Opportunities for Greenhouse Gas Emission Reduction In The Agricultural Sector Of Sonoma County

Community Climate Action Plan

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Overview

Agricultural activities affect our environment in many ways, including the direct production of greenhouse gases (GHGs). In no other sector of this Community Climate Action Plan (CCAP) is the relationship of emissions, sequestration and sources as dynamic as it is in agriculture. It is estimated that agricultural practices contributed 25 percent, 65 percent, and 90 percent of the historical anthropogenic emission of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), respectively, during the past two centuries.[1] In 2004, the US EPA estimated that agriculture contributed approximately 7% of the U.S. greenhouse gas emissions (in carbon equivalents, or CE), primarily as CH_4 and N_2O. While agriculture represents a small but relevant source of greenhouse gas emissions, it has the potential, with new practices, to also act as a sink, tying up or sequestering CO_2 from the atmosphere in the form of soil and wood carbon.[2] Some estimates calculate that terrestrial ecosystems now absorb approximately 10 percent of the annual GHG emissions from fossil fuel combustion.[3]

County Assessment

In Sonoma County, agriculture is synonymous with wine and cheese. Vineyards and dairies account for most agricultural activity in the county, both for land used and revenues generated. Total greenhouse gas emissions from the agricultural sector are a result of a complex network of sources, such as livestock, agricultural equipment, fertilizer application, soil tillage, crop residue burning, land conversion for agricultural use, processing, refrigeration and distribution. For this reason, calculating the GHG emissions from the agricultural sector of Sonoma County is more demanding than for other sectors in this plan. In 2005, the GHG Emission Inventory for Sonoma County[4] determined that the complexity of calculations would prevent inclusion of agricultural activities other than livestock. It is worth noting that standard software used by local governments to track GHG emissions[5] does not include an agriculture section, likely because of the complexities of accounting cited above, and because most communities that conduct GHG inventories are urban.

According to the 2005 inventory, emissions from livestock, primarily methane from belching, flatulence, and manure, followed by nitrous oxide from nitrogen compounds that are released as manure decomposes, accounted for 11 percent of the county-wide emissions.

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[1] Dubury, John M. "The Significance of Agricultural Sources of Greenhouse Gases," pp. 151-163, *Nutrient Cycling in Agroecosystems* , June, 1994.

[2] Lal, R. "Soil Carbon Sequestration Impacts on Global Climate Change and Food Security," pp. 1623-1627, Science, June, 2004.

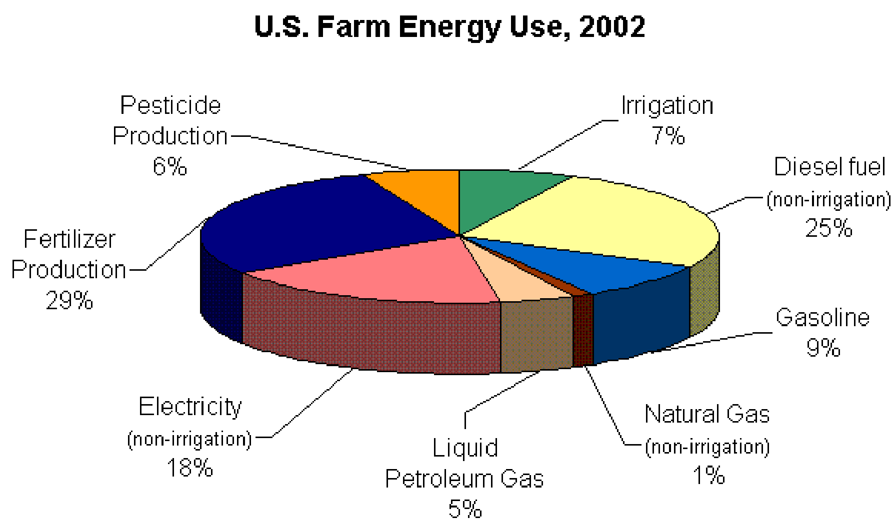
[3] Watson, R. T., M. C. Zinyowera, et al., eds. *Climate Change 1995—Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses*. New York: Cambridge University Press. 1996.

[4] Climate Protection Campaign. "Greenhouse Gas Emission Inventory for all sectors of Sonoma County, California." January, 2005.

[5] A US EPA spreadsheet tool supplied by Ryan Bell, ICLEI, was used for the inventory.

GHG emissions from Livestock	1992		2000		% Δ
Methane (CH_4) - tons	20,813		19,863		-5
Methane converted to eCO_2- tons[6]		437,066		417,115	-5
Manure-related nitrogen emissions (nitrous oxide) converted to eCO_2 - tons		7,624		7,925	+4
Total GHG (equivalent CO_2 - tons)		**444,690**		**425,040**	**-4**

The 2005 inventory also showed that there was a reduction in GHG emissions related to livestock from 1992 to 2000. This trend has continued due to the fact that dairy and beef production in the county continues to shrink. However, during this same time, the wine grape industry has consistently grown, by almost 10 percent in land use. Other activities that contribute to GHG emissions, like irrigation, fertilizer and chemical use, have also steadily increased over the same period. The following graphic represents average farm energy use distribution[7].



Notes: Total energy use for agricultural production in 2002 was 1,691 trillion Btu. This includes direct farm energy use of 1,113 trillion Btu and 578 trillion Btu for pesticide and fertilizer production. Diesel and gasoline are used in farm vehicles for mechanized planting, tilling, chemical applications, disking, and harvesting. Liquid petroleum gas and natural gas are used in large part for drying grains. Electricity is used primarily for stationary activities, such as facility operations and dairies. Energy for irrigation comes from electricity, diesel, and natural gas.

Source: Compiled by Earth Policy Institute from USDA; USDOE; Duffield; Miranowski

[6] Equivalent CO_2 – tons.

[7] This chart represents *total energy* aggregated by agricultural end use. The Sonoma County inventory uses the principles of corporate boundary setting to aggregate direct and indirect emissions. Thus the electricity, natural gas and fuel use impacts are accounted for under their respective sectors. The impacts of production of pesticides and fertilizers are outside of the scope of the inventory.

Considering the winegrape industry currently uses 35 percent of the county's farmland[8], it is safe to assume that all agricultural activities not accounted for in the 2005 inventory contribute a significant additional percentage of emissions. Even though the impacts are still not quantified, there is great potential for GHG reduction through CO_2 sequestration, enhanced agricultural practices, and efficient processing and distribution techniques. Some vineyards in the County have taken global climate change seriously and have aggressively pursued carbon neutral practices. More detailed analyses of climate friendly practices pursued by the winegrape industry are included later in this report.

Opportunities for GHG Reductions

While the sources are difficult to quantify, opportunities for GHG reduction in the agricultural sector are directly related to farming practices, social, and governmental change. In no other section of this plan are the GHG emissions so directly deeply rooted in biology. Thus, agricultural systems can be manipulated for the dual benefits of reducing greenhouse gas emissions and enhancing carbon sequestration through improved soil and irrigation practices, agricultural waste management, biogas capture and energy production, and restructuring the local food supply network. All of these issues require a multifaceted approach that will require community and governmental support. The following list of opportunities will be addressed in this report.

- Soil and irrigation practices
- Composting agricultural wastes
- Methane capture and dairy energy production
- Biomass fuel production
- Processing and operational efficiency
- CO_2 sequestration
- Land use and agricultural policies

The opportunities listed above far outweigh the potential barriers to agricultural GHG reduction in the county. These potential barriers include such issues as resistance to change, lack of funding, and current, outdated policies. All of these perceived threats can be addressed with constructive education and community mobilization about the issue in question. In doing so, it can be shown that supporting agricultural goals of minimizing GHG emissions and maximizing CO_2 sequestration can increase efficiency, production, and economic stability to our local farming community.

Soil and Irrigation Practices

Soils are the foundation of health in all terrestrial ecosystems. This thin layer of organic matter is where nutrients are absorbed to support the entire biotic pyramid. Soils can store carbon for long periods of time as stable organic matter, which reaches an equilibrium level in natural systems determined by climate, soil texture, and vegetation. If soils are disturbed by agricultural tillage or residue burning, large amounts of CO_2 are re-

[8] Sonoma County Agricultural Crop Report, 2006.

leased.[9] However, a significant portion of this carbon can be sequestered by soils managed with no till farming and other techniques. Proper irrigation can enhance carbon sequestration over native soil levels by overcoming the moisture limitation to increased plant biomass production.

Agriculture practices affect the nitrogen cycle as well. Nitrogen is more prone to being lost to ground or surface water and the atmosphere through application of nitrogen fertilizers, monocropping, and improper water management. N_2O, a common emission from agricultural soils, is a potent greenhouse gas (296 times more warming potential than CO_2) that has increased in atmospheric concentration by 17% during the past two centuries.[10] Reductions can be achieved through improved nitrogen management and irrigation water management because N_2O is generated under both aerobic conditions (where nitrification occurs) and anaerobic conditions (where denitrification occurs) in the soil.

Since the 1950's, agricultural practices began shifting toward large monocultures with increased soil amendments of synthetic fertilizers. From 1987 to 2002, there was a linear increase in the use of fertilizers and chemicals in Sonoma County,[11] which corresponded to the increase in acreage of vineyards. However, the Sonoma County Winegrape Commission (SCWC) has been taking steps to reverse the trend of increased use of nitrogen fertilizers, as well as educate its members about sustainable farming practices.

The SCWC was formed in 2006 as a non-profit marketing and educational organization, voted into existence by the Sonoma County Grape Growers Association (SCGGA). With increased funding assessed from county grape sales, the SCWC intends to continue SCGGA programs such as the Code of Sustainable Winegrowing, the Organic Producers' Group, Integrated Pest Management, and employee development programs aimed at educating about irrigation and other practices. Proper drip irrigation and time of watering can save thousands of gallons, dollars, and consequently, tons of emissions per year. With the help of these programs, the SCWC reported that pesticide use has decreased since 2002, even with the increase in acreage planted.[12]

In addition to the work on pesticide use, the SCWC also has promoted sustainable farming practices through workshops on Erosion Control Practices for vineyard owners and

[9] Allmaras, R.R. et al. "Soil organic carbon and ^{13}C abundance as related to tillage, crop residue, and nitrogen fertilization under continuous corn management in Minnesota," pp. 127 - 142, *Soil& Tillage Research* ,Vol. 55, No. 3, June, 2000.
[10] IPCC "*Climate Change 2007 - The Physical Science Basis*
Contribution of Working Group I to the Fourth Assessment Report of the IPCC
[11] USDA, National Agricultural Statistics Service, County Census Datum.
[12] Sonoma County Agricultural Crop Report, 2006.

employees. This is mostly in response to the Vineyard Erosion and Sediment Control Ordinance (VESCO), adopted by the Sonoma County Board of Supervisors in March, 2000. VESCO requires vineyards to submit an erosion and sediment control plan to the Office of the Agricultural Commissioner prior to planting or replanting.

With increased awareness of climate change, the winegrape industry and the Board of Supervisors should be convinced to take action to promote more climate friendly farming practices pertaining to more stringent soil practices aimed at sequestering and storing carbon stocks rather than releasing CO_2 in to the atmosphere. The SCWC and the County commissioners can continue their effort promoting practices like reducing the amount of disking between vines, nitrogen management and developing a more sustainable county composting program.

Composting

A shift in perspective is needed, not only in the agricultural sector, but in all sectors of our society to view "wastes" as resources. Both winegrape industry and the remaining apple producers of Sonoma County still view pruning debris (canes), unpicked fruit and processing byproducts as "waste" that has to be disposed of in the most cost-effective manner. The most common current practices for the disposal of these "wastes" are land applications of the wastewater, and burning of the canes. These are not the most sustainable methods of dealing with these resources. This represents a linear process thinking rather than closing the loop in the nutrient cycle on the farm. If the "wastes" were viewed as resources, they could capture and reutilize them in the agricultural process to create additional revenue through environmentally friendly marketing opportunities and increased soil health, resulting in increased yields.

Burning old vines and canes releases CO_2 and particulate matter into the atmosphere. Sonoma County should move to outlaw burning of wastes and encourage on-farm composting or small composting centers throughout the county. Ideally the centers would be located centrally per region to minimize transportation of organic material to and from the site. Farm-scale composting (pictured at right), is a practical way to handle organic wastes and produce a stabilized organic soil amendment at the same time. However, it involves specialized techniques for handling and managing large volumes of agricultural and food wastes, paying attention to environmental factors that produce quality humus while avoiding flies and odors. This often makes it not economical to maintain an on-farm composting system.

Currently, Sonoma Compost handles most of the residential green waste in the County. They process 300 tons of material every day in open aerobic piles. If this were processed in an anaerobic digester, most of the emissions could be captured for use in an energy production facility.

It is critical, to evaluate composting and compost in a GHG context. Transport of organics to a "centralized" facility clearly involves fossil fuel use (for now). However, a study by the Recycled Organics Unit[13] states that commercial composting of organic wastes and application of compost to agricultural soils results in net GHG reductions, even if the recycled materials needed to be transported up to 375 miles. The most important factor in this calculation is the offset of using highly energy intensive nitrogen (N) fertilizers. The benefits for compost-based agriculture would be to potentially replace most, if not all, commercial N fertilizer, thus eliminating this highly inefficient use of fossil fuels, but also avoid the over-fertilization of our soils and waterways with N, effectively reducing N_2O emissions, and keeping agricultural money in the local economy. In addition, compost is an incredibly efficient way to get more carbon into our soils quickly. It is common to bring organic matter levels up 2 or 3 percentage points in just 3-5 years with good agricultural practices and compost applications. This represents 3670 pounds of sequestered CO_2 per acre.[14] If the carbon market takes off, organic farmers with increased soil carbon sequestration abilities will have another source for income.

The problem with most small-scale, local composting centers is that they often are not economically viable. Jeff Creque, rangeland and composting expert at McEvoy Ranch, estimated that the optimal situation for Sonoma County would be three or four facilities that are large enough to be economically viable composting centers. These could be situated throughout the county and process all residential “green can” waste, equestrian and most agricultural waste that needs to be processed. Creque stresses that size does matter in composting. “It would be lovely if we lived in a society where all our food and compost was produced next door, but meanwhile, we need to work with economies of scale that DO work; as small as possible, to be sure, but viable,” he says. “I absolutely think everyone with a backyard should have a compost pile, but it is truly naïve to think (all) the material can be handled in small, neighborhood facilities. Having started a couple of such myself, I say that with confidence.”

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[13] http://www.recycledorganics.com/publications/reports/lca/lca.htm
[14] The Rodale Institute Farming Systems Trial®. 2007. http://www.newfarm.org/depts/NFfield_trials/1003/carbonsequest.shtml

Methane and Biogas Digesters

Methane is about 23 times more potent as a greenhouse gas than CO2 and is a major contributor to global warming. According to the U.S. Department of Energy, methane is responsible for about 15 percent of the greenhouse gas buildup in the atmosphere. Most modern dairies utilize a lagoon system for animal waste treatment, a practice that leads to

large emissions of methane and nitrous oxide. Closed-system anaerobic digestion (AD) of the manure has the potential to eliminate most of the lagoon emissions while conserving more nutrients and also producing a renewable energy source. By sealing off the waste storage ponds, or lagoons (pictured below left at Straus Dairy, Marin County), and capturing the methane and other gasses that are produced, the facility can then use the methane to power a generator, and utilize the electricity and waste heat for processes on the farm. In turn, the byproducts of the reaction are water and premium biosolid fibers that can be used as fertilizer or bedding on the farm, or sold for extra profit. Furthermore, this system eliminates most odors associated with the decomposing manure, which can often become an issue as encroaching urban development gets within nose-reach of the dairies.

In Sonoma County, a major source of agricultural waste, and perhaps the most potent emitter of GHG emissions in the agricultural sector, is from dairies. As our second most productive agricultural niche, there are 89 dairies in the county with an average of 330 milk cows at each. A conservative calculation estimates the methane emitted from Sonoma County dairy manure slurry lagoons alone is 180,000 tons of equivalent CO_2 per year.[15] This is roughly half of all the agricultural related methane emissions for the county. With careful legislation and appropriate funding, GHG emissions of this level could easily be avoided, while making it easier for struggling dairies to stay economically viable.

Currently, dairies in the North Bay are regulated by two Regional Water Quality boards: the North Coast Region, which has jurisdiction over operations whose water flows into the Pacific Ocean; and the Bay Area Region, covering operations whose water flows into the San Pablo Bay. However, compliance with regulations is voluntary. Marin and So-

[15] Based on assumptions: 29,000 mature cows, each weighing ~1,400 lb, with 3.65 lb of volatile solids per year in the manure per pound of cow, and a maximum potential for 3.84 cubic feet of methane to evolve per pound of volatile solids. With the further assumptions that 70% of this manure is directed into "lagoons" (probably conservative for the North Bay), and that 90% of the volatile solids therein will typically decompose into methane, the annual result is 358 million cubic feet or 7,900 tons of methane emitted from the natural breakdown of manure. Given methane's global warming potential relative to carbon dioxide of 23 (based upon a 100-year lifecycle), this is approximately 180,000 tons/yr of equivalent CO2. [Reference for methane generation factors: Kenneth Krisch, "*Proposed California Climate Action Registry Protocol for Methane Emissions from California Dairies* (Draft)," Sustainable Conservation: 26 Aug 2002. The original calculation in Ned Orrett's "High Performance Climate Protection," has been modified with updated numbers.]

noma County dairies work cooperatively with the Marin-Sonoma Animal Waste Committee, which consists of ranchers, members of regulating agencies, and representatives of allied industries. One of the primary forms of voluntary compliance is the completion of a ranch plan, which consists of inventories of animals and facilities, a list of planned management practices, and an overview of natural resources. The Sonoma County Board of Supervisors should pass an ordinance that requires all dairies to complete a ranch plan with the inclusion of a biogas digester if they have manure storage ponds on site.

For the average sized dairy in the county, the cost of installing an anaerobic digester (with a 75-80 kW generator) is around $375,000. This initial start-up cost often discourages cash-starved dairy ranchers. However, with state incentives from the CA Energy Commission's (CEC) Self Generation Incentive Plan (SGIP), federal tax incentives, and federal and private agricultural grants, such as the Dairy Power Production Program, the rancher often only has to pay one third of the installation cost. The estimated savings in utility costs for a system this size is $42,000-$60,000 per year, not to mention savings associated with heating, bedding and fertilizer production. For the average sized dairy in Sonoma County, an anaerobic digester could pay for itself in three to five years, virtually eliminating the burden of high utility costs for the dairy.

Another option would be to collect and transport the manure to a larger, centralized biogas digester plant that is operated as part of local renewable resource development[16]. This would be similar to the Ribe Biogas Plant, in Denmark, pictured below. For Sonoma County, funding could be secured through the municipal revenue bonds, with little or no cost to local dairy farmers. The dairy waste could then be mixed with other agricultural, equestrian, food service, residential "green can" wastes and wastewater treatment sludge from around the county to be processed by a utility scale biogas digester.

A vacuum truck transports pathogen free, treated manure slurry from the Ribe Biogas Plant to one of 25 decentralized fertilizer storage tanks. The latter serve the 69 farms from which the manure came, and 72 others. The Ribe Plant receives as its fuel wastes from cattle, pig, poultry, and mink farms, slaughterhouses, and food processors. Energy output (heat and electricity), formerly produced by coal, is sold to the City of Ribe. This is one of approximately 20 such biogas plants in Denmark.

Marin County is looking into an anaerobic digester facility for green waste as part of their Community Choice Aggregation plan to increase their green energy. Supervisor Charles McGlashan's office released a study that estimated a digester facility could produce 6 to

[16] See Energy Solutions online in Source Material for the Sonoma County Community Climate Action Plan.

7 megawatts of power per year, just on Marin's green waste alone. With almost double the population of Marin, Sonoma County could easily support a facility 2 to 3 times larger, if agricultural wastes were included in the fuel mix.

In the meantime, we are already seeing early adapters and innovators in the field of methane capture and utilization in Sonoma's agricultural sector. St. Anthony's Farm, an organic dairy and buttery (and rehabilitation center) west of Petaluma, has recently installed the first dairy anaerobic digester in the County. The 2.5 million gallon covered lagoon is expected to capture 17,000 cubic feet of methane per day. This is the equivalent of 135 tons of CO_2 per year. The methane will be combusted in an 80 kW generator that should offset over sixty percent of the buttery's annual electricity needs.

Although dairies are the biggest emitter, the wastewater storage ponds at wineries also emit methane. When Clos du Bois winery realized this, they installed a digester in their wastewater system to intercept all waste organic material from the winemaking process and capture the methane produced prior to releasing the water into the storage ponds. They use the methane to heat all the hot water needed in this 2 million case per year facility and replace over 75 percent of their natural gas use.

Biomass Fuel Production

The ability to grow a fuel source here in Sonoma County has been highly debated, and often discounted. Ethanol production is not a sustainable option for Sonoma County. It is a high embedded energy fuel that releases tons of CO2 during production and is produced primarily from corn, which can not be commercially grown here. Biodiesel, on the other hand, shows more promise.

Many different oil crops exist including canola (rape seed), mustard, sunflowers, safflower and even algae, all of which can be grown in Sonoma County. The following table lists figures for the various crops, their seed production per acre and the corresponding biodiesel production per acre.[17]

Potential Oil Producing Crops in Sonoma County		
Plant	**Yield** (seed lbs/acre)	**Biodiesel** (gal/acre)
Mustard	1400	61
Safflower	1500	83
Sunflower	1200	100
Canola	2000	127

A mixture of these crops could be grown in the County to supply a central processing plant. Safflower would be the least likely crop to succeed due to disease problems associated with the fog in coastal areas. However, mustard and its close relative, canola, have

[17] Crop figures from USDA/Washing State University "BioFuel Variety Trials." http://www.usda.prosser.wsu.edu/

long been used in orchards and vineyards as cover crops to reduce erosion and increase soil health. In this application, the orchards and vineyards could become dual crop producers, thus increasing their profitability and sustainability.

In the County, there are 172,000 acres of zoned agricultural lands, of which 71,000 are vineyards, apples, various fruits and nuts, and field crops.[18] If oil producing cover crops, such as mustard or canola, were planted and harvested on 65 percent of the 71,000 acres, that could yield between 2.8 and 5.8 million gallons of biodiesel fuel. That is only 27 percent of the county's agricultural lands, most of which could be in-fill, between the rows cover crops. This amount of biodiesel fuel used in county diesel vehicles and busses could offset 30,000 to 60,000 tons of eCO_2 per year.[19] While this amount of fuel will not come close to meeting the needs of Sonoma's diesel fleet, it could prove to be a worthy endeavor.

It is also important to take into account that the processing of the mustard and canola oil plant yields by-products that may be used as natural pesticides, animal feed, and fertilizers. Biodiesel (essentially an esterification conversion) is processed seed oil using methanol and sodium or potassium hydroxide (lye) and the by-product yields glycerin, a component of soap as well as material that can be processed as animal feed or composted.

This brings us back to "closing the loop" in our sustainable cycle. The idea of producing a local fuel oil crop and using the oil in the food service industry, then recycling it in a central biogas digester for fuel is intriguing. The diagram below illustrates the idea, using sunflowers as the oil crop.

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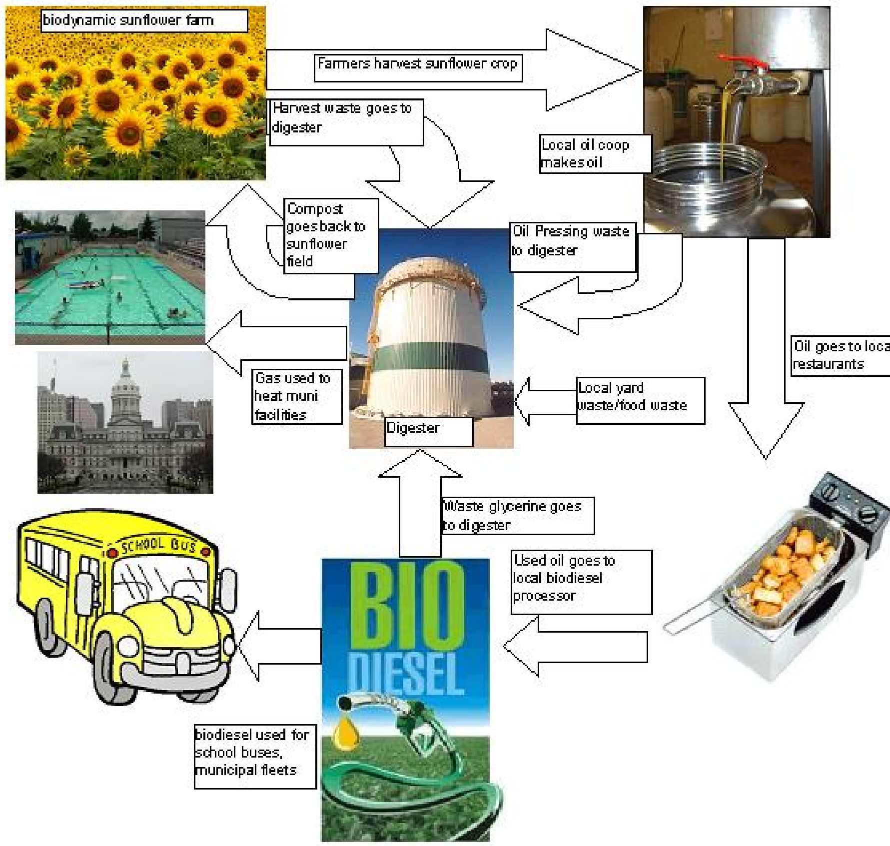
[18] Sonoma County Agricultural Crop Report, 2006.
[19] Based on assumptions: B100 Biodiesel is a carbon neutral fuel and the GHG emission factor for a diesel – heavy truck is: 21.166 lbs eCO_2 per U.S. gallon (CACP software)



This type of progressive thinking is what can propel Sonoma County ahead in reaching goals of climate protection.

The current agricultural "waste" in the County has the potential to be collected, centralized and converted to renewable energy. Orchard and vineyard prunings, pomace, lees and manure are all viable sources of feedstock for renewable energy production. The compost byproduct of the digester is then applied to the agricultural fields in place of nitrogen fertilizer, once again starting the biodynamic cycle over again.

Processing and Operational Efficiency

More and more, agricultural producers are reassessing their operational efficiency. Most of the savings in efficiency are associated with water pumping for the agricultural sector. However, the processing side of the coin offers much more diverse opportunities for efficiency. Simple measures from changing light bulbs and turning off coffee machines to substantial improvements like changing wine storage facility design all reap economical, resource, and in turn, GHG reduction benefits.

At present, economic benefits drive the market for implementing efficiency measures. Paired with incentives available through the CEC and PG&E, many of the efficiency improvements can be low or no cost to the producer. Some programs are specifically set up to help the agricultural customers employ energy efficiency best practices and are available for free consultations and possible funding or financing. Such programs include:

- Agricultural Pumping Efficiency Program, www.pumpefficiency.org
- CEC's Energy in Agriculture Program, www.energy.ca.gov/process/agriculture/index.html
- Flex Your Power Agricultural Energy Efficiency (with links to 65 incentives and several free services) http://www.fypower.org/agri/

Several wineries have been leaders in efficiency and environmental stewardship. In 2002, the Sonoma Green Business program published a document highlighting "greenovations" of the Sonoma wine industry. Between 1999 and 2002, participation of wineries in the green business program went from 8 to 50. This shows that the wine industry recognizes the environmental and financial benefits of reducing their environmental impact. In this profitable agricultural industry, voluntary emissions reduction measures are becoming the standard. The following two examples highlight outstanding achievements in this area.

FETZER
VINEYARDS

Fetzer Vineyards is an environmentally conscious grower, producer and marketer of wines. We make every effort to ensure that the wine you drink is of the highest quality and value, while managing our impact on the environment. A process to develop and initiate sustainable business practices was implemented in the mid-1980s. We don't do it because it's trendy or to make a political statement. We do it because we believe that it results in better-tasting wines and that it's simply the right thing to do. Below are some of the key platforms that form our Environmental Philosophy.

Organic Farming

We are the largest grower of certified organically grown grapes on the North Coast and one of the largest in the world. 100% of our 2,000 farmed acres are certified organic through California Certified Organic Farmers (CCOF). Our organic vineyards are farmed without the use of pesticides, herbicides or chemical fertilizers.

Carbon Emission Mitigation

In March 2000, GHG (greenhouse gas) impacts were assessed with the help of Natural Logic, Inc. With the switch to 100% renewable power, electricity-generated GHG impacts were reduced to zero, and with reductions to landfill, solid waste emissions have been reduced 92%.

Energy Conservation

We are the first and only winery to buy 100% Green Power. Photovoltaics provide 75% of the power used in our Administration Building.

Waste Reduction

Through a company-wide waste reduction effort to recycle all bottles, cardboard, plastic, aluminum, paper, antifreeze, waste oil, fluorescent tubes and glass, we have reduced waste to landfill by 94% since 1990.

Water Management

In 1998, Fetzer and UC Davis created a natural filtration system that employs gravel and sand filters and a planted reed bed. The treated water is used on the winery's organically farmed grapes and landscaping.

Earth Friendly Packaging

Our bottles are made from 40% recycled glass (post consumer waste). Case boxes are produced from 100% post consumer waste. And our bottles, cartons and capsules are accepted for curbside recycling.

Reprinted from Fetzer Vineyards website: http://www.fetzer.com/fetzer/wineries/philosophy.aspx

FROG'S LEAP

Frog's Leap Vineyard is dedicated to sustainable practices and environmental stewardship. Even though they are located in Napa County, their commitment to reducing their impact on the environment makes Frog's Leap an example worthy of highlighting in this document. Some of the climate friendly practices and improvements incorporated into their operation include:

Photovoltaic Energy

Through its commitment to provide on-site solar power, Frog's Leap Winery has reinforced its belief that thoughtful ecological decisions are also good business decisions. In February of 2005, the winery essentially "flipped the switch" becoming 100% solar powered and thereby joining a growing list of concerned businesses committed to reducing the environmental impact of conventional power sources.

LEED Certification

LEED (Leadership in Energy and Environmental Design) is a green building rating system developed by the U.S. Green Building Council (USGBC). LEED was created to define "green building" through a common standard of measurement.

In the Spring of 2005, Frog's Leap Winery welcomed the challenge to build its new Hospitality Center & Administrative Office according to the LEED standards. These standards are not only goals to strive for but provide the opportunity to learn to be better stewards of the environment.

Geothermal Energy

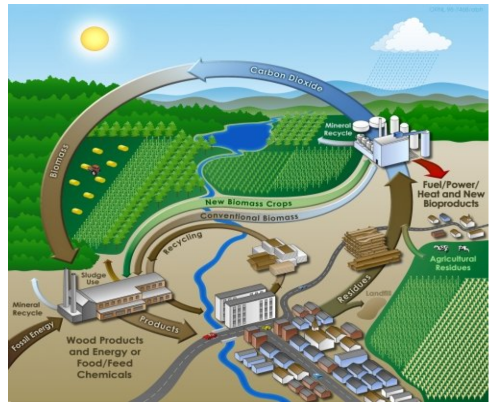
In keeping with its commitment to being sustainable through energy conservation and the utilization of renewal energy sources, Frog's Leap added geothermal heating and cooling to its overall "green" energy program. With the development of the new Hospitality Center & Administrative Office, Frog's Leap was given the opportunity to complement its existing solar energy field with geothermal energy to provide the balance of energy required to fully satisfy the needs of the entire winery and its operations.

Dry Farming

Believing that deeply rooted vines produce grapes with greater balanced flavors that are also reflective of the land, Frog's Leap currently dry farms over 200 acres of certified organic vineyards. As a secondary benefit, the water-saving benefits of dry-farming fit into our goals to be a sustainable business. The success of dry-farming relies heavily on the farmer's working of the soil through planting of cover crops and tillage throughout the growing season. This promotes an environment that increases the soil's capacity to hold water and at the same time encourages a healthy, balanced and complex biological life in the soil's structure. This "reservoir" of water and nutrients encourages deeply rooted vines, which in turn are stronger and more disease resistant.

Reprinted from Frog's Leap website: http://www.frogsleap.com/html/beinggreen.html

Carbon Sequestration



Carbon sequestration is the ability of the natural environment to absorb CO2 from the atmosphere and store it as carbon in the biomass (e.g. stalks/trunks, vines/branches, roots, etc.) for long periods of time. This process occurs naturally through photosynthesis in terrestrial plants and absorption in the ocean. The ability for the natural systems to become a "sink" for carbon emissions, removing them from the atmosphere where they contribute to climate warming, makes the agricultural sector truly unique.

Carbon sequestration can be increased by maximizing and diversifying vegetation in and around agricultural operations. For example, utilizing cover crops (especially permanent covers, pictured at left), maintaining or planting hedgerows or windbreaks, seeding unpaved roadways and other areas, and planting trees and shrubs. Perennial plants and trees are particularly good at carbon sequestration and storage. Additionally, the rate of carbon return as atmospheric CO_2 from decomposing plant tissues decreases with minimized tillage.

It was estimated that CA vineyards "fixed" 17.1 tons of CO_2 per acre in 1992.[20] At that rate, Sonoma County vineyards were responsible for absorbing approximately 1 million tons of CO_2 in 2006. Under normal conditions, most of this carbon is then recycled back into the atmosphere when the biomass is decomposed or burned. Only 2.5 percent of the fixed carbon is stored in the actual permanent vine. However, with an energy facility that uses gasification or pyrolosis of the green waste, most of the carbon assimilation in the County could be utilized to offset current power consumption from fossil fuels. This combination could prove to be a major net benefit for the County GHG reduction goals.

For dairies, the increase in stream setbacks and restoration of riparian habitats can be a permanent contribution to carbon sequestration. Programs are available to encourage and assist land owners to rehabilitate the riparian corridors. Many of these programs are associated with salmon and steelhead recovery projects. Additionally, the practice of silvopasture can increase carbon sequestration in livestock operations. Silvopasture is the integration of native trees into pastures for the purpose of making a more productive system. In addition to carbon sequestration, silvopastorialism increases soil health, creates windbreaks, provides shade and increases wildlife habitat.

Another alternative for the agricultural community is to get tax incentives by placing land in conservation easements. These easements allow for dairies, vineyards, wineries, ranchlands and other agricultural operations to set land aside for preservation. These lands

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can be restored to native ecosystems. Shrubs and trees could be grown that would remove more carbon from the atmosphere and sequester carbon for long term storage.

Forests on agricultural lands should be managed as such. The carbon stock in forests is fixed, biodiversity is much greater than in other habitats, and preserving these ecosystems is essential to climate change based policy and the future health of our ecosystem. Though most of the forest logging in Sonoma County occurred between 1850 and 1940, remaining forest lands are still threatened by agricultural activities. Between 1990 and 1997, the County lost 9,505 acres of its hardwood rangelands (oak woodlands) to vineyard conversions.[21] Some vineyards, like Benziger Vineyards, have recognized the importance of the surrounding ecosystem and have switched to a biodynamic method of wine production, where the forests on their 85 acre estate are preserved. Tax credits should also be extended to landowners who manage their forested areas as preserves

New technologies are also showing promise in the area of carbon sequestration. Scientists have been working on a product that may hold great potential for the agricultural sector. Several companies are experimenting with pyrolysis, a process in which biomass is burned at a high temperature in the absence of oxygen.[22] The process yields both a charcoal by-product that can be used as a fertilizer, and bio-oil, which is a mix of oxygenated hydrocarbons that can be used to generate heat or electricity. Because the charcoal by-product, commonly called "agrichar" or “biochar,” does not readily break down, it could sequester for thousands of years nearly all the carbon it contains, rather than releasing it into the atmosphere as CO_2. Furthermore, it would boost agricultural productivity through its ability to retain nutrients and moisture. This technology could be examined as an option for a CCA biofuel electricity plant.

[21] Merenlender, A.M. “Mapping vineyard expansion provides information on agriculture and the environment,” California Agriculture, 54(3): 7-12. 2000.
[22] Casselman, Anne. “New bill in U.S. Senate will advocate adoption of "agrichar" method that could lessen our dependence on fossil fuel and help avert global warming,” Scientific American, May 15, 2007.

Land Use and Agricultural Policies

Land use and land use change have been major contributors to global climate change. Currently, land use change is the second largest global cause of CO_2 emissions.[23] Land use and land use change can be managed to rebuild carbon stocks in soil and biomass with the potential to essentially reverse past emissions from historical land use conversions.

With population increasing and lucrative real estate values, the pressure of forest and agricultural land loss is great. Through agricultural land conservation, restoration and changes in land management, CO_2 emitted from Sonoma County's soils and forests can be minimized. Existing forest carbon stocks on agricultural lands can be maintained and additional CO_2 emissions can be absorbed from the atmosphere and stored in soils and forestland. These activities could create significant climate benefits and would also achieve other co-benefits that the public values, such as the enhancement and protection of species habitat, the local economy, water quality, and biodiversity.

While most of the management opportunities (i.e. reduced tillage, organic farming, anaerobic digesters) offer financial savings, additional incentives must be offered for widespread adoption of climate friendly farming techniques and the preservation of diversified agricultural production in a county where grapes reap the highest dollar per acre. These could be offered through the County's facilitation of the sale of GHG emission credits. The county could require a GHG mitigation fund financed by developers for any new development and gross polluters. Local agricultural producers could sell credits to developers, other industries, or the County itself. The credits would be assessed based on the protocols set up by the California Climate Action Registry (the Registry). The Registry has protocols already in place for livestock (anaerobic digesters) and forestry[24]. Similar protocols of accounting can be established for climate friendly farming practices or agricultural based energy/fuel production. The existing Registry forestry protocols also require registered forestlands to be secured with perpetual conservation easements. These easements dedicate the land to permanent forest use, securing the forest's climate benefits for the long-term. Similar conservation easements could be established for agricultural lands.

Policies such as this, that address land use and land use change, could have major impacts for the agricultural sector. An agricultural preservation act could set aside lands currently zoned as agricultural use to be protected as such. This would guard against the encroaching development of rural areas. As part of the act, any new development of housing should also be required to set aside land for agricultural use, in addition to offsetting emissions by purchasing credits from local farmers and forest owners. The specified land could be managed as community gardens for the development, thus reducing the need for importing more food from elsewhere.

[23] IPCC. Climate Change 2007: Impacts, Adaptation & Vulnerability.
[24] The Livestock Project protocols were approved June 17, 2007. More information is available about all protocols at http://www.climateregistry.org/PROTOCOLS

Sonoma County could also enact policies that specifically address what is produced and where it is distributed, such as a local agricultural production act. In keeping with the County's goal to reach net zero GHG emissions, such an act could include a holistic view of agriculture, providing sales tax based incentives to ensure a diversity of local farm products. The incentives would only be available for farmers that grow and sell a majority of their products locally. This type of incentive would encourage a more local food economy that would greatly reduce CO_2 emissions due to produce transportation to distant markets.

In addition to creating its own framework for GHG reductions, Sonoma County can work with state and federal agencies to develop agricultural incentives at those levels that would enable agricultural-based climate benefits. Even with the shortcomings of the recent Farm Bill, growing concern with climate change may fuel a change for the better at higher levels.

Solutions Summary

The agricultural sector of Sonoma County has enormous potential for GHG reductions. The following table summarizes some of the solutions proposed in this section. Each proposed action is identified with the possible implementer(s), economic and political feasibility, potential CO_2 reductions, and estimated associated costs.

Proposed Action	Implementer	Feasibility	Potential CO_2 Reduction (tons per year)	Estimated Cost
Improved Soil & Irrigation Practices	SCWC, individual farmers, County	Easy	Indeterminate (thousands)	$50,000 to $80,000/yr
Composting Facilities	County	Moderate	Up to 1.5 tons per acre-foot served per year	$350 - $500K per facility
Methane Digesters (Dairies)	Dairy Operators	Moderate	180,000[25]	$125,000 per dairy[26]
Biogas Digester (CCA Facility)	County, Private	Challenging	4,000 to 9,500 offset[27]	$14,000,000 to $26,500,000[28]
Biomass Fuel Production	Private, County	Challenging	40,000 to 60,000	$700,000 to $1,400,000[29]
Proposed Action	**Implementer**	**Feasibility**	**Potential CO_2 Reduction (tons per year)**	**Estimated Cost**
Improved Processing and Operational Efficiency	Private, Wineries	Easy	Indeterminate (thousands)	Indeterminate (most savings pay for capital costs in 3-5 years)
Carbon Sequestration / Fixation	County, Private	Moderate	Up to 300,000[30]	$50 - $80 per acre per year[31]

[25] Maximum total if all dairies installed a digester, and all methane was captured.
[26] Average cost per facility after rebates and incentives.
[27] The low numbers for this proposed action correspond to a 4.2 megawatt digester plant and the high numbers in this range are for a 10 megawatt digester plant. Potential CO_2 reductions estimated assuming biogas plant is carbon neutral, operating an average of 12 hours a day for 300 days a year offsetting current PG&E CO_2 emission level of 0.529 lbs/kWh produced.
[28] The low numbers for this proposed action correspond to a 4.2 megawatt digester plant and the high numbers in this range are for a 10 megawatt digester plant. Estimated costs are capital costs prior to any rebates or incentives.
[29] Based on cost of $700,000 for a 3 million gallon per year facility.
[30] This reduction is only achievable in conjunction with a biomass energy facility. Only 0.4 tons of CO_2 per acre are fixed "permanently" in the vine, however, if the lees and green wastes from the agricultural operations were processed in a gasification or pyrolosis plant for energy production and the agrichar byproduct applied to the soils, up to 30% of the 17 tons of CO_2 fixed per acre could be offset from atmospheric reentry. This would result in up to 300,000 tons of CO_2 assimilation per year based on 2006 vineyard acreage.
[31] For collection and hauling of green wastes.