GLOBAL WARMING AND AGRIBUSINESS: COULD METHANE GAS FROM DAIRY COWS SPARK THE NEXT CALIFORNIA GOLD RUSH?

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ABSTRACT

Methane (CH4) is one of six greenhouse gases central to climate change studies. Although it accounts for a very thin slice of the U.S. greenhouse gas emissions pie—a mere 8%—the inclusion of methane gas in climate change policy is warranted, given that it has twenty-one times the heat-trapping potential of carbon dioxide (CO_2). This atmospheric insulating trait of methane is why United States' policymakers have begun to take greater notice of its sources, both natural and anthropogenic, and have started to investigate possible ways to curb methane emissions.

Overall, total methane emissions in the United States have declined from 1990 levels. Illustrative of this phenomenon are improvements in the management of U.S. landfills, the frontrunner of anthropogenic methane gas

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emissions. Landfills contribute a full quarter of all anthropogenic methane emissions. Interestingly, emissions inventories indicate a steady decline in landfill methane emissions, yet the volume of refuse and rubbish piles in U.S. dumps continues to increase. This negative correlation, which is good news for Earth and its inhabitants, is attributed to the recent aggressive campaign to capture methane gas at landfills and convert it to renewable energy. However, unlike the phenomenon at landfills, other parameters of anthropogenic methane are demonstrating substantial increases above 1990 emissions levels, including wastewater treatment facilities and manure management in farming.

Dairy cattle and other animals in the ruminant family, along with swine and poultry, contribute a significant percentage of methane into the atmosphere. This is accomplished largely by way of manure management practices, and not bovine flatulence as is erroneously believed. The dairy industries of California and other top milk-producing states are confronting this issue head-on. Partnerships with federal and state agencies have created programs and incentives to harness livestock manure methane with anaerobic methane digesters to reduce, and in some cases completely eliminate, the enormous outputs of methane associated with manure management at concentrated animal feeding operations ("CAFOs").

This paper investigates several examples of public and private programs designed to reduce methane emissions from manure management at dairy facilities and, given that California is home to 20% of America's milk cows and remains the nation's top milk producer, this paper focuses on California programs. The paper examines policies and initiatives that promote the generation of energy from renewable energy sources, including biomass, and encourage the reduction of methane emissions associated with CAFOs. At the federal level, this includes a review of the 2002 Farm Bill and two substantial loan programs for rural business owners. At the state level, California's Dairy Power Production Program and other similar funding programs that subsidize the planning and installation of methane digesters are assessed. A significant part of the research examines California energy policy, including the Assembly and Senate bills that created the Renewables Portfolio Standard ("RPS") to encourage public utilities to purchase increasing percentages of renewable energy, including energy produced from methane capture and conversion.

Lastly, this paper will frame issues that are necessarily relevant policy considerations. What are the important factors that may, or perhaps should, influence the policymaking approach to shape methane legislation? Might dairy farms and other CAFOs become subject to the Clean Air Act and other air quality regulations as ambient quality and global warming become first-rate concerns to policymakers? Could the trading of carbon credits or similar allowances for reductions in methane gas emissions on national or international commodities markets prove to be the next California Gold Rush? With the massive and vital dairy industry of California as the economic and political backdrop to this paper, the goal is to examine how modern dairy and livestock manure management practices can influence policy that will successfully curb anthropogenic greenhouse gas emissions to mitigate climate change.

I. INTRODUCTION

Greenhouse gases ("GHG") occur naturally, cycling through the environment to facilitate atmospheric heating. Human-initiated, or anthropogenic activities also contribute to GHG emissions, subsequently impacting atmospheric heating potential.[1] For example, fossil fuel combustion is an anthropogenic activity that emits significant amounts of carbon dioxide (CO_2).[2] In 2004, carbon dioxide constituted 77% of the total anthropogenic GHG emissions worldwide; while nationally, it constituted 85%.[3] It is not surprising, then, that carbon dioxide remains the focus of climate change policymakers, as well as the standard by which all other GHGs are measured. Figures 2 and 3 illustrate the sources of the six major greenhouse gases, in the United States and worldwide. Given that carbon dioxide constitutes the greatest percentage share of total domestic and global GHG emissions, it is logical that carbon dioxide has been the obvious target of important legislation[4] and reduction efforts.[5]

Not all greenhouse gasses are homogeneous in terms of their capacities to trap heat in the atmosphere, as methane (CH4) demonstrates. Worldwide methane emissions constitute 14% of total GHG emissions, measured in carbon dioxide equivalents (CO_2Eq.).[6] In the United States, the methane share of all GHG emissions is smaller yet, constituting a mere 8% of total GHG emissions.[7] This number appears insignificant at first glance, but one ton of methane has the heat-trapping potential of twenty to twenty-one tons of carbon dioxide.[8] Therefore, the 8% share of total U.S. GHG emissions that methane accounts for actually represents much greater heat-trapping potential in the atmosphere. This fact makes any amount of anthropogenic

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1. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, Greenhouse Gases Frequently Asked Questions, http://lwf.ncdc.noaa.gov/oa/climate/gases.html (last visited May 13, 2009); U.S. DEPARTMENT OF STATE, THE FOURTH U.S. CLIMATE CHANGE ACTION REPORT TO THE UN FRAMEWORK CONVENTION ON CLIMATE CHANGE: GREENHOUSE GAS INVENTORY 20 (2006), *available at* http://www.state.gov/documents/organization/89651.pdf [hereinafter GHG INVENTORY]; *see infra* app. tbl.1.

2. *See* GHG INVENTORY, *supra* note 1; *see infra* app. fig.1.

3. *See infra* app. figs. 2 & 3.

4. Massachusetts v. EPA, 549 U.S. 497, 528-29 (2007). The Supreme Court held that CO_2 is a pollutant that can indeed be regulated by the EPA under the Clean Air Act.

5. Kyoto Protocol to the United Nations Framework Convention on Climate Change, art. 3, para. 1, Dec. 11, 1997, *available at* http://unfccc.int/essential_background/Kyoto_protocol/background/items/1351.php. International reduction efforts have been led by the 1997 Kyoto Protocol, an international treaty aimed at capping and reducing six greenhouse gases using a carbon dioxide equivalent measurement system. *Id.* at Annex A. Another example of reduction efforts are the federal standards for vehicle fuel efficiency, in 49 U.S.C.A. § 32902 (2007).

6. *See infra* app. fig.2.

7. *See infra* app. fig.3.

8. *See* GHG INVENTORY, *supra* note 1, at 19 tbl.3-1.

methane, from whatever source, worthy of conversation by drafters of global warming policy.[9]

This paper first presents an overview of the parameters of methane gas that constitute its 8% share of GHG emissions in the United States. The paper then focuses on methane emissions from manure management of livestock, particularly dairy cattle. Next, the paper investigates policies and initiatives that are currently in place to encourage methane emissions reductions in manure management. Finally, this paper considers other factors relevant to creating effective policy and meaningful incentives, whereby the goal of curbing GHG emissions through manure management practices can be achieved.

A. Anthropogenic Sources of Methane

The Environmental Protection Agency (EPA) lists major anthropogenic sources of U.S. methane emissions, in descending order measured in tons/year, as (i) the decomposition of waste in land fills, (ii) natural gas systems, (iii) enteric fermentation from livestock (the digestive process of ruminant animals, including cattle, sheep, goats and deer, which results in cud-chewing and exhalation of methane gas), (iv) coal mining, (v) farm manure management, (vi) wastewater treatment, (vii) petroleum systems, and (viii) rice cultivation, among others.[10] Table 2 demonstrates that landfills have consistently contributed the greatest amount of anthropogenic methane to the atmosphere, being the parameter responsible for 25% of U.S. methane emissions in 2004. Natural gas systems contributed 21% in 2004; enteric fermentation contributed 20%. Farm manure management and wastewater treatment each contributed about 7% of the total U.S. methane emissions in 2004.[11]

There is good news to report regarding anthropogenic methane emissions: overall, the volume of emissions has been in steady decline since 1990. In 1990, the atmosphere received 618.1 million metric tons, or teragrams, of methane, as measured in carbon dioxide equivalent ($TgCO_2Eq.$). In 2004, that number had receded to 556.7 $TgCO_2Eq$. The decrease represents a 10% reduction of methane emissions in the U.S. when compared to 1990 levels.[12]

Table 3 illustrates the change in methane emissions for each parameter, measured in tons of $CO_2Eq.$, from 1990 to 2004. Declines of methane emissions were noteworthy in landfills, showing an 18% decrease from 1990 levels.[13] "Although the amount of solid waste landfilled each year continues

9. Oliver Klaffke, *Saviour from the Acid Swamps*, NEW SCIENTIST, Mar. 20, 1999, at 13. About one-half of the world's methane emissions occur naturally, wafting into the atmosphere from bodies of water and swamps located in the Northern Hemisphere. However, this paper is limited to anthropogenic sources of methane, as opposed to natural sources, as well as related legal issues, policy considerations and mitigation efforts.

10. *See infra* app. fig.4 & tbl.2.

11. *See infra* app. fig.4 & tbls.2 & 3.

12. *See infra* app. tbl.3.

13. *Id.*

to climb, the amount of CH_4 captured and burned at landfills has increased dramatically."[14] Federal legislation aimed at reducing methane emissions from the nation's largest landfills is partly responsible for this. Next, the table shows sizeable declines in methane emissions from coal mining and petroleum systems, 31 and 35%, respectively. This is likely the result of these two sectors recent overall decline in U.S. industry. The table also shows enteric fermentation from livestock declined 4.5%.[15] This is attributed to improved diet of feedlot cattle and an overall decrease in the U.S. population of dairy and beef cattle.[16] Short of enacting federal mandatory vegan laws, or taking the less radical step of fitting the faces of every bovine in America with a catalytic converter of sorts to filter the methane out of burped exhalations, attempts at eliminating enteric fermentation and subsequent methane emissions are futile. However, diet management for livestock has proven successful at reducing enteric fermentation. [17]

Despite the 10% decline in U.S. methane emissions from 1990 levels, a phenomenon whose causes are still being hypothesized,[18] several parameters showed increases in methane emissions from 1990 levels[19]. Most alarming was the 48% increase in methane emissions from wastewater management; manure management from farming increased 26%; and natural gas systems increased 6%.[20] Of specific relevance to this paper is the increase in methane emissions in manure management.

B. Methane in the Context of Dairying

Improvements in animal diet, coupled with a retracting bovine population in the U.S., have helped reduce methane emissions from enteric fermentation from 1990 to 2004. Yet, during the same period, methane emissions from manure management greatly increased.[21] This confounding phenomenon would seem to indicate then, that a smaller population of cows is somehow responsible for the increases in methane gas. However, manure management practices are the real culprit.

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14. *See* GHG INVENTORY, *supra* note 1, at 25.

15. *See infra* app. tbl.3.

16. *See* GHG INVENTORY, *supra* note 1, at 25.

17. Kate Connolly, *Pill Stops Cow Burps and Helps Save the Planet,* THE GUARDIAN, Mar. 23, 2007, *available at* http://www.guardian.co.uk/environment/2007/mar/23/climatechange.climatechange. Scientists estimate that cows' burps are responsible for 4% of greenhouse gas emissions. German scientists have invented a pill that, when coupled with strict nutrition guidelines and feeding times, helps to reduce the methane emissions from cows' burping. *Id.*

18. Andrea Thompson, *Charge: Carbon Dioxide Hogs Global Warming Stage*, LIVESCI., Mar. 29, 2007, http://www.livescience.com/environment/070329_non_co2.html. Methane emissions worldwide have leveled off within the past decade, leaving scientists to ponder if this might be the result of methane's short atmospheric life or the gas's highly reactive quality as it enters the atmosphere. *Id.*

19. *See infra* app. tbl.3.

20. *Id.*

21. *Id.*

The explanation for this curious negative correlation begins with a cursory look at modern farming, which entails "dry lot" manure management and goes by many names: agri-business, factory-farming, and corporate-farming. Twenty (20)% of America's milk cows, or 1.83 million cows, make their residence on approximately 2,000 dairy farms that remain in California today.[22] The number of dairies throughout the nation has been in steady decline over the past three decades[23] while the average milking herd size continues to increase.[24] For example, in 2006, the average California dairy had 908 milk cows[25] which was an increase of 39% from 1996.[26] Because the emphasis in American dairying over the past two decades has been on increased milk production, the land-intensive pasture-based method of dairying is no longer economically viable. The dairy business model has effectively shifted from pasture-based to "dry lot" farming, which requires farmers to properly handle the waste, also known as liquid biomass.[27]

The storage methods associated with liquid biomass, or "wet manure management", lend themselves to creating the GHG methane. Wet manure management involves storing the liquid mixture of manure and water in open-air ponds or lagoons, for later potential use in crop fertilization. In the lagoon, the biomass is deprived of contact with oxygen, excluding the surface layer of course. The anaerobic environment beneath the surface of the lagoon promotes digestion of methane gas such that methane bubbles up to the surface and escapes into the air which is then collected under a cover.[28] This

22. California Milk Advisory Board, Real California Milk Facts, http://www.californiadairypressroom.com/Press_Kit/Dairy_Industry_Facts (last visited Nov. 16, 2009).

23. JAMES M. MCDONALD. ET AL., PROFITS, COSTS, AND THE CHANGING STRUCTURE OF DAIRY FARMING UNITED STATES DEPARTMENT OF AGRICULTURE, ECONOMIC RESEARCH SERVICE, ER-477, CHANGES IN THE SIZE AND LOCATION OF U.S. DAIRY FARMS, *available at* http://www.ers.usda.gov/publications/err47/err47b.pdf. Between 1970 and 2006, the number of dairy cow farms declined both steadily and sharply by 88% from 648,000 operations in 1970 to 75,000 in 2006.

24. *Id.* at 3. Between 2000 and 2006, the U.S. dairy industry demonstrated substantial growth in production and concentration in large dairy farms. Table 2 illustrates this by state; California dairies with herds of 500 or more cows accounted for 78% of the state's milk production in the year 2000, and by the year 2006 that number had increased to 88%. During the same time frame, the number of farms with fewer than 100 milking cows decreased.

25. Walt Cooley, "Dairy Producers Achieve New Records in 2006," *available at* http://www.ansci.umn.edu/dairy/documents/DairyStatistics2006.pdf. In 2006, there were 1,960 dairies in California with an average herd size of 908 cows as compared to the national average herd size of 147 cows.

26. *Compare* Marit Arana et al., *The Dairy Industry in California*, DAIRY CARE PRACTICES, June 1998, *available at* http://www.vetmed.ucdavis.edu/vetext/inf-da/inf-da_careprax.html *with* Cooley*, supra* note 25. From 1996 to 2006, the average milking herd size in California increased from 650 cows to 908 cows, representing a 39% increase.

27. Arana, *see supra* note 26. A "dry lot" farm is a concentrated animal feeding operation, or "CAFO," where access to pasture is minimal to none. Dry lot farming was established in California in the 1930s given the prohibitive cost of land to support pasture-based farming. *Id.*

28. EPA, U.S. METHANE EMISSIONS 1990-2020: INVENTORIES, PROJECTIONS, AND OPPORTUNITIES FOR REDUCTIONS 5-6 – 5-11 (1999), *available at* http://www.epa.gov/methane/reports/05-manure.pdf [hereinafter EPA INVENTORIES].

oxygen-free environment is essentially an incubator for methane. Furthermore, anaerobic digestion is optimal when provided an adequate and relatively constant temperature.[29]

By comparison, dry manure management is less methane-rich than wet manure management. Anaerobic digestion, described above as the chemical result of wet manure management, is severely stifled by the abundance of oxygen accompanied by the absence of water in biomass. Where biomass is in constant contact with air, as on pasture-based dairies or dairies that do not utilize lagoons, the dispersion of methane created by anaerobic digestion is a non-issue.[30]

There has been a noteworthy increase in the number of factory-farm swine operations throughout the country, particularly in the Midwest, and swine farm manure lagoons may contribute a significant share of methane emissions.[31] "[E]ven though swine are not considered large contributors of CH_4 . . . there is a potential for substantial GHG contributions when animal waste is stored and treated in anaerobic lagoons" as opposed to manure that is managed in "dry" methods.[32] In conformity with today's farm business model, the necessarily small pasture-based dairies[33] of America have been steadily replaced in top dairy states[34] by high milk-producing CAFOs.[35]

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29. *Making Methane-Recovery Work: Methane from Animal By-Products is Feasible Energy Source*, DQA QUEST, Mar. 1997, *available at* http://www.epa.gov/agstar/resources/quest.html. [hereinafter *Making Methane Recovery Work*]. Methane generation works best for dairies which have at least 300 cows and relatively warm climates. Additionally, for dairies located in northern climates, using hot water for cleaning will help maintain a constant temperature in the collection area, thereby aiding in the anaerobic digestion process. U.S. Dept. of Energy, Energy Savers, How Anaerobic Digestion (Methane Recovery) Works, *available at* http://www.energysavers.gov/your_workplace/farms_ranches/index.cfm/mytopic=30003 (last visited Feb. 10, 2010) [hereinafter Recovery]. The most important factor that affects anaerobic digestion is temperature. Digestion can occur in environments ranging in temperature from below freezing to 135°Fahrenheit (F), but it thrives at 98°F (if mesophilic digestion) or 130°F (if thermophilic).

30. EPA INVENTORIES, *supra* note 28, at 5-2.

31. Tom M. DeSutter & Jay M. Ham, *Lagoon-Biogas Emissions and Carbon Balance Estimates of a Swine Production Facility*, 34 J. ENVTL. QUALITY 198, 198 (2005).

32. *Id.* at 205.

33. The average dairy herd in Minnesota in 1992 was 48 cows. Brian Loeffler et al., *Knee Deep in Grass: A Survey of Twenty-Nine Grazing Operations in Minnesota*, *available at* http://www.extension.umn.edu/distribution/livestocksystems/DI6693.html. The average herd size in Wisconsin in 2006 was 83 cows. United States Department of Agriculture, National Agriculture Statistics Service: Statistics by State http://www.nass.usda.gov/Statistics_by_State/Wisconsin/Publications/Annual_Statistical_ Bulletin/page51.pdf (last visited Mar. 24, 2009).

34. USDA FED. MILK MARKET ADMIN.: MARKETING SERVICE BULL. (Feb. 2002), *available at* http://www.fmmacentral.com/PDFdata/msb0202.pdf. The top milk production states as of 2001 were, in descending order, California, Wisconsin, New York, Pennsylvania, Minnesota, Idaho, Michigan, New Mexico, Washington, and Texas. The first five states account for approximately 53% of all U.S. milk production, and the greatest percentage increases in production were in Idaho, New Mexico, Kansas, California, and Colorado.

35. Press Release, American Farm Bureau Federation, Report: Number of U.S. Dairy Farms Falls 5.1 Percent, October 27, 2000, *available at* http://www.fb.org/index.php?fuseaction=newsroom.newsfocus&year=2000&file=nr1027.html. Through the year 2000, milk production in the U.S. increased while the number of dairy farms decreased. In 2000, the nation experienced a

Government policies to improve public health and safety[36] were among the factors that encouraged this shift many decades ago. An indirect result of this legislation was an emphasis on milk volume, which led to the growth in herd sizes and the establishment of CAFOs. Today, we are faced with destructive environmental impacts of this agri-business model, and for purposes of this paper, the increase in methane emissions as a direct result of wet manure management.

However, the methane monster described above is being met by global communities, both scientific and commercial, in search of viable sources of renewable energy, like the biogas methane.[37] The movement to reduce methane through manure management practices, and to harness its energy potential, is still in its infancy, which makes this present era in environmental policymaking all the more exciting. With proper encouragement and partnership in the form of federal and state incentives and programs, resolution of the dairy cow and livestock methane problem in agri-business could be close on the horizon.

II. CURRENT INCENTIVES FOR DAIRY OPERATORS TO REDUCE METHANE EMISSIONS

Modern dairy operations, as well as large swine and poultry farms whose manure management practices include methane-rich, anaerobic liquid manure lagoons, have played a valuable role in recent efforts to curb methane emissions with the use of digesters.[38] A handful of U.S. farmers have employed methane digesters since the 1980s,[39] effectively serving as an empirical testing ground for improvements and perhaps proof of the technology's viability. Today, in many areas of the country, farmers are on

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substantial increase in milk production, which was a result of both a major increase in herd size and increased production per cow. For example, the average herd size in New Mexico in 2000 was 1,551 cows. This enormous number of cows can only be milked at a CAFO. Cooley, *supra* note 25.

36. The United States Public Health Service (USPHS) encouraged individual states and local milk control agencies to implement pasteurization requirements of milk in the name of public health and safety "[t]o assist States and Municipalities in initiating and maintaining effective programs for the prevention of milkborne disease," by developing a voluntary model regulation called the Standard Milk Ordinance. U.S. Food and Drug Administration, Grade "A" Pasteurized Milk Ordinance (2003 Revision): Introductory Information, Mar. 2, 2004, http://www.cfsan.fda.gov/~ear/pmo03.html#foreword.

37. *Cow Methane: A Trump Card in the Fight Against Global Warming?* CNN.com, Jan. 6, 2009, *available at* http://www.cnn.com/2007/TECH/science/10/05/cow.methane/.

38. U.S. EPA AGSTAR PROGRAM, GUIDE TO ANAEROBIC DIGESTERS, ANAEROBIC DIGESTER DATABASE (2009), http://www.epa.gov/agstar/operational.html [hereinafter GUIDE TO ANAEROBIC DIGESTERS]. Of the 125 digesters in operation as of February 2009 under the federal program AgSTAR, 19 are swine operations and five are poultry and duck operations. *Id.*

39. *See* RCM Digesters, A Long History of Digesters that Work, (Sept. 2004) http://www.rcmdigesters.com/images/PDF/BROCHURERCMDIGESTERSALT091204.pdf. Between 1982 and 2004, RCM Digesters designed and built forty digesters for dairies and other farms across the U.S. Their brochure lists dozens of farms by name and location, along with the types of digesters erected at each. *Id.* at 2, 3.

waiting lists[40] to have their farms assessed for methane digester feasibility, thanks in large part to federal programs[41] which marked the federal government's true commitment to renewable energy from farm methane.

There are at least six different models[42] of digesters used to capture methane for use as biogas.[43] All six models of digesters collect and pipe the biogas to an engine where it is combusted to power a generator, which produces electricity for use on-site or for sale to a utility company, or both.[44] Figure 8 presents a flow chart tracing anaerobic digestion of methane and the different farm uses of its by-products. The methane can be burned to power a generator, as described above, to create electricity, as well as heat, for on-farm use or for sale back to the power grid, or the methane can be purified and piped directly into a natural gas utility pipeline. Recently, successes have been made in running methane gas from manure into a hydrogen fuel cell.[45]

The marketplace has successfully engineered infrastructures necessary for methane digestion on dairy farms, and it continues to improve upon that technology. Dairies with as few as 150 milking cows, and as many as several thousand, have installed methane digesters.[46] However, the frameworks for

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40. *California Dairy Turns Cow Manure Into Power* (KGET television broadcast Mar. 3, 2008), *available at* http://www.kget.com/news/local/story/California-dairy-turns-cow-manure-into-power/4OrMt16mM0i2nGcK9vUd2g.cspx. A private company in California that fits dairies with methane digesters has a waiting list of 40 names of dairy owners who want to have their dairies assessed for viability for a methane digester(s).

41. U.S. EPA AGSTAR PROGRAM, ACCOMPLISHMENTS, http://www.epa.gov/agstar (last visited Mar. 12, 2009) [hereinafter AGSTAR ACCOMPLISHMENTS]; Farm Security and Rural Investment Act of 2002, 7 U.S.C.A. § 8106 (2006).

42. U.S. EPA AGSTAR PROGRAM, OPERATIONAL ANAEROBIC DIGESTER PROJECTS AT U.S. FARMS, *available at* http://www.epa.gov/agstar/pdf/digesters_all.xls [hereinafter AGSTAR PROJECTS]. AgSTAR and the USDA Rural Development Farm Bills have assisted with the funding and installation of six varieties of methane digesters: covered lagoon, horizontal plug flow, mixed plug flow, induced blanket reactor, complete mix, and fixed film. *Id.*

43. Leland M. Saele, *Anaerobic Digester Lagoon with Methane Gas Recovery: First Year Management and Economics*, http://www.p2pays.org/ref/21/20969. In this paper, Saele explains that anaerobic digesters are only effective and profitable when air is kept from the lagoon contents so that methane can be harvested from the slurry, and that lagoon digesters are effective in warmer climates where methane is produced year-round, as opposed to colder climates in which methane digestion is virtually halted during the winter, given the absence of naturally occurring heat. However, heat can be added. *See also Electricity from Manure Gases*, FARM JOURNAL, May 1963, *available at* http://www.green-trust.org/2000/biofuel/ methanedigestion2.htm; *infra* app. figs.7a & 7b.

44. *See infra* app. fig.8.

45. Roland Piquepaille, *A Hydrogen Fuel Cell Uses Cow Manure*, ROLAND PIQUEPAILLE'S TECHNOLOGY TRENDS, May 12, 2005, http://www.primidi.com/2005/05/12.html. University of Minnesota scientist Phil Goodrich worked with the Haubenschild Dairy program to use fuel cell technology to separate the hydrogen found in the methane, which is then used as an energy source. It is significantly quieter than conventional manure management, although maintenance is more expensive. Currently, the Haubenschild Dairy is working on using methane for automobile fuel cells. *Id.*

46. *Pipelines for Dairy Waste Digesters the Next Logical Step*, Northwest Renewable News, Dec. 31, 2008, *available at* http://nwrenewablenews.wordpress.com/2008/12/31/pipelines-for-dairy-waste-digesters-the-next-logical-step/. Four California dairies are the first in California to convert methane into ready natural gas and pipe directly into the natural gas pipeline.

federal and state policies are still evolving. To date, federal initiatives directed at methane reductions remain purely voluntary; however at the state level, legislative progress has been more tangible.[47] Although for the time being there is not yet legislation mandating the reduction of methane.

California has enacted laws requiring public utility companies to include in their energy portfolios some percentage of renewable energy.[48] Many states have enacted similar legislation, which essentially guarantees a marketplace for dairies to sell the energy generated from cow manure methane.[49] However, there continues to be significant variability in the price that public utility companies pay for renewable energy, and in most cases, the price offered does not cover the cost of its production.[50] For example, utility companies in Minnesota pay $0.04 per kilowatt hour of methane, yet it costs the Haubenschild Dairy about $0.05 to produce electricity from methane.[51]

A. Federal Initiatives

The current U.S. administration has supported preexisting voluntary federal programs aimed at capturing renewable energy from methane emissions. One such program is AgSTAR, created in 1994 through a partnership between the Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), and the U.S Department of Energy (DOE).[52] This voluntary program encourages methane recovery from manure by helping the owners of CAFOs with the capital, installation, and development costs of methane digesters.[53] In 2002, the Farm Security and Rural Investment Act ("Farm Bill") was passed.[54] Title IX of the Farm Bill established loan and financial grant mechanisms to help farmers purchase renewable energy systems, including methane digesters, and encouraged energy efficiency improvements on dairy farms,[55] emphasizing the use of renewable energy in rural businesses,

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47. U.S. Dept. of Energy, State with Renewable Portfolio Standards, http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm (last visited May 31, 2009). This interactive map of the United States provides links to each of the states' sites that describe their RPS programs. *See also* CAL. PUB. UTIL. CODE § 399.11 (West 2008); AGSTAR ACCOMPLISHMENTS, *supra* note 41. The AgSTAR site describes the incentives that are offered through federal programs.

48. CAL. PUB. UTIL. CODE § 399.11 (West 2008). §§ 399.11- 399.16, encompassed in Article 16, describe the Renewables Portfolio Standard Program.

49. Creative Energies, Sun Wind Water, *available at* http://www.cesolar.com /go.php?id=26 (last visited April 20, 2009). Twenty-one states and the District of Columbia have in place renewable portfolio standards such that consumer-generators of renewable energy have a marketplace in which to sell the excess megawatts their facilities produce.

50. Piquepaille, *supra* note 45.

51. *Id.*

52. U.S. EPA, AGSTAR PROGRAM, http://www.epa.gov/agstar (last visited May 27, 2009); AGSTAR ACCOMPLISHMENTS, *supra* note 41.

53. *Id.*

54. 7 U.S.C.A. § 8106 (2006).

55. 7 U.S.C.A. § 8106 (2006). Title IX of the Farm Bill is the energy subsection, which includes renewable energy development programs, energy efficiency improvements, and sets forth loan provisions, later revised as of January 1, 2008. *See* 7 C.F.R. §§ 4280.101-.193 (2008). For a

including "wind, solar, biomass, or geothermal source; or hydrogen derived from biomass or water."[56] The Farm Bill states that "the Secretary shall make loans, loan guarantees, and grants to farmers, ranchers, and rural small businesses to (1) purchase renewable energy systems; and (2) make energy efficiency improvements."[57] The Farm Bill targets rural businesses that are located in communities with fewer than 50,000 inhabitants, and eligible projects may receive up to 25% of their chosen project's cost in the form of a grant, and up to 50% of the cost in the form of a 20-year, low-interest loan, so long as the combined federal aid under this Act does not exceed 50% of the total cost of the project.[58] On May 22, 2008, the 110th Congress followed up the 2002 Farm Bill by overriding a presidential veto to enact into law the Food, Conservation, and Energy Act of 2008 ("2008 Act").[59] The 2008 Act largely continues the bio-energy initiatives of the Farm Bill of 2002.[60]

Although the federal government maintains AgSTAR and the loan assistance programs featured in the 2002 Farm Bill and the 2008 Act, it must be noted that the technology for methane digestion was already in use on American farms, albeit on a much smaller scale, before the inception of each of these rather recent federal assistance programs.[61] The energy crisis in the 1970s was one motivating factor for farmers to pursue alternative energy with methane digesters. Although a handful of farms continued to operate their facilities with their homegrown electricity, it was not uncommon for problematic digesters to simply fall into semi-permanent disuse.[62] Figure 5 shows that methane digesters were already in use in 1980, before AgSTAR was created some fourteen years later.[63] Figure 5 also shows that methane gas emissions were significantly reduced between 2003 and 2004.[64] This timing corresponds to the enactment of the financial incentive programs of the 2002 Farm Bill. The creation of AgSTAR, and the enactment of the energy provisions of the 2002 Farm Bill and the 2008 Act reinvigorated the climate of wet manure management in 1994 and 2002, respectively. Today, it is not

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description of the program, see USDA, Economic Research Service, Farm Bill Resources: ERS Research and Analysis, http://www.ers.usda.gov/farmbill/ (last visited May 29, 2009). *See* Electronic Code of Federal Regulations, http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=%2Findex.tpl (Select "Title 7 – Agriculture" from dropdown menu; follow "4200-4209" hyperlink; follow "4280" hyperlink) (last visited May 29, 2009) for the text of the promulgated rules.

56. 7 U.S.C.A. § 8101(5)(A)-(B) (2006).

57. *Id.* at § 8106 (2006).

58. 7 C.F.R. §§ 4280.103, 108, 125 (2009).

59. Food, Conservation and Energy Act of 2008, Pub. L. No. 110-246, 122 Stat. 1651 (2008). This Act became law on June 18, 2008. It was designed as a continuation through 2012 of its predecessor, the Farm Bill of 2002.

60. *Id.*

61. *See Electricity from Manure Gases*, *supra* note 43. This article highlights a hog farmer's installation of a methane digester on his 1,000 head ranch.

62. Richard Mattocks and Richard Wilson, *Latest Trends in Anaerobic Digestion in North America*, BIOCYCLE, Feb. 2005, at 61. Of the approximately 140 methane digesters built in the 1970s, about 85% failed or were otherwise taken out of service.

63. *See infra* app. fig.5.

64. *Id.*

untenable that a dairy with 300 cows can realize a profit from methane digesters in only a matter of years, after first making the investment in the anaerobic digesting equipment.[65] This qualifies a fairly large number of California dairies given that the average herd size in California in 2007 was 824 cows.[66] The attraction of digesters is not only found in their two major potential benefits: (1) generating energy for on-farm use, thereby supplementing or entirely offsetting the cost of purchasing electricity from a utility, and (2) generating revenue in the forms of (a) selling excess electricity to the utility grid in states that facilitate such agreements, and possibly (b) carbon credit trading.[67] In addition, digesters offer CAFOs and their neighbors the added benefits of odor and fly control.[68]

As of February 2009, there were 125 operational methane digesters in the United States.[69] Figure 6 represents the number of operational digesters in the U.S. in 2007, and the corresponding amounts of energy generated from those digesters, as measured in megawatt hours equivalent (MWh).[70] For example, California had fifteen operational digesters which produced 23,265 MWh of energy in 2007. The figure also shows that Texas, Wisconsin, and California led the nation in energy production from anaerobic digesters on dairy, swine, and poultry operations.[71] California energy policy is examined below.

In addition to the 2002 Farm Bill and its 2008 continuation, as well as AgSTAR, the federal government has created two programs that promote renewable energy via cost-sharing of the installation of methane digesters, and a grant program to assist with funding of state projects in renewable energy. The former program, the Environmental Quality Incentive Program (EQIP), provides up to $450,000 for each qualified project in renewable energy.[72] The latter program, the Conservation Innovation Grants Project (CIG), awards

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65. Mike Gamroth, *Methane Generation Part II: Is it for You?*, WESTERN DAIRY NEWS, Nov.-Dec. 2001, *available at* http://www.cvmbs.colostate.edu/ILM/proinfo/wdn/WDNDec01.pdf. In order to make on-farm power generation profitable, economic analyses have shown that a dairy needs to have a minimum of 300 cows in a high power cost area. Additionally, state and federal tax credits are available for creating new power sources, and these credits may help recover the initial investment in the digester.

66. UMass Center for Agriculture Census Analysis, http://www.umass.edu/agcenter/census/dairy-herd%20sizes.html (last visited Nov. 16, 2009).

67. Gamroth, *supra* note 65.

68. Roxanne Pillars, *Farm-Based Anaerobic Digesters*, THE MANURE TECHNOLOGIES FACT SHEET SERIES, Michigan State University Extension, *available at* http://www.agmrc.org/media/cms/FinalAnearobicDigestionFactsheet_2E11FAB524961.pdf.

69. GUIDE TO ANAEROBIC DIGESTERS, *supra* note 38; *see infra* app. fig.6.

70. *See infra* app. fig.6.

71. *See infra* app. fig.6.

72. EQIP is an outgrowth of the 2002 Farm Bill, and it provides cost-sharing and incentive payments for 1 to 3 years for a variety of projects. The aid amount cannot exceed $450K per project. USDA, Nat. Res. Conservation Serv., Environmental Quality Incentives Program, http://www.nrcs.usda.gov/PROGRAMS/EQIP/ (last visited May 30, 2009).

money at the state level, as opposed to private businesses or corporations, for projects in renewable energy.[73]

All of these federal initiatives have assisted dairy swine, and poultry farmers with the up-front costs associated with the design, purchase, and installation of methane digesters. These initiatives have been sufficient to the extent that farmers' interest is limited to using the methane from their livestock's biomass to satisfy on-farm power needs. When a farmer's digester produces more electricity than is necessary to operate the farm, an excess of energy is created. That excess energy is then available for sale to a local utility company. This can be an additional source of revenue for the farmer, but each individual state is responsible for coordinating the buyback process and setting rates.[74]

B. Public Initiatives and Policy in California

California is well on its way to recording measurable reductions in methane emissions as a result of manure management, so long as lawmakers continue to support the incentive programs and policies that enable farmers to feasibly install and maintain digester equipment. More is needed, however. Farmers need to be able to sell to public utilities any excess electricity or natural gas produced from methane capture. Utility interconnection, net metering provisions, and new billing structures are essential to encouraging farmers to introduce environmentally beneficial methane digester technology into their businesses.

Nearly two dozen California dairies have been generating electricity from methane for on-site use during the past decade. These projects have been made economically feasible through state grant programs such as the Dairy Power Production Program ("DPPP") and the Self-Generation Incentive Program,[75] in addition to the federal assistance programs outlined above. Also, California has ensured a market for renewable energy by instituting a Renewables Portfolio Standard (RPS), as well as creating net metering legislation.[76] Without such initiatives, the inclusion of methane digesters in

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73. CIP awards from $5 million to $10 million to selected projects at the federal and state levels. California, however, is not currently participating in this program. USDA, Nat. Res. Conservation Serv., Conservation Innovation Grants, http://www.nrcs.usda.gov/programs/cig/ (last visited May 30, 2009).

74. EPA, EPA CLEAN ENERGY-ENVIRONMENT GUIDE TO ACTION: POLICIES, BEST PRACTICES, AND ACTION STEPS FOR STATES 6-42 (2006), *available at* http://www.epa.gov /solar/documents/gta/guide_action_chap6_s3.pdf.

75. Self-Generation Incentive Program is the result of California Assembly Bill 970 that requires the CA Public Utilities Commission to provide financial incentives to customers who install distributed generation systems. For anaerobic digesters, the incentive is the lesser of $1,500 per kW or 40 percent of the eligible project costs. EPA, AGSTAR, DAIRY POWER PRODUCTION PROGRAM AND THE SELF-GENERATION INCENTIVE PROGRAM (2008), a*vailable at* http://www.epa.gov/agstar /pdf/ag_fund_doc.pdf.

76. WESTERN UNITED RESOURCE DEVELOPMENT, INC., DPPP DAIRY METHANE DIGESTER SYSTEM PROGRAM EVALUATION REPORT (2006), *available at* http://www.wurdco.com /DairyPowerProduction.htm (follow "Dairy Power Production Program final report (DRAFT)"

the future of the California dairy industry and energy sector would be much slower to develop, if not entirely dubious.

The California Energy Commission (CEC) has played an important role in the advancement of methane capture from California dairies. The CEC oversaw the DPPP. DPPP was comprised of two types of assistance for methane projects similar to those in the federal programs described above: (a) Buydown grants contributed up to 50% of the capital costs of a proposed methane digester project, not to exceed $2,000 per installed kilowatt (kW); and (b) Incentive payments of 5.7 cents per kilowatt-hour (kWh) of generated electricity was paid to the dairy farmer over a maximum of five years.[77] The DPPP report indicates that of the 55 applications received, 14 were selected for funding, and ten were completed before August 2006.[78] These numbers show significant interest on the part of California farmers in procuring methane digesters.

The DPPP report provides detailed case studies for each of the ten completed digester projects, which range in kW capacity from 75 to 563, with an average capacity of 230 kW.[79] The projects serve dairies whose milking herd range in size from 245 to 6,000 head.[80] Under this program, for example, a Northern California dairy with 245-cows installed a digester solely for on-site electricity generation and consumption.[81] The digester's capacity was 75 kW, processing about 61 cubic feet of methane gas per cow everyday.[82] This dairy farm's electricity usage before installation of the digester was 20,375 kWh/month (kilowatt hours/month), which amounted to $1,523/month, or $18,275/year, paid by the farmer at a rate of $0.12/kWh.[83] After installation, the digester produced an average of 21,597 kWh annually, or 2.8 kWh/day/cow.[84] The digester completely offset the dairy's electricity demand, and produced an excess of 1,222 kWh/month.[85]

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hyperlink). Net metering is a farm's ability to sell any excess power that is not used by the farm facility. Net metering laws provide for credits to be awarded for excess electricity, and those credits are applied against the customer's bill. The caveat is that at the end of a twelve month period, any credits not applied to a customer's bill are forfeited by the customer, and not paid out in dollars by the utility company. *Id.* at vi.

77. *Id.* at iv.

78. *Id.*

79. *Id.* at 13.

80. *Id.* at 15, 28.

81. *Id.* at 15, 16. Blakes Landing Dairy reported 245 lactating cows, 28 non-lactating cows, 89 heifers, 82 calves and 3 bulls.

82. WESTERN UNITED RESOURCE DEVELOPMENT, INC., *supra* note 76, at 16.

83. *Id.* at 16, 17.

84. Who per day per each of the 245 lactating cows is 20,727 kWh/month. The calculation must be adjusted up to include the biomass of the non-lactating animals, bulls, smaller heifers and calves. *Id.* at 16.

85. *Id.* at 16.

Under California law,[86] the excess electricity, then, could either be sold to the utility according to a purchase contract, or banked for credit through an incentive referred to as net metering. Net metering provides for deduction of banked credits from future electricity charges owed, however, banked credits cannot rollover from one year to the next.[87] The Blakes Landing Diary, the farm referenced above,[88] was not in a location where purchase agreements were offered, so its only available option was net metering. The farm's account at the utility company was credited for the excess energy generated from the methane digesters, at a rate equal to the retail rate at which it purchased electricity from the utility.[89] Any credits that remained unapplied at the end of a twelve month period were forfeited.[90]

Grant programs, like DPPP, that defray the capital investment in digesters are crucial to farmers' continued interest in this technology. The Northern California project described in the preceding paragraphs carried a price tag of $335 thousand. A $67 thousand buydown from DPPP and an additional $87 thousand from the U.S. EPA (through the California Regional Water Quality Board) were granted.[91] Despite these grants, there was still a $181 thousand upfront capital investment absorbed by the farmer. Theoretically, this farmer could recover his initial investment over approximately ten years,[92] assuming a stable cost of electricity and no expense for maintenance of the digester. The latter of these two assumptions is overly optimistic, however. If the farmer had not been awarded any state or federal grants, the recovery time of his $335 thousand investment would have been at least 18.3 years. Farmers would surely think twice about installing a methane digester when faced with a delayed rate of return like this.

The experimental programs initiated by the DPPP and the Self-Generation Incentive Program have demonstrated the effectiveness of methane capture for on-site use to offset electricity needs of farms, and of methane emissions reduction. For example, the 245 milk cow dairy from Blakes Landing Dairy effectively reduced its methane emissions by 78 metric tons per year, or 1,639 metric tons of CO_2 Eq.[93] To expand the campaign to reduce GHG emissions from manure management, and take the program beyond its initial, experimental phase, the California Assembly and Senate have become very

86. CAL. PUB. UTIL. CODE § 2827.9(e)(3) (West 2008), *available at* http://www.legaltips.org/california/california_public_utilities_code/2821-2827.10.aspx. At the end of the 12-month period, where the dairy has produced more electricity than that supplied by the local utility, the dairy is a net producer, "and the electrical corporation shall retain any excess kilowatthours generated during the prior 12-month period. The eligible biogas digester customer-generator [i.e., dairy] shall not be owed any compensation for those excess kilowatthours." *Id.*

87. *Id.*

88. WESTERN UNITED RESOURCE DEVELOPMENT, INC., *supra* note 76.

89. *Id.* at 10.

90. CAL. PUB. UTIL. CODE § 2827.9(e)(e) (West 2008).

91. WESTERN UNITED RESOURCE DEVELOPMENT, INC., *supra* note 76, at 15-17.

92. The initial investment of $181,000 divided by the annual savings of $18,275 *not* spent in electricity purchases = 9.9 years to recover the initial investment.

93. AGSTAR PROJECTS, *supra* note 42.

active. State policymakers recognize the energy potential of methane gas from manure and farms, and are providing mechanisms to advance the development of the renewable energy infrastructure.[94]

A series of bills was passed, beginning in 2002, allowing the state's regulatory bodies, the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC), to guide California to the forefront of renewable energy policy throughout the nation.[95] For example, Assembly Bill 2228 was passed into law in 2002, extending the benefits of net metering beyond owners of electricity-generating single-family homes and small businesses, to dairy and farm owners operating methane digesters.[96] The law requires that California utility companies use a bidding process for selecting sources of renewable energy and offer all farmer-generators long-term purchase contracts of ten to twenty years.[97]

Another example of leadership in the area of renewable energy policy is California Senate Bill 1078,[98] which established the Renewables Portfolio Standard (RPS), an idea borrowed from Iowa's 1991 law.[99] The intent of the RPS program is that a certain percentage of all the electricity provided to Californians be renewable. The goal for 2010 is that at least 20% of the electricity used by Californians be created from renewables.[100] By 2020, its RPS goal is 33%.[101] This requires an increase in renewable energy procurement of at least 1% per year. As of 2007, 11.8% of California's energy comes from renewable resources, including small hydroelectric.[102]

The sliding scale of the RPS is good news for the California dairy farmer who might be considering installing a methane digester, as it provides some

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94. GREEN JOBS, *Renewable Energy is the Centerpiece of California's Climate Response*, Nov. 21, 2008, *available at* http://www.greenjobs.com/public/industrynews/inews05112.htm.

95. *See* CAL. PUB. UTIL. CODE §§ 2827.9(a)(1), 399.11-16 (West 2008); Thelen Reid Brown Raysman & Steiner LLP, *Overview of the California Model for Encouraging Renewable Energy Development* (July 2006), *available at* http://www.constructionweblinks.com/Resources/Industry_Reports_Newsletters/Jul_26_2004/over.html.

96. CAL. PUB. UTIL. CODE § 2827.9(a)(1) (West 2008). The Legislature finds and declares that a pilot program to provide net energy metering for eligible biogas digester customer-generators would enhance the continued diversification of California's energy resource mix and would encourage the installation of livestock air emission controls that the State Air Resources Board believes may produce multiple environmental benefits. *Id.*

97. Thelen, *supra* note 95.

98. CAL. PUB. UTIL. CODE §§ 399.11-16 (West 2008). These provisions encompassed in Article 16, describe the Renewables Portfolio Standard Program.

99. IOWA CODE § 476.41 et seq. (1993). The RPS in Iowa was among the first nationally. It was last updated in 2003.

100. The original time table was to reach 20% by 2017, but the 2003 ENERGY ACTION PLAN I accelerated that deadline to 2010. This change became law in 2006 when the California Public Resource Code was amended. CONSUMER POWER AND CONSERVATION FIN. AUTH., ENERGY RES. CONSERVATION AND DEV. COMM'N, PUB. UTIL. COMM'N, ENERGY ACTION PLAN 5 (2003); CAL. PUB. RES. CODE § 25740 (West 2008).

101. California Public Utilities Commission, RPS Program Overview, http://www.cpuc.ca.gov/PUC/energy/Renewables/overview (last visited May 30, 2009).

102. The California Energy Commission, Energy Almanac, California's Renewable Energy Statistics and Data, http://energyalmanac.ca.gov/renewables/index.html (last visited May 29, 2009).

level of assurance that a market for renewable energy will still exist for several years after the farmer installs his digester. However, the state's energy policies in renewable energy procurement under California's aggressive RPS make for complicated reading, which can realistically hinder the state from accomplishing its stated RPS goals. Therefore, the gap between the state's energy objectives and the dairy operators can often be bridged by the private sector.

C. Private Sector Initiatives and Players in California

The decision to install a methane digester means facing an onslaught of paperwork and permits. However, private engineering firms are appearing in the marketplace to guide farmers through the precarious process, which averages three to four years when no permitting or engineering setbacks arise.[103]

One such private engineering firm is BioEnergy Solutions (BioEnergy), based in Bakersfield, California.[104] The company is different from other methane digester firms across the nation because it specializes in digesters that convert methane into pipeline-ready natural gas, as opposed to electricity.[105] The company's first project of this kind was launched at a 5,000-head dairy facility near Bakersfield, which pipes directly into the Pacific Gas & Electric (PG&E) utility pipeline that is regulated by the California Public Utilities Commission and California Energy Commission.[106] The dairy's covered lagoon will generate three billion cubic feet of natural gas each year, which is enough to power 50,000 homes each day.[107] As described by BioEnergy Solutions, this significant reduction in methane emissions is the equivalent to removing the CO_2 emitted from 5,300 cars.[108]

Although pioneered by BioEnergy, other firms traditionally dedicated to methane digesters for electricity generation are also tapping into the natural gas market. Microgy, a Wisconsin firm, recently unveiled its plans to construct four production facilities at large California dairy farms.[109] The natural gas collected from the dairies' methane will be piped directly into the extensive

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103. WESTERN UNITED RESOURCE DEVELOPMENT, INC., *supra* note 76. Case studies of 10 dairies indicated times between applying and installing and operating methane digesters was about 2 years.

104. BioEnergy Solutions, Frequently Asked Questions, http://www.allbioenergy.com/ (last visited May 29, 2009). BioEnergy has a waiting list of some 40 dairy operations for which it will perform feasibility analyses before it can enter into contracts to build methane digesters and sign guaranteed 10-year contracts with PG&E.

105. *Id.*

106. BioEnergy Solutions, *PG&E and BioEnergy Solutions Turn the Valve on California's First "COW POWER"*, Mar. 4, 2008, *available at* http://www.allbioenergy.com/index.php?option=com_content&task=blogcategory&id=47&Itemid=48.

107. *California Dairy Turns Cow Manure Into Power*, *supra* note 40.

108. *Id.*

109. Nora Goldstein, *Digester Developer Taps Natural Gas Markets*, BIOCYCLE, Sept. 2007, *available at* http://www.jgpress.com/archives/_free/001429.html.

natural gas pipeline network of PG&E under ten-year contracts. The CPUC has already approved a gas purchase agreement for up to 8,000 mcf of the renewable natural gas.[110]

Curiosity about methane digesters, on the part of dairy owners, has ballooned. Several engineering firms have had to create waiting lists of dairy owners who desire feasibility assessments of their facilities.[111] The two benefits to dairy owners of entering a contract with companies like BioEnergy Solutions are (1) the methane digester equipment and installation are provided at no cost to the dairy owner; and (2) the dairy owner will receive a fraction of the revenue from PG&E for the natural gas, and a portion of the revenue from sales of carbon credits.[112] Additionally, farmers incur minimal, if any, costs, yet enjoy a guaranteed ten-year stream of income. The environment is improved through reduced methane emissions. And the California energy sector gets closer to its RPS target.[113]

III. SALEABLE CREDITS FOR METHANE EMISSIONS REDUCTIONS

If all states soon adopt RPS plans, and continue to increase those plans as rapidly and as significantly as California did in 2006,[114] methane digesters could potentially become just another normal fixture on CAFOs and dairy operations. Such transformation across the landscapes of the dairy states will need great stimulus, however. The aggressive expansion of the marketplace, as demonstrated above, and a stable demand for renewable energy, may not be enough.

Revenue is an appealing motivation to business owners to justify investment in methane digesters. The existing mechanisms, such as net metering and selling excess electricity back to the grid, have not been shown to generate profit uniformly.[115] Net metering does not generate profit by design, as discussed in section II.2; and contracts to sell excess electricity from customer-generators to the utility rarely fetch a price equal to or higher than the retail price the customer is charged for electricity.[116] Contracts to sell excess electricity are rarely profitable for the farmer, given that the contract model currently endorsed by public policy mimics the standard, generally accepted, wholesale-retail model. This means that the farmer earns only a wholesale rate on the excess electricity sold to the utility.[117] Assuming this model does not change anytime soon, how else might the farmer be compensated for energy produced from cow manure methane? The answer

110. *Id.*
111. BioEnergy Solutions, *supra* note 104.
112. Carbon credits are discussed in Section III. *But see id.*
113. *See* CAL. PUB. RES. CODE § 25740 (West 2008).
114. *See* CAL. PUB. UTIL. CODE § 2827.9 (West 2008).
115. *See* CAL. PUB. UTIL. CODE §§ 399.11-16, 2827.9 (West 2008).
116. *See* CAL. PUB. UTIL. CODE §§ 399.11-16, 2827.9 (West 2008).
117. RCM Digesters, *Equal Access for American Farm Digester Electricity*, Feb. 12, 2002, *available at* http://www.rcmdigesters.com/Articles/equal_access_for _american_farm_d.html.

may lie in incentive programs tied to Renewable Energy Credits (RECs) and carbon credits.

A. Renewable Energy Credits and Carbon Credits

RECs, also known as Green Tags, are tradable commodities in the United States.[118] For every 1,000 kWh, or 1 MWh, of electricity produced, one REC is credited, and can be traded on the open market.[119] Before this can happen, however, the REC must be certified.

The firm Green-e Energy is among several U.S. firms that "provide[] independent, third-party certification to ensure . . . RECs are sourced from verified, new[120] facilities; not double-counted towards any state's renewable energy goal."[121] The Green-e Energy National Standard sets forth the requirements for certification of renewable energy credits.[122] With respect to biomass, "[a]ll facilities must be in compliance with all state and/or federal laws/rules regarding emissions."[123] This would essentially include all methane digesters installed under the 2002 Farm Bill and some installed under AgSTAR. However, renewable energy or RECs shall not be certified if "[t]he REC or the electricity from which the RECs are derived is being used simultaneously to meet a local, state, or federal energy mandate or other legal requirement."[124] Renewable energy that is generated in excess of the state's RPS mandate may be Green-e certified.[125] Under this rule, with this particular certification firm, energy generated from methane emissions in manure management can be eligible for REC certification so long as that energy is not sold to the utility for purposes of achieving the state's RPS goal. This avoids double-counting of RECs. Nonetheless, this presents a realistically problematic situation, where earning RECs might be precluded if increases in a state's RPS percentages outpace the production of renewable energy. Similarly, farmer-generators of renewable energy from methane could find themselves in direct competition with producers of renewable energy from other sources, such as wind, hydroelectric, and solar. Given the high capital expense of anaerobic digesters, guaranteed purchase contracts over a period of years are necessary.

Current problems with the RECs include: (1) There is no uniform national standard for certification of RECs; (2) No national registry exists for RECs; (3)

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118. BONNEVILLE ENVIRONMENTAL FOUNDATION, GREEN TAGS – A NEW WAY TO MARKET RENEWABLE ENERGY (2004), *available at* http://www.b-e-f.org/lib/pdf/BEF_new_re_product.pdf.

119. EPA Green Power Partnership, Renewable Energy Credits (RECs), http://www.epa.gov/greenpower/gpmarket/rec.htm (last visited May 29, 2009).

120. "New" refers to eligible facilities beginning operation or repowering after January 1, 1997. GREEN-E, NATIONAL STANDARD VERSION 1.6 5 (2008), *available at* http://www.green-e.org/docs/energy/Appendix%20D_Green-e%20Energy%20National% 20Standard.pdf.

121. Press Release, Green-e Marketplace, *The Philadelphia Phillies Join Green-e Marketplace with 100% Renewable Energy Purchase* (May 7, 2008), *available at* http://www.resource-solutions.org/where/pressreleases/2008/050708.htm.

122. *See generally* NATIONAL STANDARD, *supra* note 120.

123. *Id.* at 4.

124. *Id.* at 7.

125. *Id.*

The cost of certification may prohibit some producers of renewable energy from seeking certification; and (4) The possibility of earning RECs may be wholly eliminated if and when a state's RPS targets increase, thereby outpacing the production of renewable energy. First, there is no national unified specification process for certifying RECs.[126] Each firm that engages in certification may apply different standards and definitions. "Green" energy may be achieved in fifty different ways, for each of the fifty states. Second, the U.S. does not have a national registry for RECs issued. This creates a risk of double-counting because several certification and accounting organizations are tracking the RECs.[127] The outcome could very well create an environmental farce: The purchaser of a double-counted REC on the open market would not really be paying for the 1,000 kWh of renewable energy that was allegedly produced. Third, the certification and verification firms are for-profit businesses, charging fees up to $4,000[128] for certification of renewable energy. The median price of a REC in 2006 was $20.[129] The certification cost could be a potential barrier to farmers. Perhaps one explanation for some farmers' willingness to accept a small portion of the revenue from RECs and/or carbon credits, while leaving the majority of the revenue to the engineering firm that installs and maintains its anaerobic digester, as occurs with BioEnergy, is that the farmer is trying to avoid the certification costs. It is interesting, and somewhat shocking, that RECs trade on commodity markets, yet the process for their verification at the source is still very much in flux. No national framework governs the certification and verification processes of RECs, and monitoring is conducted by multiple agencies that operate under non-uniform guidelines.[130]

RECs encourage investment in zero-emission projects; they "do not help bring additional renewable energy capacity online" and they do not necessarily promote investment in renewable energy projects and low-GHG emission business improvements such as digesters.[131] Carbon credit trading, in contrast to REC trading, occurs domestically as well as internationally, and in more uniform methods and established markets.[132] The market price in carbon trading is higher than in RECs; the average price of one ton of carbon trades, at the time this article was written, on the Chicago Climate Exchange for

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126. Prabhu Dayal, *National Renewable Portfolio Standard (RPS) for Renewable Energy Credits (RECs)?*, UTILIPOINT INT'L INC. ISSUE ALERT, Apr. 30, 2007, *available at* http://www.ctrade.org/Images/rps.pdf.

127. EPA Green Power Partnership, *supra* note 119.

128. Green-e.org, Green-e Energy Certification Fees, http://www.green-e.org/getcert_re_obli_fees.shtml (last visited Apr. 1, 2009).

129. Andrew Kolchins, *Overview of REC Markets and Pricing, Workshop of REC Markets and Challenges*, Sept. 11, 2007, *available at* http://apps3.eere.energy.gov/greenpower/resources/pdfs/0907_rec_kolchins.pdf.

130. EPA Green Power Partnership, *supra* note 119.

131. Jeremy Elton Jacquot, *Shining a Light on the RECs vs. Carbon Offsets Controversy*, Treehugger, Jan. 24, 2008, *available at* http://www.treehugger.com/files/2008/01/shining_a_light_carbon.php.

132. *Id.*

$7.30, and when that figure is adjusted for CO_2Eq. for methane, the price jumps to $131.40.[133]

In addition to carbon credits, the Chicago Climate Exchange trades GHG Emissions Offsets, which represent the displacement of GHGs that would have been emitted had the renewable energy project not been in service.[134] To be eligible for an Emission Offset, the applicant "must provide evidence of clear ownership rights (via contract) to the environmental attributes associated with the renewable energy generation and should be able to attest that the energy generated by the renewable energy has not been sold as 'green.'"[135] This is how engineering firms that are installing methane digesters at no cost to farmers can claim ownership of the offset. Emission Offsets involve long-term purchase agreements and generally sell for 40% of the price of one ton of carbon, or about $3.50 per ton of CO_2Eq.[136]

IV. ISSUES TO CONSIDER IN THE FORWARD PUSH TO REDUCE MANURE METHANE

The pioneers of the 1970s and 1980s farmers who installed methane digesters on their dairies and swine operations laid the foundation for today's policy-makers, engineers, and modern farmers to craft an infrastructure for renewable energy from manure methane. This infrastructure balances political, economic, legal, and logistic concerns, and is very much a work in progress. Federal programs remain entirely voluntary. States have approached the issue from the demand side, requiring greater amounts of renewable energy in their energy portfolios. This has created an incentive for farmers to install anaerobic digesters. The marriage between engineering firms in the private sector and public programs that assist with capital continues to be the driving force behind the current expansion of renewable energy generation from anaerobic methane digesters.

The onus, at this juncture in time, is shifted to legislators to guide, for example, public utilities to provide better incentives that will successfully lead to more farmers' investment in anaerobic technology. First, net metering laws should be modified so that banked credits for net metered surpluses of energy do not continue to be erased at the end of the year. Why not allow these credits to be carried forward to the next year? Why not compensate the farmer for surplus energy generated? Second, utility companies should reconsider the current model of pricing schemes of the purchase contracts under which dairies sell energy (to the utility companies). The traditional

133. Chicago Climate Exchange, CFI Market Data Charting Tool, http://www.chicagoclimatex.com/market/data/summary.jsf (last visited Mar. 29, 2009). The carbon price per ton is multiplied by 18, not by 21, even though methane is 21 times as efficient at heat-trapping as carbon. *Id.*

134. Chicago Climate Exchange, Renewable Energy Emission Offsets, http://www.chicagoclimatex.com/docs/offsets/CCX_Renewable_Energy_Offsets.pdf (last visited Mar. 29, 2009).

135. *Id.*

136. *Id.*

wholesale-retail sale structure offers little financial incentive to the customer-generator, i.e, the farmer. Without the potential for tangible gain, agri-business investment in methane digester technology will be minimal at best.

In addition to fine-tuning the existing structures of net metering and contract requirements, legislators could also take a preemptive approach to curbing GHG emissions: Create rules and laws that tax emitters of methane, among other GHGs and particulates, i.e., dairies and other CAFOs.[137] Through permit fees and fines, dairy farmers would be forced into compliance with methane emissions caps. This could be accomplished by farmers either installing anaerobic digesters notwithstanding receipt of some financial assistance, or liquidating the farm. The latter would likely occur for those who could not afford to pay permit fees or penalties. This preemptive approach, however, would be certain to trigger a cascade of events, severely changing the face of dairy industry related industries. Particularly hard hit would be states with dairy-rich economies, like California and Wisconsin. Legislators and agencies should tread great with caution in taking this drastic preemptive approach.

For example, on November 28, 2008, the EPA closed the comment period after the Advanced Notice of Proposed Rulemaking for a rule proposal in which the EPA would regulate GHGs under the Clean Air Act.[138] Of specific import to this paper is the section of the rule that would require emitters of annual excesses of 100 tons of methane or other GHGs to obtain a permit. "Any dairy farm with more than 25 cows or any beef operation with more than 50 cattle would be potential emitters of that 100-ton magnitude."[139] At $43.75/ton/year, that is approximately $175 per cow, $87.50 per head of beef cattle, and $20 per hog.[140] "The average U.S. dairy farm, which now milks 155 cows, would be facing a $27,000 annual GHG permitting fee."[141] In California, the annual permit fee for the average dairy farm would be $158,000.[142] Unless standard prices for dairy, beef, pork, and poultry items were adjusted upward to compensate for at least some portion of these new operation costs, such permits would be cost-prohibitive to many farms' continued operation throughout the United States.

These permit fees seem poorly tailored to achieve the EPA's stated goal of reducing manure methane from dairies and other CAFOs because of their potentially dire indirect effects on agricultural economies. Non-compliance could realistically lead to liquidation, and widespread liquidation would lead to

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137. TheCattlesite.com, *The Gas Tax: EPA May Cost $175 per Cow* (Nov. 28, 2008), http://www.thecattlesite.com/news/25280/the-gas-tax-epa-may-cost-175-per-cow.

138. Regulating Greenhouse Gas Emissions Under the Clean Air Act (Advance Notice of a Proposed Rule-Making), 73 Fed. Reg. 44,354. (proposed July 30, 2008) (to be codified 40 C.F.R. ch. 1).

139. *Id.*

140. *Id.*

141. *Id.*

142. Based on the 2006 average herd size of 908 milking cows in California. Cooley, *supra* note 25.

some degree of economic collapse within the dairy industry and related sectors.[143] Supposing, hypothetically, that farmers were able to pay their annual permit fees to emit manure methane, that cost would get passed on to consumers in the marketplace and methane would continue to be released into the atmosphere. In either case, these EPA permit fees and penalties merely pass the buck to other sectors of society, in the forms of financial burden to farmers and consumers, and an unresolved and unmitigated GHG emission issue.[144]

Next, there is a question as to the reliability of cow methane emissions estimates that policymakers have relied on until now. Recent independent scientific research indicates that enteric fermentation in ruminants, like cows, is actually much less than originally believed, and that different animal diets cause varying levels of methane emissions in ruminants.[145] The same research informs that the feedstuffs stored on CAFOs for cows and livestock actually emit greater quantities of GHGs than manure methane and enteric fermentation.[146] These two facts alone suggest that the current estimates of animal and manure emissions, on which policymakers and public agencies rely today, may be more than just slightly inaccurate. If true, permit fee structures and penalties that are to be applicable to farmer-emitters of methane must be reconfigured to reflect with more accuracy cow and manure methane emissions. Flat permit fees on a per animal basis would be inadequate given that animals produce methane at differing levels. More research and peer review needs to be done on the rates of methane emission from the parameters of enteric fermentation and manure management in order for subsequent laws to be soundly and fairly enacted.

It is imperative that policymakers and agencies, like the EPA, and local air quality control boards, harmonize their efforts to reduce GHGs in a way that provides for sustainable dairying and livestock raising. Air quality control boards regulate emitters of smog and volatile organic compounds (VOCs), which form ozone, and include fine dust particulates, carbon dioxide, methane gas, and nitrous oxide, among others.[147] In regions of the US, including the San Joaquin Valley in California, that are non-attainment areas for federal

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143. John Hart, *Clean Air Act Not the Place for Greenhouse Gas Regulation*, North Dakota Farm Bureau, Sept. 1, 2008, *available at* http://www.ndfb.org/news/detail.asp?newsID=965. "USDA predicted dire results for farmers if the proposed changes are implemented, such as higher input costs and regulatory burdens. Consumers will likely feel the pinch as well, due to higher food prices and reduced domestic food supplies." *Id.*

144. *Id.*

145. Neal Van Alfen, Dean, C. of Agric. and Envtl Sci., UC Davis, *Keynote Address at the University of California Davis Air Quality Research Center Stakeholders Conference: Strategies for a Environmentally Sustainable Future for Dairies*, page 12 (June 2, 2008), *available at* http://airquality.ucdavis.edu/pages/events/2008/green_acres/VANALFEN.pdf.

146. Lowry A. Harper, METHANE EMISSIONS FROM GRAZING AND FEEDLOT CATTLE: MEASUREMENT, TREATMENTS, AND RESULTS [abstract]. Society for Rangeland Management 58th International Annual Meeting, Fort Worth, Texas, Feb. 7-11, 2005.

147. California Air Resources Board, Apr. 3, 2009, *available at* http://www.arb.ca.gov /html/mission.htm.

standards of ozone, the local air quality standards are higher.[148] For example, new emitters of smog-causing agents are subject to stricter emissions guidelines than those applied to existing emitters. This was the case for one particular dairy and cheese plant in Central California.[149] The dairy owner installed a $3-million methane digester on a 3,000-cow dairy, which would reduce his methane emissions from manure by 80%. However, the local air quality control board has prevented him from operating his digester because the engine powered by his dairy's manure methane emits smog-causing nitrous oxide in excess of the strict permissible guidelines[150] he is subject to as a new emitter.[151] This presents a *Catch-22* situation: tremendous amounts of methane will continue to waft into the atmosphere while a modern anaerobic digester sits idle.[152] This is an unfortunate situation. Policymakers and permit granters must harmonize their sometimes non-complimentary objectives so that the direct and indirect benefits of operating methane digesters can be quantified and weighed against those of local air quality control guidelines.

Last, inroads are being made with long-term purchase agreements in a handful of jurisdictions, and this gives dairy farmers confidence that an investment made in a methane digester is an economically sound one. In addition, programs such as that offered by BioEnergy Solutions and other similar firms throughout the nation, in which the farmer incurs no cost to install a digester, are likely to continue to meet eager embrace in the dairy sector in the upcoming months. The potential to generate substantial amounts

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148. San Joaquin Valley Air Pollution Control District, Apr. 20, 2009, *available at* http://www.valleyair.org/index.htm. In a press release from Sept. 25, 2008, the EPA approved California's request to redesignate the San Joaquin Valley Air Basin as an attainment area meeting national ambient air quality standards for PM-10, coarse particulate matter. This came after many years of the area being a non-attainment area. The enforcement of strict rules and regulations on emissions helped bring about the change.

149. John Holland, *Fiscalini Plan to Turn Methane Into Energy Runs Into Air Problems*, MODESTO BEE, July 12, 2008, *available at* http://www.modbee.com/ag/story/357872.html.

150. *See* SHERAZ GILL & RAMON NORMAN, AIR POLLUTION CONTROL OFFICER'S REVISION OF THE DAIRY VOC EMISSIONS FACTOR, SAN JOAQUIN VALLEY UNIFIED AIR POLLUTION CONTROL DISTRICT 6 (2010), *available at* http://www.valleyair.org/busind/pto/dpag/2010_VOC_Jan/Draft%20Dairy%20EF%20Report%20%281-14-10%29.pdf. Dairies and all other sources of agricultural sources of air pollution in the San Joaquin Valley were exempt from district permitting requirements until 2004. Along with the elimination of the permit exemption, regional dairies also became subject to "New Source Review" requirements, which included a requirement to utilize Best Available Control Technology (BACT) to new and expanding operations.

151. San Joaquin Valley Air Pollution Control District, Fiscalini Farms & Fiscalini Dairy Permit No. N-6311-9-0, *available at* http://www.valleyair.org/busind/pto/dpag/ATCs%20for%20Digester%20System%20at%20Fiscalini%20Farms.pdf (last visited Feb. 12, 2010). The permit, which reflects the new stricter guideline, instructs that nitrous oxide pollution from the digester's engine shall not exceed more than nine (9) parts per million volume dry (9.0 ppmvd).

152. *See* Catherine Merlo, *The Dark Side of Digesters: Regulatory Obstacles Curb Digesters' Future in California,* DAIRY TODAY, Mar. 6, 2009, *available at* http://www.agweb.com/dairytoday/Article.aspx?id=149577. The Fiscalini project was delayed by cost overruns and contemporaneous regulatory changes, and the completion of the project took twice as long as expected. The process was further frustrated by the tension between the permissible pollution emission limits and the need to locate an internal combustion engine to power the digester.

of renewable energy while reducing methane emissions from manure management is impressive. Although the existing carbon and renewable energy markets are still developing, the possibility of trading RECs, carbon credits, and emissions offsets from methane gas reductions from manure management, just may prove to be the next Gold Rush of California.

VI. CONCLUSION: MANURE METHANE OR BUST!

The generation of renewable energy from manure methane has grown steadily in dairy and livestock agribusiness throughout the nation since 1994.[153] It is the direct result of partnerships across private industry, the energy sector, agribusiness, public agencies, and legislation. In California, the boom has been seen only more recently, as the populous state leads the nation with its rigorous RPS plan and current environmentally-aware administration.[154] The chronicles of renewable energy from anaerobic digestion of manure methane are sure to expand, provided the multiple agencies working to mitigate methane emissions coordinate their efforts in a complimentary fashion from this point forward. In addition, regular reassessment of cow and manure emissions estimates, on which forthcoming regulations are to be based, as well as review of current incentive structures that utility companies offer consumer-generators of energy, are two necessary measures to ensure optimal growth in renewables and reduction of ambient methane from manure.

Methane from manure could possibly be California's next Gold Rush because of the environmental wealth its widespread adoption promises. Anaerobic methane digesters can realistically (1) reduce dairy and livestock CAFOs' manure methane outputs by 80%; (2) provide for all or nearly all the CAFOs' energy needs, displacing daily demands on electric utility grids; (3) provide for the heating needs of the CAFOs, i.e., hot water for daily washing of barns and milking equipment, thereby displacing the demands on gas utilities for heated water; (4) abate flies and odor; and (5) generate to farmer-producers of energy additional revenue from excess energy sold, RECs and carbon credits.

The dairy industry is California's leading agricultural commodity, and in 2007, it provided the labor market 435,000 full-time jobs and generated $61.4 billion in economic activity.[155] One-fifth of the nation's milk is produced in California.[156] Given the dairy industry's significance to the respective sectors of the economies of California and the United States, it is essential that climate change policies adopted have the effect of encouraging widespread dairy participation while keeping dairying a viable business and livelihood.

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153. *See infra* app. figs.5 & 6.
154. *See supra* notes 73, 75, 86, and 101.
155. California Milk Advisory Board, *supra* note 22.
156. *Id.*

APPENDIX OF TABLES AND FIGURES

Table 1. Methane (CH_4) is 21 times more effective at trapping heat than is carbon dioxide.[157]

TABLE 3-1 Global Warming Potentials (100 Year Time Horizon) Used in This Report

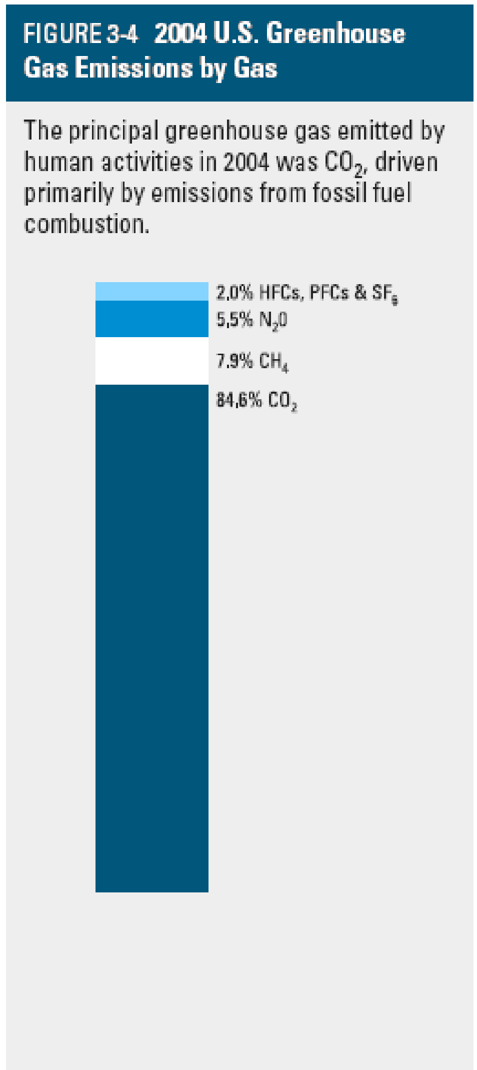
The concept of a global warming potential (GWP) has been developed to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. Carbon dioxide was chosen as the reference gas to be consistent with IPCC guidelines.

Gas	GWP
CO_2	1
CH_4*	21
N_2O	310
HFC-23	11,700
HFC-32	650
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
HFC-4310mee	1,300
CF_4	6,500
C_2F_6	9,200
C_4F_{10}	7,000
C_6F_{14}	7,400
SF_6	23,900

* The methane GWP includes the direct and indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.
Source: IPCC 1996b.

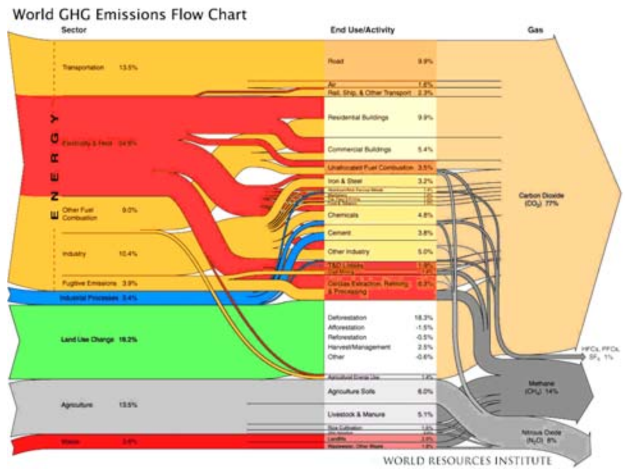
157. *See* GHG INVENTORY, *supra* note 1, at 19 tbl.3-1.

Figure 1. Anthropogenic sources of methane accounted for 7.9% of the total U.S. GHG emissions in 2004, measured in carbon dioxide equivalent, down from about 9% in 2001.[158]



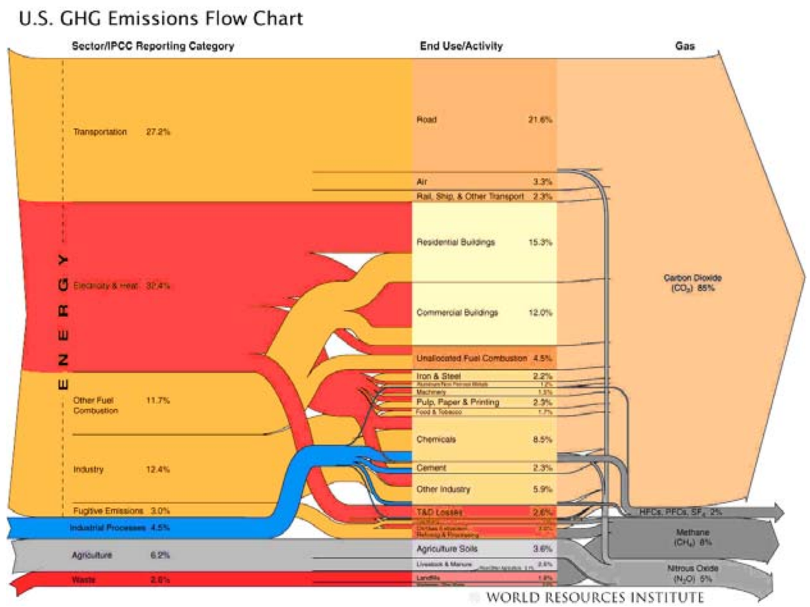
158. *See* GHG INVENTORY, *supra* note 1, at 21 fig.3-4.

Figure 2. Carbon dioxide is the biggest contributor to world green house gases, accounting for 77% of the world's GHG emissions.[159] (Compare with Figure 3.)



159. World Resources Institute, Climate Analysis Indicators Tool, Charts & Figures, http://cait.wri.org/figures.php (last visited May 25, 2009).

Figure 3. In 2004, carbon dioxide accounted for 85% of the total GHG emissions in the U.S. Over half all GHG gas emissions in the U.S. came from the transportation and energy sectors.[160]



160. World Resources Institute, *supra* note 159.

Table 2. Sources of methane gas, measured in carbon dioxide equivalent.[161]

TABLE 3-4 AND FIGURE 3-8 2004 U.S. Sources of CH_4 (Tg CO_2 Eq.)

Methane accounted for 7.9 percent of U.S. greenhouse gas emissions in 2004. Landfills were the largest anthropogenic source of CH_4, representing 25 percent of total U.S. CH_4 emissions.

Gas/Source	1990	1998	1999	2000	2001	2002	2003	2004
Landfills	172.3	144.4	141.6	139.0	136.2	139.8	142.4	140.9
Natural Gas Systems	126.7	125.4	121.7	126.7	125.6	125.4	124.7	118.8
Enteric Fermentation	117.9	116.7	116.8	115.6	114.6	114.7	115.1	112.6
Coal Mining	81.9	62.8	58.9	56.3	55.5	52.5	54.8	56.3
Manure Management	31.2	38.8	38.1	38.0	38.9	39.3	39.2	39.4
Wastewater Treatment	24.8	32.6	33.6	34.3	34.7	35.8	36.6	36.9
Petroleum Systems	34.4	29.7	28.5	27.8	27.4	26.8	25.9	25.7
Rice Cultivation	7.1	7.9	8.3	7.5	7.6	6.8	6.9	7.6
Stationary Sources	7.9	6.8	7.0	7.3	6.6	6.2	6.5	6.4
Abandoned Coal Mines	6.0	6.9	6.9	7.2	6.6	6.0	5.8	5.6
Mobile Sources	4.7	3.8	3.6	3.5	3.3	3.2	3.0	2.9
Petrochemical Production	1.2	1.7	1.7	1.7	1.4	1.5	1.5	1.6
Iron and Steel Production	1.3	1.2	1.2	1.2	1.1	1.0	1.0	1.0
Agricultural Residue Burning	0.7	0.8	0.8	0.8	0.8	0.7	0.8	0.9
Silicon Carbide Production	+	+	+	+	+	+	+	+
*International Bunker Fuels**	*0.2*	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
TOTAL	**618.1**	**579.5**	**569.0**	**566.9**	**560.3**	**559.8**	**564.4**	**556.7**

+ Does not exceed 0.05 Tg CO_2 Eq.
* Emissions from international bunker fuels are not included in the totals.

161. *See* GHG INVENTORY, *supra* note 1, at 27 tbl.3-4.

Table 3. Methane parameters. Each parameter's methane contribution to the total methane share of GHG in 1990 and in 2004. The **bold** parameters show an increase in the total share of GHG emissions. Overall, methane emissions have declined from 618.1 TgCO_2Eq. in 1990, to 556.7 TgCO_2Eq. in 2004.[162]

Methane-producing Parameter	Total % of methane share in 1990		Total % of methane share in 2004		Change from 1990
	TgCO_2 Eq.	%	TgCO_2 Eq.	%	%
Landfills	172.3	27.9	140.9	25.3	-18
Natural Gas Systems	126.7	20.5	118.8	21.3	-6
Enteric Fermentation	117.9	19.1	112.6	20.2	-4.5
Coal Mining	81.9	13.2	56.3	10.1	-31
Manure Management	**31.2**	**5.0**	**39.4**	**7.1**	**+26**
Wastewater Treatment	**24.8**	**4.0**	**36.9**	**6.6**	**+49**
Petroleum Systems	34.4	5.6	25.7	4.6	-25
Rice Cultivation	**7.1**	**1.1**	**7.6**	**1.4**	**+7**
Stationary Sources	7.9	1.3	6.4	1.1	-19
Abandoned Coal Mines	6.0	~2.3	5.6	~2.2	n/a
Mobile Sources	4.7		2.9		
Other	~3.2		~3.5		
TOTAL	618.1	100%	556.7	100%	-10

162. *See* GHG INVENTORY, *supra* note 1, at 27 tbl.3-4.

Figure 4. Graph showing sources of methane gas, which collectively accounted for 7.9% of the total U.S. GHG emissions in 2004.[163]

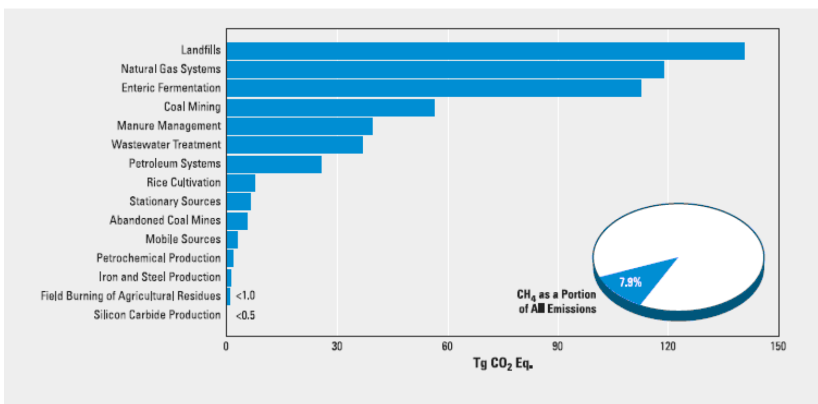
TABLE 3-8 AND FIGURE 3-13 U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (Tg CO_2 Eq.)

In 2004, U.S. greenhouse gas emissions from electricity generation accounted for one-third of total greenhouse gas emissions, and the transportation sector accounted for almost 28 percent.

Economic Sector	1990	1998	1999	2000	2001	2002	2003	2004
Electricity Generation	1,846.4	2,202.4	2,213.3	2,315.9	2,284.4	2,280.1	2,308.5	2,337.8
Transportation	1,520.3	1,753.4	1,819.3	1,866.9	1,852.7	1,898.0	1,898.9	1,955.1
Industry	1,438.9	1,452.4	1,411.0	1,409.7	1,366.6	1,346.7	1,342.7	1,377.3
Agriculture	486.3	541.6	523.9	509.5	514.4	511.0	484.2	491.3
Commercial	433.6	428.0	430.6	443.0	439.5	447.5	466.5	459.9
Residential	349.4	353.3	372.6	390.4	381.6	380.1	399.8	391.1
U.S. Territories	33.8	42.7	44.2	46.9	54.0	52.4	58.6	61.9
Total	**6,109.0**	**6,773.7**	**6,814.9**	**6,982.3**	**6,893.1**	**6,915.8**	**6,959.1**	**7,074.4**
Land Use, Land-Use Change, and Forestry	(910.4)	(744.0)	(765.7)	(759.5)	(768.0)	(768.6)	(774.8)	(780.1)
Net Emissions (Sources and Sinks)	**5,198.6**	**6,029.6**	**6,049.2**	**6,222.8**	**6,125.1**	**6,147.2**	**6,184.3**	**6,294.3**

Notes:
Parentheses indicate negative values or sequestration. The net CO_2 flux total includes both emissions and sequestration, and constitutes a sink in the United States. Sinks are only included in the net emissions total.
Totals may not sum due to independent rounding. Emissions include CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6.

Table 4.[164]



163. *See* GHG INVENTORY, *supra* note 1, at 27 fig.3-8.
164. *Id.* at 32 tbl.3-8.

Figure 5. Figure created in 2007.[165]

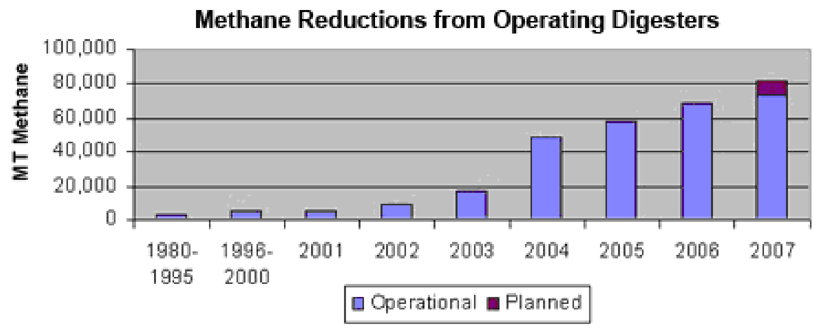
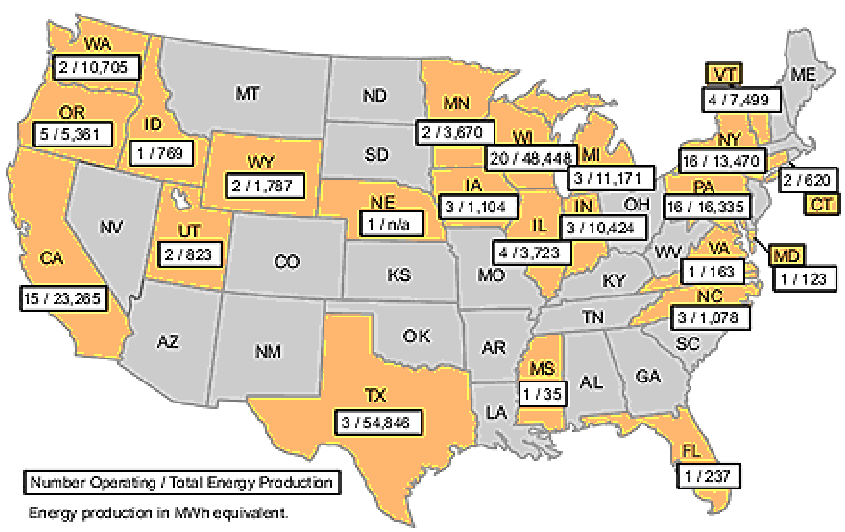


Figure 6. Figure created in 2007, indicating the number of operating methane digesters (including those funded privately, through state initiatives, and through AgSTAR) and megawatt-hours of energy production from those digesters.[166]



165. AGSTAR ACCOMPLISHMENTS, *supra* note 41.
166. *Id.*

Figure 7a. Photo of a plug flow digester next to a covered barn. The floating cover is billowing with 14-21 days worth of methane gas that is trapped underneath.[167]

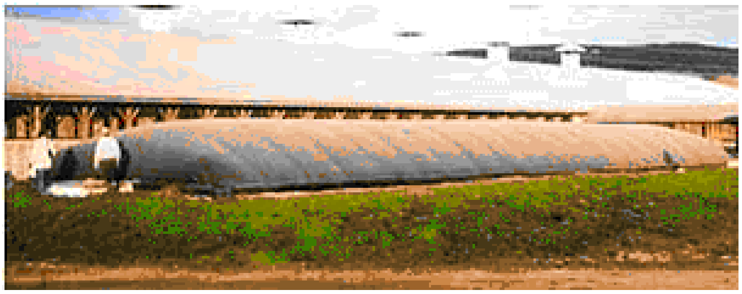
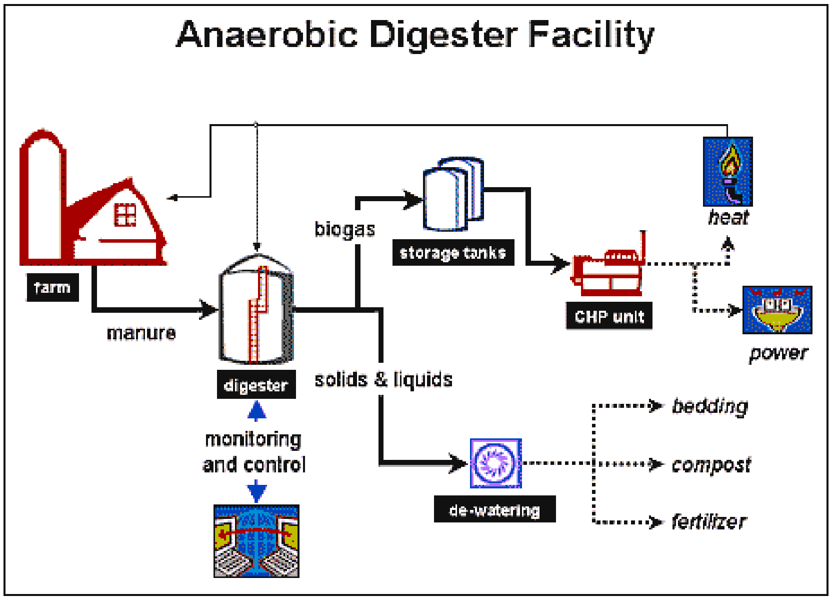


Figure 7b. Photo of a methane digester. It processes manure at a dairy with 800 cows, producing 775 kW of electricity. This is enough to power 600 homes.[168]

167. The photo in Figure 7a is from AA Dairy, a 550-cow milking herd in Candor, New York, *available at* http://www.epa.gov/agstar/profiles/aa_dairy.html (last visited Mar. 12, 2009).

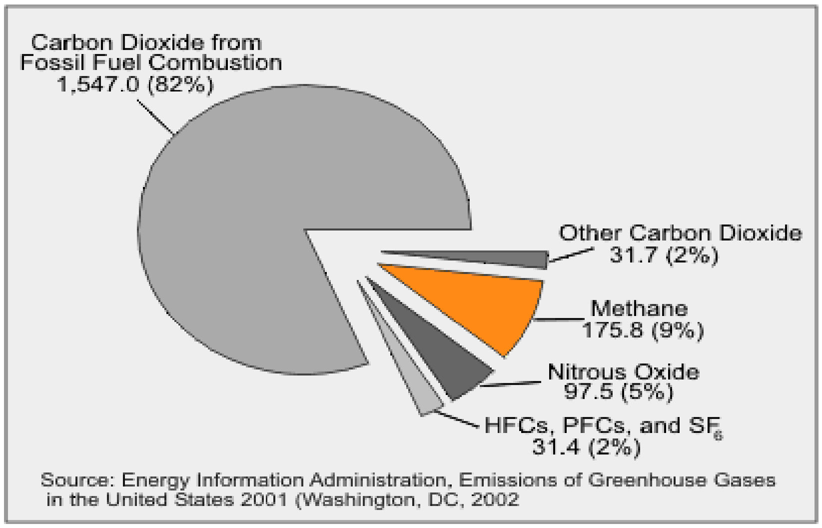
168. The photo in Figure 7b is from Five Star Dairy in Elk Mound, Wisconsin, *available at* http://farmenergy.org/success/anaerobicdigesters_five_star.php (last visited Mar. 12, 2009).

Figure 8. Beginning at the farm, follow the cycle of methane use for energy.[169]



169. Waste Management in Toronto, http://www.freewebs.com/torontowaste/newwastemanagementmethods.htm (last visited Mar. 14, 2009).

Figure 9. U.S. Anthropogenic Greenhouse Gas Emissions by Gas, 2001.[170]



170. The number in parenthesis measures million metric tons of carbon equivalent. ENERGY INFORMATION ADMINISTRATION, GREENHOUSE GASES, CLIMATE CHANGE & ENERGY (2008), *available at* http://www.eia.doe.gov/oiaf/1605/ggccebro/chapter1.html.