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EMIT LESS ACT OF 2024

ENTERIC **M**ETHANE **I**NNOVATION **T**OOLS FOR **L**OWER **E**MISSION AND **S**USTAINABLE **S**TOCK **ACT**

Workshop in Applied Earth Systems Management II

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EXECUTIVE SUMMARY

Methane (CH_4) is a powerful greenhouse gas, 86 times more potent than carbon dioxide over a 20-year period, and it has contributed to 30% of global warming to date. The agricultural sector is a significant source of methane emissions, with enteric fermentation in cattle responsible for 95% of methane emissions from ruminants. Addressing methane emissions in livestock is critical for achieving climate goals and ensuring long-term environmental sustainability.

This report, developed through an academic simulation, explores potential solutions to mitigate methane emissions from cattle. These solutions include dietary adjustments and feed additives such as tannins, seaweed, and 3-NOP; selective breeding for low-methane traits; genetic modification of cattle or their microbiomes; and developing vaccines targeting methane-producing microbes. Each approach presents unique benefits and challenges, ranging from economic feasibility and regulatory hurdles to impacts on animal health and technological readiness.

To address these challenges, the EMIT LESS Act of 2024 was introduced as bipartisan legislation focused on reducing enteric methane emissions in the agricultural sector. The Act emphasizes voluntary farmer participation and builds upon existing conservation programs within the U.S. Department of Agriculture (USDA). Its key objectives include advancing research and development of enteric methane abatement technology, implementing lab-to-farm solutions, monitoring and reviewing the effectiveness of strategies, and offering financial incentives to support adoption.

The USDA's Agricultural Research Service (ARS) will lead the research component, while the National Institute of Food and Agriculture (NIFA) will focus on integrating solutions into farming practices through education and training programs. Newly established entities, such as the Division of Enteric Methane Research (DEMR) and the Institute of Enteric Methane Program Management (IEMPM), will oversee these efforts. The Act's proposed activities are estimated to cost $90 million over two years. This budget will fund personnel, equipment, on-farm trials, and incentive programs.

Monitoring and reporting mechanisms will ensure accountability, measuring progress through metrics such as methane reductions, adoption rates among farmers, and improvements in livestock productivity. The Act aims to balance environmental sustainability with economic viability for farmers, promoting practices that reduce emissions without undermining productivity.

While the Act has bipartisan support, challenges remain, including concerns about regulatory overreach, high research and implementation costs, and ethical considerations surrounding genetic interventions. The report highlights the importance of collaboration among government agencies, academia, industry stakeholders, and farmers to overcome these barriers and achieve meaningful reductions in methane emissions.

This simulation provides a comprehensive analysis of policy design, implementation strategies, and the economic and environmental implications of reducing methane emissions in the U.S. livestock industry. The EMIT LESS Act represents a critical opportunity to advance sustainable agriculture, improve environmental outcomes, and support farmers in adopting climate-smart practices.

INTRODUCTION

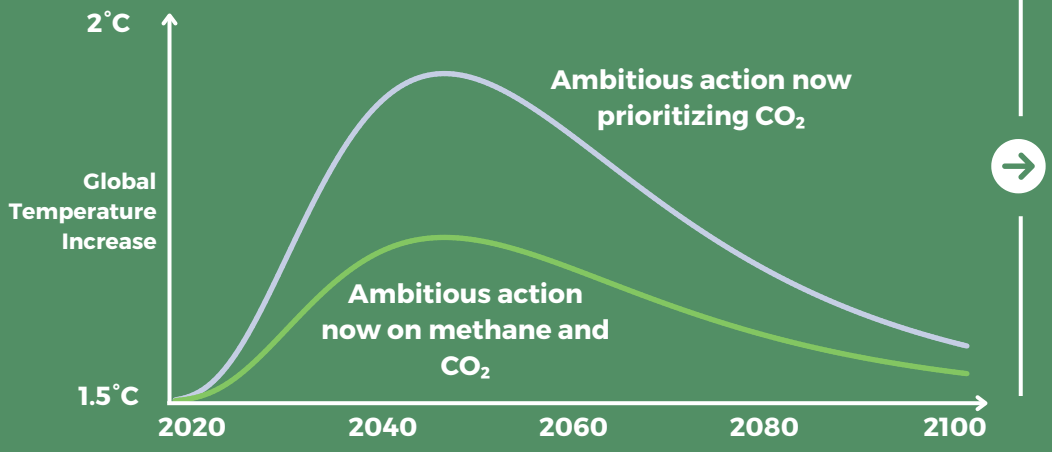
METHANE FROM AGRICULTURE

The rapid rise in anthropogenic greenhouse gas (GHG) emissions presents a severe threat to our planet by intensifying climate change, trapping heat in the atmosphere, and driving global temperatures to perilous levels (IPCC, 2022). Methane (CH_4) is of particular concern due to its potency as a GHG; in fact, in terms of global warming potential, it is 86 times more potent than carbon dioxide (CO_2) over a 20-year lifespan (IPCC, 2022). Although methane accounts for only 16% of global greenhouse gas emissions, it is responsible for 30% of global warming to date (IPCC, 2022). Approximately 40% of anthropogenic methane emissions originate from agriculture, with enteric fermentation in ruminant cattle as the primary driver, contributing around 90% of the sector's total emissions (US EPA, 2023a). Methane emissions mitigation from cattle, therefore, has the largest mitigation potential in the agricultural sector.

Ruminants produce these high methane emissions due to enteric fermentation, a process in which they break down complex carbohydrates in their rumen through microbial decomposition. This process generates methane as a byproduct, which is released primarily through eructation. A smaller amount of methane (approximately 5%) is emitted from cow manure through the breakdown of organic material. There is a substantial body of scholarly discourse on ruminant physiology from disciplines such as biology, zoology, and veterinary medicine, which establishes a robust understanding of these species and the methane emissions resulting from their diets. However, there is lively debate regarding potentially suitable interventions (Gibbs et al., 2001; Sanjorjo et al., 2023; Vetriani, 2001).

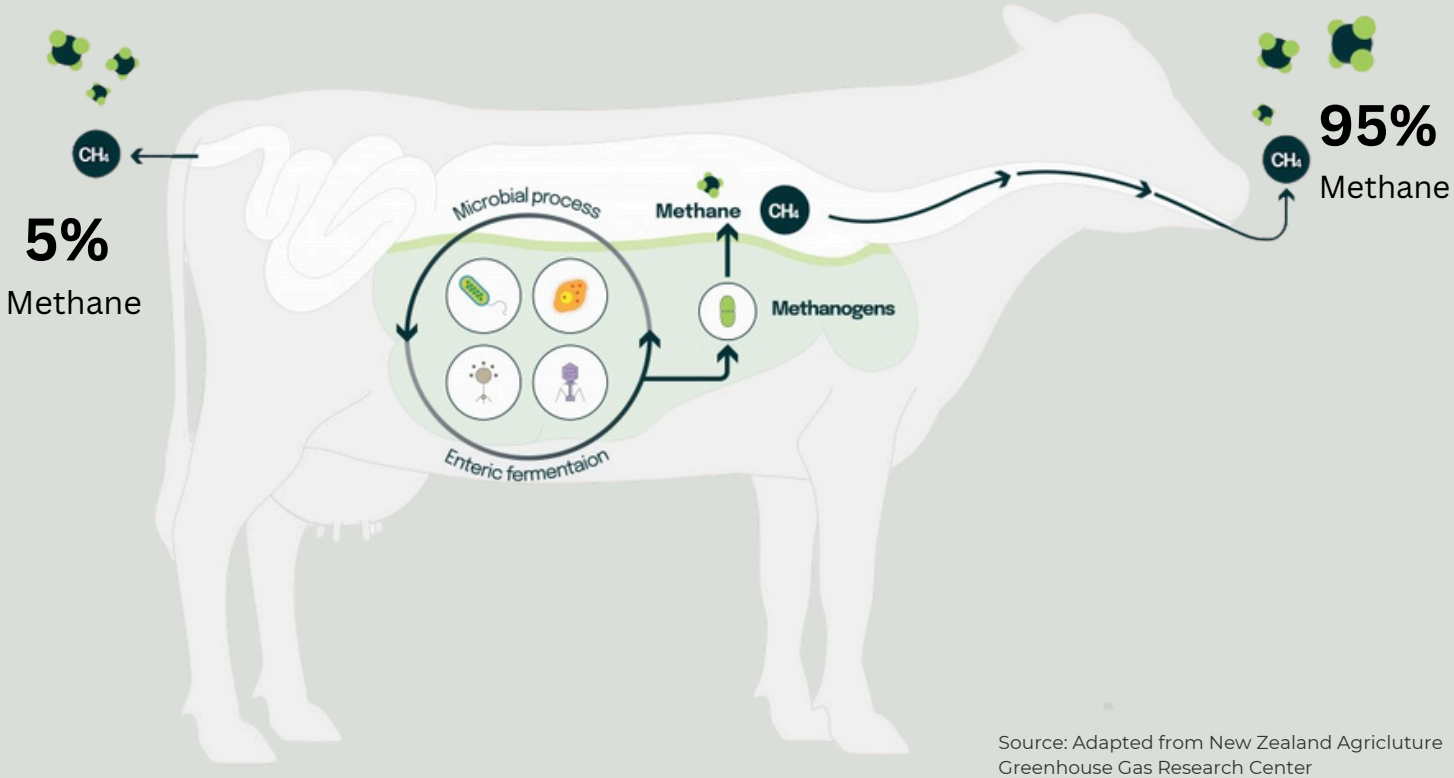
Although there have been limited examples of scaled solutions to mitigate ruminant methane emissions, some interventions have been tested in isolated studies and are based on scientific precedent involving manipulations of animal physiology, though the invasiveness of these interventions varies. This report exclusively explores methane emissions mitigation from cattle, as they account for the vast majority of ruminant methane emissions. These solutions focus on reducing methane production from enteric fermentation, which constitutes approx-imately 95% of cattle methane emissions (Song et al., 2023).

Mitigation potential of CO2 and methane



Early action to reduce both emissions of carbon dioxide and methane simultaneously leads to the **best climate outcomes** over all timescales. In contrast to CO_2, **methane doesn't have to be abated to zero.**

Source: Adapted from EDF+Business & Sun et al. 2021



Source: Adapted from New Zealand Agricluture Greenhouse Gas Research Center

SOLUTIONS OVERVIEW

There are 3 main categories of solutions and techniques that can reduce enteric methane emissions in cattle and are therefore relevant for the EMIT LESS Act:

1 Adjustment of Cattle Diet Composition and Feed Additives

This intervention involves changing cattle diets, either by altering the proportions of their current food or introducing new substances (feed additives). Typically, cattle diets in confined farming systems consist of five major components: forages, grains, protein supplements, vitamins and minerals, and additives (Ishler, 2024). Protein supplements, vitamins and minerals, and additives are used to promote further bodily development and improve health. These components are commonly provided to dairy cattle in the form of a total-mixed ration (TMR), a type of feed that combines multiple ingredients into one mix (Ishler V. A. et al., 2023).The most commonly observed practice involves adjusting the ratio of hay to grain in cattle diets within a confined feeding system to reduce methane production during the digestion process (Haque, 2018; Lileikis et al., 2023).

Recent discussions focus on feed additives as a means to decrease methane emissions. These additives, mixed into controlled diets, include plant-based options such as saponins, tannins, essential oils, and blends of garlic powder and citrus extract (Mootral, 2023; Sari et al., 2022; Vrancken et al., 2019). Other options include probiotics, prebiotics, seaweed, and 3-nitrooxypropanol (3NOP), each presenting distinct advantages and limitations that require further research (Clear Center, 2021; Jafari et al., 2019; Kulkarni et al., 2022; Lopes et al., 2016; Wasson et al., 2022).

Alternatively, interventions during fetal or early life involve adding supplements to feed during pregnancy or shortly after birth to influence microbial development in newborns, thereby promoting lower methanogenesis (Dias et al., 2024).

2 Selective Breeding and Genetic Manipulation

Selective breeding offers a viable strategy for reducing methane emissions from livestock by selecting animals that produce less methane, potentially achieving up to a 25% long-term reduction (Wall et al., 2010). This method is effective in both intensive and pasture-based systems, employing approaches such as direct phenotypic selection, indirect selection for correlated traits, and genomic selection using DNA markers (Beauchemin et al., 2008; Pickering et al., 2015; Knapp et al., 2014; Hayes et al., 2016).Moreover, combining selective breeding with dietary changes and feed additives can further enhance methane mitigation efforts (Schilde et al., 2021; X. M. Zhang et al., 2021).

Complementing this, genetic manipulation using genome-editing tools can directly alter the DNA of cattle or their methane-producing microbes, potentially reducing emissions by up to 50% without compromising animal health or productivity (Menchaca et al., 2020; Roehe et al., 2016; Difford et al., 2018; Hess et al., 2011; Sicard, 2023; Wall et al., 2010).However, both strategies face significant challenges, including the need for region-specific research, long generation times, limited effectiveness due to the complexity of traits, high costs, potential impacts on other animal characteristics, and issues surrounding ethical considerations and market acceptance (Dillon et al., 2021; de Haas et al., 2021; Gerber et al., 2013; Kramer & Meijboom, 2022; European Commission, 2015).

3 Vaccinations

Vaccines could be a potential pathway for methane reduction. ArkeaBio, a Boston-based agricultural biotechnology firm, is currently working on developing a methane-reducing vaccine (ArkeaBio, n.d.). Vaccines can influence the rumen microbiome, potentially leading to unintended changes in microbial composition, so continued research is necessary to identify more effective vaccine targets and optimize vaccination protocols (Meale et al., 2021). As is the case with all solutions, there are several controversies surrounding vaccinations.

A perfect vaccine would ideally reduce methane emissions without affecting health and production traits. However, conditions such as stability at room temperature during transport and storage impact the effectiveness of vaccines but can incur high costs, representing a significant barrier in rural areas (Gerber et al., 2013). Determining the effective frequency of vaccinations, i.e., how often to administer them, also adds complexity. These factors, along with potential negative health effects and high investment costs, make vaccination programs controversial (Gerber et al., 2013; L. Zhang et al., 2015).

Enteric methane reduction strategies are hindered by high research costs and the need for more extensive real-world studies to confirm their effectiveness.

- Larger, more diverse in vivo studies are essential to validate methane reduction solutions under real-world conditions, as current research often relies on small sample sizes or in vitro experiments, limiting reliability and practical application.
- Financial incentives and cost-effective solutions that improve animal health or productivity alongside reducing methane emissions are crucial to encourage farmer adoption and ensure widespread implementation.

EXISTING US POLICIES AND METHANE COMMITMENTS

There are a variety of government and academic initiatives tackling methane emissions broadly. The Inflation Reduction Act, a landmark piece of legislation for addressing climate change, includes provisions under Section 136 to create a Methane Emissions Reduction Program aimed at reducing methane emissions from petroleum and natural gas. This program will deliver $1.36 billion in funding to support financial and technical assistance for methane reduction and create a Waste Emissions Charge for methane. It will also require the EPA to implement stricter regulations on methane emissions through its Greenhouse Gas Reporting Program for the oil and gas industry (US EPA, 2023b).

In addition to these measures, the DOE and EPA announced in June 2024 plans to move forward with funding Research & Development-focused projects (R&D) for methane emissions reduction in the oil and gas sector, with a budget of $850 million. Similar to EMIT LESS, these funds will be allocated to projects focused on monitoring, measuring, quantifying, and reducing methane emissions (US EPA, 2024).

At the international level, the World Bank announced at the end of 2023 that it would launch at least 15 country-led methane emissions reduction programs over the next year and a half. Collectively, these programs aim to cut around 10 million tons of methane over their investment lifespans, with an emphasis on rice production, livestock operations, and waste management. At the same time, the World Bank will also support early-stage intervention projects in regions where methane emissions are expected to rise (World Bank, 2023).

Several noteworthy initiatives are being launched in the academic domain. The Harvard Initiative on Reducing Global Methane Emissions is focusing on R&D solutions for methane emissions reduction, developed with input from key stakeholders in the business and policy sectors. This initiative seeks new scientific solutions while addressing legal constraints in the U.S. and abroad that could hinder their deployment (O'Neill, 2024).

The USDA launched several regional Climate Hubs in 2014 as part of a program created by the Obama administration. These hubs coordinate research and planning to enhance agricultural resilience to climate change (USDA, n.d.). The Northeast Climate Hub, hosted at Penn State, has supported work on reducing dairy cow methane emissions through 3-NOP feed additives (Mulhollem, 2020).

When the EMIT LESS measures are enacted, they will integrate into this ecosystem of related or overlapping initiatives, making them an important frame of reference for the bill.

Global Methane Pledge

The Global Methane Pledge, launched at COP26 in 2021, is a commitment by over 150 countries to reduce methane emissions by 30% from 2020 levels by 2030. It focuses on key sectors such as energy, agriculture, and waste to drive significant emission reductions.

THE PROPOSED LEGISLATION

LEGISLATIVE OVERVIEW

Senator Michael Bennet, who introduced the Bill in the Senate

The Enteric Methane Innovation Tools for Lower Emissions and Sustainable Stock (EMIT LESS) Act (S. 4056) is bipartisan legislation introduced in the 118th Congress by Senator Michael Bennet (D-Colorado) in March 2024, with co-sponsorship from Senators Mike Crapo (R-Idaho), Tammy Baldwin (D-Wisconsin), and Jerry Moran (R-Kansas) (EMIT LESS Act, S. 4056, 118th Cong., 2024). This bill seeks to address the need for action to mitigate enteric methane emissions, an area that has historically received limited policy attention compared to methane emissions from other sources such as the oil and gas industry.

Importantly, the bill is voluntary, a feature designed to garner broader political support in Congress and among various stakeholders, including agricultural groups and independent farmers (American Feed Industry Association, 2024). The bill was referred to the Senate Committee on Agriculture, Nutrition, and Forestry shortly after its introduction, and has remained in Committee since then. The Act focuses on increasing methane mitigation efforts within the agricultural sector, primarily targeting reductions in enteric methane emissions generated through ruminant digestion.

This is achieved by driving innovation, scaling technologies, and developing relevant standards that are accessible to American farmers and ranchers (EMIT LESS Act, S. 4056, 118th Cong., 2024). By voluntarily adopting the trials supported by the bill, these farmers and ranchers would become the primary beneficiaries, receiving financial support while enhancing their management methods.

In June 2024, an identical version of the bill was introduced in the House of Representatives in the 118th Congress by Congresswoman Jasmine Crockett (D-Texas) and Congressman Marc Molinaro (R-New York), both members of the House Agricultural Committee. Congresswoman Crockett explained the motivation behind the bill: “We have the potential to expand the use of low-emission cattle feed and reduce the environmental cost of grazing without spiking costs for farmers and producers already under strain[...]” (Baethge, 2024). The two House members aim for the bicameral bill's adoption later this year (Crockett, 2024). The bill is currently under consideration in both the Senate and House committees.

The EMIT LESS Act builds upon prior U.S. commitments, such as the Global Methane Pledge of 2021, an initiative co-led by the United States to reduce methane emissions globally. The Act incorporates research findings to shape the content and structure of training programs for farmers and ranchers. These studies will also form the basis for evaluating the training's effectiveness, culminating in a comprehensive report that highlights key innovations, the economic impacts on ranchers, and overall greenhouse gas emission reductions. By integrating cutting-edge research into its training programs, the EMIT LESS Act seeks to encourage widespread adoption of methane-reducing practices, helping ranchers improve environmental sustainability while maintaining economic viability.

THE EMIT LESS ACT IN DETAIL

The EMIT LESS Act is structured around four components. Three of those—research & development, lab-to-farm integration, and payment programs—were used to create the legislative framework for the program design, while the monitoring & review component serves as an overarching performance management mechanism.

I. Research & Development

SEC. 101. CREATION OF ENTERIC METHANE PRODUCT AND PRACTICE TESTING CAPACITY THROUGH THE AGRICULTURAL RESEARCH SERVICE.

The EMIT LESS Act places responsibility on the Secretary of Agriculture, acting through the USDA, to conduct research on strategies to reduce enteric methane emissions. Through the ARS, the principal research agency of the USDA, the Act aims to oversee and fund solutions-oriented research focused on the enteric methane emissions of ruminants, particularly cattle. The Secretary is tasked with providing, operating, or retrofitting the necessary infrastructure to study baseline enteric methane emissions, evaluate the effects of enteric methane production on animal productivity and health, and assess the impacts of methane mitigation practices on greenhouse gas (GHG) emissions and animal welfare. The Bill also mandates the ARS to collaborate with stakeholders, including independent and academic research facilities, and to acquire the technologies and conduct assessments needed to fulfil these goals. This collaboration may be facilitated through the ARS and supporting institutions referenced in the bill, such as Colorado State University and its AgNext Program, which focuses on sustainability and innovation in animal agriculture (Bennet, 2024).

II. Lab-to-farm Integration

SEC. 102. TRAINING PROGRAMS FOR ENTERIC METHANE LIVESTOCK EMISSIONS.

With its research and development component, the EMIT LESS Act will establish comprehensive training programs to equip ranchers with the knowledge and skills needed to adopt innovative methane-reducing solutions, such as feed additives, enhanced grazing management, and other livestock management practices. These training initiatives will be designed to ensure that ranchers can easily integrate these methods into their existing operations, minimizing disruption while maximizing environmental benefits. Financial support will be provided to mitigate the costs of transitioning to new technologies, covering expenses like equipment, materials, and ongoing support services. Furthermore, the EMIT LESS Act, under the authority of the Food Security Act of 1985, mandates that the Secretary of Agriculture develop one or more studies focused on enteric methane emissions.

III. Monitoring & Review

SEC. 201. ON-FARM CONSERVATION INNOVATION TRIALS.

In addition to generating direct research on the science and its implementation on supported farms, the Secretary of Agriculture is expected to continuously monitor and evaluate whether the current conservation standards effectively support implementation. This ensures that revisions can be made as needed. To assess the bill's effectiveness, the Secretary is also tasked with conducting research and producing reports on the extent to which its programs have contributed to reducing methane emissions and boosting economic growth. These reports must be submitted to the Committee on Agriculture, Nutrition, and Forestry of the Senate and the Committee on Agriculture of the House of Representatives.

IV. Payment Programs

The Act will amend two existing payment programs under the Food Security Act of 1985 to include "livestock-managed practices that reduce greenhouse gas emissions."

SEC. 203. ENVIRONMENTAL QUALITY INCENTIVES PROGRAM PAYMENTS.

Environmental Quality Incentives Program

The "Environmental Quality Incentives Program" (EQIP) is adjusted in terms of scope and emphasis to specifically reference management practices and greenhouse gas emission reductions. Payments to producers that were previously only focused on factors like soil health, water quality and quantity, and nutrient management, will now also be provided for practices that reduce greenhouse gas emissions through livestock management. Payments are given for 75% of costs associated with the process of planning, implementing, and maintaining the livestock program, as well as 100% of income forgone by the producer. The amendments ensure that greenhouse gas emissions, specifically methane emissions from livestock, are explicitly eligible for priority funding (Food Security Act, H.R.6363, 118th Congress, 1985).

SEC. 204. CONSERVATION STEWARDSHIP PROGRAM PAYMENTS.

Conservation Stewardship Program

The EMIT LESS Act also amends the Conservation Stewardship Program (CSP) payments to explicitly include livestock management as a conservation measure. The bill designates livestock feed management as an activity eligible for supplemental payments, which were previously available only for resource-conserving crop rotations and advanced grazing management. Livestock feed management involves adjusting the quantity and quality of nutrients to minimize excess nutrients in manure (such as nitrogen and phosphorus), thereby reducing water contamination and lowering emissions of ammonia, greenhouse gases, and other volatile organic compounds from animal feeding operations. Supplemental payments to farmers must be no less than 150% of the annual payment amount determined for general conservation activities under the program. This annual payment covers costs related to planning, design, materials, installation, labor, management, maintenance, training, and forgone income. Payments are also based on the expected conservation benefits and the extent to which the conservation activities are integrated across the entire agricultural operation (Food Security Act, H.R. 6363, 118th Cong., 1985). Through these provisions, the bill incentivizes the adoption of livestock management practices that reduce greenhouse gas emissions by reimbursing farmers for their costs and compensating them for delivering environmental benefits.

Placing the EMIT LESS Act in the larger corpus of legislation

The EMIT LESS Act of 2024 builds on key agricultural and environmental legislation to address enteric methane emissions:

- **Agricultural Research, Extension, and Education Reform Act of 1998:** Expands Title IV by establishing training programs to develop livestock management practices that reduce methane emissions and improve monitoring of livestock health and welfare.
- **Food Security Act of 1985:** Enhances conservation efforts by modifying USDA programs, such as EQIP, to provide financial incentives for methane-reducing practices.
- **Innovative FEED Act of 2023-2024:** Aligns with efforts to advance feed additives and diet-based strategies for methane reduction, creating synergies with ongoing research initiatives.

POLITICAL LANDSCAPE

After being introduced in the Senate, the EMIT LESS Act was also introduced in the House of Representatives by Reps. Crockett (TX-30) and Molinaro (NY-30). It is currently under legislative consideration in both Congressional chambers (EDF, 2024). As of the end of March 2024, the bill has been read twice in the Senate and referred to the Committee on Agriculture, Nutrition, and Forestry.

Notably, the EMIT LESS Act is intended to be incorporated into the next iteration of the "Farm Bill" (Brooks, 2024). The next iteration, titled the Farm, Food, and National Security Act of 2024 (H.R. 8467), has been approved by the House Committee on Agriculture. However, further progress has stalled due to the United States Presidential election, ongoing budgetary concerns, and other immediate Congressional priorities (Farm Aid, 2024; House Committee on Agriculture, 2024).

A prior Hearing on Sustainable Agriculture Practices held by the House Agriculture Subcommittee on Livestock and Foreign Agriculture in 2022 highlighted debates over these issues but revealed an overall consensus on the importance of research and voluntary measures within the industry.

The bill has garnered public support from a broad coalition of stakeholders, including major agricultural, environmental, and research organizations. Key supporters include the American Feed Industry Association (AFIA), which backs the bill's emphasis on innovative feed ingredients to reduce methane emissions from livestock. Agricultural groups such as the Dairy Farmers of America (DFA), the Food and Agriculture Climate Alliance (FACA), and the National Milk Producers Federation (NMPF) support the bill for its voluntary approach, enabling farmers to adopt methane-reducing practices without regulatory mandates.

Research institutions like Colorado State University's AgNext Program, environmental organizations such as the Environmental Defense Fund (EDF), and industry leaders like the Breakthrough Institute have also expressed their support, recognizing the bill's potential to advance both agricultural sustainability and environmental protection. Corporate supporters include McDonald's and the International Dairy Foods Association (IDFA), who are aligned with the bill's goal of promoting more sustainable agricultural practices (Bennet, 2024).

OBSTACLES TO PASSAGE

The EMIT LESS Act has garnered bipartisan support; however, political challenges persist in balancing environmental objectives with agricultural interests. Critics express concerns that expanding USDA conservation programs could lead to regulatory overreach or unintentionally incentivize methane capture, potentially increasing emissions.

The bill's focus on researching solutions for enteric emissions makes it less controversial. Nonetheless, environmental advocates argue that relying on voluntary measures and incorporating the bill into the next Farm Bill may be insufficient to meet the United States' commitments under the Global Methane Pledge.

PROGRAM DESIGN

GUIDING PRINCIPLES

To achieve the long-term goal of curtailing enteric methane emissions from livestock, the Act entrusts the Secretary of Agriculture with a set of guiding principles and requirements influencing the framework of the EMIT LESS Program.

Review and Revision of Conservation Practice Standards

The Secretary is responsible for reviewing existing conservation practice standards and considering revisions or new standards that support the reduction of enteric methane emissions.

Establishment of Testing Facilities and Expertise

The Secretary must establish and operate laboratory and testing facilities through the ARS to study enteric methane emissions, including baseline levels, mitigation product efficiency and safety, as well as impacts on animal health and productivity. The ARS must also appoint expert personnel to conduct these studies.

Establishment of Training Programs at Educational Institutions

The Secretary is responsible for establishing or expanding training programs related to enteric methane emissions from livestock at eligible land-grant colleges or universities (1862, 1890, and 1994 Institutions*), with a focus on advancing practical agriculture, science, and engineering.

Reporting Emission Changes and Economic Outcomes

The Secretary is required to conduct reviews on changes in methane emissions and, if feasible, the economic outcomes resulting from livestock practices aimed at reducing enteric methane emissions. The Secretary must provide an annual report to Congress detailing the progress and results of these studies.

PROGRAM OBJECTIVES

I — **Research & Development of Methanogenesis-reducing Solutions**

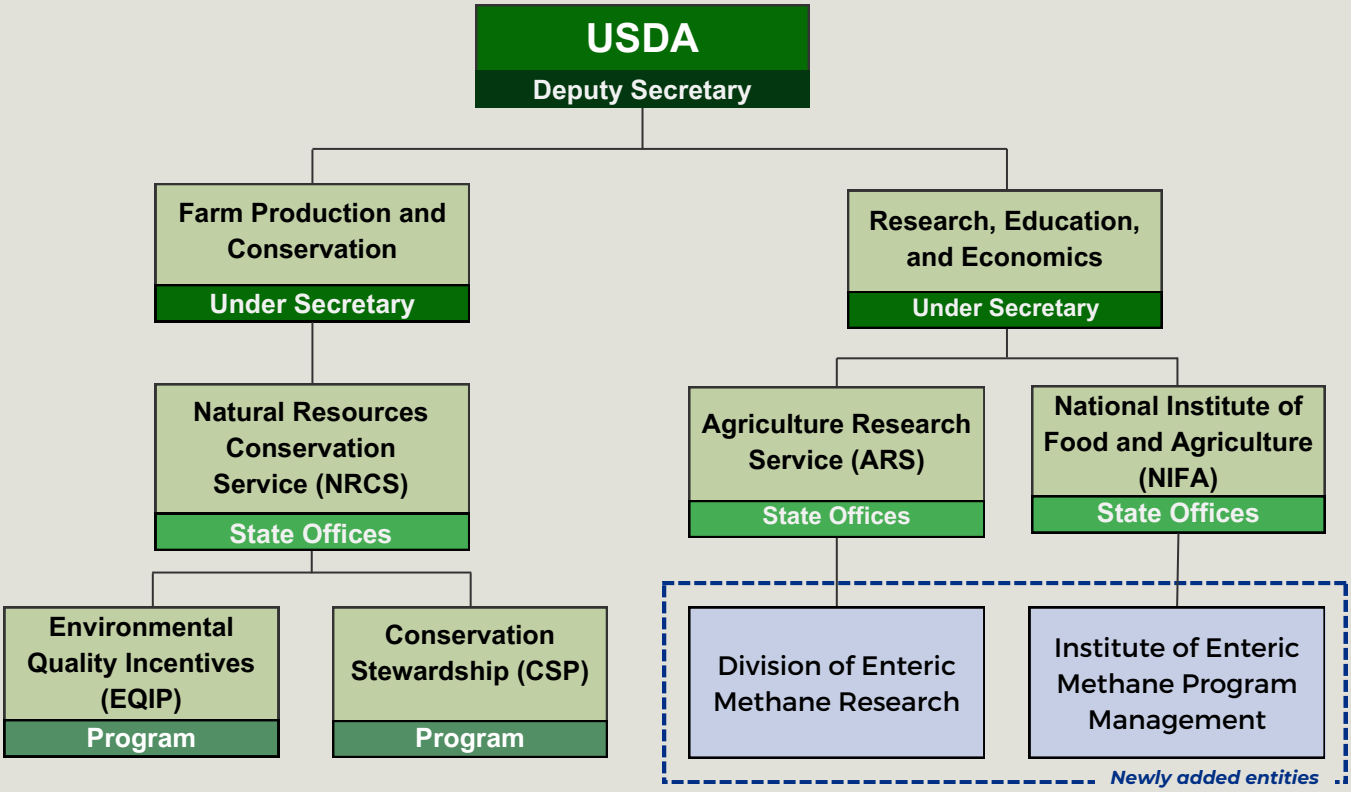
II — **On-Farm Applications and Training Programs**

III — **Financial and Technical Incentives for Voluntary Adoption of Solutions**

* 1862 institutions are land-grant colleges or universities that focus on advancing practical agriculture, science, and engineering. 1890 institutions are a group of 19 historically Black universities funded to generate high-quality agricultural research and promote skilled graduates in agricultural sciences. 1994 institutions are a group of 36 federally-recognized, tribally-controlled colleges and universities (NEA, 2022).

AGENCY FRAMEWORK

To achieve its objectives, the EMIT LESS Program will leverage existing USDA sub-agencies while establishing new organizational structures focused solely on reducing enteric methane emissions. The sub-agencies participating in this program include the ARS, leading the Research and Development objective; the National Institute of Food and Agriculture (NIFA), managing the On-Farm Application and Training objective; and the Natural Resources Conservation Service's (NRCS) payment programs, overseeing the Financial and Technical Assistance objective.



EQIP

- Expands and enhances conservation activities.
- Annual payment is offered based on stewardship level and improvement plans.
- Long-term, systems-based approach.

CSP

- New conservation projects.
- Financial and technical assistance offered.
- Project-based, one-time investments.

ARS

- Primary research entity of the USDA.
- 5-year Research Action Plan.
- Regional ARS Research Units.
- Development of agricultural technologies and solutions.
- Scientific journal publications.

NIFA

- Bridges research with practical application.
- Extension services for farmers.
- Support through grants and agreements.
- Education and outreach.

ORGANIZATION & STAFFING

The program prioritizes research and development to reduce methanogenesis in ruminant livestock, which accounts for 95% of total enteric methane emissions. By advancing knowledge on the effectiveness of various methanogenesis-reducing practices—key to the program's goals—reliable scientific studies can progress to on-farm trials and inform the creation of institutional training programs and financial assistance initiatives that promote the adoption of the most effective practices.

I. Research & Development of Methanogenesis-reducing Solutions

USDA Agricultural Research Service

As required by the Act, ARS will lead the research and development objective by establishing the appropriate infrastructure, facilities, and expertise to conduct new studies aimed at improving the general understanding of methane emissions and reduction strategies.

To maximize ARS resources and ensure thematic focus, the EMIT LESS Program will designate "methanogenesis" as a research priority in the ARS Action Plan. With this research priority in place, the Division of Enteric Methane Research (DEMR) will be created to oversee all research initiatives related to enteric methane reduction, including methanogenesis and other related areas such as feed management, rumen microbiology, and methane measurement. The DEMR will require new staff, including a Division Director (GS-13) and research staff comprising five Full-Time Equivalents (FTEs).

ARS conducts its research through regional laboratories and research units with specific thematic expertise. To support the program's research objectives, the Enteric Methane Research Laboratory will be established to work directly with the DEMR, advancing scientific understanding and developing solutions to reduce enteric methane emissions. A Chief Scientist (GS-13) and laboratory staff comprising 15 FTEs will be hired to operate the new laboratory.

This research lab will be embedded within the existing Field Research Implementation & Information Delivery geographic structure of ARS, with a specific focus on regions with significant livestock industries and methane emissions. By situating the lab within this geographic context, research findings can be highly relevant and promptly applied in areas where methane reduction efforts are most needed.

As authorized by the Act, contract-based collaboration with independent and academic research entities will be explored in the later stages of the EMIT LESS Program's development.

II. On-Farm Applications and Training Programs

NIFA

Once the technical and consistent scientific data is gathered and published by the ARS regional laboratories, the National Institute of Food and Agriculture (NIFA) will support and fund the dissemination and application of methanogenesis-reducing practices. NIFA has the capacity to create and fund on-farm application projects and training programs, facilitating the transfer of knowledge from ARS to real-world farming conditions and field trials. This approach allows for further testing of methane-reducing practices in practical settings—for example, evaluating an evidence-based, promising feed additive across a range of cattle breeds and geographical regions.

To streamline the transfer of research findings to on-farm applications, the Institute of Enteric Methane Program Management (IEMPM) will be established under NIFA. This institute will be responsible for deploying research findings from the DEMR, managing practical implementation on farms, and administering training and assistance to farmers seeking to adopt methane-reducing practices. As required by the Act, institutional training programs covering various enteric methane emissions topics, including livestock feed management and greenhouse gas monitoring, will be developed once best practices are established through practical evidence from the program's research and farm trials.

The IEMPM will be led by the Institute Deputy Director (GS-14), supported by program management staff (10 FTEs). The institute will establish a "Lab-to-Farm" Integration Officer (GS-13) responsible for managing the implementation of pilot projects on farms, tracking their performance, collecting feedback for labs, and collaborating with extension services and regional leaders to integrate research findings into broader farming practices. Within the IEMPM, a Division of Training and Outreach will be created to develop training programs for farmers, educating them on the most effective methane-reducing practices. The Division of Training and Outreach will be led by a Division Director (GS-12), supported by program management staff (5 FTEs).

Key responsibilities

The head of the research division will be responsible for research progress. The head of the Institute will be responsible for driving implementation of the grant-giving process, lab-to-farm implementation, the payment programs, and public outreach to address weaknesses and strengths presented in the SWOT analysis below.

III. Financial and Technical Incentives for Voluntary Adoption of Solutions

EQIP

To promote the voluntary adoption of methane-reducing practices, the IEMPM will collaborate with the Natural Resources Conservation Service (NRCS) through its flagship conservation programs: the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). These programs provide essential financial and technical assistance to farmers seeking to make their operations more sustainable. NRCS has an extensive geographical reach across the United States, with representatives in nearly every county and state office. By focusing on enteric methane reduction practices, the IEMPM aims to leverage NRCS's established communication, grants management, and performance management systems.

Within the IEMPM, a Division of Grants will be created to oversee and manage enteric-methane-related assistance provided through the EQIP and CSP programs. Led by a Grant Division Director (GS-12) and supported by program management staff (5 FTEs), this division will manage grant distribution and ensure funding supports the methane-reducing technologies developed by ARS and applied by NIFA. Through the EQIP framework, the Division of Grants will target short-term, project-based financial and technical assistance, offering to cover up to 75% of the upfront costs for methane-reducing infrastructure. Alternatively, within the CSP framework, the Division of Grants will encourage farmers who have already implemented methane-reducing practices to continue their long-term conservation efforts by offering annual payments based on their plans to enhance and expand sustainable practices. This approach ensures that both farmers newly adopting methane-reducing practices and those already championing sustainable agriculture are eligible for financial incentives.

PROGRAM SWOT ANALYSIS

Strength	Directly targets the source of 95% of enteric methane emissions, maximizing the objectives of the Act.
	Leverages existing USDA programs and infrastructure utilizing resources most effectively.
	Aligns with cutting-edge research in animal genomics and microbiology.
Weakness	Research is in its early stages, with various promising solutions not yet ready for widespread implementation.
	Public perception issues of solutions such as genetic modification or feed additives challenge the adoption of new practices.
Opportunity	There is potential for significant emissions reduction without major changes to farm infrastructure.
	Collateral benefits from the long-term adoption of solutions can include fewer costs to farmers from increased feed efficiency and animal productivity.
	Due to nascent research and development, there are vast opportunities for innovative solutions.
Threat	Adoption of solutions may require changes to animal diets or the introduction of feed additives, which could increase costs. (Offset by financial assistance)
	Regulatory hurdles to some solutions may exist depending on local and state laws challenging the widespread adoption of solutions.

BUDGET

The EMIT LESS Act will leverage existing resources within the USDA while also creating new positions within the Division of Enteric Methane Research under ARS and the Institute of Enteric Methane Program Management under NIFA.

The total budget allocated to the various programs is not specified in the draft version of the EMIT LESS Act. ARS's existing research infrastructure and laboratories can support the new divisions, with additional needs addressed through collaboration with stakeholders, outsourcing, and contracting. Expanding research capacity at specific regional labs will be necessary to ensure the successful implementation of the EMIT LESS program. Based on the existing ARS and NIFA annual budgets (Fiscal Year 2025) of $1.8 billion and $1.7 billion, respectively, a two-year budget of $90 million is proposed for the implementation of the EMIT LESS Act. This budget includes expenses for personnel, equipment, grant payments, and other related items.

Each newly opened office will function as an in-house expert development structure, operating with dedicated managers for communication, reporting, accounting, financial operations, administration, fundraising, and partnerships to ensure efficient operation. Additionally, the integration into the larger USDA structure as well as the collaboration between entities will ensure accountability. Key new positions will include directors and associate directors for each division, a chief scientist to oversee the overall research strategy, and lead research scientists in each regional lab within the ARS Laboratories Division to guide methane-reduction initiatives.

Additionally, Regional Methane Mitigation Leaders will be appointed to tailor methane-reduction practices to specific agricultural areas. Simultaneously, a senior "Lab-to-Farm" Integration Officer will bridge the gap between research labs and real-world farm applications. Personnel expenses will align with federal GS pay levels.

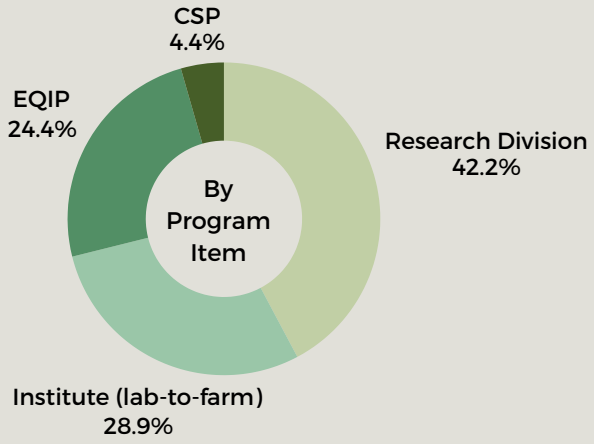
	New Positions*	GS level	Number of Staff	Salary** per Staff	Total $ p.a.
Insitute	Deputy Director	GS-15	1	$159,950	$159,950
	Division Director of Grants	GS-13	1	$115,079	$115,079
	Grant Administrator	GS-7	10	$54,577	$545,770
	Division Director of Training & Outreach	GS-13	1	$115,079	$115,079
	Program Training Manager	GS-11	10	$80,737	$807,370
	Outreach Administrator	GS-7	5	$54,577	$272,885
Research Division	Division Director of Enteric Methane Research	GS-13	1	$115,079	$115,079
	Enteric Methane Researcher	GS-12	10	$96,770	$967,700
	Total Annual Salaries		**39 Staff**		**$3,098,912**

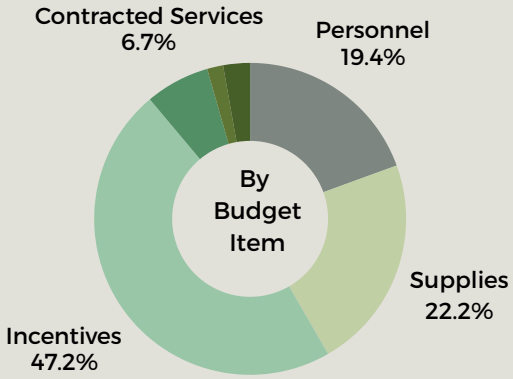
* New positions in addition to existing positions in the USDA ARS & NIFA
** Salaries are annual and based on 2024 GS-salaries

2-year Budget Overview (in million USD)

	Research Division	Institute (lab-to-farm)	EQIP	CSP	Total
1. Personnel	**9.05**	**5.8**	**2.1**	**0.55**	**17.5**
Salaries Research Personnel	7	0.5			7.5
Salaries Program Administrators	1	3	0.5	0.5	5
Salaries Field Staff	0.5	2	1.5		4
Benefits & Overhead	0.55	0.3	0.1	0.05	1
2. Equipment & Supplies	**14.5**	**3**	**1.75**	**0.75**	**20**
Laboratory Equipment	11.5	1			12.5
Field Testing Equipment	2	1	1.5	0.5	5
Office Supplies & IT Systems	1	1	0.25	0.25	2.5
3. Grants & Incentives	**12.5**	**10**	**17.5**	**2.5**	**42.5**
Research Grants	7.5				7.5
On-Farm Innovation Trials	5	10			15
Payment Programs			17.5	2.5	20
4. Contracted Services	**1.5**	**4**	**0.25**	**0.25**	**6**
External Consultants	1	1.5			2.5
Program Evaluation Services		2			2
IT Support & Maintenance	0.5	0.5	0.25	0.25	1.5
5. Travel & Transportation	**0.25**	**1.25**	**0**	**0**	**1.5**
Field Visits & Inspections		1			1
Conference & Training Attendance	0.25	0.25			0.5
6. Education & Outreach	**0**	**2.25**	**0.125**	**0.125**	**2.5**
Training Materials & Development		1			1
Public Awareness Campaign Materials		1.25	0.125	0.125	1.5
Total 2-year Budget	**37.8**	**26.3**	**21.725**	**4.175**	**90**

Budget Breakdowns





PERFORMANCE MANAGEMENT

The performance management framework for the EMIT LESS Act ensures accountability and progress toward its methane reduction goals through a structured grant-giving process, robust data collection, and measurable outcomes. The framework emphasizes equitable grant distribution across geographic regions, diverse farm types, and demographics, while also tracking the effectiveness of funded projects through detailed metrics.

The framework includes control metrics to monitor implementation and address challenges, such as the number of funded research projects, methane reductions by solution, and changes in livestock productivity and health. Additionally, the bill requires the USDA to prepare a report to Congress within the first two years, detailing the current status including baseline emissions, up-to-date progress, and a working plan for the period after the report.

GRANT APPLICATION PROCESS

During the grant application process, grants will be submitted for review by the grant administrators (GS-7) in the IEMPM. The criteria and review process for the grants will focus on ensuring a sufficient and equitable distribution of grants across geographical priorities, primarily targeting Western states such as Texas and California for both dairy and beef cows. Under the sufficient distribution of grants across different geographic regions, the total funding allocated per project category (e.g., research, on-farm application) will need to be considered.

Under equity of grant distribution, factors such as the diversity of applicants based on farm size, type, and demographic, as well as the percentage of grants awarded across different regions, will need to be taken into account. After grant administrators (GS-7) review the grant applications and select eligible applicants based on the criteria, the eligible grant applications will be submitted to the Division Director of Grants (GS-13) for the final decision on which applicants will receive grants. Approved grant applications will then be forwarded to the Deputy Director (GS-15) for final approval. Once the Deputy Director (GS-15) grants final approval, funding allocations and award notifications will be issued to successful applicants with compliance and reporting guidelines.

OUTCOME METRICS

Outcome metrics are important because they measure the actual contribution of the bill to mitigating climate change, enhancing the implementability of methanogenesis-reducing solutions, and improving animal health.

%

Reduction in enteric methane emissions from U.S. cattle farms

%

Share of U.S. cattle farms that have adopted methanogenesis solutions

%

Increase in livestock productivity, including growth rate and milk yield

#

of enteric methane-reducing solutions that are considered safe to use by the ARS

CONTROL METRICS

While the outcome metrics are most important for the intended purpose of the bill, we will define control metrics to help the responsible parties manage individual progress and identify shortcomings more effectively.

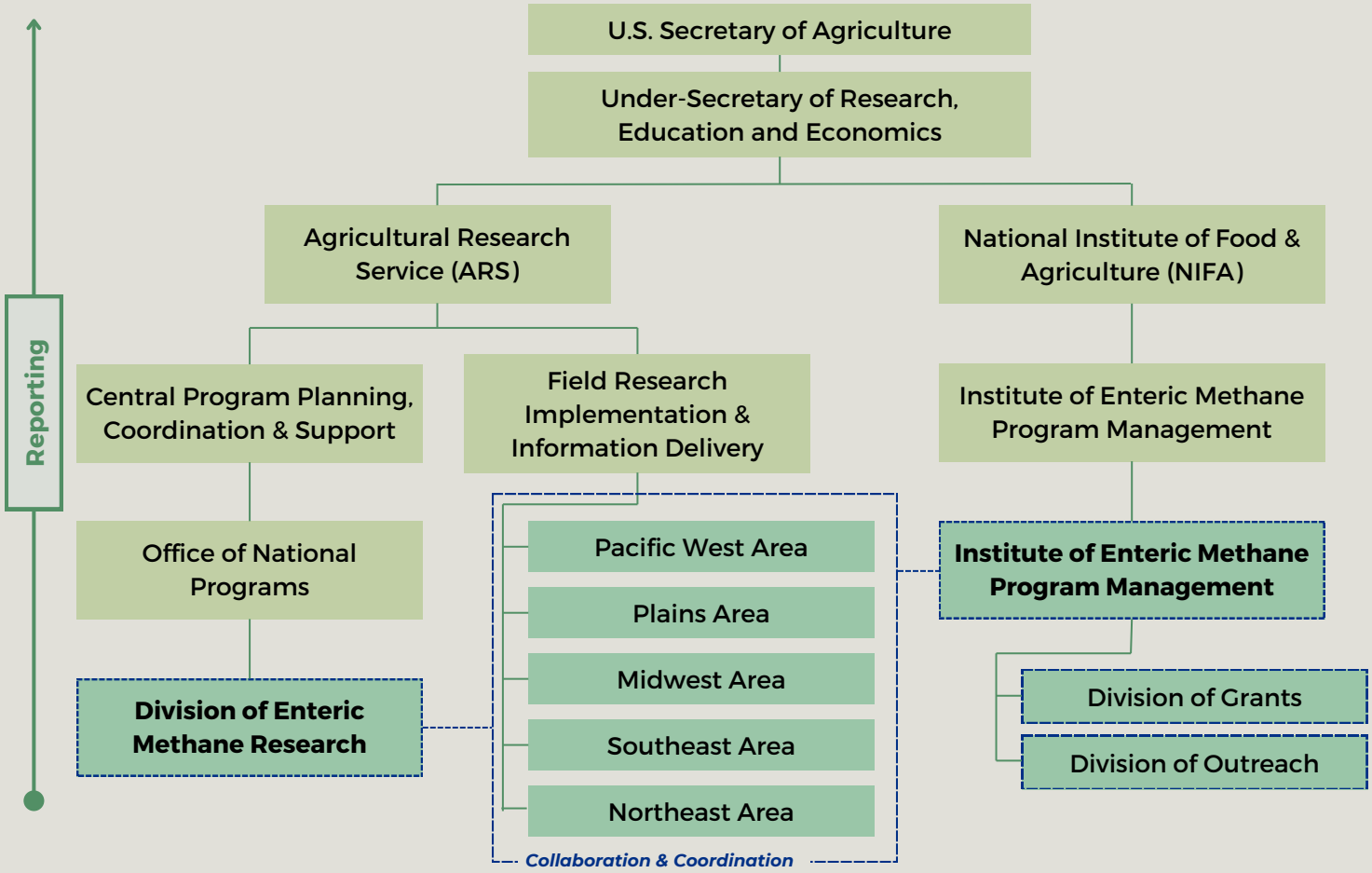
	Metrics	Data Source
I. Research & Development	# of research projects funded, categorized by mitigation practice	Grant application database
	# of completed preliminary assessments on the effects of methane-reducing practices on animal health	Research Divison Records
	% reduction in methane emissions by solution	Lab/on-farm trials
	% change in livestock productivity after implementation of solutions, including milk yield, reproductive performance, and growth rate	Lab/on-farm trials
	% decrease in mortality rate and disease incidence after implementation of solutions	Lab/on-farm trials
	% reduction of costs of implementing enteric methane mitigation practice by solution	Lab/on-farm trials
II. Lab-to-farm implementation	# of hours of technical assistance provided to farmers on implementing and monitoring enteric methane-reducing practices	Institute database
	Completion of development of educational materials and training programs for farmers	Insitute database
	% of satisfied farmers with technical assistance and support, assessed through survey and a structured feedback mechanism	Survey conducted by Institute
	% of U.S. cattle farmers participating in training programs on enteric methane reduction and best management practices	Land-grant university database

	Metrics	Data Source
III. Payment programs	# of farms participating in EQIP and CSP programs, by region and size of farm	Grant application database
	% increase in the number of farms adopting enteric methane-reducing practices, compared to previous year	Grant application database
	% of available funds distributed to implementation projects	Grant application database

ADMINISTRATIVE METRICS & FEEDBACK STRUCTURE

Metrics	Frequency
# of staff hired	Monthly
# of laboratories set up	Monthly
% of stocktake (baseline enteric methane emissions) completed	Quarterly

Reporting of progress for both the Division and the Institute follows a hierarchical approach. The main responsibility lies with the Under-Secretary of Research, Education and Economics and the Secretary of Agriculture, who has the mandate from Congress.



MASTER CALENDAR

STAGE	PHASE	TASK TITLE	TASK OWNER	Metric/KPIs Checkpoint	Stage 1			Stage 2			Stage 3			Stage 4		
					Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
STAGE 1	Secure funding & hire core staffing	Finalize budget allocations	Deputy Director of IEMPM	10% staffing goal by Stage 1												
		Begin recruiting core staff positions														
		Interview and make offers to candidates														
		Complete onboarding & initial training														
	Set up research laboratory	Identify lab locations in priority regions	EMR Chief Scientists	Lab set up in TX, OK, MI, CA, WI, ID												
		Procure equipment & materials														
		Complete setup and begin lab readiness verification														
	R&D project selection	Finalize project selection criteria	Division Director of EMR	Number of research projects funded - 100%												
		Announce proposals and open application portal														
		Collect applications and request required documentation														
		Review and score proposals														
		Select projects and notify recipients														
STAGE 2	Begin baseline data collection	Review data to assess current coverage, identify gaps	EMR Chief Scientists	Baseline enteric methane emission - 100%												
		Define key data metrics and establish protocols														
		Train staff on data collection methodologies														
		Begin data collection in targeted regions														
	On-farm financial incentives applications	Draft and finalize guidelines	Division Director, Division of Grants	Number of farms - 100%												
		Publish finalized guidelines and open for applications														
		Review and score applications														
		Finalize recipient selection and notify awardees														
	Hire staffing	Continue recruting core staff positions	EMR Chief Scientists	25% staffing goal by Stage 2												
		Interview and make offers to candidates														
		Complete onboarding & initial training														
	R&D quarterly reporting	Collect data from R&D project reports	Division Director of EMR	Report submitted to USDA												
		Review and compile findings for internal use														
STAGE 3	Continue data collection	Aggregate and analyze data to monitor progress	Enteric Methane Research Chief Scientists	Animal productivity indicators - 100%												
		Assess initial trends and identify adjustments														
	Pilot on-farm training sessions	Identify pilot participants and schedule sessions	Lab-To-Farm Integration Officer	Types of practices & technical assistance - 50%												
		Conduct pilot training sessions														
	Hire staffing	Continue recruting core staff positions	Enteric Methane Research Chief Scientists	40% staffing goal by Stage 3												
		Interview and make offers to candidates														
		Complete onboarding & initial training														
	R&D quarterly reporting	Collect data from all R&D project reports	Division Director of EMR	Report submitted to USDA												
		Review and compile findings for internal use														
	Initial supports reporting	Prepare initial public reports based on program progress	of Training & Outreach, Division Director of Grants	Report submitted to public												
		Publish reports on website and distribute to stakeholders														
STAGE 4	Data collection and monitoring	Maintain consistent data analysis with practices	Regional Methane Mitigation Leaders	Animal health and welfare indicators - 100%												
		Prepare comprehensive data summary														
	Conduct assessment and refine strategy	Gather feedback from farmers and stakeholders	Regional Methane Mitigation Leaders	Reported improvement and strategies, implemented by Stage 4												
		Analyze program performance based on indicators	Enteric Methane Research Chief Scientists													
		Adjust strategies based on findings														
	Pilot on-farm training	Conduct pilot training sessions	Lab-To-Farm Integration Officer	Practices Adoption - 50%, Development of educational materials - 100%												
		Collect feedback and refine educational materials														
	Annual report	Compile final metrics, success stories, and challenges	Division Director of EMR, Deputy Director of IEMPM	Report submitted to USDA and public												
		Submit annual report to USDA and publish online														

CONCLUSION

The EMIT LESS Act of 2024 represents a pivotal step in tackling the urgent challenge of enteric methane emissions from cattle, a significant contributor to global greenhouse gas emissions. By prioritizing research and development, integrating lab-to-farm practices, and offering financial support for farmers, this legislation establishes a strong framework for promoting sustainable agricultural practices. Its voluntary approach ensures that farmers remain central to the transition, equipped with the tools, training, and incentives needed to adopt methane-reducing solutions without compromising productivity or economic viability.

Nevertheless, successful implementation will hinge on addressing key challenges, such as the need for extensive real-world validation of proposed solutions, resolving ethical and regulatory concerns, and ensuring equitable access to resources across diverse farming systems. Ongoing collaboration among government agencies, researchers, industry stakeholders, and the farming community will be essential for driving progress and realizing the Act's objectives. The EMIT LESS Act offers a vital opportunity to reduce agricultural methane emissions while championing innovation, sustainability, and economic resilience in the livestock sector—laying the groundwork for climate-smart agriculture on a global scale.

REFERENCES

American Feed Industry Association. (2024). AFIA Applauds US House's Introduction of the EMIT LESS Act. AFIA. https://www.afia.org/news/news-release-items/afia-applauds-us-house-s-introduction-of-the-emit-less-act/

ArkeaBio. (n.d.). ArkeaBio. ArkeaBio. Retrieved August 12, 2024, from https://live-arkea-bio-corp.pantheonsite.io/
Baethge, J. (2024). Policy quick hits: USDA funding to help more than 11K agriculture workers. https://www.farmprogress.com/farm-policy/policy-quick-hits-usda-funding-to-help-more-than-11k-agriculture-workers

Beauchemin, K. A., Kreuzer, M., O'Mara, F., & McAllister, T. A. (2008). Nutritional management for enteric methane abatement: A review. Australian Journal of Experimental Agriculture, 48(2), 21–27. https://doi.org/10.1071/EA07199

Bennet, M. (2024). Bennet, Crapo, Baldwin, Moran Introduce Bill to Voluntarily Reduce Methane Emissions from Livestock. Michael Bennet. https://www.bennet.senate.gov/public/index.cfm/2024/3/bennet-crapo-baldwin-moran-introduce-bill-to-voluntarily-reduce-methane-emissions-from-livestock

Clear Center. (2021, May 27). How can cattle feed additives reduce greenhouse gas emissions? https://clear.ucdavis.edu/explainers/how-can-cattle-feed-additives-reduce-greenhouse-gas-emissions

Crockett, J. (2024, June 11). Crockett, Molinaro Introduce EMIT LESS Act to Reduce Agricultural Carbon Emissions | Representative Crockett. http://crockett.house.gov/media/press-releases/crockett-molinaro-introduce-emit-less-act-reduce-agricultural-carbon-emissions

de Haas, Y., Veerkamp, R. F., de Jong, G., & Aldridge, M. N. (2021). Selective breeding as a mitigation tool for methane emissions from dairy cattle. Animal, 15, 100294. https://doi.org/10.1016/j.animal.2021.100294

Dias, E. F. F., de Carvalho, F. E., Polizel, G. H. G., Cançado, F. A. C. Q., Furlan, É., Fernandes, A. C., Schalch Júnior, F. J., Santos, G. E. C., Ferraz, J. B. S., & Santana, M. H. de A. (2024). Fetal Programming Influence on Microbiome Diversity and Ruminal and Cecal Epithelium in Beef Cattle. Animals: An Open Access Journal from MDPI, 14(6), 870. https://doi.org/10.3390/ani14060870

Difford, G. F., Plichta, D. R., Løvendahl, P., Lassen, J., Noel, S. J., Højberg, O., Wright, A.-D. G., Zhu, Z., Kristensen, L., Nielsen, H. B., Guldbrandtsen, B., & Sahana, G. (2018). Host genetics and the rumen microbiome jointly associate with methane emissions in dairy cows. PLoS Genetics, 14(10), e1007580. https://doi.org/10.1371/journal.pgen.1007580

EMIT LESS Act, S. 4056, 118th Cong. (2024). Text—S.4056—118th Congress (2023-2024): EMIT LESS Act of 2024 | Congress.gov | Library of Congress. https://www.congress.gov/bill/118th-congress/senate-bill/4056/text

European Commission. (2015). Eight things you should know about GMOs. Topics | European Parliament. https://www.europarl.europa.eu/topics/en/article/20151013STO97392/eight-things-you-should-know-about-gmos

Farm Aid. (2024, November 20). The Latest Updates on the Farm Bill. Farm Aid. https://www.farmaid.org/issues/farm-policy/the-latest-updates-on-the-2023-farm-bill/

Food Security Act, H.R.6363, 118th Congress. (1985). Food Security Act fo 1985. U.S. Government Publishing Office.
Fouts, J. Q., Honan, M. C., Roque, B. M., Tricarico, J. M., & Kebreab, E. (2022). Enteric methane mitigation interventions. Translational Animal Science, 6(2), txac041. https://doi.org/10.1093/tas/txac041

Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., & Tempio, G (Eds.). (2013). Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations.

Gibbs, M. J., Conneely, D., Johnson, D., Lasse, K. R., & Ulyatt, M. J. (2001). CH4 EMISSIONS FROM ENTERIC FERMENTATION. IPCC: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, CORRIGENDUM (GPGAUM-Corr.2001.01, 15 June 2001), 297–320.

Haque, M. N. (2018). Dietary manipulation: A sustainable way to mitigate methane emissions from ruminants. Journal of Animal Science and Technology, 60(1), 15. https://doi.org/10.1186/s40781-018-0175-7

Hayes, B. J., Donoghue, K. A., Reich, C. M., Mason, B. A., Bird-Gardiner, T., Herd, R. M., & Arthur, P. F. (2016). Genomic heritabilities and genomic estimated breeding values for methane traits in Angus cattle1. Journal of Animal Science, 94(3), 902–908. https://doi.org/10.2527/jas.2015-0078

Hess, M., Sczyrba, A., Egan, R., Kim, T.-W., Chokhawala, H., Schroth, G., Luo, S., Clark, D. S., Chen, F., Zhang, T., Mackie, R. I., Pennacchio, L. A., Tringe, S. G., Visel, A., Woyke, T., Wang, Z., & Rubin, E. M. (2011). Metagenomic Discovery of Biomass-Degrading Genes and Genomes from Cow Rumen. Science, 331(6016), 463–467. https://doi.org/10.1126/science.1200387

House Committee on Agriculture. (2024, May 24). Committee Advances Farm, Food, and National Security Act of 2024 With Bipartisan Support. House Committee on Agriculture | Chairman GT Thompson. https://agriculture.house.gov/news/documentsingle.aspx?DocumentID=7781

IPCC. (2022). Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. doi:10.1017/9781009157926

Ishler, V. A. (2021). Dairy Sense: Hot Weather Ration Sense. https://extension.psu.edu/dairy-sense-hot-weather-ration-sense

Ishler, V. A., Rosemond, R., Beck, T., & Becker, C. (2023). Total Mixed Rations for Dairy Cows. https://extension.psu.edu/total-mixed-rations-for-dairy-cows

Jafari, S., Ebrahimi, M., Goh, Y. M., Rajion, M. A., Jahromi, M. F., & Al-Jumaili, W. S. (2019). Manipulation of Rumen Fermentation and Methane Gas Production by Plant Secondary Metabolites (Saponin, Tannin and Essential Oil) – A Review of Ten-Year Studies. Annals of Animal Science, 19(1), 3–29. https://doi.org/10.2478/aoas-2018-0037

Knapp, J. R., Laur, G. L., Vadas, P. A., Weiss, W. P., & Tricarico, J. M. (2014). Invited review: Enteric methane in dairy cattle production: Quantifying the opportunities and impact of reducing emissions. Journal of Dairy Science, 97(6), 3231–3261. https://doi.org/10.3168/jds.2013-7234

Kramer, K., & Meijboom, F. L. B. (2022). The Ethics of Innovations in Genomic Selection: On How to Broaden the Scope of Discussion. Journal of Agricultural and Environmental Ethics, 35(2), 7. https://doi.org/10.1007/s10806-022-09883-6

Kulkarni, N. A., Chethan, H. S., Srivastava, R., & Gabbur, A. B. (2022). Role of probiotics in ruminant nutrition as natural modulators of health and productivity of animals in tropical countries: An overview. Tropical Animal Health and Production, 54(2), 110. https://doi.org/10.1007/s11250-022-03112-y

Lileikis, T., Nainienė, R., Bliznikas, S., & Uchockis, V. (2023). Dietary Ruminant Enteric Methane Mitigation Strategies: Current Findings, Potential Risks and Applicability. Animals : An Open Access Journal from MDPI, 13(16), 2586. https://doi.org/10.3390/ani13162586

Lopes, J. C., de Matos, L. F., Harper, M. T., Giallongo, F., Oh, J., Gruen, D., Ono, S., Kindermann, M., Duval, S., & Hristov, A. N. (2016). Effect of 3-nitrooxypropanol on methane and hydrogen emissions, methane isotopic signature, and ruminal fermentation in dairy cows. Journal of Dairy Science, 99(7), 5335–5344. https://doi.org/10.3168/jds.2015-10832

Meale, S. J., Popova, M., Saro, C., Martin, C., Bernard, A., Lagree, M., Yáñez-Ruiz, D. R., Boudra, H., Duval, S., & Morgavi, D. P. (2021). Early life dietary intervention in dairy calves results in a long-term reduction in methane emissions. Scientific Reports, 11(1), 3003. https://doi.org/10.1038/s41598-021-82084-9

Menchaca, A., dos Santos-Neto, P. C., Mulet, A. P., & Crispo, M. (2020). CRISPR in livestock: From editing to printing. Theriogenology, 150, 247–254. https://doi.org/10.1016/j.theriogenology.2020.01.063

Mootral. (2023). Mootral introduces new methane reduction technology. https://mootral.com/knowledge-hub/mootral-introduces-new-methane-reduction-technology

NEA. (2022). Land Grant Institutions: An Overview. In NEA RESEARCH LAND GRANT UNIVERSITY BRIEF NO. 1. https://www.nea.org/sites/default/files/2022-03/Land%20Grant%20Institutions%20-%20An%20Overview.pdf

O'Neill, T. (2024, February 12). Harvard Initiative on Reducing Global Methane Emissions. The Salata Institute. https://salatainstitute.harvard.edu/methane-initiative-summary/

Roehe, R., Dewhurst, R. J., Duthie, C.-A., Rooke, J. A., McKain, N., Ross, D. W., Hyslop, J. J., Waterhouse, A., Freeman, T. C., Watson, M., & Wallace, R. J. (2016). Bovine Host Genetic Variation Influences Rumen Microbial Methane Production with Best Selection Criterion for Low Methane Emitting and Efficiently Feed Converting Hosts Based on Metagenomic Gene Abundance. PLoS Genetics, 12(2), e1005846. https://doi.org/10.1371/journal.pgen.1005846

Sanjorjo, R. A., Tseten, T., Kang, M.-K., Kwon, M., & Kim, S.-W. (2023). In Pursuit of Understanding the Rumen Microbiome. Fermentation, 9(2), Article 2. https://doi.org/10.3390/fermentation9020114

Sari, N. F., Ray, P., Rymer, C., Kliem, K. E., & Stergiadis, S. (2022). Garlic and Its Bioactive Compounds: Implications for Methane Emissions and Ruminant Nutrition. Animals, 12(21), Article 21. https://doi.org/10.3390/ani12212998

Schilde, M., von Soosten, D., Hüther, L., Meyer, U., Zeyner, A., & Dänicke, S. (2021). Effects of 3-nitrooxypropanol and varying concentrate feed proportions in the ration on methane emission, rumen fermentation and performance of periparturient dairy cows. Archives of Animal Nutrition, 75(2), 79–104. https://doi.org/10.1080/1745039X.2021.1877986

Sicard, C. (2023, April 17). Can CRISPR Cut Methane Emissions From Cow Guts? UC Davis. https://www.ucdavis.edu/food/news/can-crispr-cut-methane-emissions-cow-guts

Song, Y., Qiao, W., Westerholm, M., Huang, G., Taherzadeh, M. J., & Dong, R. (2023). Microbiological and Technological Insights on Anaerobic Digestion of Animal Manure: A Review. Fermentation, 9(5), Article 5. https://doi.org/10.3390/fermentation9050436

Sun, T., Ocko, I. B., Sturcken, E., & Hamburg, S. P. (2021). Path to net zero is critical to climate outcome. Scientific Reports, 11(1), 22173. https://doi.org/10.1038/s41598-021-01639-y

US EPA. (2023a). Greenhouse Gas Inventory Data Explorer | US EPA. https://cfpub.epa.gov/ghgdata/inventoryexplorer/#iagriculture/entericfermentation/select/select/all

US EPA. (2023b, January 20). Methane Emissions Reduction Program [Collections and Lists]. https://www.epa.gov/inflation-reduction-act/methane-emissions-reduction-program

US EPA, O. (2024, June 21). EPA, DOE Announce $850 Million to Reduce Methane Pollution from the Oil and Gas Sector [News Release]. https://www.epa.gov/newsreleases/epa-doe-announce-850-million-reduce-methane-pollution-oil-and-gas-sector

USDA. (n.d.). About the Northeast Climate Hub | USDA Climate Hubs. Retrieved November 26, 2024, from https://www.climatehubs.usda.gov/hubs/northeast/about

Vetriani, C. (2001). Archaea, Origin of. In S. A. Levin (Ed.), Encyclopedia of Biodiversity (Second Edition) (pp. 218–226). Academic Press. https://doi.org/10.1016/B978-0-12-384719-5.00177-5

Vrancken, H., Suenkel, M., Hargreaves, P. R., Chew, L., & Towers, E. (2019). Reduction of Enteric Methane Emission in a Commercial Dairy Farm by a Novel Feed Supplement. Open Journal of Animal Sciences, 9(3), Article 3. https://doi.org/10.4236/ojas.2019.93024

Wall, E., Simm, G., & Moran, D. (2010). Developing breeding schemes to assist mitigation of greenhouse gas emissions. Animal, 4(3), 366–376. https://doi.org/10.1017/S175173110999070X

Wasson, D. E., Yarish, C., & Hristov, A. N. (2022). Enteric methane mitigation through Asparagopsis taxiformis supplementation and potential algal alternatives. Frontiers in Animal Science, 3. https://doi.org/10.3389/fanim.2022.999338

World Bank. (2023). 15 programs to cut methane emissions | Greenhouse gas and global warming [Text/HTML]. World Bank. https://www.worldbank.org/en/news/factsheet/2023/12/04/world-bank-steps-up-efforts-to-address-methane-emissions

Zhang, L., Huang, X., Xue, B., Peng, Q., Wang, Z., Yan, T., & Wang, L. (2015). Immunization against Rumen Methanogenesis by Vaccination with a New Recombinant Protein. PLOS ONE, 10(10), e0140086. https://doi.org/10.1371/journal.pone.0140086

Zhang, X. M., Smith, M. L., Gruninger, R. J., Kung, L., Jr, Vyas, D., McGinn, S. M., Kindermann, M., Wang, M., Tan, Z. L., & Beauchemin, K. A. (2021). Combined effects of 3-nitrooxypropanol and canola oil supplementation on methane emissions, rumen fermentation and biohydrogenation, and total tract digestibility in beef cattle. Journal of Animal Science, 99(4), skab081. https://doi.org/10.1093/jas/skab081

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