Reducing Greenhouse Gas Emissions in the Dairy Value Chain

Multiple Layers of Complexity

RaboResearch
Food & Agribusiness
far.rabobank.com

Richard Scheper
Analyst – Dairy
+31 62 385 1987

Claudia Cammack
Analyst – Climate and Sustainability
+31 62 513 0408

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Summary

The dairy industry is facing new challenges from increasing demand for sustainable milk production and new government laws and policies targeting emissions reduction. Despite differences in farming systems, dairy's carbon footprint is similar between major exporting regions, with most greenhouse gas emissions originating on the farm in the form of methane. These emissions are categorized as direct, scope 1 emissions for farmers, but they also contribute to the scope 3 emissions of the dairy processors and retailers who purchase milk.

As various stakeholders focus on farm-level emissions from dairy, measuring and reducing these emissions can be complex. The frequent misalignment between national government and industry targets on reduction percentages, base year, and greenhouse gas targeted only add to this complexity. Furthermore, many national goals do not have targets set specifically for agriculture, let alone dairy, which can make it difficult for the dairy industry to set, measure, and reach goals.

Despite these inconsistencies, companies are taking action to reduce their emissions, with many turning to the Science Based Targets initiative for guidance on defining decarbonization pathways and aligning reduction targets with the goals of the Paris Agreement.

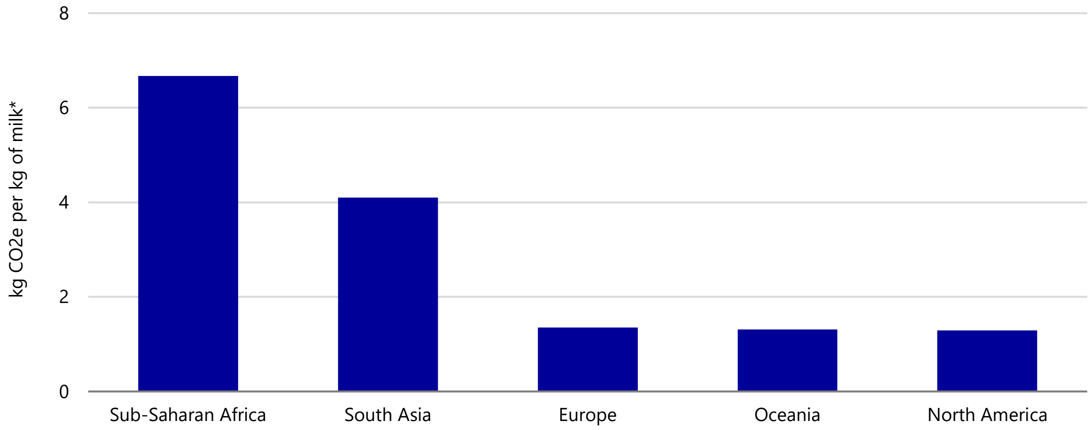
With commitments being made and targets being set, the dairy industry has been focusing on numerous strategies to reach these targets, including reducing methane emissions from enteric fermentation through efficiency and productivity gains and implementation of enteric-methane-reducing feed additives, as well as reducing emissions through improved manure management. While these levers have strong mitigation potential, there are still limitations, such as adoption rates and commercialization.

To increase the momentum of emissions reduction in the dairy industry, three important steps need to be taken: 1) alignment between government and industry targets to overcome (sometimes unnecessary) layers of complexity, 2) industry acceptance of the need to accelerate emissions reduction and prepare for this transition, and 3) industry and government incentives to increase adoption rates of on-farm mitigation levers among farmers.

Reducing Emissions in Dairy Is a Global Challenge

According to the Food and Agriculture Organization of the United Nations (FAO), the global dairy sector contributes to roughly 4% of all global greenhouse gas (GHG) emissions. This includes emissions from milk production, processing, and transportation, as well as emissions from meat produced from culled and fattened dairy animals. As such, reducing GHG emissions is a major sustainability challenge facing dairy companies worldwide. Globally, the emissions per kilogram of milk (fat and protein corrected) vary widely, ranging from 6.7kg carbon dioxide equivalent (CO_2e) in developing regions such as sub-Saharan Africa to 1.3kg to 1.4kg CO_2e in major exporting regions such as Oceania, North America, and Europe (*see Figure 1*). As the majority of global milk production occurs in developing regions, there is also an obligation to support those regions in reducing their carbon footprint.

Figure 1: Globally, emissions per kilogram of milk vary widely

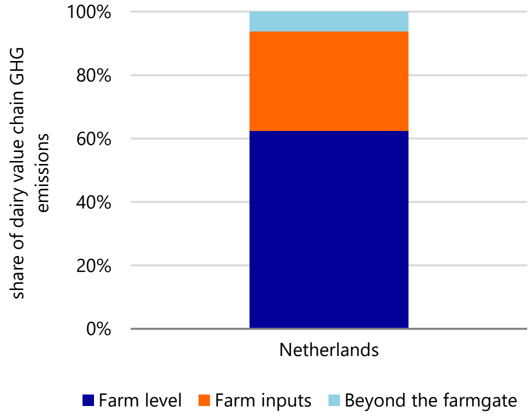


*Note: Per kilogram of milk (fat and protein corrected)
Source: FAO 2019

On-farm Emissions Account for the Largest Share in the Value Chain

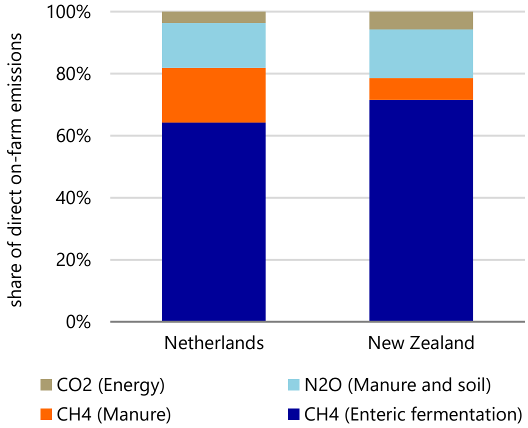
Among the major exporting regions, carbon footprints are similar despite regional and system differences. Generally, direct on-farm emissions account for the vast majority of emissions along the value chain, followed by emissions linked to farm inputs like purchased (concentrate) feed and fertilizer (*see Figure 2*). Beyond the farmgate, transport, processing, and packaging of milk and dairy products only account for a small share of total emissions.

Figure 2: The majority of dairy emissions occur at the farm level...



Source: Duurzame Zuivelketen 2021, Rabobank 2022

Figure 3: ...and result from enteric fermentation



Source: Duurzame Zuivelketen 2021, Rabobank 2022

At the farm level, the combined methane emissions (CH4) from enteric fermentation and manure roughly account for 75% to 85% of direct on-farm emissions (*see Figure 3*). The remaining emissions are largely made up of nitrous oxide (N2O) – mostly related to soil management and the storage and application of manure. CO2 emissions from energy and fuel usage generally only account for the few remaining percentages. This suggests that the feasibility of successfully implementing mitigating measures in the large exporting regions is comparable, despite the differences in environment, climate, and farming practices. For example, a feed additive used to reduce methane emissions from enteric fermentation can be implemented in multiple countries, but the effectiveness could vary depending on the farming practices and systems used.

For dairy processing companies, this means that most of their emissions sit in scope 3 and are outside their direct control.

Complexities of Scope 3 Require Collaboration

As reported by the Greenhouse Gas Protocol, scope 3 emissions are all indirect emissions not included in scope 1 and 2 that occur in the value chain of the reporting company, including both upstream and downstream emissions. For dairy processors, food companies, and retailers, the majority of their GHG emissions come from upstream scope 3 emissions through the purchase of goods and services, like raw milk from farmers. Therefore, dairy companies are held accountable for on-farm emissions like methane and nitrous oxide, even though they do not directly own or control these sources.

As such, measuring and reducing these emissions can be difficult, given the complexity and number of actors in the value chain. Scope 3 encompasses emissions throughout the life cycle of the product, including those from suppliers, distributors, and consumers. While scope 1 and 2 emissions are measured with primary data, scope 3 emissions are often estimated and measured by other parties. This is also seen in the measurement of upstream scope 3 emissions in dairy, where processors, food companies, and retailers must rely upon and collaborate with their (milk) suppliers in order to reduce their scope 3 emissions, which are largely the direct on-farm emissions of their suppliers.

Scope 1, 2, and 3 Emissions in the Dairy Value Chain

According to Greenhouse Gas Protocol, scope 1 emissions are direct emissions from owned or controlled sources; scope 2 emissions are indirect emissions from the generation of purchased energy; and scope 3 emissions are all other indirect emissions that occur in the value chain of the reporting company. In the case of a dairy processor, scope 1 (direct) emissions would come from processing raw milk at their processing plants. Scope 2 emissions would come from the energy purchased for the processing. Upstream scope 3 emissions would include the scope 1 emissions of the dairy farms where the milk was purchased (e.g. on-farm methane emissions from the cow), and downstream scope 3 emissions would stem, for example, from the transportation and waste disposal of the milk products.

Misalignment Complicates Target Setting and Scope

However, the difficulties aren't limited to measuring and reporting scope 3 emissions in the dairy value chain. The targets and goals set for these emissions also come with their own complexities. Dairy companies not only face pressure from clients, consumers, and industry peers to reduce their emissions, they must also deal with emissions reduction targets embedded into national laws and policies. These targets, however, vary in alignment, ambition, and scope. In practice, this means that stakeholders throughout the value chain are exposed to different targets.

For example, countries that have signed the Paris Agreement establish nationally determined contributions (NDCs) detailing how they will reduce their GHG emissions in order to reach the agreement's goals and limit global warming to, at most, 2 degrees Celsius, preferably 1.5 degrees. The NDCs are economy-wide, and for many countries, they do not have a specific target set for agriculture, let alone dairy. In some cases, though, the country will have an additional target that is specific to a certain sector. New Zealand, for example, aims for a 50% reduction of net emissions below its gross 2005 level by 2030 in its NDC. However, in the country's Climate Change Response (Zero Carbon) Amendment Act, the target to reduce biogenic methane emissions (from agriculture and waste) by 10% by 2030 is compared with 2017 levels. These two targets differ not only in their reference year, but also in the type of GHG considered and the sector targeted for the reduction.

Meanwhile, in the European Union, many member states have not yet specified their climate targets or aligned them with the European Commission's Fit for 55 ambitions. Some member states have created climate agreements that have stricter reduction targets and specify certain sectors, while others have only committed to the Fit for 55 goals.

For example, the Netherlands followed up the Paris Agreement with its Climate Agreement in 2019. However, alignment with the Fit for 55 goals has not been completed. Within the Climate Agreement, an additional reduction target of 3.5 megatons CO_2e by 2030, on top of the reference path, was set as target or ambition in the paragraph on agriculture and land use. But only one target could be narrowed down or specified to the primary dairy sector (a 0.8Mt CO_2e reduction of methane emissions by 2030). Some other targets – such as the aim to reduce emissions from peatland or sequestration of carbon in the soil – require a significant effort from dairy but can't be specified or done on the same scale, as they are categorized and reported in a different GHG group. Moreover, emissions that occur on the logistical and processing side of the dairy value chain are considered to be part of a different paragraph within the Climate Agreement. Even reductions in on-farm CO_2 emissions from fossil fuels (e.g. tractors using diesel) are deemed to be part of this paragraph.

This situation creates multiple layers of complexity. Dairy companies want to set targets, as they are receiving pressure from off-takers to reduce their emissions, but the lack of alignment between national governments and industry standards adds to the complexity, which could, in turn, hinder the rate of progress. This has also raised concerns within the dairy value chain that the industry will not be able to fully claim the rewards for their efforts and ambitions.

However, in the absence of common national guidance, individual companies have set their own requirements and targets.

Companies Are Taking Action To Reduce Upstream GHG Emissions

Increasingly, companies are relying on guidance in emissions reduction and net-zero target setting using the latest climate science, like the Scienced Based Targets initiative (SBTi). SBTi has specific guidance for the forest, land, and agriculture (FLAG) sector to support companies in aligning their emissions reduction targets with the goals of the Paris Agreement (limiting global warming to 1.5 degrees). Companies can set targets on a sector level, using absolute reduction targets, or on a commodity level (i.e. dairy), with intensity-based reduction targets. Worldwide, dairy and food companies have been increasingly committing to SBTi targets, creating validated reduction targets across the dairy sector in line with climate science. Companies need to set an SBTi-FLAG target (as opposed to standard SBTi targets) if they are part of a FLAG sector, such as forest and paper products, agricultural and animal-sourced food production, food and beverage processing, food and staples retailing, and tobacco, or if they are a company in any other sector with FLAG-related emissions that total more than 20% of overall emissions across scopes.

Science Based Targets initiative (SBTi)

SBTi is a partnership between CDP (formerly the Carbon Disclosure Project), the United Nations Global Compact, World Resources Institute (WRI), and the World Wide Fund for Nature (WWF). It aims to promote emissions reduction and net-zero target setting among the business community through providing clearly defined pathways for companies to reduce their GHG emissions. Targets are considered science-based if they are in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement. SBTi is active in 70 countries and covers 15 industries, such as cement and transport, as well as the FLAG sector. Decarbonization pathways under SBTi-FLAG are available in absolute sector emission reduction pathways, as well as commodity-specific, intensity-based pathways for 11 commodities in 26 regions. The reduction pathways and guidance focus on near-term (five- to ten-year) FLAG targets.

There Are Many Pathways to Achieving Targets

With more commitments being made and targets being set by either governmental bodies or companies themselves, the pathway to achieving these goals is important to consider. How these targets are achieved is not decided or specified in the target setting process, thereby allowing for innovations in potential GHG-reduction levers.

What We Know – Steps That Can Already Be Taken

There are already numerous GHG-reducing measures being brought forward by researchers, companies, and sector bodies, some of which are in the late stages of development or already being used in the dairy sector today.

Efficiency and Productivity Gains

Efficiency gains have (indirectly) been a significant factor in reducing on-farm emissions. Historical efficiency gains have been realized through a combination of improvements in genetics, feed efficiency and nutrition, farm practices, and animal welfare, contributing to higher milk yields and lifetime production per cow and lower replacement rates. In the Netherlands, for example, this contributed to a 35% decrease in carbon intensity per kilogram of milk between 1990 and 2019. As time and knowledge progresses, these efficiency gains and improvements will also contribute to future reductions in GHG emissions intensity, but to keep this progress going, a significant amount of on-farm management skills is required.

Feed and Feed Additives

Additionally, feed has been highlighted as a relevant source for considerable reduction potential. This ranges from reducing losses in the field and on the farm, to improving and maintaining the quality of feed when grown and stored, to changing feed rations for dairy cows. Much research has focused on the use of feed additives and their ability to reduce methane emissions in cows. In recent years, several such feed additives have entered the market or reached later stages of development. For example, Bovaer® (3-nitrooxypropanol) is a synthetic feed additive produced by the Dutch company DSM that suppresses enzymes in the cow's rumen so that less methane is generated, potentially reducing methane emissions from enteric fermentation in dairy cows by 30% without affecting milk productivity, based on pilots. The reduction potential varies depending on the farming system, as the potential in more intensive, controlled, and (seasonal) indoor farming systems appears to be somewhat higher. In practice, feed additives will raise operational expenses at the farm level. Furthermore, the application and monitoring of the dosage on the farm is relatively complex and requires appropriate management skills. As such, we expect that additives will likely be incorporated into compound feed in many countries. Bovaer® has been researched in over 50 peer-reviewed scientific studies and is already authorized and available for use in over 40 countries, including EU member states, Brazil, and Australia.

Manure Management

Another mitigation opportunity is through manure management (i.e. storage and application) and the adoption of anaerobic digestors, which can reduce emissions from manure. The digestors are used to stop gases from escaping manure lagoons and reaching the atmosphere, so they can, instead, be used for different purposes, such as fuel or renewable electricity. However, such installations in an on-farm setting are capital-intensive and are generally complex systems to operate, making their feasibility a challenge for farmers. Arguably, numerous measures related to manure management and storage are more (cost) effective in larger-scale and confinement farming systems.

Untapped Potential but Still Largely Unexplored

Other GHG mitigation measures that provide opportunities for reducing on-farm dairy emissions are currently being developed. Since these measures are still being explored, it's likely they will not significantly contribute to reaching GHG targets by 2030.

- Seaweed (Asparagopsis taxiformis) has shown potential to reduce methane emissions by up to 90%. However, scaling up aquaculture in order to commercially produce the seaweed can be a challenge, and the long-term effects on cows are still unknown.
- Genetics has indirectly contributed significantly to reducing on-farm emissions via efficiency gains, but it also shows potential as a lever to reduce emissions more directly by breeding cattle based on breeding values for low methane emissions. Indicators show that there are likely significant variations in enteric methane emissions between breeds and individual cows of similar breed within the same herd. Through exploiting natural genetic variation in dairy cows for methane emission traits, genetic selection plans could offer a cost-effective emissions mitigation opportunity. However, research is ongoing and looking further into the interaction between breeding objectives for environmental traits and breeding objectives for economically important traits, such as fertility and productivity.

Obstacles and Limitations to Realizing Reduction Potential

While these levers, in theory, offer strong mitigation opportunities, they vary in technical reduction potential, as well as adoption rate and current commercialization, which can make it difficult to predict their overall reduction potential in the coming years.

Many studies show the theoretical technical potential of a single measure's application at the farm level, generally assuming a maximum adoption level due to supportive incentives. As farming conditions differ greatly between farms and regions, the effectiveness starts to vary if the measure is applied by a larger group of farms where conditions are often not as optimal as in a pilot setting. The skills and time required to correctly apply and manage measures also influence the outcome.

Reduction potential can also not be stacked or accumulated endlessly. As mitigation measures are often complex, there may be correlations or links between them that affect their efficacy. If applied simultaneously, cause and effect often become blurry. In practice, applying one measure generally reduces the potential of the second measure.

Case Study: The Netherlands

From analyzing the situation in the Netherlands, we have learned that efficiency gains have (indirectly) contributed significantly to reducing on-farm emissions, with (some) measures already implemented on nearly all dairy farms. Economic and/or operational improvements, combined with limited operational expenditure (OPEX) and capital expenditure (CAPEX), also incentivize a high adoption rate. Overall, we anticipate the range of (untapped) potential in efficiency gains and operational improvements to dwindle due to a combination of diminishing returns and ongoing transitions in the Dutch dairy landscape. They are further complicated by (upcoming) additional regulations and targets to reduce ammonia emissions and nitrate leakage, possibly lowering the potential for efficiency gains.

In contrast, some levers, like feed additives and many manure management measures, are often relatively new and unknown to Dutch dairy farmers. At the same time, such levers often come with an increase in OPEX and CAPEX without clear economic advantages, guarantees, or compensation for the additional costs and may require a particular (management) skill set to realize the potential. As a result, the current adoption rate is low, and the untapped potential is high.

Incentives Are Needed To Increase Adoption of Mitigation Levers

Likely, the largest obstacle to reducing on-farm dairy emissions is not the technical potential but, rather, the feasibility of adopting mitigation practices. Some mitigation levers require little to no investment (e.g. farm practices that increase efficiency or certain generally small adjustments in management practices) and directly improve yields, lower costs, etc. In contrast, others have large theoretical reduction potential but also require a large upfront CAPEX for manure management and storage infrastructure or increase the OPEX to implement feed (additive) solutions, restricting the adoption rate.

Generally, neither OPEX nor CAPEX to reduce GHG emissions offers an economic advantage for an individual farmer at this moment. As a result, dairy farmers have to be triggered by government regulation, dairy processing company supply standards, premiums, or other incentives to meet sector or individual targets to increase adoption rates and untap the potential.

Three Requirements To Increase Momentum

As climate change is such a crucial aspect of the dairy value chain's future, gaining momentum in reducing GHG emissions is of the upmost importance. To increase momentum in the dairy industry, three important steps need to be taken.

First, alignment between government and industry targets is required to overcome (sometimes unnecessary) layers of complexity. At the same time, we need the dairy industry to embrace the need for an acceleration in GHG emissions reduction. By setting and increasing ambitions and targets, the industry has already taken the first steps in this direction. However, to gain momentum in the adoption rates of on-farm mitigation levers, farmers also need to be incentivized by the industry, through options like carbon tokens or premiums on top of the milk price. If mitigation doesn't gain momentum, the dairy industry could face the risk of government-enforced mitigation regulations that could be capital-intensive or even include herd reduction. From this perspective, it is better to take the lead rather than deal with the potentially harsher consequences that could come at a later stage.

Imprint

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Richard Scheper	Analyst – Dairy	richard.scheper@rabobank.com +31 62 385 1987
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