THE ROLE OF GREENHOUSE GAS ABATEMENT COSTS IN NORWEGIAN AGRICULTURE

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GOVERNANCE FOR GREENHOUSE GAS ABATEMENT IN NORWEGIAN AGRICULTURE

Summary

This paper analyses greenhouse gas abatement costs of a Norwegian dairy farm and discusses the results in the context of current reduction plans of the Norwegian government. Marginal abatement costs are calculated with the bio-economic farm level model FarmDyn. We show that many current initiatives do not seem to be sufficient to achieve the required greenhouse gas emission reduction targets in a cost-efficient manner. They are either not politically feasible, not politically desired, not covered by the National Inventory or not cost efficient. We conclude that current climate policies for the agricultural sector in Norway are not resilient and propose possible ways forward.

Keywords

Abatement costs, dairy, Norway, Global warming potential, Climate policies, Resilience.

1 Introduction

The reduction of greenhouse gas (GHG) emissions is a major necessity of our time. Research has become more and more confident that global warming above 1.5-2 degree Celsius compared to pre-industrial levels will have severe, and partly irreversible, consequences for most countries. The Paris agreement signed by many countries around the world therefore aims at limiting global warming well below 2 degree Celsius.

Mitigation efforts to achieve the targets set out in the Paris agreement require a concerted action from all parties and cutting emissions from agriculture and food production (CLARK et al. 2020). This implies that the Norwegian agricultural sector has to reduce its emissions, too. The question is how this should be achieved without compromising other agricultural policy objectives. Norway has ambitious policy objectives such as ensuring food security, maintaining agricultural activity in all parts of the country, and value creation. Moreover, there is a strong focus on farm income. Subsidies and other regulations are provided so that the farming community is given the same opportunity to raise income as other parts of the economy. The Norwegian agricultural sector emits about 10.5 mio. t CO_2-equ. annually (STATISTICS NORWAY 2021). About one-half or 4.5 mio. t CO_2-equ. are reported in the agricultural emission sector and stem mostly from animal husbandry and fertilizer management (MITTENZWEI AND PRESTVIK 2022). Agricultural fuel and other energy use amount up to 0.4 mio. t CO_2-equ. and are reported in the transport emission sector. Finally, land use and land use change constitute 2.2 mio. CO_2-equ. and are reported in the Land Use, Land Use Change, and Forestry sector (LULUCF). Leaving out LULUCF, agriculture has a share of 10-11 per cent of the total GHG emission in Norway.

The milk and beef sector are the most important sectors in Norwegian agriculture, accounting for half of the land use, employment, and value creation in Norway (MITTENZWEI 2018). Moreover, milk and beef are the most subsidized food products and generate the highest emissions. Any approach that aims at reducing GHG emissions in agriculture needs to include the milk and beef sector.

Although a dietary change towards a more plant-based diet and the reduction of the consumption of red and processed meat, has shown to have low social costs (MITTENZWEI et al. 2019), that measure is highly disputed and not promoted by the majority of the political parties due to negative impacts on other agricultural policy objectives. Instead, farm-level measures have been proposed by agricultural stakeholders.

Surprisingly little knowledge exists on how mitigation options affect the profitability of milk and beef farming. While there is increasing literature on the pure accounting costs of implementing mitigation technology, the economic effects of farm adjustment and profit foregone are much less understood. In this study, we close this knowledge gap by first, adapting the single farm optimization model FarmDyn to Norwegian policy, including its natural conditions, and second, calculating abatement cost curves for a Norwegian dairy farm.

The remainder of the paper is structured as follows. We introduce the data and methods in the section 2, and present results in section 3. Results are discussed in section 4, while section 5 concludes with advice on sound policy design.

2 Material and methods

2.1 Climate initiatives in the agricultural sector

In 2019, the two Norwegian farmer organizations, the Norwegian Farmers Union and the Norwegian Farmers and Smallholders Union, entered into an intentional agreement with the government to reduce GHG emissions from the agricultural sector by 5 mio. t CO_2-equ. in the period 2021-2030 (NORWEGIAN GOVERNMENT 2019). The annual emissions covered by the agricultural emission sector are estimated to be 4.5 mio. t CO_2-equ. If emission reductions are implemented linearly between 2021 and 2030, emissions will be about 22 per cent lower in 2030 compared to 2021. However, the intentional agreement covers not only GHG emissions reported in the agricultural sector, but also GHG emissions caused by agricultural activity in other emission sectors. Agricultural fuel and energy use in the transport sector amount to about 0.4 mill t CO_2-equ., while emissions associated with land use and land use change in the LULUCF sector are about 2.2 mill. t CO_2-equ. Therefore, the intentional agreement covers a total of 10.5 mill. t CO_2-equ. per year so that the ambition of a 5 mio t reduction in the 2021-2030 period rather compares to a reduction by 14 per cent between 2021 and 2030.

The intentional agreement consists of two parts. Part A contains farm level mitigation measures for which the farmer organizations are responsible. Part B consists of emission reduction through dietary change and less food waste. The government is responsible for achieving emission cuts for these two measures. The agreement does not split the overall ambition target of 5 mill. t CO_2-equ. into these two parts. Therefore, it remains open how much mitigation measures of each part will finally contribute to the target.

Three major climate initiatives targeted towards the agricultural sector in Norway were proposed in the last years: the so-called Climate Cure 2030, the farmers' own climate plan, and the White Paper on climate policy.

In 2019 the government commissioned the study *Climate Cure 2030* (NORWEGIAN ENVIRONMENT AGENCY 2020) coordinated by the Norwegian Environment Agency to analyze mitigation measures in the domestic greenhouse gas emissions that are not covered by the Emission Trading Scheme (Non-ETS sector) which includes transport and agriculture.

The mandate of the study required an overall GHG emission reduction potential of 50 per cent by 2030 compared to 2005. At this time, the official climate goal was to cut GHG emissions in the Non-ETS sector by 45 per cent in 2030 compared to 2005, and aligned to the corresponding climate objective of the EU. The Climate Cure report was released in 2020 (NORWEGIAN ENVIRONMENT AGENCY 2020) and provided a comprehensive knowledge base for the White Paper on climate policy for the 2021-2030 period that was released in 2021 (NORWEGIAN GOVERNMENT 2021). The Norwegian Farmer's Union published its own climate plan in 2020 (NORWEGIAN FARMER UNION 2020). The climate plan was a response to the intentional agreement between the two farmer unions and the government from 2019 to cut agriculture related GHG emissions by 5 mio. t CO_2-equ. between 2021 and 2030.

2.2 Abatement cost calculation

A common approach to calculate abatement costs in agriculture is the use of mathematical programming models like the farm-level model FarmDyn (Britz et al. 2014). FarmDyn simulates farm management, while the outcome represents the economically optimal farm-plan, maximizing the farm's net present value. In order to calculate abatement costs, the model is restricted by an emission ceiling. The abatement costs are calculated as the profit foregone through abatement compared to a baseline run without emission ceiling. The advantages of the approach is the consideration of detailed technology, management decisions and their interaction and combination potential (Lengers et al. 2014).

The model depicts herd management and herd demographics, feeding and grazing, cropping decisions, and fertilization. Herds are differentiated by age, gender and lactation cycle. The feed requirements of different herds are calculated using the methodology of the feed planning tool Zifo2 (LfL 2016), by considering dry matter, fibre, protein, energy and nutrient intake as well as animal performance and lactation periods. The animals can be fed with bought feedstuff or grown roughages on the farm.

Cropping decision include which crops to grow and their acreage. Grasslands can be managed as pastures or meadows with differing means of harvest (hay, silage) and different intensities (yields, stocking density and cuts per year). Crops, meadows and pastures can be fertilized with artificial fertilizer, animal manure and excreta from grazing animals to meet the nutrient demand given by the yield.

In the study at hand the FarmDyn model is applied to a Norwegian case study farm which participated in the CLIMPLEMENT project financed by the Research Council of Norway (2019-2022). In the project, detailed data was raised on farm with the help of the farming family. Key attributes of the case study farm are listed in table 1 below.

Table 1: Overview on the case study farm

Location	• Viken, Norway
Reference year	• 2019
Land endowment	• 33.6ha arable land • 31.2ha grassland
Grown crops	• Wheat, oat, barley
No. of cows	• 37 Norwegian Red dairy cows + offspring
Sold milk per year	• 32500ltr
No. of sold bulls	• 20
Labor endowment	• 3400 hours per year

Source: Own illustration

The model is calibrated to the case study by restricting the solution to the given endowments of land, labor and the existing production technology (stable system, milking parlor, mechanization). Because the FarmDyn model originates from Germany, the background data was adapted to the case study region. This includes prices, yields, process length and length of different work tasks. Where possible, data raised on the case study farm is used, if not it is taken from Norwegian farm planning data (Ebbesvik 2020). Where Norwegian data is still missing the models default settings are utilized which are based on Achilles (2016). The policy environment in which the case study farm operates is depicted, too. This includes fertilizer restriction, degressive payment schemes for animal husbandry, grazing and small farmers schemes.

The abatement capabilities of the model are determined by the emission calculation methodology, the decision realm of the model and included abatement technology. Here the emission accounting follows the Norwegian national inventory under the Kyoto protocol (NIR 2019). Considered emissions are methane, nitrous dioxide and carbon dioxide from enteric fermentation, manure management in stables and storage, manure application, fertilization, excreta of grazing animals, liming and crop residues. Up-stream emissions are not covered because they are considered in the climate action plans of the respective sector where they occur.

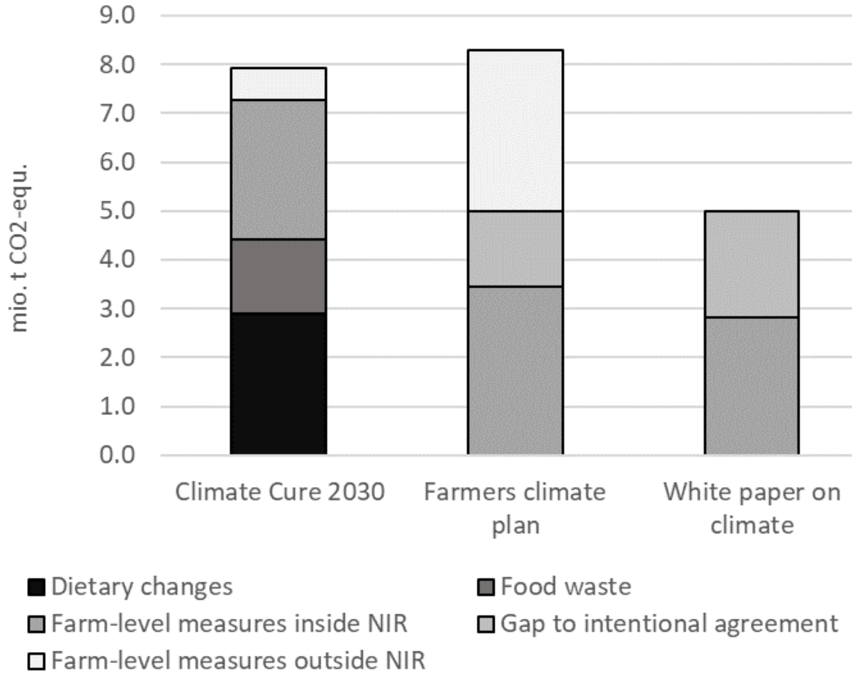
Included abatement measures comprise explicit technology like manure pit coverage and manure application technology or variable management decisions like fodder optimization, intensity management, fertilization practice, cropping decisions, herd size management and grazing management. In accordance with the national inventory due to the gravity of methane emissions from enteric fermentation in the total emissions we use a tier three emission calculation methodology to account for changes in emissions due to changes in feeding. This does not include feed additives as these are not legally allowed. Finally, the model chooses the cost-efficient mix of abatement-measures in the optimization.

3 Results

3.1 Climate initiatives

Figure 1 displays the climate measures in the three climate initiatives for the agricultural sector in Norway. The figure distinguishes measures which can be included in the National Inventory Report (NIR), measures that are not included in the NIR and the gap in the respective plans to reach the ambition of 5 mio. t CO_2-equ. in the agricultural sector. For the Climate Cure 2030 initiative the measures dietary change and food waste are also considered.

Figure 1: Greenhouse gas abatement measures in three climate initiatives for the agricultural sector in Norway



Source: Own illustration

The Climate Cure 2030 report contains mitigation measures that by far exceed the climate ambition. Dietary changes that bring the current diet more in line with official dietary guidelines are estimated to cut 2.9 mio. t CO_2-equ. in the 2021-2030 period. These changes imply, among others, a reduction in the consumption of red and processed meat and an increase of fruits and vegetables. The reduction of food waste in the food value chain from producer to consumer adds another 1.5 mio. t CO_2-equ. in emission cuts. Therefore, the two measures alone would be almost sufficient to achieve the target set by the intentional agreement. Climate Cure 2030 also includes a wide range of mitigation measures at the farm level that can be reported in the NIR. Their overall GHG emissions reduction potential is almost as high as the dietary change option. Finally, Climate Cure 2030 included some measures that Norway would not be able to report in the NIR and that therefore, would not contribute in the achievement of Norway's international mitigation obligations.

The farmers' own climate plan lists neither dietary changes nor food waste reduction as mitigation options. This is in part because a reduction of red meat consumption is actively opposed by the farmers' organizations and because, following the principle of the intentional agreement, the farmers are only responsible for mitigation measures at the farm level. Still, the climate plan contains climate measures at the farm level some of which can currently not be included in the national inventory due to measurement and methodological issues. The total amount of GHG emission reductions of farm level measures within the NIR is slightly higher than in the Climate Cure report with 3.45 mill. t CO_2-equ. However, this amount falls short of the ambition target so that a gap of 1.55 mill. t CO_2-equ. remains. The potential of mitigation options not covered by the national inventory is 3.45 mill. t CO_2-equ.

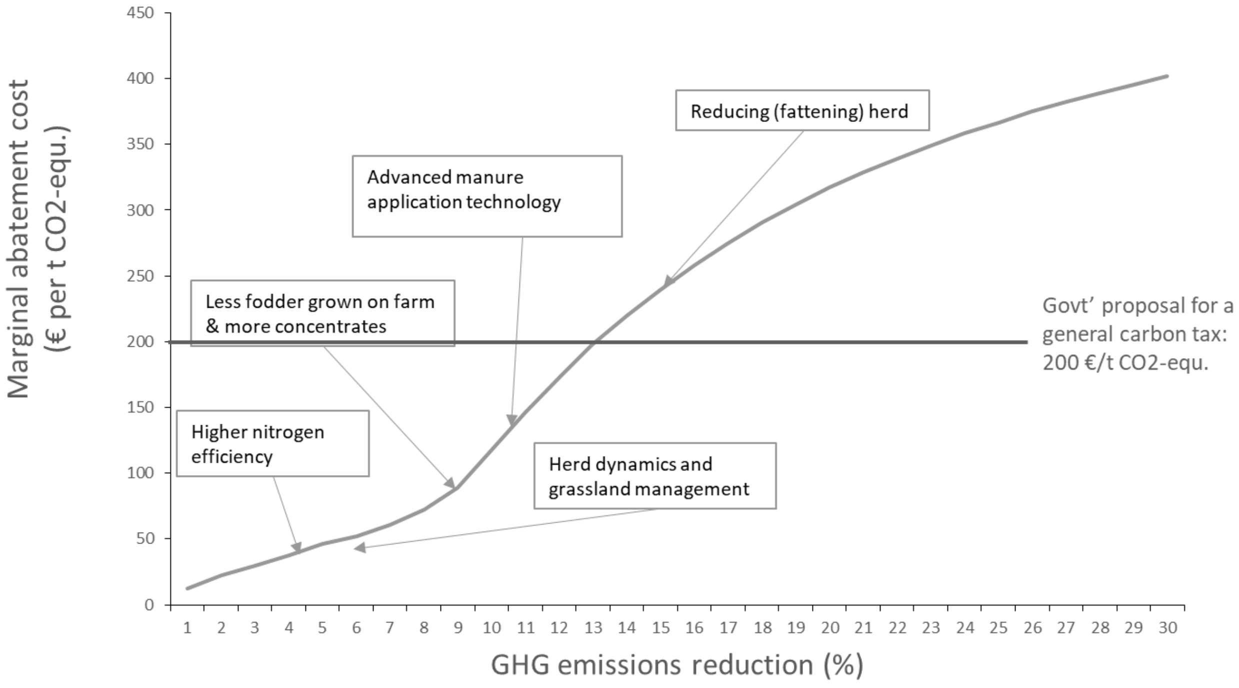
The government's White paper on climate policies for the 2021-2030 period basically follows the farmer's climate plan. It includes farm level measures amounting to 2.8 mill. t CO_2-equ. which is somewhat lower than the farmers' own climate plan. The White paper mentions dietary changes and less food waste as options to reduce GHG emissions from agriculture, but does not quantify a certain level of emission cuts. Therefore, there is still a gap between the specific mitigation options listed in the White paper and the ambition target of 2,2 mill. t CO_2-equ. Given the reduction potential of less food waste estimated in Climate Cure 2030 of 1.5 mill. t CO_2-equ, it becomes clear that either some dietary change will be necessary to achieve the ambition target or new farm level measures that can be included in the NIR, must be proposed.

Neither the farmers' climate plan nor the White paper have assessed the marginal abatement costs for the proposed measures. This has, however, been done for the mitigation options in Climate Cure 2030. It turns out that the social abatement costs per reduced t CO_2-equ. are lowest, partly negative, for dietary change and food waste. Farm level measures have abatement costs above 150 € per reduced t CO_2-equ.

3.2 Abatement costs of the case study

Without abatement efforts, the case study farm emits a total of 443,738 kg CO_2-equ. with the majority of emissions stemming from enteric fermentation, manure management and fertilizer use. Figure 1 shows the abatement costs per ton emitted CO_2-equ. for 30 per cent emission reduction.

Figure 2: Abatement cost curve of case study farm



Source: Own illustration

Lower reduction efforts up to 9 per cent are possible at costs lower than 100€ per ton CO_2-equ. The measures to reach these first abatement steps are small adjustments in management, such as lowering the date of first insemination of heifers, a small increase in the amount of grazing and a better fertilizer management through small changes in grassland management. Further abatement (10-15 per cent) is bound to higher costs (100-240€ per t CO_2-equ.) and requires investment in technology. The use of manure injection for application enables direct abatement of ammonia and therefore spares indirect GHG emissions. Furthermore, the higher nitrogen efficiency decreases the need of mineral fertilizer which also reduces emissions. Besides the investment in manure application technology, the farm extensifies the grassland production which spares fertilizer and ultimately emissions. The extensification reduces the yield and requires the purchase of fodder to sustain the herd. Emissions arising from the production of fodder outside the farm boundaries are not considered. Abatement above 15 per cent is only achievable by reducing the number of fattened bulls. This substantially reduces the farm income resulting in high abatement costs over 240€ per ton CO_2-equ. Due to the high profitability of cereal production and dairying these branches are excluded from on-farm reduction efforts.

4 Discussion

To our knowledge no other study estimated abatement costs of Norwegian farms before, despite the ambitious targets formulated in the farmers union climate plan and the climate White paper. However, other studies with a different regional scope confirm the findings at hand in that substantial savings on farms are bound to substantial costs (MOSNIER et al. 2019, CECCHINI et al. 2018).

Our results suggest that emission reductions up to 10 per cent are achievable at comparably low costs. The abatement measures to reach this reduction are a diffuse mix of adjustments in management. These might differ among farms and are hard to translate into an actual action plan and therefore it is questionable if they are fully covered in the NIR. Opportunities arise where measures have the potential of combined benefits with other policy goals. For example, increasing the nitrogen efficiency through better manure application technology and reducing the amount of applied fertilizer can contribute to the reduction of water pollution and acidification, too. Other measures, such as shifting fodder production outside the farms boundaries may pose the danger of emission leakage, meaning, emissions are not abated but pushed outside the analyzed system boundaries (ARVANITOPOULOS et al 2021).

A macroeconomic analysis using a CGE-model for Norway showed that a 50 per cent emission reduction in the Non-ETS sector by 2030 compared to 2005 would imply a carbon tax of about 370 € per ton CO_2-equ. (FÆHN et al. 2020). The government proposed a carbon tax of 200 € per ton CO_2-equ. in its White paper on climate policy (NORWEGIAN GOVERNMENT 2021). Our model results indicate that a carbon tax of 200 € per t CO_2-equ. would reduce GHG emissions by about 14 per cent. This reduction is about the same level as the target set out in the intentional agreement. If abatement costs of our study farm are higher than the sectoral average, the intentional agreement could possibly be achieved in a cost efficient way - under the condition that all emission reductions achieved would be covered by the NIR. However, as most emissions in agriculture are related to dairy and beef, we can hypothesize that relative emission cuts need to be higher in these two sectors than in other sectors. If this is the case, the achievement of the emission target in the intentional agreement would not be achieved in a cost efficient way for society as the marginal abatement costs would be higher than the general carbon tax. Given that the cost-efficient measures in our case study are partially not translatable into an action-plan for farmers or might lead to emission leakage further indicates shortcomings in the economic feasibility.

If a carbon tax of 370 € per ton CO_2-equ. would be needed, the picture changes. Based on the study farm, emission reduction in the agricultural sector would become more competitive compared to mitigation options in other Non-ETS sectors. However, abatement at such level would have potentially negative impacts on other agricultural policy objectives such as less land use and less food production.

We expect that emission efforts are influenced by farm profitability. This effect is not visible when abatement costs are calculated for one single farm only, but should become clearer when more farms are analyzed. In this respect, we plan to expand the analyzed sample of dairy farms from the Norwegian farm register (i.e., the equivalent to the EU FADN database) to assess variation in abatement costs due to location, farm size and farm management.

Against this background, drawing conclusions about sectoral abatement costs from a single dairy farm is limited. The study farm seems to have implemented mitigation options already (e.g., environmental-friendly manure application technology) and is positioned above the average farm. We hypothesize that abatement costs for the average Norwegian dairy farm will be somewhat smaller than for our study farm.

The review of the climate initiatives for the agricultural sector shows that mitigation measures with lower costs, such as dietary change, are not pushed by farmers or the government. In the case study, one abatement measure that was associated with high costs for the farmer was the reduction of the bull-fattening herd, i.e. reducing red-meat production. While this is one of the key aspects of the Climate Cure 2030 plan and bound to low societal costs it adversely effects associated farmers through lower farm income. This might explain the preference of the farmers union of mitigation measures with higher costs, but, in sum, those fail short in achieving the envisaged GHG emission reduction target the agricultural sector has set itself. As a consequence, there is considerable uncertainty about how to reduce GHG emission reductions in the agricultural sector. This is an indication of a lack of good governance since farmers are left in a veil of political uncertainty regarding climate policy in agriculture, potentially facing high societal costs without achieving desired goals (BRINKERHOFF 2017).

5 Conclusion

This paper calculates GHG abatement costs of a Norwegian dairy farm and discusses the results in the context of climate policy in Norwegian agriculture. Results indicate high abatement costs for meaningful abatement if compared with the price of carbon offsets. Given this, we find that policy-makers and farmers have rather high ambitions illustrated by the intentional agreement to reduce greenhouse gas emissions by about 14 per cent by 2030 compared to 2005. However, it remains unclear how these emissions are to be achieved and whether they can be achieved in a cost-efficient manner. The intentional agreement seems to have been made in a veil of ignorance. A first step forward would include more and better knowledge on the economic and environmental effects of emission reduction at the farm level.

The governance of climate politics in Norway does not seem to be robust as farmers face considerable uncertainty about future (climate and agricultural) policies. This is especially true for policy-makers and society’s position regarding dietary changes towards a less meat-based diet. This option is not favored, but cost-efficient. Figures show that the per-capita consumption of red meat is slightly decreasing (NORWEGIAN HEALTH DIRECTORATE 2022), but the reasons for this development are unclear (VATN et al. 2022). Rather than developing a forward-looking climate policy for the agricultural sector in Norway, policy-makers seem to hesitate to make unpopular decisions. It may still be the case that Norwegian agriculture accomplishes the emission reduction target set out in the intentional agreement, but this will then rather be despite of, and not because of, good governance. A second step forward could be to provide more and better guidance to farmers on the desirable contribution of dietary change, food waste reduction and mitigation options at the farm level to achieve the ambition of the intentional agreement.

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