Financé par le gouvernement du Canada
Funded by the Government of Canada
Canada
Funded by the European Union
Financé par l'Union européenne

EU-CANADA CETA AGRICULTURE DIALOGUE WORKSHOP

GHG Reduction in Livestock Production

OUTCOMES REPORT

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ACKNOWLEDGEMENTS

We would like to thank the research and policy experts of the Directorate General for Agriculture and Rural Development of the European Commission, and Agriculture and Agri-Food Canada for their support throughout this project.

EXECUTIVE SUMMARY

This outcomes report is an outgrowth of the second in a series of five joint events between Canada and the European Union (EU) "to promote sustainability, environmental stewardship and climate action in agriculture, within the framework of the Agriculture Dialogue" under the Canada-EU Comprehensive Economic Trade Agreement (CETA)[1]. This workshop, titled Greenhouse Gas (GHG) Reduction in Livestock Production, brought together over 110 Canadian and European livestock sector stakeholders. These workshop participants explored the policy context, as well as good practices, research and innovation for GHG reduction in livestock production. A final wrap-up conference will summarize the reports from the various workshops (i.e., soil health; GHG reduction in livestock production; fertilizer use in agriculture; pesticide use in agriculture; and organic agriculture).

This report synthesizes what was heard at the workshop; the report does not provide a comprehensive overview of the latest policy and research on GHG reduction in livestock production. As a result of the focus in some discussions, some subsections of the report provide more detail on the experiences in the European Union, while other subsections delve further into the Canadian context. Similarly, some discussions focused more on one sector, such as beef cattle, devoting less time to other sectors, such as dairy cattle and other ruminants.

Workshop participants discussed enteric methane emissions from grain- and pasture-based diets, as well as manure management and treatment of effluents. Stakeholders identified the following issues and challenges to the reduction of GHG emissions from livestock production:

Overarching issues and challenges

- Regional and production-system differences prevent the application of a "one-size-fits all" approach
- The broader picture is complex, because stakeholders must identify and mitigate potential trade-offs (e.g., biodiversity, animal health and welfare, and pollution swapping)
- Need to take a systems approach to assessing GHG emissions from integrated crop-livestock systems
- Increased work and/or costs for livestock producers to implement current GHG mitigation strategies
- Research and data collection limitations, which result in knowledge gaps for the broader sector
- Challenges with the regulatory approvals process which can delay the adoption of new products and technologies
- Public perceptions and regulations can cause barriers to the adoption of GHG reduction strategies

1 Canada-European Union. (June 2021.) European Union-Canada Summit – Joint Statement, p. 3-4. Retrieved from https://pm.gc.ca/en/news/backgrounders/2021/06/15/canada-european-union-summit-joint-statement.

Enteric methane emissions

Grain-based diets

- Challenge of deciding how, exactly, to attribute GHG emissions to different sectors within the agricultural industry (e.g., the grains and oilseeds sector versus the livestock sector)
- High level of feed efficiency in grain-based production systems limits opportunities for "easy wins" in terms of production improvements to decrease GHG emissions
- Need to increase by-product use and the upcycling of food waste in grain-based systems

Pasture-based diets

- The climate constrains the grazing season
- The options for the use of feed additives are limited
- Need to develop management practices and forage varieties that optimize quality and lower GHG emissions
- GHG emissions measurement systems are limited. Some mitigation strategies should be validated under pasture-base systems

Manure management and treatment of effluents

- Costs to install and repair manure management systems
- Added responsibilities to monitor these management systems
- Specialized knowledge required to manage anaerobic digesters
- Limited use of anaerobic digesters in Canada
- Acidification of manure is only possible in open tanks
- Acidification is scarcely used in Canada and poorly used in Europe
- Lack of an ammonia policy in Canada
- Need for greater adoption of manure management practices such as composting

Despite this broad range of challenges, livestock sector stakeholders were optimistic about a range of beneficial management practices and research initiatives to reduce enteric methane emissions, as well as GHG emissions from manure and effluents. Farmers, researchers, other stakeholders in the agri-food value chain, and policymakers all must contribute to the shared goal of reducing these GHG emissions, workshop participants said.

As the EU and Canada continue their work, they can consider the following 14 recommendations.

RECOMMENDATIONS FOR THE SCIENTIFIC COMMUNITY

Recommendation 1

Strengthen scientific networking between the EU and Canada to address regional, national and global gaps in knowledge related to GHG emissions in livestock production.

Recommendation 2

Collaborate to enhance tools for quantifying GHG emissions in livestock production. These tools must recognize regional and production system differences.

Recommendation 3

Continue efforts to standardize the approach to lifecycle analysis (LCA) models, particularly around emissions from feed production and valuable animal by-products.

Recommendation 4

Deepen knowledge on existing national and regional farm management decision-making tools for GHG emissions reductions in farming systems, including livestock production systems. Explore opportunities for fine-tuning these tools and adopting them in multiple sectors.

Recommendation 5

Prioritize research projects that support the circular economy, particularly in terms of practical opportunities to support nutrient recovery from manure and increased use of by-products and food waste as feed.

Recommendation 6

In addition to the effects on GHG emissions, assess the impacts of feed additives on livestock productivity and performance.

Recommendation 7

Develop a systems approach to reducing GHG emissions by exploring how to best incorporate multiple beneficial management practices within each production system.

RECOMMENDATIONS FOR POLICYMAKERS

Recommendation 8

Take a holistic and systems approach to ensure policies do not cause unintended consequences (e.g., pollution swapping) and to ensure policies are workable at the farm level.

Recommendation 9

Develop farm support programs (e.g., cost-share programs, carbon credits) that incentivize producers to adopt beneficial management practices that reduce GHG emissions.

Recommendation 10

Seek opportunities, where appropriate, to streamline the regulatory approvals process for products and technologies that reduce GHG emissions while maintaining the rigorous commitment to ensuring animal welfare and food safety and minimizing environmental impacts.

RECOMMENDATIONS FOR ALL LIVESTOCK PRODUCTION STAKEHOLDERS

Recommendation 11

Leverage a multi-disciplinary (e.g., sciences and social sciences) and multi-stakeholder approach (e.g., government, researchers, farmers and industry suppliers) to address GHG emissions in livestock production. This work must communicate the urgency of GHG emission reduction strategies, the research findings, and the beneficial management practices that livestock producers use.

Recommendation 12

Develop case studies and models to support a collaborative, community approach to the use of anaerobic digesters to overcome challenges of scale, which limit the adoption of this technology.

Recommendation 13

Leverage the role of retailers to support and encourage farmers in the adoption of GHG mitigation strategies by offering premiums or incentives for livestock products produced with low GHG emissions.

Recommendation 14

Develop public awareness campaigns to showcase the relationships between livestock production, human food, and the environment.

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INTRODUCTION

INTRODUCTION

1.1 · EVENT AND REPORT CONTEXT

In June 2021, at the Canada-European Union Leader's Summit, the leaders committed to "launch a series of joint events to promote sustainability, environmental stewardship and climate action in agriculture, within the framework of the Agriculture Dialogue" under the Canada-EU Comprehensive Economic Trade Agreement (CETA)[2].

A series of five events will explore the policy context and showcase good practices, and research and innovation taking place in Canada and the EU. This workshop, titled Greenhouse Gas (GHG) Reduction in Livestock Production, was the second in the series. The workshop was held online on March 10, 2022, from 8:45 am EST to noon (14:45 – 18:00 CET). Over 110 livestock production stakeholders in Canada and the EU attended the event, including:

- Researchers and academics;
- Government officials;
- Not-for-profit representatives;
- Farmers;
- Industry stakeholders.

EU-Canada CETA Agriculture Dialogue Sustainability Workshops

1) Soil Health (See the Outcomes Report)
2) Greenhouse Gas Reduction in Livestock Production
3) Fertilizer Use in Agriculture
4) Pesticide Use in Agriculture
5) Organic Agriculture

A final wrap-up conference will summarize the reports from the preceding workshops.

The objectives of the GHG Reduction in Livestock Production workshop were as follows:

- To enhance collaboration on GHG reduction in livestock production between EU and Canadian stakeholders representing government, civil society and academia;
- To facilitate shared learning with a focus on enteric methane emissions from both grain- and pasture-based diets, as well as manure management and treatment of effluents.

To accomplish these objectives, the GHG Reduction in Livestock Production Workshop began with a panel discussion with EU and Canadian experts on the relevant policy context. Next, workshop participants split into breakout sessions, where subject-matter experts discussed the issues and challenges to resolution for reducing GHG emissions in livestock production. Finally, the workshop participants returned to the plenary session where policy and subject-matter experts collaborated to explore ways to address these challenges and advance mitigation efforts at regional and international scales. (Please see Annex 6.1 for the full workshop agenda.)

2 Canada-European Union. (June 2021.) European Union-Canada Summit – Joint Statement, p. 3-4. Retrieved from https://pm.gc.ca/en/news/backgrounders/2021/06/15/canada-european-union-summit-joint-statement.

This Outcome Report synthesizes the discussions and findings from the workshop; the report does not provide a comprehensive overview of the latest policy and research on GHG reduction in livestock production. As a result of the focus in some discussions, some subsections of the report provide more detail on the experiences in the European Union, while other subsections delve further into the Canadian context. Similarly, some discussions focused more on some sectors, such as beef cattle, devoting less time to dairy cattle and other ruminants.

The paper provides an overview of the situation, in terms of the current state of GHG emissions in livestock production and the global challenges related to reducing these emissions. The relevant policy context in the EU and Canada is outlined, as well as the joint initiatives and efforts. A more detailed overview of the topics of enteric methane emissions, and manure management and the treatment of effluents follows the policy context. The report outlines the issues and challenges to resolution and explores potential solutions. The report concludes with a series of recommendations for livestock production stakeholders in Canada and the EU to collaborate to enhance knowledge and the adoption of practices that reduce GHG emissions from the sector.

1.2 · GHG REDUCTION IN LIVESTOCK PRODUCTION: SETTING THE CONTEXT

Globally, the demand for livestock products is increasing as the world population rises and becomes more urbanized, and as incomes grow in developing countries[3]. Agricultural industry stakeholders must determine how to meet this growing demand for livestock products while minimizing the environmental impacts of this sector, which accounts for 14.5% of GHG emissions linked to human activity[4].

The three key GHGs from the livestock sector are:

- Methane (CH_4), which is produced through the rumination (digestive) process, as well as manure storage and processing[5]
- Nitrous oxide (N_2O), which is produced from manure storage, urine deposition on pasture, fertilizer application (organic and mineral), and mineral nitrogen fertilizer synthesis
- Carbon dioxide (CO_2), which is produced through feed production, processing, and transportation, as well as mineral fertilizer synthesis and energy consumption[6]

3 G. Grossi, P. Goglio, A. Vitali and A. Williams. (January 2019.) "Livestock and Climate Change: Impact of Livestock on Climate and Mitigation Strategies." *Animal Frontiers*. Vol. 9, No. 1, p. 69.

4 P.J. Gerber, H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci, and G. Tempio. (2013.) *Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities*. Food and Agriculture Organization of the United Nations, p. xii.

5 P.J. Gerber, H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci, and G. Tempio. (2013.) *Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities.* Food and Agriculture Organization of the United Nations, p. 14 and 17.

6 P.J. Gerber, H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci, and G. Tempio. (2013.) *Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities.* Food and Agriculture Organization of the United Nations, p. 20.

These GHGs have significant climate change potential. However, the lifespan of the different GHGs varies; methane has a short half-life of approximately 10 years, while nitrous oxide and carbon dioxide have much longer half-life[7]. While the reduction of methane emissions is a powerful lever to slow global warming[8],[9] carbon dioxide emissions must also be reduced; a holistic approach to addressing GHG emissions is crucial.

ENTERIC METHANE EMISSIONS

Ruminants consume cellulose (more generally plant cell-wall components), which is an important carbohydrate produced by photosynthesis. Humans cannot digest cellulose; ruminants can. So, the livestock sector converts this carbohydrate into products humans can use: meat and milk.

Through enteric fermentation, bacteria, methanogen microorganisms, and fungi in the ruminants' forestomach break down the feed the animal eats, converting it into energy and microbial protein. The fermentation process also produces carbon dioxide and methane, which the animal releases through eructation (belching). The amount of enteric methane produced is most dependent on the level of feed intake, the type of feedstuff and the digestibility of the diet[10].

Emissions vary between grain-fed and pasture-fed diets. Depending on the quality of the pasture, grass-fed cattle can take longer to reach market weight than their grain-fed counterparts, and animals on grass-fed diets typically have higher methane emissions on an intensity basis (i.e., emissions per unit of animal product)[11]. However, permanent grasslands can serve as carbon sinks, which can help to compensate for the GHG emissions from livestock[12]. Grain-fed livestock production systems depend on the production of crops for feed, which can lead to competing demands for cropland use and also create GHG emissions. Local production strategies, such as pasture management[13], also influence emission intensities. Livestock on high-quality pasture can have high performance and lower emissions.

7 United Nations. (January 2022.) "5 things you should know about the greenhouse gases warming the planet." *UN News*. Retrieved from: https://news.un.org/en/story/2022/01/1109322.

8 Ilissa B Ocko, Tianyi Sun, Drew Shindell, Michael Oppenheimer, Alexander N Hristov, Stephen W Pacala, Denise L Mauzerall, Yangyang Xu, and Steven P Hamburg. (May 2021.) "Acting rapidly to deploy readily available methane mitigation measures by sector can immediately slow global warming." *Environmental Research Letters* 16, 5. Retrieved from https://iopscience.iop.org/article/10.1088/1748-9326/abf9c8?addl_info=2021%0AThe%20fastest%20way%20to%20slow%20warming.

9 Michelle Cain, John Lynch, Myles R. Allen, Jan S. Fuglestvedt, David J. Frame and Adrian H Macey. (2019). "Improved calculation of warming-equivalent emissions for short-lived climate pollutants." *Climate and Atmospheric Science 2:29*. Retrieved from https://doi.org/10.1038/s41612-019-0086-4.

10 E.M. Ungerfeld, K.A. Beauchemin, and C. Muñoz. (2022.) "Current Perspectives on Achieving Pronounced Enteric Methane Mitigation from Ruminant Production." *Frontiers in Animal Science*. Vol. 2, p. 3. Retrieved from: https://doi.org/10.3389/fanim.2021.795200.

11 A. Broocks, E. Andreini, M. Rolf, and S. Place. (March 2017.) "Carbon Footprint Comparison Between Grass- and Grain-finished Beef." Oklahoma State University. Retrieved from: https://extension.okstate.edu/fact-sheets/carbon-footprint-comparison-between-grass-and-grain-finished-beef.html.

12 P.J. Gerber, H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci, and G. Tempio. (2013.) Tackling Climate Change Through Livestock: *A Global Assessment of Emissions and Mitigation Opportunities*. Food and Agriculture Organization of the United Nations, p. 41.

13 A.N. Hristov, J. Oh, C. Lee, R. Meinen, F. Montes, T. Ott, J. Firkins, A. Rotz, C. Dell, A. Adesogan, W. Yang, J. Tricarico, E. Kebreab, G. Waghorn, J. Dijkstra, and S Oosting. (2013.) *Mitigation of Greenhouse Gas Emissions in Livestock Production – A Review of Technical Options for Non-CO_2 Emissions*. Edited by Pierre J. Gerber, Benjamin Henderson and Harinder P.S. Makkar. FAO Animal Production and Health Paper No. 177, p. 52.

MANURE MANAGEMENT AND THE TREATMENT OF EFFLUENTS

The amount of GHG emitted as methane and nitrous oxide through manure storage or processing "is linked to environmental conditions, type of management and composition of the manure," with the organic matter and nitrogen levels being key factors[14]. For example, liquid manure stored in a lagoon or tank typically has higher methane emissions, while solid manure that is composted and/or land applied has higher nitrous oxide emissions.

14 G. Grossi, P. Goglio, A. Vitali and A. Williams. (January 2019.) "Livestock and Climate Change: Impact of Livestock on Climate and Mitigation Strategies." *Animal Frontiers.* Vol. 9, No. 1, p. 70.

2

POLICY CONTEXT

2 · POLICY CONTEXT

2.1 · EU POLICIES

The EU recognizes that animal agriculture contributes to GHG emissions globally, but also plays a crucial role in the economic vitality of the farm sector in Europe. Solutions to this global challenge must target environmental, social, and economic aspects of agriculture.

The European Green Deal charts a path to climate-neutrality by 2050 and the Farm to Fork Strategy outlines how the agri-food industry will help attain this goal, including areas of actions that will reduce the environmental impact of livestock farming. The Strategy also presents plans to enable producers to tap into the circular bioeconomy where animal manure and animal waste can be used to generate renewable energy.

The European Commission's priority is to support the scale-up of climate solutions to reduce GHG emissions from agriculture. The European Green Deal contains key components to facilitate the scaling up of solutions.

The new Common Agricultural Policy (2023 – 2027) will be committed to ensuring a sustainable future for European producers and 40% of the budget will be relevant to climate action[15]. In step with the European Green Deal, the new Common Agricultural Policy will be a key tool for reaching the targets in the Farm to Fork Strategy and Biodiversity Strategy.[16] The Common Agricultural Policy's green architecture is based on three pillars:

- Environment and climate;
- Public, animal and plant health;
- Animal welfare.

New enhanced conditionality for farmers includes 9 Good Agricultural and Environmental Conditions,[17] and 11 Statutory Management Requirements. In terms of mitigation of climate change, the goal is two-pronged: reduce emissions and increase carbon sinks simultaneously.

€387 billion in funding has been allocated to the Common Agricultural Policy for 2021-27. €291.1 billion will come from the European agricultural guarantee fund, while the remaining €95.5 billion will come from the European agricultural fund for rural development.

The Zero Pollution Action Plan is an initiative under the European Green Deal that details the action needed to reach key milestones by 2030 and to be on track for zero pollution by 2050. For example, by 2030, the EU plans to "improve soil quality by reducing nutrient losses and chemical pesticides' use by 50%." This, together with strengthened action for cleaner air, will require livestock producers to implement advances in manure management[18].

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15 European Commission. (December 2021.) "The new common agricultural policy: 2023-27." Retrieved from https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en.

16 The Biodiversity Strategy seeks to "protect nature and reverse the degradation of ecosystems" to benefit people, the planet, and climate. See European Commission. (n.d.) "Biodiversity strategy for 2030." Retrieved from https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en.

17 Please see Annex III for more information on rules on conditionality. European Parliament. (December 2021.) "Regulation (EU) 2021/2115. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2021.435.01.0001.01.ENG.

18 European Commission. (May 2021.) "Zero Pollution Action Plan." Retrieved from https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_en.

The EU Methane Strategy also stems from the European Green Deal. This Strategy is a comprehensive policy framework covering cross-sectoral and sector-specific actions within the EU and internationally to reduce methane emissions. The Strategy outlines plans to improve stakeholders' understanding of methane sources and mitigation solutions in livestock production via lifecycle analysis research.[19]

The European Climate Law makes the goals set out in the European Green Deal legally binding, which includes achieving climate neutrality by 2050 and the intermediate goal of reducing net GHG emissions by at least 55% by 2030 compared to 1990 levels[20]. The EU has increased its National Determined Contribution (NDC) accordingly[21].

As a milestone on the path towards overall climate neutrality by 2050, the European Commission has proposed to make the EU land sector (encompassing agriculture and land use, land-use change and forestry) climate neutral by 2035[22]. Carbon removals and remaining non-carbon dioxide emissions – including methane from livestock – must balance by then.

The Nitrates Directive aims to protect ground and surface waters against pollution caused by nitrates[23].

The EU is a leader in research on emissions from livestock production. For example, in 2019, the European Commission's Joint Research Centre published a technical report that found livestock breeding can reduce the EU livestock emission intensity by 8% by 2029[24]. EU stakeholders also contribute to international research initiatives such as the Global Research Alliance on Agricultural Greenhouse Gases' Livestock Research Group (LRG).

Through the various strategies and initiatives, the Directorate General for Agriculture and Rural Development of the European Commission turns research and innovation into farm-level actions through the European Innovation Partnership for Agriculture (EIP-AGRI) by linking farmers with researchers to develop on-the-ground solutions in the field. As of the timing of this workshop, more than 2,200 groups are addressing livestock production systems across the EU.

19 European Commission. (November 2020.) "EU Strategy to Reduce Methane Emissions." Retrieved from https://ec.europa.eu/energy/sites/ener/files/eu_methane_strategy.pdf.

20 European Commission. (June 2021.) "European Climate Law." Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119.

21 Germany and the European Commission. (December 2020.) "The update of the Nationally Determined Contribution of the European Union and its Member States." Retrieved from: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/European%20Union%20First/EU_NDC_Submission_December%202020.pdf.

22 European Commission. (July 2021.) Proposal for a Regulation of the European Parliament and of the Council Amending Regulations (EU) 2018/841 as regards the scope, simplifying the compliance rules, setting out the targets of the Member States for 2030 and committing to the collective achievement of climate neutrality by 2035 in the land use, forestry and agriculture sector, and (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2021:554:FIN

23 Council Directive. (December 1991.) "Concerning the protection of waters against pollution caused by nitrates from agricultural sources." Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1561542776070&uri=CELEX:01991L0676-20081211.

24 European Commission. (2019.) "Impact of animal breeding on GHG emissions and farm economics." JRC Technical Reports. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/7be9ee17-d9bf-11e9-9c4e-01aa75ed71a1/language-en.

Many research projects are underway to support the implementation of beneficial GHG mitigation practices on EU farms. Some of these projects include:

- Life Carbon Dairy – French dairy carbon plan
- Life Beef Carbon – Demonstration actions to mitigate the carbon footprint of beef production in France, Ireland, Italy, and Spain
- Life Green Sheep – Demonstration and dissemination actions to reduce the carbon footprint of sheep farming
- Life Carbon Farming – Development and implementation of a result-based funding mechanism for carbon farming in EU mixed crop/livestock systems
- ClieNFarms – Climate Neutral Farms
- Climate Farm Demo – A European-wide network of pilot farmers implementing and demonstrating climate smart solutions for a carbon-neutral Europe
- ERA-GAS ERA-NET for Monitoring and Mitigation of Greenhouse Gases from Agri- and Silvi-Culture – Collaboration to exchange knowledge and develop technologies, strategies and solutions to reduce the GHG emissions of livestock systems

2.2 · CANADIAN POLICIES

In June 2021, Canada's Net-Zero Emissions Accountability Act received Royal Assent. The act formalized a commitment to achieve net-zero emissions by 2050 and established the target of 40 to 45% reductions below 2005 levels by 2030 as Canada's enhanced National Determined Contribution (NDC). Canada's strengthened climate action plan, *A Healthy Environment and a Healthy Economy*, presents the policies and programs that promote tangible actions towards meeting these national targets and economic and environmental progress. In March 2022, the Government of Canada released its first Emissions Reduction Plan which includes a series of measures to reach its 2030 emissions reduction targets, including over $1.05 billion in new program and research funding related to the agricultural industry.

$200 million in funding has been allocated to the On-Farm Climate Action Fund for 2021 to 2023. $185 million in funding has been earmarked for the 10-year Living Labs project.

The Agricultural Climate Solutions (ACS) program enables producers to contribute to meeting the 2030 emissions reduction target. The ACS program is part of the Natural Climate Solutions Fund and is led by Agriculture and Agri-food Canada (AAFC). Two streams exist under the ACS: the Living Labs Initiative and the On-Farm Climate Action Fund. These programs support producers in adopting management practices that can reduce emissions and increase carbon storage.

The Agricultural Clean Technology (ACT) program aims to scale the adoption of clean technologies that are needed to enable the agricultural industry to thrive in a low-carbon economy. The program offers support for adoption and innovation in green energy and energy efficiency, precision agriculture, and the bioeconomy.

The Canadian Agricultural Partnership (Partnership) is a five-year (2018 – 2023), $3-billion, federal-provincial-territorial initiative to strengthen the agricultural sector. In particular, $438 million is available for cost-shared programs between the federal and provincial/territorial governments that are designed to raise producers' awareness of environmental risks and accelerate the adoption of on-farm technologies and practices. Under the Partnership, the Canadian government committed to advancing producers' roles in the bioeconomy through initiatives such as the Biomass Cluster. This initiative accelerates innovation in processing agricultural biomass, such as using animal manure and waste to create renewable energy and sustainable materials.

Consultations are underway for Canada's next five-year Agricultural Policy Framework and are guided by the Guelph Statement: A Vision to 2028, which identifies GHG reductions and improved carbon sequestration as priority areas.

Canadian scientists are among world leaders striving to improve the economic, environmental, and social sustainability of the livestock sector. For example, AAFC researchers lead projects under the Sustainable Beef and Forage Science Cluster to advance approaches to measuring methane emissions and to identify innovative mitigation solutions in feed management. AAFC researchers have also played a key role in the FAO Livestock Environmental Assessment and Performance Partnership, contributing to the development of several guidance documents on characterizing and reducing GHG emissions in livestock.

A VISION TO 2028

"Canada is recognized as a world leader in sustainable agriculture and agri-food production and drives forward to 2028 from a solid foundation of regional strengths and diversity, as well as the strong leadership of the Provinces and Territories, in order to rise to the climate change challenge, to expand new markets and trade while meeting the expectations of consumers, and to feed Canadians and a growing global population."

- The Guelph Statement

2.3 · EU AND CANADA JOINT INITIATIVES AND EFFORTS

As Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, Canada and the EU strongly support international climate action. As of March 2022, 111 countries – including the EU and Canada – have signed the Global Methane Pledge to reduce methane emissions by at least 30% by 2030, compared to 2020 levels. The work under this pledge will focus on five key sectors: power, road transport, hydrogen, steel, and agriculture[25].

Canada and the EU both signed the Global Methane Pledge and serve as leading partners in the Climate and Clean Air Coalition agriculture initiative.

The European Commission and Canada are also leading partners in the Climate and Clean Air Coalition (CCAC) agriculture initiative, which aims to increase the ambition of NDCs by showcasing beneficial management practices in agriculture that can reduce GHG emissions, especially those practices that increase productivity in livestock farming while reducing methane.

Canada and EU countries are both members of the Global Research Alliance on Agricultural Greenhouse Gases (GRA). The GRA "provides a framework for voluntary action to increase cooperation and investment in research activities" focused on GHG mitigation efforts while maintaining a dedication to food security[26].

25 United Nations Framework Convention on Climate Change. (2021.) "World Leaders Kick Start Accelerated Climate Action at COP26." Retrieved from https://unfccc.int/news/world-leaders-kick-start-accelerated-climate-action-at-cop26.

26 Global Research Alliance on Agricultural Greenhouse Gases. (n.d.) "About Us." Retrieved from: https://globalresearchalliance.org/about/.

3

ISSUES AND CHALLENGES TO RESOLUTION

3 · ISSUES AND CHALLENGES TO RESOLUTION

3.1 · OVERARCHING ISSUES AND CHALLENGES

REGIONAL AND PRODUCTION-SYSTEM DIFFERENCES

Significant differences exist throughout the global livestock sector; production practices and emission intensities, meaning "emissions per unit of animal product," vary by region and by species[27]. For example, the feedlot system in Canada is heavily based on feeding grain concentrates, while, in parts of Europe (such as in Ireland), beef production systems tend to be very forage-based due to the cost of production. As a result, a "one-size-fits-all" approach to reducing GHG emissions in the sector will not work.

Ruminants produce milk and meat. In some countries and regions, production of these two protein sources is specialized; some operations produce beef, for example, while others mainly produce milk. Male dairy calves and female dairy calves that do not enter milk production cycles can be used for beef production and, in some countries, dairy cows represent a major component of the beef produced. In other locations, a single system produces milk and meat. In France, for example, some efficient livestock systems produce both commodities within one farming operation. Research continues into which approach works best for which region and which production system.

THE COMPLEXITIES OF THE BROADER PICTURE

Agricultural industry stakeholders must look at the broader picture, both in terms of considering the implications for the production system and for all types of GHG emissions. Efforts to reduce GHG emissions can lead to trade-offs in terms of the environmental impact of the livestock sector, biodiversity, animal health or welfare, social acceptability, and land use competition for food versus feed. For example, a transition from a pasture-based system to a fully confined system could decrease GHG emissions. That strategy, however, could also have animal welfare implications and necessitate the expansion of land used for feed production while putting carbon storage in grasslands at risk.

Similarly, in the process of reducing the emission of one type of GHG, livestock producers might cause another type of pollution to increase. This concept is called pollution swapping. For example, greater inclusion rates of dried distillers grain plus solubles (DDGS) in a cattle diet might decrease enteric methane production and intensity, but increase the amount of nitrous oxide emissions from manure[28]. To more carefully consider the issue of pollution swapping, some scientists recommend the use of disaggregated GHG emissions instead of carbon dioxide equivalent per unit output[29].

27 P.J. Gerber, H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci, and G. Tempio. (2013.) *Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities.* Food and Agriculture Organization of the United Nations, p. xii.

28 S. Terry, C. Romero, A. Chaves, and T. McAllister. (2020.) "Nutritional Factors Affecting Greenhouse Gas Production from Ruminants: Implications for Enteric and Manure Emissions." In *Improving Rumen Function*. Burleigh Dodds Science Publishing, Cambridge, UK. p. 4.

29 John Lynch. (2019.) "Availability of disaggregated greenhouse gas emissions from beef cattle production: A systematic review." *Environmental Impact Assessment Review*, 76, p. 69-78. Retrieved from: https://doi.org/10.1016/j.eiar.2019.02.003.

CHALLENGES FOR PRODUCERS

Current GHG mitigation strategies often bring additional work and/or costs for livestock producers. For example, in both Canada and the EU, covered lagoons are beneficial for reducing GHG emissions if properly sealed, but these manure storage systems can be costly to build. Farmers also need to monitor them closely, and they can be hard to access for repairs, which are often expensive. Similarly, in Canada, the cost of anaerobic digesters is prohibitive for smaller operations, which might need to source co-digestates to supplement the manure to make biogas production profitable.

In contrast, the feed additive 3-NOP (3-Nitrooxypropanol) – which received final market approval in the EU[30], but not yet in Canada – "shows tremendous promise" as an enteric methane inhibitor when added to cattle diets[31]. However, the product has not necessarily been associated with an increase in performance, so livestock producers do not yet have an economic incentive to incorporate this feed additive into their operations.

RESEARCH AND DATA COLLECTION LIMITATIONS

Research on GHG reduction strategies is often narrow in scope, which results in knowledge gaps for the broader sector. For example, much of the research on feed additives to date has focused on confined systems, given the relative ease with which livestock diets can be controlled and additives administered in these systems. In contrast, less is known about the use of feed additives in pasture systems as they are more difficult to administer, and impacts are harder to measure in grazing systems. Researchers also still have much to learn about other potential mitigation strategies, such as vaccines and genetic selection for low-emitting animals[32].

Controversial debate surrounds the impact of animal production based on abundant contradictory data interpretations and the difficulties in quantifying natural processes linked to agricultural production and land use.

The amount of baseline data on GHG emissions is another limiting factor. "Textbook values" are not reflective of real-world conditions on farms. It is also easier to collect baseline data in some production systems than in others. For example, GHG emissions can be monitored and quantified reliably in typical feedlot and research settings, but these measurements are much more difficult to collect in pasture-based settings. Evaluation of soil carbon sequestration to potentially balance methane emissions is even more difficult.

Researchers need a method to confirm whether actual reductions in GHG emissions align with modelling predictions. Our current quantification systems are not sufficiently scalable to the full size of the livestock industry. Relatedly, researchers need a good accounting system to track improvements. The need for

30 European Union. (April 2022.) Commission Implementing Regulation (EU) 2022/565 of 7 April 2022 concerning the authorisation of a preparation of 3-nitrooxypropanol as a feed additive for dairy cows and cows for reproduction (holder of the authorisation: DSM Nutritional Products Ltd, represented in the Union by DSM Nutritional Products Sp. z o.o.). Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R0565&qid=1650355467497.

31 Aklilu W. Alemu, Liana K. D. Pekrul, Adam L. Shreck, Calvin W. Booker, Sean M. McGinn, Maik Kindermann and Karen A. Beauchemin. (February 2021.) "3-Nitrooxypropanol Decreased Enteric Methane Production from Growing Beef Cattle in a Commercial Feedlot: Implications for Sustainable Beef Cattle Production." F*rontiers in Animal Science*. Retrieved from: https://doi.org/10.3389/fanim.2021.641590.

32 P.J. Gerber, H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci, and G. Tempio. (2013.) *Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities*. Food and Agriculture Organization of the United Nations, p. xiii.

accurate and collated data is vital to help guide the implementation of beneficial management practices (BMPs), but also to help shape the development of policy.

A lack of consistency exists in terms of the levels of measurements required by different stakeholder groups. The current levels of data, for example, are not sufficient for the claims some retailers want to make. Livestock industry stakeholders lack a system to collate data in a way that removes redundancy in reporting.

REGULATORY APPROVALS CHALLENGES

The regulatory approvals process can delay the adoption of new technologies and products that offer benefits for GHG reduction in livestock production, some workshop participants said. For example, workshop participants believe that Health Canada, through alignment with the U.S. Food and Drug Administration, will likely classify 3-NOP as a drug, which is anticipated to result in a lengthy approvals process which will delay the commercial use of this product. The Canadian regulatory framework says that drugs specifically target the alteration of microbial populations, which 3-NOP does. However, 3-NOP alters microbial populations to offer environmental benefits, rather than to control infectious agents as other drugs do. Registration of 3-NOP in Canada would likely have been simpler if its regulatory requirements were viewed strictly from an environmental perspective and if it was classified as a feed additive, some workshop participants said.

The approvals process in the EU was also rather lengthy for 3-NOP; the product was subject to an assessment of the European Food Safety Authority.

PUBLIC PERCEPTIONS AND REGULATORY CONSTRAINTS

Different regulatory frameworks, scientific approach or public perceptions can lead to a different use of some technologies or products. For example, while growth-enhancing technologies (hormonal implants, antibiotics, and beta-agonists, such as ractopamine) are regulated for use in Canada, some of these products cannot be used in the EU, nor in beef exported to the EU. Research shows, however, the use of hormonal implants and beta-agonists results in anywhere from a 5 to 20% improvement in feed efficiency. This improved efficiency results in a substantial reduction in GHGs through reduced time to slaughter, which equates to reduced manure production and reduced feed inputs.

Uncertainty over consumer acceptance of new technologies, such as 3-NOP, could also be a disincentive for on-farm use; farmers might be worried about market access challenges.

3.2 · ENTERIC METHANE EMISSIONS

Grain-based and pasture-based production systems are inherently intertwined. In the EU, in many cases, cattle rearing falls in “between” these two types of systems. In the Canadian beef sector, cattle are typically born in pasture-based systems and moved to grain-based systems to reach market weight. Both systems also help to meet market demand. Neither system is inherently stronger than another; both have unique strengths in terms of production efficiencies, animal welfare, and environmental considerations. For example, pasture-based systems can serve as carbon sinks that support biodiversity, while grain-based systems can realize production efficiencies.

The connected nature of these systems can also pose challenges from the perspective of GHG reduction strategies. For example, cattle bred for better performance on a pasture-based diet might have lower performance on a grain-based diet and vice versa.

GRAIN-BASED DIETS

It is challenging to decide, how, exactly, to attribute GHG emissions to different sectors within the agricultural industry. For example, grain corn is a key component of cattle diets in much of the EU and Eastern Canada, while barley and wheat are central to cattle diets in Western Canada. The GHG emissions related to the production of these crops might be calculated separately from the GHG emissions related to cattle production. However, to fully understand the amount of GHG emissions from grain-fed systems, researchers must consider the emissions from the full system, stretching from feed production through to cattle finishing.

Grain-based systems are also already efficient, in terms of the number of days on feed to produce meat, so "easy wins" are limited to make production improvements to decrease GHG emissions, some workshop participants said. In Canada, for example, cattle are typically fed high levels of grain during the finishing period to put on weight quickly and efficiently. Current research suggests that differences in emissions between feedlot operations are small, so limited options exist to improve a segment of lower-performing operations through the adoption of practices used by their higher-performing counterparts[33].

PASTURE-BASED DIETS

Producers in pasture-based systems face limitations due to the climate, which constrains the grazing season. Typically, producers move cattle into more sheltered environments in the winter months. Climate change will pose further challenges for pasture-based systems, as extreme weather events (i.e., droughts and floods) significantly impact the quantity and quality of forage available on pasture.

Producers using pasture-fed systems have more limited options for the use of feed additives compared to producers using confined systems.

In pasture-based systems, the options for measuring GHG emissions are more limited than in feedlot systems. In the latter settings, researchers can use such technologies as lasers and FTIR (Fourier transformation infrared spectroscopy) to conduct measurements. In pastures, wind, lower density, and animal movement can impact GHG measurement techniques. Some new technologies, however, are under development.

3.3 · MANURE MANAGEMENT AND TREATMENT OF EFFLUENTS

As is the case with livestock production systems, manure management systems vary by country and region.

Overall, in Europe, 40 to 50% of manure is managed in liquid systems, workshop participants estimated. In some regions with a large concentration of livestock, manure is treated and exported to other areas.

In Atlantic Canada, smaller dairy operations typically handle solid manure, while, in Ontario, Quebec and Western Canada, larger dairy operations tend to handle liquid manure. In the Canadian beef industry, manure is typically in solid form. This manure is either deposited directly on pastures or collected from feedlot pens or enclosed structures and spread on fields. Liquid manure, in contrast, is typically stored in uncovered concrete tanks and applied to fields once or twice a year. The bulk of this manure is spread in the fall, although some is also spread in the spring. In some parts of British Columbia that receive a lot of rain, producers have roofs over their manure storages, but they are still open to air exchange. Canadian farm surveys indicate that less than 5% of livestock farmers have covered manure tanks[34].

33 The discussion of efficiency in grain-based systems centred on a Canadian example.

34 The discussion provided more information on the regional variation across Canada than across Europe.

CHALLENGES WITH MANURE STORAGE SYSTEMS

Covered systems can be expensive to build. Covered lagoons also pose logistical challenges for producers, as they must actively monitor these systems. High winds, ice, and ponding water can damage covered systems, which can be difficult to access to make necessary repairs. This repair work is often costly, too. As such, covered lagoons might not be a feasible option for many producers, despite the benefits they can offer for reducing GHG emissions.

GHG emissions are influenced by the weather; as temperatures rise in the summer, so too do emissions from lagoons. Cold weather, in contrast, tends to suppress emissions.

ANAEROBIC DIGESTERS

Specialized knowledge is required to manage anaerobic digesters; typically, livestock producers do not want to shift their focus from food production to running these systems.

Canadian farms have very few anaerobic digesters; only about 60 anaerobic digesters are in use across the country[35]. Typically, they are fed with manure from pig and dairy operations due to the nature of the manure catchment system and supplemented with food waste from restaurants or processing plants. Anaerobic digesters are currently not a feasible solution for smaller operations because of the cost of construction and the need to supplement the manure with co-digestates. The relatively cheap price of electricity in Canada might serve as another deterrent to the construction of anaerobic digesters, workshop participants said[36].

In the EU, the use of anaerobic digestion is progressing. In 2018, for example, over 18,000 units were installed[37]. Agricultural feedstocks (including livestock manure, farm residues, plant residues and energy crops) are the driving force of the European biogas market. They represent roughly 65 to 70% of the market share.

ACIDIFICATION

While acidification reduces GHG emissions, it is only possible with manure stored in open tanks, not with manure stored in closed tanks or underground systems (i.e., underneath barn floors). Alternate GHG reduction strategies are necessary for closed storage tanks or underground systems.

Canadian livestock producers do not use acidification, workshop participants said. This technology is also poorly used in Europe.

DIFFERENCES IN REGULATION

In the EU, Directive (EU) 2016/2284 establishes emission reduction commitments for several atmospheric pollutants, including ammonia. In contrast, Canada has no ammonia policy to formally guide the reduction in ammonia emissions, workshop participants said. However, Canadian producers develop nutrient management plans to identify and adhere to BMPs for storing, treating and using manures and other nutrients on their farms[38].

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35 Canadian Biogas Association. (n.d.) "Current Status and Future Potential of Biogas Production from Canada's Agriculture and Agri-Food Sector." Retrieved from: https://biogasassociation.ca/resources/canadian_agricultural_biogas_study.

36 As Canada has such a small number of anaerobic digesters, workshop participants had a more fulsome discussion of the factors influencing the Canadian situation.

37 UABIO. (March 2020.) *European Biogas Association Statistical Report 2020*. Retrieved from: https://uabio.org/en/materials/7524/.

38 See, for example, Ontario Ministry of Agriculture, Food and Rural Affairs. (2016.) "Preparing a Nutrient Management or Non-Agricultural Source Materials (NASM) Strategy/Plan." Retrieved from: http://www.omafra.gov.on.ca/english/nm/preparing.htm.

POSSIBLE

4

POSSIBLE SOLUTIONS

4 · POSSIBLE SOLUTIONS

Once workshop participants identified some of the shared and regional challenges to GHG reduction in livestock production, they explored possible solutions. As production systems differ between and within Canada and the EU, these solutions are not a one-size-fits all approach; producers will have to leverage a combination of strategies that make the most sense for their individual operations. Scientists, policymakers, and other stakeholders also have key roles to play in the GHG reduction efforts.

4.1 · ENTERIC METHANE EMISSIONS

FEEDING STRATEGIES

Workshop participants discussed the desire to extend the grazing season as much of the year as possible, as pasture-based systems involve reduced fuel use and less carbon emissions than typical confined systems. An extended grazing season could also reduce the GHG emissions associated with manure storage and application.

By providing high-quality forages (including legume forages and grass silages) and pastures, farmers can reduce emissions. Legume forages, for example, can reduce cattle's methane production and nitrous oxide emissions by 5%. In Northern Ireland and France, producers are establishing multi-species swards, which are pastures with multiple species of forages. In these settings, producers realize about a 20% reduction in emissions, resulting from a decrease in nitrous oxide emissions linked to forage production and lower ruminal methane emissions[39]. Producers also need to use fewer inputs, such as of mineral fertilizer applications, and are enhancing biodiversity in their operations. Some producers and researchers see multi-species swards as a way forward for a segment of the industry[40].

Feed additives, such as 3-NOP, polyunsaturated fatty acids, and essential oils, can decrease emissions. A red seaweed, ***Asparagopsis taxiformis***, also holds promise. Researchers continue to study optimal diets and develop and analyze feed additives to reduce GHG emissions. In the EU, some researchers are studying the early use of feed additives, spanning from birth to 14 weeks of life. Scientists are measuring the long-term beneficial effects of this early administered feed additive, and this research must be accelerated, workshop participants said.

Research should continue on the use of feed additives in pasture-based systems. Slow-release options and encapsulation technology should be considered, workshop participants said. In Ireland, early laboratory work is underway on this front.

Feeding strategies also impact the quality of the manure; a reduction in crude protein in diets, for example, should reduce the nitrogen loss all the way through the system and, consequently, nitrous oxide emissions.

39 A. Lüscher, I. Mueller-Harvey, J. F. Soussana, R. M. Rees, and J. L. Peyraud. (April 2014.) "Potential of Legume-based Grassland–livestock systems in Europe: A Review." *Grass and Forage Science*, p. 206-228. Retrieved from: https://onlinelibrary.wiley.com/doi/full/10.1111/gfs.12124.

40 In Western Canada, for example, many producers use native grasslands, so new forage multi-species swards likely are not a fit for these operations. Weather may also limit forage options.

LIFETIME REPRODUCTIVE EFFICIENCY

The lifetime reproductive efficiency of livestock influences GHG emissions. Producers seek to reduce the average first calving age, to increase the number of lactations per cow, and to shorten the interval between calvings. Producers generally aim for at least one calf per cow per year. Producers can closely monitor and cull their herds shortly after cows stop calving. The goal is to reduce the lengths of non-productive periods in the herd, and the number of non-productive animals. Improving the reproductive performance of cows has a positive impact on production efficiency, which indirectly decreases GHG emissions. However, producers need to balance improved reproductive performance and animal welfare by ensuring cows have rest periods between calvings.

ANIMAL BREEDING AND GENETICS

To improve the efficiency of grain-based systems, producers can fatten more crossbred calves from dairy herds and reduce the number of calves produced in beef herds; the carbon footprint of calves from the dairy industry is lower because it is diluted by the production of milk, workshop participants said.

Research is underway to select more metabolically efficient animals, as well as animals with lower methane emissions per kilogram of dry matter intake. One simple method is cross-breeding. Through this breeding strategy, producers can leverage heterosis (hybrid vigor), which can increase milk yields, cow lifetime productivity, and average calf weaning rate[41]. This breeding strategy is underappreciated for improving the efficiency of herds, workshop participants suggested. Producers also strive for efficient herds with high rates of average daily gain, which reduces the number of days on feed – thus decreasing the days to slaughter, which decreases GHG emissions from those animals.

A European network of scientists are partnering with leading microbiome researchers in New Zealand to fine-tune a system which can help to predict which animals will be low or high emitters based on microbiome samples. At this stage, the predictions are about 75% accurate. The researchers are also expanding the use of these tools. More research is needed to gain a fuller understanding of the microbiome and how it contributes to the production of methane in the rumen.

As this example shows, genetic selection is a complex process; focusing on the selection of a single trait (e.g., reduced enteric methane emissions) can have an unknown number and extent of potential trade offs. As a result, genomic selection for feed efficiency and reduced enteric methane emissions will take time. So, improvements to feeding strategies could be a key area of focus for a reduction of GHG emissions between now and 2030, while improvements in animal genetics could be a key area of focus for 2050 reductions targets and beyond, workshop participants said.

VACCINES

Research is underway on anti-methanogen vaccines to reduce GHG emissions from livestock, but this work has yet to produce very convincing results, workshop participants said. The benefits of vaccines include the fact that they would need to be administered infrequently and would involve minimal work for producers[42]. Vaccines are a mitigation strategy that can be considered over the longer term and would have application in extensive grazing systems.

41 J.A. Basarab, J.J. Crowley, M.K. Abo-Ismail, G.M. Manafiazar, E.C. Akanno, V.S. Baron, and G. Plastow. (April 2018.) "Genomic retained heterosis effects on fertility and lifetime productivity in beef heifers." *Canadian Journal of Animal Science*. Accessed from https://doi.org/10.1139/cjas-2017-0192.

42 P.J. Gerber, H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci, and G. Tempio. (2013.) Tackling Climate Change Through Livestock: *A Global Assessment of Emissions and Mitigation Opportunities*. Food and Agriculture Organization of the United Nations, p. 60.

4.2 · MANURE MANAGEMENT AND TREATMENT OF EFFLUENTS

STORAGE AND TREATMENT SYSTEMS

Covered lagoons and closed storage tanks help to reduce ammonia and methane. Covered lagoons, for example, can reduce emissions up to 80%. Covered systems are more commonly used in Ireland, France and Germany than in other parts of the EU. Aeration also reduces methane emissions. However, livestock producers' central goal is to produce meat and milk, not to manage the manure from their livestock. As a result, researchers must strive to create manure management systems that require minimal oversight and maintenance.

Producers can flush the manure out of the barn more frequently, and then better manage the methane in their manure storage tanks. When possible, producers can also decrease the duration of manure storage before field applications or processing in anaerobic digesters. An Agriculture and Agri-Food Canada study, for example, examined the anaerobic digestion of stockpiled and fresh manure. The stockpiled manure had more emissions, the researchers found. However, producers also face constraints in their opportunities for manure application; for example, in some parts of Canada, and in Europe with periods allowed for land application under the nitrate directive, producers have a short window in the spring to apply manure before planting season begins.

Interest is growing in the composting of manure, and research is underway in this field, workshop participants said.

ACIDIFICATION

European research shows that acidification with sulphuric acid does not damage concrete storage tanks, even if the manure is in the tanks for several months. Low-dose acidification, at the rate of 2 kilograms of acid per tonne of manure, resulted in a 50% reduction in methane, a Danish study found. This rate was also cost effective, and the technology is easy to adopt. The sulphate in the acidified manure is a co-benefit when the manure is applied to fields. The lessons from Denmark could be leveraged in Canada and other EU member states to help overcome the barriers to the use of this technology.

About 15% of Canadian producers use additives that are marketed as reducing odour, making the manure easier to mix or spread, and/or improving fertilizer value. So, if those stakeholders promoting acidification additives highlight the production benefits, Canadian producers might be willing to incorporate acidification into their operations[43].

43 The discussion focused on opportunities to encourage Canadian producers to use this technology.

ANAEROBIC DIGESTERS

A tremendous opportunity exists to expand the use of anaerobic digesters in Canada, workshop participants said[44]. However, the return on investment must be improved for producers. Two strategies to improve the profitability of these systems are:

- Charging tipping fees for substrates from other sectors
- Acquiring complementary substrates that enhance methane yield

Anaerobic digester users must also be careful dealing with digestate, as it can be high in ammonia.

In some areas, producers combine digestate with poultry manure to help offset the lower amount of nitrogen available in the digestate.

Anaerobic digesters are much more common in some areas of the EU; Germany, for example, has 9,000 anaerobic digesters. The German system is driven by the electricity market, and the construction of gas pipelines helped in the scaling up of this technology. The rising prices of gas and petrol could serve as an incentive for the expanded use of anaerobic digesters, workshop participants said.

Producers and researchers in areas where anaerobic digesters are less commonly used, such as Canada, can learn BMPs from some of their European counterparts, workshop participants added.

MANURE APPLICATION STRATEGIES

Direct injection of manure is a typical mitigation strategy. However, this application strategy also can bring the trade-off of increased production of nitrous oxide and nitrate leaching.

LEVERAGE THE CIRCULAR ECONOMY

In closed storage tanks and covered lagoons, methane can be captured and used.

Anaerobic digesters produce biogas but also offer opportunities for nutrient recovery, as the digestate is a source of fertilizer that can be applied to fields. If the pathogens are eliminated, algae grown from digestate can perhaps be fed to cattle; further research is needed in this area.

The use of small-scale centrifuges is starting to emerge as a possibility for nutrient recovery on smaller farms.

The rising costs of synthetic fertilizers might serve as a further impetus to leverage the circular economy and capture all available nutrients from manure for field application. In Belgium, for example, ammonia emissions in stables are captured to create fertilizer. Ammonium sulphate can be captured from liquid manure and used as a fertilizer too.

Researchers must continue their work to find practical ways to support nutrient recovery from manure.

LEVERAGE OPPORTUNITIES OF SCALE

In Western Europe, 80% of manure is produced on 4% of farms, given the sheer size of these operations. These operations may be able to leverage economies of scale to adopt new manure management treatments and technologies.

44 As Canada has a small number of anaerobic digesters compared to some European countries, the discussion centred on opportunities to expand the use of this technology in Canada.

Opportunities may also exist to take a collaborative approach at a community scale to leverage the use of anaerobic digesters. This community approach would serve multiple farms, and local dairy, pork, and poultry manures could all be processed in these systems. Dedicated teams could manage the anaerobic digesters, removing the additional responsibilities from farmers. Case studies would need to be developed and shared to find a practical approach to facilitate such community initiatives.

4.3 · OVERARCHING SOLUTIONS

INDUSTRY SUPPORTS

Farmers' broader support networks (including farm advisors, equipment suppliers, feed suppliers, etc.) have a role to play in encouraging and supporting the adoption of GHG reduction strategies.

Farmers must be supported with strong tools to help them make decisions and implement BMPs most suited to their individual operations. In Europe, for example, research projects, such as those listed in Section 2.1, support the on-farm implementation of beneficial GHG mitigation practices. In the UK, consultants work with farmers to identify sources of GHG emissions and implement reduction strategies. Some European countries also offer farmers advisory services to support their work in this field.

Several computer-based decision-making tools exist. For example, at the global scale, the Food and Agriculture Organization (FAO) of the United Nations has the Global Livestock Environmental Assessment Model (GLEAM-interactive), which is "designed to support governments, project planners, producers, industry and civil society organizations to calculate emissions using Tier 2 methods."[45] The Cool Farm Alliance's free online Cool Farm Tool allows farmers to calculate their GHG emissions, measure their biodiversity, and calculate their water footprints. In Canada, AAFC's Holos "estimates greenhouse gas emissions based on information entered for individual farms."[46] Dairy Farmers of Canada also offers Dairy Farms +, which is a sustainability assessment tool. However, these tools typically do not include economic and production considerations, which are important for farmers.

Livestock industry stakeholders in Canada and the EU could collaborate to exchange knowledge on the strengths and weaknesses of their current farm management decision-making tools to improve their local and regional offerings for farmers.

Policymakers can also consider the creation and implementation of incentives to encourage farmers to reduce GHG emissions. These initiatives could focus on situations where the BMP to reduce emissions does not also offer production benefits. At this point, for example, feed additives for the reduction of GHG emissions are quite costly and do not show production benefits.

45 Food and Agriculture Organization of the United Nations. (2017.) "Global Livestock Environmental Assessment Model. Interactive. A Tool for Estimating Livestock Production, Greenhouse Gas Emissions and Assessing Intervention Scenarios VERSION 2.0." Retrieved from: https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1070763/.

46 More work is underway on improving the user-friendliness of this tool. See Agriculture and Agri-Food Canada. (January 24, 2020). "Holos software program." Retrieved from https://agriculture.canada.ca/en/agricultural-science-and-innovation/agricultural-research-results/holos-software-program.

MODELLING AND MEASUREMENTS

Researchers must collaborate to standardize the approach to lifecycle analysis (LCA) models. Particularly, the scientific community must reach a consensus about how to measure the impact of feed production on GHG emissions from livestock production. Researchers need to consider nitrous oxide emissions from fertilizer production and use it in calculations of GHG emissions from livestock production, some workshop participants said. Researchers also need to consider whether to attribute emissions from by-products fed to cattle as GHG emissions from livestock production, other workshop participants added.

It would also be valuable to consider the broader circular economy, some workshop participants said. For example, scientists should reach a consensus on how to attribute livestock emissions between meat and dairy products and other valuable animal by-products, such as leather production and energy produced from burning some animal fats.

Researchers must continue to collaborate to improve the precision of quantification systems for GHG emissions in livestock production.

Researchers can continue to build on the modelling and measurement work underway through the FAO's Livestock Environmental Assessment and Performance Partnership (LEAP).

Improved modelling and measurement systems for GHG emissions will enable researchers to track change over time and better understand the benefits of various GHG reduction strategies.

Verra, a carbon credit certifying organization based in the United States, has developed a methodology for estimating enteric methane emissions reductions from introducing feed additives in livestock diets. The methodology is a major step in enabling feed additives to be factored into carbon offset/credit programs. The methodology is informed, in part, by the Government of Alberta's Quantification Protocol for Reducing Greenhouse Gas Emissions from Fed Cattle.

HOLISTIC AND SYSTEMS APPROACH

A systems and holistic approach is critical to reduce GHG emissions in livestock production. Farmers can both directly and indirectly decrease GHG emissions from livestock production by improving production efficiency; decreases in the total amount of GHG emissions, as well as emissions intensities, are vital[47].

Researchers must look at the broader farm system when conducting their research on GHG mitigation in livestock production. When seeking to address one type of GHG emissions, scientists must ensure the mitigation strategy does not cause pollution swapping, or negative effects for animal welfare and/or biodiversity. For example, the intensification of a production system may make it more efficient and thus reduce GHG emissions, but this strategy could negatively impact biodiversity and/or animal welfare.

Relatedly, scientists must continue to seek win-win solutions for producers. New technologies or products that help to reduce GHG emissions in livestock production must be easy and cost-effective for producers to implement. These new technologies or products must bring co-benefits for farmers. Ideally, the BMP will also offer production efficiencies, which provides an economic incentive to the implementation of a practice or strategy to reduce GHG emissions. Other co-benefits could include improved animal welfare, a reduction in other kinds of pollution, and/or the preservation of on-farm biodiversity. For example, researchers conducted a study in an Alberta feedlot to see how the use of a concrete base (in contrast to the traditional

47 K. A. Beauchemin, E. M. Ungerfeld, R. J. Eckard and M. Wang. (2020.) "Review: Fifty Years of Research on Rumen Methanogenesis: Lessons Learned and Future Challenges for Mitigation." *Animal*, Vol. 14, p. s2. Retrieved from: https://doi.org/10.1017/s1751731119003100.

clay) influenced animal health and welfare (e.g., lameness), manure management, and GHG emissions. The concrete reduced nitrous oxide and methane emissions from manure, and the amount of contaminating clay in the manure from the pen floor, so there was less product to gather and apply to the field, the scientists found.

To support the search for win-win solutions and ensure farm-level considerations are incorporated into the development of new mitigation strategies, farmers should be involved throughout the research process, not simply at the implementation stage. Researchers must work with farmers because, ultimately, they are the final users of the technologies and products. The Living Laboratories initiative provides a strong and successful model of this approach, as this initiative leverages the co-creation of solutions to overcome industry challenges and accelerate adoption of BMPs. Both Canada and the EU have Living Laboratories. Opportunities may exist for Canada to leverage lessons learned in the EU, as Canadian Living Laboratories have focused on soil and water conservation to date. The next round of Living Laboratories in Canada will include livestock research.

Scientists must ensure they present their research in a plain-language format so it is accessible for the broader agricultural community.

As no single mitigation strategy will "fully solve" the challenges, researchers must continue to study the use of multiple BMPs within a production system to see if any synergies can be produced and to analyze any additional challenges that arise. For example, farmers can use high-quality feed and feed additives. Researchers can explore the use of multiple feed additives in a single diet, or at different production stages. On the manure management side, researchers can consider a strategy that leverages acidification, anaerobic digestion, and composting. Acidification might help to preserve the nitrogen in the digestate, which is an important nutrient for crop production.

In some countries, producers are already trying to use multiple mitigation strategies within a single production system. For example, in Ireland, researchers are developing breeding strategies to select animals with lower methane emissions. Producers seek to use efficient cattle diets and feed additives for cattle in confined systems.

When creating these multifaceted mitigation strategies, they must be tailored to meet the unique needs of each region, each production system, and each species.

Policymakers must ensure that any policies consider the broader system and ramifications. Policymakers should collaborate with scientists to ensure their work reflects current research and consult farmers to ensure policy is workable at the farm level. Policymakers should also be flexible to revisit and revise policy as scientific knowledge evolves, as much remains to be learned.

To support the advance of research, policymakers should consider offering programs to incentivize producers for trialling new management strategies to reduce GHG emissions. These strategies may negatively impact production efficiency, so the economic costs to farmers should be offset while researchers continue to seek "win-win" solutions.

THE ROLE OF THE OTHER LINKS IN THE SUPPLY CHAIN

To address GHG emissions in livestock production, all industry stakeholders have a role to play; the responsibilities should not be placed fully on farmers. In the Baltic region, for example, cooperatives seek to produce emissions-neutral milk, and farmers use an app to calculate their carbon emissions. Participating producers focus on ecological farming, which has a positive impact on national emissions calculations.

Retailers can influence – and support – production practices on the farm level that reduce GHG emissions. Scientists and policymakers should help to ensure retailers understand the issues at hand, as well as the associated on-farm BMPs, and encourage retailers to offer premiums or incentives to farmers for livestock products produced with low GHG emissions.

REGULATORY APPROVALS

While thorough approvals processes are necessary to ensure the safety of products and to preserve consumer trust in food production, governments can seek ways to streamline the regulatory approval process for products that reduce GHG emissions. Sharing of regulatory portfolios across regulatory agencies can greatly reduce the time required to complete regulatory assessments. It would be beneficial to shorten the timeline from the research pipeline to commercial adoption of new technologies and products whenever feasible.

PUBLIC MESSAGING

Often, mainstream media focuses on the negatives associated with livestock production, such as GHG emissions and deforestation. However, it is important to tell consumers the "good news" stories about the industry, including the benefits livestock production brings for biodiversity and grasslands. Guardians of the Grasslands, for example, is a short Canadian documentary that highlights the role of ranching in preserving the Great Plains grasslands, which is an endangered ecosystem. The "Cows on the Planet Podcast," available on Spotify and Apple Podcasts, addresses the most controversial issues in beef cattle production and emphasizes the various trade-offs in production systems so consumers can make informed purchasing decisions. Outreach on the benefits of the livestock industry can begin in the school system by teaching students more about the sources of their food. Outreach efforts should also reach the broader public outside of the school setting.

Industry stakeholders need to develop clear and positive messaging regarding the use of new products and technologies, such as feed additives. This messaging should underscore how stringent the approval process is and regulations are. Messaging must be deliberate and highlight the environmental benefits of the new products and technologies. Proactive messaging campaigns can help to facilitate public approvals for new products and technologies that support GHG emission reductions and production efficiencies.

5

CONCLUSIONS WITH RECOMMENDATIONS

5 · CONCLUSIONS WITH RECOMMENDATIONS

The agricultural industry must simultaneously meet the growing demand for livestock products while minimizing the environmental impacts of the sector. This workshop focused on ways to reduce GHG emissions, while recognizing the need to protect animal health and welfare, biodiversity, and other environmental considerations. Livestock producers, of course, are central to these efforts to reduce GHG emissions, as they are responsible for herd management and food production. Producers across Canada and the EU already strive for production efficiencies in their operations, which help to decrease GHG emissions. For example, producers:

- Use high-quality feed (e.g., highly digestible forage, well-preserved silage)[48]
- Implement strong breeding programs and support herd health
- Employ good manure management and application practices (e.g., by following 4R Nutrient Stewardship)

Scientists continue to advance our knowledge of GHG emissions from livestock production and develop strategies to reduce these emissions. For example, researchers study the use of feed additives and breeding strategies to improve herd efficiency and reduce enteric methane emissions. Scientists seek to improve systems for measuring emissions so livestock industry stakeholders (and, particularly, farmers) can better understand changes over time and refine the use of associated BMPs to support further reductions. Other stakeholders in the livestock sector – including consultants, feed suppliers, and retailers – also have a role to play. These stakeholders can support knowledge transfer to producers and the adoption of BMPs. The public should better understand the livestock industry's efforts to improve production efficiencies and decrease GHG emissions. Then, the public can use this knowledge to make informed decisions about consumption practices. Policymakers support the work underway at the farm and scientific levels through policies and programs designed to advance knowledge and implement initiatives to meet key targets.

Farmers, researchers, other stakeholders in the agri-food value chain, and policymakers all must contribute to the shared goal of reducing GHG emissions from livestock production. The following recommendations will help the scientific community, policymakers, and all livestock sector stakeholders chart an action-oriented path ahead that will enable the sector to strengthen food security while decreasing GHG emissions.

RECOMMENDATIONS FOR THE SCIENTIFIC COMMUNITY

1. **Strengthen scientific networking between the EU and Canada to address regional, national and global gaps in knowledge related to GHG emissions in livestock production.**
   - **1.1.** Leverage findings from European and Canadian counterparts to develop studies tailored to regional and local conditions.
   - **1.2.** Prioritize research on strategies that offer opportunities for rapid implementation in the short term while continuing to work on strategies that hold more promise in the longer term. For example, research on feeding strategies (i.e., diets and feed additives) can be leveraged to meet emissions reduction targets by 2030, while research on animal genetics and vaccines can be leveraged to meet emissions reduction targets by 2050.

48 A.N. Hristov, J. Oh, C. Lee, R. Meinen, F. Montes, T. Ott, J. Firkins, A. Rotz, C. Dell, A. Adesogan, W. Yang, J. Tricarico, E. Kebreab, G. Waghorn, J. Dijkstra, and S Oosting. (2013.) Mitigation of Greenhouse Gas Emissions in Livestock Production – A Review of Technical Options for Non-CO2 Emissions. Edited by Pierre J. Gerber, Benjamin Henderson and Harinder P.S. Makkar. FAO Animal Production and Health Paper No. 177, p. ix.

2. **Collaborate to enhance tools for quantifying GHG emissions in livestock production. These tools must recognize regional and production system differences.**

3. **Continue efforts to standardize the approach to lifecycle analysis (LCA) models, particularly around emissions from feed production and valuable animal by-products.**
   - **3.1.** Reach a consensus on how to "account" for the GHG emissions from fertilizer production and use associated with feed production.
   - **3.2.** Reach a consensus on whether to attribute emissions from by-products fed to livestock as emissions from livestock production.
   - **3.3.** Reach a consensus on how to attribute livestock emissions between meat and dairy products and other valuable animal by-products, such as leather production or the energy produced by burning some animal fats.

4. **Deepen knowledge on existing national and regional farm management decision-making tools for GHG emissions reductions in farming systems, including livestock production systems. Explore opportunities for fine-tuning these tools and adopting them in multiple sectors.**
   - **4.1.** Discuss the strengths and weaknesses of the existing tools (e.g., Cool Farm Tool, Holos, etc.).
   - **4.2.** Explore how to improve the tools, as well as how to expand the use of these tools in the farm community.

5. **Prioritize research projects that support the circular economy, particularly in terms of practical opportunities to support nutrient recovery from manure and increased use of by-products and food waste as feed.**

6. **In addition to the effects on GHG emissions, assess the impacts of feed additives on livestock productivity and performance.**

7. **Develop a systems approach to reducing GHG emissions by exploring how to best incorporate multiple beneficial management practices within each production system.**
   - **7.1.** Ensure these GHG reduction strategies are easy and cost-effective for producers to implement.
   - **7.2.** Strive for strategies that offer the most co-benefits (e.g., production efficiencies, improved animal welfare, on-farm biodiversity, etc.) and minimize trade-offs (e.g., pollution swapping).

RECOMMENDATIONS FOR POLICYMAKERS

8. **Take a holistic and systems approach to ensure policies do not cause unintended consequences (e.g., pollution swapping) and to ensure policies are workable at the farm level.**
   - **8.1.** Regularly revisit and consider updates to policy as scientific knowledge evolves.

9. **Develop farm support programs (e.g., cost-share programs, carbon credits) that incentivize producers to adopt beneficial management practices that reduce GHG emissions.**

10. **Seek opportunities, where appropriate, to streamline the regulatory approvals process for products and technologies that reduce GHG emissions while maintaining the rigorous commitment to ensuring animal welfare and food safety and minimizing environmental impacts.**

RECOMMENDATIONS FOR ALL LIVESTOCK PRODUCTION STAKEHOLDERS

11. **Leverage a multi-disciplinary (e.g., sciences and social sciences) and multi-stakeholder approach (e.g., government, researchers, farmers and industry suppliers) to address GHG emissions in livestock production. This work must communicate the urgency of GHG emission reduction strategies, the research findings, and the beneficial management practices that livestock producers use.**
    - **11.1.** Ensure materials are presented in a plain-language format that highlights the co-benefits (e.g., production efficiencies) for farmers.
    - **11.2.** Expand on the good work underway through the Living Laboratories initiative.
    - **11.3.** Leverage lessons learned through EU initiatives on beneficial practices for collaborative research in the livestock sector for the next round of Canadian Living Laboratories.

12. **Develop case studies and models to support a collaborative, community approach to the use of anaerobic digesters to overcome challenges of scale, which limit the adoption of this technology.**

13. **Leverage the role of retailers to support and encourage farmers in the adoption of GHG mitigation strategies by offering premiums or incentives for livestock products produced with low GHG emissions.**

14. **Develop public awareness campaigns to showcase the relationships between livestock production, human food, and the environment.**
    - **14.1.** Leverage opportunities to embed lessons on livestock production (e.g., the environmental benefits of the industry, the practices and technologies used to reduce GHG emissions, etc.) in public-school curriculums.
    - **14.2.** Highlight success stories about the good work underway on farms (e.g., biodiversity preservation).
    - **14.3.** Initiate a proactive messaging campaign to educate consumers about feed additives and the role of livestock in GHG emissions and climate change. Provide a high-level overview of the development, testing and regulatory processes to underscore the safety of the products. Explain the environmental benefits associated with the use of these products.

6

ANNEXES

6 · ANNEXES

6.1 · WORKSHOP AGENDA

AGENDA

Plenary session I:

MANAGING GREENHOUSE GAS EMISSIONS IN LIVESTOCK PRODUCTION – POLICY CONTEXT

08:45-09:25 EST/14:45-15:25 CET

Moderator:

BRONWYNNE WILTON, PhD

- Kevin Norris, *Agriculture and Agri-food Canada: Acting Director, Resilient Agriculture Policy Division, Strategic Policy Branch*
- Brigitte Misonne, *European Commission DG AGRI: Head of Livestock Products*
- Tim McAllister, *Agriculture and Agri-food Canada: Research Scientist, Ruminant Nutrition & Microbiology*
- Kerstin Rosenow, *European Commission DG AGRI: Head of Research and Innovation*

Break - 5 min: Transition to Parallel Sessions

PARALLEL SESSIONS:

09:30 – 11:00 EST / 15:30 – 17:00 CET

GROUP A	GROUP B	GROUP C
Enteric methane emissions –grain-based diet	**Enteric methane emissions –pasture-based diet**	**Manure management and treatment of effluents**
Moderator **FRANCOIS EUDES** *Research Scientist, Agriculture and Agri-food Canada*	**Moderator** **JEAN LOUIS PEYRAUD** *INRA*	**Moderator** **FRANK O'MARA** *Director of Teagasc, President, Animal Task Force*
Rapporteur **STEPHANIE TERRY** *Research Scientist, Agriculture and Agri-food Canada*	**Rapporteur** **FLORENCE MACHEREZ** *Secretary General of the Animal Task Force, European Partnership, INRA*	**Rapporteur** **RAJINIKANTH RAJAGOPAL** *Research Scientist, Agriculture and Agri-food Canada*

Break - 10 min: Transition back to Plenary

Plenary session II:

REPORTING BACK FROM THE BREAKOUT SESSIONS

11:10 EST – 12:00 EST / 17:10 – 18:00 CET

Moderator

BRONWYNNE WILTON

PhD

Rapporteurs:

STEPHANIE TERRY
Research Scientist, Agriculture and Agri-food Canada

FLORENCE MACHEREZ
Secretary General, Animal Task Force, INRA

RAJINIKANTH RAJAGOPAL
Research Scientist, Agriculture and Agri-food Canada

Reactions:

MARC DUPONCEL, *DG AGRI*

TIM MCALLISTER, AAFC

BRIGITTE MISONNE, *DG AGRI*

KEVIN NORRIS, *AAFC*

6.2 · BIOGRAPHIES OF PANELLISTS, MODERATORS AND RAPPORTEURS

SENIOR EXPERT AND WORKSHOP MODERATOR

Dr. Bronwynne Wilton is the principal and lead consultant at Wilton Consulting Group in Fergus, Ontario. Bronwynne holds a PhD in rural studies and is experienced in managing comprehensive, full value-chain research and stakeholder engagement processes related to sustainability, innovation, strategic planning, regional agriculture and food strategies. Bronwynne is the project lead for the development of the Canadian Agri-Food Sustainability Initiative (CASI).

PLENARY SESSION I PANELLISTS

Dr. Marc Duponcel is Head of Sector Research in the Directorate-General for Agriculture and Rural Development of the European Commission.

Dr. Tim McAllister is a Principal Research Scientist with Agriculture and Agri-Food Canada at the Lethbridge Research and Development Centre in Lethbridge, Alberta. He has been working in the area of methane emissions from cattle for over 20 years and has published over 100 scientific papers on the topic. He chairs the FAO Livestock Environmental Assessment and Performance steering committee.

Brigitte Misonne is the Head of Unit for Animal Products in the Directorate-General for Agriculture and Rural Development of the European Commission. She has overall responsibility for monitoring market developments, building up market knowledge, and designing Union intervention. She oversees the Common Agricultural Policy (CAP) reform. Brigitte raises awareness of the Green Deal and accompanying animal product sectors on their sustainability path.

Kevin Norris is the acting director of the Resilient Agriculture Policy Division, Strategic Policy Branch at Agriculture and Agri-Food Canada. Prior to this, Kevin was the acting director of the Environment Policy team within the Strategic Policy Branch at AAFC. During this time, these teams advanced several agri-environmental policies related to natural climate solutions, agricultural clean technologies, and increasing on-farm adoption of beneficial management practices, including as part of Canada's strengthened climate plan.

Kerstin Rosenow is the Head of the Research and Innovation unit in the Directorate-General for Agriculture and Rural Development of the European Commission, where she is responsible for programming, managing and monitoring agricultural research under Horizon Europe and the European Innovation Partnership for Agricultural Productivity and Sustainability. Previously, she was head of unit in the European Commission's Research Executive Agency.

PARALLEL SESSION MODERATORS

Dr. François Eudes is a Director Research, Development and Technology at Agriculture and Agri-Food Canada, and lead for the Forage and Beef Sector Strategy. Located in Lethbridge, Alberta, he holds a PhD in Plant Science from the University of Laval in Quebec.

Dr. Frank O'Mara is Director of Teagasc and President of the Animal Task Force, a European public-private partnership working on the European Commission research and innovation agenda.

Dr. Jean Louis Peyraud a senior scientist on ruminant nutrition and grazing at INRAe and has published over 150 peer reviewed papers. He is special adviser of the Scientific Director of Agriculture at INRAe and was chair of the Animal Task Force until 2021. Jean Louis produced scientific foresights on the future of livestock farming for INRAe and for the European Commission. He is chair of a French PPP called 'GIS Avenir Elevages." Jean Louis is also a member of the French Academy of Agriculture.

PLENARY SESSION II RAPPORTEURS

Florence Macherez holds a master's degree in Mandarin Chinese and international Trade (INALCO, Paris, 1994). She has been working at Idele since 2001. Since 2015, she has served as a project manager supporting European Projects proposals for a French PPP called "GIS Avenir Elevages." As Secretary General of the Animal Task Force, Florence is at the interface of a wide range of European stakeholders in the livestock sector.

Dr. Rajinikanth Rajagopal is a Research Scientist in Management and Treatment of Effluents at Agriculture and Agri-Food Canada (Sherbrooke Research and Development Centre). Dr. Rajagopal is involved in R&D activities aimed at developing unique scientific knowledge that can be used as an ideal agricultural waste bio-refinery model towards circular economy concept to achieve substantial economic and environmental benefits.

Dr. Stephanie Terry is a Beef Cattle Systems Research Scientist with Agriculture and Agri-Food Canada at the Lethbridge Research and Development Centre. Her research focuses on nutritional and technological strategies to improve the environmental and productive performance of beef cattle.

6.3 · PARALLEL SESSION SPEAKERS AND NOTETAKERS

GROUP A: ENTERIC METHANE EMISSIONS – GRAIN-BASED DIET

NAME	AFFILIATION	ROLE
Andre Bannink	Wageningen Livestock Research	Speaker
Stefania Colombini	University of Milan	Speaker
Brenna Grant	Canfax Research Services	Speaker
Monica Hadarits	Canadian Roundtable for Sustainable Beef	Speaker
Lena Höglund-Isaksson	IIASA	Speaker
Sharon Huws	Queen's University Belfast	Speaker
Peter Lund	Aarhus University	Speaker
Tim Mahler	Agriculture and Agri-Food Canada	Notetaker
Tim McAllister	Agriculture and Agri-Food Canada	Speaker
Adam Shreck	Feedlot Health by Telus Agriculture	Speaker
Shelia Torgunrud	Agriculture and Agri-Food Canada	Notetaker
David Yanez-Ruiz	Spanish Research Council (CSIC)	Speaker

GROUP B: ENTERIC METHANE EMISSIONS – PASTURE-BASED DIET

NAME	AFFILIATION	ROLE
Valerio Abbadessa	DG AGRI, European Commission	Notetaker
Aklilu Alemu	Agriculture and Agri-Food Canada	Speaker
Josselin Andurand	IDELE	Speaker
Vern Baron	Agriculture and Agri-Food Canada	Speaker
Chaouki Benchaar	Agriculture and Agri-Food Canada	Speaker
Reynold Bergen	Beef Cattle Research Council	Speaker
Benjamin Campbell	Canadian Cattlemen's Association	Speaker
Joanne Conington	SRUC	Speaker
Silvija Dreijere	Latvian Rural Advisory and Training Center	Speaker
Thomas Duffy	CEJA	Speaker
Tyler Fulton	CCA	Speaker
Benjamin Vallin	DG AGRI, European Commission	Notetaker
Tim Van De Gucht	ILVO	Speaker
Sinead Waters	Teagasc	Speaker

GROUP C: MANURE MANAGEMENT & TREATMENT OF EFFLUENTS

NAME	AFFILIATION	ROLE
Barbara Amon	Leibniz Institute for Agricultural Engineering and Bioeconomy	Speaker
Cinthia Braidwood	Agriculture and Agri-Food Canada	Notetaker
Christopher Bush	Catalyst Agri-Innovations Society	Speaker
Ike Edeogu	Olds College	Speaker
Gary Lanigan	Teagasc	Speaker
Betty Lee	DG AGRI, European Commission	Notetaker
Mickaël Lepage	Agriculture and Agri-Food Canada	Notetaker
Davide Nicodemo	DG AGRI, European Commission	Notetaker
Gillian O'Sullivan	Farmer/Veterinarian	Speaker
Søren Petersen	Aarhus University	Speaker
Rich Smith	Retired from Alberta Beef Producers	Speaker
Andrew VanderZaag	Agriculture and Agri-Food Canada	Speaker
Céline Vaneeckhaute	Université Laval	Speaker

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