Greenhouse Gas Reduction Opportunities in the U.S. Fluid Milk Value-Chain

The Sustainability Summit: Creating Value through Dairy Innovation

Briefing Paper

hank you for participating in the **Sustainability Summit: Creating Value through Dairy Innovation** to be held June 17-19th in Rogers, Arkansas. As you know, this meeting offers an unprecedented opportunity to affirm our shared commitment to consumers, the environment and one another—and your experience and unique perspective will be crucial to our collective success.

Our focus for the Sustainability Summit will be to identify breakthrough approaches to reduce greenhouse gas emissions by designing business strategies—specifically within the fluid milk value chain—to build economic, social and environmental value.

In preparation, we have created this briefing paper for your review. It includes important information about the context and current data, as well as some ideas to inspire innovative thinking.

How to use this report

This paper is divided into three parts: Introduction, Executive Summary, and Report. The Introduction provides an overview of the dairy industry and the key macro drivers of sustainability. The Executive Summary highlights the macro findings of the footprint and a summary of the nine opportunity areas. The Report profiles the footprint and opportunities within each step of the fluid milk supply chain more deeply.

The nine opportunity areas discussed in this document represent the contributions of dozens of industry experts (see acknowledgements) and have been included to provide background and context leading up to the ummit. These opportunities are not meant to be exhaustive; there are other innovations to reduce carbon in fluid milk, but can be further developed in the Summit with broad collaboration.

As you read through this brief, please keep the following questions in mind:

- What additional opportunities come to mind to reduce greenhouse gases and generate business value?
- How can these opportunities be more widely adopted?
- How can the opportunities be combined to create additional value?
- Who are the key stakeholders to champion these opportunities?
- What are the business models that will make these opportunities a viable reality and resounding success?
- What are the regulatory barriers that need to be overcome?
- How can education and dissemination of these opportunities be accomplished?

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INTRODUCTION

his briefing paper is a primer for the June 17-19th "Sustainability Summit: Creating Value through Dairy Innovation" in Rogers, Arkansas. The Summit will be an action-focused dialogue among leading internal and external dairy industry stakeholders to develop solutions to reduce the industry's greenhouse gas emissions while generating business value through innovation. To support this dialogue, this document provides an overview of the greenhouse gas "footprint" in the U.S. fluid milk value-chain as well as a preliminary analysis of opportunities to reduce greenhouse gases.

What is an Appreciative Inquiry Summit[1]?

The summit will be facilitated by Professor David Cooperrider of Case Western Reserve University, pioneer of the Appreciative Inquiry process that has been used in a wide variety of contexts to create large-scale positive change. For example, Professor Cooperrider led a Global Compact Leaders Summit with 500 world leaders at the United Nations last year in New York City. The Global Compact meeting focused on promoting responsible global corporate citizenship and was attended by company CEOs, heads of international labor and civil society organizations, heads of U.N. agencies and selected government ministers.

What is appreciative inquiry? To appreciate means to value—to understand those things worth valuing. To inquire means to study, to ask questions, to explore. Appreciative Inquiry is, therefore, a collaborative exploration to identify and understand a particular group's strengths, their greatest opportunities, and their aspirations and hopes for the future, and to build a shared plan of action that will help create that future.

.n appreciative inquiry summit is a whole system working meeting that engages a cross-section of as many internal and external stakeholder groups as possible -- groups that care about and have a stake in the future of the industry. This means more diversity and less hierarchy than is usual in a working meeting, and a chance for each person and stakeholder group to be heard and to be exposed to other perspectives on the challenges and opportunities facing the group. Each individual has been selected because of their ability to contribute as decision makers, influencer or activators to make the opportunities viable.

The summit is task focused, not simply an educational event or a conference. Through a highly participative process you will build a shared vision, explore opportunity areas, and create a practical action plan. This plan will build on the historic strengths of the industry in stewardship of the land and protection of the environment, and will engage the entire value chain – from feed farming through retail – in developing innovative solutions that benefit the dairy industry and society. The outcome of the summit will be a collective commitment to action.

[1] Go to http://appreciativeinquiry.case.edu/ for more information on Appreciative Inquiry

Dairy Industry Overview

The dairy industry has a unique value chain that reaches from farmers, associations and cooperatives to processors, retailers and consumers. The economic impact of the U.S. dairy industry is estimated at close to $200 billion[2] and is responsible for well over 900,000 jobs nationwide[3]. The reach is felt abroad with exports having an annual value of more than $3 billion and represent 9%[4] of the total amount of dairy products sold.

Today there are approximately 59,000 total dairy farms in the United States and, on average, there are 155 cows per farm[5]. Each cow has an average production of 2,300 gallons of milk per year. In total there are 9.1 million cows that produce an annual output of over 180 billion lbs. of fluid milk[6]. The multiplied economic impact of dairy farmers and cooperatives they own is estimated at over $172 billion[7]. This is almost 10% of the total agricultural farm sales within the United States[8].

An estimated 100 dairy associations[9] have diverse objectives ranging from representing dairy farmers in regulatory / policy matters, providing educational programs, assisting with milk production and promoting dairy products for consumption. These associations exist on both a national and local level.

The approximately 200 dairy cooperatives account for roughly 11% of all agricultural sector markets of farm cash receipts. Dairy Cooperatives market 86%[10] of all milk delivered to plants in the United States. By themselves, cooperatives total sales account for $38 billion[11].

There are over 1,000 processing plants nationwide. These locations account for nearly 182 billion lbs. of dairy products. Of this total output, 57 billion lbs. is for fluid milk alone[12]. The remaining output is spread across products such as: cheese, yogurt, ice cream, and powdered milk. With an impact to our economy of about $140 billion, processors contribute significantly to the dairy value chain[13].

[2] Summation of the Economic Impact of Processors, Co Ops, Retail and Farms.
[3] U.S. Dairy Markets & Outlook, Page 4
[4] USDEC
[5] USDA February 2008 Milk Production Report
[6] 2007 IDFA Dairy Facts
[7] Rodger Cryan 2008 NMPF Page 9
[8] USDA United States Fact Sheet
[9] 2008 Encyclopedia of Associations
[10] USDA: Cooperatives in the Dairy Industry
[11] Estimate of 2007 prices from
USDA (2006) Farmer Cooperative Statistics

[12] IDFA2007 Dairy Dairy Facts
[13] U.S. Dairy Markets & Outlook, Page 4

What is Driving Sustainability?

Global climate change, accelerated by the build-up of greenhouse gases in the atmosphere, has captured the unprecedented attention of government, industry and the public at large – illuminating a host of new challenges. The dairy industry has not been exempt from the need to change, and in this dynamic environment, new challenges constantly appear on the horizon. Confronting and anticipating these challenges presents both opportunities to improve environmental performance *and* drive business value – ensuring a sustainable future for people and the planet. To harness the dairy industry's collective strengths in charting a bold path forward, it's important to understand some key drivers behind the movement commonly referred to as "sustainability," the sources of greenhouse gas emissions in fluid milk, and the areas of opportunity that can potentially create big wins for the dairy industry and the environment.

Forces that have shaped economic growth over the past century are shifting dramatically; leading companies are incorporating sustainability principles into strategic business plans as never seen before. The era of abundant and cheap forms of energy, water and natural resources that gave rise to the largest expansion of wealth in history has been replaced by a time where global population growth and rapidly expanding economies of countries such as India and China are placing increasing demands for food, land resources, fresh water, and straining the ecological systems that support the world's economy. The U.S., with less than 5% of the world's population, currently consumes 22%[14] of the world's energy and is the 2nd largest emitter of greenhouse gases after China[15].

Food Supply and Demand

The price of corn, soy, and wheat has increased significantly in recent months, generating headlines over concerns about rising food prices worldwide[16]. The rise in food prices has several drivers that suggest this is a long-term trend. First, the high growth rate of the world's developing economies means that millions of people have experienced increased standards of living, including more protein rich diets. Second, on the supply side, while there have been advancements in productivity, supply has not been able to keep pace with demand. Lastly, the rising price of oil has increased costs of the petro-based inputs to agricultural production, like fertilizer, and has prompted a large conversion of agricultural land from food crops to bio-energy crops.

Land Resources

Global population, which has doubled since 1960 to 6.5 billion today, has created increased competition for a finite amount of land. Urban areas are expanding rapidly, and many U.S. cities are encroaching on prime agricultural land. One-third of the world's cropland is losing topsoil at a rate far faster than it can be replenished, jeopardizing its long-term productivity[17]. Over half of the earth's rangelands are overgrazed, causing them to decline into deserts.

Water Scarcity

Access to fresh water may be the most challenging problem in the developing world over the next decade, as agriculture, industry, and residential use increase. Over 1.1 billion people in the world do not have access to clean drinking water, leaving them struggling with inadequate sanitation and waterborne diseases[18]. Water tables around the world have been falling at alarming rates, including the major foreign food producing

[14] http://css.snre.umich.edu/css_doc/CSS03-11.pdf
[15] Netherlands Environmental Assessment Agency website
Time Magazine "The World's Growing Food-Price Crisis" February 7, 2008
[17] Lester Brown, "Plan B 2.0" page 84
[18] Blue Planet Run Website - Water Facts

nations of China and India. Much of the U.S. West and Southeast are facing long-term droughts and are struggling with division of water rights among recreation, agriculture, urban areas, and natural habitats.

Recently, the U.S. Climate Change Science Program (CCSP) in conjunction with the USDA released a major study showing that climate change is already affecting U.S. agriculture. Rising temperatures will reduce productivity of dairy farming and water shortages could also have a negative effect on the dairy industry. The study is the most comprehensive examination of climate change for U.S. ecosystems.[19]

Ecological Systems Threatened

In 2005 the United Nations released the first Millennium Ecosystem Assessment, which found that over the past 50 years humans have altered ecosystems more rapidly and extensively than in any comparable time in human history. While the economic growth generated by resource extraction from these ecosystems has resulted in enormous gains in standards of living and well-being, it has also resulted in the degradation of 60% of the world's ecosystems. The report concluded that if measures are not taken to protect these systems, which provide clean air, water, and materials to fuel the world economy and sustain life, then the harmful consequences of this degradation could grow significantly[20].

Society's Response

Consumers have taken an increasing interest in understanding where their food comes from, and how it is produced. Companies have both responded to the growing demand for sustainably produced food products, and have used sustainability as a driver for innovation that produces better products and improved environmental performance. Sustainability has moved from the niche Whole Foods customer to the mainstream masses of Wal-Mart, from Patagonia to J.C. Penny's. A few examples include: Unilever's announcement that they would only purchase palm oil from sustainably cultivated and harvested forests – ensuring a long-term supply of raw materials for their products[21]; and Wal-Mart's recent "Earth Month" advertising campaign in April 2008, which featured earth-friendly products to their 200 million customers[22]. These forces will continue to drive innovation in the food and beverage sector, including the dairy industry.

Regulation

Climate change is emerging as a national dialogue, with all 2008 presidential candidates in favor of a national carbon trading scheme. Over 80% of executives believe that climate change legislation will be enacted within the next five years.[23] Local and state governments have responded by legislating carbon accounting and reductions. California passed AB32, a landmark bill that requires a 25% reduction in greenhouse gas emissions from 1990 levels by 2020. Twenty-three states have passed renewable portfolio standards, which set targets and timelines for renewable energy production. This has fostered the growth of voluntary carbon markets such as the Chicago Climate Exchange, where the price of carbon has risen from $2 to $6.45 per metric ton in 2008 alone. Carbon is increasingly becoming either a cost or a revenue opportunity for businesses, and if carbon trading legislation is passed in the U.S. it will likely cause the price of carbon to increase as the market expands.

Business Sector

[19] **The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States. May 28, 2008**

[20] Millennium Ecosystem Assessment website

[21] Wall Street Journal "After Protests, Unilever Does About-Face on Palm Oil" May 2, 2008

[22] Brandweek, May 5, 2008

[23] McKinsey Quarterly, "How companies think about climate change: A McKinsey Global Survey", February 2008

The innovation curve is growing in the sustainability sector; it is estimated private equity firms in the next two years will invest \$6.2- \$8.0 billion for alternative energy business ideas[24], and this statistic does not consider the investment in total sustainable business opportunities. As with any paradigm shift the rewards are to those who innovate early. Being ·een typically has not been en vogue; it is perceived as being inconvenient or lacking in taste, or reserved for the environmentalists. However, corporate America is starting to see green. Companies are investing in innovation to create eco-cool and eco-chic products positioned to be the best in class and at a lower price, delivering a compelling business model driving sales and reducing cost. The end result: A profit loss statement that is truly "green".

Sustainability in the Dairy Industry

Sustainability is not a fad, as the underlying drivers described above show. It is an inevitability that industries will either respond thoughtfully through leadership and innovation, or will react to from a defensive position.

This can be clearly seen in the impending changes that greenhouse gas accounting will have on business. Just as public companies must report earnings, in the future companies will likely need to account for every pound of carbon emitted, which is why more than 3,000 of the world's largest corporations have made commitments to voluntarily report emissions to the Carbon Disclosure Project. Political support for carbon reduction, carbon trading, carbon taxes, and other carbon-related laws is growing, and in all likelihood the U.S., with the next presidential administration, will pass national legislation that will put a price to carbon.

The dairy industry finds itself at the crossroads of how to respond to a carbon-constrained world. It can be proactive or reactive. It can choose not to take an active role in shaping this new business environment, and run the risk of having greenhouse gas legislation pass that does not benefit the farmer or processor; run the risk of having consumers see dairy as part of the problem, a high carbon drink, and face increased competition ·om food and beverage companies that develop products that meet consumers taste and desire to help the planet; and run the risk of not being able to extract value from one of the industry's most under-valued byproducts, methane, as the private and public sectors pour billions of dollars into the development of alternative energy.

Or the dairy industry can be proactive by viewing the growing public awareness of greenhouse gases (GHGs) as an opportunity to be part of the solution to climate change. The dairy industry can inspire the innovations in products and processes that can increase profits and market share – and be better for the planet. By turning waste into revenue, designing more efficient operations, capturing carbon credits, creating innovative products, and a host of other ideas, the dairy industry can actively shape its own future. As the dairy industry increasingly looks to fulfill consumer demand, there are many inherent strengths and opportunities that can be leveraged to capitalize on new consumer demand.

One of the big steps in the creation of that future is the Sustainability Summit. It will be unique opportunity for the representatives of the industry to build a vision, generate the ideas, and design the plans that will place the industry on a more competitive and more sustainable pathway.

[24] Wharton Finance and Investment, 2007

Footprint Summary

Scope & Methodology

Greenhouse gases (GHGs) are a range of gases that occur in the atmosphere both naturally and through human activities including operating power plants and driving passenger cars. Each greenhouse gas interacts differently in the atmosphere. The potency of a gas depends on its ability to trap heat in the atmosphere and the length of time it remains there before breaking down. Because of these different potentials, GHGs are reported in the uniform metric of carbon dioxide equivalents. Other GHGs discussed in this paper include methane (CH_4: 23 times as potent as carbon dioxide), nitrous oxide (N_2O: 296 times as potent as carbon dioxide), and refrigerants (HFC/HCFC refrigerants that range from 400 – 12,000 times the potency of carbon dioxide).[25] A carbon footprint is a common term for a life cycle analysis of greenhouse gas emissions; it is a measure of the amount of GHGs emitted by a given activity, measured in units of carbon dioxide.[26]

To understand where in the fluid milk supply-chain the GHG emissions occur, a scan-level footprint analysis was conducted using secondary research. The intent of the scan-level footprint is to provide a high level view of the GHG impacts along the fluid milk supply-chain. It is a tool to provide a directionally correct estimate to begin understanding the big picture of GHG emissions of time in the production of fluid milk, and what strategies to reduce GHG are worth investigating more closely.

The scan-level footprint draws upon data from twenty secondary sources to calculate emissions from each stage in the fluid milk value chain. The purposes of the scan is to help identify where there are opportunities for innovation, it is not a peer reviewed scientific study.

The University of Arkansas is currently conducting a peer reviewed life cycle assessment of greenhouse gases for the fluid milk value chain. To date the study has sampled the processing and distribution stages of the value chain and will be surveying approximately 1,000 farmers this summer.

The University of Arkansas is in the process of conducting a Life Cycle Assessment for fluid milk which will be published subsequent to the Sustainability Summit. In contrast to the carbon footprint presented here, the life cycle analysis will provide a detailed review of emissions sources across the fluid milk value chain. The study will be the first comprehensive view of the greenhouse gas emissions for the U.S. fluid milk value chain and will provide credibility and a true measurement.

Some preliminary data from the milk processor survey, conducted by the University of Arkansas, has been used to refine and validate the scan-level footprint. Results of the scan-level footprint have been reviewed in collaboration with the University of Arkansas and have been validated against, domestic sets of data, twelve international studies of foreign dairy industries and through interviews with experts in government, industry, non-governmental organizations and universities.

[25] Intergovernmental Panel on Climate Change (IPCC)
[26] http://www.carbonfootprint.com Carbon Footprint LTD accessed Nov 10, 7:39am CST

Footprint Findings

he figure below shows the aggregated results of the scan-level footprint for fluid milk that shows the relative size of GHG emissions across the value-chain. Crop and milk production make up the majority of emissions. This is a common pattern in Life Cycle Assessments where the early steps in the value-chain, which require extraction or use of natural resources, and often have larger GHG emissions due to the large amounts of energy and/or high quantity of inputs required. While the steps further down the value-chain, (processing, packaging, and transportation of product) may have a smaller relative footprint, they are still significant contributors to GHG emissions and represent an opportunity to add business value to all stages of the fluid milk value-chain.

The estimated total aggregate GHG emissions for fluid milk per the scan-level footprint is 28.8 million metric tons of GHG, which is about 0.47% of the 6,170.5 million metric tons of net GHG emissions released in the entire U.S. in 2006[27]. The fact that fluid milk registers as a percentage of U.S. emissions makes it an incredible opportunity for the stakeholders at the Summit to generate innovations that not only benefit the dairy industry, but makes a measurable reduction in U.S. GHG emissions as well.

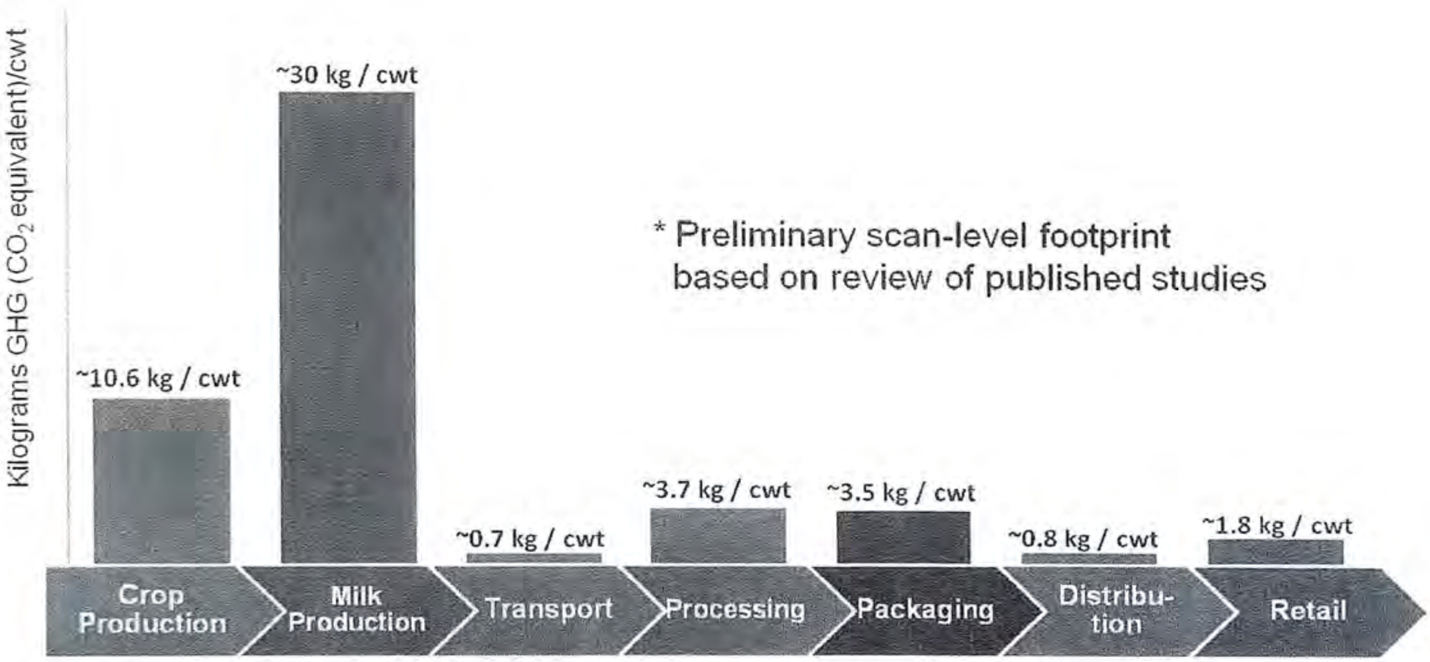

Figure 1 Scan-level GHG Footprint v2.0 for fluid milk.

[27] U.S. EPA – Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1996-2006

Footprint Reductions

Measuring greenhouse gases is important as it provides the starting point, but the real challenge is how to reduce carbon while increasing business value. The purpose of the Dairy Industry's two part Carbon initiati\ is to measure and find innovations. While Figure 1 reveals the relative GHG impacts throughout the fluid milk value-chain, Figure 2 identifies selected opportunities to reduce GHGs. These nine opportunities have been selected because they represent practices and innovations for reducing GHGs that also have the potential to generate business value. Opportunities have been identified for each part of the supply-chain. Engaging the entire milk industry to work together as a system to generate and implement innovations can clearly drive progress at all levels of the value-chain. Even if emissions in, for example, trucking and logistics are a relatively small part of the fluid milk footprint, the reduction opportunities are still significant and can generate meaningful business value. The Summit has invited an array of individuals to develop innovations. These opportunities are not exhaustive and with ingenuity of the individuals at the Summit, there are likely to be new opportunities proposed.

The reduction potential for each opportunity has been assessed using a "full potential" model, which is based on a 100% adoption rate for the practices identified to reduce GHG emissions. The full potential reduction is not a target, but rather sets the extreme limit that enables establishing appropriate reduction targets. In actuality the reduction potential for each opportunity will vary depending on many factors, such as region and scale of operations.

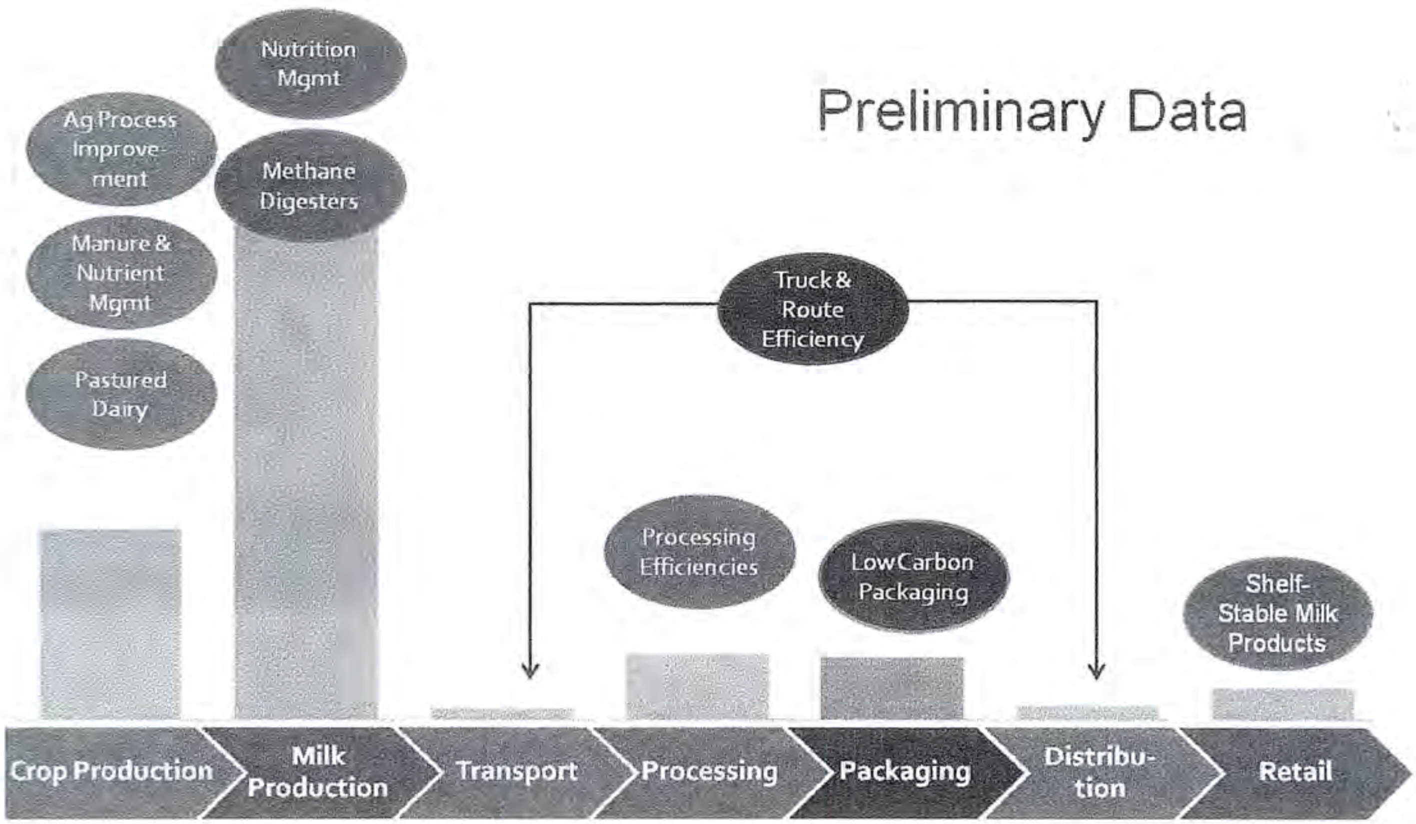

Figure 2: Estimated Relative GHG Emissions (bar) and reduction opportunities (square) by value-chain step

Summary of Opportunities

Crop Production

Growing crops to feed dairy cows is one of the most GHG-intensive steps in the fluid milk supply-chain. The primary sources of emissions are fuel use, nitrous oxide emissions from soil, and energy use in the production of commercial fertilizer. Opportunities exist to meaningfully reduce emissions from this stage of production while also reducing inputs and production expenses. These opportunities include enhanced **agricultural process improvements** (which includes precision agriculture, conservation tillage, and nitrogen management), **and improved capture of nutrients from dairy manure**. In addition, improving the **use of pastures** for those dairies for which it is applicable can also create a net reduction in emissions. In summary, the full potential of these opportunities could reduce total emissions from crop production by approximately 20%.

Milk production

On the dairy farm, the most significant source of GHG emissions comes from the cows themselves. Enteric fermentation during digestion causes the cows to release methane, which is 23 times as potent as carbon dioxide. Manure can also be a significant source of methane, as it releases methane if it decomposes anaerobically. Urine releases nitrous oxide, particularly if cows are fed too much protein. Converting methane from manure into energy through **anaerobic digestion**, enhancing **nutrition management**, and using feed additives that reduce enteric methane production in cows, could, using a full potential model, reduce GHGs by 52%, this reduction would be the equivalent of taking an estimated 1.5 million U.S. cars off the road for a year[28].

Processing

The majority of a milk processing facility's energy requirements are attributed to steam production and distribution, refrigeration, lighting, compressed air and motors. Natural gas, or, in some cases, fuel oil, is used as an input to the boiler to generate steam for thermal processes (e.g. pasteurization and cleaning). Electricity is primarily used for refrigeration, lighting, compressed air and motors. The major reduction opportunities in processing plants are categorized as practices in **energy efficiency, energy production, and "next practices" such as alternatives to thermal processing.** Energy efficiency using existing technologies and retro-fit measures such as optimized boilers, insulation improvements, and efficient lighting that offer significant operating cost savings often improve system reliability. Technologies like cogeneration (capturing waste-heat from on-site gas-fired turbines) can reduce GHGs through more efficient electricity generation, but also use the waste heat as an energy source to further reduce processor energy bills. Combined, these practices could reduce the overall emissions associated with milk processing by 40%. Next practices like extending plant shut-down periods and employing alternatives to heat treatment will require policy level changes, but could offer further GHG reduction potential.

Packaging

Paperboard and plastic are the dominant milk packaging materials in the U.S. (the HDPE gallon jug represents 65% of total sales). The majority (90%) of energy use and GHG emissions associated with milk packaging – regardless of type – are related to the production of the material (not including container formation). Therefore, efforts to **reduce raw material inputs**, for example, through alternative formats, have the greatest potential to reduce emissions associated with packaging. In addition, by **improving the energy efficiency of container formation equipment**, such as blow molding machinery, processors and the milk packaging equipment supply-chain could further reduce GHG emissions in the packaging stage.

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[28] U.S. EPA Green Power Calculator, www.epa.gov/greenpower/pubs/calcmeth.htm

Transportation & Distribution

In the raw milk transportation stage, an insulated tanker picks up raw milk that has been cooled to approximately 38 degrees F from multiple dairy farms and travels to the processing plant. In the processed milk distribution stage, the packaged milk is distributed in refrigerated trucks to the store. Diesel is the industry's primary greenhouse gas emissions source. **Truck & route efficiencies** offer significant emission reductions and cost savings potential. Wal-Mart and other retailers with significant logistics infrastructure have utilized truck equipment specifications that have demonstrated fuel consumption reductions of 10 to 20 percent and expect savings of $300 million annually.

Sales channel

Due to the relatively low level of emissions in comparison to other lifecycle stages, the focus of this chapter is on the opportunity to increase the market share and sales of fluid milk by offering it in other parts of the store. The dairy industry has already seen success through industry-led pilots to increase merchandising of milk in channels such as foodservice, quick service restaurants and airports, and through partnership with retailers. **Shelf-stable milk**, while less than 1% of milk sold in the U.S. today, holds the possibility to increase sales by merchandising milk in additional touch-points throughout the store (e.g. non-refrigerated beverage, cereals and baking aisles, impulse counter). The dairy industry could further provide relevant and convenient product choices throughout grocery food chains aisles, superstores and wholesale clubs tailoring the product to targeted groups (e.g. Hispanic, kids, and moms).

pportunity Criteria

A review of the predominant industry "baseline practices", "best practices," and, where relevant, "next practices," was performed to identify opportunities to improve performance and reduce carbon. These opportunities may not be available or viable in all regions or applications, but in aggregate provide a menu of innovations that, if widely adopted, can significantly reduce greenhouse gases.

Opportunities were selected with the intent that each portion of the value-chain could derive positive business and environmental value. They were evaluated based on their ability to reduce emissions in a scalable, practical, and cost-effective way; their ability to decrease costs and/or increase revenues; and the viability of using an industry-wide collaboration to bring them to fruition.

The reduction potential for each GHG reduction opportunity has been assessed assuming a "full potential model" or 100% adoption rate of identified emissions reduction practices. This is not a target, but rather sets an upper limit that enables the setting of appropriate targets.

Crop production

GHG Impacts and Activities

Crop production for dairy feed represents the first step in the fluid milk value-chain. Nationally, corn and soy comprise the bulk of feed used by the industry with grass, hay, other crops, dietary supplements, and sometimes food wastes comprising smaller but important fractions of the average diet. Roughly 25% of feed stocks are grown on dairy farms, with the remainder purchased on the commodity grain markets[29]. Grass and hay forage grown on farms represents less than 0.5% of total feed by value. Ultimately, producing these inputs, both on dairies and crop farms, is the milk value-chain's second most GHG intensive process.

The primary sources of GHG emissions in crop production is the energy used in fertilizer production, emissions from fuel use in farm equipment, and nitrous oxide emissions from agricultural soils. Nitrous oxide emissions occur naturally in agricultural fields, however emissions are amplified when excess nitrogen is available in soils. The addition of commercial fertilizers is a key driver of this nutrient availability.

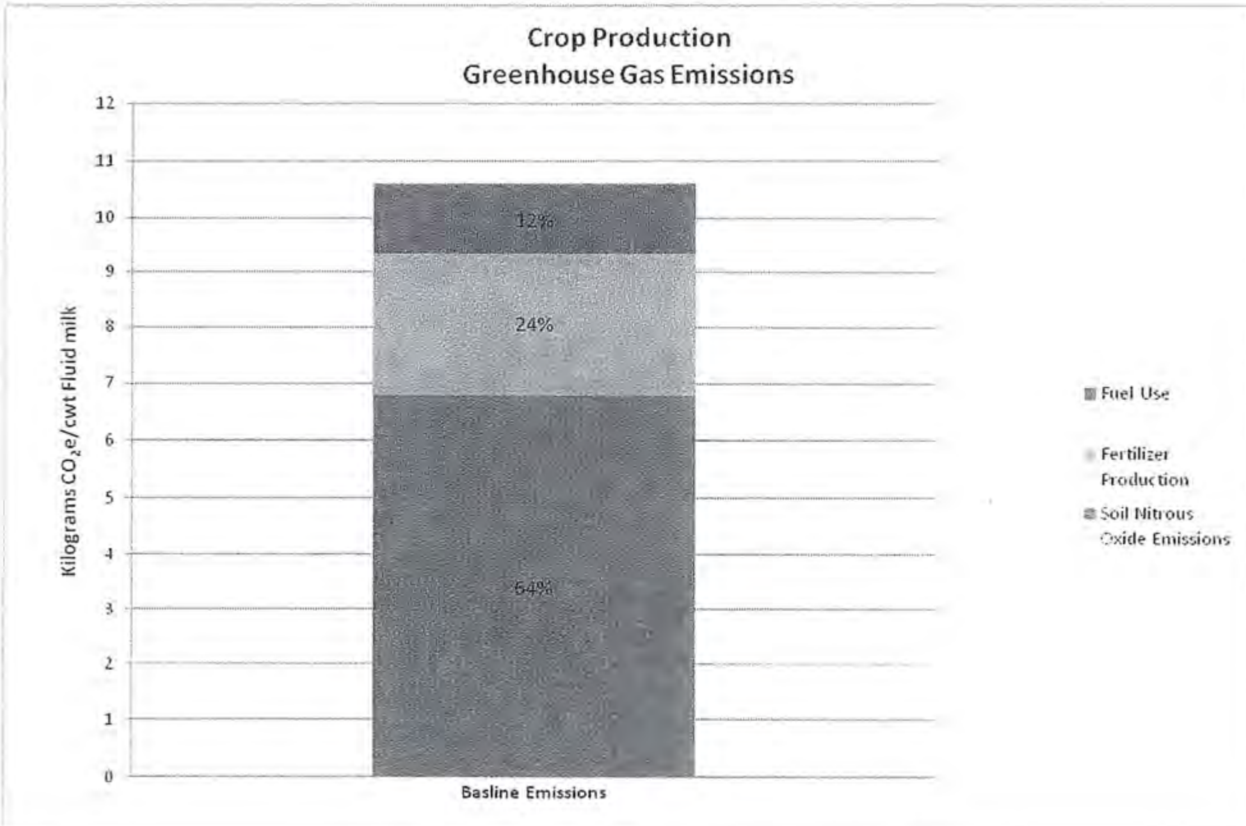

Figure 3: Baseline GHG emissions from crop production

Footprint Methodology

The carbon footprint of growing feed crops for the dairy industry was calculated based on U.S. average emissions values for crop production from several domestic data sets. Life Cycle Assessment data from the U.S. Department of Energy's National Renewable Energy Lab provided emissions values on a per acre basis for

[29] USDA, ERS. (2005). Agricultural Resource Management Survey, Cost Overview

the primary crops of a representative dairy cow diet. Emissions are calculated for crop production in conventional agriculture systems for the primary dairy feed stocks of corn, soybeans, and hay.

'eduction Potential

Γhis analysis identifies a suite of opportunities to reduce GHG emissions from crop production while generating economic value for producers. First, improving manure use to maximize nutrient value to crops and enhancing the efficiency of commercial fertilizer hold the "full potential" to reduce total emissions from crop production by 15%. Second, driving adoption of precision guidance systems on crop and dairy farms represents a "full potential" reduction in fuel use and emissions of nearly 2%. Third, improving the management of existing pastures using existing management techniques to more fully capture the value of these resources can reduce the industry's emissions by roughly 2% annually. Finally, full adoption of no till agriculture in growing all crops for the dairy industry can sequester over two million metric tons of CO_2e a year, providing a "full potential" reduction in net emissions from crop production of 30%.

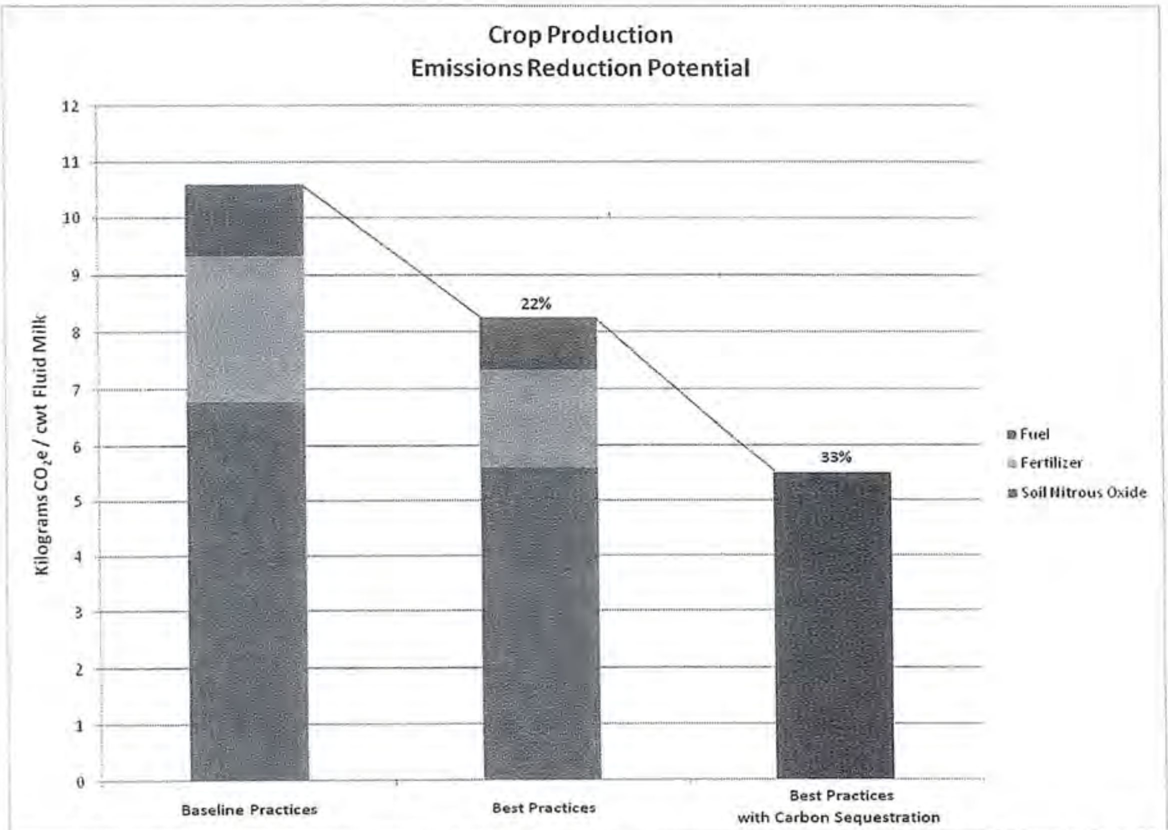

Figure 4: Baseline and potential reductions for GHG emissions from crop production with a "full potential" model

Baseline and Best Practices

Below is a summary of the baseline and best practices in crop production.

Stages of Excellence for GHG Reduction in Crop Production	
Agriculture Process Improvement	
Baseline Practices	**Best Practices**
• Minimal efforts to increase efficiency of nitrogen application • Less than 10% of producers currently practice no till crop production on a continuous basis, however, 25% use no till • 5% adoption of precision guidance technologies	• Appropriate timing and rate of nitrogen fertilizer application • All current no till producers adopt continuous no till • Double current adoption to 10% of dairy industry crop production
Manure and Nutrient Management	
Baseline Practices	**Best Practices**
• Nationally, 40% of nutrient value in manure is lost because of application at incorrect rates	• Manure produced on dairies is applied at appropriate rates and times to maximize nutrient capture and offset commercial fertilizer use
Pastured Dairy	
Baseline Practices	**Best Practices**
• One quarter of dairies using pasture manage herds in continuous grazing systems	• Managed intensive grazing systems in place on pastured dairies to increase productivity and enhance carbon sequestration of pasture lands • Where appropriate, create additional pasture land by converting from other land uses

Reduction Opportunities

As a large source of carbon emissions in the milk value-chain, reduction opportunities in crop production are significant. After reviewing baseline and best practices in crop production, five opportunities were identified to reduce carbon, these include: conservation tillage, nitrogen management, precision agriculture, manure nutrient use, and pastured dairy. Below is a summary of each practice, barriers to adoption, and pathways to adoption.

Agriculture Process Improvement

Precision Agriculture

Precision agriculture is a suite of technologies and practices that seek to use resources and apply inputs in an accurate and site-specific manner, with the goal of maximizing yields while minimizing production costs. Mo accurate application of inputs reduces overlap and waste while site-specific application uses less of inputs overall. Precision guidance based on GPS technology allows producers to reduce fuel use and GHG emissions by 5% through a technology whose adoption is a net cost savings in many cases.[30] By doubling the current rate of adoption to 10% of producers, the industry could save more than 1 million gallons of diesel fuel annually, worth over $4.1 million at a price of $4.08 per gallon.[31] Through these savings, the emission of more than 10,000 metric tons of GHG could also be avoided.

Barriers to Adoption

Currently approximately 5% of U.S. producers use precision guidance technology. Adoption is constrained by equipment costs and a lack of awareness of the benefits of precision guidance.

Pathways to Adoption

Rising input cost and labor savings are expected to grow as fuel prices rise.[32] As input costs grow the opportunity exists to highlight the benefits of precision guidance to the producer. The dairy industry can increase adoption by aligning support across its network of co-ops, producers, and equipment suppliers to address the efficiencies and potential cost savings of precision agriculture.

<u>Conservation Tillage</u>

No till cultivation is the practice of planting crops with minimal soil disturbance. When practiced over multiple years and with no tillage in between annual plantings, this opportunity has the potential to sequester carbon at annual rates of 0.3 metric tons per acre or more, dependent on climate and soils. Because of this, continuous no till cultivation is certified by the Chicago Climate Exchange as a verified carbon sequestration activity and, as a result, a potential new income stream for producers.[33] Today, no till cultivation is practiced on 24% of corn acres and 31% of soybean acres across the U.S. and is a demonstrated, successful cultivation practice. Continuous no till, however, is adopted by only 5% to 10% of these producers. Full adoption of continuous no till by all producers that feed the dairy industry could remove more than two million metric tons of CO_2e annually and create more than $12 million in new income for crop producers at current voluntary market prices for carbon of $6 per metric ton. It is important to note that this full potential adoption should not be interpreted as a target but rather a framing of the potential magnitude of this reduction opportunity.

Barriers to Adoption

No till agriculture in corn and soy is predicated on the use of specific machinery, herbicides, and herbicide resistant crop strains. In addition, some crops experience short-term yield reductions of 2% to 10% over the first two to three years of cultivation and the costs of new equipment can limit adoption of no till for producers practicing conventional tillage. As a result, a level of capital investment is required for adoption. However the more significant barrier is a lack of access to appropriate information. While regionally adapted practices and examples of successful use of continuous no till agriculture are available across the U.S., this information has not to date been readily available to the industry at large. In addition, carbon offsets are an emerging issue in agriculture with considerable uncertainty among producers about their financial value and risks.

Pathways to Adoption

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30 Griffin, T.W., J. Lowenberg-DeBoer, D.M. Lambert, J. Peone, T. Payne, and S.G. Daberkow. 2004. Adoption, Profitability, and Making Better Use of Precision Farming Data. Staff Paper #04-06. Department of Agricultural Economics, Purdue University.

31 Energy Information Administration website accessed 6/10/08 http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp

32 Batte, M., Ehsani, M.R. Precision Profits: The Economics of a Precision Agricultural Sprayer System. Department of Environmental, Agricultural, and Developmental Economics. The Ohio State University. AEDE-RP-0056-05

33 McConkey, B.G., Lian, B.C., Padbury, G. and Heck, R. Prairie Soil Carbon Balance Project: Carbon Sequestration from Adoption of Conservation Cropping Practices. Final Report to GEMCo, Semiarid Prairie Agriculture Research Centre. 2000. 173pp.

Increased adoption of continuous no till by crop producers will require significant support from third party vendors, land grant universities and extension offices to support training in new practices and—for many—new or modified equipment. The dairy industry can meaningfully address these barriers through its existing network of producers, co-ops, and processors. Through these channels the industry can highlight the benefit of continuous no till agriculture through reduced GHG emissions and through the increasing value of carbon credits. These channels can also link producers to regional networks of no till farmers including practitioners, academic, and industry support.

Nitrogen Management

Until recently there has been little incentive for producers to closely manage nitrogen use in fields. The risks of reduced yield when insufficient nitrogen is available in soils generally outweighed potential savings from reduced fertilizer costs. The result is the practice of applying additional nitrogen to ensure full yields. However, nitrogen additions to agricultural soils is a potent driver of nitrous oxide emissions and these emissions can be reduced by applying only as much nitrogen as is needed for full crop yield. Through the efficient use of nitrogen fertilizers, the dairy industry can avoid the emission of more than 280,000 metric tons of CO_2e and save producers nearly $20 million at a price of $523 per ton of anhydrous ammonia.

Barriers to Adoption

The primary barrier to increased efficiency in applying fertilizer is a lack of access to the information needed by producers to make good decisions about efficiently managing fertilizer application. Data limitations about the impacts of cropping history, soil temperature, and late-spring nitrogen concentrations constrain producers in making efficient fertilizer decisions. In addition, perceptions of reduced yields continue to provide a strong incentive for producers to err on the side of over-application.

Pathways to Adoption

Several states including Iowa, Nebraska, and Pennsylvania have developed initiatives to address nitrogen fertilizer use through a combination of producer outreach efforts. Iowa State University, for example, promoted soil tests and created a website which tracked daily soil temperatures and trends for each county in the state to aid producers in making timing decisions. Extracting the successful strategies from initiatives like these and expanding their scope to the entire dairy industry would enable dairy producers nation-wide to make more efficient fertilizer decisions. Additionally, the Natural Resources Conservation Service supports insurance programs that help producers make efficient fertilizer plans by insuring them against yield reductions from insufficient nitrogen. By broadcasting this program's utility the dairy industry can provide farmers with the tools they need to make more efficient and cost-saving decisions.

Manure and Nutrient Management

The dairy industry produces more than 150 million tons of manure annually. Of this nearly 25 million tons containing 106 million pounds of available nitrogen are applied to fields at concentrations above plant growth requirements thereby wasting valuable nutrients.[34 35 36] Most dairies produce more manure than they can appropriately apply to their own land base; this creates an opportunity to offset commercial fertilizers applied to other nearby cropland. By ensuring that manure is applied at appropriate concentrations to a larger land

[34] Ribaudo, M. et al. Manure Management for Water Quality: Costs to Animal Feeding Operations of Applying Manure Nutrients to Land. U.S. Department of Agriculture, Economic Research Service, Resource Economics Division. Agriculture Economics Report 824

[35] Gollehon, N. et al. Confined Animal Production and Manure Nutrients. U.S. Department of Agriculture, Economic Research Service, Resource Economics Division. Agriculture Information Bulletin 771

[36] Kellogg, R. et al. Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients. U.S. Department of Agriculture, Economic Research Service, Resource Economics Division. 2000

base the dairy industry has the opportunity to reduce its GHG footprint by 68,000 tons of carbon dioxide equivalents annually.

arriers to Adoption

Efficient use of manure nutrients is constrained by on-dairy and on-farm storage limitations; insufficient access to management and application information and 3rd party service providers; and transportation costs as one ton of dry manure contains just three to twenty pounds of nitrogen.[37]

Pathways to Adoption

Overcoming these barriers requires innovative models of collaboration between dairies, farmers, and additional parties to resolve the storage and transport constraints. Dairies producing excess fertilizer must identify feasible storage solutions and nearby crop producers willing to accept manure. Methane digesters, discussed later in this document, represent a compelling opportunity to resolve both storage constraints and concerns about manure odors. Additionally, models exist where satellite composting sites aggregate, store, and process manure from several nearby dairies.

Pastured Dairy

Pastured dairy, or grazing dairy herds for some portion or all of the year, is a production system already in use on many dairies. However, because pastures maintain organic matter they, like no till agriculture systems, sequester carbon and can reduce an operation's net GHG emissions. In other words, while a dairy farm produces GHGs from a variety of sources including energy and fuel use, carbon sequestered in pastures acts as negative emission and reduces a dairy's net emissions. Several studies have demonstrated that producers who use pasture to meet the majority of their herds' dietary needs have significantly reduced GHG emissions[38]. Today, in many states where climate is conducive, roughly 50% of producers use pastures to ıeet some fraction of their herds' dietary needs[39]. Of these producers roughly half practice continuous grazing which, compared to intensive grazing, is a less efficient method of providing forage and of sequestering carbon. An opportunity exists to help transition producers who already practice some degree of grazing to improved grazing practices. By doing this the industry could reduce emissions by 300,000 metric tons of CO_2e per year. In addition, land use changes—for example converting from cultivated alfalfa to perennial grasses and forbs—where appropriate, can further reduce a producer's emissions profile. Finally, while pastured dairy is a less efficient production system where cows produce less milk the cost of production is also lower and, when properly managed, can yield increased profit margins.

Barriers to Adoption

Managed pasture grazing represents a fundamental management change for producers who currently continuously graze their herds. Navigating this transition requires infrastructure development including cross fencing, temporary fences, water development and a philosophical change in how herds are managed. As a result, the primary barriers are capital expenditure requirements and access to information to support successful management of intensive grazing.

Pathways to Adoption

Capital requirements for infrastructure developments could be defrayed through several cost-sharing programs offered by federal agriculture agencies. The Natural Resource Conservation Service's (NRCS)

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[37] Zublena, J.P. et al. Nutrient Content of Dairy Manures. North Carolina Cooperative Extension Service. Publication AG-439-29. 996.

USDA ARS. 2008 Unpublished data.

[39] Generally this includes dairies in the Midwest, Southeast, and New England regions although the amount of a herd's dietary needs that can be met by pasturage varies by climate, management practices, and site-specific constraints.

Environmental Quality Incentives Program (EQIP) provides funds that offset 25%-30% of the costs of infrastructure development for qualifying activities. By prioritizing these projects within NRCS, the dairy industry can help to ensure that producers who want to migrate to managed grazing receive these competitive funds. Additionally, training and demonstration projects have been successful in sharing management practices for successful and profitable pastured dairy. Through its network of experts, producers, processors, and co-ops the industry can link existing pasture-based dairies with producers and develop demonstration projects and training sites.

Milk Production

GHG Impacts and Activities

The milk production stage includes all the activities on the dairy farm excluding crop production. The analysis included electricity use on the farm, emissions from the animals (enteric fermentation), and emissions from the manure and urine (manure management). The GHG emissions in the milk supply-chain are due largely to the cows themselves. Cows generate methane during digestion in a process called enteric fermentation, which accounts for approximately 59% of the GHGs emitted on the farm. Manure releases methane if it undergoes anaerobic decomposition and the urine contains nitrogen, which is released in the form of nitrous oxide. Both of these processes are included in the Manure Management impact category, which accounts for 35% of the GHG emissions. Electricity use on the dairy farms makes up the remaining 6%.

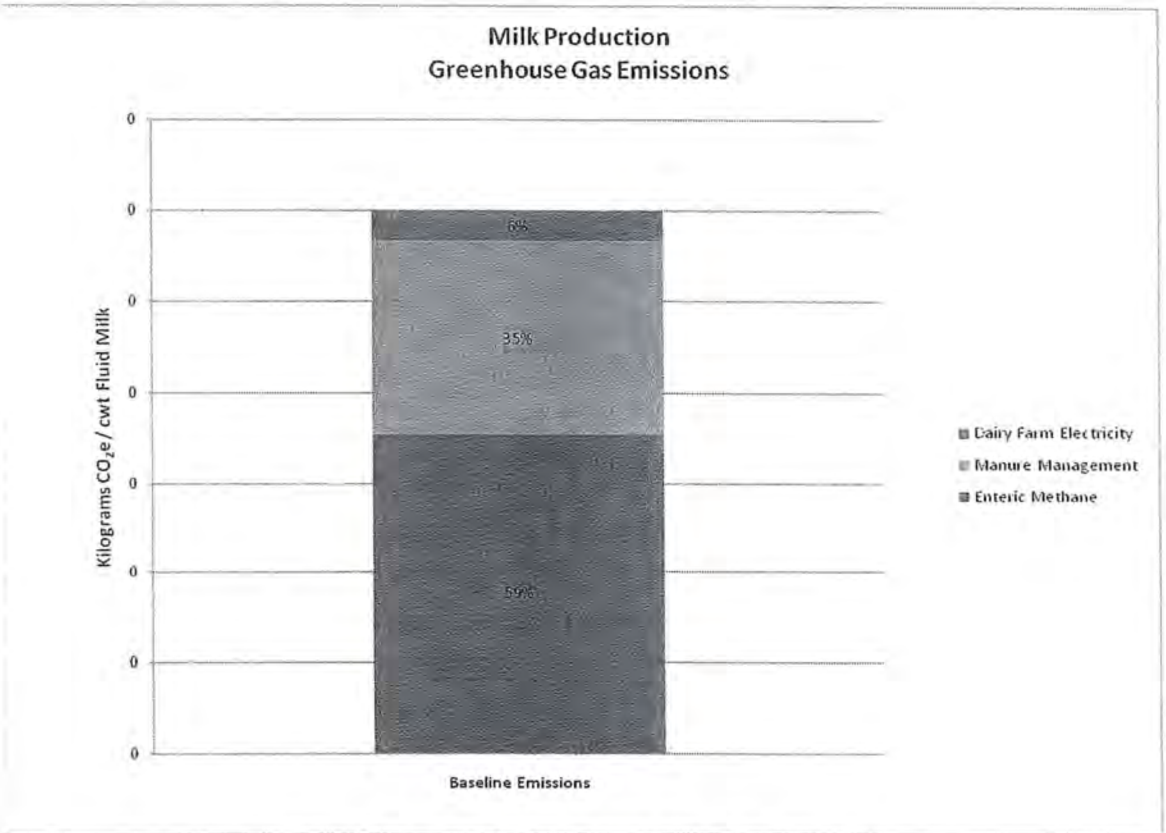

Figure 5: Baseline GHG emissions from milk production

Footprint Sources and Methodology

Total greenhouse gas emissions from U.S. milk production were assembled based on calculated enteric and manure emissions as well as extrapolated data for on-farm fuel and energy consumption. Calculated results were compared against reported values from a review of emissions from the New York state dairy industry and industry-wide studies from Norway and Australia.

Reduction Potential

rom the feed to the manure, there are ways to significantly reduce emissions and save money, and some could even become new revenue streams. Based on a "full potential" model, an estimated 12% reduction in

GHGs can be achieved by implementing currently viable best practices. The next practice areas include ideas opportunities where industry-wide collaboration could be useful to reach an estimated full potential reduction of 52%.

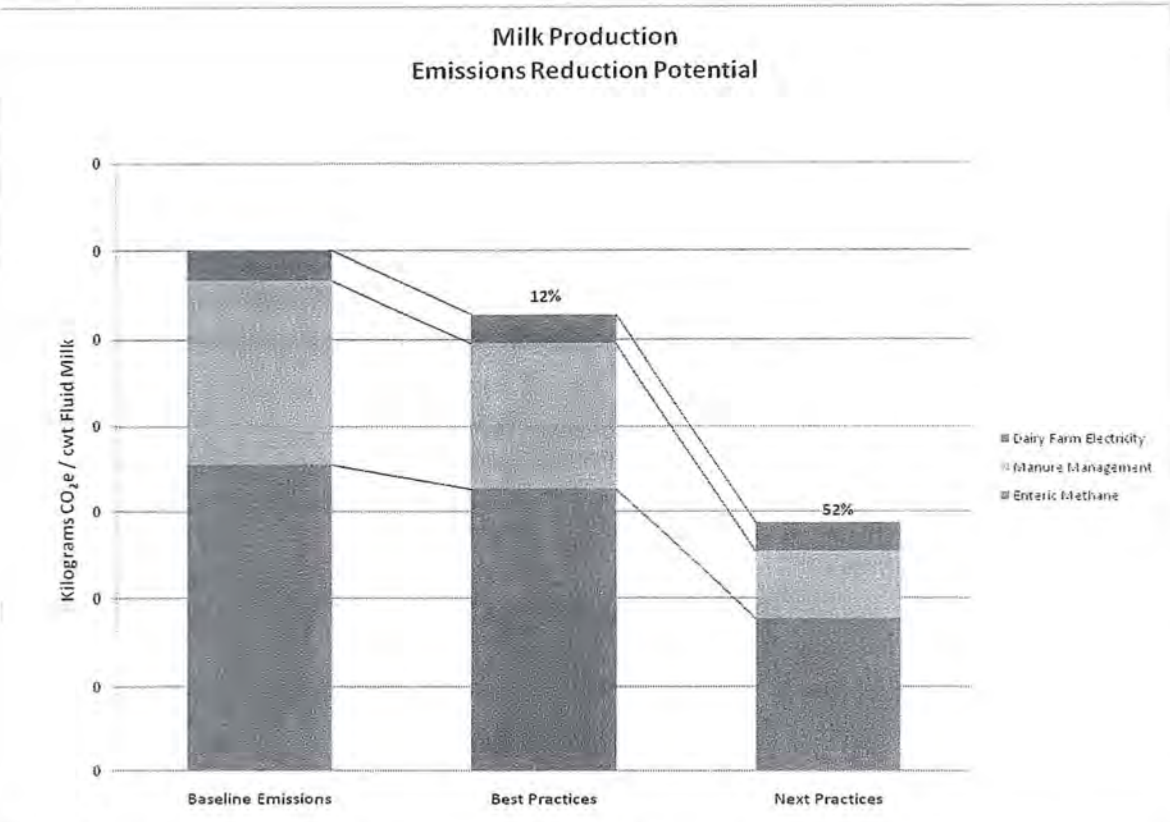

Figure 6: GHG reductions based on implementation of Best and Next Practices using a "full potential" model

These reduction potentials are based on the combination of several practices. The table below highlights some of the next and best practices that could significantly reduce GHG emissions. Since GHG emissions are not currently regulated, most farm management practices are not implemented with that in mind. Instead, they focus on animal health and productivity, water quality and other non-GHG air emissions. Coincidentally, best management practices in terms of other environmental impacts often overlap or are complementary to practices that reduce GHG emissions. However, significant barriers such as access to information and capital to implement best practices will need to be overcome for the industry to make significant progress.

The table below illustrates some best practices and next practices in milk production. The bolded opportunities are accounted for in the reduction potentials noted above.

The table below illustrates some best practices and next practices in milk production. The bolded opportunities are accounted for in the reduction potentials noted above.

Practices for Greenhouse Gas Reduction in Milk Production		
Enteric Fermentation (Methane from cows)		
Baseline Practices	**Best Practices**	**Next Practices**
• Emphasis on production efficiency; no efforts to reduce GHG emissions	• **Specialized feed additives currently available** • Nutritionist consulted for TMR feed plan focused on feed efficiency & higher yields • Feed mixtures are planned, reduced fiber • Feed techniques to increase productivity • Targeted breeding	• **Specialized feed additives (most currently in R&D) –methane vaccine, bacteria additives, feed alternatives, protected feed** • Feed alternatives and right amount of protein fed
Manure Management (Methane from manure)		
Baseline Practices	**Best Practices**	**Next Practices**
• Manure management plan; does not include methane reduction options • Manure pits and lagoons are well-maintained	• **Anaerobic methane Digesters (flare methane)** • Composting manure into fertilizer or bedding • Spreading manure to offset or eliminate need for commercial fertilizers *(highlighted in previous section)*	• **Anaerobic methane digesters generating biogas (covered lagoon, complete flow, or plug flow) - combine with lagoons or pits to minimize CH4 & odor, generate bio-gas electricity, and create alternative value from manure sludge (fertilizer, bedding, compost, etc)** • Anaerobic Co-digestion: Digest combined food waste with manure
Energy Consumption & Production (Milking, cooling, housing equipment, fuel use)		
Baseline Practices	**Best Practices**	**Next Practices**
• Little or no effort to reduce energy use	• Plate-type milk pre-cooler • Variable speed drive vacuum pumps • Efficient lighting • Mostly local channels • Preventive maintenance of machinery & equipment	• **Generate power with anaerobic methane digesters** • Only local channels • Renewable energy: solar and wind power

Reduction Opportunities

Nutrition Management

As mentioned above, the largest contributor to the carbon footprint of fluid milk is the dairy cow, with the most of the impact coming from enteric fermentation, a process that creates methane in the rumen of the cow as it digests its food.

Many milk producers already reduce the carbon footprint of milk by maximizing the feed efficiency of each cow and increasing the per cow milk production. In the last hundred years, the average milk production per cow has almost quintupled! Producers improve feed efficiency through selective breeding, carefully controlling the feed mix rations, and proper animal care. Additionally, a growing variety of additives and supplements are available to improve feed efficiency even more. Although exact penetration is unclear, industry experts estimate that over 95% of dairies use some form of feed additive.[40] Some feed additives that improve milk production also reduce methane. While manufacturers of feed additives have traditionally offered products solely targeting increasing milk production, their focus is now broadening to explore products that reduce environmental impacts as well.

Research on methods to reduce emissions from livestock has not been a priority in the U.S. However, foreign governments are funding research on feed additives that reduce GHG emissions from bovine rumen, urine, and manure, and are finding potential. In Australia, researchers have been developing a methane vaccine that targets the bacteria that live in the rumen of the cow and produce the gas. They have seen methane reductions of up to 80% in a test tube and 13% in animal trials.[41] Another technology patented by the Australian government is a protected feed that allows the food to pass further into the digestive system of the cow. This not only reduces methane production, but has the added benefit of decreasing the cholesterol in the milk and producing butter that is more spreadable when cold.[42] In the U.K., researchers are studying the role of protein in the cow's diet and the link between feeding too much protein and excess nitrous oxide emissions in the urine.[43]

Barriers to Adoption

Any discussion of regarding technology to improve milk production must address the opinions of the consumer. Consumers are increasingly concerned about what goes into their milk, and milk producers are wary of introducing new technologies that could provoke fear and distrust of the safety and wholesomeness of their milk.

Pathways to Adoption

For the short-term, the industry could stimulate demand for and development of alternatives by ensuring that carbon offsets for emissions reductions can be recognized. For the long-term, the industry should support research to reduce GHG emissions from livestock by guiding research and development through a widespread, transparent, and inclusive evaluation process. For any new technology or methods to be successful, the industry will need to such a process to promote broad acceptance among milk producers and consumers.

[40] Blu Skye interview findings. April 22, 2008.
[41] Blu Skye interview findings, March 11, 2008.
[42] "Less gas, more dollars from livestock," CSRIO Australia (Sep. 11, 2000). Retrieved Jan. 2008: http://www.csiro.au/files/mediarelease/mr2000/prDigestion.htm
[43] Blu Skye interview findings, March 17, 2008.

Methane Digesters

In addition to milk, cows give producers valuable byproducts from their manure. Anaerobic fermentation turns manure into methane gas, which can be used either as fuel or to generate electricity or sulfur. Further, remaining solids can be used for bedding, compost, or fertilizer.

In addition to reducing GHGs (methane emissions reduced by 25-90%[44]), methane digesters provide producers with additional benefits including:

- Air quality benefits through odor control (up to 90%[45]) from storage and field application, and controlling hydrogen sulfide and ammonia emissions.
- Water quality benefits in the form of stabilizing manure organics, significantly reducing pathogens, and providing nutrient management predictability and flexibility.
- Revenue and potential cost savings from:
  - Energy savings/sales and carbon offset revenues
  - Better nutrient management to create pathogen-free compost, fertilizer, or bedding. Digesters help to convert more organic nitrogen into ammonium, the primary constituent of commercial fertilizer. If properly applied, the producer can help to optimize plant uptake, thereby using potentially better nutrient management techniques to achieve optimal crop yields.

Barriers to Adoption

The main barrier to widespread digester adoption is the increased hassle and time commitment required for the producer to go through the tedious permitting, funding, construction and maintenance process. Approval and development of methane digesters demands an extraordinary dedication on the part of the producer, which is why there are only 111 farms in the U.S. that use digesters[46]. Other barriers include:

- *Information:* Concerns and misconceptions about the technology exist and there are only a handful of demonstrable projects on farms today. Successful projects seem to require a producer willing and able to gain expertise in engineering, construction, and maintenance.
- *Utility Incentives:* Many states still offer only low or non-existent utility incentives.
- *Low Economies of Scale:* Digesters typically use standardized parts (concrete, pumps, pipes, turbines); they won't get cheaper through economies of scale alone.
- *Economics:* Digesters have about a six-year payback, and given the significant capital required and lack of favorable financing (banks often require the entire farm as collateral to secure a digester loan) available to build one, it is little wonder that only 111 digesters are in operation. However, the underlying economics of digesters look promising. For example, a $550,000 digester, with a 5-year payback goal at a 10% cost of capital, and with approximately $60,000 - $70,000 per year in additional revenues (bedding or fertilizer), would have to earn at least $0.10/kWh for the energy or $42/metric ton for carbon offsets to be considered profitable. While both of these prices are higher than today's market of $.08/kWh and $6/metric ton, they are likely to come within reach in the short to medium-term as carbon becomes increasingly regulated and energy prices continue to escalate.

Pathways to Adoption

The industry must think creatively about a model that incorporates expertise in constructing and maintaining digesters; facilitates funding; reduces maintenance costs; and builds foolproof technologies. To make digesters

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[44] EPA AgStar, "Market Opportunities", Industry Expert Interviews
[45] State of Oregon, Digester Fact Sheet: http://www.oregon.gov/ODA/energy_methane.shtml
[46] EPA AgStar, "Market Opportunities"

attractive to both producers and financers, a combination of technology, regulation, economics, and new partnership models is needed that allows producers to easily convert their manure into marketable byproducts and provide them with revenue for the energy, carbon, and solids value.

A 3rd party financing model is one promising way to overcome some of the economic and technical barriers. A financing company, with a network of digester experts to contract with, would be responsible for the approval, construction, and ongoing maintenance/operations of the digester in exchange for revenue sharing of the marketable byproducts. This would alleviate much of the burden producers currently bear. Models similar to this have worked very well in the solar industry, with arrangements called Power Purchase Agreements (PPAs) in which financing companies cover the capital costs and take ownership of a photovoltaic system, and then sell the generated power to the user at a contracted price.

Additionally, changes in carbon regulation and the development of incentives for renewable energy that can be used for digesters would encourage their growth, as state rebates and federal tax credits have for the solar and wind power industries.

If the key financial and regulatory hurdles can be overcome, digesters represent a sizeable growth opportunity. Currently only 0.19% of farms have digesters. If dairy farms with over 500 head (2,623 farms or ~3.4% of U.S. dairy farms, and 80% of the power generating potential) added digesters[47], it would reduce CO2e emissions by 4.4 million metric tons, a 15% reduction in the carbon footprint for fluid milk. The annual 1 million MWh of electricity those digesters would generate could replace in equal measure the amount of utility generated power, further reducing CO_2e emissions by 660,000 metric tons[48]. A dairy producer could yield approximately $30,000/year if they sold their electricity at market price ($0.08/kWh[49]). Combining this with revenues from bedding, fertilizer, compost, and carbon credits (which range from today's $6/ton to potentially $40/ton), the average producer could earn $100,000 - $180,000/year. For the U.S dairy industry this translates to a potential of $475 million of additional annual revenue.

[47] EPA AgStar, "Market Opportunities", Methane generation potential based on the manure management system used, geographi region, thermal conversion rate, and digester technology selected
[48] EPA AgStar, "Market Opportunities"
[49] U.S. Dept of Energy, 2004 - average price for energy/kWh

Processing

GHG Impact and Activities

Processing fluid milk represents the third largest stage of emissions in milk's lifecycle, the result of energy use at the processing facility in the form of electricity and fuel (approximately 35% and 65% of total energy use, respectively).

The majority of a milk processing facility's energy requirements are attributed to steam production and distribution, refrigeration, lighting, compressed air, and motors. Natural gas (or, in some cases, fuel oil, diesel or propane) is used as an input to the boiler to generate steam for thermal processes (e.g. pasteurization and cleaning), whereas electricity is primarily used for refrigeration, lighting, compressed air and motors.

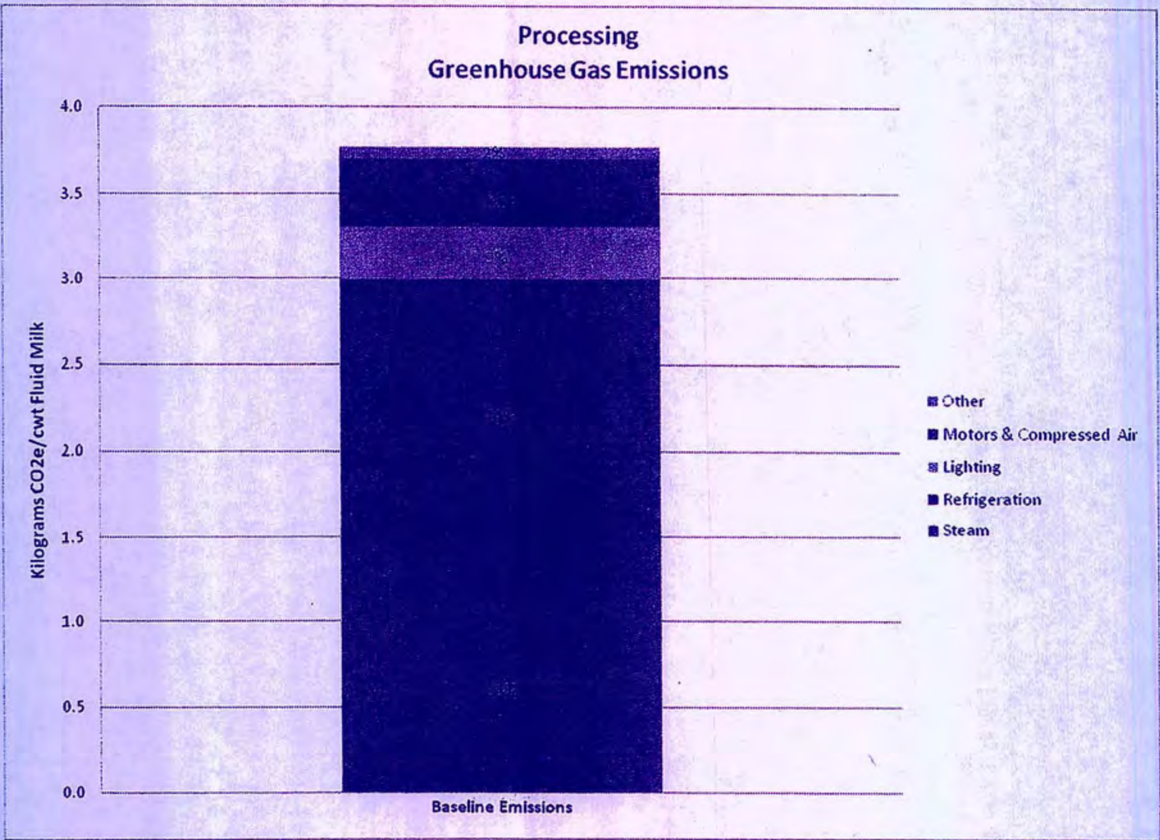

Figure 7: Greenhouse gas emissions from baseline practices in processing

Electricity: About 50% of electricity generated in the U.S. is from coal-fired central power plants, heavy emitters of carbon dioxide (CO_2).[50] Due to losses in transmission, waste heat, and other variables, only a small portion of every kWh generated is actually converted to useful energy at the processing facility. Opportunities to increase efficiency at the point-of-use can reduce unnecessary demand on the grid.

Natural Gas & Fuel Oil: Burning natural gas or fuel oil for energy also releases CO_2: natural gas emits 28% less lbs CO_2/MMBtu than fuel oil.[51]

Energy Information Administration. Electricity Generation. December, 2007. http://www.eia.doe.gov/neic/infosheets/electricgeneration.html

[51] EPA. "Unit Conversions, Emissions Factors, and Other Reference Data." November 2004.

Through improved energy efficiency (reducing fuel and electricity requirements), as well as currently available technologies such as cogeneration, fluid milk processors could achieve industry-wide reductions in GHG emissions of up to 40%.

Footprint Methodology

Emissions from milk processing were calculated based on reported values of purchased fuels and electricity use from the U.S. Census Bureau's 2007 manufacturing census for the fluid milk sector. Purchased values were extrapolated from total emissions based on U.S. average emissions by fuel type and a national average for electricity generation.

Reduction Potential

The reduction potentials shown in Figure 8 are based on current adoption of a range of practices reported in a U.S. fluid milk industry-representative processing plant survey sample, assuming a goal of "full-potential" (i.e. 100% adoption). Baseline data accounts for industry-wide adoption of specific best practices (listed in Figure 9). Survey data was collected from a total of 49 fluid milk processing plants, which collectively process 25% of U.S. milk (or, 1.5 billion gallons), based on 2007 production levels. Processing sites surveyed consumed a combined total of 430 million kWh and 4.3 million MMBtu for processing fluid milk only.[52]

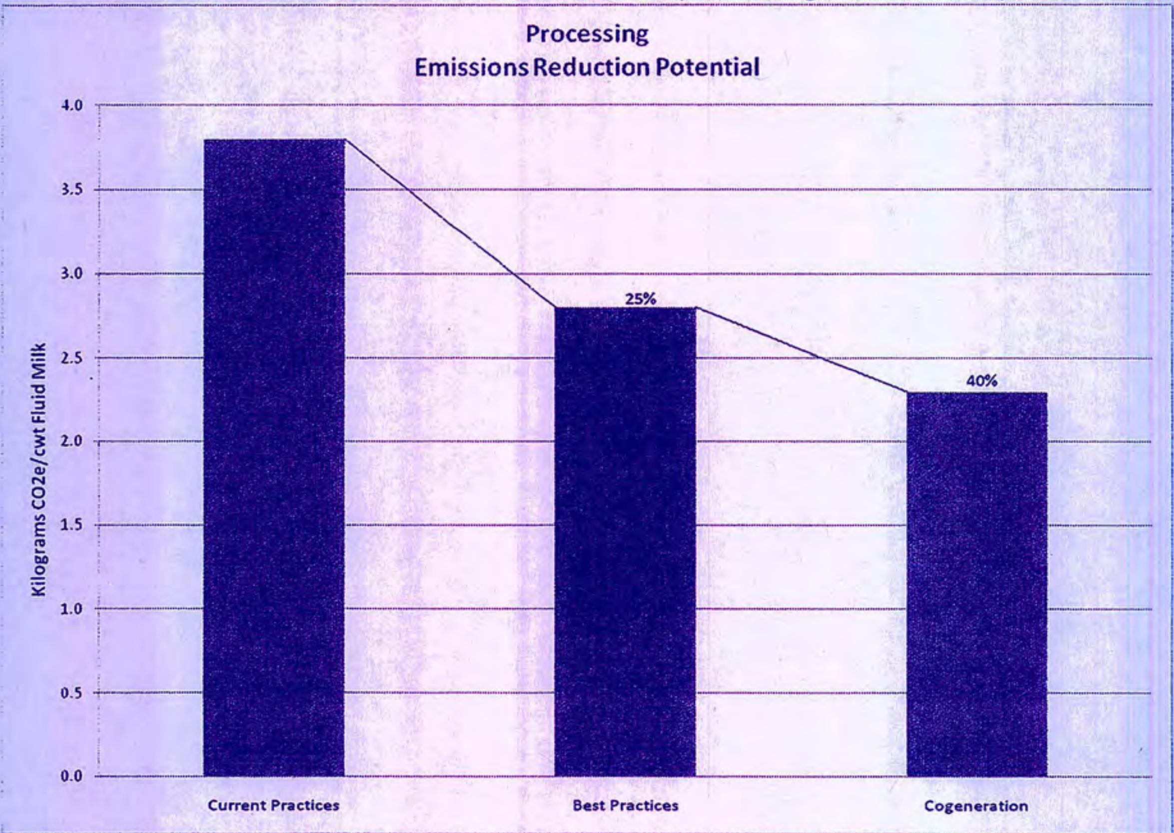

Figure 8: Processing Emissions Reduction Potential based on a "full potential" model

[52] University of Arkansas. Processor Survey - Preliminary results. 2008.

The table below illustrates some best practices in energy efficiency, energy production and next practice technologies and procedures (not currently viable). The bolded opportunities are accounted for in the reduction potentials noted above.

Practices for Greenhouse Gas Reduction in Processing	
Energy Efficiency Best Practices	
Fuel Use	**Electricity Use**
• **Steam trap/leak maintenance program** • **Increase regeneration efficiency** • **Insulation improvements** • **Boilers optimized for maximum efficiency** • **Boiler condensate recovered to make-up water** • **Boiler economizer**	• **Insulation improvements** • **Recovery of waste heat from refrigeration process** • **Energy efficient lighting** • **Variable speed drive motors** • **Efficient compressed air system** • **Detect/repair compressed air leaks** • Absorption chillers (utilizing waste heat) • Ice-bank storage built during off-peak times to maximize compressor capacity
General	
• Programs and targets currently in place to improve plant energy efficiency • Energy management control systems or sub-metering to monitor systems or process performance, energy usage • Preventative maintenance program in place • Technical assistance, training and/or assessment supplied by government, utility or other third party	
Energy Production Best Practices	
Fuel & Electricity	
• **Cogeneration** • Biogas generated on premises provides input to boiler or other process • Potential for using biogas from neighboring dairies • Use of renewable energy sources such as solar, wind	
Next Practice Processing Technologies & Procedures	
Fuel & Electricity	
• Alternatives to thermal processing • Shut-down cleaning requirements extended beyond 24-hour period	

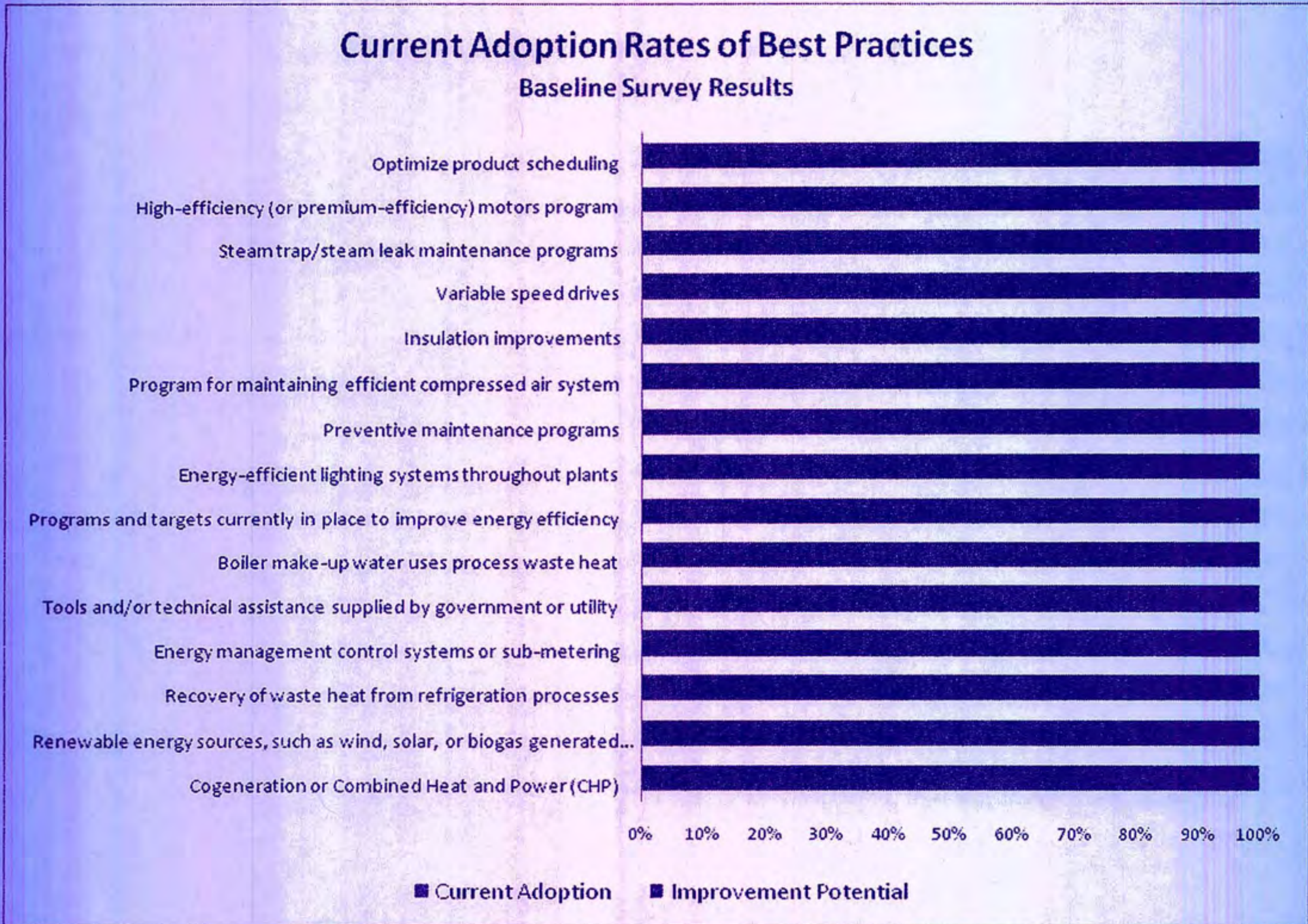

Figure 9: Baseline Survey Results: Current Adoption Rates of Best Practices

Reduction Opportunities

Processing Efficiency

Energy Efficiency

Energy management best practices go straight to the bottom line – reductions in energy use are directly correlated to reductions in cost by lowering electricity and fuel purchase. There exists tremendous potential to simultaneously reduce emissions and uncover significant savings, especially in light of ever-rising energy costs. For example, estimates by qualified U.S. Department of Energy steam system engineers indicate that many fluid milk plants could reduce fuel use by 10 to 15%.[53]

Energy efficiency practices often provide additional unforeseen benefits, such as improved system reliability, avoided maintenance and shut-down costs and increased productivity. An optimally efficient steam system, for example, produces steady and uniform pressures and temperature, and therefore a higher quality product and more consistently satisfied customers.

True savings and reduction potential can only be determined on a plant-specific basis. However, generally speaking, many of the above practices can be implemented within a 2-year payback. High-efficiency motors,

[53] Blu Skye interviews and secondary research

for example, can cost 40% more than standard motors, however this cost is recovered quickly through energy savings. The U.S. Department of Energy audited a dozen industrial retrofits of motor systems around the country and found an average energy savings of one-third, with a payback of a year and a half.[54] Government nd utility-sponsored financial incentives and rebates are often available. For companies willing to seek out more creative capital financing and flex their capital budgets to accommodate longer-term paybacks, the savings can climb into hundreds of thousands of dollars.

A number of operational improvements can also be made at *low or no cost.* These include:

- Optimizing product scheduling to minimize equipment changeover;
- Improving insulation;
- Tuning boiler for optimal air/fuel mixture;
- Paying the incremental cost for high efficiency equipment (such as electric motors);
- Reporting and repairing of steam and compressed air leaks.

Energy Production

Best practices in energy production include cogeneration, using biogas generated from milk wastes to produce energy, and the use of other renewable energy sources such as solar and wind power.

Cogeneration, or combined heat and power systems (CHP), use a single source of fuel to produce both electrical and thermal energy at the point of use. The average efficiency of fossil-fueled power plants in the U.S. is 33 percent; in other words, two-thirds of the energy in the fuel is lost as heat. By using waste heat recovery technology to capture a significant proportion of this wasted heat, CHP systems typically achieve total system efficiencies of 60 to 80 percent.[55]

Because CHP is more efficient, less fuel is required than with separate heat and power; thus, cogeneration offers significant greenhouse gas reduction potential. Some estimates indicate cogeneration technologies at dairy processing facilities have the potential to reduce emissions by 30-40%.[56] A cogeneration system at one U.S. fluid plant is saving $75,000/year by using waste heat recovery to satisfy thermal needs, and requires approximately 21 percent less fuel than typical onsite thermal generation and purchased electricity. Based on this comparison, the system reduces CO_2 emissions by an estimated 663 tons per year.[57] Such "micropower" systems are attractive to low-risk seeking capital investors, and state or federal matching grants or utility-sponsored incentives are often available. While electrical and gas prices greatly affect the economic viability of cogeneration, increasing energy costs throughout the U.S. have prompted renewed interest.

Anaerobic digestion is another proven technology capable of providing a renewable energy source with reduced carbon emissions, in addition to waste management benefits. A milk processing facility's ready supply of organic wastes (generated through onsite treatment of effluent from milk processing) can be converted to methane biogas suitable for boiler fuel, or a CHP system. The UK is currently exploring the commercial and technical feasibility of *centralized* anaerobic digestion, combining livestock manure with milk and other food processing waste.

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[54] Romm, Joseph. Cool Companies: How the Best Businesses Boost Profits and Productivity by Cutting Greenhouse Gas Emissions. 2006.

[55] EPA. Combined Heat and Power Partnership. http://www.epa.gov/chp/basic/efficiency.html

Dairy Australia. "Eco-Efficiency for the Dairy Processing Industry." August, 2004.

[57] NYSERDA Project Description. http://chp.nyserda.org/facilities/details.cfm?facility=52

EPA. "EnergyStar 2005 CHP Award Winners"

Barriers to Adoption

Most fluid milk plants operating today have not adopted the full range of viable energy management best practices due to a number of factors. Capital budgeting constraints are a primary obstacle. Energy efficiency projects are often given low priority relative to core business spending and not accommodated within alread tight operating budgets. In addition, short-term hurdle rate requirements (24-36 months or less) are common in the industry, preventing consideration of higher capital items with longer-term savings potential. For example, cogeneration systems, with total installed costs as much as $1,000/kW, often do not meet stringent payback thresholds (although true cost can only be determined on a site-specific basis and could be significantly lower).[58] Time and human resource constraints are also considerable obstacles for plant managers and operators, yet training as well as on-the-ground technical assistance is often needed to implement these best practices. It is common for operators to have limited engineering expertise, and on-site technical assistance is uncommon. Lastly, potential for full improvement – and thus, associated savings –cannot be properly assessed without first measuring an accurate baseline. Many fluid milk plants do not monitor systems or process performance.

Pathways to Adoption

Executive will and leadership is essential to driving lasting change throughout the industry and in each plant. Fluid milk processors should align around a common set of industry-wide benchmarks and guiding principles that govern project planning and purchasing decisions with an eye toward energy efficiency and long-term returns. Implementation of basic monitoring and control mechanisms is essential for accurately assessing true energy and cost reduction potential. To accelerate adoption of best practices, processors could jointly fund industry-appropriate energy assessment and technical assistance teams. This effort could leverage energy service companies (ESCOs), as well as tap existing government & utility-sponsored programs to provide both financial (e.g. third-party leasing agreements, matching grants) and technical assistance (audits, feasibility studies, training). Some firms, acting as third-party owner-operators, can offer alternative financing (e.g. operating leases), often at a low or zero upfront cost of capital, for major energy projects. Design-build-finance-operate contracts, often in combination with government grants, can make large capital items such as anaerobic wastewater treatment systems financially viable. Volume purchasing may also enable individual processors to meet desired price points for equipment, such as energy efficient motors. Resources including grants, technical assistance and training for industrial energy efficiency projects have been largely untapped by fluid milk processors. Some examples can be found at the links below.

- **DSIRE** is a comprehensive source of information on state, local, utility, and federal incentives that promote renewable energy and energy efficiency: http://www.dsireusa.org/
- The **Department of Energy's Office of Industrial Technology's Save Energy Now Program**: http://www1.eere.energy.gov/industry/saveenergynow/
- This **EPA CHP Partnership** questionnaire evaluates whether a facility may be a good candidate for cogeneration: http://www.epa.gov/chp/project-development/qualifier_form.html

Next Practices: Alternative Processing Technologies

Alternatives to thermal processing may have the potential to reduce energy demands associated with producing steam needed for pasteurization. While some countries have explored such technologies, they are not currently used in commercial production. Regulatory policy is the largest hurdle; current FDA food safety regulations strictly mandate the use of pasteurization as the only recognized standard for destroying harmful

[58] "An Integrated Assessment of Energy Savings and Emissions Reduction Potential for Combined Heat and Power." http://www.eere.energy.gov/de/pdfs/chp_integrated_assessment.pdf

pathogens found in raw milk. In addition, the high cost of capital for equipment changeover is a major constraint. Processors could support research to explore the viability of alternative technologies; work directly with the Food and Drug Administration and the Department of Energy to drive toward mutual goals; and romote pilot demonstration and/or technology verification projects. In addition, increasing product run times beyond the current 24-hour restriction (due to federal cleaning requirements) may provide energy savings. Processing facilities would have to demonstrate viability through a strict bacterial monitoring process to prove product contamination has been avoided.

Reduce Milk Loss & Product Recovery

Milk loss in a fluid milk plant can range between 1% and 3%. Lost milk creates a wastewater load and can lead to increased waste management costs. In addition, this reduces the efficiency of all resources used in production. The initial step in reducing milk loss is to understand the degree and location of the losses. Many options are available to monitor such loss, and once understood, low cost/no cost procedural changes and employee training can significantly improve the situation.

Some processors have installed varying technologies to recover milk that would otherwise be lost. Commonly potable water is used to flush lines and vessels and the resulting milk/water solution is captured and retained. The mixture can then be subject to reverse osmosis or other technology to remove excess water. Subject to not insubstantial FDA limitations, the recovered product can be used in some dairy products.

Packaging

GHG Impact and Activities

Energy consumed in the manufacture and transport of milk packaging material accounts for 7% of milk's total lifecycle GHG emissions. Plastic (85%) and paperboard (15%) are the dominant milk packaging materials in the U.S., with the HDPE gallon jug representing 65% of total sales.[59]

Emissions occur during material production (from energy used to process and convert raw material), container formation (from energy used to operate blow molding and carton forming equipment, often at the milk processing site) and transport of the raw materials. In addition, "embedded energy," or energy not combusted, is factored into some packaging life cycle assessments to account for the energy content of a fuel source (e.g. petroleum) when used as a raw material. A smaller percentage of emissions also occur at the end-of-life stages of a package, in the form of energy used in recycling or the release of methane from landfill (not included below).

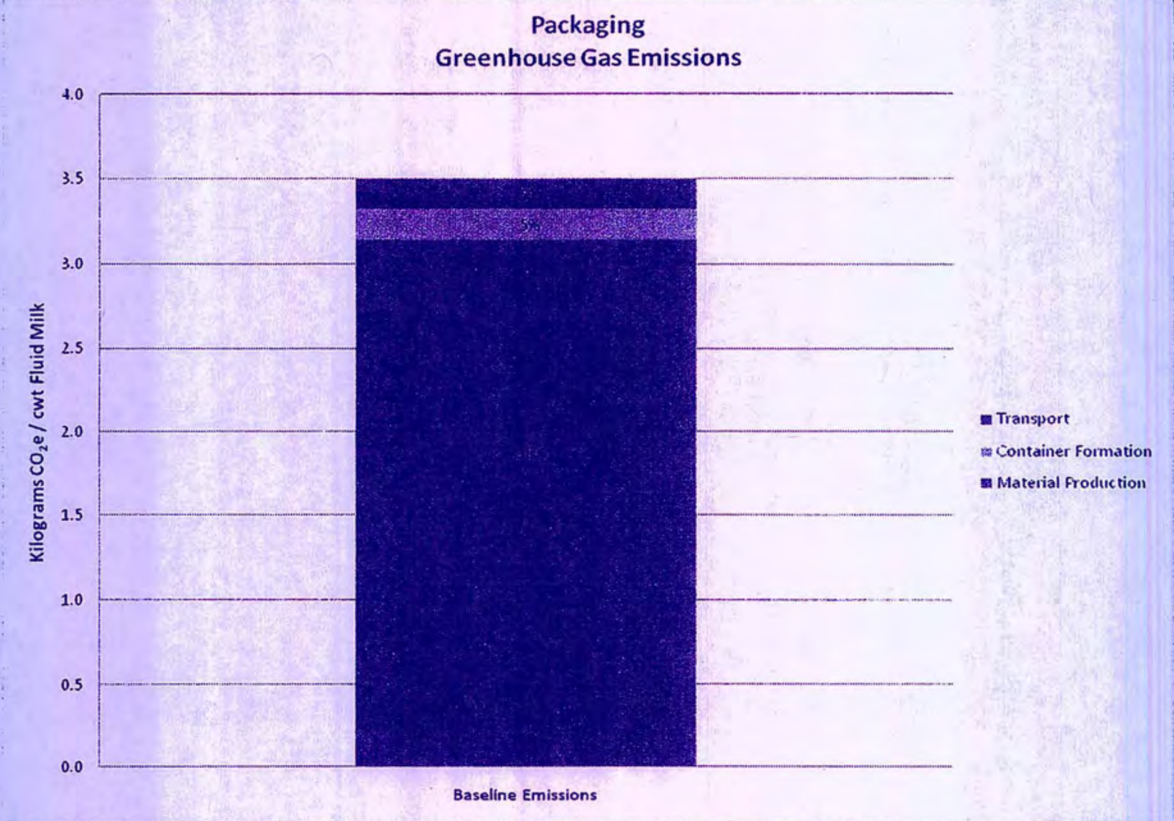

Figure 10: Packaging Greenhouse Gas Emissions

Improved energy efficiency in container formation equipment could reduce the embodied carbon in milk packaging by 1%. Processors could also work with their supply-chains to improve energy efficiency in the material production stages (processing and conversion of raw material to resins and paperboard).

[59] USDA. "Packaged Fluid Milk Sales in Federal Milk Order Markets, by Size and Type of Container." 2006.

Footprint Methodology

Emissions from fluid milk packaging were directly calculated based on U.S. data of units sold by container size and type and emissions values for material production, transport, and container formation. In addition, missions are calculated for secondary packaging use including milk crates.

Reduction Potential

Data published in the U.S. show that the majority (90%) of energy use associated with milk packaging – regardless of type – is in the *production of the material* (not including container formation).[60] Therefore, efforts to reduce raw material inputs, for example, through alternative formats, have the greatest potential to reduce emissions associated with packaging. In addition, by improving the energy efficiency of container formation equipment, such as blow molding machinery, processors and the milk packaging equipment supply-chain could reduce GHG emissions in the packaging stage by 1%.

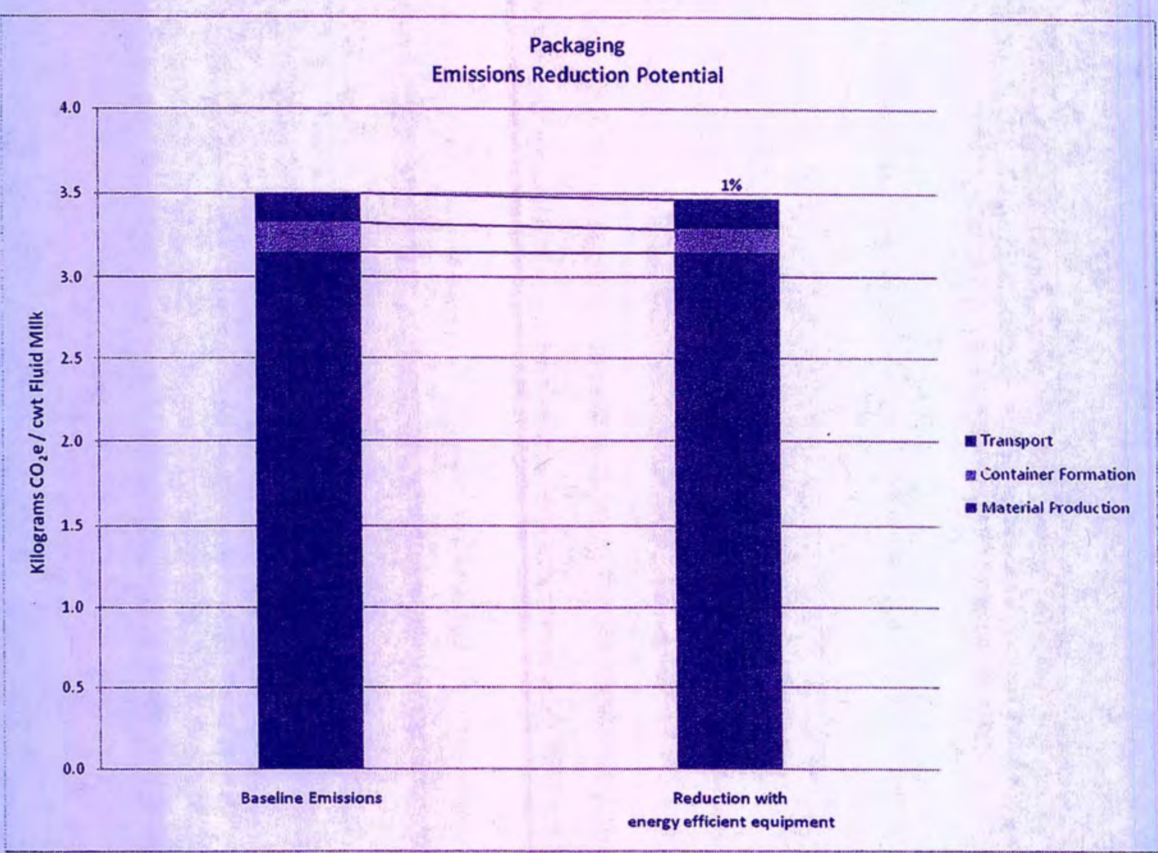

Figure 11: Packaging Reduction Potential using a "full potential" model

[60] Keoleian & Spitzley. "Guidance for Improving Lifecycle Design and Management of Milk Packaging." *Journal of Industrial Ecology*. 1999. University of Michigan, Center for Sustainable Systems.

The table below illustrates some best practices in packaging, the bolded opportunities are accounted for in the reduction potentials above.

Practices for Greenhouse Gas Reduction in Packaging

Baseline Practices	Best Practices
• Existing gallon jug is already light weight • Minimal efforts to improve energy efficiency of container forming equipment • Limited investment/availability in new energy efficient equipment • Some efforts to improve cube and eliminate secondary packaging, e.g. stackable gallon	• **Maximize energy efficiency of container forming equipment** • Increase material reduction, e.g. light-weighted gallon or alternative formats • Design package to maximize cube utilization • Reduce or eliminate need for secondary packaging • Widespread use of renewable energy sources for manufacture of material, transport • Adopt sustainable protocols in overall package design process

Reduction Opportunities

Low Carbon Packaging

Material Reduction

Light-weighting, or using fewer material inputs in the production of a package – offers the greatest potential for emissions reduction as well as cost savings, by cutting raw material and energy costs. The "light makes right" principle is supported by research that has found a strong correlation between weight reduction and life cycle energy reduction. For HDPE bottles, gable top carton and LDPE pouches, a simulated 10% weight reduction resulted in 10% less life cycle energy requirements.[61] The gallon has already undergone a weight reduction of 30% in the past 20 years[62], but concept testing is underway in the U.K. to further reduce half-gallon sizes through "handleless" and other designs estimated to reduce raw materials by up to 30%.[63]

Milk pouches (approximately 1 liter), common in Canada and emerging in the U.K. and other parts of Europe, are currently the lowest-carbon existing format. Energy required in the material production stage for the pouch is approximately one quarter of the energy required for both the carton and HDPE jug.[64] In the UK, GreenBottle is piloting an innovative format using a pulped recycled cardboard outer case (resembling a jug) with an inner plastic liner pouch. Ecolean (Sweden) has launched a source-reduced pouch made from conventional plastics (polyethylene and polypropylene) and 40% calcium carbonate (chalk).

Energy Efficient Forming Equipment

Container forming equipment, either for blow molding (often done on-site at the processing facility) or paperboard forming, uses significant electricity due to compressed air demands. Suppliers are beginning to

[61] Ibid

[62] American Chemistry Council. "Lifecycle of a Plastic Product"

[63] WRAP UK. Milk Concept Room. http://www.wrap.org.uk/retail/tools_for_change/concept_room/milk.html#slide3

[64] Keoleian & Spitzley. "Guidance for Improving Lifecycle Design and Management of Milk Packaging." *Journal of Industrial Ecology*. 1999. University of Michigan, Center for Sustainable Systems. "Comparison of material production and total life cycle energy (MJ) per 1.000 gal of milk delivered."

produce more energy efficient equipment, but there is potential to further increase efficiency through upgrades and maintenance of existing machinery.

'arriers to Adoption

Both material reduction and improved energy efficient forming equipment have cost implications. Technical feasibility of further light-weighting the gallon is unknown, and is not being explored in the U.S. The reduction potential for new formats, such as milk pouches, must be balanced by careful consideration of consumer acceptance, preference and ease of use, as well as retail merchandising. Some pouches require the use of a reusable jug container, which could present product contamination and hygiene concerns. Other obstacles to material reduction include maintaining properties important for product quality (e.g. light barrier), sterility, durability, and leakage (e.g. during transport).

Pathways to Adoption

To catalyze innovation opportunities, milk processors and packaging suppliers might want to consider joining forces to co-design concept testing for light-weighting and alternative formats, develop pilot projects to test the viability of pouches in the marketplace, or partner on energy efficiency benchmarks and guiding principles.

Reducing GHG embodied in milk packaging is only one element of a broader sustainable packaging strategy that must also account for end-of-life considerations (e.g. recycling, energy recovery), use of recycled raw materials, sourcing and other considerations. The industry should consider formation of a broader, multi-stakeholder working group to holistically address the full spectrum of packaging considerations. In the UK, a multi-stakeholder coalition led by Waste & Resources Action Programme (WRAP)[65] has developed a process to recycle and reuse post-consumer plastic milk containers back into new plastic containers. Private investment in onsite product of rHDPE at the milk processing facility will enable the industry to reach its target of 50% ecycled material in all UK plastic HDPE milk containers by 2020 or sooner.[66]

Energy Efficient Supply-Chains

By working together with paperboard and resin supply-chains, milk processors can align on industry-wide purchasing guidelines to drive best practices in raw material manufacturing, capturing energy efficiency and use of renewable energy. Some leading companies are already answering the call: International Paper has pledged to reduce total U.S. GHG emissions by 15% from 2000-2010. Tetra Pak met its goal to reduce per package energy use by 15% since 2002, and has a current goal to reduce use of fossil fuels by 10% by 2008.

Secondary Packaging Retention

The dairy processing industry is replacing 20 million HDPE plastic milk crates each year. A single milk crate weighs approximately 3 pounds, the weight equivalent of 65 half-liter water bottles. Cumulatively this amounts to 60,000,000 pounds of HDPE plastic resin per year. Replacement is necessitated by loss due to theft for the value of the resin, misuse by business customers and consumers, and inappropriate disposal. These significant losses have been ongoing for decades, but have escalated due to increased demand for recycled plastic resin and a higher concomitant price paid for recycled resin. If left within the distribution system, milk crates can be reused hundreds, if not thousands, of times before they become worn and need to be replaced. Though it is an isolated situation, some milk crates have been in use for as long as 30 years. When worn or damaged, milk processors typically return crates to crate manufacturers where they are recycled into new milk crates. Challenges to increasing the retention time in the logistical system are created by the

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WRAP is a UK-based organization that helps individuals, businesses and local authorities to reduce waste and recycle more, making better use of resources and helping to tackle climate change. http://www.wrap.org.uk/.

[66] DEFRA (UK), 2008. "The Milk Roadmap." http://www.defra.gov.uk/environment/consumerprod/pdf/milk-roadmap.pdf

multifaceted sources of loss. For-profit theft of milk crates must be handled differently than innocent misuse by customers and consumers. The former likely involves working with the recycling industry to stop the acceptance of stolen milk crates, strengthening laws and increased enforcement and prosecution of wrongdoers; the latter is likely best handled by education and enhanced awareness of the positive sustainability aspects of the milk crate.

Transportation & Distribution

In dividing the steps of the milk value-chain, there is a distinction between transportation from the farm to the processor and distribution from the processor to sales channels. In the transportation step, an insulated tanker truck picks up raw milk that has been cooled to approximately 38 degrees F from multiple dairy farms and travels to the processing plant, whereas in the distribution step, the packaged milk ready for the dairy case is transported in refrigerated trucks to the store. The primary GHG from both steps is diesel emissions. While distribution does use refrigerants like HFC, which are considered a powerful GHG, current research shows that refrigerant leakage is not a major source of emissions.

Footprint Methodology

Transportation

GHG emissions from transportation of milk from milk producers to processors occur almost exclusively from the consumption of diesel fuel in transport vehicles. Total emissions were calculated based on data for average fleet efficiency, tanker capacity, and miles traveled. These data were also validated against initial results from the processor survey conducted by the University of Arkansas.

Distribution

Total emissions from distribution of packaged milk from processors to retail locations were calculated using data on average fleet transport capacity, fuel efficiency, and miles traveled. These data were validated against initial results from the processor survey conducted by the University of Arkansas. Data from industry experts and initial results from the University of Arkansas processor survey indicate that HFC refrigerant emissions from refrigerated transport are an insignificant source of emissions.

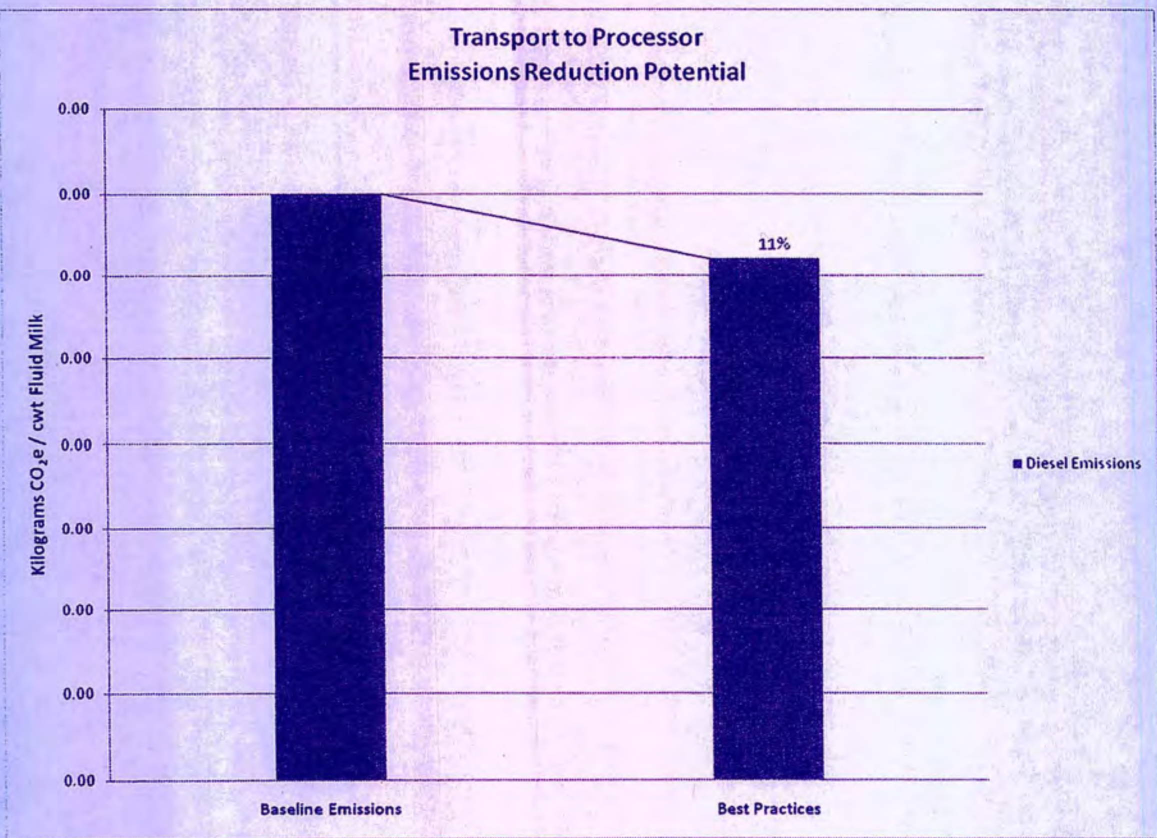

Figure 12: Transport Emissions Reduction based on a "full potential" model

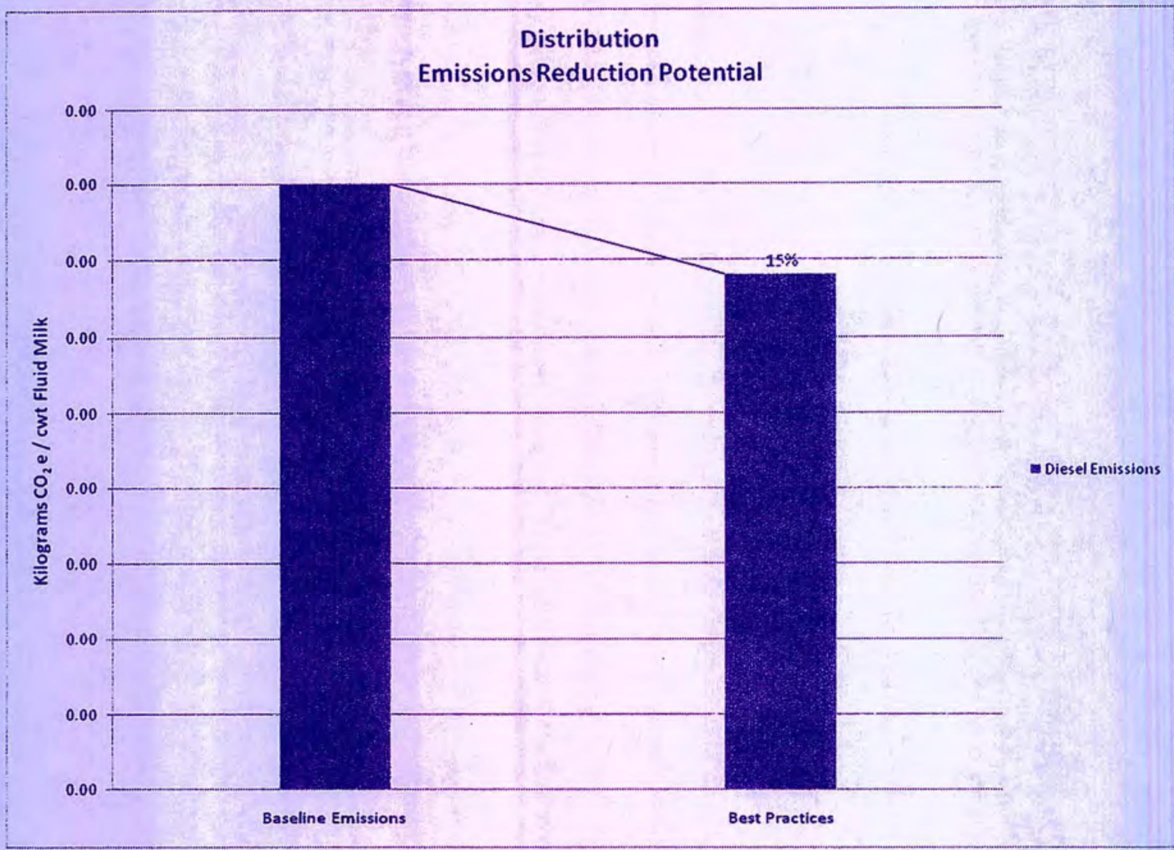

Figure 13: Distribution Emissions Reduction based on a "full potential" model

Reduction Opportunities

Truck & Route Efficiency

Advancements in heavy duty vehicle technology offer significant improvements in efficiency and emissions performance.[67] These improvements also lead to a significant cost savings. Since 2005, Wal-Mart has improved fleet fuel efficiency by 15%, avoiding the emission of 100,000 metric tons of CO_2e. While the trucking industry averages 6 miles per gallon, Wal-Mart's fleet now averages 7 miles per gallon. By investing in idle reduction technologies, advanced aerodynamics, speed controls and tire improvements, Wal-Mart is reducing emissions by 670,000 tons of CO_2 and saving over 60 million gallons of diesel fuel annually, or approximately $300 million annually. Additionally, Wal-Mart has publicly committed to increase their truck fleet fuel efficiency by 25% by 2008 and 100% by 2015.[68]

Parties desiring to lead in this space are finding ways to work together through partnering with the U.S. government. Wal-Mart, along with J.B. Hunt Transport, FedEx Express & Freight, UPS, IKEA, Sharp Electronics, Office Depot, Interface and others are members of the EPA SmartWay Transport Partnership. EPA's "SmartWay designation" for over-the-road tractor-trailer combination trucks is a design-based specification, developed on the basis of test results for individual components (tires, wheels, aerodynamic equipment, auxiliary power units, and engines) demonstrated to improve fuel efficiency and reduce emissions.[69]

[67] Transportation and Regional Programs Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. *SmartWay Fuel Efficiency Test Protocol for Medium and Heavy Duty Vehicles, Working Draft.* EPA420-P-07-003, November 2007 p. 5.
[68] EPA SmartWay, http://www.epa.gov/smartway/partners/wal-mart-stores.htm. Retrieved May 2, 2008.
[69] EPA420-P-07-003, November 2007, p. 5.

SmartWay also offers new equipment specifications that can reduce fuel consumption by 10 to 20 percent for 2007 long-haul truck and tractor models.

Wal-Mart has also seen gains in efficiency through route optimization and purchasing perishable products, such as milk, from more local suppliers. Where price was previously the main driver of supplier selection, now freshness has also become a high priority and has prompted Wal-Mart to source more products from local markets.[70]

Barriers to Adoption

The main barriers to improving truck efficiency are lack of capital to make the efficiency improvements and the difficulty of changing behaviors. Many companies serving the dairy industry are small operations that might not have the funds available to make the necessary upgrades. The continuing trend of soaring oil prices has caused many of these operators to go out of business. Although some efficiency improvements are linked to behavior changes, such as speed control and engine idle reduction, behaviors can be difficult to change overnight.

Pathways to Adoption

The transporters who touch the dairy industry could be encouraged to join EPA's SmartWay Program to track best practices. Through SmartWay, EPA collaborates with industry and other stakeholders to provide incentives for adopting cleaner, more fuel efficient transportation technologies to benefit the environment.[71] SmartWay introduced a loan program in November 2006 that provides information on several lenders that loan to owner-operators and small trucking companies to help pay for technologies that will save fuel while reducing pollution. SmartWay is using Small Business Administration (SBA) approved lenders, as well as other financial institutions, to help owner-operators and small trucking companies. These loans offer affordable monthly payment plans. Most truckers will save more money each month in lower fuel costs than the cost of loan repayment, thereby increasing their profit.[72]

Interview with Jeff Smith, Wal-Mart Logistics,

[71] Ibid.

[72] EPA SmartWay, http://www.epa.gov/smartway/financing.htm Retrieved May 2, 2008.

Retail

GHG Impact and Activities

Energy consumed by the refrigeration of milk at the sales channel step accounts for less than 4% of milk's total life cycle emissions. Although this is a relatively low level of emissions in comparison to other life cycle stages, there is an opportunity to increase milk sales through additional consumer touch-points within various retail channels.

Footprint Methodology

Greenhouse gas emissions from the retail sales of fluid milk's are calculated based on electricity use in cold storage and refrigerated display as well as HFC refrigerant loss. Average inventory turnover, energy usage, and HFC usage at selected retail locations were incorporated in calculations of total retail emissions in the fluid milk value chain.

Figure 14: Retail Greenhouse Gas Emissions

<u>Shelf-stable Milk Products</u>

Shelf-stable, or aseptic, milk is processed at higher temperatures (289 °F for 2-4 seconds) under sterile conditions, and packaged under sterile conditions, to enable ambient storage of the final product. This process eliminates the need for refrigeration during distribution, storage and merchandizing. Currently, less than 1% of milk sold in the U.S. is shelf-stable.[73] However, the potential to merchandize milk in additional touch-points throughout the store (e.g. non-refrigerated beverage, cereals and baking aisles, impulse counter), and tailor the product to target consumer groups (e.g. Hispanic, kids and moms), provides the opportunity to increase the propensity of consumers to purchase milk.

Barriers to Adoption

The U.S. consumer has been reluctant to embrace shelf-stable milk. Research in this area suggests this is largely due to taste and sensory perception; technologies and practices used to process shelf-stable milk tend to produce a "burnt" flavor, the result of higher heat treatment. For this reason, growth in the shelf-stable category has been limited to flavored and organic milk products, the majority of current shelf-stable sales. Lo

[73] Datamonitor, 2007.Global Industry Guide: Milk in the United States.

consumer demand has in turn led to insufficient supply, limited processing capacity, long transport distances and higher retail prices.

athways to Adoption

Processors and retailers have the potential to catalyze increased demand for shelf-stable milk products by launching pilots in target markets that focus on improved placement, marketing and merchandizing. In existing shelf-stable plants, training coupled with improvements in processing equipment technology can improve product taste. In addition, the industry could support research to improve the taste, as well as develop research instruments to gather consumer insights. Looking to the future, processors could also collaborate to investigate incremental technologies being patented in Europe to identify best practices, such as oxygen infusion and the use of flavor to improve taste.

Multiple View of GHG Opportunities

The opportunities presented above are designed to reduce GHG emissions and increase business value on their own. However, many of these opportunities can be used in concert with one another to provide even more value. Here are some thought starters to reflect on where opportunities start adding even more value when combined together. One can imagine there are many more synergistic opportunities that will create tremendous business value for the dairy industry.

Manure Management & Digesters

One of the barriers to more effective use of manure as a fertilizer is the large percentage of water manure contains, which significantly increases its transportation costs. Methane digesters can help overcome this barrier as they dry out the manure, thereby lowering its weight. Additionally, digesters create manure that is more spreadable, increasing the efficiency and effectiveness of its application as a fertilizer.

Digesters and Agricultural Process Improvements

On-farm methane digesters can be an on-site source of biofuels to operate tractors and other farm equipment.

Processing Efficiencies & Digesters

Processors co-located with dairy farms can use methane digesters generate electricity to power their operations. This on-site generation of electricity would be a lower CO2e form of energy than centralized power plants, since there is no transmission required.

Manure Management & Pastured Dairy:

Pastured dairy can help manage manure by spreading at slower rates over wide areas where through aerobic decomposition methane production is limited. Moreover, this broadcast application of manure helps to naturally fertilize pastures preserving their productivity.

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