high value product – high premium.
Increase cow numbers (up to 30). Trying to calf at 2 years old
Change to twice a day milking. More solar panels – depending on battery storage.
Plant up steep sided streams with trees to offset C footprint.

2. Which mitigation measures / practices were already taken?

Reducing calving age

Produces cheese on farm

Tree planting

Use of renewable energy (solar panels)

3. Which mitigation measures are planned to be implemented and how?

Methane blocker as feed additive.

The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

Wind turbine to use more clean energy.

Renewable energy production (RES) at farm.

The purpose of the measure is the production of renewable energy on the farm by installing solar panels.

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.

Enteric methane blocker purchase and precision distribution to reduction CH.

Renewable energy production (RES) at farm.

The measure envisages placing 50 kW solar panels and 50 kW wind turbines on the farm, which will produce 180,753 kWh of electricity.

5. Equipment involved, investment and economic

Methane blocker as feed additive.

The measure is easy to implement, but requires the purchase of a methane blocker EUR 2,044. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself.

Renewable energy production (RES) at farm.

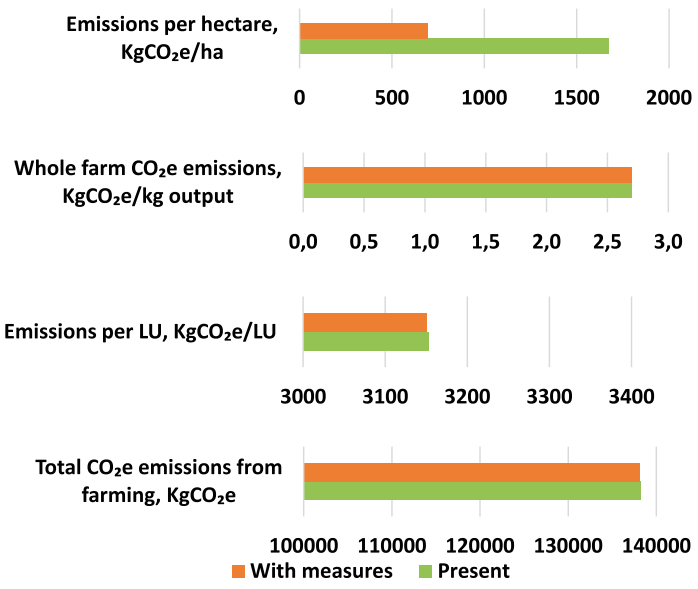
The investment for the purchase and assembly of the panels and turbines is EUR 240,000 and the service life is 20 years for solar photovoltaic and 25 years for wind turbines. Operational costs are EAR 4,000 per year. The value of the produced electricity is 28,460 EUR per year.

7. Quote of farmer:

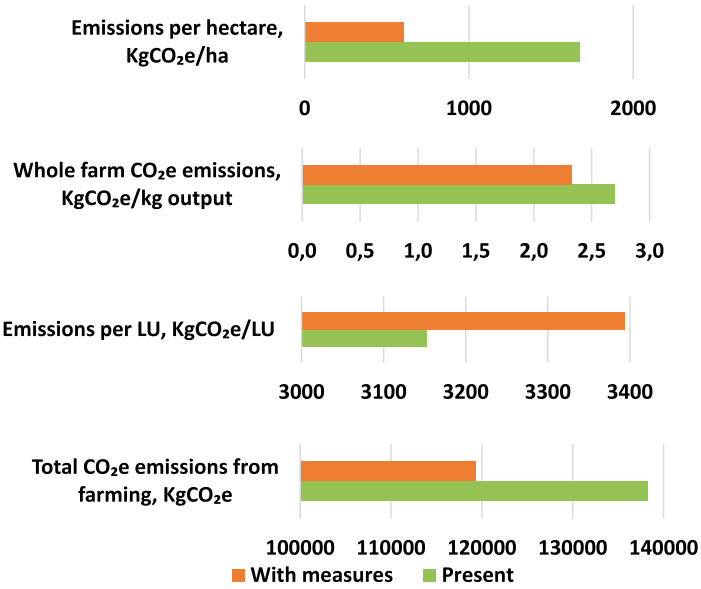
"Need more positive attitudes fueled by the press and news but everyone needs to play their part"

8. Table: Farm GB_7 emissions calculations results with Agrecalc tool

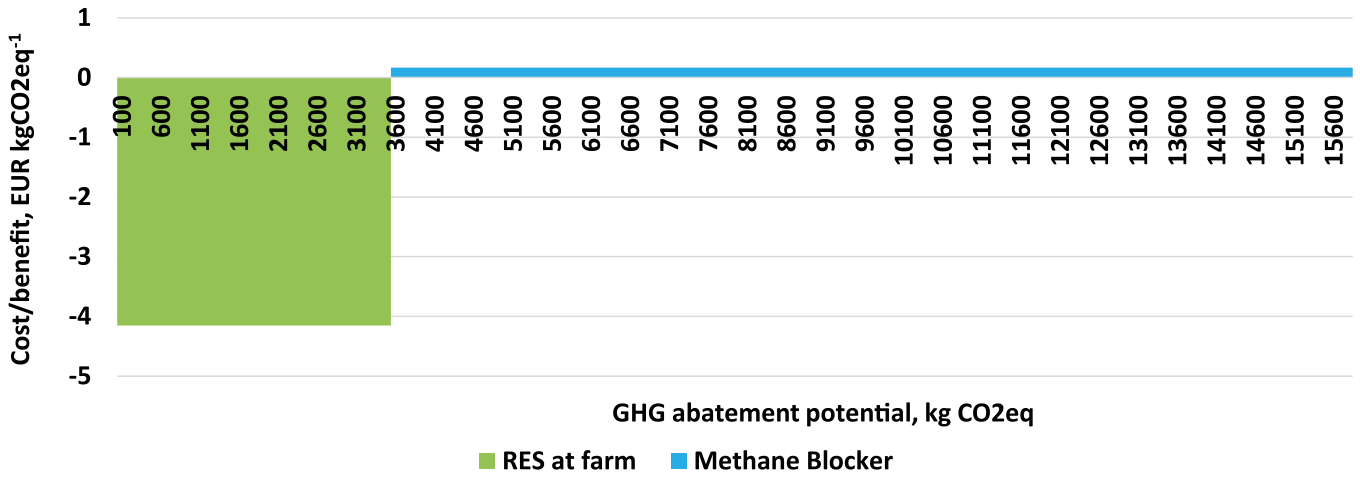
GHG emissions reduction with RES use

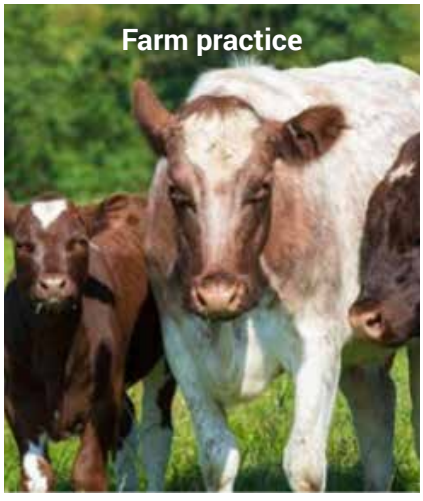


GHG emissions reduction with CH blocker use



9. Economics: MACC curve GB_7 with all simulated measures





1. Description of farmers' future strategy on development of farm and reduction of emissions

Stopped buying in replacements now from within herd - more efficiency. Sexed semen.
Now producing beef calf (700). Decreased electricity use. Improved forage yield

2. Which mitigation measures / practices were already taken?

Decreased inorganic fertilizer use

More precision use of organic fertilizer

Improved manure storage (covered)

Installed biomass burner (renewable energy use)

3. Which mitigation measures are planned to be implemented and how?

Cover crops for increased C sequestration.
The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

More legumes/protein grown on farm.
Reduce imported concentrates and produce more on farm.

Feeding methane inhibitor.

Mechanical manure separation.

Energy saving equipment.
More energy efficient.

4. Expected effects on emissions (based on tool calculations)

Feeding methane inhibitor.
Enteric methane blocker purchase and precision distribution to reduction CH.

Mechanical manure separation.
The saved N in manure allows to reduce the use of urea by 5,663 EUR per year. The measure does affect also the reduction of GHG emissions (241,445 kg CO2eq)..

5. Equipment involved, investment and economic

Feeding methane inhibitor.
The measure is easy to implement, but requires the purchase of a methane blocker EUR 66,065. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself. The measure does not affect ammonia emissions.

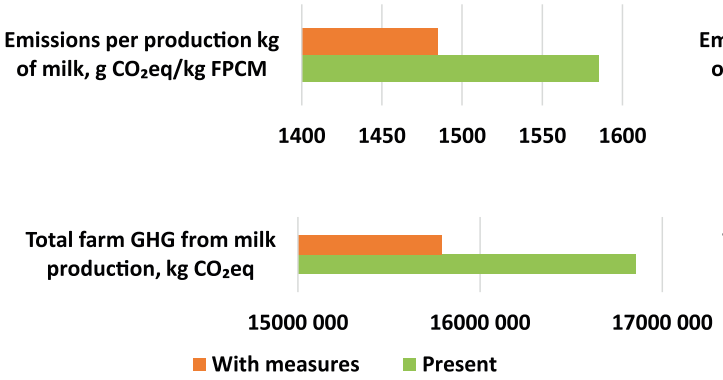
Mechanical manure seperation.
For mechanical manure separation, a separator (EUR 43,320) is required, as well as the construction of an additional pool for liquid (EUR 20,000). Electricity required for the operation of the separator (EUR 7048 per year), as well as maintenance and operating costs (EUR 866 per year). At the same time, the saved N in manure allows to reduce the use of urea by 32,500 EUR per year. The measure does not affect ammonia emissions.

7. Quote of farmer:

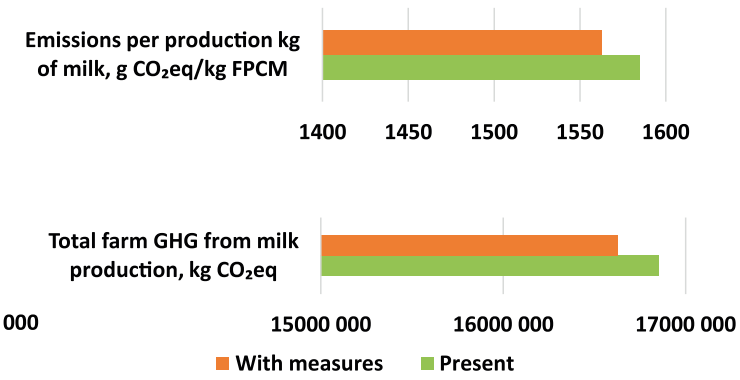
"Bench marking group to help benchmark climate change efficiencies would be useful"

8. Table: Farm GB_8 emissions calculations results with ANCA tool

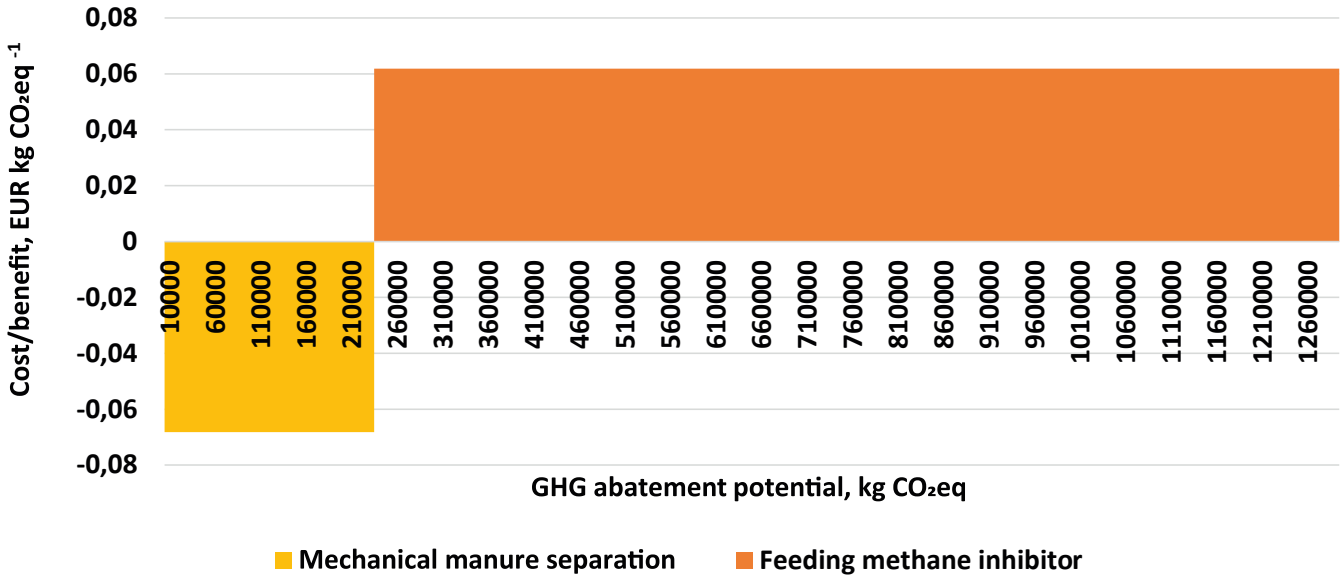
CO_2 emissions reduction with feed methane inhibitor



CO_2 emissions reduction with manure separation



9. Economics: MACC curve GB_8 with all simulated measures



Poland

1. Description of farmers' future strategy on development of farm and reduction of emissions

Recently, tools regulating the management of both natural fertilizers (of which the farm produces a lot - mainly manure) and artificial fertilizers have been introduced to a greater extent. Shift towards more sustainable production. However, mechanisms supporting such activities are still lacking. As a family farm, we need both substantive and financial support to introduce more sustainable tools that have a positive impact on the environment. The farm delivers milk to the local dairy, where consumers are increasingly interested in buying sustainable dairy products, which motivates us as producers to care for the environment. Thus, in the future, we plan a more conscious and sustainable production that cares for animals and the soil on which future dietary components for our animals is grown.

2. Which mitigation measures / practices were already taken?

Improved herd longevity

Improvement of the nutritional value of the silage prepared on the farm

Better manure management in the context of the current crisis

- **Photovoltaic panels and energy storage**
- **Use of heat recovery systems to heat water for washing the milking parlor**

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.

improving the nutritional value of silages (less NDF).

Methane blocker as feed additive.

RES (solar energy) at farm.

Investing in batteries that store energy produced from photovoltaic panels for the night.

Energy saving equipment.

Purchase of a tractor that will consume less fuel for daily work, i.e. during preparing TMR for cattle

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.

Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Methane blocker as feed additive.

Enteric methane blocker purchase and precision distribution to reduction CH_4.

5. Equipment involved, investment and economic

Increase feed efficiency.

Significant changes in farming, reduced veterinary costs (135 EUR per year) and saved feed costs (180 EUR per year), in the same time, measure provide additional work for the distribution of feed to workers (900 EUR per year) and reseeding of grasslands to improve feed quality (3,315 EUR per year).

Methane blocker as feed additive.

The measure is easy to implement, but requires the purchase of a methane blocker (EUR 4,320). There is no evidence of significant changes in productivity that would affect income, except for the increase in milk fat content (EUR 2,280), nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself. The measure does not affect ammonia emissions, but ensures the reduction of GHG emissions (73,057 kg CO_2eq).

6. Attention points when implementing measures

Increase feed efficiency.

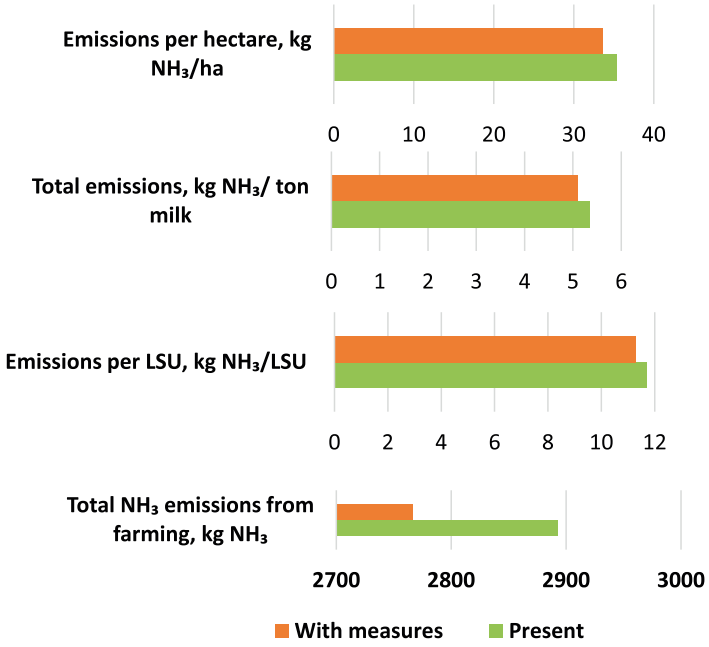
It is difficult to express the expected effect financially.

7. Quote of farmer:

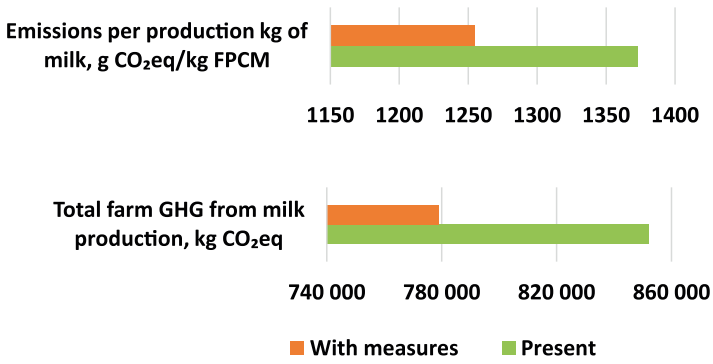
"The current prices of milk (lower by about 50 groszy per kilogram compared to last year) and the current prices of some feed components make it difficult to invest in modern technologies that take into account environmental protection"

8. Table: Farm PL_1 emissions calculations results with ANCA tool

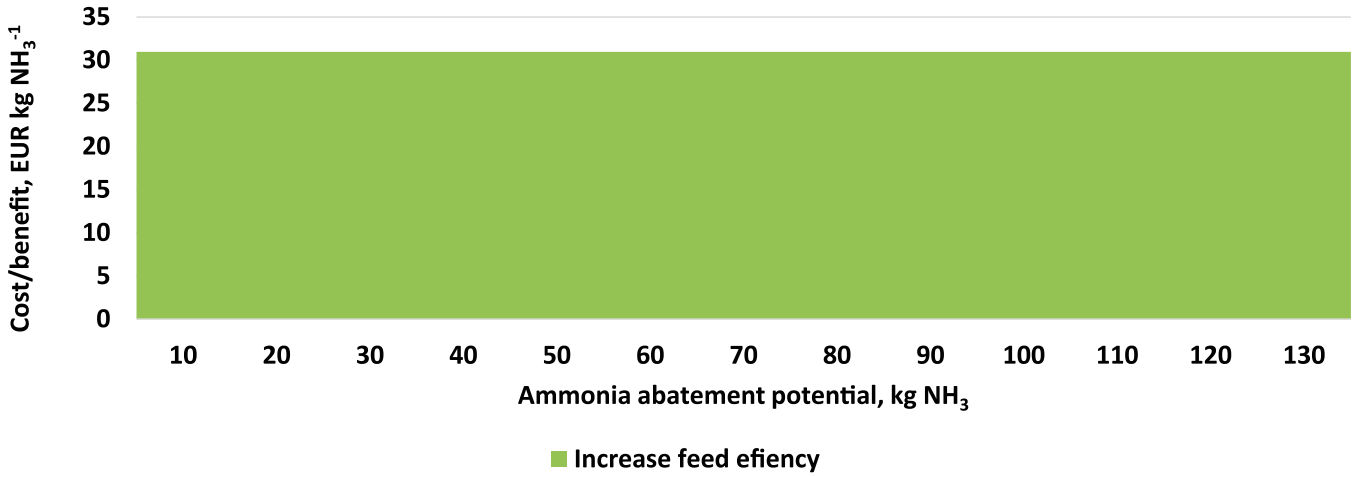
NH_3 Emission reduction with improve feed efficiency



GHG emission reduction with CH_4 inhibitor feed



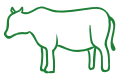
9. Economics: MACC curve PL_1 with simulated measure



1. Description of farmers' future strategy on development of farm and reduction of emissions

In the current situation in Poland, little attention is still paid to the impact of animal production on the environment. However, the economic situation itself (significant increase in the prices of electricity and costs of production) forces us to look for alternative sources of savings, i.e., the installation of photovoltaic panels. The farm has the 9th productivity in Europe (over 17,000 kg of milk) and is working on maintaining and improving animal welfare. The farm focuses on ad hoc activities. Thinking about the robotization of the milking process – so far not profitable due to high efficiency, there would be 40 dairy cows per milking robot. Reducing the use of artificial fertilizers on the farm.

2. Which mitigation measures / practices were already taken?



Improved herd longevity

Precision farming

Applying novelties in the market to use more sustainable, local products

Rumi Gold – wheat grain-based feed

Photovoltaic panels and energy storage

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency

improving the nutritional value of silages (less NDF)

Improvement of the longevity of cows

Improvement of the longevity of cows extending the low number of lactations (1.8) to the value of 2.5, while maintaining the current average milk yield (17.000 kg)

Methane blocker as feed additive.

Covering manure storage.

Installation of photovoltaic panels and energy storage.

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.

Reduce the energy per cow by 5 to 10%. The assumption is made that less feed is needed for the same amount of milk produced.

Covering manure storage.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

5. Equipment involved, investment and economic

Increase feed efficiency.

The realization of the event does not require significant investments. Significant changes in farming, reduced veterinary costs (295 EUR per year) and saved feed costs (180 EUR per year), in the same time, measure provide additional work for the distribution of feed to workers (900 EUR per year) and reseeding of grasslands to improve feed quality (975 EUR per year).

Covering manure storage.

Covering 1,840 t of manure with covering material cost EUR 5,518 that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 3,054 per year. Lifetime of covering material 7 years. The measure does affect also the reduction of GHG emissions (684 kg CO2eq).

6. Attention points when implementing measures

Increase feed efficiency.

It is difficult to express the expected effect financially.

7. Quote of farmer:

"Increasing the longevity and health of cows is one of the key to the economic success"

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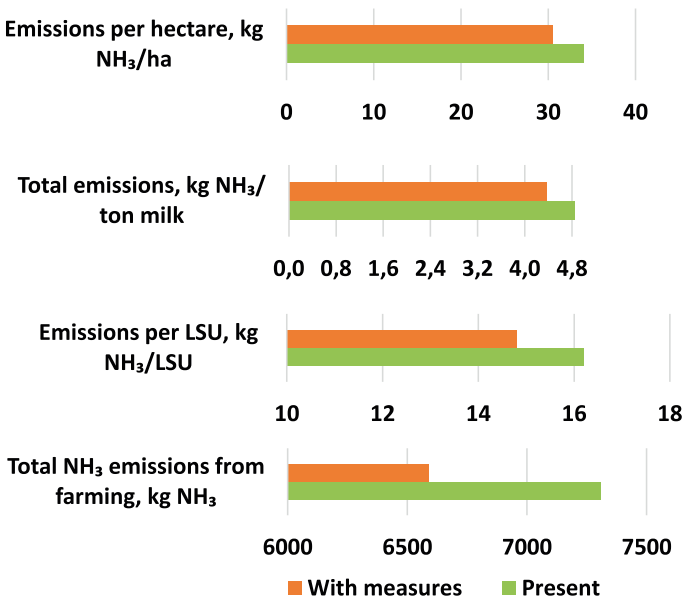
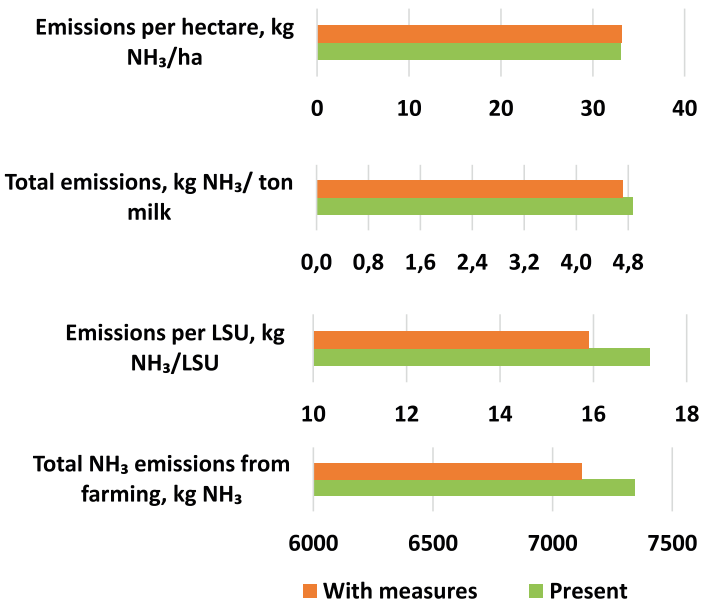
8. Table: Farm PL_2 emissions calculations results with ANCA tool

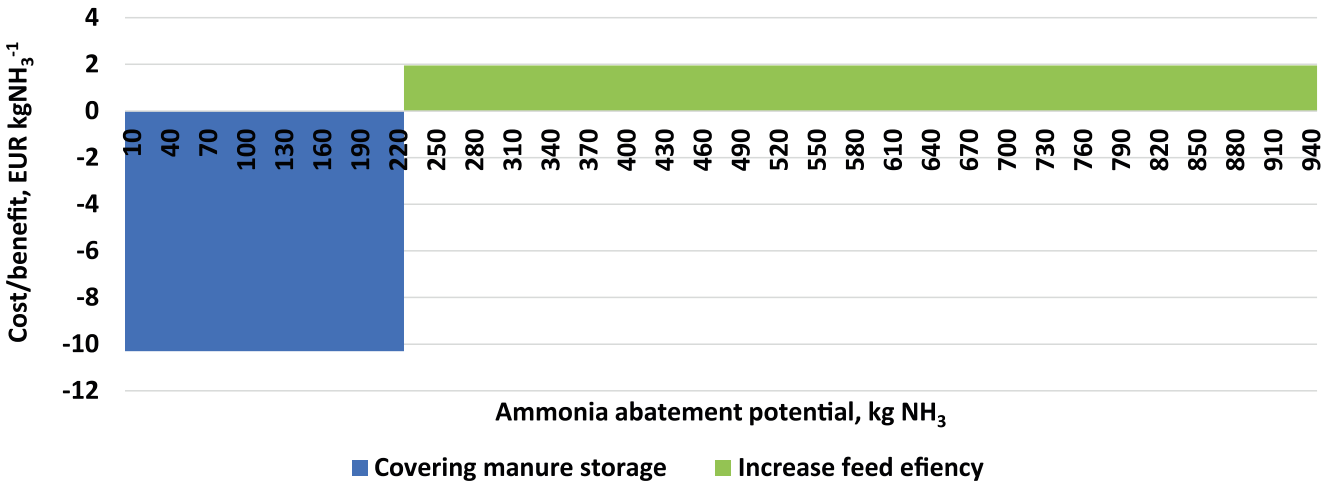
Emission reduction with improve feed efficiency



Emission reduction with cover manure storage



9. Economics: MACC curve PL_2 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

The farm focuses on new, automated technologies for the production and management of a herd of dairy cows. Keeping animals on slats is a challenge in terms of the environment, although we do/use separation in bedding. We are thinking about acidifying slurry to reduce ammonia emissions, but we know that in the Netherlands farmers with similar farms are introducing other low-emission solutions (toilets for cows). Unfortunately, these are very cost-intensive solutions. Therefore, a comprehensive approach should be taken to issues related to the environment and broadly understood agricultural production. Both substantive and financial support is required.

2. Which mitigation measures / practices were already taken?

Increasing the health and welfare of animals to increase the number of lactations in the herd

Better feed quality, both forage and concentrate

Application of the precise feeding and herd management

- **Soil application of slurry**
- **Use of a separator for beds**

Investment in photovoltaic panels

3. Which mitigation measures are planned to be implemented and how?

Methane blocker as feed additive.

The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

Acidification of manure.

The main goal is to reduce nitrogen losses during manure storage and application to the soil

Construction of a biogas plant.

Precise fertilization of fields.

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.

Enteric methane blocker purchase and precision distribution to reduction CH_4.

Acidification of manure.

The measure is relatively complex but provides a significant GHG reduction effect.

5. Equipment involved, investment and economic

Methane blocker as feed additive.

The measure is easy to implement, but requires the purchase of a methane blocker EUR 10 400. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself.

Acidification of manure.

Manure acidification requires equipment EUR 50,000 (for 7 years), as well as sulphuric acid EUR 61,992. Generally, soil liming requires EUR 55,296. At the same time, the N stored in manure results in a benefit of EUR 16,589, which makes the measure cost-neutral.

6. Attention points when implementing measures

It is difficult to express the expected effects financially.

7. Quote of farmer:

"As breeders, we are aware of the growing role of sustainable agriculture, but the question remains whether we can afford it and to whom the products obtained from this type of production will ultimately be dedicated"

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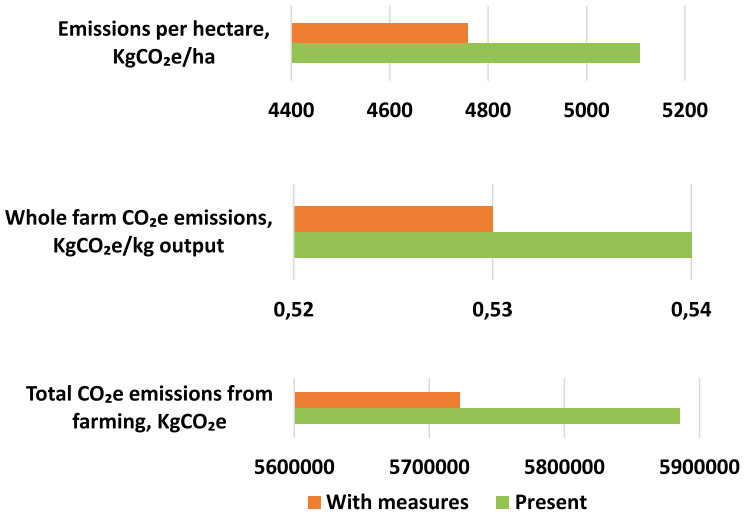
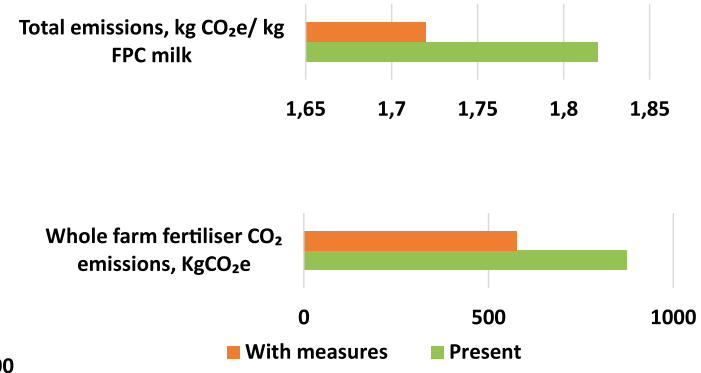
8. Table: Farm PL_3 emissions calculations results with Agrecalc tool

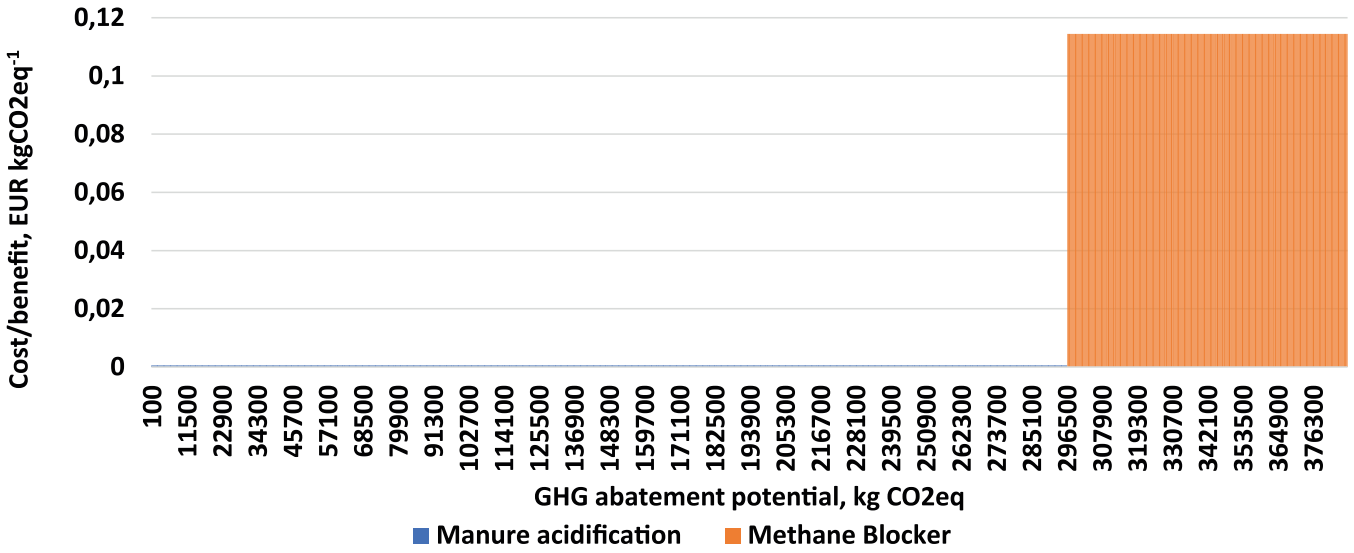
GHG emissions reduction with CH_4 blocker use



Emission reduction with manure acidification



9. Economics: MACC curve PL_3 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

The farm, both in animal and plant production, has been pursuing a policy of care for the environment for many years. This is important, in terms of public opinion, as a farm has over 2,500 animals and is located near a medium-sized city. The farm has a very open policy, focusing on modern and innovative solutions.

2. Which mitigation measures / practices were already taken?

Improvement of longevity and health of cows

Improvement of nutrient utilization by animals (genetic program and selection of dietary components used)

Delivering liquid manure in the future the after-fermentation product directly to the field

Precision farming (reduction of fertilization, examination of the amount of humus, the use of tracks with a larger span from 24 to 36 m to lower fuel consumption

Construction of a slurry biogas plant (power 44 kW) and photovoltaic panels

3. Which mitigation measures are planned to be implemented and how?

Methane blocker as feed additive.
The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

Increase feed efficiency.
Feed efficiency is improved through improved animal management (incl. health).

Biogas plant.
Construction of another three slurry biogas plants with a capacity of 44 kW each.

Increasing the number of lactations.
from 3.5 to 4.5 (genetic selection, improved health and welfare).

4. Expected effects on emissions (based on tool calculations)

Methane blocker as feed additive.
Enteric methane blocker purchase and precision distribution to reduction CH_4.

Increase feed efficiency.
The realization of the event does not require significant investments. Reduce the energy per cow by 5 to 10%. Feed efficiency VEM -5%, same production per cow.

5. Equipment involved, investment and economic

Methane blocker as feed additive.
The measure is easy to implement, but requires the purchase of a methane blocker EUR 114 960. There is no evidence of significant changes in productivity that would affect income, nor is there any evidence of significant changes in costs, except for the purchase of 3-NOP itself.

Increase feed efficiency.
Significant changes in farming, which provide for the reseeding of grasslands (9 750 EUR per year), additional work for the distribution of feed to workers (1 800 EUR per year). At the same time, changes in feed quality will improve cow welfare. The feed saving provides a benefit of EUR 3,240 and veterinary costs are reduced by EUR 3,593.

6. Attention points when implementing measures

It is difficult to express the expected effects financially

7. Quote of farmer:

"Even such large farms as Jarosławiec have to think about robotizing the process of obtaining milk"

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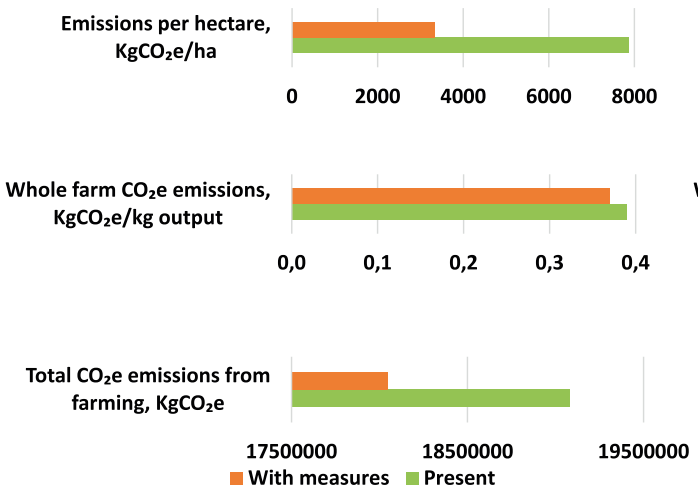
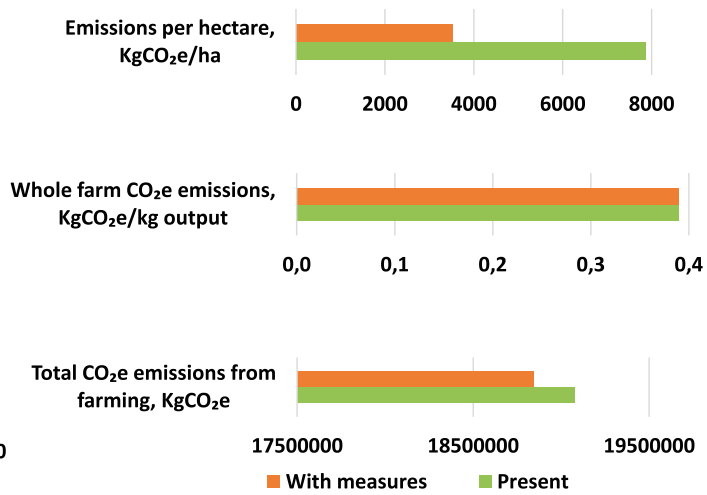
8. Table: Farm PL_4 emissions calculations results with Agrecalc tool

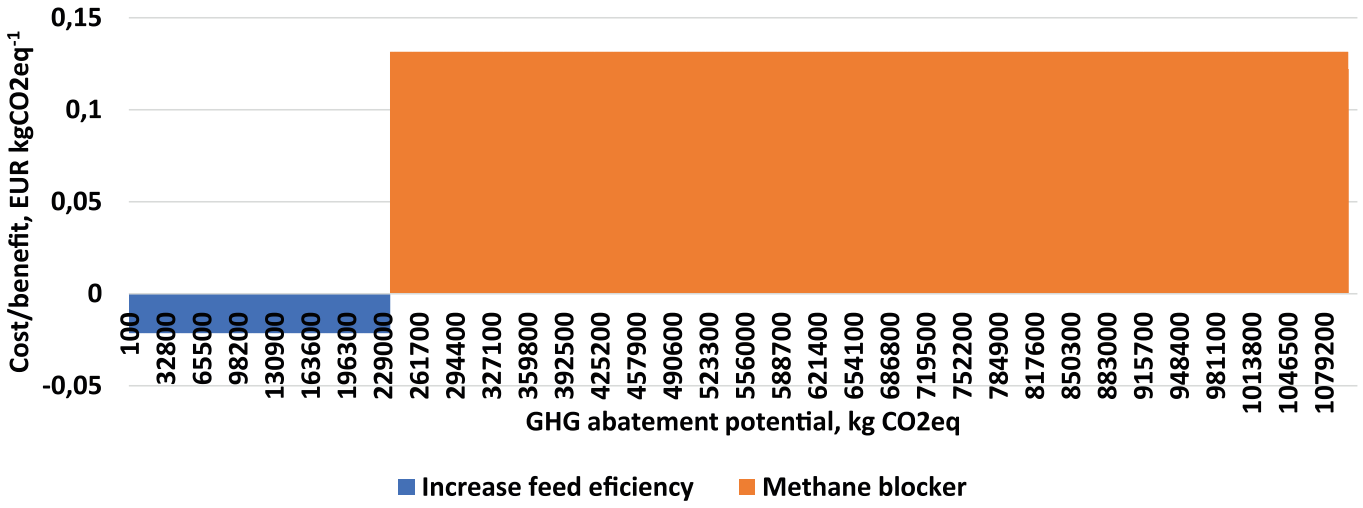
GHG emissions reduction with CH_4 blocker use



GHG emissions reduction with increase feed efficiency



9. Economics: MACC curve PL_4 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Cow maintenance technologies used on our farm require changes, but too small production (on average 10 dairy cows) does not allow us to do so. In addition, our successor, due to the small cultivation area and the captive system used in the barn, thinks about combining external work only with agricultural cultivation and not with dairy cattle breeding - thus it is difficult to think about future investments in limiting animal production on the environment. Currently, the farm still meets all the assumed environmental standards.

2. Which mitigation measures / practices were already taken?

Reducing the use of artificial fertilizers in field cultivation - the use of manure

Plowing after manure field application

Use of heat recovery systems to heat water for washing the milking system

3. Which mitigation measures are planned to be implemented and how?

Covering solid slurry storage.

Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

Increase feed efficiency.

Feed efficiency is improved through improved animal management (incl. health).

Maintaining the dairy production as long as the current owners have enough strength and the law allows it.

4. Expected effects on emissions (based on tool calculations)

Covering solid slurry storage.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

Increase feed efficiency.

The realization of the event does not require significant investments. Reduce the energy per cow by 5 to 10%. Feed efficiency VEM -5%, same production per cow.

5. Equipment involved, investment and economic

Covering solid slurry storage.

Covering 182 t of manure with covering material cost EUR 10 800, that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 419 per year. Lifetime of covering material 7 years.

Increase feed efficiency.

Significant changes in farming, which provide for the reseeding of grasslands - 780 EUR per year. At the same time, changes in feed quality will improve cow welfare. The feed saving and veterinary costs are reduction provides a benefit of EUR 49.

6. Attention points when implementing measures

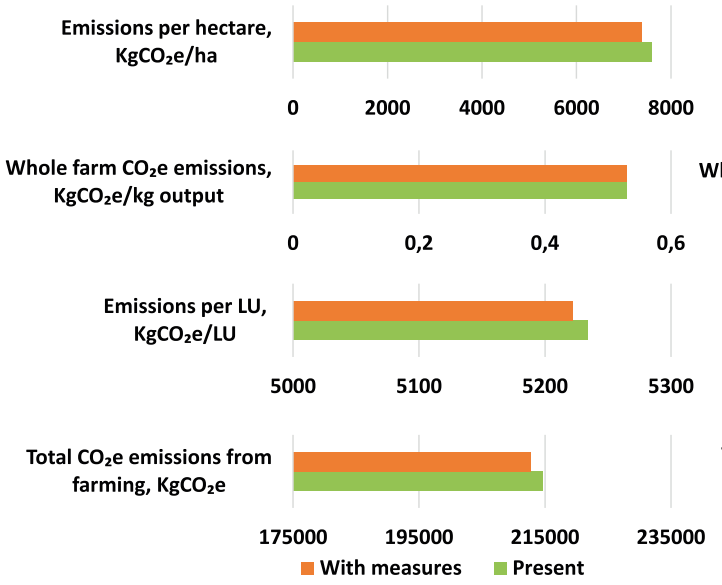
It is difficult to express the expected effects financially

7. Quote of farmer:

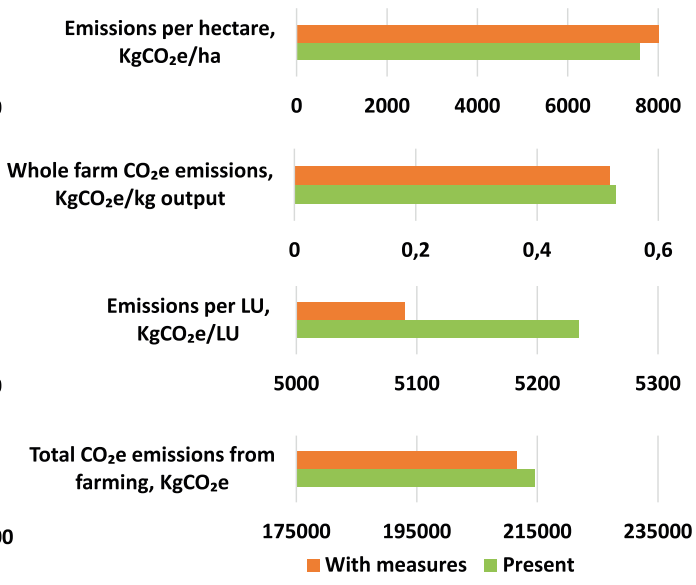
"The current scale of production and a large amount of manual work in animal handling lead to the decision to limit or stop milk production in the near future."

8. Table: Farm PL_5 emissions calculations results with Agrecalc tool

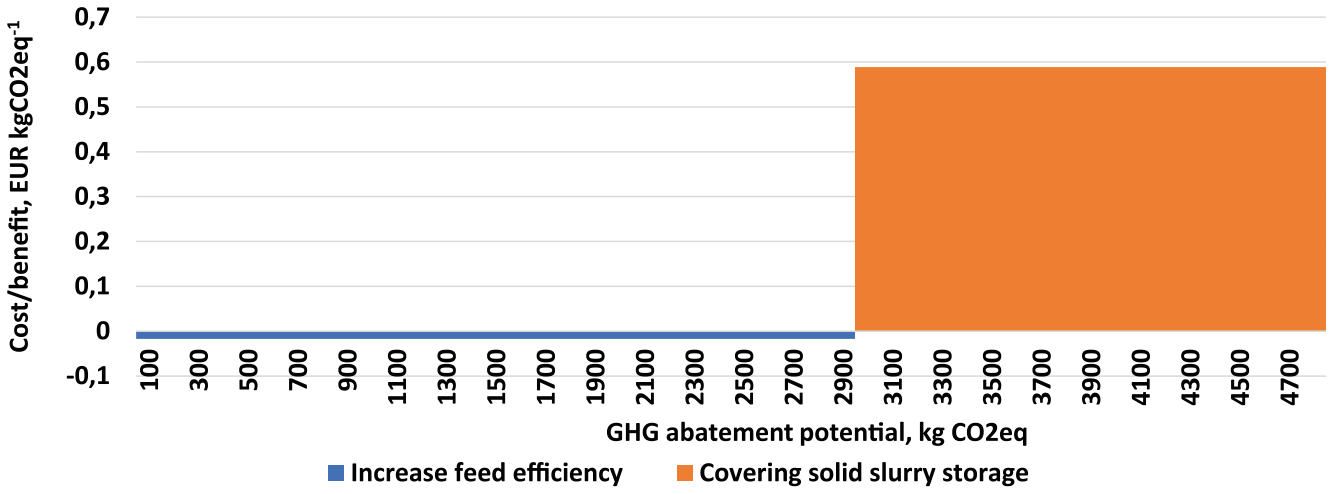
GHG emission reduction with comering slurry storage



GHG emissions reduction with feed efficiency



9. Economics: MACC curve PL_5 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

Dairy production is the only source of income for the family thus we try to follow changes, including environmental guidelines for animal/dairy production. Recent investments (photovoltaic panels, irrigation) are intended to reduce production costs. We also use by-products from a nearby juice factory to feed our cows. Thus, we are trying to contribute to more sustainable milk production. The local dairy is also starting to pay attention to environmental aspects, so recently we, as breeders, have also started to think more about the environment. However, substantive and financial support is needed to meet these challenges.

2. Which mitigation measures / practices were already taken?

Improving the nutritional quality of the feed used

Increasing the number of lactations in the herd

Reducing the use of artificial fertilizers in field cultivation - the use of manure

Photovoltaic installation

3. Which mitigation measures are planned to be implemented and how?

Increase feed efficiency.

Feed efficiency is improved through improved animal management (incl. health).

Renewable energy production (RES) at farm.

- Thinking about a small biogas plant for better utilization of manure resources on the farm.
- „Energy storages" for the existing photovoltaic installation

Better management of manure to increase humus content in the soil (introduction of no-till farming)

4. Expected effects on emissions (based on tool calculations)

Increase feed efficiency.

The realization of the event does not require significant investments. Reduce the energy per cow by 5 to 10%. Feed efficiency VEM -5%, same production per cow.

RES (solar energy) at farm.

The measure envisages placing 20 kW solar panels on the farm, which will produce 16,300 kWh of electricity.

5. Equipment involved, investment and economic

Increase feed efficiency.

Significant changes in farming, which provide for the reseeding of grasslands – 2 535 EUR per year. At the same time, changes in feed quality will improve cow welfare. The feed saving and veterinary costs are reduction provides a benefit of EUR 432.

RES (solar energy) at farm.

The investment for the purchase and assembly of the panels is EUR 26,000 and the service life is 20 years. The value of the produced electricity (price 0.16 EUR kWh-1) is 2,608 EUR per year.

6. Attention points when implementing measures

It is difficult to express the expected effects financially

7. Quote of farmer:

"We are open to novelties also in the environmental aspect, but these activities should be strengthened both substantively and economically"

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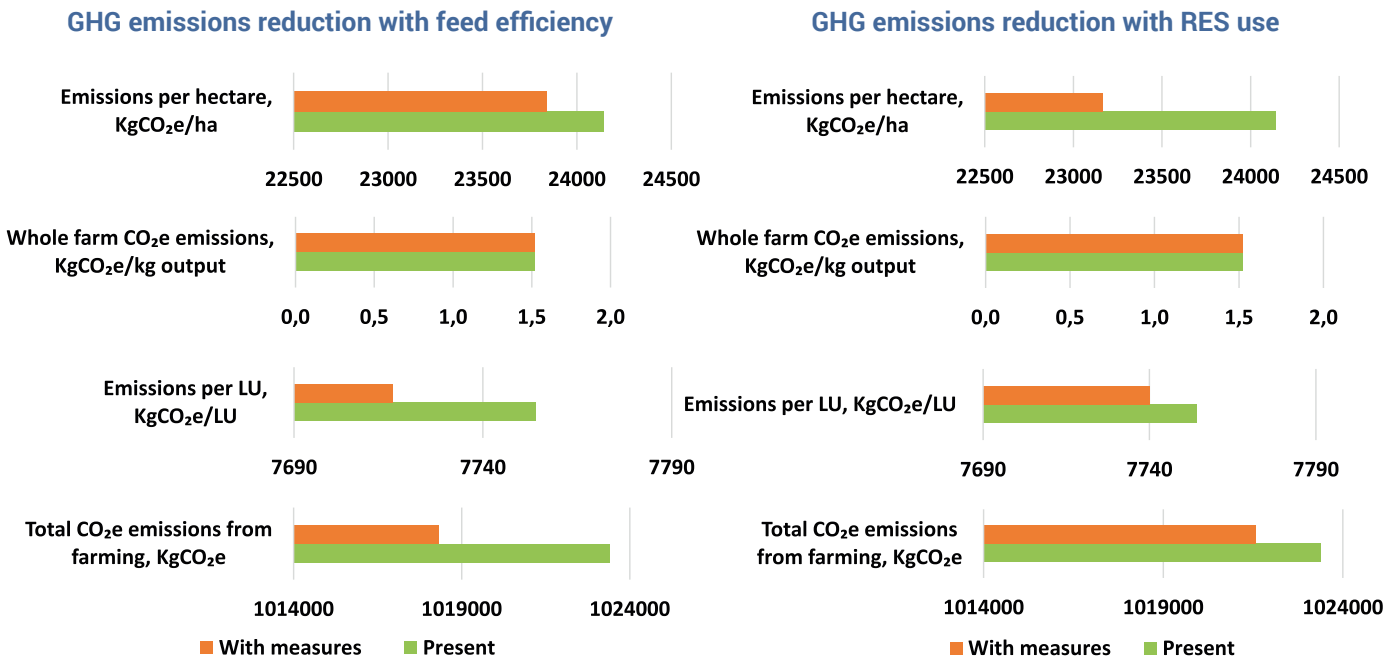
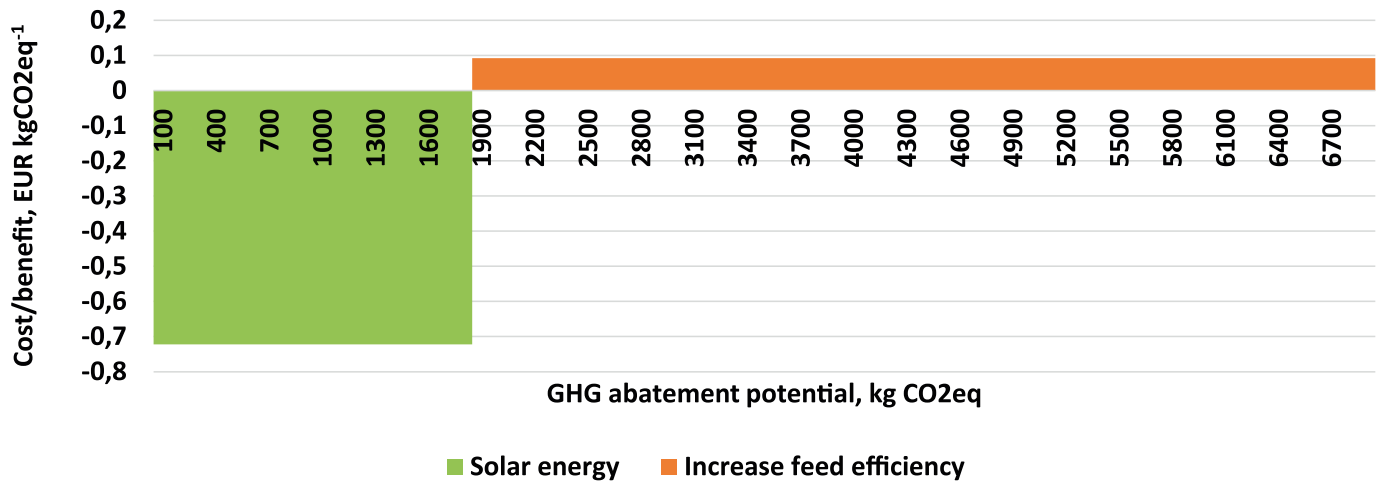
8. Table: Farm PL_6 emissions calculations results with Agrecalc tool



9. Economics: MACC curve PL_6 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

The farm belongs to the Poznań University of Life Sciences and is very interested in modern technologies, used in both animal and plant production. The farm conducts research to reduce using artificial fertilizers. The legumes are used to fix nitrogen in the soil. A great emphasis is put to increase the biodiversity in the fields (both in the soil and on their surface). The farm uses biological plant protection replacing the use of fungicides with bacteria and also continually improves animal welfare and health. Energy independence and precise farming is the priority.

2. Which mitigation measures / practices were already taken?

Precision farming
(reduction of fertilization, no-tillage cultivation, humus test, field mapping)

Improvement of nutrient utilization by animals
(genetic program and selection of dietary components used)

Improvement of longevity and health of cows

Photovoltaic panels on farm buildings and in fields - 15 ha

3. Which mitigation measures are planned to be implemented and how?

Adding probiotics to the feeding ration.
The essence of the measure is to ensure the enrichment of cow feed with probiotics, which improve the metabolism of cows.

RES (biogas) at farm.
Construction of a biogas plant for various substrates (power 500 kW) .
- **Better logistics** – delivering fuel to working machines, not vice versa
- **Use of after fermentation products instead of artificial fertilizers**

4. Expected effects on emissions (based on tool calculations)

Adding probiotics to the feeding ration.
Enteric methane probiotic supplements purchase and precision distribution to reduction CH_4.

RES (biogas) at farm.
The measure envisages placing 500 kW biogas plant on the farm, which will produce 1,520,000 kWh of electricity and 8,250 m^3 bio methane.

5. Equipment involved, investment and economic

Adding probiotics to the feeding ration.
The cost of probiotic supplements is EUR 5,600. Additional work for the workers for the preparation of feed 900 EUR per year. At the same time, feed quality improvements provide EUR 1,080 feed cost savings.

RES (biogas) at farm.
The investment for biogas plant is assumed EUR 1,875,000 and the service life is 20 years. The value of the produced electricity (price 0.16 EUR kWh-1) is 243,200 EUR per year and methane - EUR 734,250.

6. Attention points when implementing measures

It is difficult to express the expected effects financially

7. Quote of farmer:

"The future of the farm is the automation of the milking process; there is no information about programs reducing the negative impact of animal production on the environment"

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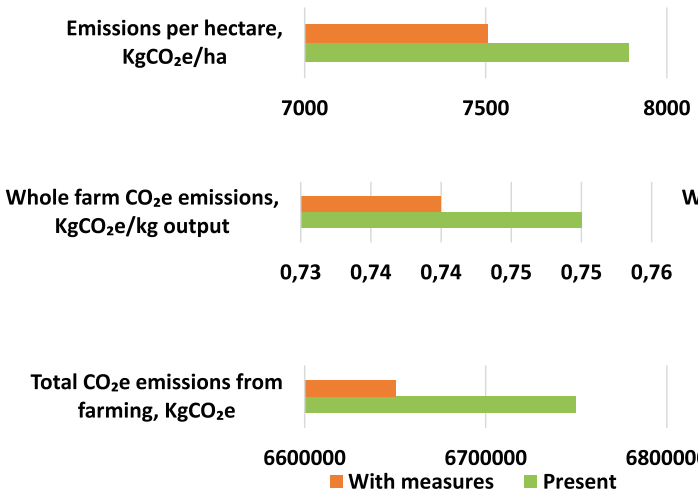
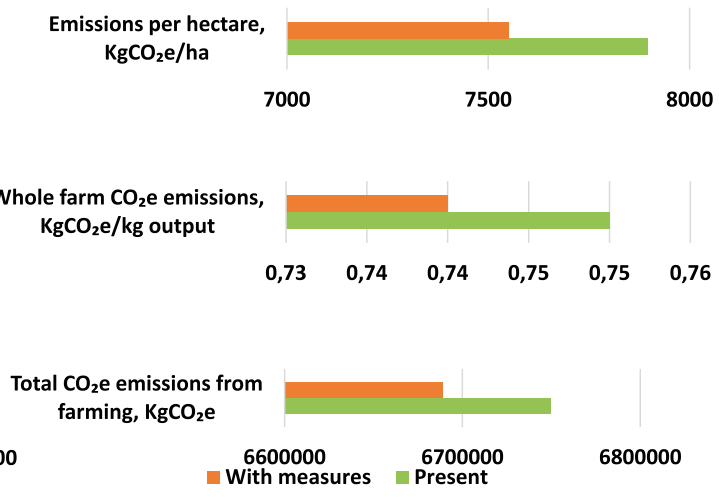
8. Table: Farm PL_7 emissions calculations results with Agrecalc tool

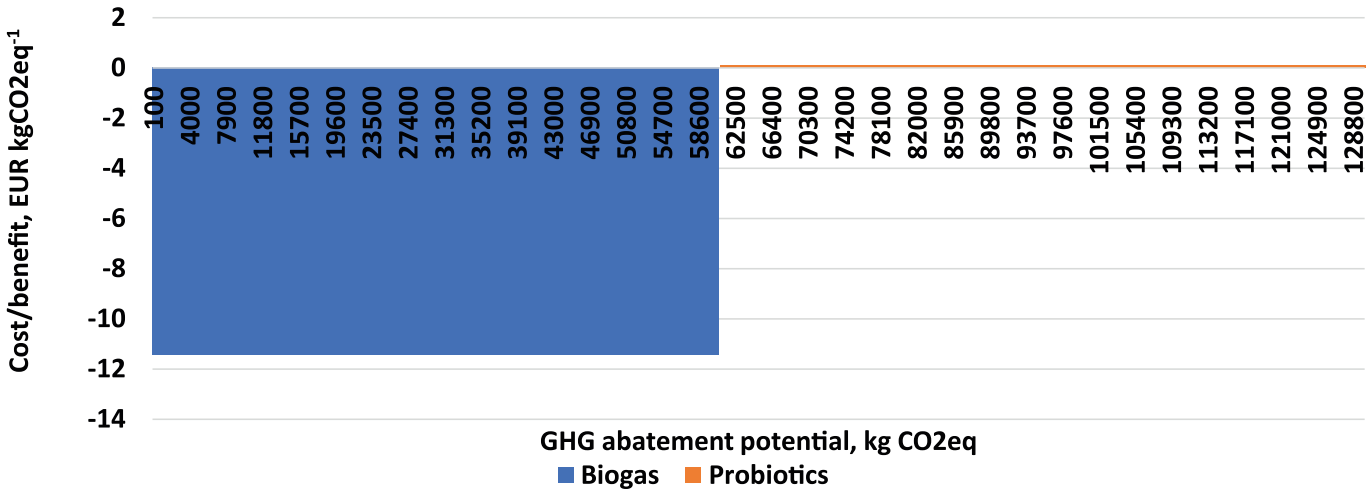
GHG emission reduction with probiotics use



GHG emission reduction with biogas production



9. Economics: MACC curve PL_7 with all simulated measures



1. Description of farmers' future strategy on development of farm and reduction of emissions

As the largest biodynamic farm in Poland and one of the largest in Europe, we are conscious breeders in terms of environmental protection. The farm puts great emphasis on both animal welfare and soil biodiversity. The farm has been taking care of the environment for years by running ecological production. The obtained products, such as GTS-certified milk (traditional specialty guaranteed), are produced with the greatest environmental care. The farm focuses on renewable energy sources to be more pro-environmental.

2. Which mitigation measures / practices were already taken?

High animal welfare

Improved herd longevity

Maximizing the use of pastures

Renewable energy sources

3. Which mitigation measures are planned to be implemented and how?

Covering solid slurry storage.

Installing a tank cover conserves N in the manure and will require less purchased inorganic fertilizer.

Increase feed efficiency.

Improvement of the nutritional value of feed used in winter

- **Maintaining the current pro-ecological policy of the farm**
- **Investments in renewable energy sources.**

4. Expected effects on emissions (based on tool calculations)

Covering solid slurry storage.

Reduction of methane is expected to be 47% and reduction of ammonia 80%.

Increase feed efficiency.

The realization of the event does not require significant investments. Reduce the energy per cow by 5 to 10%. Feed efficiency VEM -5%, same production per cow.

5. Equipment involved, investment and economic

Covering solid slurry storage.

Covering 1185 t of manure with covering material cost EUR 135,000, that ensures non-evaporation of nitrogen and mineral fertilizer savings of EUR 2,730 per year. Lifetime of covering material 7 years.

Increase feed efficiency.

Significant changes in farming, which provide for the reseeding of grasslands – 16,575 EUR per year. Additional work for farmers is assumed EUR 1,800 per year. At the same time, changes in feed quality will improve cow welfare. The feed saving and veterinary costs are reduction provides a benefit of EUR 1570.

7. Quote of farmer:

"We are an example of sustainable animal production not only in Poland but also in Europe"

6. Attention points when implementing measures

It is difficult to express the expected effects financially

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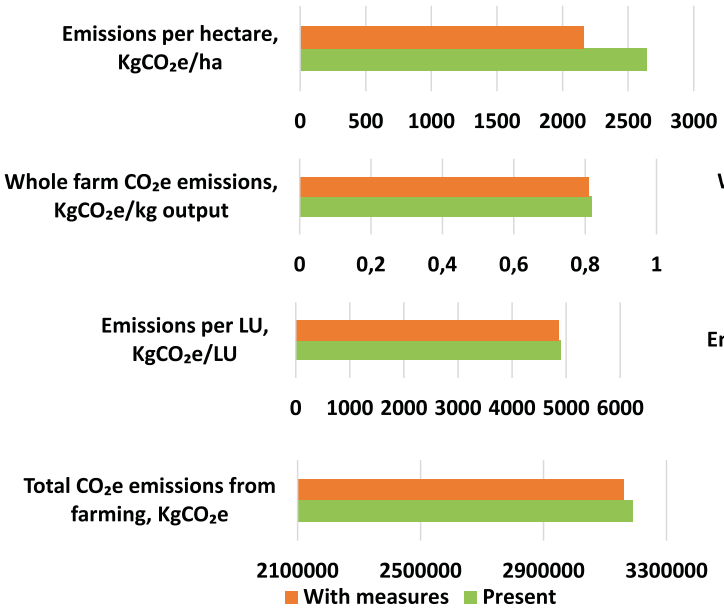
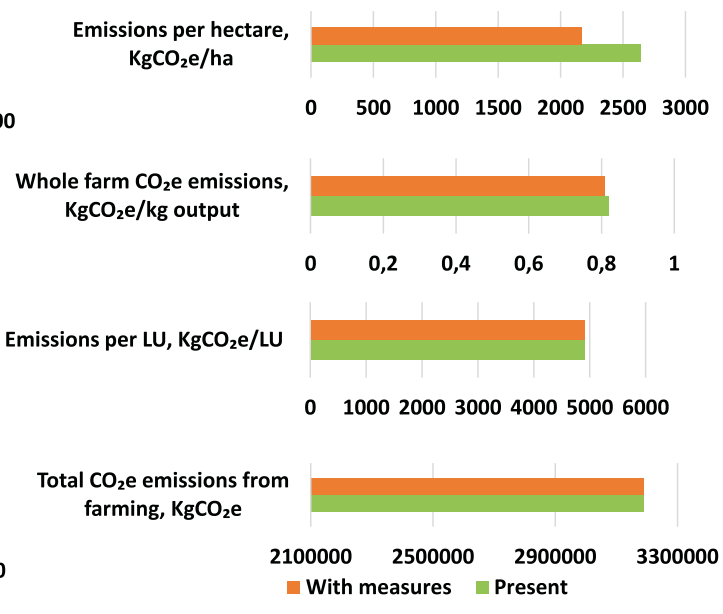
8. Table: Farm PL_8 emissions calculations results with Agrecalc tool

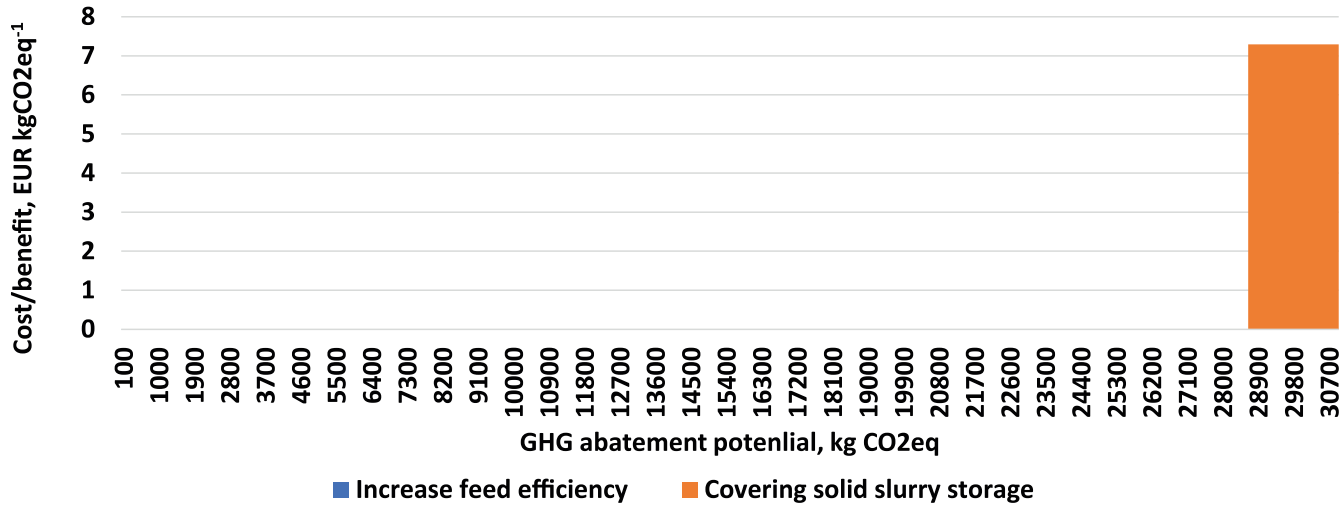
GHG emission reduction with increase feed efficiency



GHG emissions reduction with slurry covering



9. Economics: MACC curve PL_8 with all simulated measures



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