The 'Dark Horse' of Climate Change:

Agricultural Methane Governance in the United States and Canada

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KEY FINDINGS:

1. The US and Canada are falling behind peer countries (including some European countries and New Zealand) in terms of agricultural methane mitigation policy.
2. Neither country is considering mandatory agricultural emissions reductions, cuts in livestock production, or inclusion of agriculture in any form of greenhouse gas pricing scheme.
3. Supply-side, technically-oriented policy solutions to livestock methane emissions will, in the near term, be unable to achieve any significant emissions reduction.
4. Neither the US nor Canada is considering policy approaches that even approximate the types of comprehensive changes to the food system that will be necessary to avert catastrophic climate scenarios.

INTRODUCTION

Methane emissions took the spotlight at the 2021 United Nations Climate Change Conference of Parties (COP26) in Glasgow, Scotland. In the run-up to COP26, the United States (US) and European Union (EU) announced the Global Methane Pledge, a voluntary commitment to reduce global methane emissions by at least 30 percent below 2020 levels by 2030. To date, 111 countries, representing roughly 70 percent of the global economy and nearly half of global anthropogenic methane emissions, have signed on.

To stave off near-term global warming and buy time to decarbonize the global economy, the Intergovernmental Panel on Climate Change (IPCC) has explicitly called on nations to slash methane emissions, the second most prominent greenhouse gas (GHG) after carbon dioxide. Given that methane has a short-term global warming potential 87 times greater than that of carbon dioxide over a 20-year time horizon but only persists in the atmosphere for roughly a dozen years, mitigating methane emissions will have almost immediate benefits in reducing global warming (The Economist 2021). As such, the Global Methane Pledge represents perhaps one of the most significant global efforts to maintain the viability of limiting global warming to 1.5 degrees Celsius in the near term, as established under the Paris Agreement of 2015.

Although undoubtedly a tremendous step forward in global climate policy development, the lack of sector-specific targets or enforcement mechanisms gives countries tremendous latitude in how they interpret and implement the Pledge. The structure of the agreement, moreover, allows countries to sidestep one of the largest, and perhaps politically thorniest, sources of anthropogenic methane emissions: livestock agriculture.[1]

As signatories to the Global Methane Pledge, the US and Canada have fallen short of comprehensively addressing methane emissions—what Viveca Morris[2] refers to as "cow-shaped holes"—by failing to include consequential livestock methane mitigation policies[3] (Morris 2021). Recent climate research has demonstrated that even if global combustion of fossil fuels were to cease immediately, emissions from the global food system alone would preclude 1.5 degrees Celsius of warming and threaten the preclusion of 2 degrees Celsius of warming by 2100 (Clark et al. 2020). Given that roughly half of emissions from the global food system stem from livestock production, the failure of two of the world's largest producers, consumers, and exporters of livestock and animal source food products to take concrete steps to comprehensively address livestock methane represents an enormous climate threat. The US and Canada are relying primarily on emissions reduction from their oil and natural gas sectors to fulfill their Pledge commitments, while signaling their intent to utilize voluntary, incentive-based mechanisms to reduce agricultural methane emissions primarily from livestock waste.

Both countries' histories of agricultural methane governance, however, demonstrate that these voluntary, incentive-based mechanisms do not decrease emissions. In fact, agricultural methane emissions have increased in the US and Canada over the last thirty years. Despite the proliferation of policies promoting voluntary, incentive-based mechanisms to decrease livestock methane emissions at the federal and sub-federal levels in the US and, to a lesser extent, in Canada, both countries maintain an elaborate system of subsidies for livestock and animal feed that perpetuates their statuses as major global livestock producers. As such, both countries have failed to seriously engage with the issue of agriculture methane to date at the federal level. While there have been some important policy innovations at the state and provincial level, most notably in California, these efforts fall far short of achieving significant emissions reduction and bode poorly for the future of American and Canadian methane mitigation policy.

1 Livestock agriculture is also commonly referred to as animal agriculture and these terms are often used interchangeably in the literature.

2 Viveca Morris is executive director of the Law, Ethics, and Animals Program at Yale Law School.

3 In her piece, Morris was referring just to the US, but her point applies to Canada as well.

Agricultural methane has a distinct set of politics and political logic that makes it different from other anthropogenic methane sources or the most prevalent GHG, carbon dioxide (Rabe 2022). Technically feasible agricultural methane mitigation strategies have relatively limited abatement potential, and economically feasible strategies even less so (Ocko et al. 2021). As such, the only way to significantly decrease livestock methane emissions in the near term is to substantially reduce the number of livestock produced, a prospect that is outside the bounds of mainstream political consideration in the US and Canada. American and Canadian agricultural methane mitigation policy, or lack thereof, represents a type of political enforcement of the status quo characterized by misguided mitigation policies that target only a small fraction of livestock methane emissions, while fundamentally reinforcing the existing scale of livestock production.

Despite the seriousness of the climate threat posed by agricultural methane emissions and the potential of mitigation to have near-term climate benefits, the policy sciences have generally overlooked livestock's contribution to the climate emergency and the governance of agricultural methane. This paper attempts to fill that gap by examining the American and Canadian approaches to agricultural methane governance at the federal and sub-federal levels. While the need to rapidly reduce GHG emissions from fossil fuels is widely acknowledged, the same urgency for food system emissions reduction is severely lacking in the US and Canada. In spite of their relatively small share of the global population, the US and Canada are two of the world's largest producers of the most methane-intensive livestock products, beef and pork, and in the case of the US, dairy. As such, Canada and the US have disproportionate responsibility for global livestock methane emissions, estimated to comprise six percent of total global GHG emissions[4] (Gerber et al. 2013).

At the federal level, existing American and Canadian agricultural methane policies have failed to achieve any meaningful impact on emissions. Even in the most promising state and provincial level efforts, namely California, agricultural methane mitigation efforts to date have demonstrated that technical solutions will simply be unable to achieve the scale of emissions reduction necessary in the near term. As such, the only viable policy solutions to address agricultural methane are to begin to draw down livestock production and consumer demand for red meat and dairy products, a prospect that appears highly unlikely given the political and cultural consensus around carnism[5] and the absence of political will (Sievert et al. 2020). Thus, even the most thoughtful and comprehensive livestock methane mitigation policies, such as those developed in California, will have only marginal impacts, at best, without targeting the quantity of livestock produced and consumers' dietary preferences. In detailing the American and Canadian federal and sub-federal approaches to agricultural methane mitigation, this paper hopes to demonstrate the gap between what is currently being done and the scale of the approaches necessary to limit global warming to 1.5 degrees Celsius.

Methodology

The research conducted for this paper falls into two categories. First, I conducted a wide-ranging literature review across multiple disciplines including agricultural science, nutrition, environmental health, veterinary medicine, environmental science, energy, civil engineering, economics, climate science, health policy, food and agricultural policy, climate policy, environmental policy, and energy policy to identify technically feasible methane mitigation strategies and existing types of methane mitigation policies, whether 'supply-side' (i.e., targeting livestock digestion and waste) or 'demand-side' (i.e., targeting demand for red meat and dairy products). This research was substantially supplemented by journalism and think tank sources, given the relative scarcity of academic research on agricultural methane mitigation policy. Second, I conducted extensive research on existing methane mitigation policies in the 60 sub-federal jurisdictions (50 American states and 10 Canadian provinces) and two federal governments examined for this paper. This research led to the development of a data set of federal and sub-federal methane mitigation policies, summarized in the Appendix, which served as the basis for many of the conclusions drawn in this paper as well as the selection of sub-federal cases examined below.

4 Emerging climate research suggests that this may be a significant underestimate (Hayek et al. 2021).

5 Originally coined by sociologist Melanie Joy, carnism refers to an ideology that positions consumption of meat "as 'natural, normal, and necessary' on the basis that humans evolved to eat meat and survival and strength depend on it" (Sievert et al. 2020).

AGRICULTURAL METHANE'S CONTRIBUTION TO CLIMATE CHANGE

Until recently, climate policy analysis has focused primarily on policy approaches to carbon dioxide emissions resulting from fossil fuel combustion. While reigning in carbon dioxide emissions will be necessary to avert the most catastrophic climate scenarios, the scale and potency of agricultural methane emissions render reductions in carbon dioxide emissions insufficient to limit global warming to 1.5 or 2 degrees Celsius.

As such, agricultural methane emissions have become the 'dark horse' of climate change (Fountain 2020). Although comprising only a small fraction of global GHG emissions (roughly 6 percent), agricultural methane is a growing source of emissions and represents an underexamined and likely underestimated component of the global climate crisis (Gerber et al. 2013; Hayek et al. 2021).

In the US and Canada, the federal and sub-federal governments that have taken action to address agricultural methane have focused almost entirely on the small fraction of emissions (roughly 25 percent) resulting from livestock waste, as these policies do not require changes to the scale or predominant mode of livestock production. Acknowledging the need to comprehensively address the remaining 75 percent of emissions that result from livestock digestion has become, effectively, a third rail of climate politics in the US and Canada. As will be described below, mitigation strategies addressing livestock digestion are at a very early stage of development and have largely unproven animal health impacts and mitigation efficacy. As such, addressing the vast majority of livestock methane emissions would necessitate substantial reductions in red meat and dairy production—a taboo in American and Canadian politics. The American and Canadian policy approaches to agricultural methane that will be described in this paper demonstrate the circumscribed nature of methane mitigation policy in both countries. The US and Canada are sidestepping the question of whether the current scale of domestic livestock production is compatible with limiting global warming to 1.5 degrees Celsius.

Livestock agriculture, specifically red meat and dairy, is the primary source of global agricultural methane emissions[6] and a major contributor to anthropogenic global warming. In the US and Canada, beef cattle, dairy cattle, and swine are the major sources of agricultural methane emissions.[7] Livestock agriculture is estimated to be responsible for roughly 15 percent of anthropogenic GHG emissions (including methane, nitrous oxide, and carbon dioxide) and nearly 25 percent of anthropogenic global warming (Lazarus et al. 2021). Methane is the predominant GHG from the global livestock sector, comprising 44 percent of sector emissions and roughly six percent of global GHG emissions (Gerber et al. 2013). However, emerging climate research stemming from advancements in aerial surveillance technology (i.e., 'top down' estimates) indicate that intensively raised livestock[8] may be emitting far greater quantities of methane from waste decomposition than is reported through conventional 'bottom up' estimates (Hayek et al. 2021). As such, methane emissions from intensive livestock agriculture may be significantly higher than is currently reported.

6 Rice cultivation also results in methane emissions although at a much smaller scale than livestock production.

7 Sheep, goats, and other ruminants such as buffalo also produce methane, however, they are produced in much smaller numbers than cattle or swine in the US and Canada.

8 Intensive livestock production involves keeping animals in confinement (rather than on pasture) and thus amassing enormous amounts of waste on small quantities of land, largely disconnected from crop land. Livestock waste in intensive livestock production is generally allowed to decompose anaerobically, thus emitting large quantities of methane.

Table 1: Comparison of Global, American, and Canadian Methane and Agricultural Emissions

	Methane emissions (as a percentage of total GHG emissions)	Percentage of total anthropogenic methane emissions from livestock agriculture	Agricultural emissions (inclusive of all GHG)	Agricultural methane emissions (as a percentage of total GHG emissions)
Global[9]	16%	44%	11%	6%
United States[10]	10%	37%	10%	4%
Canada[11]	13%	29%	8%	4%

Climate scientists have only recently come to understand the magnitude of the threat posed by agricultural methane and the reality that it will be impossible to avert disastrous levels of global warming without addressing the issue of livestock agriculture. GHG emissions from agriculture broadly, and livestock agriculture specifically, were hitherto considered necessary to feed a growing and upwardly mobile global population projected to reach nearly 10 billion people by the end of the 21st century (United Nations 2019). Not till 2006 was the first definitive research quantifying GHG emissions from the global livestock sector published by the Food and Agriculture Organization (FAO) of the United Nations. As such, knowledge of the climate impacts of livestock agriculture is relatively new compared to the understanding of the climate impacts of fossil fuel combustion.

In Canada and the US, which serve as the primary focal points of the research in this paper, methane constitutes 8 and 10 percent of GHG emissions, respectively, nearly half of which is associated with livestock agriculture (Environment and Climate Change Canada 2021a; US EPA 2021). The vast majority of agricultural methane emissions in both countries is directly attributable to beef and dairy cattle and, to a lesser extent, swine. Since 1990, agricultural methane emissions have increased by 16 percent in the US and 2 percent in Canada, largely driven by increased livestock production in America[12] and the low-cost, emissions-intensive manure management techniques employed on large-scale dairy and swine operations in both countries.

Limitations of Agricultural Methane Mitigation

There is a need for methane mitigation policy to address the quantity of livestock produced and consumed, rather than the methane intensity of animal source food products, because existing methane mitigation strategies are simply not highly effective. A recent study examining the impact of available technically and/or economically feasible methane mitigation measures acknowledges that without consideration of radical policy changes (such as enforcement of universal vegan or vegetarian diets, meat taxes, inclusion of livestock emissions in carbon pricing schemes, etc.) only approximately one-third of methane emissions from livestock agriculture can currently be abated through technically feasible mitigation strategies (Ocko et al. 2021). More soberingly, only two percent of methane emissions from livestock can be mitigated through economically feasible strategies (i.e., strategies with no net cost based on current cost assessments) (Ocko et al. 2021).

The vast majority of agricultural methane emissions result from enteric fermentation, a natural and essential part of ruminant livestock's digestion systems, and there are few commercially available, highly effective strategies to reduce these emissions. Only approximately a quarter of agricultural methane emissions in the US and Canada are the result of waste decomposition and manure management practices, and are thus more amenable to mitigation strategies.

9 Sources: Center for Climate and Energy Solutions 2021; Gerber et al. 2013; US EPA 2016.

10 Source: US EPA 2021.

11 Source: Environment and Climate Change Canada 2021a.

12 The number of beef and dairy cattle in Canada has declined over this time period.

While the mitigation strategies described below can reduce some fraction of methane emissions from enteric fermentation and manure management, most of these strategies are extremely expensive, generate little to no revenue for farmers and ranchers (even with government subsidies), have unproven mitigation potential, are not yet commercially available, and/or have unknown impacts on animal, and subsequently human, health. As such, the capacity of policy to achieve significant reductions of livestock methane emissions by focusing on methane intensity exclusively without reducing the quantity of livestock produced is extremely limited.

Supply-side Methane Mitigation Strategies

Methane emissions from livestock agriculture result from two distinct processes: ruminant livestock digestion and the decomposition of livestock waste in anaerobic conditions. Animal productivity (e.g., animal growth rate, efficiency of animal husbandry, etc.) also impacts the GHG intensity of beef, pork, and dairy products. To date, the vast majority of policy engagement regarding agricultural methane mitigation in the US and Canada has focused on manure management strategies, despite the fact that these represent only 25 percent of livestock methane emissions in both countries.[13] Table 2 provides an overview of supply-side methane mitigation strategies by animal.

Table 2: Overview of Methane Mitigation Strategies by Animal

Methane Mitigation Strategy	Beef Cattle	Dairy Cows	Swine
ANIMAL PRODUCTIVITY			
Improve animal health	X	X	X
Optimize breeding for livestock production efficiency	X	X	X
ENTERIC FERMENTATION			
Improve animal feed by increasing protein content and digestibility	X	X	
Feed additives	X	X	
Genetic engineering	X	X	
Methane suppressing vaccines	X	X	
Wearable devices		X[14]	
MANURE MANAGEMENT			
Transition from 'wet' to 'dry' manure management techniques (i.e., solid storage, solar drying, scraping, vacuuming, etc.)		X	X
Transition from 'wet' to 'unmanaged' techniques (i.e., raising animals on pasture or feedlot)		X	X
Capture methane emissions from 'wet' manure management (i.e., biogas) and use it to reduce its potency (methods described below)		X	X
Use biogas to generate electricity		X	X
Refine biogas to biomethane/renewable natural gas and inject into natural gas pipelines and/or compress for vehicle fuel		X	X
Flare biogas on-site		X	X
Capture methane emissions from 'wet' manure management and refine biogas into other high-value fuels, chemicals, or gasses using thermochemical or biological pathways		X	X

13 Globally, methane emissions from livestock waste represent an even smaller percentage of livestock emissions given that most livestock animals globally are raised extensively (i.e., on pasture, not in confinement).

14 To date, early-stage wearable devices are being tested only on dairy cows. Theoretically, these could be used for beef cattle, particularly those kept on feedlots.

Ruminants (such as cattle, sheep, and goats) have a large forestomach, or rumen, where microbes ferment food and produce methane as a byproduct. This process, known as enteric fermentation, results in the exhalation or eructation of methane into the atmosphere.[15] Emissions from enteric fermentation are the source of the overwhelming majority of livestock methane emissions, comprising approximately 75 percent of methane emissions from livestock in the US and Canada. The amount of methane produced through enteric fermentation is a function of the animal's diet and generally tracks the overall cattle population. Low-quality and high quantities of feed, such as grass, result in greater methane emissions as grasses are "relatively low in protein and high in fiber which reduces digestibility" and enhances methane production (USDA 2016).[16] Both Canada and the US indirectly support improved animal feed through a variety of subsidies for grains (e.g., corn) and oilseeds (e.g., soy). Feed additives, ranging from seaweed and edible oils to pharmaceuticals, are already being employed by some corporate agribusinesses, yet there has been extremely limited policy engagement regarding feed additives in both countries. To date, methane suppressing vaccines,[17] genetically engineered cattle,[18] and wearable devices[19] remain highly experimental strategies that are not yet commercially available in the US or Canada.

Over the last thirty years, methane emissions from the decomposition of livestock waste have grown dramatically because of the low-cost manure management techniques employed in industrial-scale livestock production. Consolidation of the swine and dairy industries and the concomitant rise in Concentrated Animal Feeding Operations (CAFOs)[20] [21] have resulted in the increased use of 'wet' manure management systems that have much higher methane emissions than 'unmanaged' or 'dry' manure management systems. While a wide variety of 'wet' manure management techniques exist, the most common are liquid and slurry systems, where waste is washed out of barns and flushed into large holding containers (pits, lagoons, tanks, ponds, etc.). In these conditions, livestock waste decomposes anaerobically, releasing large quantities of methane, as well as carbon dioxide and nitrous oxide (another extremely powerful short-lived climate pollutant). When animals are raised on pasture, their manure is considered 'unmanaged': it decomposes aerobically and produces carbon dioxide and nitrous oxide, but little to no methane.[22] 'Dry' manure management techniques, such as solid storage or solar drying, ideally should have largely the same emissions potential as 'unmanaged' manure. However, there is wide variability in site-specific mitigation outcomes for 'dry' manure management, making it difficult to quantify emissions reduction relative to a facility's baseline emissions (California Air Resources Board 2021).

Methane emissions from livestock waste on CAFOs can be mitigated by capturing those emissions and using the captured gases to reduce their potency. Livestock waste that is managed under 'wet' (and some 'dry') conditions can be utilized as a feedstock for biogas recovery systems, commonly referred to as methane digesters or anaerobic digesters.[23] [24] While there are a wide variety of biogas recovery systems, they all involve covering the manure storage container and capturing methane, carbon dioxide, nitrous oxide, water vapor, and other trace gases (collectively known as biogas) released during manure decomposition. This biogas can simply be flared, used to

15 Non-ruminant, mammalian livestock (i.e., swine, horses, mules, etc.) produce much smaller amounts of methane as fermentation takes place in the intestines which have a significantly lower methanogenic capacity than the rumen.

16 Quality here refers to protein content and digestibility, which are the key drivers of methane emissions from enteric fermentation. From a consumer perspective, however, grass-fed beef and dairy cattle may be considered higher quality.

17 Methane suppressing vaccines, particularly in sheep, have been experimented with in Australia and New Zealand.

18 In the US, the Food and Drug Administration (FDA) has approved genetically engineered pigs for human consumption. Although the genetic engineering efforts were designed to make pork accessible to people with meat allergies, this demonstrates that there is a viable regulatory pathway in the US for cattle that are genetically engineered for reduced methanogenic capacity.

19 Cargill, a privately held, US-based global food corporation, is experimenting with wearable devices on dairy cows in the United Kingdom.

20 CAFOs in the US are defined as agricultural enterprises where more than 1,000 animal units (i.e., 1,000 beef cattle, 700 dairy cows, or 2,500 swine) are raised in confined situations but the acronym is used colloquially as a short-hand for industrial-scale livestock production (USDA National Resources Conservation Service n.d.). Internationally, industrial-scale livestock production is referred to as Intensive Livestock Operations (ILOs), whereas in Canada they are referred to as Concentrated Feeding Operations (CFOs). This paper will use the term CAFOs.

21 CAFOs were originally pioneered by the American poultry industry in the mid-20th century and the CAFO model of agriculture spread to the swine and dairy industries beginning in the 1970s.

22 The quantity of methane produced depends largely on the climate, with manure decomposing in warmer and wetter conditions releasing more methane (Key et al. 2011).

23 Generally, only CAFOs generate enough animal waste to fuel a biogas recovery system; smaller animal feeding operations can operate a biogas recovery system if they combine livestock waste with other feedstocks (i.e., organic waste such as food waste, other agricultural wastes, etc.).

24 The predominate biogas recovery system is anaerobic digestion.

generate electricity, or further refined into biomethane (commonly referred to as renewable natural gas, RNG) or other chemical products. RNG is interchangeable with fossil natural gas and can be injected directly into natural gas pipelines and/or compressed for vehicle fuel. Capturing and using biogas reduces the potency of methane but does result in carbon dioxide emissions.[25] A highly effective and well-managed biogas recovery system can reduce methane emissions from livestock waste by 80 percent.[26] Biogas can also be captured and refined using advanced thermochemical or biological pathways to transform biogas into other high-value fuels or chemical products, such as methanol (Vasco-Correa et al. 2018).[27] Biogas recovery systems on CAFOs can cost anywhere between $400,000 to $17 million USD to build depending on the technology used, the size of the operation, and state-specific permitting requirements (California Air Resources Board 2021; Jacobs 2019). Equipment to upgrade biogas to biomethane or other products can cost millions of additional dollars.[28]

Agricultural Methane Mitigation Policies in the US and Canada

Canada and the US have drawn from a similar 'policy playbook' to address agricultural methane emissions while diverging in their emphases on 'supply-side' (i.e., targeting emissions from livestock digestion and waste) and 'demand-side' (i.e., targeting demand for red meat and dairy products) mitigation strategies. The US, at the federal and state levels, has pursued a wide range of supply-side methane mitigation strategies that focus almost entirely on emissions from livestock waste through various subsidies and incentives for developing biogas recovery systems and generating electricity or RNG from them.[29] California has gone far further than any other state in developing a comprehensive set of supply-side methane mitigation policies, although the ability of these policies to achieve significant emissions reduction remains unclear. In contrast, while the Canadian federal government has had limited engagement with supply-side mitigation strategies, it has recently shifted its stance toward demand-side mitigation through the development of the 2019 Dietary Guidelines which emphasize the need for Canadians to transition away from mammalian sources of protein (including beef, pork, and dairy). At the provincial level, there has been more experimentation with various supply-side methane mitigation strategies, including policies in Alberta that incentivize the reduction of methane emissions from enteric fermentation. Although their relative emphases differ, American and Canadian livestock methane mitigation strategies have neither achieved significant emissions reductions to date, nor fundamentally altered the scale or mode of domestic livestock production.

Table 3: Overview of Supply-side and Demand-side Methane Mitigation Policies in the US and Canada

Supply-side Methane Mitigation Policies					Demand-side Methane Mitigation Policy
Economic Subsidies & Incentives	**Electricity Generation**	**Renewable Natural Gas Generation**	**GHG Emission Offsets**	**Methane Reduction Target**	**Dietary Guidelines**
• Financial/ tax incentives and subsidies • Agricultural loans & grants • Funds for renewable energy/ GHG reductions	• Renewable Portfolio Standards/ Renewable Energy Targets • Feed-in tariffs • Interconnection standards • Net metering • Green power purchase programs	• Renewable Fuel Standard (US Federal) • Low Carbon Fuel Standard (CA, OR, WA , & BC) • Clean Fuel Standard (Canada Federal—offsets only) • RNG purchase programs • RNG mandates	• Cap-and-trade programs • Output-based pricing systems • Pan-Canadian Framework (recognition of offsets)	• California's S.B. 1383	• Canada's 2019 Dietary Guidelines

25 As such, biogas is a renewable fuel, but not zero emission.

26 There is limited evidence that existing biogas recovery systems can achieve this quantity of emissions reduction.

27 These facilities, known as biorefineries, exist in Europe, but there has been limited market penetration of biorefineries using livestock waste in North America.

28 Beyond the initial capital costs, there are a host of other expenses related to energy conversion, maintenance, and management associated with biogas recovery systems.

29 Economic research has consistently demonstrated that the crucial factor for farmers in deciding whether to build a biogas recovery system is the amount of capital costs covered by public funding (Cowley et al. 2017). In essence, if the government does not pay for biogas recovery systems, they generally do not get built.

AMERICAN FEDERAL POLICY: FOCUSED ON VOLUNTARY WASTE-TO-ENERGY PROGRAMS

To date, the US federal government has pursued an entirely voluntary, incentive-based approach to agricultural methane focused on emissions from livestock waste, while simultaneously maintaining an elaborate system of subsidies for livestock and animal feed.

Although US federal methane mitigation policy has had minimal impacts on methane emissions and hewed to the 'productivism' ethos of American agricultural policy, the 117th Congress and the Biden administration have demonstrated some interest in addressing livestock methane including emissions from enteric fermentation (Sievert et al. 2020). Most specifically, in February 2022, Secretary of Agriculture Tom Vilsack[30] announced the launch of the US Department of Agriculture's (USDA) Partnerships for Climate-Smart Commodities, a $1 billion USD pilot program to fund climate-smart agriculture and forestry projects, including projects designed to mitigate methane emissions from both manure management and enteric fermentation. While this marks the first executive branch action specifically designed to mitigate methane emissions from enteric fermentation, it is too soon to tell how much funding will be directed towards livestock projects, as opposed to other agriculture and forestry projects. Although the Partnerships for Climate-Smart Commodities program may signal a shift in the federal approach to livestock methane towards more concrete efforts to address emissions from enteric fermentation, this pilot program does not fundamentally change the federal government's exclusive reliance on voluntary, incentive-based approaches to livestock methane.

Existing federal policies that target agricultural methane generally fall into two categories: economic subsidies/incentives for biogas recovery systems, and the Renewable Fuel Standard (RFS) and RFS-supporting policies. Economic subsidies and incentives for biogas recovery systems range from tax code provisions for renewable energy systems to a wide variety of USDA programs that offer technical and financial assistance for on-farm biogas recovery systems.[31] The most notable of the USDA programs is AgSTAR. Founded in 1994 as a joint program of the USDA, Environmental Protection Agency (EPA), and Department of Energy (DOE), AgSTAR not only provides technical and financial assistance for on-farm biogas recovery systems, but also tracks biogas recovery system data and serves as a knowledge hub for the biogas industry. As of February 2022, there are 317 operating agricultural biogas recovery systems in the US.

The federal RFS is a flexible policy instrument that has been adapted since 2014 to increase production of RNG from livestock waste for vehicle fuel. Currently, the RFS faces competing headwinds from a recent Supreme Court decision that undermines the RFS, as well as Congressional efforts to adapt the RFS to the increasing electrification of vehicles, leaving the future of the RFS as a key federal methane mitigation policy unclear. The RFS, created through the 2005 Energy Policy Act and 2007 Energy Independence and Security Act, requires that the US transportation fuel supply includes specified volumes of renewable fuels, the vast majority of which derive from corn (i.e., ethanol). In 2014, the EPA approved RNG from livestock waste as a cellulosic biofuel.[32] During President Obama's second term, it became increasingly clear that there would not be significant legislative progress on

30 Secretary Vilsack served as Secretary of Agriculture during the full eight years of the Obama administration and was reappointed by the Biden administration. Prior to his appointment as Secretary of Agriculture by President Obama, Vilsack was a two-term governor of Iowa, the country's largest corn and pork producing state.

31 Additional USDA programs that support on-farm biogas recovery system development include the Bioenergy Program for Advanced Biofuels, Biorefinery Assistance Program, Conservation Innovation Grants (CIG), Environmental Quality Incentives Program (EQIP), and Rural Energy for America Program (REAP). CIG and EQIP are both programs of USDA's Natural Resources Conservation Service.

32 Cellulosic biofuel is a category of advanced biofuel defined as any renewable fuel besides corn starch ethanol and must be at least 60 percent less GHG intensive than gasoline.

climate change. As such, the re-classification of RNG as a cellulosic biofuel represented one of the few viable avenues for methane mitigation from the agricultural sector during the latter half of the Obama administration.[33] The cellulosic biofuel classification ensured that RNG would receive some of the largest renewable identification number (RIN) credits.[34] In addition, this policy supports state-level fuel standards by ensuring that waste-to-RNG projects qualify for federal RIN credits as well as state-level credits for renewable fuels.[35] Since the 2014 classification of RNG from livestock waste as a cellulosic biofuel, production has increased sixfold, demonstrating the importance of reliable revenue and regulatory requirements for incentivizing mitigation of methane emissions via the capture of biogas from livestock waste.

However, the future of the RFS and its ability to incentivize RNG development remains uncertain. In July 2021, the Supreme Court reversed two Tenth Circuit rulings in *HollyFrontier Refining v. Renewable Fuels Association* in a 6-3 decision that in practice will expand the number of small refiners eligible for small-refiner exemptions (SREs).[36] While the decision directly impacts corn-based ethanol (not cellulosic biofuels), the decision undermines the RFS, potentially "opening it to further political meddling" (Alexander 2021). At the same time, a legislative proposal in the House of Representatives would expand the RFS to incentivize biogas electricity generation for powering electric vehicles. H.R. 5899, the Biomass and Biogas for Electric Vehicles Act, introduced by Rep. John Garamendi (D-CA), would allow electricity generated from biogas to qualify for RIN credits. While a so-called 'pathway' for biogas-generated electricity to power electric vehicles exists, the EPA has yet to approve pending applications from electricity-generating biogas producers for RINs (Heller 2021a). As such, the EPA faces competing pressures undermining and calling to expand the RFS, leaving the ability of RINs to support biogas recovery system development and operation uncertain.

The past two administrations have either ignored or largely failed to address the issue of agricultural methane. Obama's 2008 presidential campaign connected with Iowa caucus voters, in part, by calling for reform of industrial agriculture, challenging market consolidation, and regulating pollution from CAFOs. Obama and then Secretary of Agriculture Vilsack launched a number of attempts to reform livestock production, all of which failed in the face of tremendous opposition from industry and Congressional intransigence (Pollan 2016). These failures made public funding for biogas recovery systems the only politically feasible option for the administration to pursue. The Trump administration attempted to cement the status quo in livestock agriculture through various EPA rulemaking efforts that would effectively prohibit the EPA from taking regulatory actions against CAFOs.[37]

Although President Biden has emphasized his commitment to a 'whole of government approach' to climate change, he and now two-time Secretary of Agriculture Vilsack[38] are focused entirely on research efforts and voluntary, incentive-based mechanisms to reduce livestock methane. In the lead-up to COP26, the Biden administration announced two new international climate policy initiatives pertinent to agricultural methane: the Global Methane Pledge and the Agriculture Innovation Mission for Climate (AIM4C). Following the announcement of the Global Methane Pledge in the fall of 2021, the White House Office of Domestic Climate Policy released the *U.S. Methane Emissions Reduction Action Plan* which outlines the White House plan to reduce methane emissions from multiple sectors, including agriculture. Unsurprisingly, the agricultural section is focused exclusively on voluntary, incentive-based strategies to

33 Congressional inaction on climate change post-2010 was driven by the split party control of Congress, the lingering impacts of the Great Recession souring public sentiment on climate action, the rise of the Tea Party as a force in American politics, and a lack of consensus within the Democratic Party after the failure of the American Clean Energy and Security Act (Meyer 2017). As such, the administration focused its climate agenda on executive actions. The administration's *Climate Action Plan – Strategy to Reduce Methane Emissions* and companion *Biogas Opportunities Roadmap* laid out biogas recovery system development as the key methane mitigation priority for the agricultural sector and tapped the USDA, DOE, and EPA to work together to "use existing programs as a vehicle to enhance the utilization of biogas systems" (US DOE 2014).

34 RFS compliance is tracked through renewable identification numbers (RINs) which are purchased by obligated entities to meet the biofuel volume requirements.

35 California, Oregon, and more recently Washington state have renewable fuel programs that incentivize RNG production from livestock waste.

36 SREs relieve small oil refineries of the obligation to purchase RINs.

37 These included rules to codify exemptions for air toxics reporting by CAFOs, exclude CAFOs from environmental reviews required under the National Environmental Policy Act (NEPA), and de-prioritize CAFOs as an enforcement or compliance priority for the EPA (Baron 2018; Earthjustice 2019; Lilliston 2020).

38 During the Trump administration, Secretary Vilsack served as the President and CEO of the U.S. Dairy Export Council. According to publicly available records, his annual salary was nearly $1 million USD.

reduce emissions from livestock waste through renewable energy development and alternative manure management practices (White House Office of Domestic Climate Policy 2021). The Plan also includes efforts across the USDA and DOE to increase the measurement of agricultural methane emissions and invest in research on methane reducing technologies and practices.

The second Biden administration international initiative targeting agricultural methane, AIM4C, was launched at the UN Food Systems Summit in September 2021. A joint initiative between the US and United Arab Emirates, AIM4C seeks to accelerate investment in research and innovation in 'climate smart' agriculture. One of the 'innovation sprints' sponsored by AIM4C is the Greener Cattle Initiative, a public-private partnership between the Foundation for Food & Agriculture Research (FFAR),[39] the Innovation Center for U.S. Dairy, and other industry partners to invest in research on reducing methane emissions from enteric fermentation.[40] While at first glance the Greener Cattle Initiative appears to be a promising step, the Initiative's paltry budget of $5 million USD (half of which was contributed by FFAR) belies the Biden administration's minimal financial commitment to investing in research and development of mitigation strategies for enteric fermentation.

Although Congress has, for the most part, neglected agricultural methane as a climate policy priority, the 117th Congress may be beginning to take this climate threat seriously. Two pieces of legislation have been re-introduced in Congress in 2021 that target agricultural methane emissions through novel approaches, while the House-passed version of the Build Back Better Act (a budget reconciliation bill) would increase funding for existing farm bill conservation, rural energy, and biofuels programs.[41] However, as of this writing in February 2022, the likelihood of any of these bills passing wanes as the 2022 Congressional midterm elections approach and Senate Democrats remain divided on the Build Back Better Act.

The Growing Climate Solutions Act (S. 1251, H.R. 2820), originally introduced by Senators Debbie Stabenow (D-MI) and Mike Braun (R-IN), would authorize the USDA to create a voluntary carbon offset market for farmers and ranchers and provide technical assistance to participants. The bill specifies that livestock emissions reductions, including methane, achieved through feed/feed additives, manure management practices, or on-farm energy generation would qualify for carbon offsets. While the bill passed 92-8 in the Senate in 2021 with overwhelming bipartisan support and significant endorsements from agricultural and business interest groups, it has stalled in the House. Conservative lawmakers oppose the expansion of the USDA into carbon offset markets, which already exist in the private sector, and believe that current USDA conservation programs are sufficient. Liberal lawmakers and interest groups are concerned that the benefits of the carbon offset market will accrue to only the largest and most polluting agricultural producers. (Heller 2021b; Heller 2022). Although increasingly unlikely to pass as the midterm elections approach, if passed, the Growing Climate Solutions Act would be the most consequential piece of federal livestock methane mitigation policy since the 2014 classification of RNG as a cellulosic biofuel.

The second piece of legislation, the Farm System Reform Act of 2021 (H.R. 4421 and S. 2332), represents a significant, although largely symbolic, shift within the Democratic Party on agricultural methane.

39 FFAR was established by Congress in the Agricultural Act of 2014 to advance the research mission of the USDA. It was refunded in the 2018 Farm Bill.

40 The Greener Cattle Initiative will sponsor researched focused on feed additives and feed ingredients that reduce emissions from enteric fermentation, breeding of low-methane emitting cattle, the microbiome of the rumen, technology to measure methane emissions, and socioeconomic analysis of mitigation practices and technologies (Foundation for Food & Agriculture Research n.d.).

41 A number of other pieces of legislation that address livestock methane through more conventional approaches have been introduced in the 117th Congress covering issues such as expanding the Rural Energy for America Program (H.R. 4162, S. 2243) and converting 'wet' manure management systems to 'dry' or 'unmanaged' manure management systems (H.R. 2803).

Introduced in the House and Senate by Representative Ro Khanna (D-CA)[42] and Senator Cory Booker (D-NJ),[43] respectively, the Farm System Reform Act would mandate a far more aggressive approach to livestock agriculture and agricultural methane than the Growing Climate Solutions Act. The Farm System Reform Act would, among other radical changes, put a moratorium on the development or expansion of CAFOs, force CAFOs to cease operation by 2040, and provide transition assistance for CAFO operators. This legislation has garnered only a small number of Democratic co-sponsors, most of whom are among the most liberal members of Congress, including Senators Bernie Sanders (I-VT) and Elizabeth Warren (D-MA) and Representatives Cori Bush (D-MO) and Rashida Tlaib (D-MI). Unsurprisingly, this legislation has failed to gain significant traction in Congress; there is not a single Republican co-sponsor or support from major business or agricultural groups.[44] Although largely a symbolic piece of legislation, the Farm System Reform Act represents a major shift within the Democratic party on agricultural policy. Democrats have generally supported the status quo of elaborate commodity subsidies in American agriculture in exchange for Republican support for nutrition programs (Bosso 2017). That this legislation has been introduced in Congress at all is a milestone, indicating that at least the progressive wing of the Democratic party has put serious agricultural methane mitigation policy on their political agenda.

The House-passed version of the Build Back Better Act (H.R. 5376), a budget reconciliation bill which at the time of this writing in February 2022 appears to be moribund,[45] would provide $81.7 billion USD for forestry and agriculture provisions. Over $21 billion USD would be spent on various USDA conservation programs, some of which provide funding for biogas recovery system development (e.g., the Environmental Quality Incentives Program would receive $9 billion USD). Biofuel and rural energy programs, which incentivize the development of biogas recovery systems and electricity and RNG generation, would receive $15 billion USD. While the legislation includes a novel 'methane fee,' it would only apply to emissions from the oil and natural gas sector. Notably, in August 2021, the Senate adopted a $3.5 trillion USD budget framework as an initial step to allow committees in the House and Senate to begin drafting the eventual budget reconciliation plan. Senator Joni Ernst (R-IA) introduced a largely symbolic amendment that passed 66-32, banning EPA regulation of on-farm methane emissions, demonstrating the bipartisan consensus that regulating livestock emissions remains a political non-starter. As such, the Build Back Better Act epitomizes political enforcement of the status quo: Congressional Democrats' ambitious climate agenda would spend enormous sums of taxpayer dollars to incentivize marginal methane emissions abatement, while fundamentally maintaining the scale of domestic meat and dairy production.

In the face of congressional intransigence on agricultural GHG emissions, the Biden administration is utilizing the Commodity Credit Corporation[46] to fund pilot projects that provide technical and financial assistance for producing and quantifying the GHG benefits of 'climate smart' commodities. Vilsack announced the launch of the new Partnerships for Climate-Smart Commodities in February 2022 which will make $1 billion USD from the Commodity Credit Corporation available in funding for a wide variety of agricultural and forestry projects including manure and feed management to reduce emissions from livestock waste and enteric fermentation. While this pilot program will be time bound (projects can last one to five years), it may be an effort designed to jumpstart agricultural producers' participation in private carbon markets by underwriting adoption of climate-smart practices and quantification of their emissions reduction. Republican leaders of the House and Senate agricultural committees

42 Rep. Khanna is a practicing Hindu; many Hindus adhere to a vegetarian diet and reject beef consumption entirely.

43 Sen. Booker is the first openly vegan senator on the Senate Committee on Agriculture, Nutrition, and Forestry.

44 Over 100 small-scale farmers and 300 organizations have signed letters in support of this legislation including the ASPCA, Waterkeeper Alliance, Food & Water Action, and Family Farm Action.

45 Senator Joe Manchin (D-WV) stated publicly in December 2021 that he is unable to support the House-passed version of the Build Back Better Act.

46 The Commodity Credit Corporation was established in 1933 as a key farm safety net program which, among other powers, purchases surplus farm commodities.

expressed concerns over the use of the Commodity Credit Corporation for funding climate projects and the failure of USDA to secure congressional approval for non-emergency use of Commodity Credit Corporation funding. USDA will accept proposals through the end of May 2022; as such, it remains unclear how much funding will be directed towards livestock methane mitigation projects, as opposed to projects addressing other agricultural and forestry emissions sources and sinks. However, the fact that emissions from enteric fermentation are included at all represents a significant shift in the USDA's approach to livestock methane.

Overall, the federal approach to agricultural methane can be characterized as supportive of large-scale meat and dairy production, with little regard for the climate. Given that Democratic states like California and New York and Republican states like Texas and South Dakota are home to extremely large livestock industries, it is difficult to imagine real congressional progress on agricultural methane, particularly given the Senate's rural bias. Furthermore, the Biden administration has initiated a number of executive actions, ranging from federal pandemic aid to enhancing meat packing competition, designed to reduce the rapidly increasing price of red meat products and thus sustain consumer demand.[47] In the US, voluntary, incentive-based mechanisms are the only methane mitigation strategy that Congress and the Executive Branch can agree upon. However, even the limited legislative efforts to expand the types of voluntary, incentive-based mechanisms for methane mitigation have stalled in Congress, forcing the Biden administration to use executive authority to make incremental progress.

CALIFORNIA: THE CLEAR FRONT-RUNNER

California has been at the forefront of American environmental policy since the 19th century and has led the US in policies addressing climate change since 2002. As the country's largest economy and agricultural producer, the state has balanced rapid economic growth with protecting its fragile environment and mitigating GHG emissions through the development of highly sophisticated regulatory agencies, particularly the California Air Resources Board (CARB) (Vogel 2019). Since the passage of A.B. 32, the California Global Warming Solutions Act of 2006, the California legislature has given CARB "sweeping authority to administer the state's wide-ranging efforts to reduce greenhouse gas emissions" (Vogel 2019). However, agriculture generally, and methane specifically, were excluded from the state's cap-and-trade program, which CARB developed as the primary mechanism to achieve the GHG emissions reduction legislated by A.B. 32.

California is home to over 1.7 million dairy cows, making it the country's largest milk-producing state and providing nearly 20 percent of American milk. This has made California, along with Texas (the country's largest beef producer and fifth largest milk producer), the state responsible for the largest amount of total GHG emissions from livestock agriculture. Methane accounts for approximately nine percent of GHG emissions in California; livestock are responsible for 54 percent of California's methane emissions, with nearly 90 percent of livestock methane derived from dairy cows (Barker 2016). As with many other aspects of California environmental policy, the state has had to find a delicate balance between mitigating GHG emissions and preserving the state's dairy industry.

In 2014, the California legislature passed S.B. 605 requiring CARB to develop a comprehensive plan to reduce emissions of short-lived climate pollutants (SLCPs), including methane. Methane is by far the largest source of SLCPs in California, representing approximately 60 percent of SLCPs. In response to S.B .605, CARB developed a *Proposed Short-Lived Climate Pollutant Reduction Strategy*, published in early 2016, which included a target of reducing statewide methane emissions by 40 percent. This proposal was subsequently codified by S.B. 1383 in 2016 which, for the first time in US history, mandated a 40 percent reduction in methane emissions from livestock waste below 2013 levels by

47 Between October 2020 and October 2021, the price of beef increased by 22 percent and the price of pork by 16 percent. The rising price of meat products represents nearly half of the increase in Americans' grocery bills.

2030, with enforcement beginning in 2024. Continuing the state legislature's penchant for outsourcing regulatory specifics to CARB, S.B. 1383 called on CARB to develop a comprehensive regulatory strategy to reduce SLCP emissions and begin implementing this strategy by 2018. The legislation included a number of strictures, including that any regulations developed be technically and economically feasible, cost-effective, and minimize leakage of the livestock industry to other states and countries. Most importantly, methane emissions from enteric fermentation were excluded from the mandate; emissions reductions from enteric fermentation can only be achieved through voluntary mechanisms.[48]

S.B. 1383 is a landmark piece of legislation that establishes the most aggressive agricultural methane reduction targets codified into US law. The successful passage of this legislation can be attributed to three primary factors, including the pivotal role of state Senator Ricardo Lara in developing this legislation, the commitment of then Governor Jerry Brown to climate and environmental issues, and a Democratic-controlled state legislature that has expressed concern over the evermore frequent climate-related natural disasters impacting the state. Former state Senator Lara, now California's Insurance Commissioner, is one of California's most innovative climate and environmental policy entrepreneurs.[49] He is the author of both S.B. 605 and S.B. 1383 and has championed a host of other climate policies in the state legislature and as Insurance Commissioner. Former Governor Brown, a stalwart champion of climate and environmental policy, was concluding his fourth term as governor and had long pushed California to adopt the country's most aggressive climate policies.[50] California's Democratic-majority in the legislature has eased the passage of climate-related bills (S.B. 1383 passed in the state Senate 23-12) and is responsive to increasing voter concern about the already disastrous impacts of climate change on the state, exemplified by the ever-worsening fire season.

Based on the mandate established by S.B. 1383, CARB, in partnership with the California Department of Food and Agriculture (CDFA), has approached mitigating methane emissions from livestock waste by spending hundreds of millions of dollars of auction monies from the state's cap-and-trade fund to pay for methane mitigation strategies. The showering of public funding on the state's dairy industry to reduce emissions appears to be CARB's primary strategy to adhere to the stricture in S.B. 1383 to minimize leakage of the dairy industry out of state. CARB and CDFA implemented two programs, the Dairy Digester Research and Development Program (DDRDP) and the Alternative Manure Management Program (AMMP), which through December 2020 distributed $289 million USD to California's dairy farmers (California Air Resources Board 2021). For the state's large dairy farms (i.e., over 4,000 cows), DDRDP gives grants of up to $3 million USD for development of biogas recovery systems, thus covering a significant portion of initial capital costs for most projects.[51] For dairy farmers with less than 4,000 cows, AMMP gives significantly smaller grants for these farms to implement 'dry' manure management techniques, primarily vacuuming or scraping systems.[52]

While biogas recovery system technology has been available since the 1970s, very few California dairy farms had implemented them until recently. Approximately 90 percent of California's dairy industry is based in the San Joaquin Valley, a region perennially out of compliance with the federal Clean Air Act's National Ambient Air Quality Standards (NAAQS) (Gloy et al. 2010). As such,

48 The legislation acknowledges there are no existing cost-effective or scientifically proven strategies to reduce methane emissions from enteric fermentation that would not damage animal health, public health, or consumer acceptance.

49 Lara has also made history as the first openly gay person to be elected to statewide office in California.

50 Brown and Lara accepted the 2017 Climate and Clean Air Award for outstanding policy for their work on SLCPs in S.B. 1383.

51 In California, biogas recovery systems cost $3–17 million USD depending on the technology used and the size of the operation (California Air Resources Board 2021).

52 The average alternative manure management system in California costs $600,000 USD (California Air Resources Board 2021).

CARB has historically declined to give dairy farms permits for biogas recovery systems in the San Joaquin Valley, as burning biogas (flaring or for electricity generation) results in nitrous oxide emissions that are regulated under NAAQS. As such, electricity generation from biogas recovery systems in the San Joaquin Valley has been extremely expensive, due to the need for "costly emissions control technologies or expensive electricity generating technologies such as microturbines" (Lee et al. 2018). Since 2013, on-farm biogas recovery systems have qualified for carbon offsets under California's cap-and-trade system,[53] but these offsets were insufficient to make biogas recovery system development economical, while maintaining NAAQS compliance.

In response to conventional air pollution concerns, and building off a 2015 change in California's Low Carbon Fuel Standard (LCFS)[54] that qualified RNG as eligible for LCFS credits, CARB's agricultural methane reduction plan calls for the development of a system of centralized digesters in the San Joaquin Valley that would produce RNG, rather than electricity. RNG from livestock waste is eligible for the largest LCFS credits, nearly ten times the value of carbon credits under the state's cap-and-trade system (Gasper et al. 2020; Lee et al. 2018). As such, CARB has developed a methane regulatory policy environment that ensures the viability of methane reductions from manure: it covers the capital costs (paying dairy farmers to build biogas recovery systems and develop a centralized RNG refining center) and ensures a consistent source of revenue (sales of RNG, LCFS credits, and carbon offset credits). Currently, the vast majority of revenue from biogas recovery systems in California that generate RNG is from government-created fuel credits (LCFS and RIN), leaving dairy farms with biogas recovery systems extremely vulnerable to fluctuations in fuel credit prices and potential policy shifts (Barker 2016).[55] As of February 2022, there are 77 operating agricultural biogas recovery systems in California, representing nearly a quarter of all biogas recovery systems in the US.

S.B 1383, and the use of the majority of funds dedicated to addressing livestock methane going to biogas recovery system development, has not been without controversy. First, California has a much smaller cluster of organic, pasture-based dairy farms along its North Coast. Milk production costs on the North Coast are approximately 70 percent higher than in the San Joaquin Valley, where cows are kept in confinement, primarily on CAFOs. Since these North Coast dairy farms already employ 'unmanaged' manure management techniques, they are not eligible for DDRDP or AMMP funds. As such, S.B. 1383 is seen as favoring CAFOs over farmers who already employ more sustainable manure management practices and prioritize animal welfare (California Air Resources Board 2018).

Second, environmental justice advocates have opposed using the state's valuable cap-and-trade dollars to reward one of the state's most polluting industries, without requiring dairy CAFOs to better protect surrounding communities from the environmental harms of millions of tons of livestock waste concentrated in the San Joaquin Valley (e.g., ground and surface water contamination, air pollutants, airborne pathogens, etc.) (California Air Resources Board 2018). Biogas recovery systems do not significantly reduce the quantity of manure, even

53 Quebec and California have harmonized their cap-and-trade programs, representing one of two examples of sub-federal cooperation on agricultural methane between the US and Canada.

54 Oregon and British Columbia have both adopted Low Carbon Fuel Standards that are very similar to California's. Washington state adopted a similar Clean Fuel Standard in 2021 that will go into effect in 2023. The adoption of LCFS by British Columbia represents the other example of cooperation at the sub-federal level on the issue of agricultural methane between the US and Canada. However, British Columbia's LCFS has been designed to promote biomass energy development primarily from trees infested with pine beetles, rather than livestock waste. To date, there has been no bilateral cooperation between the national governments of the US and Canada on agricultural methane.

55 There is significant uncertainty regarding both LCFS and RIN revenue. Prices for LCFS and RIN credits fluctuate dramatically year to year. Given the overwhelming dependence of California's biogas recovery systems on these government credits for revenue, this poses a key risk for California's dairy farms that implement biogas recovery systems (Lee et al. 2018). While the LCFS is considered politically 'safe' in California, there remains uncertainty about what will happen to LCFS credit calculations after enforcement of S.B. 1383 goes into effect in 2024. Currently, methane reductions are not mandatory and thus avoided methane emissions are eligible for LCFS credits. After 2024, when methane emission reductions are mandatory, avoided methane emissions will not be eligible for LCFS credits, unless the California legislature intervenes and amends the law.

after the capture of biogas; as such, dairy farms still have enormous amounts of livestock waste to manage even after processing through a biogas recovery system. Lastly, AMMP projects do not qualify for carbon offsets or other environmental credits and thus lack revenue streams to sustain the ongoing operation of labor-intensive 'dry' manure management systems. Despite California's leadership in many areas of environmental policy, the state legislature has done nothing to fundamentally challenge the CAFO model in California and very little to address the environmental injustices experienced by the plurality of Latino communities in the San Joaquin Valley.

Unfortunately, California is not on track to meet the methane emissions reduction target established by S.B. 1383. In an interim progress report published by CARB in June 2021, CARB projects that by 2030, California's dairy and livestock sector will have achieved roughly half of the emissions reduction necessary to meet the 40 percent reduction mandate (California Air Resources Board 2021). The 278 DDRDP and AMMP projects funded by CARB through December 2020 will only achieve roughly a nine percent reduction of methane emissions from livestock waste below 2020 levels by late 2022. CARB estimates that an additional 230–420 projects will be necessary to achieve the 40 percent reduction target without the advent of commercially available, effective emissions reduction strategies for enteric fermentation.[56] As such, California will likely need to spend enormous amounts of additional money on biogas recovery systems, alternative manure management projects, and revenue streams for biogas recovery systems (LCFS and cap-and-trade) to achieve S.B. 1383's emissions reduction mandate.

California has, by far, the most comprehensive approach to addressing livestock methane emissions of any American state (see Appendix). In addition to the policies described above, California has enacted a comprehensive suite of policies that support biogas recovery system development and operation, including a feed-in tariff, renewable portfolio standard, interconnection standards, net metering, tax incentives, commercial PACE financing, and other agricultural loan and grant programs. The combination of 'carrots' (DDRDP, AMMP, environmental credit revenues, etc.) and 'sticks' (a mandatory 40 percent cut in methane emissions from livestock waste below 2013 levels) is unique among states. The California approach is defined by the state's willingness to throw enormous amounts of money at its dairy industry, in the hopes of mitigating some methane emissions and keeping the dairy industry in-state. Like many of California's other environmental and climate policies, the state is attempting to 'green' one of its most polluting industries, rather than risk losing a key industry in an impoverished region or directly confront consumer behavior (Vogel 2019). However, its limited effectiveness in achieving emissions reduction to date does not bode well for the future of American livestock methane mitigation policy.

56 The FDA is currently reviewing 3-Nitrooxypropoanol (3-NOP) as a feed additive with the potential to reduce methane emissions from enteric fermentation by 20–40 percent. However, FDA approval is not anticipated in the near term.

CANADA'S APPROACH TO AGRICULTURAL METHANE

Canadian Federal Policy: Some Demand-Side Policy Progress

Canadian federal policy has mostly ignored the issue of agricultural methane; however, Ottawa has recently focused on a demand-side (i.e., targeting consumer demand for red meat and dairy products) methane mitigation strategy by encouraging Canadians to eat less red meat and dairy. While the Canadian federal government under Prime Minister Justin Trudeau has made significant climate policy progress through the enactment of the Pan-Canadian Framework on Clean Growth and Climate Change and the Clean Fuel Standard, these advancements have almost entirely excluded agriculture. Unfortunately, Environment and Climate Change Canada projects increases in agricultural emissions through 2030 (Dobson et al. 2019). To date, the most significant demand-side policy that targets agricultural methane is the updated 2019 Dietary Guidelines. However, in the 2021 federal elections, agricultural methane policy proposals were included in many party platforms, perhaps signaling increased interest in addressing this source of GHG emissions.

Canada's 2019 Dietary Guidelines represent a major step forward in Canadian nutrition policy. The new guidelines clearly articulate that Canadians should diversify their protein sources and transition away from mammalian sources of protein toward plant-based proteins. The Dietary Guidelines have been recognized by a number of environmental organizations as an example of 'climate smart' nutrition guidelines. While the updated Dietary Guidelines are a significant achievement and put Canada far ahead of the US in terms of sustainable nutrition policy, the Organisation for Economic Co-operation and Development (OECD) projects that red meat consumption in Canada will remain static without some sort of market intervention (e.g., a meat tax) (Dyer et al. 2020). Tellingly, Canada did not include sustainable diets in its updated 2021 Nationally Determined Contribution,[57] signaling that the federal government has no intention of putting 'teeth' behind the updated Dietary Guidelines (Nilsson 2021).

Despite the progress described above, Ottawa has failed to develop specific supply-side programs or policies designed to reduce agricultural methane. This is in part due to federal, provincial, and territorial responsibilities regarding agriculture and the environment enshrined in the Constitution Acts of 1867 and 1982, as well as tensions stemming from the West-East divide (Macdonald 2020; Swallow et al. 2016). Ottawa regularly walks a political tight rope regarding the Canadian livestock industry; beef production is concentrated in the western provinces of Alberta and Saskatchewan, while Ontario and Quebec in the east are home to the largest pork and dairy industries. As such, policies that would encourage the development of biogas recovery systems (such as those enacted in the US) would be seen as directing funding toward the East. The West-East divide has thus prohibited Canada from pursuing federal agricultural policy that specifically bolsters biogas recovery system development. For example, the Canadian Agricultural Partnership, Canada's current five-year agricultural policy framework, has a number of innovation and sustainability programs administered at the provincial and territorial level that could theoretically be used to help fund biogas recovery system development, but it does not lay this out as a specific policy objective. While a number of other federal programs address agricultural GHG emissions, none are specifically focused on methane nor have the type of resources that could spurn widespread adoption of methane mitigation strategies.[58]

57 Nationally Determined Contributions were developed as part of the Paris Agreement and serve as a vehicle through which countries report their commitments to reducing national emissions.

58 These include the Agricultural Clean Technology Program, the Agricultural Greenhouse Gases Program, Holos software, and various tax incentives for renewable energy projects.

The climate policy gains made under Prime Minister Trudeau have almost entirely excluded agricultural methane. Trudeau's Liberal party is highly reliant on votes from Quebec and Ontario, where most dairy and swine farmers live. Dairy farmers, in particular, represent a powerful political constituency that Trudeau has been loath to anger. Under the Pan-Canadian Framework on Clean Growth and Climate Change, direct emissions from livestock agriculture are excluded from every Canadian carbon pricing scheme, including the federal benchmark and federal backstop.[59] As such, Canada's agricultural sector is the single largest source of uncovered emissions (Dobson et al. 2019).[60] The original Clean Fuel Standard proposal included gaseous fuels, but is now limited to liquid fuels and thus does not mandate the inclusion of livestock waste-derived RNG.[61] However, RNG from livestock waste will be eligible for offset credits from the Clean Fuel Standard.

Internationally, although Canada is a signatory to both the Global Methane Pledge and AIM4C, both Canadian commitments exclude livestock methane for the most part. Canada's Pledge consists of a 75 percent emission reduction goal from the oil and natural gas sector, while only nodding to the continuation of federal agricultural programs that support best management practices, including methane mitigation (Environment and Climate Change Canada 2021b). Canada has committed $550 million CAD to AIM4C but designated this investment toward research efforts regarding soil carbon sequestration from livestock grazing, thus abstaining from supporting the Greener Cattle Initiative (Fawcett-Atkinson 2021). Given the modest support for agricultural clean technology in the Liberal party platform and Trudeau's 2021 reelection, there appears to be limited appetite to pursue additional methane mitigation policies.

However, the politics of agricultural methane governance may be shifting, as evidenced by the 2021 federal election party platforms. Trudeau's Liberal party pledged to triple funding for agricultural clean technology programs, some of which can be used to fund biogas recovery system development. The Conservative Party, led by Erin O'Toole, proposed an RNG mandate, modeled on British Columbia's, of a 15 percent RNG requirement for Canada's natural gas supply by 2030. Unsurprisingly, the Green Party, led by Annamie Paul, went far further than any other party by including in its platform calls to end subsidies for industrial livestock production, support farmers in transitioning away from industrial livestock production, establish emission reduction targets for the livestock sector, promote reduced consumption of animal source food products, and adopt comprehensive animal welfare legislation. These party platforms demonstrate that livestock methane is slowly moving from obscurity to mainstream political debate in Canadian federal politics.

Finally, it is important to understand Canadian agricultural policy generally, and the lack of progress on agricultural methane specifically, within the context of bilateral relations with the US. Since 1989, there has been tariff-free trade of most agricultural products between Canada and the US. Given the size differential between the two countries' agricultural sectors and Canada's reliance on the US as its largest export market, Canadian agricultural policy has been shaped by concerns regarding competitiveness with American agriculture and protecting key industries. The Canadian dairy industry is highly protected through the supply management system,[62] which has given rise to a type of 'dairy nationalism' by which Canada exerts economic nationalism through the protection of politically important industries and autonomy from American markets (Rioux 2019).

59 Agricultural GHG offsets are recognized under the *Pan-Canadian Greenhouse Gas Offsets Framework*.

60 The varying size of provincial agricultural and livestock industries is a key driver in the divergence among carbon pricing coverage among provinces (Dobson et al. 2019).

61 Alberta, British Columbia, and Quebec have instituted provincial policies that incentive livestock-waste derived RNG.

62 Supply management limits both imports and exports. Poultry and eggs are also included in the supply management system.

Supply management has its own set of extremely sensitive domestic politics and is a constant thorn in the side of trade relations with the US.[63] More than half of Canadian beef and two-thirds of Canadian pork is exported, primarily to the US. As such, Ottawa is careful to maintain the competitiveness of the beef and pork industries and has been loath to place burdens on agricultural producers that are price-takers on international markets (Mussell et al. 2019). Ottawa generally emphasizes the efficiency gains, particularly in Canadian beef, made over the last 40 years and the fact that Canadian livestock has one of the lowest GHG emission intensities in the world. Numerous government reports, perhaps most notably the Barton Report, single out Canadian agriculture and livestock as key engines of economic growth via exports, particularly if Canada can continue to quantify the low-GHG intensity of its livestock.

Overall, the Canadian federal government has approached agricultural methane through an even more hands-off approach than the US. Canada's 2019 Dietary Guidelines that promote mostly plant-based diets are commendable and represent the only progress on demand-side methane mitigation policy in either country. However, Ottawa does not appear to have any interest in advancing sustainable diets to actually achieve emissions reductions. In terms of supply-side methane mitigation policy, federal agricultural programs targeting methane emissions from livestock waste are limited and the new Clean Fuel Standard will have only modest incentives for livestock-derived RNG. The Canadian federal approach to livestock methane can be characterized as signaling the need to reduce red meat and dairy consumption, while maintaining the scale and structure of the Canadian livestock industry and the competitiveness of livestock exports.

ONTARIO: CANADA'S RETREATING FRONT-RUNNER

Until 2018, Ontario was the provincial leader regarding agricultural methane. The second largest milk-producing province, Ontario is home to nearly two-thirds of Canada's roughly 60 agricultural biogas recovery systems. The 2009 Green Energy and Economy Act established Canada's highest feed-in tariffs for biogas-generated electricity. In addition to the feed-in tariff program, the Ontario Ministry of Agriculture, Food and Rural Affairs developed a biogas financial assistance program that gave out grants of up to $400,000 CAD to help defray capital costs. While the feed-in-tariff program concluded in 2016, the 20-year contracts established under the program were still ongoing.

However, the 2018 election of Premier Doug Ford, which can, in part, be attributed to opposition to renewable energy projects and high electricity prices, marked a further retreat from Ontario's commitment to biogas-generated electricity. The Ford administration canceled a number of feed-in-tariff contracts for biogas recovery systems, leaving these farms without a consistent source of revenue. Although the Ford administration indicated in its *Made-in-Ontario Environment Plan* an interest in clean fuels such as RNG, the only tangible outcome of this plan has been a pilot program to support RNG-development from agricultural and food waste. To date, Ontario has failed to enact a comprehensive suite of subsidies and incentives for RNG that would make it a viable renewable fuel. The case of Ontario demonstrates the importance of economic incentives as a key lever in mitigating agricultural methane emissions, as well as the vulnerability of methane mitigation policy to elections and swings in political sentiment.

63 The Biden administration launched the first trade dispute under the new United States-Mexico-Canada Agreement (USMCA) in May 2021, accusing Canada of breaking an agreement to partially open its protectionist dairy markets. In January 2022, a dispute panel published a legally binding decision against Canada's allocation of dairy Tariff Rate Quotas but affirmed Canada's right to maintain its supply management system (Hansen-Kuhn 2022).

ALBERTA: PROVINCIAL DURABILITY OF AGRICULTURAL OFFSETS

Alberta, home to Canada's largest beef industry and approximately 40 percent of Canadian cattle, was the first North American jurisdiction to establish an agricultural carbon offset program. Despite being Canada's largest source of agricultural methane emissions, Alberta's agricultural carbon offset protocols have not only been remarkably durable, but also extremely influential internationally. Originally established in 2007 through an amendment of the Climate Change and Emissions Management Act and the passage of the Specified Gas Emitters Regulation Act, Alberta's agricultural carbon offset program was designed to help large, industrial emitters reduce their GHG intensities. Regulated entities were required to voluntarily reduce their emissions, pay fees on emissions over a threshold quantity, or buy carbon offsets. This established a market for the agricultural sector to change its practices in order to earn carbon credits. As Alberta's climate policy has evolved since 2007, agricultural carbon offsets have remained a key pillar of Alberta's approach. Under Alberta's current Technology Innovation and Emissions Reduction (TIER) system, biogas production and methane-suppressing cattle feed qualify for carbon offsets. In addition to agricultural carbon offsets, Emissions Reduction Alberta (formerly the Climate Change Emissions Management Corporation)[64] has used carbon pricing revenue from the Climate Change and Emissions Management Fund to fund a wide variety of pilot programs designed to reduce agricultural methane emissions. These pilots have included projects such as feeding red algae to cattle and whole herd genetic management systems.[65]

Alberta's approach to agricultural offsets has been incredibly influential in North America and globally; however, there is no evidence that provincial agricultural methane emissions have actually decreased as a result of this policy (rather than from fluctuations in the size of the cattle herd). As such, voluntary agricultural carbon offsets may sound like a promising, market-based solution to policymakers when, in reality, offsets seem to have had little impact on GHG mitigation. As home to both large fossil fuel reserves and a large beef industry, Alberta appears to be simply shifting money from the energy to the agricultural sector, while agricultural methane emissions continue largely unabated.

64 Large GHG emitters in Alberta are required to reduce their GHG intensities; this intensity reduction can be achieved by improving operational efficiency, buying carbon credits from Alberta's carbon offset system, or paying into the Climate Change and Emissions Management Fund for every ton over the reduction limit. The Climate Change Emissions Management Corporation, now Emissions Reduction Alberta, invests monies paid into the Fund by regulated companies. Emissions Reduction Alberta has a mandate to use these investments to "reduce GHG emissions and grow Alberta's economy by accelerating the development and adoption of innovative technology solutions" (Emissions Reduction Alberta n.d.).

65 Whole herd genetic management systems essentially involve culling all but the most productive animals.

INTERNATIONAL EXAMPLES OF METHANE MITIGATION STRATEGIES

The US and Canada, unfortunately, are not outliers globally in terms of engagement with the issue of agricultural methane. However, New Zealand and the EU have enacted, or are beginning to enact, policies that are far more aggressive than the American or Canadian approaches. To date, the European approach to agricultural methane mitigation serves as a cautionary tale against voluntary, incentive-based methane mitigation strategies. A small number of European countries and New Zealand are beginning to consider far more drastic approaches that would reduce the quantity of livestock produced.

Policy engagement around agricultural methane mitigation has been most advanced in Europe until quite recently. The EU has invested enormous sums of money in agricultural GHG programs that have not yielded any significant reduction in emissions. Despite spending nearly €120 billion on various agricultural GHG mitigation programs through the EU's Common Agricultural Policy (CAP) since 2014, GHG emissions from European farms have not declined since 2010 (European Court of Auditors 2021). The European Court of Auditors, the EU's financial watchdog, attributes this lack of progress in agricultural emissions reduction to the fact that livestock is the largest source of European agricultural emissions and the CAP promotes, rather than restricts, animal products. Their findings point to the reality that it will be impossible to make progress on agricultural GHG emissions without addressing the quantity of livestock produced. The EU approach to date is perhaps best exemplified by the case of Germany, which has pursued livestock methane emissions reduction through an 'engineering-first' approach that has led to the development of 10,000 biogas recovery systems in Germany. German biogas recovery systems are supported by a suite of policies that incentivize biogas-generated electricity and RNG production. These policies have made Germany the world leader in biogas recovery system development, yet Germany has failed to achieve meaningful agricultural emissions reductions.

This lack of progress to date on agricultural GHG emissions and livestock methane has prompted the EU to adopt a more aggressive mitigation framework embodied in the *Farm to Fork Strategy*, which explicitly calls for a reduction in animal source food consumption.[66] Individual European countries are also beginning to take more drastic approaches. For example, the Netherlands recently announced a €25 billion initiative to buy out livestock farmers as a means of reducing domestic livestock production by a third.[67] Ireland has announced a mandatory cut in GHG emissions from the agricultural sector between 22–30 percent.[68] These efforts represent a fundamental shift in European methane mitigation from a voluntary, incentive-based approach to one that centers dietary change, cuts in livestock production, and mandates for emissions reduction.

In contrast to the European approach, New Zealand is addressing agricultural methane by incorporating it into its existing carbon pricing scheme. New Zealand is the first country to pass legislation that establishes legally binding methane mitigation targets for livestock agriculture and will include agricultural methane in its Emissions Trading Scheme. Agriculture is the single largest source of New Zealand's GHG emissions, amounting to about half of total emissions.[69] In 2019, New Zealand's parliament passed the Climate Change Response (Zero Carbon) Amendment Act which mandates emissions reporting from the agricultural sector beginning in 2024 and specifies a 10

66 How this will be achieved specifically remains unclear.

67 This has been primarily motivated over concerns regarding conventional air and water pollution stemming from large quantities of livestock produced in a small, densely populated country.

68 The target is currently being finalized, but the higher end of the target would require downsizing Ireland's cattle herd.

69 Methane emissions from livestock agriculture represent over a third of the country's GHG emissions and have grown by roughly 14 percent since 1990.

percent methane emissions reduction target by 2030 and a provisional reduction target of 24–47 percent by 2050 (Farmers for Climate Solutions 2021). New Zealand is in the process of assessing how agricultural methane and nitrous oxide emissions will be calculated, reported, and priced. Although undoubtedly an enormous step forward in methane mitigation policy development, the emissions reduction target for agricultural methane is far less stringent than for other GHG sources, indicating the power of New Zealand's livestock industry in shaping methane mitigation policy.

These international examples demonstrate the extent to which the US and Canada are beginning to fall behind peer countries in terms of agricultural methane mitigation policy. Neither country is considering mandatory agricultural emissions reductions, cuts in livestock production, or inclusion of agriculture in any form of GHG pricing scheme. The example of the EU's CAP provides a warning that American and Canadian lawmakers should heed in the futility of mitigating livestock methane through voluntary, incentive-based mechanisms.

CONCLUSION

Overall, the cases of the US and Canada demonstrate how little policy engagement exists regarding agricultural methane as well as how far both countries must go as two of the world's largest livestock producers, consumers, and exporters.

To date, the US has taken an entirely supply-side approach to methane emissions by subsidizing and incentivizing extraordinarily expensive biogas recovery systems. The US supply-side mitigation strategy may be shifting towards some efforts to reduce emissions from enteric fermentation, although how much actual progress will be achieved on this front remains entirely unclear. Canada has taken a light-touch, demand-side approach by encouraging reduced consumption of red meat and dairy products, while engaging in limited supply-side livestock methane mitigation policy. At the sub-federal level, only a small number of American states and Canadian provinces are attempting to address agricultural methane. And even here, there is no clear evidence that any significant agricultural methane emissions reduction has been achieved at the state or provincial level to date, perhaps with the exception of California, which anticipates a nine percent reduction in emissions from livestock waste below 2020 levels by the end of 2022 (California Air Resources Board 2021). California and Alberta have both had enormous influence, in their respective countries and internationally, in driving climate policy innovations. However, their records on agricultural methane do not bode well for the future of climate and agricultural policy in either country. The fact that livestock agriculture exists in every American state and Canadian province, combined with the enormous cultural and political power of the agricultural sector, means that federal and sub-federal action on this large, and growing, source of GHG emissions has been timid at best.

The lackluster state of American and Canadian methane mitigation policy is not an accident of history.[70] There are concentrated, vested interests in the livestock and food industries that have been a decisive force in blocking progress on reducing red meat and dairy consumption and addressing livestock emissions (Lazarus et al. 2021; Nestle 2013; Sievert et al. 2020). Voters also represent a major obstacle to effective methane mitigation policy: Americans and Canadians are among the largest per

70 It is impossible to disentangle both countries' history of settler colonialism, ethnic cleansing of Indigenous peoples, chattel slavery in the case of the US, and the central role of agriculture and ranching in European colonization of North America with contemporary agriculture in the US and Canada.

capita consumers of meat and dairy products globally.[71] The fact that the overwhelming majority of American and Canadian voters eat meat and dairy[72] exerts 'indirect influence' on politicians, rendering policymakers reluctant to challenge the acceptability of meat and dairy production and consumption (Crenson 1971).

For the foreseeable future, significant agricultural methane mitigation cannot be achieved through 'stealth' regulatory interventions and will instead have to be accomplished through livestock quantity reductions, a mitigation strategy that is uniquely visible to meat and dairy consumers. To date, only the most left-wing American and Canadian politicians have called for meaningful reductions to livestock production; as demonstrated by the results of the 2020 US federal election and 2021 Canadian federal election, this is not a message that resonates with voters.

Climate scientists are in consensus: the climate crisis has reached an inflection point and the global community has only a few decades left to achieve enormous reductions in anthropogenic GHG emissions if we are to have any reasonable hope of limiting global warming to less than 2 degrees Celsius. The scale of the climate threat posed by agricultural methane, and the substantial near-term benefits of mitigation, demand an aggressive and comprehensive mitigation approach that not only attempts to address supply-side emissions from livestock, but also takes a far more muscular stance to demand-side reductions in meat and dairy consumption, particularly in the Global North.[73] As has been demonstrated in this paper, technically-oriented policy solutions to livestock methane emissions will, in the near term, be unable to achieve any significant emissions reduction. While estimates range regarding the scale of necessary cuts to red meat and dairy consumption to limit global warming, one such effort, the EAT-Lancet Commission, found that a greater than 50 percent reduction in red meat consumption globally will be essential if global warming is to be limited to 1.5 or 2 degrees Celsius (Willet et al. 2019). Neither the US nor Canada is considering policy approaches that even approximate the types of comprehensive changes to the food system that will be necessary to avert catastrophic climate scenarios.

Recent climate research has demonstrated that the longer it takes the global economy to wean itself off combustion of fossil fuels, the more severe reductions in food system emissions will need to be in order to limit global warming to 1.5 or 2 degrees Celsius. Given the outsized global influence of American agriculture and agricultural policy, it will be incumbent on the US to take action in order to spur global change.

The political enforcement of the status quo in agricultural methane governance has rendered the issue of livestock agriculture perhaps the most serious climate threat that Canada and the US are unwilling, or unable to, meaningfully address.

71 Americans eat more meat than any other nation on earth, and while Canadians eat less meat overall, they eat more beef than Americans.

72 Approximately 10 percent of Canadians are estimated to be vegetarian or vegan. Estimates for Americans range from 5–13 percent.

73 People in the Global North, particularly Americans and Canadians, eat far more red meat and dairy than is necessary nutritionally, contributing to a wide variety of non-communicable diseases. Countries of the Global North also have the resources necessary to ensure their populations can eat a diverse, mostly plant-based diet that meets nutritional requirements.

APPENDIX

Table 4 provides a high-level overview of federal and sub-federal supply-side methane mitigation policies enacted in the US and Canada. States and provinces highlighted in blue represent the top ten producers of beef cattle, dairy cattle, and swine in the US and the top two producers in Canada.

Table 4: Overview of Supply-side Federal and Sub-federal Agricultural Methane Mitigation Policies

Jurisdiction	Economic Subsidies & Incentives	Electricity Generation	Renewable Natural Gas Generation	GHG Emission Offsets	Methane Reduction Target
UNITED STATES					
Federal					*Global Methane Pledge
Alabama					
Alaska					
Arizona					
Arkansas					
California (dairy cattle)					*Livestock methane specific target
Colorado					
Connecticut				*RGGI	
Delaware				*RGGI	*executive target
Florida (beef cattle)	*local option only				
Georgia					
Hawaii					*executive target
Idaho (dairy cattle)					
Illinois (swine)					
Indiana (swine)					
Iowa (swine)					
Kansas (beef cattle)					
Kentucky (beef cattle)					
Louisiana					*executive target
Maine	*local option only			*RGGI	
Maryland				*RGGI	
Massachusetts				*RGGI	
Michigan (dairy cattle)					*executive target
Minnesota (dairy cattle & swine)					
Mississippi	*local option only				
Missouri (beef cattle & swine)					
Montana (beef cattle)					*executive target
Nebraska (beef cattle & swine)					
Nevada					

Jurisdiction	Economic Subsidies & Incentives	Electricity Generation	Renewable Natural Gas Generation	GHG Emission Offsets	Methane Reduction Target
New Hampshire				*RGGI	*executive target
New Jersey				*RGGI	*executive target
New Mexico (dairy cattle)					*executive target
New York (dairy cattle)				*RGGI	
North Carolina (swine)					*executive target
North Dakota (beef cattle)					
Ohio (swine)					
Oklahoma (beef cattle & swine)					
Oregon					
Pennsylvania (dairy cattle)					*executive target
Rhode Island				*RGGI	
South Carolina					
South Dakota (beef cattle & swine)					
Tennessee					
Texas (beef & dairy cattle)					
Utah					
Vermont				*RGGI	
Virginia					
Washington (dairy cattle)					
West Virginia					
Wisconsin (dairy cattle)					
Wyoming					
CANADA					
Federal			*Clean Fuel Standard offsets for RNG	*agricultural offsets recognized under the Pan-Canadian Framework	*Global Methane Pledge
Alberta (beef cattle)					
British Columbia					
Manitoba					
New Brunswick					
Newfoundland & Labrador					
Nova Scotia					
Ontario (dairy cattle & swine)			*pilot only		
Prince Edward Island					
Quebec (dairy cattle & swine)					
Saskatchewan (beef cattle)					

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The 'Dark Horse' of Climate Change:

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