

Biogas or Bull****?

*The Deceptive Promise of Manure Biogas
as a Methane Solution*



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Executive Summary

Creating energy from animal manure has an intuitive appeal: Hundreds of millions of animals raised for food on U.S. factory farms each year produce massive volumes of waste that generate methane emissions, an extremely potent greenhouse gas. Anaerobic digesters can capture those methane emissions to produce so-called “biogas,” which can generate electricity or be processed into transportation fuel. This strategy is the cornerstone of the Biden administration’s methane reduction plan for the agriculture sector,¹ and the Inflation Reduction Act has infused billions of dollars into programs and tax incentives that can be used to support biogas production.

The stakes for this strategy to work are high. The world is on track to reach a 2°C increase in temperature this century, which will have catastrophic impacts, including for our food and agriculture system.² Rapidly reducing methane emissions, a short-lived greenhouse gas with a global warming potential 80 times higher than carbon dioxide over a 20-year time frame, is a crucial part of the pathway to limit global temperature increases.³ The U.S. has joined more than 150 countries in signing the Global Methane Pledge to reduce methane emissions by 30% from 2020 levels by 2030.⁴ Animal agriculture is the largest source of U.S. methane emissions, so focusing on climate solutions for this sector should be a priority.⁵

However, this report provides evidence that manure biogas will further entrench inherently unsustainable and unjust systems of industrial animal agriculture and fossil fuel energy for decades to come – all for methane reduction benefits that have been considerably overstated by the U.S. government, are inadequately tracked, and are insufficient to meet climate targets.

Manure biogas is incompatible with the goals of environmental justice and public health

Manure biogas systems are typically feasible only at the largest concentrated animal feeding operations (CAFOs), or factory farms, which are major drivers of climate change and other forms of pollution, disproportionately affecting low-income communities and communities of color. Manure biogas relies on the existence and perpetuation of CAFOs using the most hazardous manure management practices. It fails to address CAFOs’ harms to rural communities, workers, farmed animals, and the environment. In fact, its production generates additional environmental, public health, and safety concerns for communities living near CAFOs and biogas plants, including increased production of ammonia during anaerobic digestion, higher concentrations of nutrients in the leftover material (digestate) that contribute to water pollution, new pipelines and trucks to transport manure or biogas through communities, and more toxic air pollution from biogas processing than is produced by fossil gas.

This report provides evidence that manure biogas will further entrench inherently unsustainable and unjust systems of industrial animal agriculture and fossil fuel energy for decades to come – all for methane reduction benefits that have been considerably overstated by the U.S. government, are inadequately tracked, and are insufficient to meet climate targets.

We make the case that policies rewarding biogas production create three perverse incentives for CAFO operators and biogas producers: 1) to utilize inferior manure management practices that maximize methane production, 2) to increase herd sizes to maximize manure production, and 3) to increase consolidation to take advantage of the economies of scale inherent in biogas production. Each of these trends will exacerbate the environmental and public health harms associated with CAFOs and the harms from various stages of manure biogas production. The perverse incentives to utilize emissions-maximizing manure management practices and increase herd sizes also undermine manure biogas's key selling point: that it will significantly reduce methane emissions.

Our report offers new evidence that methane reductions from manure biogas systems are overstated and insufficiently tracked by the U.S. government and that even these overstated reductions are insufficient to curb agricultural methane emissions in line with President Biden's commitment to the Global Methane Pledge. However, there are alternative agricultural methane reduction strategies that are both cost-effective and equitable.

President Biden's methane reduction plan for the agriculture sector largely relies on voluntary adoption of digesters and aspires to reduce methane emissions by only 9% by 2030. In contrast, we found that gradually reducing herd sizes as part of a just transition and implementing feasible alternative manure management practices at a large number of dairies can achieve more than half of the methane reductions needed to meet the Global Methane Pledge target for agriculture - and without all the environmental and health harms associated with manure biogas.

This report provides some of the first quantitative evidence that CAFOs with digesters are more likely to increase their herd sizes relative to statewide populations. We compared the herd sizes of 73 dairy facilities with digesters at the time the digester was installed with recent herd size data obtained from state permits, and our findings support the notion that policies rewarding biogas production incentivize increasing herd sizes. We also modeled emissions from these dairies to show how changes in herd sizes and different manure management strategies impact methane emissions.



Key findings of our original research:

1 Herd sizes at facilities with digesters grew 3.7% year-over-year, which is 24 times the growth rate for overall dairy herd sizes in the states covered by our data set.

Overall, the 73 facilities with dairy digesters in our data set added nearly 85,000 dairy cows total. If these dairy populations continued to grow at their historical rates, each farm would add an average of 177 cows per year to their herds in the next year, producing 10 million pounds of waste per year – enough to fill more than 1,000 semi-trucks.

2 Accounting for these herd size changes and measuring the emissions reductions from a baseline of feasible alternative manure management strategies, the dairy CAFOs in our data set reduced their annual methane emissions by only 11% from the baseline year to the most recent year for which herd size data is available.

This is nearly six times less than the reductions estimated using EPA's assumptions that there were no changes in herd sizes and that if these facilities did not have digesters, they would be utilizing the most methane-generating manure management strategy of a manure lagoon.

3 Installing dairy digesters will fall far short of the ambition needed to reduce agricultural methane emissions in line with President Biden's commitment to the Global Methane Pledge.

Assuming 500 new dairy digesters were installed by 2030 and those digesters yielded emissions reductions comparable to those in our dataset, their associated methane emissions reductions would account for less than a quarter of the reductions needed to reduce agricultural methane emissions by 30%.

4 Reducing herd sizes and implementing feasible alternative manure management strategies on a large number of dairy farms could yield 55% of the reductions that are needed to slash agricultural methane emissions by 30% in 2030.

We modeled reducing herd sizes by 20% and implementing feasible alternative manure management scenarios on 1,500 large dairies and found that this strategy would yield more than half of the reductions needed to reduce agricultural methane emissions in line with the Global Methane Pledge.

5 Paying dairy farmers to reduce their herd sizes would be nearly three times more cost-effective than subsidizing anaerobic digesters.

If the government paid producers to reduce their herd sizes through a per-cow payout equal to the average net revenue per cow over the last ~20 years, the cost of mitigating one metric ton of CO₂e would be less than \$10 total. This is nearly three times less than the cost of mitigating one metric ton of CO₂e by installing digesters, and it would be more consistent with administration's commitment to environmental justice. Paying farmers to reduce herd sizes or transition to another type of farming would also make dairy farming more profitable for the farmers who remain in the sector, because profits are currently suppressed by low prices driven by an oversupply relative to demand.

6 Data collection and disclosure from CAFOs with digesters is wholly insufficient to accurately measure methane emissions.

Given the massive amount of public federal funding dedicated to subsidizing manure biogas, it is astonishing that neither the Environmental Protection Agency nor the Department of Agriculture is monitoring and reporting on methane emissions from CAFOs with digesters or collecting basic information such as animal populations in ways necessary to understand whether these investments are resulting in actual GHG reductions.



Incentivizing manure biogas production increases the competitive advantage for large-scale producers, contributes to industry consolidation, and crowds out funding for truly effective conservation practices.

Anaerobic digesters are expensive to construct and operate, making them economically feasible only for the largest farms and only with considerable public subsidies in most cases. This further tilts the playing field in favor of the largest livestock operators that are positioned to capitalize on policies and incentives rewarding manure biogas production, contradicting President Biden's commitment to ensure fair markets for livestock producers. Ironically – and tragically – pasture-based producers who are using the best (least methane-producing) manure management strategies in the first place are not able to produce and sell manure biogas since they do not collect waste in methane-producing lagoons, making it even harder for them to compete with CAFOs.

Incentivizing manure biogas production increases the competitive advantage for large-scale producers, contributes to industry consolidation, and crowds out funding for truly effective conservation practices.

These expensive subsidies and incentives are diverting tax dollars away from truly clean, renewable sources of energy like wind and solar and away from farmers and ranchers who want to employ agricultural conservation practices that have meaningful climate, soil, and water benefits. Because digesters and related infrastructure (e.g., lagoon covers) are so expensive to construct, grants and loans covering their capital costs comprise a considerable portion of the budget for several USDA conservation programs, which are consistently overdrawn. Plus, 22% of once-operational digesters are now shuttered, making digester subsidies an even more wasteful use of taxpayer resources.⁶

Moreover, because manure biogas requires expensive capital investments for infrastructure (e.g., anaerobic digesters, pipelines, and natural gas processing facilities), it will take years or decades for biogas companies and CAFO operators to recoup initial costs. Therefore, government support for building out manure biogas now risks locking us into the factory farming and fossil fuel systems that manure biogas production depends on for decades to come.

With a narrowing timeframe to stave off the worst impacts of climate change, we need aggressive action to reduce methane from the country's largest source – not voluntary measures that marginally reduce methane emissions while entrenching the highly polluting factory farming and fossil fuel systems driving climate change and environmental injustice in the first place. At a time when there is scientific consensus that high-polluting countries like the United States need to shift away from fossil fuels and

reduce industrial livestock production, support for manure biogas does the opposite. Manure biogas – or “factory farm gas” – is a greenwashing measure that actively undermines the Biden administration’s commitments to fighting the climate crisis, achieving environmental justice, and ensuring fair markets for producers.

We conclude by offering the following policy recommendations:

Overarching policy recommendation:

Redirect resources currently supporting manure biogas (i.e., grants and loans for digesters, technical assistance, tax credits, and incentives for biogas production) to more cost-effective methane reduction solutions that do not exacerbate environmental injustice and industry consolidation. Instead, policies should support a just transition away from factory farming to regenerative agriculture and away from fossil fuels to truly renewable energy.

Additional policy recommendations:

- 1** Do not create new funding streams or other policy incentives for manure biogas.
- 2** Prevent double-dipping between subsidies, tax incentives, and programs like the Renewable Fuel Standard and California’s Low Carbon Fuel Standard. Related, ensure GHG reductions attributed to manure biogas are not double-counted.
- 3** Set a specific methane reduction target and pathway for the agricultural sector aligned with the Global Methane Pledge.
- 4** Require and improve methane monitoring and reporting from livestock operations.
- 5** Pursue agricultural methane reduction strategies that support environmental justice and fair markets for producers:
 - Methane emissions from industrial livestock facilities should be monitored, publicly disclosed, and regulated in a way similar

to how the administration has approached regulating methane emissions from the oil and gas sector.

- Leverage procurement to shift federal purchasing and food service toward plant-forward menus, which have drastically lower embedded methane emissions.
- Prioritize funding for pasture-based livestock production in USDA conservation programs such as EQIP and REAP.
- Implement policies such as the Farm System Reform Act⁷ that support a just transition to pastured animal production and plant-based food production, including placing a moratorium on large factory farms and providing voluntary buyouts for farmers who want to transition away from operating a CAFO.
- Reduce food waste.

6 Regulate waste from both CAFOs and digesters, including treatment and application of digestate.

7 Require disclosure of basic data from CAFOs and digester operators, and fund and conduct research to assess the impacts of manure biogas policies on methane emissions, industry consolidation, and rural communities.

8 In instances where public funds have already been designated to support manure biogas, grants and loans should include conditions and exclusions to reduce public health and environmental harms and increase transparency.



I. Introduction

Creating energy from animal manure has an intuitive appeal: Hundreds of millions of animals raised for food on U.S. factory farms each year produce massive volumes of waste that generate methane emissions, an extremely potent greenhouse gas. Anaerobic digesters, oxygen-free systems that use bacteria to break down organic material like manure, can capture those methane emissions to produce so-called “biogas.” Manure biogas can generate electricity or be processed into transportation fuel and injected into pipelines. However, this report provides evidence that promoting manure biogas will exacerbate pollution and safety risks to communities living near industrial livestock operations and biogas plants and entrench our current, inherently unsustainable systems of industrial animal agriculture and fossil fuel energy – all for methane reduction benefits that are overstated, inadequately tracked and studied, and insufficient to meet climate targets. Promoting manure biogas is a greenwashing measure that will actively undermine the Biden administration’s commitments to achieving environmental justice and ensuring fair markets for producers.

Animal agriculture is a leading source of methane emissions, accounting for around one-third of both global and U.S. methane emissions.⁸ Methane emissions from animal agriculture stem primarily from two sources: the digestive process of ruminant animals (e.g., cattle and sheep) and the manure produced by animals kept at concentrated animal feeding operations (CAFOs) or factory farms. The Biden administration has committed to achieving a 30% reduction in methane emissions as part of the Global Methane Pledge and has thrown its weight behind the voluntary adoption of anaerobic digesters as the primary solution for reducing agricultural emissions.⁹ The stakes are high for this strategy to work given the narrowing window to avert the most catastrophic impacts

of climate change, but, as this report argues, the evidence that manure biogas is a viable strategy to meet our climate commitments is misguided.

Rather than regulate the industrial animal agriculture industry like other emissions-intensive sectors, policies on both the federal and state levels reward industrial-scale agriculture polluters through lucrative incentives that encourage the expansion of manure biogas under the guise of climate change mitigation. For example, multiple federal programs, which have been infused with billions of dollars thanks to the Inflation Reduction Act, are supporting the production of manure biogas through guaranteed loans, grants, and tax credits that subsidize the capital costs of installing anaerobic digesters.¹⁰ Other policies, most notably California’s Low Carbon Fuel Standard (LCFS), are driving the demand for factory farm gas by allowing CAFOs to generate credits from installing and operating anaerobic digesters that can be sold to companies to pay for their pollution.

This report will delve into the extensive subsidies and incentives available to industrial-scale livestock operations and energy corporations to produce factory farm gas. We argue that these policies create perverse incentives for CAFOs to use manure management strategies that maximize methane generation, to expand livestock herds to produce as much manure as possible, and to consolidate such that even fewer farms confine an even larger number of animals. We present original research that provides new evidence of the trend for CAFOs with digesters to increase their herd sizes, and we make the case that methane reductions from manure digesters are overstated, insufficiently tracked, and inadequate for meeting climate targets.

- **Section II** will briefly review why factory farming is fundamentally incompatible with a just, healthy, and sustainable food system.
- **Section III** will review the basics of manure biogas production and provide an overview of the multitude of federal and state subsidies and incentives supporting manure biogas.
- **Section IV** reviews the non-climate environmental and public health impacts from each stage of biogas production, focusing on the adverse impacts to environmental justice communities living near CAFOs.
- **Section V** argues that policies rewarding manure biogas production create perverse incentives to increase herd sizes, use inferior manure management practices, and concentrate production among a smaller number of large farms.
- **Section VI** makes the case that emissions reductions from biogas are overstated and insufficiently tracked and that even these overstated reductions will fail to meet President Biden's climate commitments. We present original research showing that dairy CAFOs with digesters have increased their

herd sizes relative to statewide population trends. We model methane reductions from large dairies and find that implementing a gradual reduction in herd sizes and alternative manure management practices at a large number of dairies will yield significantly greater methane reductions than installing digesters at the smaller number of facilities where they would be economically feasible.

- **Section VII** offers policy recommendations to achieve meaningful methane emission reduction targets from the agricultural sector, including by supporting a just transition away from CAFOs and fossil fuels and through alternative agricultural methane reduction strategies.
- **Section VIII** concludes by reiterating the incongruity between President Biden's commitments to fighting climate change, achieving environmental justice, and ensuring fair markets for producers, and his administration's support for manure biogas. Instead, we revisit alternative policies that would realize a vision for a just, healthy, and sustainable food system.



II. Factory farming is unsustainable and unjust

The vast majority of farm animals slaughtered for food each year in the United States are raised in industrial facilities known as concentrated animal feeding operations (CAFOs) or factory farms.¹¹ Animal agriculture is a major driver of climate change, accounting for 20% of global greenhouse gas (GHG) emissions and nearly 60% of emissions from the global food system.¹² Animal agriculture is also the leading source of U.S. methane emissions, accounting for more than one-third of U.S. methane emissions.¹³ Because methane is a powerful but short-lived climate pollutant, rapidly reducing methane emissions is critical to meeting global climate targets.¹⁴ Most of the methane emissions from animal agriculture come from the digestive process of ruminant animals (e.g., cattle and sheep), while other emissions stem from the large amount of manure produced – the vast majority of which is from CAFOs – and the manner in which it is managed.¹⁵ Alarmingly, while overall U.S. methane emissions have declined 16.6% since 1990, agriculture-related methane emissions rose by 7.2% during that same period.¹⁶ This correlates with the proliferation of factory farms in the United States.¹⁷

CAFOs do not just contribute to the worsening climate situation. Factory farms are significant drivers of land use change and biodiversity loss and are incredibly water-intensive.¹⁸ Additionally, the massive quantities of waste generated by industrial-scale farms cause considerable water and air pollution, degrading the environment and threatening the public health of the communities they are in, which are disproportionately communities of color and low-income communities.¹⁹ Manure from industrial dairy and hog operations, which is typically stored as liquid in giant manure lagoons and periodically applied to spray fields, contains pathogens, antibiotic-resistant bacteria, and heavy metals.²⁰ The sprayed, untreated waste can contaminate the soil and run off into waterways, causing harmful downstream effects.²¹ The manure also contains hazardous

gases and particulate matter, causing toxic air emissions and noxious odor.²² Studies have shown that people living near factory farms face higher risk and severity of respiratory illnesses, digestive issues, headaches, and other serious health conditions.²³ They are also subject to a reduced quality of life, including lower property values and mental stress, due to pollution from CAFOs.²⁴

CAFOs are often intentionally located in areas where marginalized communities lack the political or economic power to adequately address the negative impacts these industrial facilities have on their communities.²⁵ Increased consolidation of industrial animal agriculture has allowed just a handful of corporate entities to control nearly every aspect of factory farming, from production to processing, including the location of the farms themselves.²⁶ In fact, just four companies control 73% of beef processing, 67% of pork processing, and 54% of chicken processing.²⁷ Over the last three and a half decades, this has resulted in fewer and larger farms.²⁸ Consolidation causes problems for both farmers and consumers by reducing competition, limiting product availability, and driving up costs. As made evident during the COVID-19 pandemic, “supply chain fragility” also increases when just a handful of companies control all aspects of the livestock production process; a problem at one end quickly impacts all other stages.²⁹ Corporate consolidation of animal agriculture has hurt workers, too: Decreases in wages, cuts to benefits, and more dangerous workplace conditions have all accompanied corporate consolidation.³⁰ Finally, the corporate consolidation of the animal agriculture industry has increased inhumane treatment of the animals raised in these facilities.³¹ Tens or even hundreds of thousands of animals are confined together in unsanitary conditions, unable to engage in natural behaviors or sometimes even turn around in their cages, rarely seeing the light of day.³² Meanwhile, producers using environmentally sound and humane practices

are being undercut by CAFOs that are not held accountable for their harms to workers, communities, animals, and the environment.

Any climate “solution” that maintains this highly polluting industrial agricultural model is not a solution at all. As we detail further in this report,

the production of manure biogas will not only fail to address most harms associated with CAFOs but will do the opposite by causing additional environmental and public health risks and further entrenching this fundamentally unsustainable, unjust model of raising animals for decades to come.

Industrial animal agriculture is largely unregulated



The industrial model for animal agriculture has become dominant in part due to a lack of government oversight. Despite evidence that CAFOs contribute to more air pollution deaths each year than coal plants, they are not regulated under the Clean Air Act like any comparable industrial polluter.³³ Similarly, despite EPA’s long-standing acknowledgement that agriculture is the primary source of pollution of rivers and streams, two-thirds of CAFOs do not even have a permit under the Clean Water Act, and the agency consistently fails to enforce this requirement.³⁴ CAFOs are also exempt from the Emergency Planning and Community Right-to-Know Act, which requires reporting on hazardous and toxic chemicals, and the Comprehensive Environmental Response, Compensation and Liability Act (also known as “Superfund”), which enables EPA to hold corporations liable for cleaning up accidents or spills of hazardous pollutants.³⁵ Congress even precludes EPA from merely measuring and publicly reporting on GHG emissions from manure management systems.³⁶ Farms with fewer than 10 employees cannot be inspected by OSHA, there are no federal laws concerning on-farm treatment of animals,ⁱ and there is no meaningful regulation of animal-raising claims such as “humane,” “sustainable,” or “raised without antibiotics.”³⁷ This unique lack of regulation means that communities, workers, farmers, and taxpayers are the ones paying for the cost of the damage caused by CAFOs instead of the corporations that control and profit off of them.

ⁱ A limited exception to this is the Organic Livestock and Poultry Standards rule, which the U.S. Department of Agriculture’s National Organic Program finalized on October 25, 2023. For the first time, producers who participate in the organic program are required to comply with certain federal animal welfare standards as of January 2024.

III. Manure Biogas 101

To meet the Global Climate Pledge, the United States must reduce its overall methane emissions by 30% below 2020 levels by 2030. The Biden administration has focused on expanding the production of manure biogas as a strategy for reducing methane from animal agriculture. This, coupled with support from Congress and state legislatures, is helping drive increased construction of anaerobic digesters across the country.³⁸

Biogas is a mixture of gases created through anaerobic digestion. During anaerobic digestion, bacteria break down organic material (in this case, animal waste) in a closed, oxygen-free environment known as a digester.³⁹ What is left behind from bacteria “eating” the waste is a combination of gases, primarily methane and carbon dioxide, as well as solid and liquid material (also called “digestate” or “effluent.”)⁴⁰ The digestate, commonly used as animal bedding or as fertilizer, is a highly concentrated, nutrient-rich by-product that must be carefully managed to prevent increased nutrient pollution.⁴¹ The gas can be used to generate heat or electricity on-site or electricity sold onto the electric grid, it can be processed into so-called “Renewable Natural Gas,” or it can be converted to Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG) and used as vehicle fuel. Labeling this gas as “biogas” or “renewable” is industry greenwashing. Manure “biogas” is inseparable from the highly polluting factory farming industry. “Factory farm gas” better reflects the true nature of this form of dirty energy; these terms are used interchangeably throughout the report.

According to the U.S. Environmental Protection Agency (EPA), a farm is a good candidate for anaerobic digestion if it has at least 500 cows or 2,000 hogs, and “regularly collect[s] liquid, slurry or semi-solid manure with little or no bedding” or has “5,000 hogs with deep pit manure management systems.”⁴² Thus, factory farm gas systems rely on large herds of animals

producing huge quantities of liquid waste stored in the least environmentally sound manner in order to be financially viable. Even for these facilities, anaerobic digesters are not typically economically feasible without substantial subsidies.⁴³ This means that the largest and most polluting CAFOs are best positioned to capture the benefits of the many taxpayer-funded subsidies and other policy incentives for producing manure biogas, while pasture-based and integrated smaller-scale livestock producers, whose manure methane emissions are significantly lower, are completely excluded.

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Photo by © SRAP

Many taxpayer-funded programs support factory farm gas at both the federal and state level

These programs support the biogas industry through technical assistance as well as financing for both factory farm gas infrastructure (e.g., anaerobic digesters) and the sale of the biogas itself.

Programs that support factory farm gas infrastructure

Federal grant and loan programs

Several USDA programs have provided grants, cost-sharing agreements, and loans for manure digester projects for decades, including the Environmental Quality Incentives Program (EQIP) and the Rural Energy for America Program (REAP).⁴⁴ For example, according to an analysis from Taxpayers for Common Sense, between 2010 and 2021, USDA Rural Development awarded \$78M in REAP funds to anaerobic digesters and biogas.⁴⁵ **Appendix A** provides a more complete list of available federal funding sources. USDA encourages applicants to “stack” these programs in order to cover the entire cost of constructing the digester system, including building related infrastructure like natural gas pipelines.⁴⁶ This means taxpayers may sometimes cover the full capital costs associated with this dirty energy source.⁴⁷ The Inflation Reduction Act (IRA), passed in 2022, infused billions of dollars into these programs and created new programs that could support digesters, such as the Empowering Rural America (New ERA) Program and the Powering Affordable Clean Energy (PACE) Program, which were created to support the development of renewable energy projects in rural communities.⁴⁸

Federal tax incentives

There are incentives throughout the U.S. tax code that support energy production from renewable sources, and the IRA expanded a number of them to include factory farm gas. For example, the Investment Tax Credit for Energy Property was specifically expanded by the

IRA to provide up to a 30% tax credit for any “qualified biogas property system” that converts biomass to gas.⁴⁹ Similarly, the Clean Electricity Production Tax Credit, a technology-neutral tax credit for the production of clean electricity, was also expanded by the IRA to include biogas derived from biomass that is used to generate electricity.⁵⁰ Other tax incentives that are likely to benefit the factory farm gas industry and were extended and added through the IRA include Incentives for Biodiesel, Renewable Diesel and Alternative Fuels; the Alternative Fuel Refueling Property Credit; and the Alternative Fuel and Low-Emission Aviation Technology Program.⁵¹

Technical assistance

The federal government facilitates building methane digesters beyond financial assistance. For instance, USDA provides technical assistance through EQIP, including feasibility assessments for anaerobic digesters, advice on installing anaerobic methane digesters, and support for upgrading existing anaerobic lagoons.⁵²

EPA similarly supports factory farm gas through its AgSTAR Program, which provides free technical assistance and guidance for both digester developers and farms.⁵³ EPA’s newly created Greenhouse Gas Reduction Fund also provides technical assistance for clean technology projects, including anaerobic digestion, through two grant competitions.⁵⁴ Frustratingly, EPA, whose mission is to protect human health and the environment, is not only failing to regulate industrial livestock and manure biogas production but is actively propelling the factory farming industry by inducing it to produce animal waste and receive these financial benefits.

State-level programs

The push to increase the number of anaerobic digesters is not coming just from the federal government. There are programs on the state level that provide public tax dollars to build methane digesters and the related infrastructure. For example, Minnesota’s Methane Digester Loan program provides up to \$250,000 in no-interest loans to help “finance the purchase of necessary equipment and the construction of a system that will use manure to produce

electricity.”⁵⁵ There are similar programs in other states, including Maryland, California, and Massachusetts.⁵⁶ Several states, including Iowa, Wisconsin, Colorado, and South Carolina, also utilize tax incentives to offset the cost of constructing and operationalizing anaerobic digesters.⁵⁷

Because methane digesters are very expensive to build and maintain, developers heavily rely on these government handouts for the digesters to be economically viable.⁵⁸ Without the subsidies and technical assistance provided, it is likely that fewer digesters would be built in the United States. More significantly, these methane digester subsidies and incentives are diverting tax dollars away from truly clean, renewable sources of energy like wind and solar and away from farmers and ranchers who want to employ agricultural conservation practices that have meaningful climate, soil, and water benefits.

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Programs that support the sale of factory farm gas

Beyond subsidizing the capital costs associated with anaerobic digesters and other factory farm gas infrastructure, government programs also prop up this industry by incentivizing or requiring the use or sale of biogas.

Renewable Portfolio Standards

Most states have a Renewable Portfolio Standard (RPS), also known as a Renewable Energy Standard (RES), that requires or encourages electricity providers to provide a minimum share of electricity from renewable sources.⁵⁹ Biomass is typically defined as a renewable source option, and several states include gas from animal waste as part of that category.⁶⁰ For example, in Maryland, utilities are currently required to provide 31.9% of power from “tier 1” renewable energy sources.⁶¹ Biomass is considered a “tier 1” fuel source, and the statute’s definition of biomass explicitly includes gas produced from anaerobic digestion of animal waste or poultry waste as an eligible source.⁶² Similarly, Maine’s Renewables Portfolio Standards categorizes “anaerobic digestion of by-products of waste from animals” as a Class I Resource. Class I Resources must constitute 10% of an electricity provider’s portfolio of supply sources.⁶³ In North Carolina, the Renewable Energy and Energy Efficiency Portfolio Standard goes a step further when it comes to factory farm gas, mandating that electric public utilities subject to the law source .2% of their total electric power from swine-based manure biogas.⁶⁴

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Federal Renewable Fuel Standard

The federal Renewable Fuel Standard (RFS) also supports the sale of factory farm gas. It mandates that a certain volume of renewable fuels, including biomass-based diesel, is mixed in with traditional petroleum-based fuel, creating a guaranteed market for the biofuel industry.⁶⁵ Renewable fuel producers create Renewable Identification Number (RIN) credits, which they then sell to fossil fuel companies that use them to comply with the requirements of the RFS.⁶⁶

Since 2014, EPA has allowed “Renewable Natural Gas” created from manure biogas to generate RINs.⁶⁷ Recently, EPA proposed expanding the RFS to include renewable electricity RIN (eRIN) credits for charging electric vehicles. The proposal would have allowed factory farm gas and other forms of dirty biomass to serve as a qualified feedstock and generate eRIN credits, significantly growing the demand for manure biogas under the RFS.⁶⁸ However, the final rule removed this proposal, though the biogas industry is actively lobbying the EPA to revive this proposal and allow manure biogas as a qualified feedstock to generate eRINs.⁶⁹

Federal Energy Business Programs

USDA’s Rural Business Cooperative Service (RBCS) operates programs that are designed to increase production of biogas and digestate. These programs include the Advanced Biofuel Payment Program, the BioPreferred Program, and the Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program.⁷⁰

California’s Low Carbon Fuel Standard

California is the largest demand-side driver of the factory farm gas market through its Low Carbon Fuel Standard (LCFS). The LCFS was developed to “decrease the carbon intensity of California’s transportation fuel pool and provide an increasing range of low-carbon and renewable alternatives.”⁷¹ Each year, the California Air Resources Board (CARB) sets carbon intensity (CI) standards for transportation fuels. Low carbon fuels below the CI standard receive credits, while fuels above the CI benchmark receive deficits.⁷² Transportation fuel providers must show they are meeting the LCFS CI standards and can do that by acquiring (trading) or earning more credits than deficits.⁷³

CAFOs both inside and outside California can participate in the program by generating credits from installing and operating anaerobic digesters to produce manure biogas. Currently, manure biogas has an extremely large negative CI score, one even better than electric vehicles powered by renewable electricity, so it generates a large subsidy.⁷⁴ This is because CARB gives participating CAFOs credit for both reducing methane emissions from manure under the assumption that wet, methane-generating manure is an unavoidable byproduct of livestock production, and for replacing fossil fuels with higher CI scores.⁷⁵ Ultimately, LCFS distorts the market for transportation fuels, boosting fuels derived from manure above truly renewable sources, and incentivizes CAFO operators to generate as much methane – and therefore as much manure – as possible in order to capitalize on the hefty subsidies. We will further explore how these programs create perverse incentives for CAFO operators and biogas companies in

Section V.



All told, CAFOs are experiencing a windfall of taxpayer dollars between the funding available to build digesters as well as lucrative payouts for selling biogas. In other words, a CAFO operator can receive subsidies to cover the capital costs associated with a new digester, claim tax breaks for the same activity, and then generate ongoing income from selling credits to a program like LCFS or RFS or to a voluntary carbon market. Meanwhile, many of these

programs are double or even triple counting the emissions reductions attributable to digesters, with the same purported emissions reductions being counted toward multiple programs, thereby inflating climate progress. For example, research has shown that the LCFS takes credit for the same emissions reductions as California's state-funded Dairy Digester Research and Development Program.⁷⁶

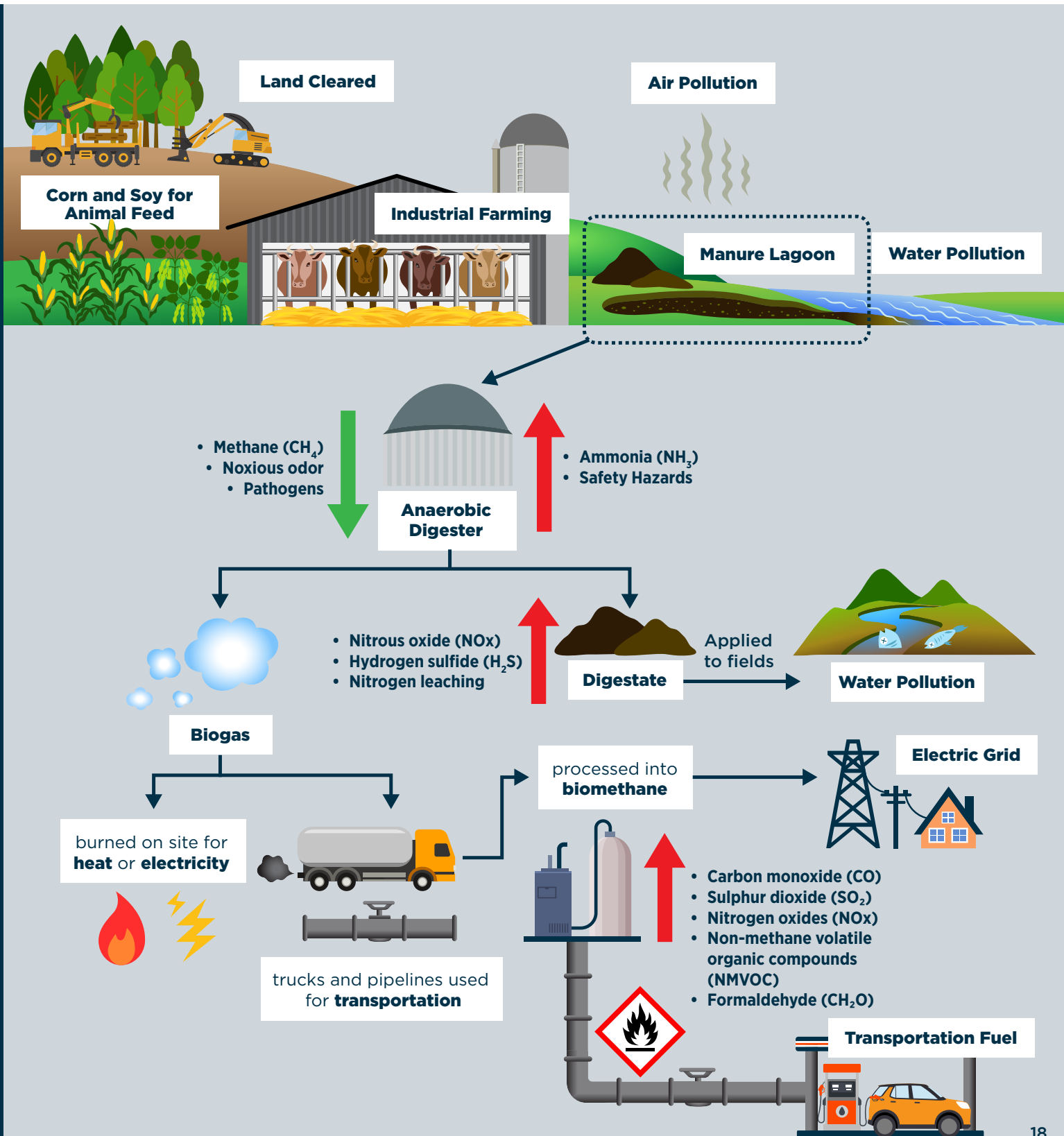
Case study: Pixley Biogas Digester benefited from multiple government programs



The Pixley Biogas Anaerobic Digester in Tulare County, California, has taken advantage of multiple documented sources of public funding. The 1.4-million-gallon digester – part of the state's first pipeline cluster⁷⁷ – is housed on 4J Farms Dairy and is supplied by manure from 1,800 dairy cows, as well as food waste trucked in from surrounding communities.⁷⁸ Installed in 2014, the project received federal and state financing for construction and ongoing income from California's Low Carbon Fuel Standard (LCFS) carbon credit market.⁷⁹ It utilized a \$4.6 million grant from the California Energy Commission's (CEC) vehicle surcharge program, on top of funding from the U.S. Department of Agriculture, though the specific amount is unknown due to a lack of transparency from USDA's Environmental Quality Incentive Program.⁸⁰ The company contracted to construct the digester projected the total cost of the project at \$12 million.⁸¹ A 2020 report to the California Energy Commission noted that the digester would not have been economically viable without federal and state grant support.⁸²

IV. Public health and environmental impacts from manure biogas production

In this section, we will review the stages of manure biogas production and the impacts each has on public and environmental health.



Feedstock production

The first stage of producing biogas is generating the feedstock for the digester: animal manure, in this case. The upstream impacts of animal manure include clearing land and using large quantities of fertilizer and pesticides for animal feed production, plus all the harms of CAFOs outlined in **Section II**.

Proponents of biogas argue that we should accept CAFO production of meat and dairy as a baseline and that the massive volumes of waste they produce – and the methane released into the atmosphere from that waste – are a given. They attribute all these downstream impacts of producing animal manure to meat and dairy products and none to its co-product, biogas.

Only if one accepts the status quo model for industrial animal production as the baseline can it be argued that manure biogas has any benefits. Instead, we need a just transition away from CAFO production to a sustainable amount of higher-welfare, pasture-based production of animals coupled with more plant-based foods produced using regenerative practices. In that system, there is no role for manure biogas, because manure is naturally distributed on the land and its nutrients are cycled through the soil. To accept a system that collects waste in massive cesspools is to surrender the goals of environmental justice and land stewardship from the outset.

Case study: Grady Road Project doubles down on risks to Duplin County residents



Photo by © Cape Fear River Watch

In Duplin County, North Carolina, CAFOs disproportionately harm communities of color.⁸³ Families who have lived in the county for generations have endured the rapid consolidation of surrounding farmland, increased road traffic, foul odors, and air and groundwater pollution. Now, with the expansion of factory farm gas, Duplin County residents have to contend with a brand-new natural gas pipeline. Smithfield, the nation's largest pork producer, proposed a \$30 million, 30-mile pipeline to convert methane captured by anaerobic digesters into biogas from 19 surrounding hog farms.⁸⁴ The nearby communities voiced concerns about leaks and explosions from the pipeline, carbon monoxide emissions from the collection facility, and an increased demand for manure pits, which contribute to nitrogen runoff into wells and waterways.⁸⁵ However, these concerns were ignored: According to Align RNG, the company responsible for executing the pipeline, the project was completed in the first quarter of 2023.⁸⁶

Transporting manure

Because methane digesters often need to be kept running almost constantly to be cost-effective, many operations pipe or truck in manure from other CAFOs, which comes with additional risk as well as wear and tear on the local infrastructure. For example, at a manure digester in Wisconsin, pipelines transporting manure from surrounding farms have spilled more than 400,000 gallons of manure in three separate incidents over a three-year period.⁸⁷

Anaerobic digestion and storage

The anaerobic digestion process does mitigate some problems for communities compared to a CAFO using a lagoon and sprayfield system without a digester. There is some evidence that manure digesters reduce odors.⁸⁸ Some anaerobic digesters reach high temperatures that can kill some pathogens (e.g., *E. coli*) in animal waste that can contaminate drinking water.⁸⁹ Again, however, these impacts can be considered benefits only if we accept CAFOs with lagoon and sprayfield systems operating largely without oversight as the baseline.

Other aspects of the anaerobic digestion process actually exacerbate or create new harms to local communities, even when compared to the lagoon and sprayfield system.

Anaerobic digestion increases emissions of ammonia, an air pollutant associated with

respiratory illness and irritation of the eyes, nose, and throat.⁹⁰ A study published in the journal *Agriculture, Ecosystems, & Environment* estimates that digestion increases cumulative NH_3 emissions from manure by 81%, mostly from storage.⁹¹ Several other studies substantiate the claim that facilities with digesters emit more ammonia than conventional hog or dairy operations.^{92,93} Distance to one or more CAFOs has been identified as a key variable for predicting exposure to atmospheric ammonia, so increasing these emissions exacerbates an already-prominent health risk for neighboring communities.⁹⁴ While there are available technologies to mitigate some of the increased ammonia emissions from anaerobic digestion, they are not required and are rarely deployed.⁹⁵

The Environmental Protection Agency identifies several major safety hazards associated with anaerobic digestion systems, including drowning, electric shock, explosion, asphyxiation, and burns.⁹⁶ In 2021, an experienced diver attempting to fix equipment in a million-gallon anaerobic digester died.⁹⁷ T. Renee Anthony, a University of Iowa professor of Occupational and Environmental health, commented on the case by warning, “Every farmer that has a digester or manure storage needs to know there are life-and-death consequences of going into those spaces.”⁹⁸ Accidents can also arise from storing the biogas and digestate resulting from the anaerobic digestion process.⁹⁹



Case study: Catastrophic explosion from White Oak Farms digester



For decades, North Carolina residents – particularly in low-income communities and communities of color – have been subject to air and water pollution from the numerous industrial hog operations in the state.¹⁰⁰ To curb the environmental impacts of these facilities, the state placed a moratorium on new or expanded hog operations in 2007.¹⁰¹

Despite the moratorium, in 2013, White Oak Farms in Fremont, North Carolina, was permitted to add 60,000 hogs to its farm operations.¹⁰² Using a loophole in the moratorium law, the expansion was conditioned on the construction of an anaerobic digester to meet or exceed the statute's five environmental performance standards.¹⁰³ White Oak Farms constructed an 8.75-million-gallon, unlined digester that began operating in April 2019. The facility sells its methane to Duke Energy.¹⁰⁴

On May 30, 2022, the farm's digester experienced a catastrophic failure originating from a fissure in its plastic covering.¹⁰⁵ As a result of the rupture, more than 3 million gallons of sludge spilled across the farm and into adjacent wetlands, causing ammonia levels in nearby wells to skyrocket to 12 times the allowed concentration.¹⁰⁶ DEQ had approved multiple permits allowing White Oak Farms to add up to 20,000 pounds of food waste and 210,000 pounds of hog carcasses a day in addition to the manure from the hog operation, which vastly increased methane production.¹⁰⁷ However, during the COVID-19 pandemic, the farm operation dwindled to between 50 and 100 hogs, while the food waste and carcass supply remained consistent. The imbalance likely contributed to pressure build-ups that ultimately led to the facility's rupture.¹⁰⁸

Following the spill, DEQ was required by law to notify the public of the event but did not disclose any details, including the nature of the waste released.¹⁰⁹ Ultimately, in July 2022, DEQ issued notice to White Oak Farms, finding the facility failed to update its permits to reflect COVID operating populations and that it accepted more food waste than allowed. The facility was later fined \$34,520 for the incident¹¹⁰ but is now seeking to profit from its negligence: It is reportedly planning the construction of a new digester that will use the contents of the spill as a foundation for future feedstock.¹¹¹

Digestate

The anaerobic digestion process creates a digestate, a highly concentrated, nutrient-rich byproduct that must be carefully managed to prevent pollution.¹¹² As **Section III** noted, digestate can be used for livestock bedding and, in moderation, can be applied to the soil as fertilizer, reducing (but not eliminating) the need for chemical fertilizers.¹¹³ However, because nitrogen and phosphorous are more concentrated in digestate compared to fresh or composted manure,¹¹⁴ digestate can cause nitrogen leaching, nitrous oxide emissions, residual methane, ammonia, hydrogen sulfide emissions, and odorous gases when applied in excess or without proper application protocols.¹¹⁵ In areas with intensive livestock production, there is often an oversupply of nitrogen and phosphorous relative to the land available to which digestate can be applied.¹¹⁶ In these cases, excess nutrients enter surface and ground water, contaminating sources of drinking water and causing water eutrophication and harmful algal blooms, dead zones (i.e., areas of water bodies with less dissolved oxygen, resulting in a notable die-off of marine life), and fish kills.¹¹⁷

According to the USDA Natural Resource and Conservation Service's practice standard for anaerobic digestion, land applying digester effluent – compared with fresh manure – may have a higher risk for both ground and surface water quality problems.¹¹⁸ Compounds such as nitrogen, phosphorus, and other elements

become more soluble than fresh compost due to anaerobic digestion and therefore have higher potential to move with water.¹¹⁹ The digestion process also concentrates heavy metals in digestate.¹²⁰ In effect, because anaerobic digestion concentrates nutrients, effluent that *does* end up in a body of water is more damaging than fresh or composted manure and requires careful management.

Despite these concerns, there are few laws and regulations pertaining to the use of digestate, and the minimal requirements that do exist are inadequately enforced. For example, digestate cannot be safely applied when the ground is frozen, and several states ban or restrict digestate application in winter months.¹²¹ However, new evidence from satellite imagery in Wisconsin reveals that the state's 330 CAFOs land-applied waste 951 times during February and March.¹²² This rate is comparable to the rest of the year, indicating that the winter ban “did little to reduce winter land application.”¹²³

Most CAFOs are required to follow nutrient management plans (NMPs) under the Clean Water Act and similar state laws to prevent excess application of nutrients,¹²⁴ though again, compliance and enforcement are severely lacking in many cases.^{125,126} One glaring regulatory loophole is that when digestate is sold or given away to crop producers, it can be applied without an NMP, since NMPs are only required for livestock operations.

Case study: Michigan's Coldwater River turns “ink black” from digestate

In early 2019, a prized trout stream in Michigan turned “ink black” after at least 10,000 gallons of digested waste were applied on snow-covered and frozen ground that could not absorb it and flowed into the river.¹²⁷ It was the third manure spill into the Coldwater River in the past year. Lance Climie, president of Schrems West Michigan Trout Unlimited, lamented in an interview with MLive, “I mean when you look at the Coldwater watershed over the decades, we have thousands and thousands of volunteer hours and dollars put into it, and it's getting trashed. These manure spills are going to kill the streams.”¹²⁸



Photo by © Michael Kransz

Transportation, processing, and combustion of biogas

The transportation, processing, and combustion of manure biogas creates additional harm to nearby communities and environmental damage.

As Table 1 shows, biogas plants emit more carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC), and formaldehyde (CH₂O) compared to fossil gas combustion in large wall-fired gas boilers. A 2020 paper in *Applied Sciences* found that biogas is, on average, 10 times more toxic to human health than natural gas.¹²⁹

Table 1. Many pollutants from biogas processing exceed those from fossil gas processing.

Pollutant	Biogas Emission factor (g per GJ)	Fossil Gas Emission factor (g per GJ)
Carbon monoxide (CO)	256-310	35
Sulphur dioxide (SO ₂)	25	0.25
Nitrogen oxides (NOx)	202-540	118
Non-methane volatile organic compounds (NMVOC)	10-21.15	2.32
Formaldehyde (CH ₂ O)	8.7-14	0.003

Source: Adapted from a chart developed by the Applied Economics Clinic based on data from 1) Kristensen et al. (2004). "Emission Factors for Gas Fired CHP units." Danish Gas Technology Centre and National Environmental Research Institute of Denmark. Available at https://www2.dmu.dk/1_viden/2_Miljoe-tilstand/3_luft/4_adaei/doc/EmissionfactorsforgasfiredCHPunits.pdf. p. 10. 2) Nielsen, M., et al. (2014). "Danish emission inventory for stationary combustion plants." *Danish Centre for Environment and Energy (DCE)*; No. 102. Available at: <http://dce2.au.dk/pub/SR102.pdf>. p. 124. 3) U.S. EPA. (1998). 1.4 Natural Gas Combustion. 42, 7(Fifth Edition), 11. https://www.epa.gov/sites/default/files/2020-09/documents/1.4_natural_gas_combustion.pdf

When biogas is used to power internal-combustion engines that generate electricity on-site, these pollutants add to the pollutants from CAFOs themselves. Because CAFOs are often disproportionately located in low-

income communities and communities of color, burning biogas on-site exacerbates poor air quality in communities already overburdened by pollution. For example, as petitioners point out in their *Petition for Rulemaking to Exclude all Fuels Derived from Biomethane from Dairy and Swine Manure from the Low Carbon Fuel Standard*, the Lakeview Dairy Biogas project in Kern County, California, uses two internal-combustion engines to produce over 1,000 kW of electricity on-site.¹³⁰ Even with the required pollution control technology, this project emits 4.58 tons/year of NOx, 1.98 tons/year of PM10 (fine particulate matter), and 3.18 tons/year of VOC.¹³¹ Compared to a natural gas combined-cycle plant in a nearby town, the Lakeview digester project produces much higher levels of NOx, SOx, and VOC emissions per unit of electricity generated.¹³² Meanwhile, communities in California's San Joaquin Valley, which are disproportionately Latino and low income, already suffer some of the worst air and water quality in the country due in large part to the concentration of dairy factory farms. The California Air Resources Board acknowledges that 1,200 residents of the San Joaquin Valley die prematurely each year from PM2.5 pollution alone.¹³³ Producing and combusting manure biogas on-site leads to even worse air quality, exacerbating public health harms and environmental injustice.

Because concentrated animal feeding operations are often disproportionately located in low-income communities and communities of color, burning biogas onsite exacerbates poor air quality in communities already overburdened by pollution.

Case study: Noxious odors from Ohio's Dovetail digester



Both public and school officials from two Ohio towns, Bath Township and Fairborn, have opposed the nearby Dovetail anaerobic digester facility due to health concerns and odor levels.¹³⁴ A new high school was built within a mile of the digester, and Fairborn school officials soon voiced concerns about the effect of noxious odors emitted from the facility on students and staff.¹³⁵ The school district, local zoning council, and Ohio Environmental Protection Agency (EPA) have all taken legal action against Renergy, the facility's parent company, regarding unpermitted odor and air pollution. The Ohio EPA settled their case out of court under the condition that the facility comply with multiple Clear Air Act provisions within 60 days. Meanwhile, both townships are engaged in active litigation against the facility as of 2023.¹³⁶

When biogas is not burned on-site, biogas must be processed and transmitted – either through a network of pipelines, in trucks, or a combination of both – and then combusted in an engine, turbine, or boiler.

Building new pipelines to transport biogas comes with the same problems as building pipelines for any other methane gas. Pipelines are built through the communities that are already burdened by factory farm pollution, sometimes using eminent domain and lowering property values. Pipelines can leak or explode, endangering human, wildlife, and environmental health. A 2022 report by U.S. PIRG, Environment America Research & Policy Center, and Frontier Group identified almost 2,600 natural gas pipeline incidents between 2010 and 2021 that were serious enough to be reported to the federal government, 328 of which resulted in explosions that killed 122 people and injured 603.¹³⁷ These leaks collectively released 26.6

billion cubic feet of methane, equivalent to emissions from more than 2.4 million passenger vehicles driven for a year.¹³⁸ A 2018 paper in the journal *Science* found the leakage rate in the U.S. gas supply chain equaled 2.3% of U.S. gross gas production, 60% higher than the EPA's estimate.¹³⁹

Manure biogas does not always have a practical end use. When it is overproduced and a facility lacks sufficient storage, biogas is flared or burned off. This process releases heat-trapping gases such as carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen oxides (NOX), as well as particulate matter (PM), contributing to air pollution and climate change.¹⁴⁰

Finally, investing in even more pipeline infrastructure runs counter to the indisputable need to move away from a fossil fuel-based energy system toward electrification that utilizes truly renewable sources of energy.

Case study: Poultry biogas spurs Eastern Shore Natural Gas pipeline extension, digester facility construction, and environmental justice investigation

Sussex County, Delaware, is the top chicken-producing county in the United States.¹⁴¹ Eastern Shore Natural Gas (ESNG) is attempting to develop three new pipeline terminals in the county to receive biogas supplied by several large industrial-sized digester plants that BioEnergy Development Corp. (BDC) is in various stages of proposing, constructing, and operating.¹⁴² BDC proposed a \$50 million expansion project to install a new anaerobic digester plant in neighboring Seaford, Delaware, to collect poultry waste from the area and four nearby states.¹⁴³ BDC also intends to rely on public wastewater systems to process its industrial waste from the digester.¹⁴⁴

As described further in **Section V**, large volumes of water are needed to make poultry manure suitable for biogas production since raw poultry litter does not emit methane until it has been exposed to an anaerobic environment.¹⁴⁵ The Seaford facility plans to be served by a private well to source the estimated 35,000 gallons needed for daily operations.¹⁴⁶ The main farms supplying BDC are subsidiaries of poultry giant Perdue,¹⁴⁷ the fourth-largest chicken producer in the U.S.¹⁴⁸ Perdue Farms contracts with more than 260 farms in Delaware that produce and process 1.2 million pounds of poultry a week.¹⁴⁹ In 2019, BDC entered into a 20-year partnership with Perdue Farms to capture and manage organic material from Perdue's processing facilities and take over the former Perdue AgriRecycle Facility in Seaford, Delaware.¹⁵⁰

The proposed pipeline terminals, which will be housed within the new Seaford facility, provoked local concerns about increased environmental impacts, including traffic, diminished property values, and safety hazards, such as the potential for gas explosions.¹⁵¹ In the years before building pipelines to transport the biogas, BDC proposes using trucks to move gas from the Seaford digester through residential neighborhoods with homes, churches, schools, and school bus routes.¹⁵² Advocates estimate that approximately 70,000 truckloads would be required to transport waste in and gas and wastewater off the site each year.¹⁵³

The Seaford operation also poses serious environmental justice concerns, as Sussex residents living near the proposed facility and terminals are significantly more likely to be people of color and people of limited English proficiency.¹⁵⁴ In December 2022, advocates filed a Title VI environmental justice complaint with the U.S. Environmental Protection Agency on behalf of communities of color and people of limited English proficiency, alleging that the Delaware Department of Natural Resources and Environmental Control (DNREC) and Sussex County, Delaware, violated the public's rights to information and public participation when reviewing permits for BDC's factory farm gas and composting facility in Seaford, resulting in discrimination against the local community.¹⁵⁵ EPA accepted this complaint in September 2023, and as of the publication of this report, is still conducting its investigation.¹⁵⁶

Despite significant public outcry and the unresolved Title VI complaint, Delaware approved BDC's permits in September 2023.¹⁵⁷

Photo by © American Public Power Association



Beyond the harms from each of the stages of biogas production outlined above, it is important to remember that manure digesters do nothing to address many of the harms from factory farming to public health and safety, farmers and workers, and animals. They do nothing to curb the use of antibiotics administered to livestock, a driver of antibiotic resistance in humans. They do nothing to prevent the next pandemic from originating in a factory farm and spreading, a serious risk identified by the World Health Organization.¹⁵⁸ They do nothing to support farmers locked in unfair contracts or protect workers on farms and in slaughterhouses. They do nothing to minimize the suffering of the more than 9 billion animals raised for food in intolerably cruel conditions.

In the next section, we argue that the constellation of policies subsidizing and incentivizing factory farm gas create perverse incentives that entrench the underlying factory farming and fossil fuel systems, which are fundamentally unsustainable and incompatible with achieving environmental justice.

Investing in even more pipeline infrastructure runs counter to the indisputable need to move away from a fossil fuel-based energy system toward electrification that utilizes truly renewable sources of energy.



V. Policies rewarding factory farm gas production create perverse incentives

A famous anecdote describes a policy implemented by the British colonial government in Delhi designed to control the population of venomous cobras. The government offered a bounty for each cobra head, and as expected, residents responded by hunting cobras. When the cobra population appeared to fall off, bounties continued to be claimed at the same rate. Industrious snake catchers had figured out that they could breed cobras for profit.

If the government rewards the production of biogas with lucrative subsidies and incentives, CAFO operators and energy companies are likely to produce more biogas. The two key strategies to increase biogas production are to use manure management practices that generate more methane that can be captured and sold and to increase animal herd sizes, either by displacing animals from smaller farms, adding new animals, or both. Both strategies exacerbate environmental injustice, undermine the methane-reducing potential of digesters, and create an even more imbalanced playing field for small and sustainable livestock producers.

Incentivizing manure biogas creates a perverse incentive for emissions-maximizing manure management practices

Generally, dry manure management practices generate fewer methane emissions than wetter manure management practices on a continuum from pasture-based management producing the least methane to an uncovered anaerobic lagoon producing the most methane.¹⁵⁹ As the California Department of Food and Agriculture has noted based on a 2015 review of field-based dairy manure management studies, "... methane emissions can be dramatically reduced – perhaps by more than 90 percent – when dry systems are used (Owen and Silver, 2015)."¹⁶⁰ Anaerobic digesters are compatible only with wet systems. See Table 2 for a description of common manure management practices and their associated methane conversion factors, or the fraction of volatile solids converted to methane.



Table 2. Methane emissions from various manure management systems

Manure Management System ^a	Methane Conversion Factors ^b	Description
Lagoon	78%	A type of liquid storage system designed and operated to combine waste stabilization and storage. A lagoon is a lined, usually open, storage pit for manure. Recycled lagoon surface water is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.
Liquid Slurry	42%	Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods of less than one year.
Solid Storage	5%	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.
Drylot	1.5%	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.
Pasture/Range/Paddock	1.5%	The manure from pasture and range grazing animals is allowed to lie as deposited and is not managed.
Composting	0.5-1.0%	Composting is the biological oxidation of a solid waste including manure, usually with bedding or another organic carbon source typically at thermophilic temperatures produced by microbial heat production.
Digester	10%	Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO ₂ and CH ₄ which is captured and flared or used as a fuel.

- a. In many cases, an operation will manage some of its manure using one practice and some of its manure with another practice, so to calculate total methane emissions for an operation, the MCF is multiplied by the percentage of waste managed using that practice, the volatile solids produced per animal per day, the number of animals, and the methane production capacity of the manure.
- b. Methane conversion factors, the percentage of feed energy converted to methane, vary by temperature, and the MCF values in this table represent temperate climates around 20 degrees Celsius.

Source: Adapted from Tables 10.17 and 10.18 from *2006 IPCC Guidelines for National Greenhouse Gas Inventories*¹⁶¹

Policies that reward production of biogas based on the volume produced incentivize the manure management practices that create the most methane and, in effect, penalize producers for using methane-reducing manure management practices. This challenges the underlying assumption of biogas proponents that the methane emissions avoided through anaerobic digestion would have otherwise occurred. In fact, a rational producer may shift to manure management practices that *maximize* methane emissions to maximize profits from biogas production.

For example, a dairy that is composting manure, a dry management practice with low methane production, would be incentivized to instead collect manure as liquid that produces methane that can be captured by a digester and sold as biogas. Threemile Canyon, a mega-dairy in Oregon, used solid-liquid separation (SLS), a manure management practice that reduces methane emissions by partially removing organic and inorganic solids from manure. In fact, a 2019 study that modeled emissions from various manure management methods,

Incentivizing manure biogas creates a perverse incentive for increasing animal herd sizes

including anaerobic digestion, found that on its own, SLS “can achieve significant GHG emission reductions (38%) even greater than [anaerobic digestion] when using actual performance data from operating systems.”¹⁶² However, once Threemile began participating in California’s Low Carbon Fuel Standard Program, it stopped doing SLS before sending waste to the digester in order to maximize the methane emissions that could be captured and sold as credits under the program.¹⁶³ Some dairies, however, may opt to continue using SLS before digestion because it supports digester efficiency.¹⁶⁴

These perverse incentives are made especially clear in the case of poultry, which naturally produce dry litter that emits little methane. A policy focused on reducing methane emissions would have little to no impact on poultry manure management practices. However, because current policies are instead targeted at maximizing biogas production, poultry operators are starting to add thousands of gallons of water per ton of poultry litter manure¹⁶⁵ so that their litter does produce methane that can be captured through anaerobic digestion and sold. Even in a best-case scenario, this practice creates novel methane emissions from digester leakage while squandering vast quantities of water.

EPA, through its AgSTAR Program, actually encourages practices to maximize methane emissions from digesters such as using co-digestion and liquifying poultry litter to turn it into a viable digester feedstock.¹⁶⁶

An obvious way to produce more biogas from animal manure is to raise more animals. Those additional animals generate emissions from feed production and enteric fermentation that cannot be mitigated by digesters, which, depending on the original population of animals and the number of new animals added to the herd, can partially or fully offset the emissions reductions from manure management. Measuring this effect is challenging, but this section will present some of the evidence for this trend, and the following section includes a novel analysis we conducted that shows an increase in animal herd sizes associated with facilities with digesters relative to state population trends.

Aaron Smith, a professor of agricultural economics at University of California, Davis, published a popular blog post in 2021 entitled “What’s Worth More: A Cow’s Milk or its Poop?” that questioned whether the lucrative subsidies for manure biogas from California’s LCFS Program were incentivizing producers to increase their herd sizes.¹⁶⁷ He found that a California cow’s manure was worth about half as much as that cow’s milk. It is common sense that a significant (50%) increase in per-cow revenues would lead some producers to add more cows to their herds. In a 2023 update, Smith relays that California’s dairy herd sizes have in fact stayed constant since 2019.¹⁶⁸ However, it is possible that without the LCFS incentives, California dairy herd sizes would have decreased from 2019 to 2022, continuing the downward population trend in the state that began in 2007 and reducing methane emissions.¹⁶⁹ Also, Smith does not consider how California’s LCFS might have led to increased herd sizes in other states with dairies participating in the program.



Case Study: Iowa law spurs herd expansion



In 2021, Iowa passed a bill to allow animal feeding operations to exceed the state’s previously established confined livestock caps as long as producers install anaerobic digesters to treat all manure.¹⁷⁰ Shortly after passage, nine dairy farms applied to increase their herd sizes.¹⁷¹ As a result, the new law has allowed operations like Meadowvale Dairy, a CAFO with egregious and repeat Clean Water Act violations,¹⁷² to increase its herd size from just under 6,000 milking cows to a population of over 9,000 in 2022.¹⁷³

Incentivizing manure biogas contributes to consolidation and increases the competitive advantage for large-scale producers

Virtually every sector of the U.S. farm economy has experienced consolidation in the last several decades; a smaller number of farms are producing more food. The pace of consolidation in dairy far exceeds the pace of consolidation in most other sectors of U.S. agriculture.¹⁷⁹ In 1987, there were 146,685 dairy farms, half of which had herds of 80 or fewer. By 2017, only 54,599 dairy farms remained, and their average herd size was 1,300 cows.¹⁸⁰ As we noted in **Section II**, this consolidation concentrates power among agribusiness corporations and leads to unfair payment schemes for farmers, insufficient pay and inadequate protections for farm workers, and limited choices and higher prices for consumers.¹⁸¹ Recognizing this, the Biden administration has pledged to address consolidation, particularly in the meat and poultry sectors, to “create a fairer, more resilient, and more dynamic economy.”¹⁸²

While not among the strongest forces driving the trend toward consolidation, incentives for manure biogas can exacerbate consolidation and create an even more unfair playing field for producers.

Dairy and hog producers that do not aggregate manure in lagoons are fundamentally excluded from market opportunities to produce manure biogas, giving the CAFOs that they compete with a further competitive advantage. Even among farms that do collect waste in lagoons, economies of scale for biogas production disproportionately benefit the very largest producers.

In a 2022 paper commissioned by the Union of Concerned Scientists, Amin Younes and Dr. Kevin Fingerman find that dairies are incentivized to consolidate to take advantage of the economies of scale created by California’s LCFS program.¹⁸³ Modeling profits from LCFS for various-sized farms,ⁱⁱ they find that dairies with 100 or fewer cows cannot make any profits, dairies with 1,000 cows can make 24 cents per gallon of milk, and dairies with 15,000 cows can make 39 cents per gallon of milk. They conclude, “This creates clear

ii Using a Carbon Intensity score equal to the average of currently available manure-based bioelectricity pathways.

market distortions in favor of large, confined operations, which could exacerbate the already-present trend of market consolidation.” They also affirm in their analysis that under the LCFS program, dairies are incentivized to purchase more cows, independent of consolidation.

Modeling profits from the Low Carbon Fuel Standard for various-sized farms, Amin Younes and Dr. Kevin Fingerman find that dairies with 100 or fewer cows cannot make any profits, dairies with 1,000 cows can make 24 cents per gallon of milk, and dairies with 15,000 cows can make 39 cents per gallon of milk.



Industry statements acknowledge perverse incentives from manure biogas policies

The meat, dairy, and biogas industries have publicly acknowledged that incentives for producing manure biogas, such as California’s LCFS and EPA’s Renewable Fuel Standard, could distort the market. Here are some of their own statements, many of which were collected by Food & Water Watch:

- The general manager of Threemile Canyon mega-dairy in Oregon told the Statesman Journal, “The most valuable product that we have [at Threemile Canyon] is natural gas.”¹⁷⁴
- “We used to joke about how funny it would be if we could make more money off the poop than the milk,” [California mega-dairy Bar 20’s] Steve Sheheady said. “And now we’re essentially here.”¹⁷⁵
- A principal at a global agribusiness consulting firm noting that cow manure may be worth more than milk in the future – “[s]o, there is a gold rush to install this kind of technology on large-scale dairy farms” in order to profit off the programs such as the EPA’s Renewable Fuel Standard or California’s LCFS.¹⁷⁶
- The president of Calgren Renewable Fuels in Pixley, California, explaining how to generate the most credits under LCFS: “The cow’s manure is washed down in a wet manure management system. That generates the biggest credit for us.”¹⁷⁷
- The executive director of Dairy Cares, a lobbying group for the California dairy industry: “Dairy biogas is way too expensive ... It doesn’t pencil out and it doesn’t make all that much sense from an environmental standpoint. It’s a pipe dream.”¹⁷⁸

Public funding for manure digesters crowds out funding for truly effective conservation practices

Because digesters and other infrastructure to produce manure biogas (e.g., lagoon covers) are so expensive to construct, grants and loans covering their capital costs eat up a considerable portion of the budget for several USDA conservation programs, which are consistently overdrawn. For example, while roughly three in four farmers were turned away from USDA's Environmental Quality Incentives Program in 2022, the program spent more than \$128 million on practices associated with CAFOs, including \$2 million on subsidizing just seven anaerobic digesters, the single-costliest practice eligible for the program.¹⁸⁴ That \$2 million could have instead helped 238 farmers plant cover crops, according to a 2023 report from the Institute for Agriculture and Trade Policy.¹⁸⁵ This further tilts the playing field in favor of CAFO operators at the expense of small-scale and sustainable producers wishing to implement effective conservation practices.

Because digesters and other infrastructure to produce manure biogas (e.g., lagoon covers) are so expensive to construct, grants and loans covering their capital costs eat up a considerable portion of the budget for several USDA conservation programs, which are consistently overdrawn.

In this section, we have made the case that policies rewarding biogas production create three perverse incentives for CAFO operators and biogas producers: 1) to utilize inferior manure management practices that maximize methane production, 2) to increase herd sizes to maximize manure production, and 3) to

increase consolidation to take advantage of the economies of scale inherent in biogas production. Each of these trends will exacerbate the environmental and public health harms associated with CAFOs detailed in **Section III** and the harms from various stages of manure biogas production outlined in **Section IV**. Further, these trends contribute to a competitive disadvantage to small-scale and pasture-based livestock producers. The perverse incentives to utilize emissions-maximizing manure management practices and increase herd sizes also undermine manure biogas's key selling point – that it will significantly reduce methane emissions. The following section presents additional evidence that methane reductions from manure biogas are overstated and inadequately tracked and that increasing manure biogas production is an ineffective climate strategy, especially compared to proven, more cost-effective strategies that do not undermine environmental justice.



VI. The methane reduction benefits of manure biogas are overstated, inadequately tracked, and insufficient to meet climate targets

Manure biogas should be rejected as a climate strategy on the basis that it fails to address most harms from CAFOs, deepens our investment in the current harmful models of industrial agriculture and fossil fuel energy, and creates pollution and public safety risks for neighboring communities. On top of that, the methane reduction potential from manure biogas systems has been substantially overstated by the U.S. government, is insufficiently tracked and studied, and falls far short of the ambition needed to meet President Biden's commitment to the Global Climate Pledge. We provide evidence from existing research, as well as our own original research, and we offer alternative methane reduction solutions that are more cost-effective and conducive to environmental justice.

Overall Key Findings:

Methane reductions from CAFOs with digesters are likely overstated by EPA and biogas proponents because of 1) a failure to account for emissions driven by increasing herd sizes and 2) an assumption that the baseline from which methane reductions are measured is the most methane-generating manure management practice. Despite the extensive public investments in digesters, there is a shocking lack of emissions monitoring and tracking, and independent research contradicts government and industry methane estimates from CAFOs with digesters. However, even the overstated reductions from digesters will fail to reduce agricultural methane emissions in alignment with President Biden's commitment to the Global Methane Pledge. In contrast, we estimate

that gradually reducing herd sizes as part of a just transition and implementing alternative manure management practices across large dairies could generate more than half of the methane reductions needed to meet the Global Methane Pledge target.

President Biden's Methane Reduction Action Plan aspires to reduce agricultural methane emissions by only 9%

In November 2021, after signing the Global Methane Pledge, President Biden released a Methane Reduction Action Plan laying out the administration's strategies to meet this target.¹⁸⁶ While the Plan acknowledges that agriculture is the largest source of U.S. methane emissions, the only agricultural strategies it proposes are entirely voluntary and largely focused on manure management technologies, like anaerobic digesters. The Plan states that "the Administration has proposed funding that, cumulatively, would enable methane emissions reductions from manure, rice, and enteric sources by as much as 26 million metric tons [in CO₂e] in 2030" and that "reducing methane emissions from manure management systems at these levels is the equivalent of 500 farms installing anaerobic digesters; 1,200 farms installing lagoon covers with flares; and 250 farms installing solids separators." The Plan does not offer a source for its calculations.

Even if these efforts are successful, reducing agricultural methane emissions by 26 MMT CO₂e in 2030 would amount to only a 9%

reductionⁱⁱⁱ in agricultural methane emissions when the Global Methane Pledge calls for a 30% combined reduction across all sectors. Because agriculture is the largest source of methane emissions, other sectors would need to reduce methane emissions by 43% to achieve the 30% reduction that the administration has committed to make.^{iv} The Plan does not offer a pathway for these steep reductions. A modeled pathway to the 30% reduction target developed by the Center for Global Sustainability at the University of Maryland does include strategies to achieve dramatic reductions in methane from oil and gas and from waste, but its “all-in” pathway would require ambitious state and federal policies yet to be enacted.¹⁸⁷

In other words, even without the evidence we present in the following subsections that these methane reduction benefits from digesters are overstated, the Biden administration’s plan for reducing agricultural emissions does not come close to the level of ambition needed to meet the Global Methane Pledge.

Existing research demonstrates GHG emissions reductions from manure biogas are overstated

There are several pieces of evidence that emissions reductions from manure biogas are overstated by the U.S. government. For example, the process of anaerobic digestion can also increase emissions of nitrous oxide,¹⁸⁸ a greenhouse gas that is 265 times as potent as carbon dioxide on a 100-year timescale,¹⁸⁹ partially offsetting methane emissions reductions. Importantly, changes in nitrous oxide emissions are not included in EPA’s methodology for calculating changes in greenhouse gas emissions resulting from anaerobic digestion.¹⁹⁰

iii The Action Plan estimates a reduction of 26 MMT CO₂e from the included agriculture strategies. Total methane emissions from agriculture in 2020 equaled 281 MMT CO₂e according to EPA’s Greenhouse Gas Emissions Inventory. $26 \text{ MMT CO}_2\text{e} / 281 \text{ MMT CO}_2\text{e} = 9\%$.

iv $30\% \text{ of } 742.2 \text{ MMT CO}_2\text{e} \text{ (total 2020 methane emissions per EPA’s Greenhouse Gas Emissions Inventory)} = 222.66 \text{ MMT CO}_2\text{e}$. Subtracting 26 MMT CO₂e from agriculture leaves 196.66 MMT CO₂e that must come from sources other than agriculture ($461.2 \text{ MMT CO}_2\text{e}$ according to EPA’s emissions inventory). $196.66 / 461.2 = 43\%$.

Remote sensing technologies have also cast doubt on the efficacy of digesters in reducing methane emissions. For example, a 2023 paper published in *Atmospheric Environment* estimated methane emissions from dairy CAFOs in California using mobile optical remote sensing and found that facilities with covered lagoons presumed to have digesters did not emit significantly less methane per animal than facilities with uncovered lagoons and no digesters.¹⁹¹ Across all CAFOs in the study, measured CH₄ emissions were 60% higher than the rates reported in the California Air Resources Board (CARB) inventory.¹⁹²

There is also evidence that biogas supply chains leak significantly more than EPA has estimated.¹⁹³ Research has shown that in some cases, leakage alone could mean that factory farm gas would “provide minimal to zero climate benefits.”¹⁹⁴

Finally, digesters are complex and expensive to operate, which has contributed to many digesters shutting down. Of the 441 once-operational digesters that EPA has tracked in its Livestock Anaerobic Digester Database, 98 (or 22%) have since shut down.¹⁹⁵ Taxpayer investments in digesters are especially unappealing considering that digesters have nearly a 1-in-4 chance of shuttering.

A 2023 paper published in Atmospheric Environment estimated methane emissions from dairy-concentrated animal feeding operations in California using mobile optical remote sensing and found that facilities with covered lagoons presumed to have digesters did not emit significantly less methane per animal than facilities with uncovered lagoons and no digesters.



Photo by © SRAP

Our original research demonstrates GHG emissions reductions from manure biogas are overstated and insufficiently tracked

Our original research sought to model actual emissions changes from CAFOs with operational digesters considering the perverse incentives to increase herd sizes and utilize inferior manure management practices described in **Section V** and to model methane reductions from hypothetical alternative strategies, including decreasing herd sizes and implementing feasible alternative manure management practices.

Methodology

We obtained a list of manure digester projects from the U.S. EPA AgSTAR Livestock Anaerobic Digester Database, which, at the time of our analysis in October 2022, included data available through May 2022. We limited our analysis to digester projects that were listed as operational, began operating in 2017 or earlier,^v and were designated as large CAFOs.^{vi} In order to assess changes in herd sizes over time, we reviewed National Pollution Discharge Elimination System (NPDES) permits issued by states to facilities in the AgSTAR database that met the criteria

above. We obtained permit information only from states that made this information available online,^{vii} and we excluded facilities that did not have an NPDES permit issued in 2020 or later. Our dataset included 77 facilities, including 73 dairies, two swine operations, and two cattle operations, across nine states. Given the small number of non-dairy facilities, we chose to limit our analysis to the 73 dairy facilities across eight states.

We calculated year-over-year herd size changes at dairies with digesters by comparing the total animal units listed in the AgSTAR database at project start dates (which, for our dataset, ranged from 1999 to 2017) with livestock numbers listed in the most recent available state NPDES permits for each facility. We compared facility herd size changes to changes in the statewide animal population over the same time periods.

Then we modeled changes in methane emissions for each dairy facility using different sets of assumptions about the baselines from which methane reductions were calculated and about employing other methane-reducing strategies, namely alternative manure management practices and decreasing herd sizes. Table 3 describes the three scenarios we modeled.

v We chose to assess digesters that had been in operation for more than four years in order to capture longer-term herd size trends.

vi We limited our analysis to facilities designated as Large CAFOs because they should be required to obtain NPDES permits, which are what we used to assess changes in herd size.

vii Note: Idaho also makes NPDES permit data available online, but we were unable to use any Idaho permit data, because all facility permits were issued either the same year as, or prior to, the AgSTAR project start dates.

Table 3. Methane modeling scenarios for CAFOs in our dataset

	Baseline (AgSTAR year) Manure Management	Post (NPDES year) Manure Management	Post (NPDES year) Herd Size	Description
Scenario 1	Uncovered Lagoon: 95% Solid Storage: 5%	Digester: 95% Solid Storage: 5%	No change in herd size.	The baseline from which we measure emission reductions from the digester is the most methane-generating manure management scenario where the facility would have stored 95% of its manure in an uncovered lagoon and 5% in solid storage. This scenario assumes facilities experienced no changes in herd size. This mirrors the assumptions EPA uses in estimating methane reductions from facilities using digesters.
Scenario 2	Uncovered Lagoon: 45% Composting: 50% Solid Storage: 5%	Digester: 45% Composting: 50% Solid Storage: 5%	Actual measured herd size change.	The baseline from which we measure emission reductions from the digester includes a feasible alternative manure management scenario where 50% of the facility's manure was composted, 45% was stored in an uncovered lagoon, and 5% was solid storage.
Scenario 3	Uncovered Lagoon: 95% Solid Storage: 5%	Uncovered Lagoon: 45% Composting: 50% Solid Storage: 5%	20% hypothetical reduction in herd size.	No digester was installed, herd sizes decreased by 20% on average, and farms moved from a baseline of 95% lagoon/5% solid storage to implementing alternative manure management practices (50% composting/45% lagoon/5% solid storage).



We estimated methane emissions per animal from manure management and enteric fermentation using a model that relied on the calculations and default values provided in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, described in greater detail in **Appendix B**.

We also assessed how these reductions stack up against the level of ambition needed to meet the Global Methane Pledge target of a 30% reduction in methane emissions from 2020 levels by 2030, with the assumptions utilized under each scenario. We projected the modeled methane reductions per dairy facility that we calculated from our data set using Scenarios 1 and 2 (the digester scenarios) onto the 500 facilities that the Biden administration has indicated it hopes will install digesters, and we projected the modeled methane reductions from Scenario 3 (the non-digester scenario) onto 1,500^{viii} similarly sized dairy farms.

Finally, we compared the cost of mitigating one ton of CO₂e from a dairy operation by subsidizing a digester with the cost of mitigating the same emissions by providing a per-cow payout equal to the average net return of a dairy cow over the last 20 years.

A more detailed methodology and discussion of assumptions and limitations can be found in **Appendix B**.



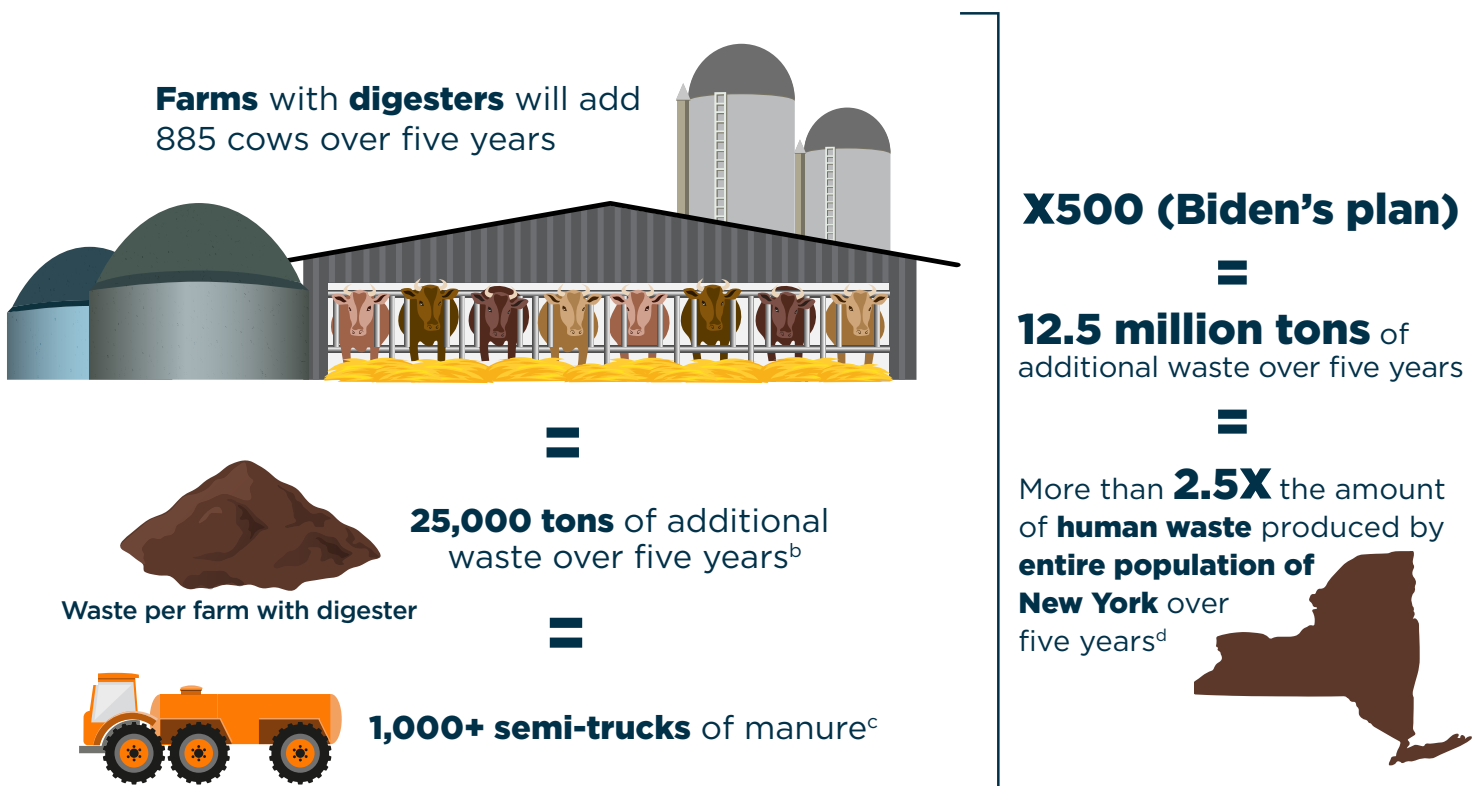
viii 1,500 was selected as a subset of the number of large (>1,000 cows) dairy farms in the U.S., which totaled 1,953 in the 2017 Census of Agriculture. As discussed in Appendix B, information about the actual manure management practices at large dairies was unavailable, so this assumes that the 1,500 dairies are utilizing lagoon manure management as their baseline manure management strategy, which is common according to the EPA.

Key Findings

1 Herd sizes at facilities with digesters grew 3.7% year-over-year, 24 times the growth rate for overall dairy herd sizes in the states covered by our dataset. Overall, the dairies in our dataset added nearly 85,000 dairy cows total between the year they installed a digester until the most recent year for which data was available. As shown in Figure 1, if

these dairy populations continue to grow at their historical rates, each farm will add 177 cows per year on average to their herds. While these results do not prove a causal link between digesters and herd sizes, this finding supports the notion that digesters – in combination with policies that reward biogas production – incentivize increased herd sizes.

Figure 1: Herd size growth in dairies with digesters will generate massive volumes of waste



a. On average, dairy cows produce 156 lb. of waste per day. Natural Resources Conservation Service. (n.d.). Agricultural Waste Management Field Handbook. U.S. Department of Agriculture. <https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=31475.wba>

b. 177 cows x 156 lbs. waste per day x 365 days = 10 million lbs. of waste per year. 10 million lbs. x 5 = 50 million lbs.

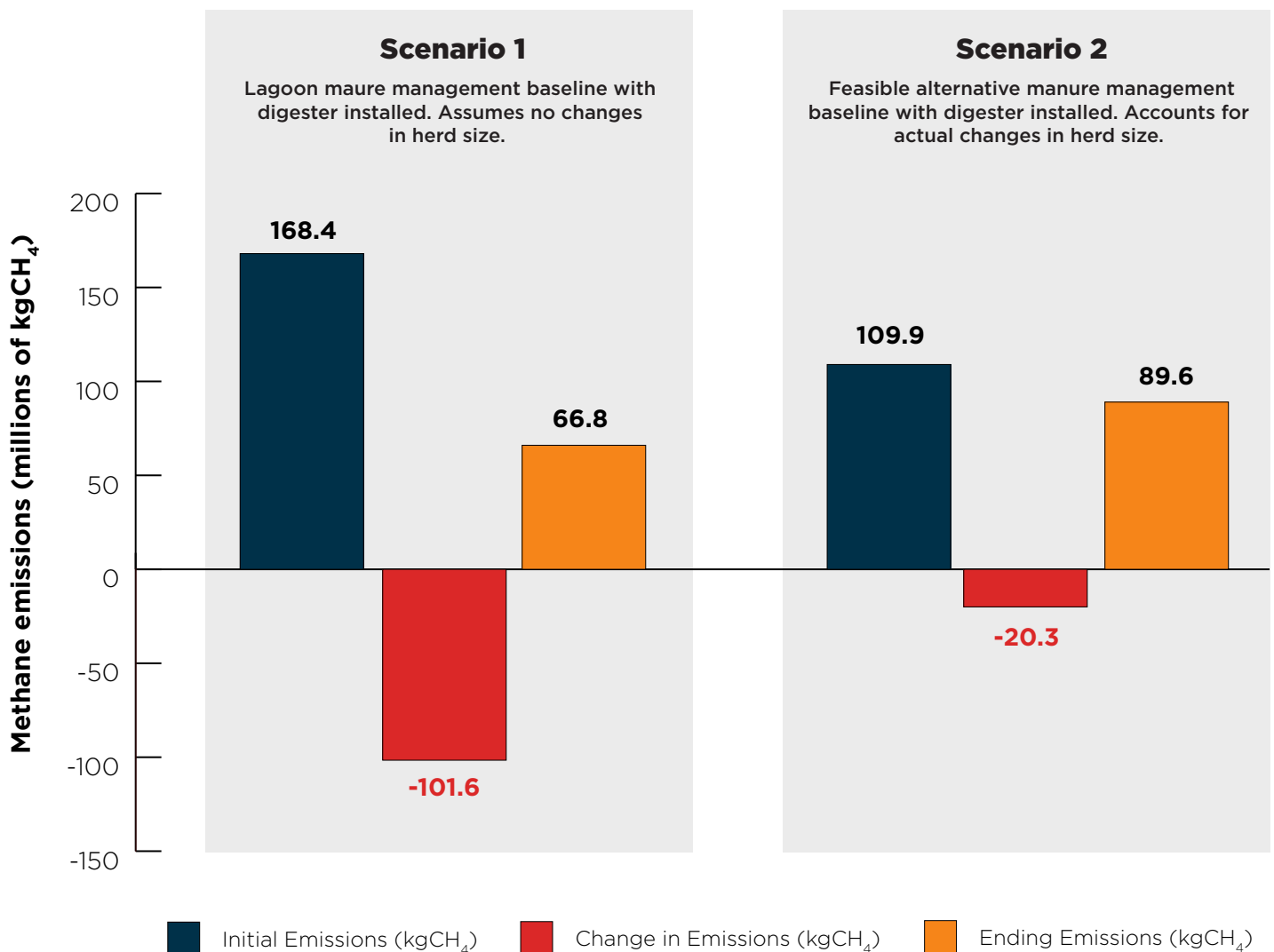
c. Tarradell, M. (2020, June 22). A Guide to Truck Weight, Classification, and Uses. TCS Fuel. <https://www.tcsfuel.com/blog/truck-weight-classification/>

d. The average human produces around 103 pounds or .05 tons of waste per year. Rose, C., Parker, A., Jefferson, B., & Cartmell, E. (2015). The Characterization of Feces and Urine: A Review of the Literature to Inform Advanced Treatment Technology. *Critical Reviews in Environmental Science and Technology*, 45(17), 1827-1879. <https://doi.org/10.1080/10643389.2014.1000761>. The population of New York is - 20,000,000. U.S. Census Bureau QuickFacts: New York. (n.d.). Retrieved March 11, 2024, from <https://www.census.gov/quickfacts/fact/table/NY/PST045223>. 20,000,000 people x .05 tons = 1,000,000 tons human waste.

2 Accounting for these herd size changes and measuring the emissions reductions from a baseline of feasible alternative manure management strategies, the dairy CAFOs in our dataset reduced their annual methane emissions by only 11% from the baseline year to the most recent year for which herd size data is available (Scenario 2). This is nearly six times less than the reductions

estimated using EPA's assumptions that there were no changes in herd sizes and that if these facilities did not have digesters, they would be utilizing the most methane-generating manure management strategy of a lagoon (Scenario 1). Figure 2 shows the results of these two modeled scenarios for the 73 dairies in our dataset.

Figure 2: Dairy methane emissions reductions are sensitive to assumptions about herd sizes and baseline manure management practices



3 Installing dairy digesters will fall far short of the ambition needed to reduce agricultural methane emissions in line with the Global Methane Pledge.

As shown in Figure 3, assuming 500^{xiii} new dairy digesters were installed by 2030 and those digesters yielded emissions reductions comparable to those in our dataset, their associated methane emissions reductions would account for less than a quarter of the reductions needed to reduce agricultural methane emissions by 30%.

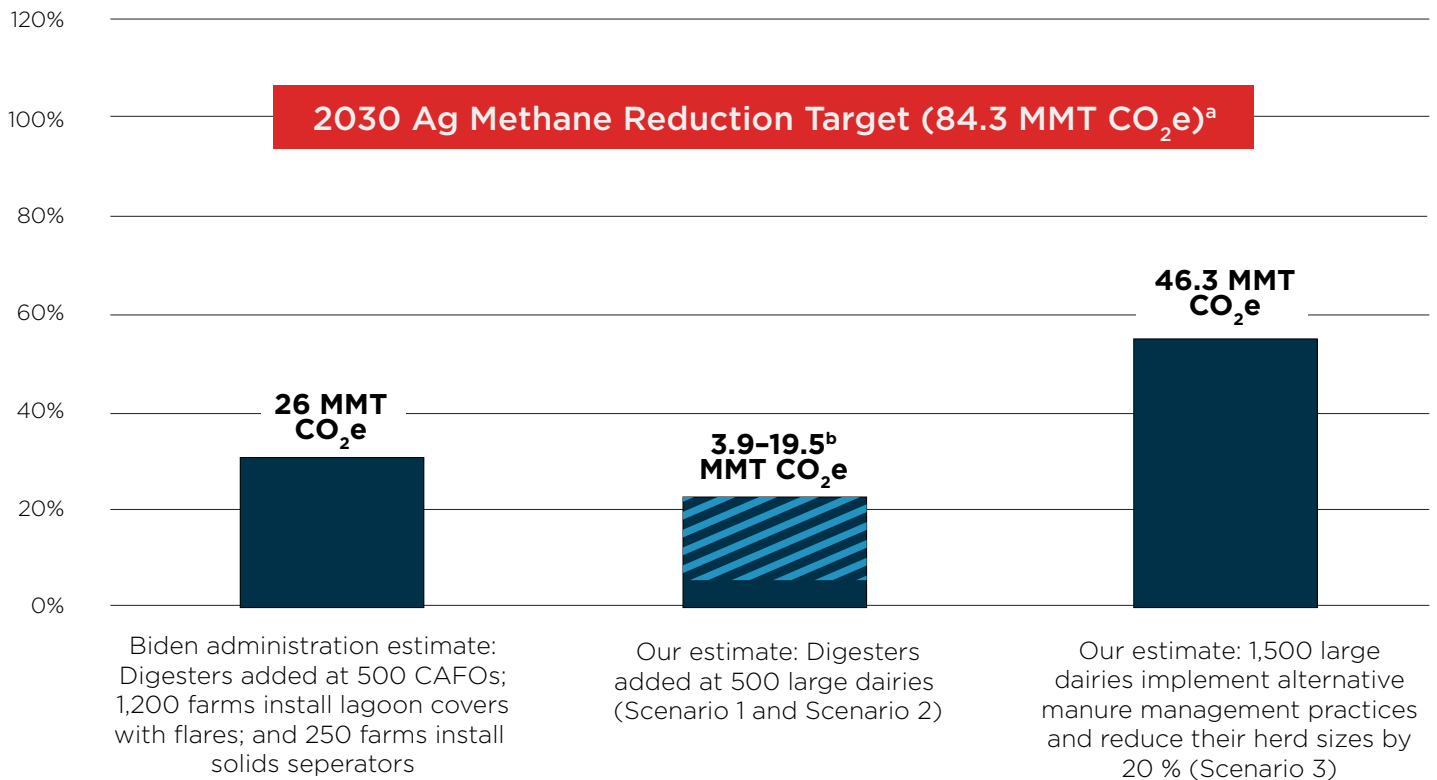
4 Reducing dairy herd sizes by 20% and implementing feasible alternative manure management strategies on 1,500 large dairies could yield 55% of the reductions needed to slash U.S. agricultural methane emissions by 30% by 2030.

The non-digester scenario that we modeled (Scenario 3) yielded a 48% reduction in emissions from the CAFOs in our dataset. Crucially, this scenario can be applied to a large number of dairies – not just those for which installing a digester is economically feasible. Reducing herd sizes by 20% and implementing feasible alternative manure management scenarios on 1,500 large dairies would yield 55% of the reductions needed to reduce agricultural methane emissions by 30% in 2030. This outcome could be achieved through a variety of policies, including a CAFO moratorium and buyout as envisaged by the Farm System Reform Act,¹⁹⁶ capping herd sizes for the largest dairies, requiring or incentivizing alternative manure management strategies, or setting limits on methane emissions or other pollution at dairies. In summary, to reduce dairy methane emissions and other pollution, the most effective intervention is to reduce the number of cows raised on dairies using a lagoon system, the most methane-intensive and environmentally damaging manure management strategy. The full results from this analysis are summarized in Figure 3.



xiii President Biden’s Methane Reduction Action Plan loosely calls for installing 500 digesters, which is why we used 500 in our model.

Figure 3: Methane emissions reductions from reducing herd sizes by 20% and implementing alternative manure management practices exceed those from digester strategies.



- a. This assumes proportional reductions from each sector to achieve a 30% reduction in methane emissions by 2030 from 2020 levels. Methane emissions from agriculture in 2020 equaled 281 MMT, so a reduction of 84.3 MMT in 2030 would be needed.
- b. The shaded portion indicates the difference between our high-end estimate assuming no changes in herd size and a baseline lagoon manure management strategy (Scenario 1) and our low-end estimate accounting for actual changes in herd size and assuming a baseline of alternative manure management strategies (Scenario 2).



While a cost-benefit analysis of policies to reduce dairy methane emissions is beyond the scope of our research, simply paying dairy producers to reduce their herd sizes would be nearly three times more cost-effective than subsidizing methane digesters without the harms of biogas documented in this report. Paying dairy farmers to decrease their herd sizes or transition to farming a less GHG-intensive agricultural product altogether would be less expensive than subsidizing digesters without undermining President Biden’s environmental justice goals – and it could make dairy farming more profitable for producers.

According to USDA’s Economic Research Service, dairy farms with 1,000 head or more generated an average net return of only \$1.12 per hundredweight between 2005 and 2018, which is about \$260 per cow.^{xiv} Aaron Smith calculated that a digester costs around \$636 per cow per year for a 2,000-head operation (and produces only \$68 worth of energy).^{xv} CARB calculated the cost of mitigating one metric ton of CO₂e by installing digesters through its Dairy Digester Research and Development Program at \$29 (including \$9 of taxpayer investments and \$20 of private investments).^{197,xvi} A 2023 study in *Atmosphere* calculated mitigation cost of digesters at a range of \$39 to \$69 per metric ton of CO₂e for large (>2,000 head) dairies.^{198,xvii} If the government paid producers to reduce their herd sizes through a per-cow payout equal to the average net return per cow over the last ~20 years, the cost of mitigating one metric ton of CO₂e would be less than \$10 total.^{xviii}

xiv Calculated as follows: 23,150 pounds of milk per cow in 2018 per USDA NASS data / 100 (cwt) = 2,315 * \$1.12 = \$260

xv This includes initial capital costs of \$4.8M amortized over 10 years at a 7% discount rate and ongoing costs of \$588,000 per year to operate the digester.

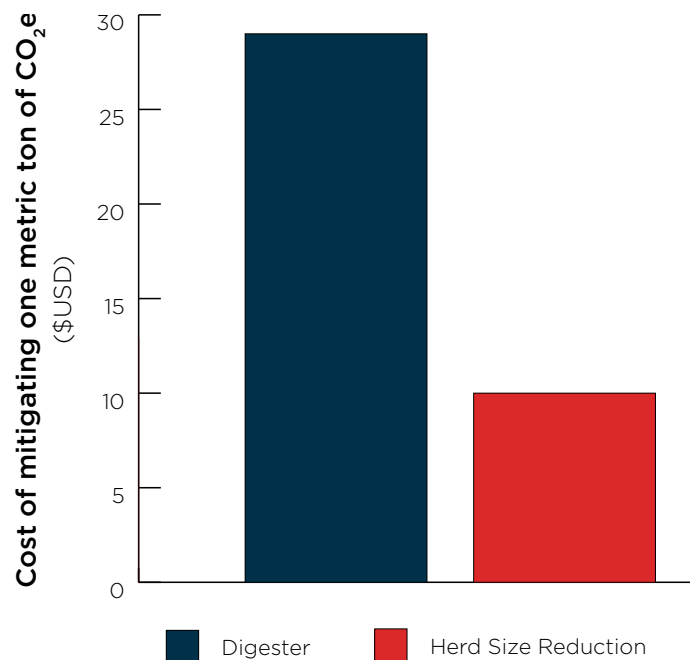
xvi This figure excludes ongoing costs to operate the digester, which are typically not covered by subsidies.

xvii The same study estimated the mitigation costs associated with a variety of alternative manure management practices on large dairies, which ranged from \$36/per metric ton of CO₂e mitigated to \$229/per metric ton of CO₂e mitigated.

xviii 10,500 liters of milk produced per cow * 2.5 kg CO₂e per liter from Poore & Nemecek (2018) = 26,250 kg CO₂e = 26.25 metric tons CO₂e.

Figure 3 compares CARB’s lower calculation of the cost of mitigation of one metric ton of CO₂e using a digester with the mitigation cost we calculated to pay farmers to reduce their herd sizes.

Figure 4. Paying farmers to reduce their dairy herd sizes is a more cost-effective dairy methane reduction strategy than subsidizing manure digesters



Paying farmers to reduce herd sizes or transition to another type of farming would also make dairy farming more profitable for the farmers who remain in the sector because profits are currently suppressed by low prices, driven by an oversupply relative to demand.¹⁹⁹ It could also reduce the costs to taxpayers associated with current dairy subsidies; in 2021, USDA paid out over \$1.2 billion through the Dairy Margin Coverage program.²⁰⁰

Also, unlike installing digesters, a gradual decrease in animal herd sizes – coupled with sufficient regulatory oversight and enforcement – would support the goals of environmental justice by reducing pollution for neighboring communities.

5 Data collection and disclosure from CAFOs with digesters is wholly insufficient to accurately measure methane emissions.

The strength of our analysis is admittedly limited due to suboptimal data quality and limited data pertaining to herd sizes and manure management practices and no data on actual methane emissions gathered through facility-level monitoring, all of which is connected to the lack of regulation and oversight of CAFOs discussed in **Section II**. For example, the AgSTAR database relies on voluntary reporting and publicly available information such as news articles and press releases to determine animal herd sizes at the time digesters became operational. Given the massive amount of public federal funding dedicated to subsidizing manure biogas outlined in **Section III**, it is astonishing that neither EPA nor USDA is directly monitoring methane emissions from livestock operations or even collecting basic information such as animal populations necessary to understand whether these investments are resulting in actual GHG reductions.

More detailed results and a discussion on data limitations are offered in **Appendix B**.



VII. Policy Recommendations

Overarching policy recommendation:

Redirect resources currently supporting manure biogas (i.e., grants and loans for digesters, technical assistance, tax credits, and incentives for biogas production) to more cost-effective methane reduction solutions (outlined in greater detail below) that do not exacerbate environmental injustice and industry consolidation. Instead, policies should support a just transition away from factory farming to regenerative agriculture, and away from fossil fuels to truly renewable energy.

Additional policy recommendations:

- 1 Do not create new funding streams or other policy incentives for factory farm gas.** At a minimum, federal and state governments should not add to the windfall of funding and incentives already available to support manure biogas detailed in **Section III** of this report.
- 2 Prevent double-dipping between subsidies, tax incentives, and programs like the Renewable Fuel Standard and California's Low Carbon Fuel Standard. Related, ensure GHG reductions attributed to manure biogas are not double-counted.** The ability of biogas developers to stack federal and state funding and incentives to support biogas production has created a manure gold rush and exacerbated the perverse incentives discussed in **Section IV**. Double-counting the benefits across these programs (i.e., attributing the same GHG reductions to more than one policy) has inflated the impacts of each program.

- 3 Set a specific methane reduction target and pathway for the agricultural sector aligned with the Global Methane Pledge.** To fulfill the U.S.'s obligation under the Global Methane Pledge to reduce global methane emissions by at least 30% from 2020 levels by 2030, the Biden administration should establish a methane reduction goal and detailed, evidence-based reduction strategies specific to the agriculture sector in line with that ambition. As discussed in **Section V**, its current proposed strategy would reduce methane emissions by only 9% in 2030 in a best-case scenario. States should also set their own goals for reducing methane emissions from agriculture and develop plans and policies to achieve those reductions.



4 **Require and improve methane monitoring and reporting from livestock operations.**

For more than a decade, Congress has prevented EPA from requiring reporting of GHG emissions from manure management through an Appropriations rider. Measuring and publicly disclosing GHG emissions from CAFOs is a critical and obvious first step to managing these emissions. EPA should also fund technological innovation to improve methane monitoring from livestock facilities, without which we cannot accurately assess the efficacy of agricultural methane reduction interventions.

5 **Pursue agricultural methane reduction strategies that support environmental justice and fair markets for producers:**

- Methane emissions from industrial livestock facilities should be **monitored, publicly disclosed, and regulated** in a way similar to how the administration has approached regulating methane emissions from the oil and gas sector. Policies should be targeted toward reducing methane emissions from agriculture, not toward maximizing biogas production. For example, EPA could grant a petition asking it to list and regulate industrial animal agriculture operations as stationary sources of methane under Section 111 of the Clean Air Act.²⁰¹
- **Leverage procurement** to shift federal purchasing and foodservice toward plant-forward menus, which have drastically lower embedded methane emissions. A recent report found that methane emissions from one year of direct federal food purchasing equaled 5.8 million metric tons of methane emissions (in CO₂e).²⁰² Cutting those in half by replacing some beef, pork, and cheese purchases with plant-based sources of protein would eliminate 17.3 million metric tons of methane in CO₂e between 2025 and 2030 and save food costs.
- **Prioritize funding for pasture-based and smaller-scale integrated livestock production** in USDA conservation programs such as EQIP and REAP. Insofar as USDA's conservation programs

continue to fund CAFOs, grants and loans should be restricted to cost-effective alternative manure management practices that support environmental justice goals.

- Implement policies such as the Farm System Reform Act²⁰³ that **support a just transition to pastured animal production and plant-based food production**, including placing a moratorium on large factory farms and providing voluntary buyouts for farmers who want to transition away from operating a CAFO.
- **Reduce food waste.** Landfills accounted for 15% of U.S. methane emissions in 2019, and EPA estimates that food waste constitutes 24% of materials in landfills. The food waste reduction organization, ReFED, recommends policies and programs that “target food waste prevention at the source” and has modeled pathways to reduce food waste by 50% by 2030.²⁰⁴



6 Regulate waste from both CAFOs and digesters, including treatment and application of digestate. As discussed in **Sections II** and **IV**, CAFOs and digesters are not subject to sufficient oversight and should be comprehensively regulated under the Clean Air Act, Clean Water Act, and state environmental laws. Enforcement of the minimal current requirements must be strengthened.

7 Require disclosure of basic data from CAFOs and digester operators, and fund and conduct research to assess the impacts of manure biogas policies on methane emissions, industry consolidation, and rural communities. As we discussed, the research we presented in **Section VI** provides initial evidence for the incentive to increase herd sizes to maximize manure biogas production and for the overestimating of GHG reductions from digesters, but further research utilizing more-reliable data is needed. Congress, EPA, and USDA should prioritize further research to explore these trends, including by requiring the disclosure of basic information from CAFOs and digester operators, including facility locations, herd sizes, and manure management strategies and by directly monitoring air and water pollution from CAFOs with and without digesters.

8 In instances where public funds have already been designated to support manure biogas, grants and loans should include conditions and exclusions to mitigate public health and environmental harms and increase transparency. Unfortunately, as we laid out in **Section III**, a significant amount of public money has already been directed toward subsidizing manure biogas production. To increase transparency and mitigate harms to communities from the myriad public health and environmental risks associated both with CAFOs and manure biogas, federal grants and loans should exclude the most harmful projects and place conditions on all projects. For example, operations with a history of environmental or worker safety violations or operations that cannot demonstrate sufficient acreage of farmland available to apply digestate should be ineligible for grants and loans. All applicants should be required to provide an Environmental Justice and Community Impact Assessment conducted by an approved third party to assess cumulative impacts of producing manure biogas. Recipients of grants and loans should be prohibited from expanding their herd sizes and required to use best available technologies and management practices to limit pollution. Adherence to conditions must be ensured through robust enforcement.



VIII. Conclusion

Solar energy is renewable because the sun will keep shining, and wind energy is renewable because wind will keep blowing. Manure biogas can be considered renewable only if we accept that factory farms will keep spewing pollution into rural communities, fueling the climate crisis with emissions from animal feed and enteric fermentation, and raising billions of animals in intolerably cruel conditions that risk public health year after year. We should not accept that. Instead, we should implement policies that support a just transition away from factory farming to regenerative agriculture and away from fossil fuels to truly renewable energy.

In 2021, when President Biden signed his major executive order to tackle the climate crisis, he vowed that “it’s not time for small measures; we need to be bold.”²⁰⁵ Two months later, he issued an executive order that pledged to “strengthen [the federal government’s] commitment to deliver environmental justice to all communities across America.”²⁰⁶ Finally, three months after

that, President Biden signed an executive order pledging to enhance competition in the American economy, including by addressing industry consolidation in the livestock sector.²⁰⁷

This administration’s support for manure biogas undermines each of these commitments. As this report lays out, there are harmful, unintended consequences to incentivizing factory farm gas that will not only impair the United States from fulfilling its climate goals but will also make it impossible to achieve environmental justice for communities impacted by CAFO pollution and make the playing field even more unfair for small and pasture-based meat and dairy producers.

Federal and state governments must prioritize solutions that take bold actions to reduce emissions, center the communities harmed by factory farm pollution, and support a just transition to the healthy, fair, and sustainable food system we desperately need.



Appendix A: Federal programs supporting manure biogas

Program Name	Department / Agency	Type of Support	Eligible Use of Funds
Federal Renewable Fuel Standard (RFS)	Environmental Protection Agency	Access to markets & revenue	The RFS is a policy that requires transportation fuels sold in the United States to contain a minimum amount of renewable fuel. Renewable fuel includes biomass-based diesel, cellulosic biofuel, advanced biofuel, and total renewable fuel.
Environmental Quality Incentives Program (EQIP)	U.S. Department of Agriculture Natural Resources Conservation Service	Cost-share & technical assistance	NRCS provides agricultural producers with technical help and financial assistance to plan and implement environmental improvements, also known as conservation practices. Relevant conservation practices that can be funded include installing anaerobic methane digesters and upgrading existing anaerobic lagoons by installing covers and collecting methane.
Value-Added Producer Grants (VAPG)	U.S. Department of Agriculture Rural Development	Grants	Grants are provided to help agricultural producers enter value-added activities related to the processing and/or marketing of bio-based, value-added products. There is an anaerobic digestion-specific portion of this grant.
Regional Conservation Partnerships Program (RCPP)	U.S. Department of Agriculture Natural Resources Conservation Service	Grants	NRCS co-invests with partners to implement projects that address conservation challenges. Anaerobic digesters can sometimes be included in the program depending on state policies year-to-year.
Conservation Innovation Grants (CIG)	U.S. Department of Agriculture Natural Resources Conservation Service	Grants	Grants are provided to support the development of innovative new tools, approaches, practices, and technologies to further natural resource conservation on private lands. Projects improve agricultural operations while addressing water quality, air quality, soil health, and/or wildlife habitat challenges.
Payments for Specified Energy Property in Lieu of Tax Credits (Federal 1603 Program)	U.S. Treasury Department Internal Revenue Service	Grants	Grants are provided to reimburse businesses for a portion of the cost of installing certain energy projects, including anaerobic digesters on farms.

Climate Pollution Reduction Grants	Environmental Protection Agency	Grants	Grants are provided to states, local governments, tribes, and territories to develop and implement plans for reducing greenhouse gas emissions and other harmful air pollution. Eligible implementable measures include anaerobic digestion projects.
Greenhouse Gas Reduction Fund (GGRF)	Environmental Protection Agency	Grants	The program is implemented via three grant competitions, two of which provide financing and technical assistance for clean technology projects, including anaerobic digestion.
Biomass Research and Development Initiative	Department of Energy/ U.S. Department of Agriculture	Grants	Grants are provided for projects addressing research, development, and demonstration of biofuels and bio-based products and the methods, practices, and technologies for their production.
Carbon Utilization and Biogas Education Program	Department of Energy	Grants	Grants are provided to state and local governments to procure and use products derived from captured carbon oxides.
Rural Energy for America Program (REAP)	U.S. Department of Agriculture Rural Development	Grants & loan guarantees	Funds are provided to agricultural producers and rural small businesses to install renewable energy systems (RES), including anaerobic digesters, or to make energy efficiency improvements. Agricultural producers can also apply for new energy-efficient equipment and new system loans for agricultural production and processing.
Empowering Rural America Program (New ERA)	U.S. Department of Agriculture Rural Development	Grants & loan guarantees	Funds are provided to make energy efficiency improvements to eligible generation and transmission systems, to purchase, build, or deploy renewable energy, zero-emission systems, carbon capture storage systems, or to purchase renewable energy.
Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program	U.S. Department of Agriculture Rural Development	Loan guarantees	Loans are provided to assist in the development, construction, and retrofitting of new and emerging technologies. These technologies are: advanced biofuels, renewable chemicals and biobased products.
Business and Industry (B&I) Loan Guarantees	U.S. Department of Agriculture Rural Development	Loan guarantees	Loans are provided to businesses located in a rural area to install commercially proven renewable energy facilities such as anaerobic digesters for the business.

Conservation Loans	U.S. Department of Agriculture Farm Service Agency	Loan guarantees	Loans are provided to implement conservation practices on farms and ranches as part of an NRCS-approved conservation plan. Conservation practices include established NRCS conservation practice standards as well as specific actions such as manure digestion systems.
Title XVII Innovative Energy Loan Guarantee Program	U.S. Department of Energy	Loan guarantees	LGP provides borrowers access to capital, flexible financing, and expert project support to help reinvigorate, advance, and transform America's energy infrastructure including waste to energy projects. LGP can provide first-of-a-kind projects and other high-impact, energy-related ventures with access to debt capital that private lenders cannot or will not provide.
Farm Ownership Loans	U.S. Department of Agriculture Farm Service Agency	Loans	Loans are provided to help farmers and ranchers purchase or enlarge family farms, improve and expand current operations, increase agricultural productivity, and assist with land tenure. Funds can be used to purchase, improve, or build any type of structure on farm owned by the applicant.
Powering Affordable Clean Energy Program (PACE)	U.S. Department of Agriculture Rural Development	Loans	PACE provides borrowers with up to 60 percent loan forgiveness of loans used for renewable energy projects that employ wind, solar, hydropower, geothermal, or biomass, as well as for renewable energy storage projects. At least 50 percent of the population served by the project must live in communities with populations of 20,000 or fewer.
Advanced Biofuel Payment Program	U.S. Department of Agriculture Rural Development	Subsidies	Quarterly payments are made for the actual quantity of eligible advanced biofuel produced during the quarter. Annual incremental payment for producers who increase production over the previous fiscal year
Biofuel Producer Relief Programs	U.S. Department of Agriculture Rural Development	Subsidies	Payments are made to US-based producers of biofuel, biomass-based diesel, or renewable fuel to offset unexpected market losses as a result of the COVID-19 pandemic.

Renewable Electricity Production Credit (PTC)	U.S. Treasury Department Internal Revenue Service	Tax credit	The PTC compensates producers on a per kilowatt-hour basis for renewable energy. Renewable energy includes electricity generated from landfill gas (LFG), open-loop biomass, municipal solid waste resources, small irrigation power facilities, wind, closed-loop biomass and geothermal resources.
Energy Investment Tax Credit (ITC)	U.S. Treasury Department Internal Revenue Service	Tax credit	The ITC reimburses a set percentage of installation costs. It provides a 30% credit for "qualified biogas properties" and up to 50% for projects in "high energy areas." "Waste energy recovery" is also included as an eligible use of the tax credit.
Alternative Fuel Credit (Form 4136)	U.S. Treasury Department Internal Revenue Service	Tax credit	A tax incentive is available for alternative fuel that is sold for use or is used as a fuel to operate a motor vehicle. Alternative fuel includes "compressed or liquefied gas derived from biomass."
AgSTAR	Environmental Protection Agency/ U.S. Department of Agriculture	Technical assistance & education	AgSTAR is a collaborative program that promotes the use of biogas recovery systems through: 1) Outreach materials / project development tools; 2) Resources that connect farmers with funding options; 3) Events to bring stakeholders together to share knowledge; 4) Information, stats, profiles on digesters; 5) Pre-feasibility analysis; 6) Newsletters / listserve; and 7) Access to experts to assist in planning.

Chart compiled by Juli Obudzinski

Appendix B: Detailed Research Methods, Results, and Limitations

This section provides more-detailed research methods, results, and limitations from the analysis in **Section VI**.

Methods

Data Sources

AgSTAR Data Set

We obtained a list of manure digester projects from the U.S. EPA AgSTAR Livestock Anaerobic Digester Database, which is based on data available through May 2022 (this was the most recent data set our had available as of October 2022, when this research was conducted).²⁰⁸ While this database is imperfect (see *Limitations* section below), we believe it is the most comprehensive existing publicly available data set as of publication of this report.

We downloaded the database from the AgSTAR website as an xlsx file, which included 416 projects categorized as either operational or under construction, along with a second list of 90 projects that had been shut down. We limited our analysis to digester projects that met the following criteria:

- **Currently Operational:** We excluded digesters that were categorized in the AgSTAR database as either under construction or shut down.
- **Operational Start Date of 2017 or Earlier:** We chose to assess digesters that had been in operation for more than four years in order to capture longer-term herd size trends.



- **Located on Large Livestock Operations:** We limited our analysis to projects on large operations, which we defined using the “Large CAFO” size thresholds included in EPA’s CAFO regulatory definitions²⁰⁹ (i.e., facilities that had at least 700 dairy cows, 1,000 cattle, 2,500 swine, or 30,000 chickens). We included this criterion because facilities designated as Large CAFOs should generally be required to obtain NPDES permits, which is what we used to assess changes in herd size.
- **Livestock Data Included in AgSTAR Database:** The database included five operational facilities with start dates prior to 2018 that lacked any information about herd size.^{xix} We excluded these operations from our analysis.

Application of the criteria above yielded an initial data set of 187 facilities with digesters.

xix “Barham Farms Complete Mix Digester;” “Pilgrim’s Pride Sumter Digester;” “REnergy—Dovetail Energy, LLC Digester;” “UW Oshkosh Foundation—Witzel, LLC Digester;” and “Woodcrest Dairy Digester.”



State CAFO Permits

In order to assess changes in herd sizes over time, we reviewed NPDES permits issued by states to facilities in the AgSTAR database that met the criteria above. We obtained permit information only from states that made this information available online (12 of 33 states included in our initial AgSTAR data set published NPDES data online).^{xxde}

We excluded from the analysis three facilities^{xxi} with state permits that predated the AgSTAR start dates, and four facilities^{xxii} with most-recent state permit dates that were the same year as the project start date listed in the AgSTAR database. (Since AgSTAR lists only the year that each digester became operational, we were unable to determine whether state permits issued in the same year were issued before or after the AgSTAR digester start date.) We also excluded facilities that did not have permit information available in 2020 or later to more accurately reflect recent herd size trends. The addition of this dataset criterion left 77 facilities, including 73 dairy facilities, two swine operations, and two cattle operations located in nine states. According to AgSTAR and state permits, five of the dairy facilities had swine, beef cattle, or horses. Given the small number of swine and cattle operations, we limited our

analysis to the 73 dairy facilities, which were in eight states, and to their dairy populations only (excluding the swine, cattle, and horses in those facilities).

Calculations

Assessing herd size changes

We calculated herd size changes over time at facilities with digesters by comparing the total animal numbers listed in the AgSTAR database at project start dates (which, for our dataset, ranged from 1999 to 2017) with livestock numbers listed in the most recent available state NPDES permits for each facility.

Unfortunately, the reporting methodology used in the AgSTAR database was not always consistent with that used in state NPDES permits. For instance, the AgSTAR database lists animal numbers only for “dairy,” while several state permits listed dairy animal units rather than animal numbers, sometimes listed heifers, and occasionally presented animal number ranges (e.g., “700–1,600 cows”).

Animal numbers to Animal Units (AU) conversion factor

We used a conversion factor^{xxiii} of 1.4 AU to one dairy cow to calculate animal units based on animal numbers (and to convert animal units to animal numbers when necessary).

xx Idaho also makes NPDES permit data available online, but we were unable to use any Idaho permit data because all facility permits were issued either same year as, or prior to, the AgSTAR project start dates.

xxi Big Sky West Dairy Digester, Kettle Butte Dairy Digester, and AgPower Jerome LLC - Double A Dairy Digester.

xxii Roeslein Alternative Energy - Valley View Farm Digester, Roeslein Alternative Energy - Locust Ridge Farm Digester, Bettencourt - Rock Creek Dairy Complex Digester, and Dry Creek Dairy Digester.

xxiii We used the conversion factors specified in EPA’s “Guide Manual on NPDES Regulations for Concentrated Animal Feeding Operations” (see section 2.3 Calculating the Number of Animal Units on p. 5), for all animal types.

Dates

Since the AgSTAR database lists only the year each facility became operational, we used July 2, the midpoint of the year, to calculate annual herd size changes over time.^{xxiv} In several cases, the actual issuance dates of state permits were unavailable; in these cases, we used the publication date or “updated as of” date listed on the state website.

IPCC method for calculating emissions from livestock and manure management

The methane emission model we utilized was developed by Jeffrey Moridani, Bella Weksler, and Sophie Davison at University of California, Berkeley, and relied on the calculations in Chapter 10 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. A copy of their full calculator tool and mapped formulas can be provided upon request. Default values included the following:

Average weight: 658 kilograms per 1 animal unit (AU)

Weight Gain: 0 assumes all heifers are fully grown.

C_{fi} = 0.386 for lactating

C_a = 0 for stall

Fat content = 4%

Milk = 34.09 kilograms per day

Pregnancy coefficient: C_{preg} = 10%

C = 0.8 for females

Digestible energy expressed as a percentage of gross energy E% = 60% (default)

Methane conversion factor (enteric fermentation) Y_m = 6.5% (default)

Methane conversion factor (manure management) MCF% = See Table 2 in **Section VI**.

Digester leakage rate: 10%

^{xxiv} Note: We did not adjust for leap years.



Calculating changes in methane emissions

We calculated changes in annual methane emissions using the following scenarios:

Scenario 1:

The baseline from which we measure emission reductions from the digester is the most methane-generating manure management scenario where the facility would have stored 95% of its manure in an uncovered lagoon and 5% in solid storage. This scenario assumes facilities experienced no changes in herd size.

- This scenario was chosen because it mirrors the assumptions EPA uses in estimating methane reductions from facilities using digesters.
- Change in methane emissions using this scenario was calculated as:



$$\Delta \text{ Annual methane emissions} = \frac{\text{Emissions}_{NPDES} - \text{Emissions}_{AgSTAR}}{\text{Emissions}_{AgSTAR}}$$

Where

$$\text{Emissions}_{NPDES} = \text{AU_Emissions}_{NPDES} \times \text{AU}_{AgSTAR}$$

$$\text{Emissions}_{AgSTAR} = \text{AU_Emissions}_{AgSTAR} \times \text{AU}_{AgSTAR}$$

$$\begin{aligned} \text{AU_Emissions}_{NPDES} &= \text{Emissions per animal unit in the year of the NPDES data} \\ &= \text{Enteric} + \text{Manure_management}_{NPDES} \\ &\quad (\text{via the calculator tool described above}) \end{aligned}$$

$$\begin{aligned} \text{AU_Emissions}_{AgSTAR} &= \text{Emissions per animal unit in the year of the AgSTAR data} \\ &= \text{Enteric} + \text{Manure_management}_{AgSTAR} \\ &\quad (\text{via the calculator tool described above}) \end{aligned}$$

$$\text{Enteric} = 230 \text{ kgCH}_4/\text{year}$$

$$\text{Manure_management}_{NPDES} = 47 \text{ kgCH}_4/\text{year}$$

$$\text{Manure_management}_{AgSTAR} = 468 \text{ kgCH}_4/\text{year}$$

$$\text{AU}_{AgSTAR} = \text{Animal units in the year of the AgSTAR data}$$

Scenario 2:

The baseline from which we measure emission reductions from the digester includes a feasible-alternative manure management scenario where 50% of the facility's manure was composted, 45% was stored in an uncovered lagoon, and 5% was solid storage. This scenario accounts for actual measured changes in herd size.

- The manure management strategy in this scenario represents a feasible alternative to lagoon management – the most methane-generating manure management strategy – for the large CAFOs in our dataset. It assumes the dairies, as their baseline and after the installation of the digester, use solid liquid separation (SLS) to separate and compost the solid components of their manure. While the efficacy of separators varies substantially (from removing 5% of total solids to more than



85%), we assume a separator (or separators) that removes 50% total solids to be managed as compost.^{210,211} This scenario also accounts for actual measured changes in herd size.

- This scenario was calculated as follows:

$$\Delta \text{ Annual methane emissions} = \frac{\text{Emissions}_{\text{NPDES}} - \text{Emissions}_{\text{AgSTAR}}}{\text{Emissions}_{\text{AgSTAR}}}$$

Where:

$$\text{Emissions}_{\text{NPDES}} = \text{Emissions per AU}_{\text{NPDES}} \times \text{AU}_{\text{NPDES}}$$

$$\text{Emissions}_{\text{AgSTAR}} = \text{Emissions per AU}_{\text{AgSTAR}} \times \text{AU}_{\text{AgSTAR}}$$

$$\text{Emissions per AU}_{\text{NPDES}} = \text{Enteric} + \text{Manure_management}_{\text{NPDES}}$$

(via the calculator tool described above)

$$\text{Emissions per AU}_{\text{AgSTAR}} = \text{Enteric} + \text{Manure_management}_{\text{AgSTAR}}$$

(via the calculator tool described above)

$$\text{Enteric} = 230 \text{ kgCH}_4/\text{year}$$

$$\text{Manure_management}_{\text{NPDES}} = 33 \text{ kgCH}_4/\text{year}$$

$$\text{Manure_management}_{\text{AgSTAR}} = 226 \text{ kgCH}_4/\text{year}$$

$$\text{AU}_{\text{NPDES}} = \text{Animal units in the year of the NPDES permit}$$

$$\text{AU}_{\text{AgSTAR}} = \text{Animal units in the year of the AgSTAR data}$$

Scenario 3:

No digester was installed, herd sizes decreased by 20% on average, and farms moved from a baseline of 95% lagoon/5% solid storage to implementing alternative manure management practices (50% composting/45% lagoon/5% solid storage).

- This scenario was chosen to represent a feasible alternative to installing an anaerobic digester.
- This scenario was calculated as follows:

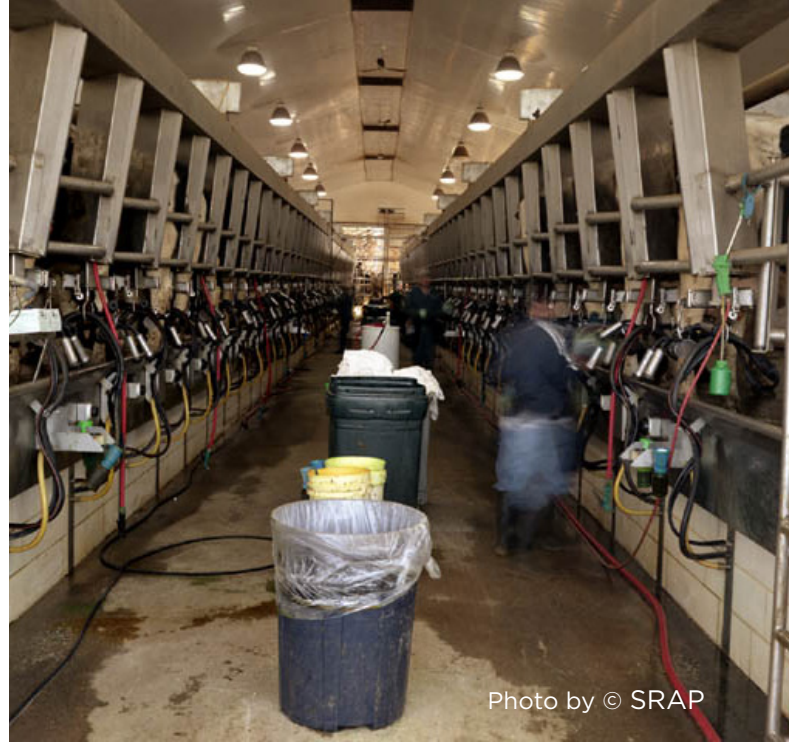


Photo by © SRAP

$$\Delta \text{ Annual methane emissions} = \frac{\text{Emissions}_{\text{NPDES}} - \text{Emissions}_{\text{AgSTAR}}}{\text{Emissions}_{\text{AgSTAR}}}$$

Where:

$$\text{Emissions}_{\text{NPDES}} = \text{Emissions per AU}_{\text{NPDES}} \times (\text{AU}_{\text{AgSTAR}} \times .8)$$

$$\text{Emissions}_{\text{AgSTAR}} = \text{Emissions per AU}_{\text{AgSTAR}} \times \text{AU}_{\text{AgSTAR}}$$

$$\text{Emissions per AU}_{\text{NPDES}} = \text{Enteric} + \text{Manure_management}_{\text{NPDES}}$$

(via the calculator tool described above)

$$\text{Emissions per AU}_{\text{AgSTAR}} = \text{Enteric} + \text{Manure_management}_{\text{AgSTAR}}$$

(via the calculator tool described above)

$$\text{Enteric} = 230 \text{ kgCH}_4/\text{year}$$

$$\text{Manure_management}_{\text{NPDES}} = 468 \text{ kgCH}_4/\text{year}$$

$$\text{Manure_management}_{\text{AgSTAR}} = 226 \text{ kgCH}_4/\text{year}$$

$$\text{AU}_{\text{AgSTAR}} = \text{Animal units in the year of the AgSTAR data}$$



Comparing modeled changes in methane emissions to Global Methane Pledge target

Finally, we compared how these reductions stack up against the level of ambition needed to meet the Global Methane Pledge target of a 30% reduction in methane emissions from 2020 levels by 2030, with the assumptions utilized under each scenario. We projected the modeled methane reductions per dairy facility that we calculated from our dataset using Scenarios 1 and 2 (the digester scenarios) onto the 500 facilities that the Biden administration has indicated it hopes will install digesters, and we projected the modeled methane reductions from Scenario 3 (the non-digester scenario) onto 1,500 similarly sized dairy farms, which is a subset of the number of large (>1,000

head) dairy farms identified in the 2017 Census of Agriculture (1,953 farms).²¹² We had to make an assumption about baseline manure management scenarios for these 1,500 dairies because of a lack of available data on current manure management practices for large dairies.

We utilized EPA's Greenhouse Gas Equivalencies calculator to convert methane emissions calculated using the methods described above to CO₂e to match the units in EPA's Greenhouse Gas Inventory for 2020 methane emissions from agriculture.²¹³ Notably, EPA uses a 100-year time-scale for methane's GWP,^{xxv} which will underestimate emissions relative to the 20-year timescale GWP for methane that many scientists argue should be adopted.²¹⁴

xxv EPA's GHG Equivalencies calculator uses a factor of 28 to convert CH₄ to CO₂e assuming a 100-year timescale for methane's GWP. The IPCC's guidance offers a range of factors from 28 to 36, so this represents the lowest or most conservative emissions estimate.

Results

Herd size changes

For the 73 facilities in our dat set, we estimated 84,201 additional dairy cows were added between the starting and ending year, which represents an annual year-over-year herd size increase of 3.7%,^{xxvi} which compared to a .15% increase over the same time periods in the state dairy populations for each state.^{xxvii} Table B1 shows the full results from our herd size analysis.



Table B1. Change in Dairy Population From AgSTAR Year (Start Date) to NPDES Year (End Date)

State	Facilities	Baseline Total Dairy Population (AgSTAR)	Ending Total Dairy Population ^a (State Permit)	Change in Dairy Population	% Change Dairy Population	Avg Change in Dairy Population Per Facility	Avg YoY Facility Population Change ^b	Avg YoY Statewide Population Change ^c
INDIANA	5	19,950	19,480	-470	-2.4%	-94	0.9%	0.9%
MICHIGAN	5	15,030	17,731	2,701	18.0%	540	2.2%	2.0%
MINNESOTA	2	3,900	5,341	1,441	36.9%	720	2.1%	-0.6%
MONTANA	1	750	800	50	6.7%	50	0.5%	-3.1%
NEW YORK	23	43,610	86,100	42,490	97.4%	1,847	6.6%	0.1%
PENNSYLVANIA	5	5,912	11,927	6,015	101.7%	1,203	5.6%	-1.1%
WASHINGTON	2	6,500	11,130	4,630	71.2%	2,315	-0.8%	0.6%
WISCONSIN	30	76,565	103,909	27,344	35.7%	911	2.4%	0.1%
Total	73	172,217	256,418	84,201	48.9%	1,153	3.7%	0.15%

- While AgSTAR data included only dairy cows, some state permits reported dairy and heifer populations separately, which we combined to represent the total dairy population.
- Each value in this column represents the unweighted average of the year-over-year (YoY) growth rate for the dairy facilities in that state. For each state, we calculated the YoY growth rate for every individual facility and then averaged these rates without giving more weight to larger facilities or facilities that have been operating over a longer period of time. The total YoY growth rate of 3.7% weights each facility equally.
- Similarly, each value in this column represents the unweighted average of the YoY growth rate for the statewide dairy populations in each state. For each state, we calculated the YoY growth rate of the statewide dairy population between the baseline (AgSTAR) year and post (state permit) year for every individual facility in that state, and then we averaged these rates to derive the state's overall average growth rate. The total YoY growth rate of .15% weights each facility equally.

xxvi 3.7% is an unweighted average YoY growth rate. We also calculated the average YoY growth rate weighted to the baseline (AgSTAR) population (5%), to the ending (NPDES) population (3.0%), and to the years the facilities were in operation (3.1%).

xxvii When we included the other species of animals present at these dairies, these animals yielded an additional increase of 3,888 animal units, or the equivalent of 2,777 dairy cows.

Modeled methane emissions

Accounting for the actual herd size changes in Scenario 2 and measuring the emissions reductions from a baseline of feasible alternative manure management strategies, the dairy CAFOs in our data set reduced their annual methane emissions by only 11% from the baseline year to the most recent year for which herd size data is available (Scenario 2). This is nearly six times less than the reductions estimated using EPA's assumptions that there were no changes in herd sizes and that if these facilities did not have digesters, they would utilize the most methane-generating manure management strategy of a lagoon (Scenario 1).

If the dairy CAFOs in our data set reduced their herd sizes by 20% and implemented feasible alternative manure management strategies without a digester, they could reduce their annual methane emissions by 48 (Scenario 3). Table B2 shows the full results of each modeling scenario.

Comparing modeled changes in methane emissions to Global Methane Pledge target

Table B3 shows the results from scaling the per-farm average emissions reductions from Scenarios 1 and 2 to 500 large dairies and from Scenario 3 to 1,500 large dairies.

Table B2. Modeled Changes in Dairy Methane Emissions

	Description	Assumption for Initial MMS	Assumption for Ending MMS	Assumption for change in herd size	Initial Emissions (kgCH ₄)	Ending Emissions (kgCH ₄)	Change in Emissions (kgCH ₄)	% Change
Scenario 1	Baseline is lagoon manure management. Assumes no change in herd size.	95% lagoon 5% solid storage	95% digester 5% solid storage	No change	168,379,661	66,785,753	-101,593,908	-60
Scenario 2	Baseline is feasible alternative manure management scenario. Uses actual measured changes in herd size.	50% composting 45% lagoon 5% solid storage	50% composting 45% digester 5% solid storage	Actual measured change	109,866,180	89,598,869	-20,267,310	-10.8
Scenario 3	Baseline is lagoon manure management. Assumes no digester, herd sizes decreased by 20%, and feasible alternative manure management strategies adopted.	95% lagoon 5% solid storage	50% composting 45% lagoon 5% solid storage	20% decrease	168,290,452.4	87,892,944	-80,397,509	-48

Table B3. Scaled dairy methane emissions reductions

	Average annual emissions reductions (kgCH ₄)	Average annual emissions reductions (million metric tons CO ₂ e)	Scaled to 500 dairies (CO ₂ e MMT)	Scaled to 1,500 dairies (CO ₂ e MMT)
Scenario 1	-1,391,697	0.0390	19.5	N/A
Scenario 2	-277,634	0.0078	3.9	N/A
Scenario 3	-1,101,336	0.0308	N/A	46.3

Limitations of Our Analysis

● **Small data set**

Only 187 projects in the AgSTAR database met our initial criteria. Only 12 states made usable NPDES permit data available online, and only nine states included data from 2020 or later, which yielded a state permit dataset of 77 facilities. We limited our analysis to the 73 operations that confined dairy cows and to only the dairy populations for those facilities (excluding the swine, beef cattle, and horses at five of those facilities).

- Lack of NPDES permit data Even in states that made NPDES permit data available, we were unable to find permit information for every digester project. This could indicate that:
 - The CAFO didn't have an NPDES permit. This could be because the facility does not discharge into waters of the U.S. and is therefore not required to obtain an NPDES permit, or it could reflect a regulatory or reporting failure by the state agency. (See EPA's 2021 NPDES CAFO Permitting Status Report, completed 7/20/22, to find the total number of CAFOs and number of CAFOs with NPDES permits by state.)²¹⁵
 - State permit records were incomplete or inaccurately reported.
 - The facility was sold and/or renamed. (In some cases, we were able to identify name changes/ownership transfers and find permit data for renamed facilities, but it's likely that we missed some facilities.)

- The digester and the CAFO have different owners and/or are managed/ permitted separately.

- **Inconsistent reporting methodology**
(See *Assessing Herd Size Changes* above.)

- **Imprecise dates**
(See *Dates* above.) Note that our methodology likely underestimates annual herd size changes because we sometimes used state permit data publication dates rather than actual permit issuance dates.

- **Inability to capture continuous herd size trends**
NPDES permits provide only a snapshot of herd size in time; it would be valuable to see yearly herd size changes to better assess long-term trends.

- **Inaccurate/incomplete data**
We know that the AgSTAR database and state NPDES permits are not always accurate. For instance, based on conversations with state regulators, we learned that certain digester projects listed as operational in the AgSTAR database have been shut down. We also identified a facility in the AgSTAR database that listed data for another CAFO owned by the same company. Similarly, for the methane emissions modeling, we did not have data on the actual manure management practices utilized by the facilities in our data set either before they installed a digester or after.

- **Inability to capture herd size changes caused by several potentially significant factors:**

- **Facility expansions that occurred immediately before construction of digesters**

This phenomenon is described in pp. 10–15 of the Petition for Reconsideration²¹⁶ submitted by Food & Water Watch, Animal Legal Defense Fund, Association of Irrigated Residents, et al., and we also found evidence of the trend when assessing Idaho’s NPDES permits.

- **Changes in herd size at other facilities that contribute waste to the digester**

Several digesters are classified as “multi-farm digesters” or “centralized digesters” – our analysis does not capture changes in herd sizes at the ancillary operations that contribute waste to these digesters. Similarly, a CAFO operator might own several CAFOs and use a single digester to process all the waste – in this case, our analysis would capture changes in herd size only at the single CAFO where the digester is located (i.e., rather than the change in total herd size under common ownership).

- **Inability to assign causation to herd size changes**

We were unable to determine causation using this method. Even if we could determine causation, we still could not determine whether increases in herd sizes are being driven by consolidation or a net increase in animal production.

- **Lack of information on manure management strategies**

We were not able to determine the actual manure management strategies of the facilities in our data set during the baseline year nor the most recent year, again due to a lack of data collection and disclosure at the state or federal levels.

- **Emissions model restricted to methane**

Importantly, our emissions modeling is restricted to methane emissions and does not account for increases in nitrous oxide emissions from anaerobic digestion or increases in nitrous oxide and carbon dioxide emissions from the additional feed required to support additional animals in the herds of the facilities in our data set.



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