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Reducing cold chain GHG emissions in Norwegian fish and meat industry sectors

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ABSTRACT

The food chain represents a climate impact of major concern as it is a significant source of greenhouse gas (GHG) emissions. Norway has a long coastline with perfect conditions for salmon farming and well-established fisheries, in addition to a large area suitable for grazing, making seafood and meat important food sectors. Several companies in Norway have already taken steps to reduce emissions, while many still have a long way to go. In this paper, measures to reduce GHG emissions in the meat and seafood industry and the possibilities for reaching the goal of climate neutral food businesses are explored. The focus is post-harvest gate with emphasis on refrigeration. The objective was to identify the needs and measures of greatest impact within the Norwegian food industry. For that aim, interviews and a workshop with relevant companies were performed to share knowledge, discuss challenges, and create synergies. This paper summarizes the activities, the results, and the conclusions.

Keywords: food systems, cold chain, refrigeration, greenhouse gas emission, sustainability.

1. INTRODUCTION

Measuring sustainability through SDG index scores shows that for the second year in a row, the world is no longer making progress on reaching the SDGs. The list of SDG index scores is topped by four Nordic countries, yet these countries still face major challenges in achieving several SDGs, especially on goals 2 (zero hunger) and 12-15 (responsible consumption and production; climate action; life below water; life on land) (Sachs et al., 2022). Common for these goals is that they are all represented in the food value chain, underlining that a change in food systems is critical for sustainable development. A third of the global anthropogenic GHG emissions come from food systems, originating from all steps from production to consumption (Crippa et al., 2021). At the same time as being a driver to climate change, food systems are also being at risk from it (Dury et al., 2019). Other current risks in European food systems are a series of ongoing crises; war, energy crisis and the COVID-19 pandemic (FAO, 2022). This increases insecurity in food supply and forces new thinking.

According to the Farm to fork strategy, a change in the current practices is needed to reduce emissions and achieve the climate and environmental objectives of the Green Deal (European Commission, 2020). The challenges are global, however there are differences between countries and regions. Hence solutions must be seen in not only global food systems, but national and regional systems.

Livestock farming has a strong heritage in the Nordic countries. Norway has only 3% arable land, but about 50% of the total area is suitable for grazing (Bardalen et al., 2020), making meat production an important industry. The biggest industries in the Norwegian meat sector are pig, poultry, cattle and sheep. Norwegian meat industry also encompasses reindeer husbandry, mainly located in the indigenous Sámi area in the north. Seafood is another important food industry in Norway because of the long coastline with perfect conditions for salmon farming and well-established fisheries. The seafood industry in Norway consists of both wildly caught (traditional fishery) and aquaculture. Pelagic fishery (e.g., herring, mackerel and blue whiting) and aquaculture industry (especially salmon) are the main, representing about 4/5 of the total production volume (Fiskeridirektoratet 2021b;2021c). Of these, products from farmed fish are related to the highest GHG

emissions (Winther et al., 2020). Therefore, aquaculture was selected as the main focus when exploring the seafood industry in this work.

Many Norwegian companies still have a long way to go to reach the national goal of 50% emission reduction in 2030 and climate neutrality in 2050 (Bardalen et al., 2020). However, there are many cross-sectoral opportunities to discover, learn and inspire. The meat and seafood industry were explored in this paper due to their importance in volume and value creation, making them central for the work towards a more sustainable food system in Norway.

2. METHOD

Interviews and a workshop were performed to collect data on industry perception of emissions and sustainability from the Norwegian meat and seafood industry. The methods were different for the meat and seafood industry, but the aim and questions were formulated in the same way to ensure comparability.

To collect data from the Norwegian meat industry, interviews with a pre-defined thematic framework were conducted. The main topics were (1) introduction, (2) terms and definitions, (3) sustainability work, (4) goals and hopes for the future, and (5) barriers and opportunities. To find possible interview participants, an initial mapping of members from the Norwegian meat and poultry industry organisation (KLF) was conducted. To ensure a representative group from industry, a total of 35 small and large actors representing slaughter, processing, import and sale of pig, poultry, eggs, cattle, sheep, and reindeer were contacted by email and asked to participate in an interview. Potential research participants and their confidentiality were protected by obtaining approval from the Norwegian Data Protection Services (SIKT). Participants received information about the project's purpose and how interview data would be anonymized, stored and used. The interviews took place after informed (written) consent was secured.

To investigate industry perception from the Norwegian seafood sector, a national aquaculture conference was targeted. 104 participants from a variety of positions and companies within aquaculture were present. A stand was put up in the conference area where project members interacted with the conference participants. Color-coded sticky notes were used to collect and categorize data. The participants were asked to write down thoughts on (1) sustainability work, (2) goals and hopes for the future, (3) barriers, and (4) future opportunities.

3. INDUSTRY PERCEPTION OF EMISSION REDUCTION

Companies in the Norwegian meat industry described their industry using the words small (in size and volume), fragmented, and geographically dispersed with great distances in between actors. The industry consists of a few big dominating actors and multiple smaller ones. However, it was mentioned that there is a trend towards a decrease in number and increase in size of actors with larger productivity. The unique landscape of mountains and fjords in Norway making production and transportation logistics challenging was also mentioned. This has also been concluded by Kjuus et al. (2008) and Wood et al. (2019), who have explored Nordic food systems. The size distribution of actors is also seen in the Norwegian aquaculture, where the 10 biggest companies produced 67% of salmon and trout in 2021 (Fiskeridirektoratet, 2021a).

Most companies expressed proudness of the Norwegian food industry, frequently mentioning the low use of antibiotics in meat and fish production, and the production of meat and milk from the same cow (combi-cow) which has a lower carbon footprint than regular cattle meat. The next chapters will present input from actors in the meat and seafood sector regarding sustainability within the Norwegian food industry, as summarized in Fig. 1.

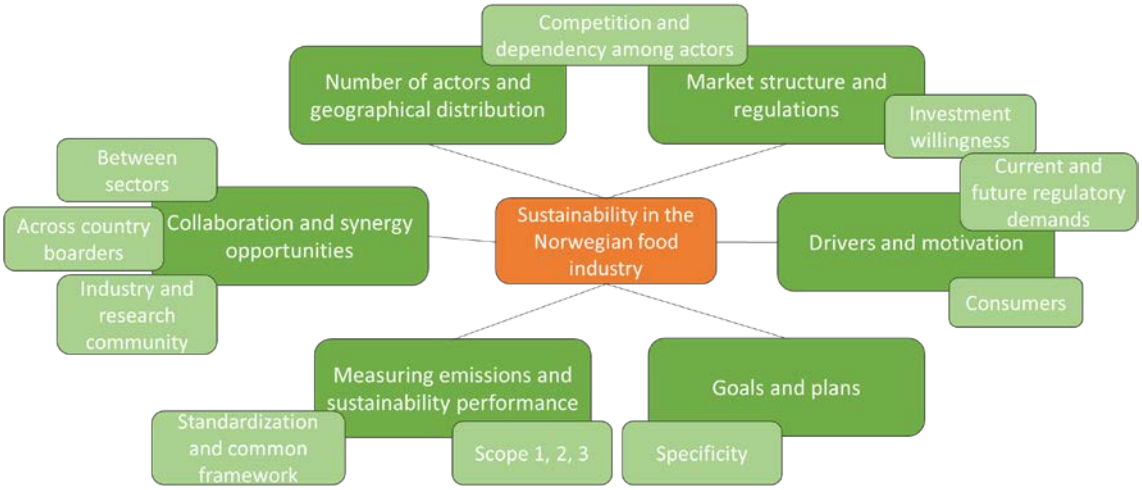

Figure 1: Overview of findings from the study regarding influencing factors on sustainability within the Norwegian food industry.

3.1. Market structure

Norway and other Nordic countries have a strong tradition of cooperative organizations in the food industry. The Norwegian meat industry is mainly divided in two; the cooperative Nortura (owned by 17100 farmers) and the private meat- and poultry industry (about 140 companies) organized in the meat and poultry industry organization KLF (Kjøtt- og fjørfebransjens Landsforbund). The cooperative tradition was also brought up by several companies in this work when asked to characterize the Norwegian food industry. Unique for Norway is that the dominant cooperatives have the responsibility for market regulations within their respective areas (Kjuus et al., 2008). This makes Nortura the market regulator for meat and eggs in Norway. Several meat actors described the close relationship with regulatory authorities and cooperatives as a challenge being too controlling for the companies and creating competition between actors. It was also mentioned as a limiting factor for change, as it can be difficult to advocate for change without support from the biggest companies and cooperatives. Kjuus et al. (2008) also proposed that the Norwegian meat industry structure has contributed to increased conflict rate between private actors and cooperative companies.

The Norwegian seafood industry has a tradition for cooperatives only in the fisheries, where five sales organizations (cooperatives owned by the fishermen) exercise public authority for the Directorate of Fisheries to handle the marine sales laws (Pettersen and Kårstad, 2021). The Norwegian aquaculture deviates from this tradition, where most fish farming companies are stock corporations and private ownership companies (Nøstbakken and Selle, 2019). The seafood actors in this work still described regulations as a barrier for increased sustainability, mentioning regulations regarding the use of sludge and novel feed ingredients as important barriers.

The Norwegian grocery retail market is also characterized by several cooperations and integration forms, dominated by a handful of the largest grocery store chains. It is also a high degree of vertical integration, with wholesale and retail functions typically owned by the same company (Kjuus et al., 2008). For example, the three largest poultry companies in Norway have close and integrated relationships with each of their grocery chain (Pettersen and Kårstad, 2021). The position of power held by the grocery store chains was stated to be a driver for emission reduction from the companies in this study. Retail stores are demanding more sustainable products and have specific requirements and indicators to follow, pushing the industry to make changes to be able to sell their products in the stores.

3.2. Sustainability perception and work

When asked about how sustainability is defined and perceived, several of the companies from both seafood and meat industry expressed that the term is worn out and has “lost” its meaning. This challenge was also mentioned in a report from Bardalen et al. (2020)., who stated that the unclear definition of sustainability

from the start has led to a weakening of the word's credibility. Vague formulations and underlying economic interests can lead to a varying degree of dedication, and confusion among both industry and consumers.

Large variations were identified within how and why companies in the Norwegian food industry included sustainability in their strategy. Some companies had been working systematically with sustainability for many years and had dedicated positions this, while other companies had just recently put it on the agenda and could not afford dedicated personnel for this.

The companies expressed that consumer demand was one of the motivations for working towards reduced emissions, however it was underlined that even though the consumer allegedly is more aware and wants to take sustainable choices, price is often the determining factor at the end. Other industrial drivers for decreased emissions were increased profit, meeting future demands from the government and EU, and requirements from the retail stores.

3.3. Sustainability goals and measurement of performance

All the participating food industry actors had sustainability on the agenda and had specific goals for their company. However, large variations were identified in the ambitiousness and specificity of the goals, ranging from covering a limited number of SDGs to detailed and measurable goals tailored for the specific industry. There were also variations in how open and available these goals were for the public. A complete overview of the sustainability goals and measures taken by the companies in this work is presented in Table 1. Many of the participating companies stated that they aim to be climate neutral or climate positive by 2050, and one company aimed to reach this already in 2030. Other goals that were mentioned by several actors were related to biodiversity, health, waste, energy efficiency, packaging, animal welfare, and feed. Most of these goals focuses primarily on the production step, an issue that is explored further in section 3.4.

Many of the companies in this study had already started monitoring their own GHG emissions and the reduction measures, documenting it in either internal or public reports available on their websites. However, such data monitoring and calculations were based only on scope 1 (direct emissions from own production) and scope 2 (indirect emissions from e.g. heating and cooling). Some companies wanted to expand their analysis to scope 3 (emissions from further out in the chain), but underlined that this would require more resources than what most companies have at place today.

The large differences between sustainability goals and emission measurements between food actors was also reported by Bardalen et al. (2020), who looked at sustainability goals and reports of some Norwegian food actors. The authors did not find examples of companies reporting comprehensively in all dimensions of sustainability. Common for all the initiatives and measurements today are that they are created by individual actors of the industry based on own judgment and evaluation. This can contribute to huge differences between similar actors and can confuse the consumer. Many companies also highlighted "greenwashing" as a concern when actors can choose what indicators to monitor and present.

The differences in sustainability measurements can also be related to the lack of a common framework on how monitor and calculate emissions. Even though some companies already measure and report emissions, several meat and seafood actors stated that they miss a standardized set of indicators as well as the procedure of collection, storage and sharing of emission data. According to Bardalen et al. (2020), there is already a lot of data collection in the Norwegian meat industry. However, this data is not in a universal system, but in a range of data bases, formats and with different owners of the data. The same conclusion was drawn by Winther et al. (2020) when gathering energy data from fish farms, service vessels and well boats; necessary data are already being monitored, but are not structured into a common management system available for all. This can complicate documentation and make comparison of performance among similar actors difficult. Standardisation of emission monitoring and sharing could also enable knowledge transfer between different parts of the cold chain of both meat and fish. This way one can find the greatest measures to obtain a more sustainable food chain in a system perspective (DNVA, 2022; Wood et al., 2019).

Table 1: Sustainability goals and measures for meat and seafood actors participating in the work.

Sustainability cat.	Meat industry	Seafood Industry	Both Industries
Resource use, including food loss and waste 	Reduce food loss and waste with 75% Increase shelf life of products. Use companies such as TooGoodToGo to reduce waste. Utilize faulty production. Make use of the whole animal. Buy guarantees of origin for water. Use all resource and avoid overproduction.	Use all resources, also dead fish. Increase use of sludge to recover nutrients, produce biogas, fertilizer, pyrolysis, feed for insects. Collect 1/3 sludge (dry weight) per kg feed. Use Integrated Multi-Trophic Aquaculture (IMTA) to recycle nutrients.	General focus on increased utilization of resources. Increase use of byproducts as animal feed or in fertilizer production Explore and research the food safety aspect of using rest raw material and sludge for feed production.
Energy use 	Increase use of renewable energy sources (solar panels, wind power etc.). Use of energy savings measures: LED lights, reduce leakages, heat recovery. Have efficient cooling processes. Have energy efficient barns by 2027. 30% reduction in energy use.	Use sludge as an energy source such as biochar or biogas.	Reuse spillover heat in factory/farm or in neighboring factories.
Climate footprint 	Reduce scope 1 and 2 emissions with 70% by 2030. Reduce scope 3 emissions with 50% by 2030. Become climate positive by 2030. Be climate neutral by 2030 (or 2025) (at least for scope 1 and scope 2) Aims to reduce emissions in factory. Label all products with climate footprint.	Use technological development and automation to reduce emissions. Increase production with minimal emissions and negative consequences. Reduce plastic pollution	Reduce emissions
Feed 	Reduce GHG emission from feed production with 50%. Norwegian/locally produced feed, Reduce use of ingredients that could have gone to human consumption. 100% soy free feed.	Reduce fish mortality will also reduce feed consumption. Use feed ingredient from a lower trophic level. Reduce feed loss by using AI and video tools.	Use of novel feed ingredients (desire a change in regulations). Increase feed efficiency. Less imported soy as feed in ingredient.
Packaging and waste 	Use less and thinner plastic packaging. Have less “air” in packaging. Use “climate smart” and recyclable packaging. Sort waste. Minimize packaging waste.	Collect and reuse sludge	Waste can be delivered to biogas production. Reduce and recycle waste
Value chain 	Aims to streamline factories. Have fewer and bigger farms. Optimize processing. Bonuses for sustainability performance Use bigger trucks to increase transport load and reduce number of trips. Have electrical vehicles by 2025.	Increase production with maximal profits and minimal emissions and negative consequences. Have a fully integrated value chain. Use data and technology to enhance decision making.	Have profitable operations.
Biodiversity 	Aims to have no loss of biodiversity. 30% reduction of area use.	No lice or escapes of farmed salmon to protect wild salmon population. Protecting biodiversity and marine ecosystems.	Conserving the rainforest (by reducing or replacing soy from Brazil)
Social aspects and consumption 	Reduce fat and salt in products. Support the Sami culture through reindeer production. Increase price per kg, reduce volumes. Increase production of meat replacement products	Salmon is healthy source of protein and omega-3 fatty acids. Support rural value creation and indigenous relationships. Ensure human rights.	Produce healthy animal protein and contribute to public health. Support employees and the local community Contribute to decent payment throughout the value chain.
Animal welfare 	Limit the use of medicines. Limit number of animals per area. Have free-ranging animals. Employ veterinarians on farms. Produce more on the animal's principles. Reduce feed related diseases with 40%.	Reduce escapees and sea lice by using new production forms such as closed cages. No disease or pain for the fish. Image/AI measurements of welfare. Reduce farmed fish mortality. Increase animal welfare for cleaner fish used in salmon production.	Ensure good animal welfare.
Sustainable Development Goals	7, 8	6, 1, 17	2, 3, 4, 5 , 9, 12, 13, 14, 15

3.4. Focus on the production step and lack of system thinking

Common for actors within both the meat and seafood sector was the major focus on the production side when discussing emissions, especially focusing on resource utilization and reduced waste.

For the meat industry, the greatest concerns were emissions from ruminant husbandry. As for resource utilization and waste, the focus was mostly on using the whole animal, e.g. producing sausages of cut-offs, and reduce plastic packaging. Actors within the aquaculture industry expressed that the use of rest raw materials is already quite high, and that their main challenge regarding resource utilization is the high mortality and reduced growth caused by salmon lice and disease, leading to resource waste in terms of feed, energy, fuels, and chemicals. It was also reported an increasing interest in the use of sludge as a valuable by-product from aquaculture. The focus on the production step can indicate a lack of system thinking in the Norwegian food industry. According to Wood et al. (2019) an integrated, whole food system approach is essential for transformation towards sustainable food chains.

The Norwegian industry focus on emissions from the production step also reveal a gap from the current emission status in European food chains. On a global scale there has been a doubling of emissions from processes from pre- and post-production, and for European production these numbers are higher than for farm gate emissions and land use change (Tubiello et al., 2022). Hence there lies great opportunities for emission reduction in Norwegian food industry if the focus is moved also further out in the food chain. Producing perishable food products, both seafood and meat industry are depending on cooling as an important part of post-production. As temperature control is energy demanding and can result in GHG emissions and leakage of refrigerants with high GWP, there are several measures that can be taken to improve the cold chain. If done sufficient, it can also decrease food loss in the chain (UNEP and FAO, 2022). Winther et al. (2020) found that phasing out refrigerants with high climate emission potential onboard fishing vessels was one of the main reasons why GHG emissions from capture fisheries have been reduced the last years. The authors underlined the importance of shifting to natural refrigerants and avoiding taking the step over HFCs with high global warming potential. This importance is transferable to the aquaculture and meat industry as well, and monitoring and identifying means of reduction of HFC refrigerants is highly recommended.

3.5. Growth and investment willingness

Two major differences between Norwegian aquaculture and the meat industry identified in this work are the growth ambition and the willingness and possibilities to invest in new technology and equipment for emission reduction. In the aquaculture industry there are clear ambitions for growth, both from the industry and the government side. Actors in this study expressed that there are major challenges that limits the growth, however the investment willingness from the producers and technology suppliers is high. This can be explained by Norwegian aquaculture being one of the fastest growing industries, exporting salmon for over seven billion Euros in 2021 (Fiskeridirektoratet, 2021a). Actors in the meat industry on the other hand, expressed that the focus on high profits in the industry acts as a limiting factor towards increased sustainability. They highlighted that growth should happen through increased value per product and not in increased production volume. This is currently being done by several meat industry actors through product development of e.g., vegetarian meat-replacing products, driven by a decreasing demand for meat consumption among consumers.

When asked about investment willingness and new thinking, several participants mentioned the energy crisis as both an obstacle and an opportunity for emission reduction in the industry. Increased energy prices leave less room to prioritize investments and research to become more sustainable. Simultaneously, companies report that the increased energy prices also have driven the transition towards more efficient energy use. Examples are energy recovery, heat recovery and investment in renewable energy sources such as installations of solar panels. These investments usually pay off, especially when energy prices are high. However, it was stated that not all actors have the finances to initiate such investments. Several companies also expressed a symbiotic collaboration with neighbouring companies, either using or providing surplus heat

or cold. Such energy optimization measures can be transferable to other sectors and can be an opportunity to create synergies if experiences and knowledge are shared across actors in the food chain.

3.6. Collaboration and synergy opportunities

A common perspective on ocean- and land-based food production is important to create synergies to reduce emissions and move towards sustainability (DNVA, 2022). Even though the meat and seafood industries are different in structure, finance and policies, the current work revealed some common challenges and opportunities for emission reduction. Here lies possibilities to create synergies. Both industries expressed a wish for a common set of indicators for monitoring and sharing emission data. In addition, they are both depending on the use of refrigeration in the cold chain, from processing to consumer. A sufficient cold chain is also key for reducing post-harvest food loss and waste by extending shelf life of food products (UNEP and FAO, 2022), a topic which all the participants in this work were concerned about.

Food chain actors in this work also mentioned increased collaboration across Nordic country borders as an opportunity to reduce emissions. Nordic countries share many strengths and challenges. Having wealthy economies and strong social and institutional foundations with high levels of social and political trust makes Nordic countries well positioned to make crucial steps in research and innovation, as well as implementing new technology in the industry. Another Nordic advantage is the strong preference for collaboration among relevant stakeholders, used widely in project funding and policy development (Wood et al., 2019).

The collaboration preference was also mentioned by several food actors in this work. The industry expressed a desire for better information between industry and research communities, as not all actors are aware of the opportunities for collaboration and available funding types from e.g. the Norwegian research council. Several participants also highlighted that poor communication between industry and research communities can lead to new technologies promoting emission reduction never are taken into use. Wood et al. (2019) also stated that collaboration between researchers and food system actors can enhance legitimacy, ownership and political acceptance of research on emission reduction. These opportunities are currently being explored in several ongoing projects, for example the H2020 project ENOUGH and the NFR project CONNECT (see acknowledgements).

3.7. Limitations of the study

Most of the participating companies in this work had ambitious targets and a clear sustainability strategy, however it should be noted that the study had a small sample size. Participation was voluntarily and information about the purpose of the study was given in advance, possibly yielding a bias among participants already being interested in sustainability work. The statements from the participants can still give an indication on opinions and trends in the Norwegian food industry. Hence the results of this study give no clear conclusion, but rather suggestions for further work and focus to reduce emissions in the Norwegian food chain.

4. CONCLUSIONS

Norway's nature and climate specific prerequisites makes meat and fish production important. However, the industry experience big challenges regarding emissions and sustainability. In this work, challenges and opportunities regarding sustainability were explored through interviews and a workshop with actors from the Norwegian meat and seafood industry. The actors explained sustainability as a confusing term with lack of standardization for the specific industry. All actors in this study had sustainability on their agenda to some extent, but goals and prioritizations varied from company to company. Economy was the main factor determining the degree of sustainability work in the actors.

Common for the meat and seafood industry actors was that the biggest concerns regarding emissions were in the production step. These concerns were linked to emissions from ruminants and feed in the meat industry, and feed and high mortality rates among aquaculture actors. In addition, ownership forms, cooperatives and market regulations were regarded as a challenge in the meat industry.

The paper identified a gap between industry perception of emissions and the status in European food chains. Even though emissions from the production step are regarded as highly important, there are big challenges in the steps before and after production in the food chain, which seems to have a smaller focus among Norwegian meat and seafood industry actors. If one look at opportunities and solutions to reduce emissions further out in the food chain, the importance of refrigeration is common for both meat and seafood as perishable food products. Looking for solutions in the cold chain can create synergies in the meat and seafood sector and reduce food loss if done sufficiently. Collaboration and knowledge transfer regarding energy optimization in terms of utilizing surplus heat and cold is also identified as a synergy opportunity.

Suggestions for further work are closer collaborations among meat and seafood actors for investigating energy optimization and emission reduction in the cold chain, both in Norway and across country boarders. Standardizing monitoring and reporting of emission data is desired in the industry and can clear the way for considering the seafood and meat sector as one food system. Lastly, it is suggested to increase collaboration between industry and research communities, to ensure that innovative technologies on emission reduction are being developed and taken into use.

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