Colorado Agricultural Energy Market Research
Phase I: Gaps Analysis

Colorado Energy Office

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Robert D. Naranjo

Sarah Ruen Blanchard

Tony Frank

Garrett Shields

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INTRODUCTION

The Colorado Energy Office (CEO) is undertaking research to study agricultural sector energy use in Colorado to identify the following:

1. Key agricultural market segments and their baseline energy use
2. Potential energy and technology focus areas
3. Best practice incentives, policies, and programs (financial and technical) that CEO can support through coordination, education and outreach, and/or implementation.

This gaps analysis summarizes existing data, identifies key information resources for CEO, and highlights data gaps. The analysis ends with an assessment of the key data gaps that—if addressed—would allow for a deeper understanding of the Colorado agricultural sector and improved ability to track and quantify future energy improvements as a result of programmatic impacts.

Purpose Statement:
The gaps analysis represents Phase I of the CEO agricultural market research study. Following the gaps analysis, a survey of agricultural operations in Colorado will be administered to fill in some of the identified gaps; results will be reported in Phase II of the project, as described below.

> *<u>Phase I—Gaps Analysis:</u> The purpose of this gaps analysis is to collect and aggregate existing market research data on agricultural sector energy use and renewable energy potential in Colorado, as well as to identify any qualitative or quantitative information or data gaps.*
>
> *<u>Phase II—Market Research Report:</u> The purpose of the market research report is to provide CEO with policy, program, and incentive recommendations based on best practice approaches in other states. The recommendations will serve as a basis for CEO's Agricultural Energy Program in fiscal year 2014, and will include a suite of non-funding-oriented action items that CEO could support, including leveraging federal, state, utility, nonprofit, and other third-party resources and supporting innovative policy or regulatory approaches.*

DEFINING "AGRICULTURE"

For the purpose of this project, the agricultural sector will be defined using the U.S. Department of Agriculture's (USDA's) terminology. The definition classifies a farm as "… any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the year." In addition, "… acreage designated as 'land in farms' consists primarily of agricultural land used for crops, pasture, or grazing."[1] Both the U.S. Census Bureau and USDA currently use this definition for agriculture, which has been in place since 1974.

This analysis will not include food processing (or food manufacturing) in the definition of agriculture, which is consistent with both USDA and the North American Industry Classification System (NAICS), which lists agricultural activities in NAICS 111–112 (Crop and Animal Production), but lists food manufacturing as NAICS 311, which is part of the Manufacturing series (NAICS 31–33).[2]

OVERVIEW

For this gaps analysis report, a comprehensive set of data and informational resources were collected to identify energy data and energy technology information that is available and relevant to key agricultural market segments in Colorado. The analysis indicates a **severe gap in state-level and farm-level energy data for the State of Colorado**. In the absence of needed energy consumption data, a supplementary analysis of some key economic, geographical, and cultural information can support market segmentation and indicate initial focus areas for CEO.

Table 1 below provides a high-level overview of the gaps analysis. Significant data gaps exist on every level (national, state, and farm-level), especially for agriculture energy consumption data in British thermal units (Btu) or kilowatt hours (kWh), and the number of gaps are magnified as one attempts to look deeper into specific market sub-segments.

TABLE 1: Agriculture Sector Data Sources

Data Level	Data Type		Data Availability	Primary Data Source(s)
National	Energy Data	Energy Consumption	N	GAP
		Energy Expenses	Y	• 2007 USDA Census of Agriculture • USDA-NASS *2008 Farm and Ranch Irrigation Survey* • USDA-ERS Farm Wealth and Income Statistics, 1949–2011 • 2009 USDA Census of Horticulture Specialties
		Renewable Energy Installations*	Y	• USDA-NASS *2009 On-Farm Energy Production Survey*
	Econ Data	Number of Operations	Y	• 2007 USDA Census of Agriculture
		Production Value	Y	• 2007 USDA Census of Agriculture • USDA-ERS Farm Wealth and Income Statistic, 2009–2013
State	Energy Data	Energy Consumption	N	GAP
		Energy Expenses	Y	• 2007 USDA Census of Agriculture • USDA-NASS *Colorado Agriculture Statistics Bulletin 2012* • USDA-NASS *2008 Farm and Ranch Irrigation Survey* • USDA-ERS Farm Wealth and Income Statistics 1949–2011 • 2009 USDA Census of Horticulture Specialties
		Renewable Energy Installations*	Y	• USDA-NASS *2009 On-Farm Energy Production Survey*
	Econ Data	Number of Operations	Y	• 2007 USDA Census of Agriculture • USDA-NASS *Colorado Agriculture Statistics Bulletin 2012* • 2009 USDA Census of Horticulture Specialties
		Production Value	Y	• 2007 USDA Census of Agriculture • USDA *Colorado Agriculture Statistics Bulletin 2012* • CU-Leeds School, *Colorado Business Economic Outlook 2013*
Agricultural Market Segments	Energy Data	Energy Consumption	N	GAP
		Energy Expenses	N	GAP
		Renewable Energy Installations	N	GAP
	Econ Data	Number of Operations	Y	• 2007 USDA Census of Agriculture • 2009 USDA Census of Horticulture Specialties
		Production Value	Y	• 2007 USDA Census of Agriculture • USDA *Colorado Agriculture Statistics Bulletin 2012* • 2009 USDA Census of Horticulture Specialties • CU-Leeds School, *Colorado Business Economic Outlook 2013*

*For small wind, solar, and digester systems only.

In the absence of needed energy consumption data, what follows is a supplementary analysis of economic, geographical, and cultural information that can support market segmentation and indicate initial focus areas for CEO. The analysis ends with an assessment of the key data gaps that—if addressed—would allow for a deeper understanding of the Colorado agricultural sector and an improved ability to set a baseline, as well as track and quantify future energy improvements as a result of CEO's programmatic and policy impacts.

AGRICULTURAL MARKET SEGMENTS IN COLORADO

This analysis reveals that the Colorado agricultural sector consists of four key economic market segments: (1) Livestock; (2) Field Crops; (3) Greenhouses, Nurseries, and Sod; and (4) Orchards. **Two industries—*Field Crops* and *Livestock*—make up the majority of the market** (nearly 96% in terms of production value) and have important sub-segments, as noted below.[3]

TABLE 2: Agriculture Sector Segments and Sub-Segments

Key Market Segment	Description	Sub-Segments
Livestock	Ranching, animal feed operations, and dairies; accounting for 61% of cash receipts for the sector in 2012.	Ranching
		Animal Feed Operations
		Dairies
Field Crops	Cultivated plants grown commercially on a large scale; accounting for 28% of cash receipts for the sector in 2012. Other smaller field crops account for approximately 7% of cash receipts for the sector in 2012.	Corn
		Wheat
		Hay
		Potato
		Barley
		Other Crops
Greenhouses, Nurseries, and Sod	Shrubs, plants, fruits, and vegetables for retail sale; accounting for 3% of cash receipts for the sector in 2012.	*(Diverse, numerous sub-sectors)*
Orchards	Large groves of fruit-bearing trees; accounting for less than 1% of cash receipts for the sector in 2012.	Peach
		Cherry
		Apple

(*Note:* The Phase II Market Research Report will identify energy opportunities that are specific to key sectors, as well as those that are crosscutting.)

GEOGRAPHIC DATA

Colorado's agriculture sector stretches literally to all corners of the state, and just about everywhere in between. Significant agricultural activity, as measured by USDA's *2007 Census of Agriculture*, is occurring in 63 of Colorado's 64 counties. San Juan County, in southwestern Colorado, is the only county without agricultural production.[4] The *Census of Agriculture* provides a wide range of detailed information on each county that allows for an understanding of the unique features of agriculture production in various regions of the state (e.g., orchards are found mainly in Western counties; cantaloupe production is centered in the lower Arkansas River Valley; and a significant share of the state's potatoes are grown in the San Luis Valley). Every five years, USDA conducts the *Census of Agriculture*, with the most recent being for 2007. The results of the 2012 census will be released in early 2014. Census data becoming more outdated produces a data gap.

For example, the most recent data is over five years old, and it cannot be compared alongside other data sets that are collected annually.

The Census' county-level data provides an understanding of where agriculture production is concentrated in terms of market value, expenses for fuel and utilities, and use of agricultural inputs such as fertilizer. In Colorado, this area of concentration is 11 contiguous counties in the Northeast part of the state—stretching roughly from the northern Front Range to the eastern border. Table 3 below provides a sample of data from this 11-county region, including its proportion of the state total for several measures: market value of products sold, total cropland, and cattle inventory. In 2007, the 11 counties combined accounted for 29% of the state's farms; made up 67% of the state's total market value of agricultural products sold; and held 57% of the total cattle inventory involved in ranching, feedlots, and dairies.[5] Thus, **the Northeast region is a critical focus area for the development of future targeted agricultural energy programs.**

TABLE 3: Agriculture Production from Northeast Colorado Counties, 2007[6]

County	Market Value of Agricultural Products Sold ($1,000)	Total Farm Production Expenses ($1,000)	Number of Farms	Total Cropland (acres)	Irrigated Land (acres)	Cattle and Calves Inventory (number)
Adams	$153,438	$129,965	895	546,942	16,963	15,240
Boulder	$34,037	$39,382	746	54,425	33,871	10,771
Broomfield	$958	$581	24	4,944	959	348
Kit Carson	$336,986	$289,766	786	885,783	118,020	167,031
Logan	$442,107	$406,090	1,035	603,016	100,278	196,689
Morgan	$493,863	$480,405	894	322,969	94,611	229,147
Phillips	$142,983	$110,765	334	355,613	63,734	34,819
Sedgwick	$70,277	$46,394	193	196,399	40,040	14,376
Washington	$130,173	$105,307	1,010	854,392	37,553	60,269
Weld	$1,539,072	$1,377,792	3,921	987,892	327,836	565,327
Yuma	$711,391	$633,123	970	697,792	263,820	265,777
Total for Region	$4,055,285	$3,619,570	10,808	5,510,167	1,097,685	1,559,794
Total for Colorado	$6,061,134	$5,431,280	37,054	11,483,936	2,867,957	2,745,253
Region as % of State	**67%**	**67%**	**29%**	**48%**	**38%**	**57%**

Source: *2007 Census of Agriculture*, USDA-NASS.

Data for all Colorado counties can be found in Appendix C (page 25), with information provided on total market value of agricultural products sold, total expenses, and additional content highlighting the nature of agricultural operations for each county.

KEY TECHNOLOGIES AND APPLICATIONS: ENERGY & AGRICULTURE IN COLORADO

To understand the opportunities for agricultural energy efficiency, renewable energy, and fuel usage in Colorado, this analysis identified the existing energy-use technologies and applications being utilized in agricultural operations across the United States, including within the key market segments noted above. Table 4 below summarizes the primary energy efficiency and alternative energy-production opportunities for each market segment. These opportunities were identified by performing a thorough review of several of the reports listed in Appendix B, including—specifically—those conducted by the American Council for an Energy-Efficient Economy, the Southwest Energy Efficiency Project, the Oregon Department of Agriculture, and the Colorado Department of Agriculture. For each primary segment, sub-segments were developed through a review of multiple data sources that provide economic, production, and land-use information for Colorado's agriculture sector.

TABLE 4: Colorado Agriculture Market Segments and Energy Opportunities

Primary Economic Market Segment	Sub-Segments*	Energy Use/Efficiency Opportunities	Energy-Production Opportunities
Field Crops	• Corn • Wheat • Hay • Barley • Potatoes • Others	• Irrigation • Tillage / Planting Practices • Harvesting • Storage / Drying • Fertilizer / Chemical Use	• Small Wind • Solar PV • Small Hydro • Biomass Feedstock
Livestock	• Animal Feed Operations • Dairies • Ranching	• Ventilation • Fans • Lighting • Heating / Insulation • Pasteurizing • Cooling / Storage • Waste Use / Handling • Conveyor Systems • Stock Water Pumping	• Methane Digesters • Biomass Feedstock • Solar Thermal • Geothermal • Solar PV • Small Hydro
Greenhouses / Nurseries / Sod	• Shrubs / Landscaping • Vegetables / Fruits • Sod	• Lighting • Insulation	• Geothermal • Solar Thermal • Solar PV
Orchards / Fruit	• Peach • Cherry • Apple	• Irrigation • Harvesting	• Solar PV • Small Hydro

*Sources: *Colorado Business Economic Outlook 2013,* CU Leeds School of Business; *2007 Agricultural Census,* USDA-NRSC; and *2012 Colorado Agricultural Statistics Bulletin,* USDA-NRCS.

Energy consumption in the agriculture sector can be broken down by three key on-farm uses:

1. Fuels for running farm equipment and transporting
2. Natural gas and propane for heating and powering equipment
3. Electricity for pumped irrigation, lighting, and a wide range of other needs.

Currently, there is no publicly available data that allows for a detailed examination of energy consumption in Colorado by agricultural market segment (such as *Field Crops* or *Livestock*); however, the data do indicate where energy-use and energy-related expenses are occurring, particularly within the two key market segments discussed below.

Field Crops

The *Field Crops* market segment in Colorado involves more than 11 million acres of cropland, with approximately 6 million acres being harvested annually.[7] Of Colorado's 2.9 million acres of irrigated land, approximately 65% is used for the production of corn and hay.[8] Crop operations in Colorado with powered irrigation are using a significant amount of electricity as their energy source, and this use can be the primary cause of utility peak loads in regions with **irrigated farming**.[9] In Colorado, an estimated 42% of farms include some irrigated land, with operations applying 1.6 acre-feet of water per acre on average.[10] Approximately half of Colorado's irrigated land is irrigated through **sprinkler systems involving powered pumps,** and the other half is irrigated through gravity flow systems.[11] In Colorado, the average pumped irrigation well is powered by a 67-horsepower engine during the irrigation season.[12] To power irrigation in Colorado in 2008, electric expenses totaled more than $73 million, which is more than 50% of the agricultural sector's total expenses for electricity in 2008.[13, 14] (Unfortunately, USDA surveys do not break utility expenses down by peak charges and usage charges). Recent advancements for irrigation efficiency include the installation of more efficient motors, variable speed drives, and remote soil sensing equipment for more precise placement of sprinklers. Using these improved technologies has been shown to consistently deliver up to 40% savings for electricity and water.[15] The potential exists for the average Colorado farmer to save more than $5,000 per year on electricity costs for irrigation alone after adopting these improved technologies and practices.[16].

In addition, crop production is dependent on diesel fuel to run farm equipment. A crop farm's equipment consists of **tillage, planting, and harvesting equipment**, which are significant energy users. Information provided in the form of crop enterprise budgets from the Colorado State University (CSU) Extension—discussed in the Data Analysis section (page 11)—indicates that the total expenses for running these types of field crop equipment can be as high as $28 per acre. Some recent improvements in the use of this equipment have included the adoption of precision-GPS systems, which help improve efficiency by not overlapping the same parcel in field operations.[17] Other farms have moved toward a no-till or a reduced-tillage system to decrease diesel consumption and improve soil quality. **Crop drying systems** are another area in field crop production where energy is used and can be improved upon through renewable or advanced heating systems. Conventional crop drying, although not used widely in Colorado,[18] relies on natural gas, propane, or electrically driven field process heating equipment that dry plants for production. Finally, crop production involves significant indirect or "embedded" energy costs from **fertilizer** and **chemical** applications (*Note:* Energy consumed through the fertilizer production process will not be addressed in detail in this analysis).

Livestock—Animal Feed Operations

An Animal Feed Operation (AFO) is an agricultural operation where large numbers of animals are concentrated in a facility or small area, such as a hog farm, cattle feedlot, or egg-production facility with poultry. Many of these operations require significant **ventilation systems** and **lighting**, which consume electricity.[19] **Grain elevators** and **conveyor belts** are other aspects of AFOs that involve systems relying on electrical motors. In addition, **pumps** are used in the process of continually

filling stock water for the animals. AFOs also have facility heating needs that can be enhanced by improvements to a facility's **thermal seal** and **insulation**.

In Colorado, there are more than 14,000 agricultural operations involved in the cattle industry with an inventory of more than 2.7 million cows (many of these operations are ranches that would not be categorized as AFOs).[20] In addition, poultry and hog operations have inventories of more than 5 million and 700,000, respectively, in the state.[21] Available data from the USDA National Agricultural Statistics Service (NASS) provides figures for the total inventory and number of livestock sold, but lacks detail on the concentration of the particular livestock type within an AFO. Additional information on the level of concentration will support the development of opportunities for use of biomass waste from AFOs.

Ventilation systems within AFOs (especially confined AFOs) consume very large amounts of energy, and anecdotal evidence has shown that implementing energy efficiency measures—like improved insulation and higher efficiency fans—could reduce energy costs. A report by the Southwest Energy Efficiency Project noted that one Colorado hog operation "… reduced its gross electricity consumption per hog by 42%, and peak demand for electricity per month per hog by 43% compared to a 'business as usual' farm by improving energy efficiency and at the same time generating 437 megawatt hours of electricity per year from hog waste."[22] Payback on the optimization of ventilation systems (including proper sizing and variable speed drives) has been reported at 2.2 years; and replacing older, inefficient fan blades has a payback of 1–2 years.[23] The relatively quick payback on ventilation measures could make this type of project viable, likely without external financial incentive, if farm operators are educated on the opportunity.

Livestock—Dairy Production

A dairy is a specialized AFO that produces milk from cows. In Colorado, there are approximately 450 agricultural operations with an average of 128,000 milk cows in service throughout the year.[24] The dairy industry is a prime candidate for the development of a comprehensive "energy tool box." Along with having all of the energy consumption technologies previously described for other AFOs, dairy operations also use energy for **vacuum pumps** that generate the suction for milking cows and powering **pasteurizing, milk cooling**, and **refrigeration systems**.[25] On average, U.S. dairy farms consume between 800–1,200 kWh per cow annually, with about 50% of the electricity used going toward milk-production equipment, which includes milk cooling, vacuum pumps, and water heating.[26] Refrigeration alone accounts for around 25% of all electricity consumed on a dairy farm. It has been noted that installing high-efficiency refrigeration systems can result in 2.5% savings in kilowatt hours used.[27] Additionally, the CSU Extension has identified that using refrigeration systems with scroll compressors are 15%–20% more efficient than traditional reciprocating compressor systems.[28]

ENERGY EXPENSES ON THE FARM

This gaps analysis finds that there is no recent data on energy consumption by source for the agricultural sector in Colorado; however, a study was conducted by Iowa State University that identified U.S. agricultural energy consumption data by source for 2002.[29] In this study, it was found that U.S. farms direct and indirect energy consumption totaled 1.7 quadrillion Btu, with diesel and electricity consumption being the largest sources, after fertilizers (as shown in Figure 1). Diesel comprised 27.3% (or 0.46 quads) of total agriculture energy consumption, and electricity comprised 20.7% (or 0.35 quads).

The 2007 Census does provide measures for overall expense categories, four of which are energy related: (1) fuels, (2) utilities, (3) fertilizer, and (4) chemicals. However, unlike the fuels category, the utilities category is not a pure measure of costs for an energy source. The data for utilities is comingled with other utility-type expenses, such as cost of electricity, telephone charges, Internet fees, and water purchased. For this project, utilities will be used as an indicator of electric costs with an understanding that it is not a precise measure. Unfortunately, the Census does not provide this same energy expense data for each agricultural segment. As a result, there is a significant data gap for understanding energy expenses as they relate to other business expenses and revenue within specific types of agricultural operations.

Colorado's total energy-related expenses in the agricultural sector for 2007 were $252 million for fuels and $141 million for utilities.[30] The 2011 estimates from the *Colorado Agriculture Statistics Bulletin* provide similar energy-use statistics, with a slightly higher percentage going to fuels—$327 million spent on petroleum fuels and oils and $161 million on electricity.[31] Without including fertilizer and chemical expenses, the agricultural sector's energy expenses were $393 million or 7.2% of total expenses in 2007. Figure 2 shows the total 2007 expenses for Colorado's agriculture sector by category, with energy-related expenses highlighted in red. In addition, Appendix D (page 28) provides agricultural energy-related expenses for all 64 Colorado counties. An analysis of the state's 2007 county-level energy-related expenses indicates that only six counties (Weld, Yuma, Kit Carson, Logan, Washington, and Morgan) made up nearly 40% of total expenses for gasoline, fuel, and oils. In addition, five of those six counties (Weld, Yuma, Morgan, Kit Carson, and Logan) made up more than 45% of total utility expenses; all located in the Northeastern part of the state.

The largest energy-related expense category is *gasoline, fuels, and oils*, making up 4.7% of total expenses; this category includes diesel fuel that is used to run farm equipment on cropland. Additional expenses for cropland operations include "fertilizer, lime, and soil conditioners," "utilities," and "chemicals." The utilities category includes expenses for electricity costs used to power irrigation pumps, motor systems, heating and cooling, and other uses.

FIGURE 1: U.S. Farm Energy Use by Source, 2002[1]

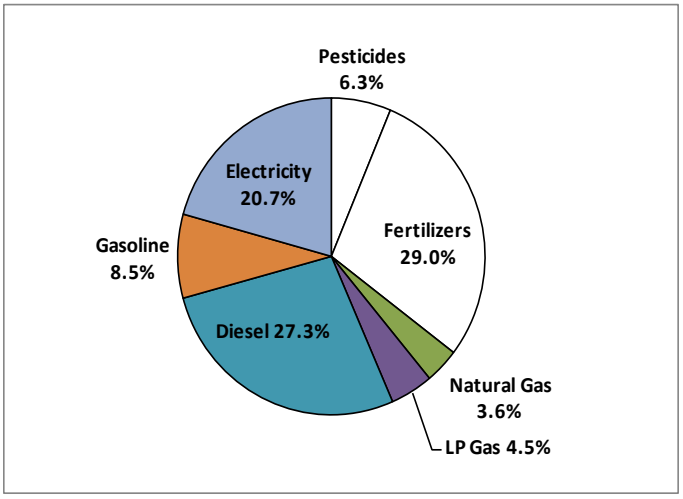
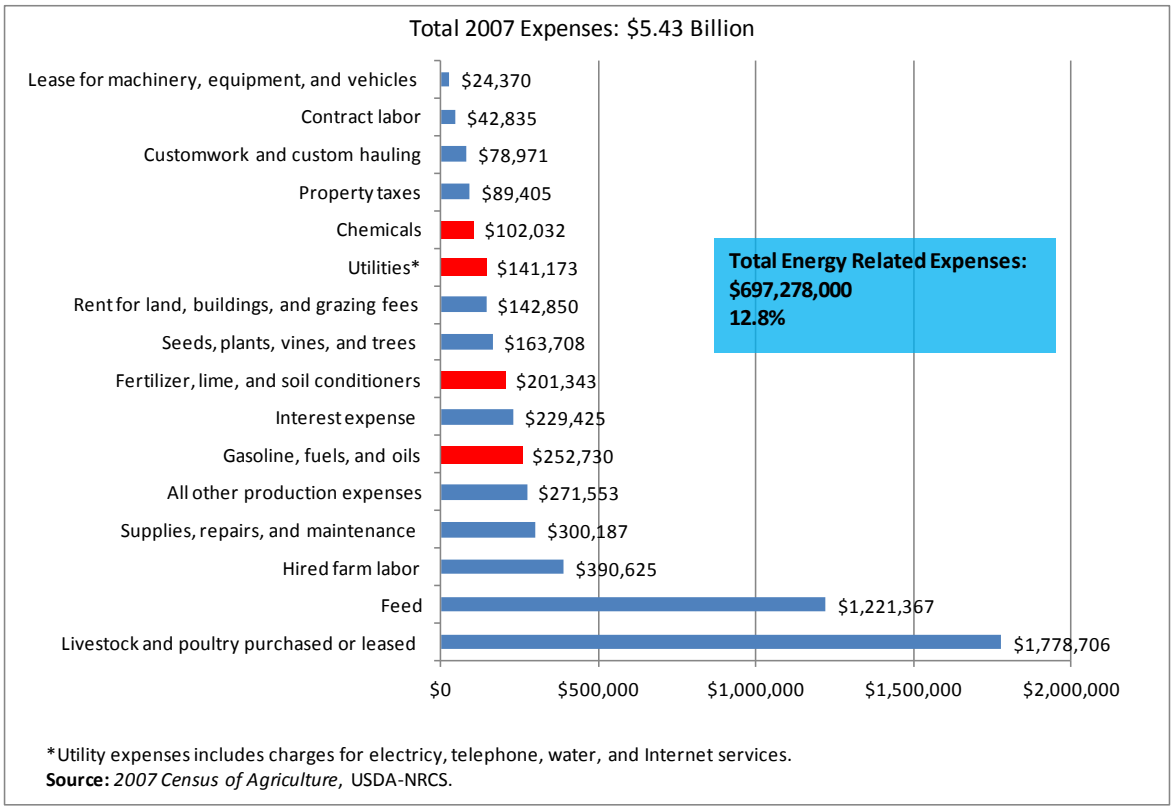


FIGURE 2: Colorado Agriculture Expenses, 2007 ($1,000s)



The CSU Extension creates annual crop enterprise budgets for 13 field crops that include pre-harvest and harvest energy-related expenses per year on a per acre basis.[32] *These budgets are defined as guidelines and do not reflect actual energy expenses or use.* The budgets include three estimates for each enterprise based on different geographic regions of the state, to include the Northeastern, Southeastern, and Western regions. The amount of energy-related expenses in the budgets varies greatly by the types of crops produced, as well as by whether they were produced through powered irrigation. A comparison of 2011 Northeastern Colorado crop enterprise budgets for corn, grain, and dryland winter wheat showcases the difference in energy cost by the type of crop produced:

Corn: The crop budget for irrigated corn is estimated to have the following energy-related expenses per acre: $79.45 for irrigation energy; $27.54 for fuel; and $185.30 for fertilizer and herbicide.[33] The direct energy expenses per acre in this budget are $106.99, with irrigation being a higher cost than fuel.

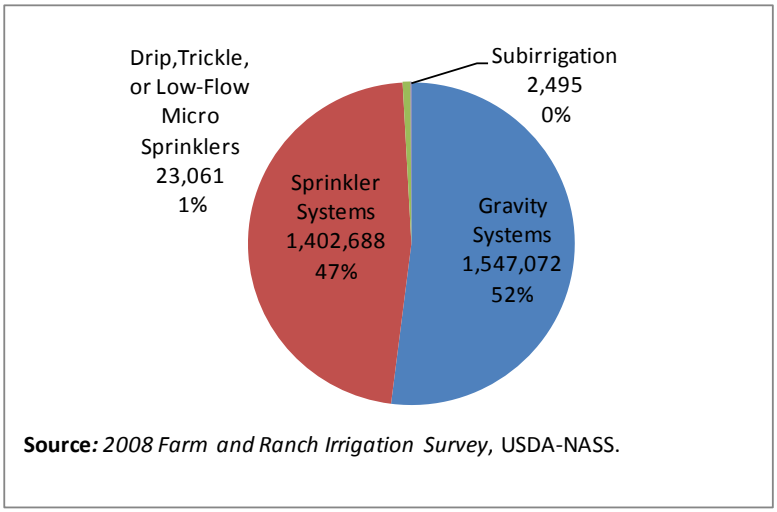
Wheat: The crop enterprise budget for dryland winter wheat is estimated to have the following energy-related expenses per acre: $20.60 for fuel and $50.33 for fertilizer and herbicide.[34] The total direct energy expenses in the wheat budget are $20.60, with fuels being the only direct energy expense.

Within these crop types, opportunities for energy savings can be found by comparing the enterprise budgets for different types of farm practices for the same crop. For example, the difference in fuel expenses in the 2010 budgets for dryland wheat conventionally tilled versus an operation using a reduced till practice to produce wheat is $3.45 per acre.[35, 36] In 2010, this would have been an estimated savings of more than 22% in fuel expenses. (CSU Extension also creates agriculture enterprise budgets for vegetables, fruit, and livestock ranching enterprises. However, with the exception of ranching, they have not been updated in recent years).[37] A future initiative, beyond the scope of this project, could include the development of a methodology to estimate Colorado energy expenses from field crop production for each region of the state by applying CSU Extension crop enterprise budgets with annual USDA-NASS statistics for planted and harvested cropland acres in each region of the state. This would require additional, more detailed, and more accurate information on the specific farming practices applied each year (e.g., reduced tillage, irrigated or dryland) for each region.

IRRIGATION

Approximately 2.9 million acres of Colorado's farmland is irrigated, and 42% of farms in Colorado reported some irrigation on their land in 2007.[38] Figure 3 provides a summary of the irrigation methods used. The USDA-NASS's *2008 Farm and Ranch Irrigation Survey* data indicates that about 1.4 million acres of Colorado farmland is irrigated using sprinkler systems.[39]

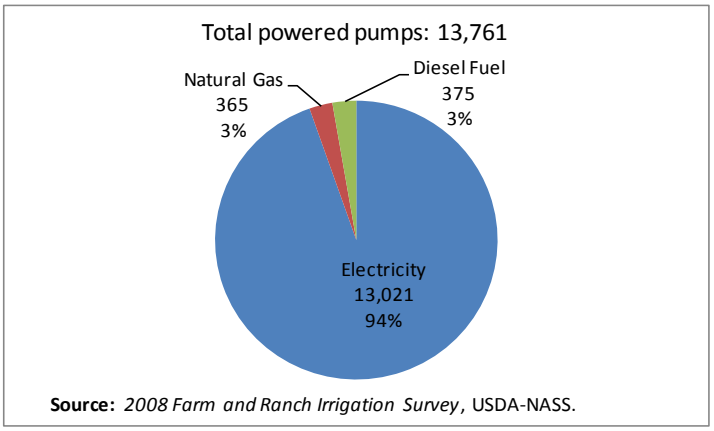
FIGURE 3: Colorado Irrigation Methods by Acres Irrigated, 2008



Source: *2008 Farm and Ranch Irrigation Survey*, USDA-NASS.

The survey also provides data, summarized in Figure 4, which indicates that among Colorado's 13,761 powered irrigation pumps, 94% are powered by electricity and only 6% are powered by natural gas or diesel fuel. [40]

FIGURE 4: Colorado Energy Sources for Powered Irrigation Pumps, 2008



Source: *2008 Farm and Ranch Irrigation Survey*, USDA-NASS.

COLORADO AGRICULTURAL SECTOR: DATA ANALYSIS

Identifying available energy data, as well as data gaps, is critical to establishing a framework for engaging the agricultural market to participate in potential energy programs. One significant gap is that energy data for the Colorado agriculture sector (as well as for the nation) is limited to expense information, and it fails to provide data in primary energy units for energy consumption (e.g., Btu, kWh, therms, or gallons). Moreover, another gap is that the energy-related expenses data available within the USDA Census of Agriculture does not attribute or breakout the expenses for any agricultural market segments. It does, however, provide energy-related expenses at the county level.[41] Primary energy unit data is not available for the agriculture sector from other federal or state data sources. The U.S. Department of Energy's (DOE's) Energy Information Administration (EIA) includes agriculture consumption data within the industrial sector, but does not collect data in a "bottom up" approach; therefore, no information is obtained directly from agricultural operations. Instead, it collects energy sales information at a level that is not adequate to isolate the agriculture sector data from other industrial sector data (verified through direct discussions with EIA staff).[42]

DATA SOURCES

The USDA-NASS provides critical data for the understanding of energy use in the agriculture sector. Every five years the USDA-NASS conducts the Census of Agriculture to collect data, including energy expense data, at the county and state level for all Colorado agricultural operations. Agriculture producers are legally required to report information to the Census. The 2007 Census was conducted in 2008 and released in February 2009. Additional, relevant data collection efforts managed by the USDA-NASS to supplement the Census include the *Farm and Ranch Irrigation Survey* (last conducted in 2008) and the *On-Farm Renewable Energy Production Survey* (last conducted in 2009). The primary drawback of the Census is that the data may be several years old and not accurately reflect current agricultural activity.

The USDA-NASS Colorado Field Office partners with the Colorado Department of Agriculture to conduct an annual survey of agricultural production. The results from the survey are published in the annual *Colorado Agriculture Statistics Bulletin*, which was last published in 2012 with data primarily from 2011.The annual bulletin provides more timely information than the Census on state-level energy-related expenses from USDA's Economic Research Service. It also provides information on primary crops and livestock at the state and county levels; however, the figures are estimates derived from a sample of phone survey participants. In addition, the bulletin does not have the comprehensive set of data at the county level for numbers and types of operations, as well as irrigation methods.

In addition to the USDA data sources, several reports were reviewed for this project that provided valuable information to support the development of market segments and helped to identify on-farm renewable energy-production opportunities. These reports include *Rural Electric Efficiency Prospects* by the Southwest Energy Efficiency Project, *Agriculture and Energy in Oregon* by the Oregon Department of Agriculture, and *Colorado Agriculture: Land, Water, Energy Use and Bioenergy Potential* by Resource Analysis, Inc. Other useful reports and data sources are listed in Appendix B (page 15).

CONCLUSION: DATA GAPS AND RECOMMENDATIONS

In collecting and analyzing the data for this report, several data gaps were identified. These data gaps are listed below, along with recommendations for how CEO could work to bridge the gaps. Where possible, these data gaps will be addressed in Phase II of this project through the survey and in-depth interviews of farmers and ranchers, as noted within the recommendations below.

1. Primary Energy Consumption Data for the Agriculture Sector: At present, neither DOE/EIA nor USDA provide primary energy consumption data at the state level in units such as kWh, therms, or Btu for the agriculture sector or its sub-sectors. EIA includes agriculture consumption data within the industrial sector, collecting energy sales information at a level not adequate to isolate the agriculture sector for energy consumption as a separate segment.[43] This information would allow CEO and other states to develop a methodology for measuring the energy intensity of the agriculture sector (economic output per unit of energy consumed). This data would also allow CEO to better measure the effectiveness of future initiatives by establishing a baseline for particular market segments that programs and policies may be targeting. The baseline of energy intensity would allow CEO to more easily track progress and report the success and impact of its programs and policies.

   Recommendation: CEO should consider future collaboration with the Colorado Department of Agriculture in working with the USDA-NASS to collect and report primary energy consumption data. This type and level of data collection may be burdensome to utilities and farms; however, it is essential for creating a baseline for energy improvement that will help CEO set realistic and clear goals where its achievement can be measured and verified.

2. Energy Use/Expense Data for Colorado's AFOs: USDA-NASS data sources provide detailed information at the state and county levels for livestock inventory by type (e.g., milk cow, chicken layer). However, they do not provide details on the amount of livestock within specific AFOs, or the type of technologies used for feeding and dealing with animal waste. Understanding the number of livestock within each AFO would be beneficial in understanding the composition of the sector—whether there is one very large operation and numerous other small operations, or if there are multiple mid-sized operations. Additional information detailing the size and locations of AFOs would allow CEO and other organizations to better assess the opportunity and determine the potential impact of new energy-efficient technologies and alternative energy projects, such as installing/upgrading biomass waste-to-energy systems.

   Recommendation: The survey and interviews being conducted in Phase II of this project hope to inform this data gap by seeking greater information on AFOs and gauging their interest in greater energy efficiency and energy-production opportunities. The information collected through the survey and interviews could be sufficient enough to estimate the types and amount of equipment for this sub-segment, and this information will feed into the development of the market analysis, informing the types of programs and policies that will be recommended to CEO. Additionally, in the future, CEO should consider partnering with the Colorado Department of Public Health (the agency overseeing the permitting application of AFOs) in order to receive more detailed information about AFO operations. CEO should also consider collaboration with the Colorado Livestock Association and Western Dairy Association to gain a better understanding of energy uses and technologies in Colorado AFOs and dairy operations.

3. Need for Information on Farm Vehicle Equipment and Potential for Greater Fuel Efficiency: A set of data collection measures is needed, which could be supported by CEO, to track the energy consumption of farm vehicle equipment, including data on type of operation, age of equipment, fuel efficiency measures, and type of engines. This data would be useful in developing options for more efficient or flex fuel/electric/compressed natural gas vehicles for the sector. Even determining the average types and amount of equipment for each agricultural sub-segment would be useful for understanding where opportunities exist.

   Recommendation: The survey and interviews being conducted for this project hope to inform this data gap by seeking greater information on farm vehicles and gauging farms' interest in greater fuel efficiency. The information collected through the survey and interviews could be sufficient enough to estimate the types and amount of equipment for agricultural sub-segments, and this information will feed into the development of the market analysis, informing the types of programs and policies that will be recommended to CEO.

4. Need for Additional Information on the Current Level of Efficient Irrigation Equipment Installed, by Region, Among Colorado Farmers and How Local Utility Rate Structures for Irrigation Impact Decision-Making: Since electricity is used in 94% of all powered irrigation pump systems, increasing efficiency could have a significant impact. By identifying the current level of equipment efficiency by regions of state, as well as how utility rate structures affect decision-making, there would be an opportunity to move this market toward high implementation of efficient technologies.

   Recommendation: The examination of utility incentive programs for irrigation efficiency—including evaluation of irrigation rate structures—under Phase II of this project aims to estimate the level of usage across different types of irrigation systems and provide a comparison of these systems using available energy efficiency information. The survey and interviews being conducted will also inform this data gap by obtaining greater information on farm irrigation equipment installed and determining respondents' level of interest in making energy efficiency improvements. The information from additional research and surveys will assist CEO in identifying regions where additional collaboration should occur with irrigated farm operations, rural electric associations, and other electric utilities to increase irrigation efficiency.

5. Need for Additional Information from Agriculture Producers on Barriers for Renewable Energy Development to Support On-Farm Applications: Only small wind, solar, and methane digester projects are tracked in the USDA *On-Farm Renewable Energy Production Survey*. More data would be useful on other renewable energy systems installed or being pursued, such as geothermal or small hydro. It would also be useful to know what types of agricultural operations are installing these systems, as well as the driving factors behind the decision to pursue implementation.

   Recommendation: CEO should conduct outreach to USDA-NASS to suggest that a broader set of renewable energy systems and other types of energy improvement for alternative fuel uses (e.g., electric/compressed natural gas vehicles) be added to the existing survey. The survey being conducted during Phase II of this project hopes to inform this data gap by seeking data on renewable systems that agriculture producers have installed or are considering to install, as well as the factors behind implementation decisions.

APPENDIX A: COLORADO AGRICULTURE & ENERGY HIGHLIGHTS

Agriculture Market Segmentation:

- Sixty-three of Colorado's 64 counties have significant agricultural production. Only San Juan County in the Southwestern region of the state does not have agricultural production (USDA, 2007 Census of Agriculture).
- Eleven contiguous counties in the Northeast region—extending from the northern Front Range to the eastern border—make up more than 65% of Colorado agriculture's market value and expenses. In addition, these counties contain nearly 40% of the state's irrigated land and more than 55% of its cattle inventory (USDA, 2007 Census of Agriculture).
- In 2012, the cattle sub-sector alone accounted for an estimated 47% of Colorado's total agricultural market value (University of Colorado Leeds School of Business, Colorado Business Economic Outlook 2013). The cattle industry includes ranch, feedlot, and dairy operations that are found throughout the entire state.
- Corn produced for grain and silage has the greatest market value among Colorado's crops, accounting for an estimated 34% of the total market value of crop production (University of Colorado Leeds School of Business, Colorado Business Economic Outlook 2013).

Agricultural Energy Issues:

- The "gasoline, fuels, and oils" category is the highest energy cost for Colorado's agricultural sector, accounting for 4.7% of total expenses (USDA, 2007 Census of Agriculture). This category includes diesel fuel to run equipment on cropland.
- An estimated 42% of Colorado farms include some irrigated land. On average, Colorado farmers apply 1.6 acre-feet of water per acre to the state's 2.9 million acres of irrigated land. Approximately half of the irrigated land is irrigated through sprinkler systems that involve powered pumps; the other half is irrigated through gravity flow systems (USDA, 2008 Farm and Ranch Irrigation Survey).
- Electricity is the energy source for more than 94% of Colorado's powered irrigation pumps on agricultural lands (USDA, 2008 Farm and Ranch Irrigation Survey).
- If the cost for fertilizer and chemicals are included in energy expenses, agricultural producers in Colorado face an estimated 12.8% of their total costs from energy expenses (USDA, 2007 Census of Agriculture).
- In 2009, 602 of Colorado's 37,000 farms reported having an on-farm renewable energy system. These farms reported information about the installation and operation of 504 solar photovoltaic systems, 147 small wind turbines (1–100 kilowatts), and 117 solar thermal projects (USDA-NASS, 2009 *On-Farm Renewable Energy Production Survey*).

APPENDIX B: KEY DATA SOURCES

Org	Data Source	Description
25x'25	University of Tennessee Agricultural Economics. (2006). *25% Renewable Energy for the United States By 2025: Agricultural and Economic Impacts*. Burton C. English, Daniel G. De La Torre Ugarte, Kim Jensen, Chad Hellwinckel, Jamey Menard, Brad Wilson, Roland Roberts, and Marie Walsh. Available at http://www.25x25.org/storage/25x25/documents/RANDandUT/ut_ea_report.pdf	A study designed to determine the feasibility of agriculture to provide 25 % of U.S. total energy needs. The analysis also looks at the associated impacts to agriculture and overall economy of achieving the goal. **Strengths:** Provides information from McNeil Technologies, 2000, "Assessment of Biogas-to-Energy Generation Opportunities at Commercial Swine Operations in Colorado," prepared for the state of Colorado and U.S. Department of Energy. **Weaknesses:** National in scope; lack of energy efficiency project information for agriculture.
25x'25	North American Colleges and Teachers of Agriculture (NACTA). (2008 guest position paper). *Research and Education Priorities in Agriculture, Forestry, and Energy to Achieve the 25x25 Renewable Energy Vision*. Duane Acker and National 25x'25 Agriculture/ForestrySteering Committee. Available at http://www.25x25.org/storage/25x25/documents/PartnerContactDocuments/march_2008_nacta_journal-6-page_ver.pdf	Summarizes high priority research and education focus areas, as identified by a variety of public and private sector scientists, in order to achieve the 25x25 vision. **Strengths:** Lists a number of state educational partners to support energy improvements on farms. **Weaknesses:** Lack of focus for on-farm efficiency and renewable energy projects.
25x'25	*Summary of Responses, 25x'25 2011 Partner Survey*. Available at http://www.25x25.org/storage/25x25/documents/Reports/summary_report_on_partner_survey.pdf	Summary of 25x'25 partner responses to a nine-question online survey from January 2011 that asked for feedback on top priorities for energy policy, programs, education, and outreach. **Strengths:** Provides several low-cost means to communicate information to support energy efficiency and renewable energy development in the agriculture sector. **Weaknesses:** The comments and feedback are not ranked by priority. The summary is described in terms of themes expressed by respondents.
25x'25	25x25 Energy for Economic Growth (EEG) Initiative. (2012). *Pathways for Accelerating and Expanding Distributed Renewable*	A progress report on the Energy for Economic Growth Initiative's

	Energy Generation in America. Available at http://www.25x25.org/storage/25x25/documents/Distributed_Energy/energy_for_economic_growth_-_pathways_for_accelerating_and_expanding_renewable_energy_generation_in_america_final.pdf	work to create incentive policies to accelerate distributed renewable energy generation through rural electric utilities and other power providers that serve rural communities. **Strengths:** Provides a framework for future development of incentive-based rate policies for rural utilities. The project leaders include two Colorado participants with Delta-Montrose Electric Association and the Colorado Agriculture Energy Task Force. **Weaknesses:** Incentive models have a significant focus on Germany.
ACEEE	American Council for an Energy Efficient Economy. (2013). *Frontiers of Energy Efficiency*. Research report U131. Dan York, Maggie Molina, Max Neubauer, Seth Nowak, Steven Nadel, Anna Chittum, Neal Elliott, Kate Farley, Ben Foster, Harvey Sachs, and Patti Witte. Pages 212-218 cover agriculture. Available at http://aceee.org/research-report/u131	Provides an overview of national trends and state level programs for advancing energy efficiency in the agriculture sector. Includes an overview of existing organizations and programs that should be considered in developing agriculture energy programs. Highlights the key drivers for energy efficiency adoption that involve information and outreach; in addition, lists key technologies to match with multiple agriculture segments. Provides a summary of current best practice energy efficiency programs for agriculture in NY and CA. **Strengths:** This report provides a valuable framework for developing opportunities and program structure.
ACEEE	American Council for an Energy Efficient Economy. (2010). *States Stepping Forward: Best Practices for State-Led Energy Efficiency Programs.* Research report e106. Michael Sciortino. Pages 23-25. Available at http://aceee.org/research-report/e106	This report provides a summary of Maryland Energy Administration's Statewide Farm Energy Audit Program, including program design, performance, and lessons learned. **Strengths:** A best practice program evaluation led by a state energy office.
ACEEE	American Council for an Energy Efficient Economy. (207). *Ag Energy Efficiency Infrastructure*. Research report ie072. Susanne Brooks and R. Neal Elliott. Available at http://aceee.org/research-report/ie072	**Strengths:** Explores the strengths and weaknesses of energy efficiency program in the agriculture sector and opportunities for programs to be supported through the 2002 Farm Bill. **Weaknesses:** It is not

		built around the current 2008 Farm Bill framework.
ACEEE	American Council for an Energy Efficiency Economy. (2005). *Energy Efficiency Programs in Agriculture*. Research report ie051. Elizabeth Brown, R. Neal Elliott, and Steve Nadel. Available at http://aceee.org/research-report/ie051	**Strengths:** The report focuses on program design for the agriculture sector and provides a comprehensive summary in the appendix of over 50 energy efficiency programs that support the agriculture sector at the state and local level. **Weaknesses:** Report dates back to 2005, so many of these programs may no longer be active.
ACEEE	American Council for an Energy Efficiency Economy. (2005). *On-Farm Energy Use Characterization*. Research report ie052. Elizabeth Brown, R. Neal Elliott, and Steve Nadel. Available at http://aceee.org/research-report/ie052	**Strengths:** Characterizes the agriculture sector's energy use and sources for the nation and for six states. **Weaknesses:** Does not use Colorado as a sample state for characterization.
ACEEE	American Council for an Energy Efficient Economy. (2005). *Potential Energy Efficiency Savings in Agriculture Sector.* Research report ie053. Elizabeth Brown and R. Neal Elliott. Available at http://aceee.org/research-report/ie053	**Strengths:** This report provides a methodology for estimating the costs savings from agriculture energy uses, including motor systems, onsite transportation, and lighting. **Weaknesses:** Cost savings are dated.
CDA	Colorado Department of Agriculture. (1999). *Colorado's Net Irrigation Requirements for Agriculture, 1995*. Antony Frank and Dr. David Carlson. Available at http://cospl.coalliance.org/fedora/repository/co:3072/ag92ir71999internet.pdf	Develops and describes a methodology using available data sources to estimate the annual irrigation required for consumptive use on the state's irrigated land by county and crop. **Strengths:** Indicates counties with high irrigation uses. **Weaknesses:** Does not provide any energy related data associated with irrigation requirements.
CDA	Colorado Department of Agriculture. *Advancing Colorado's Renewable Energy Program*. Forty-nine project reports completed between 2007-2011. Available at: http://www.colorado.gov/cs/Satellite/ag_Conservation/CBON/1251629087263	Final reports of renewable energy demonstration and research projects funded by the Colorado Department of Agriculture's Advancing Colorado's Renewable Energy (ACRE) program. Provide good information on technologies for a variety of projects, including small wind and small hydro, among others. **Strengths:** A wide range of renewable energy projects and biomass to energy projects that the agriculture sector is pursuing and researching. **Weaknesses:** Only

		provides one energy efficiency project.
CDA	Colorado Department of Agriculture. *New Direction and Focus for ACRE*. Available at http://www.colorado.gov/cs/Satellite/ag_Conservation/CBON/1251628474554	A short three-page document that outlines the future design of the ACRE program to support agriculture in Colorado to adopt energy improvements. The CDA is seeking to go beyond demonstration projects and support adoption by a high number of agriculture operations for energy efficiency, solar thermal, micro hydro, and targeted research. **Strengths:** Allows for coordination between future state agency programs to support the agriculture sector.
CDA	*The Colorado Department of Agriculture ACRE Program*: *Success metrics and recommendations for the future.* (December 30, 2011). An evaluation conducted by the StEPP Foundation, of the ACRE Program. Available at http://www.colorado.gov/cs/Satellite/ag_Conservation/CBON/1251628474554	A summary of the projects supported by the ACRE program and their impact. It also provides a set of recommendations for future program design and targets. **Strengths:** Allows for improved coordination between future state agency programs.
CEO	State of Colorado. (2007). *Colorado Climate Action Plan 2007*. Page 13. Available at http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline%3B+filename%3D%22Colorado+Climate+Action+Plan.pdf%22&blobheadervalue2=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251819436674&ssbinary=true	Includes an estimate of the agriculture sector's contribution to the Colorado's total greenhouse gas emissions and recommendations specific to agriculture to reduce emissions. **Strengths:** Provides a model for potential incentive programs to support energy efficiency and conservation practices. **Weaknesses:** Does not provide recommendations for efficiency with direct energy uses.
CEO	Wind Utility Consulting for the Colorado Energy Office and U.S. Department of Energy. (2005). *Distributed Wind Generation for Northeast Colorado*. Available at http://rechargecolorado.org/images/uploads/pdfs/b6708bde95335b14a5a9ee1da6b306a7.pdf	Provides an assessment of the use of existing substations for wind energy development on Highline Rural Electric Association's (REA) system in northeastern Colorado. **Strengths:** Good overview of REA distribution systems for supporting local energy projects. **Weaknesses:** Does not focus on on-farm, direct use wind energy projects.
CEO	Resource Analysis, Inc. for McNeil Technology contract with the Colorado Energy Office and U.S. Department of Energy. (2004). *Colorado Agriculture: Land, Water, Energy Use and Bioenergy Potential*.	An assessment of data sources available that characterizes Colorado agriculture's energy use and provides methodologies for

		estimating energy use. Provides opportunities for energy production from agricultural biomass and bio-waste. **Strengths:** A good set of data sources and methodologies to consider updating in future years. **Weaknesses:** The data were dependent on outdated data in the USDA's 1997 Census of Agriculture.
CEO	*Connecting Colorado's Renewable Resources to the Markets* (SB-91 Report). (2008). Report of Colorado Senate Bill 07-91 Renewable Resource Generation Development Areas Task Force. Available at http://www.colorado.gov/cs/Satellite/GovEnergyOffice/CBON/1251597774824	Provides locations in Colorado that are high quality resource areas for wind energy, solar energy, hydroelectric power, geothermal, biomass and biofuels. **Strengths:** Indicates agriculture regions of the state with high quality renewable energy resources. **Weaknesses:** Focused on utility scale and commercial scale development that are not on-farm energy systems.
CREA	Review of 22 rural electric web pages for agriculture rates and programs. Links to Colorado REAs available at http://www.coloradorea.org/ColoradoCoops/ElectricCoops.aspx	Information has been collected from Colorado REAs that currently indicates 12 have agriculture rate classes (including irrigation) and 9 have programs that support agriculture. **Strengths:** Detailed information on 2013 irrigation rates for several REAs. **Weaknesses:** Information does not indicate the level of agriculture participation in rate classes such as commercial and does not provide program outcomes.
CRS	U.S. Congressional Research Service. (2004). *Energy Use in Agriculture: Background and Issues*. Randy Schnepf. Available at http://cnie.org/NLE/CRSreports/04nov/RL32677.pdf	The report that provides information relevant to the U.S. agricultural sector on energy use, emerging issues, and related legislation. **Strengths:** Provides a valuable pie chart from the USDA of direct and indirect energy sources. **Weaknesses:** The data and information is more than 10 years old.
CRS	*Renewable Energy Programs and the Farm Bill: Status and Issues*. (2011). Congressional Research Service Report for Congress. Randy Schnepf. Available at http://ieeeusa.org/policy/eyeonwashington/2011/documents/renewenergyfarmbill.pdf	A report to Congress providing a summary of renewable energy incentive programs in the 2008 Farm Bill. **Strengths:** Programs that can be leveraged by states. **Weaknesses:** The 2012 Farm Bill

		may not have the same programs or may have reduced funding for energy programs.
CRS	*Renewable Energy Programs in the 2008 Farm Bill*. (2010). Congressional Research Service Report for Congress. Megan Stubbs. Available at http://www.nationalaglawcenter.org/assets/crs/RL34130.pdf	A report to Congress providing a summary of energy programs in the 2008 Farm Bill. **Strengths:** Programs that can be leveraged by states. **Weaknesses:** The 2012 Farm Bill may not have the same programs or may have reduced funding for energy programs.
CRS	*Environmental Quality Incentives Program (EQIP): Status and Issues*. (2010). Congressional Research Service Report for Congress. Megan Stubbs. Available at http://www.nationalaglawcenter.org/assets/crs/R40197.pdf	A report to Congress covering the USDA Natural Resources Conservation Service's (NRCS) Environmental Quality Improvement Program (EQIP) which can support on-farm energy improvements that reduce air emissions. **Strengths:** Program that can be leveraged by states. **Weaknesses:** The 2012 Farm Bill may not have the same programs or may have reduced funding for environmental programs.
CSU	Colorado Agricultural Enterprise Budgets: *Colorado Crop Enterprise Budgets*. Colorado State University Extension. 2011 and later years. Available at http://www.coopext.colostate.edu/ABM/cropbudgets.htm *Livestock Enterprise Budgets*. Colorado State University Extension. 2011 and later years. Available at http://www.coopext.colostate.edu/abm/livestock.htm *Vegetable Enterprise Budgets*. Colorado State University Extension. 2009 and later years. Available at http://www.coopext.colostate.edu/abm/vegetables.htm *Fruit Enterprise Budgets.* Colorado State University Extension. 2010 and later years. Available at http://www.coopext.colostate.edu/abm/fruit.htm	On a per acre and a per unit of livestock, provides estimated input costs, including energy related expenses estimated for multiple crops, vegetables, fruits and ranching operations in various regions throughout the state. These estimates are used for budgeting and are not actual expenses. **Strengths:** A breakdown of estimated energy costs involved for Colorado agriculture based on type of operation and practices. **Weaknesses:** Does not provide budgets for concentrated animal feed operations. Several budgets are outdated. They do not indicate the number of farmers using a particular practice (e.g. reduced tillage).
CSU	*2011 Survey of San Luis Valley Agricultural Energy Practices and Interests*. (February 10, 2011). Presentation to the Southern Rocky Mountain Agriculture Conference and Trade Show. Jeanna Paluzzi. Available at http://www.colostate.edu/Depts/SLVRC/disease/SRMAC2011/PaluzziSRMAC2011.pdf	Provides summary of survey responses from 122 agricultural operations in the San Luis Valley. The results cover energy efficiency, renewable energy, and motivating factors. **Strengths:** Information on awareness and interests for agriculture operations in Colorado.

		Weaknesses: Limited to the San Luis Valley region.
CU	University of Colorado Leeds School of Business Economic Outlook. (2012). *Colorado Business Economic Outlook 2013.* Available at http://leeds.colorado.edu/asset/publication/2013beof.pdf	An estimate of the agriculture sector's 2012 production and market value broken down by major segments along with a forecast for 2013. **Strengths:** Provides the most current economic data for Colorado's agricultural segments. **Weaknesses:** Does not provide energy expense data.
NASEO	NASEO Agriculture & Rural Development Task Force – Documents Library. Mississippi Development Authority Energy Division - Mississippi Rural Business Opportunity Grant program documents and 2008 presentation to NASEO. Available at http://www.naseo.org/taskforces/agriculture/documents/index.html	Provides valuable information on the Mississippi Development Authority's grant program, which supports energy improvements for the agriculture sector. **Strengths:** A model program to research further. **Weaknesses:** Focuses on Mississippi's agriculture sector.
NASEO	*Sample Agriculture Organization Outreach Document*. (2002). Available at http://www.naseo.org/taskforces/agriculture/archive/documents/Sample_Agriculture_Organization_Outreach_Document.pdf	A sample outreach document for state energy offices to use in developing outreach material to agricultural organizations. **Strengths:** A state government template to consider for communicating with the agriculture sector. **Weaknesses:** Uses information from the outdated 2002 Farm Bill.
NASEO	*Agriculture Biomass Summaries Draft*. (2002). Available at http://www.naseo.org/taskforces/agriculture/archive/documents/project_summaries.pdf	A summary of state agriculture biomass programs in 2002. **Strengths:** Model programs to consider for biomass to energy. **Weaknesses:** Outdated list of programs from more than 10 years ago.
NEEA	Agriculture Irrigation Energy Efficiency Initiative, Northwest Energy Efficiency Initiative. Available at http://neea.org/docs/overviews/neea-irrigation-initiative-overview.pdf?sfvrsn=2	A one page summary document of NEEA's irrigation energy efficiency initiative, including information on the goal, program, and partners. **Strengths:** A model program for agriculture irrigation efficiency. **Weaknesses:** Focuses on northwestern states.
NEEA	*Strategic Energy Management Market Assessment Study: Dairies, Irrigators, and Nurseries*. (2012). Prepared by Market Strategies International for Northwest Energy Efficiency Alliance. Available at http://neea.org/docs/reports/strategicenergymanagementassessmentstudyaa14717eaf7c.pdf	A report that details the findings of research to determine the level of Strategic Energy Management practices among the Dairies, Irrigators, and Nurseries sectors in the northwestern U.S. **Strengths:** A model for

		measuring the commitment of the agriculture sector for energy improvements. **Weaknesses:** Focuses on northwestern states.
NW Dairy Assn.	*Oregon Dairy Digester Feasibility Study Report*. (2010). Submitted by ECOregon for the Northwest Dairy Association. Available at http://energytrust.org/library/reports/100125_DairyBiogasSummaryReport.pdf	A summary report of feasibility studies conducted for anaerobic digestion facilities in Oregon. **Strengths:** Information for future development of digesters in Colorado. **Weaknesses:** Focuses on Oregon, which has a more humid climate conducive to digester development.
ODA	Oregon Department of Agriculture. (2011). *Agriculture and Energy in Oregon*. Stephanie Page. Available at http://www.oregon.gov/ODA/docs/pdf/ag_energy_report.pdf	An overview of Oregon's agricultural sector for energy use and production. The report involved two surveys for agricultural producers and professionals that support farm operations. Provides recommendations to support the industry to make energy improvements in the future. **Strengths:** A good overview of agriculture energy uses for key segments. **Weaknesses:** Focuses on Oregon's agriculture sector.
SWEEP	Southwest Energy Efficiency Project. (2008). *Rural Electric Efficiency Prospects*. Tom Potter. Available at http://www.swenergy.org/publications/reep/REEP.pdf	A report focused solely on opportunities for electric efficiency opportunities in rural states in the Southwest U.S., including Colorado. Provides significant detail on agriculture irrigation expenses within REA's service territory in northeastern Colorado. **Strengths:** A good overview of energy uses and conservation practices for the agriculture sector in Colorado. **Weaknesses:** Limited to energy uses from electricity.
U.S. Census	U.S. Census Bureau. *Statistical Abstract of the United States: 2012 - Agriculture Section 17*. Available at http://www.census.gov/prod/2011pubs/12statab/agricult.pdf	A collection of summary data from the USDA's 2007 Census of Agriculture. **Strengths:** Highlights where Colorado agriculture ranks compared to other states in production measures. **Weaknesses:** Is a summary of Census of Agriculture data and does not provide energy data for the agriculture sector.
USDA	United States Department of Agriculture, National Agricultural Statistics Service. (2012). *2012 Colorado Agricultural Statistics*	A survey conducted annually on the Colorado agricultural

	Bulletin. Available at http://www.nass.usda.gov/Statistics_by_State/Colorado/Publications/Annual_Statistical_Bulletin/Bulletin20122.pdf	industry. The Bulletin provides estimates of agricultural production based on phone surveys from 2011 and earlier years at the state and county level. **Strengths:** Provides annual energy related expense data from the USDA Economic Research Service. **Weaknesses:** The amount of county level data and number of farms for each segment is limited.
USDA	United States Department of Agriculture Economic Research Service. U.S. and State Farm Income and Wealth Statistics. Available at http://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics.aspx	Provides annual farm expense data at the national and state level from 1949 to 2011. The data include tables for fuel and oil expenses and for electricity. **Strength:** The data are updated annually. **Weaknesses:** The data are not provided per county or broken down by agriculture segments. The data are based on a survey that is used to estimate expenses.
USDA	U.S. Department of Agriculture, National Agricultural Statistic Service. (2009). *2007 Census of Agriculture*. Available at http://www.agcensus.usda.gov/ Volume 1, Chapter 2, Colorado county level tables available at http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Colorado/ Volume 1, Chapter 1, Colorado state level tables available at http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Colorado/	The Census of Agriculture is conducted every five years, providing the most detailed data of U.S. farms and ranches and the people who operate them. Agricultural data are provided for every state and county in the United States. **Strengths:** Comprehensive data at the county level including energy expenses. **Weaknesses:** The current available Census data are from 2007. The 2012 census will not be available until 2014.
USDA	U.S. Department of Agriculture, Census of Agriculture. (2010). *2008 Farm and Ranch Irrigation Survey*. Available at http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Farm_and_Ranch_Irrigation_Survey/index.php	The survey provides data that supplement the basic irrigation data collected from all farm and ranch operators in the 2007 Census of Agriculture. **Strengths:** Provides valuable information on the type and number of irrigation systems and their power source at the state level. Also provides irrigation expenses by power source. **Weaknesses:** Does not provide county level data to better target irrigation systems for energy improvements.
USDA	U.S. Department of Agriculture, Census of Agriculture. (2011). *2009 On-Farm Renewable Energy Survey*. Available at	A survey of farms and ranches for small wind, solar, and digester

	http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/On-Farm_Energy_Production/index.php	installations at the state level. Also includes information on energy audits conducted at the state level. **Strengths:** A survey specific to agriculture producers for on-farm systems. **Weaknesses:** Does not provide county level data or the type of operation installing the system.
USDA	U.S. Department of Agriculture. *2009 Census of Horticultural Specialties*. Available at http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Census_of_Horticulture_Specialties/	A comprehensive census of the Horticulture segment within the agriculture sector, including greenhouses, nurseries and sod operations. Provides national and state level information on operations with $10,000 or greater in production value. **Strength:** A good overview of the many types of operations at the state level. **Weaknesses:** Does not provide county level data and only conducted every 10 years.
USDA	USDA Rural Development Energy Programs. Available at http://www.rurdev.usda.gov/energy.html USDA Rural Energy for America Program, Announced Awards, October 19, 2012. Available at http://www.rurdev.usda.gov/SupportDocuments/rdREAPListOct102012.pdf	USDA program information for the Rural Energy for America Program that can support on-farm energy efficiency and renewable energy projects development. **Strengths:** Program that can be leveraged by states. **Weaknesses:** The 2012 Farm Bill may not have the same programs or may have reduced funding for energy programs.
USDA	USDA NRCS Colorado Environmental Quality Incentive Program (EQIP) website. Available at http://www.co.nrcs.usda.gov/programs/eqip/eqip.html	USDA program information for EQIP that can support energy improvements that reduce air emissions. **Strengths:** Program that can be leveraged by states. **Weaknesses:** The 2012 Farm Bill may not have the same programs or may have reduced funding for environmental programs.
USDOE	U.S. Department of Energy, Energy Information Administration. *Annual Energy Outlook 2013*. Available at http://www.eia.gov/forecasts/aeo/er/index.cfm	Includes consumption data and forecast for the industrial sector, which encompasses more than three million establishments engaged in manufacturing, agriculture, forestry, fishing, construction, and mining. **Weaknesses:** Does not provide energy consumption data for the agriculture sector. It is collected at a sales level above agriculture end users.

USGS	*Estimated Use of Water in the United States in 2005*. USGC Circular 1344. Available at http://water.usgs.gov/watuse/data/2005/index.html	2005 data on Colorado water withdrawals for farm irrigation and livestock uses. **Weaknesses:** Does not provide energy use data associated with irrigation withdrawals. Data are from more than seven years ago.

APPENDIX C: COLORADO AGRICULTURE BY COUNTY 2007

County	Market value of agricultural products sold ($1,000)	Total farm production expenses ($1,000)	Average Profit Margin	Farms (number)	Cropland (acres)	Irrigated land (acres)	Orchards (number)	Cattle and calves inventory (number)	Poultry-Layers inventory (number)	Hogs and pigs inventory (number)	Sheep and Lamb inventory (number)
Adams	$153,438	$129,965	15.3%	895	546,942	16,963	13	15,240	2,867	2,473	2,470
Alamosa	$91,413	$66,916	26.8%	316	91,098	94,030	-	11,652	387	278	2,376
Arapahoe	$28,835	$29,153	-1.1%	627	151,344	1,688	-	6,627	1,570	928	545
Archuleta	$7,389	$9,272	-25.5%	306	18,925	14,542	5	6,250	533	20	662
Baca	$111,202	$98,118	11.8%	777	718,687	55,679	2	56,845	533	(D)	85
Bent	$82,220	$64,503	21.5%	311	185,702	50,450	-	49,574	537	(D)	90
Boulder	$34,037	$39,382	-15.7%	746	54,425	33,871	28	10,771	(D)	285	1,343
Broomfield	$958	$581	39.4%	24	4,944	959	-	348	-	-	(D)
Chaffee	$8,091	$7,196	11.1%	223	21,872	15,139	5	7,928	362	15	(D)
Cheyenne	$71,098	$47,522	33.2%	380	512,038	33,038	-	34,382	85	(D)	(D)
Clear Creek	$127	$792	-523.6%	27	1,431	81	-	(D)	78	-	(D)
Conejos	$31,569	$26,825	15.0%	535	123,022	119,126	-	31,434	605	218	8,026
Costilla	$26,660	$23,687	11.2%	241	59,045	63,525	-	7,893	468	60	383
Crowley	$110,922	$105,540	4.9%	268	62,368	9,849	-	71,549	729	134	1,282
Custer	$8,424	$8,226	2.4%	226	26,000	18,217	-	6,575	173	(D)	104
Delta	$46,800	$43,185	7.7%	1,294	67,298	66,169	186	33,689	2,997	558	10,293
Denver	$561	$774	-38.0%	24	207	(D)	-	(D)	-	(D)	(D)
Dolores	$8,849	$7,592	14.2%	279	82,075	9,377	11	4,497	324	85	31
Douglas	$15,941	$26,150	-64.0%	1,080	35,067	3,453	12	6,222	1,652	175	698
Eagle	$4,836	$7,034	-45.5%	152	12,331	11,128	1	6,166	146	(D)	(D)
El Paso	$39,423	$46,837	-18.8%	1,529	88,668	15,915	7	26,072	4,524	405	458
Elbert	$40,724	$49,457	-21.4%	1,402	224,007	12,368	-	45,540	2,314	279	1,140
Fremont	$19,306	$22,807	-18.1%	924	25,569	11,845	61	15,337	2,247	136	639
Garfield	$22,203	$29,010	-30.7%	623	50,435	43,720	27	19,238	1,556	289	8,676

Gilpin	$328	$298	9.1%	27	307	(D)	-	21	(D)	-	-
Grand	$9,365	$10,944	-16.9%	229	38,831	43,130	-	13,867	160	58	235
Gunnison	$10,731	$11,499	-7.2%	217	33,829	40,729	-	15,350	568	100	(D)
Hinsdale	$826	$523	36.7%	21	787	1,887	-	1,279	-	-	-
Huerfano	$12,264	$12,166	0.8%	309	35,769	13,889	1	13,962	340	37	105
Jackson	$21,199	$13,803	34.9%	120	80,270	89,603	-	33,841	49	-	76
Jefferson	$11,107	$17,799	-60.3%	540	15,217	4,205	10	2,443	1,313	22	236
Kiowa	$68,390	$47,228	30.9%	425	616,758	3,266	2	18,332	473	(D)	80
Kit Carson	$336,986	$289,766	14.0%	786	885,783	118,020	1	167,031	335	(D)	291
La Plata	$19,791	$27,168	-37.3%	1,076	76,772	66,025	32	21,708	2,515	225	9,341
Lake	$612	$904	-47.7%	29	6,116	2,715	-	515	(D)	(D)	-
Larimer	$128,123	$113,596	11.3%	1,757	119,984	63,405	28	50,926	4,279	409	14,436
Las Animas	$25,397	$28,118	-10.7%	585	109,509	35,066	1	49,257	521	77	356
Lincoln	$70,969	$57,548	18.9%	542	575,968	9,652	-	51,655	473	652	95
Logan	$442,107	$406,090	8.1%	1,035	603,016	100,278	-	196,689	1,301	26,592	1,211
Mesa	$61,230	$65,245	-6.6%	1,767	131,178	64,272	280	34,102	(D)	316	3,966
Mineral	$126	$846	-571.4%	15	1,756	847	-	163	(D)	-	-
Moffat	$28,303	$26,634	5.9%	503	135,148	28,472	1	25,994	821	415	60,416
Montezuma	$26,673	$27,254	-2.2%	1,123	103,916	57,087	70	20,195	1,484	65	5,546
Montrose	$67,160	$61,100	9.0%	1,045	93,262	85,656	43	47,338	(D)	675	19,792
Morgan	$493,863	$480,405	2.7%	894	322,969	94,611	3	229,147	(D)	12,311	793
Otero	$111,187	$99,210	10.8%	569	92,911	55,217	2	75,706	717	145	3,424
Ouray	$3,604	$5,280	-46.5%	105	10,152	10,681	2	6,049	236	(D)	(D)
Park	$5,262	$9,974	-89.5%	282	55,900	9,933	-	8,653	538	(D)	52
Phillips	$142,983	$110,765	22.5%	334	355,613	63,734	-	34,819	241	(D)	(D)
Pitkin	$2,027	$2,953	-45.7%	82	4,785	9,971	-	2,525	203	-	-
Prowers	$263,321	$218,430	17.0%	636	552,476	103,205	-	104,225	585	(D)	239
Pueblo	$49,251	$44,409	9.8%	881	73,537	24,606	8	47,792	2,298	658	1,777
Rio Blanco	$15,563	$15,299	1.7%	285	55,197	22,992	1	23,658	277	608	22,304

Rio Grande	$85,360	$57,782	32.3%	390	114,370	102,792	-	14,188	375	42	10,005
Routt	$34,115	$35,541	-4.2%	610	129,874	43,527	-	22,397	417	92	8,903
Saguache	$91,456	$69,505	24.0%	242	118,229	103,292	2	20,640	267	47	2,229
San Juan	-	-	-	-	-	-	-	-	-	-	-
San Miguel	$3,350	$5,386	-60.8%	123	17,807	12,694	-	7,044	507	140	452
Sedgwick	$70,277	$46,394	34.0%	193	196,399	40,040	-	14,376	258	(D)	(D)
Summit	$1,097	$1,779	-62.2%	41	7,119	10,509	-	1,768	-	-	-
Teller	$1,069	$2,895	-170.8%	126	8,846	1,405	-	2,257	270	8	21
Washington	$130,173	$105,307	19.1%	1,010	854,392	37,553	-	60,269	988	2,730	1,456
Weld	$1,539,072	$1,377,792	10.5%	3,921	987,892	327,836	30	565,327	2,791,770	5,971	190,008
Yuma	$711,391	$633,123	11.0%	970	697,792	263,820	2	265,777	557	(D)	(D)
Colorado Total[1]	$6,061,134	$5,431,280	10.4%	37,054	11,483,936	2,867,957	877	2,745,253	3,902,950	882,695	413,450

[1]Colorado Total may not equal sum of county totals due to data not being provided by USDA for disclosure reasons (D).
(D) USDA symbol used in 2007 Census of Agriculture to indicate data withheld to avoid disclosing data for individual farms.
Source: 2007 USDA Census of Agriculture, Volume 1, Chapter 2, Colorado County Level: Table 1: County Summary Highlights

APPENDIX D: COLORADO AGRICULTURE ENERGY RELATED EXPENSES BY COUNTY 2007

County	Gasoline, fuels, and oils ($1,000s)	Utilities ($1,000s)	Fertilizer, lime, and soil conditioners ($1,000s)	Chemicals ($1,000s)
Adams	$8,528	$5,462	$6,242	$5,014
Alamosa	$4,237	$4,497	$6,296	$4,152
Arapahoe	$2,096	(D)	$891	$699
Archuleta	$644	$245	$123	$30
Baca	$9,478	$2,770	$9,719	$3,594
Bent	$3,382	$1,854	$1,131	$786
Boulder	$2,394	$1,370	$1,699	$545
Broomfield	$52	$30	$32	$8
Chaffee	$753	$430	$192	$25
Cheyenne	$5,977	$1,534	$6,431	$2,704
Clear Creek	$67	$62	(D)	(D)
Conejos	$3,645	$2,134	$1,772	$585
Costilla	$2,343	$2,260	$2,097	$1,299
Crowley	$1,733	(D)	$160	$109
Custer	$951	$266	$312	$29
Delta	$3,021	$1,848	$2,062	$1,235
Denver	$57	$47	(D)	(D)
Dolores	$1,229	$324	$688	$120
Douglas	$2,099	$880	$348	$281
Eagle	$593	(D)	$110	$52
El Paso	$4,989	$1,585	$1,473	$1,031
Elbert	$4,773	(D)	$877	$171
Fremont	$1,880	$736	$268	$140
Garfield	$2,431	$914	$729	$199
Gilpin	$20	$9	(D)	$1
Grand	$1,080	$461	$136	$58
Gunnison	$1,149	$361	$163	$29
Hinsdale	$68	$14	$8	$1
Huerfano	$1,365	$499	$78	$52
Jackson	$1,280	$568	$603	$26
Jefferson	$1,163	$785	$93	$123
Kiowa	$5,459	$989	$4,532	$3,839
Kit Carson	$13,133	$6,791	$15,309	$7,941
La Plata	$78	$63	$8	(D)
Lake	$2,694	$1,111	$1,336	$368

Larimer	$6,957	$4,074	$2,880	$1,416
Las Animas	$2,831	$880	$314	$171
Lincoln	$6,296	$1,157	$4,057	$3,518
Logan	$10,590	$5,914	$9,663	$4,976
Mesa	$4,813	$2,540	$2,555	$1,373
Mineral	$90	$60	(D)	$1
Moffat	$2,864	$735	$638	$277
Montezuma	$2,857	$1,661	$1,556	$587
Montrose	$3,507	$2,478	$3,333	$1,599
Morgan	$10,070	$7,594	$7,843	$4,764
Otero	$4,084	$1,995	$1,919	$1,044
Ouray	$492	(D)	$221	$47
Park	$1,011	$216	$60	$23
Phillips	$5,652	$4,466	$9,427	$4,699
Pitkin	$233	$139	$35	$34
Prowers	$9,942	$2,766	$4,280	$2,916
Pueblo	$4,088	$1,470	$1,108	$792
Rio Blanco	$1,695	$606	$528	$103
Rio Grande	$4,491	$4,748	$7,880	$4,621
Routt	$2,311	$793	$619	$290
Saguache	$4,029	$4,241	$8,140	$3,021
San Juan	-	-	-	-
San Miguel	$719	$196	$197	(D)
Sedgwick	$3,439	$2,145	$5,100	$2,121
Summit	$135	$108	$46	$20
Teller	$416	$55	$5	$4
Washington	$10,126	$3,006	$8,067	$4,892
Weld	$36,428	$23,808	$22,573	$12,382
Yuma	$17,722	$19,463	$32,370	$10,996
Colorado Total[1]	**$252,730**	**$141,173**	**$201,343**	**$102,032**

[1]Colorado Total may not equal sum of county totals due to rounding and data not provided for disclosure reasons (D).
(D) USDA symbol used in Census of Agriculture to indicate data withheld to avoid disclosing data for individual farms.
Source: 2007 USDA Census of Agriculture, Volume 1, Chapter 2, Colorado County Level: Table 3: Farm Production Expenses

APPENDIX E: DATA GAPS BY MARKET SEGMENT

Field Crops	Data Availability / Gaps	Source(s)
Number of operations	• 24,938 farms with cropland: ○ 11,483,936 cropland acres ○ 5,888,926 acres harvested • 15,774 farms with irrigated land ○ 2,867,957 acres	2007 USDA Census of Agriculture
Location of operations	• Primarily eastern Colorado counties	• 2007 USDA Census of Agriculture
Energy uses	• Planting, Tillage, Harvesting Equipment • Irrigation • Fertilizer / Chemicals	• CSU Extension
Energy sources	• Electricity ○ Powers 94% of irrigation pumps • Diesel and gasoline fuels • Natural Gas	• USDA *2008 Farm and Ranch Irrigation Survey*
Energy consumption	• Not Available - Gap	- GAP-
Energy expenses	• Gap – USDA 2007 Census of Agriculture does not breakdown energy related expenses for "Utilities", or "Gasoline, fuels, oils" by segment • Irrigation expenses $78 million in 2008 • CSU Extension crop enterprise budgets for 13 major crops that include estimated "fuel" and "irrigation energy" expenses per acre in 2011 in later years. These are not actual expense figures but estimates based on CSU Extension's understanding of common practices. • "Gasoline, fuels, and oils" expenses $252 million – not segmented for field crops, however much of it goes to field crops. Highest energy related expense in 2007 Census of Agriculture. • Fertilizer expenses $201 million – [assume it is applied mainly to cropland] • Chemical expenses $102 million - [assume it is applied mainly to cropland]	• USDA-NASS *2008 Farm and Ranch Irrigation Survey* • CSU Extension • 2007 USDA Census of Agriculture • 2007 Census of Agriculture • 2007 USDA Census of Agriculture
Equipment/technology being powered for energy uses	• Irrigation pumps and sprinklers: 47% of irrigated acres in Colorado by sprinkler system – Gap (data needed in terms where efficient systems are installed at the county level) • Field Equipment – Gap (more detail on the types of engines and purchase cycle of equipment for typical field crop	• USDA *2008 Farm and Ranch Irrigation Survey* • 2007 USDA Census of Agriculture

	operations). 2007 USDA Census of Agriculture provides data for these type of equipment that are on farms. ○ Trucks including pickups – 73,350 ○ Tractors – 61,571 ○ Grain and Bean Combines – 4,322 ○ Forage Harvesters – 2,437 ○ Hay Bailers – 11,281	• SWEEP Report • Oregon Department of Agriculture Report
Renewable energy potential/opportunity	• Small Windy Systems • Solar PV • Small Hydro – working with Irrigation Ditch Companies	

Ranches	Data Availability / Gaps	Source(s)
Number of operations	• 14,685 farms with cattle and calves inventory (a number of these are feedlots and dairies) ○ 2.7 Million inventory of all cattle and calves • 1,600 farms with sheep and lamps inventory ○ 413,000 inventory of sheep and lambs	• 2007 USDA Census of Agriculture
Location of operations	• Farms with cattle and sheep operations throughout the state • Concentration of cattle and calves in northeastern Colorado	• 2007 USDA Census of Agriculture
Energy uses	• Vehicle equipment • Stock water • Irrigation of pastureland	• SWEEP Report • Oregon Department of Agriculture Report
Energy sources	• Fuels • Electricity	
Energy consumption	• Not Available - Gap	- GAP-
Energy expenses	• Not Available by segment – Gap • CSU Extension Enterprise Budgets for cow-calf and sheep ranch operations. These are estimates for budgeting based on understanding of common state practices and not actual expenses. Energy related expenses include fuel and irrigation energy.	• CSU Extension Enterprise Budgets
Equipment/technology being powered for energy uses	• Not Available - Gap	- GAP-
Renewable energy potential/opportunity	• Solar PV • Small Wind • Small Hydro	

Feedlots	Data Availability / Gaps	Source(s)
Number of operations	• Not Available – Gap (need information on the level of concentration of cattle in feedlots – contact Livestock Association, Colorado Dept. of Public Health and Environment. Survey and interviews will collect information on feedlots)	- GAP-
Location of operations	• Gap – Not clear, however there is a concentration of cattle and calves in northeastern Colorado	• 2007 USDA Census of Agriculture
Energy uses	• Stock water • Conveyor Belts • Space Heating • Lighting	• SWEEP Report • Oregon Department of Agriculture Report
Energy sources	• Not Available - Gap	- GAP-
Energy consumption	• Not Available - Gap	- GAP-
Energy expenses	• Not Available - Gap	- GAP-
Equipment/technology being powered for energy uses	• Not Available - Gap	- GAP-
Renewable energy potential/opportunity	• Methane digesters • Solar PV • Small Wind • Solar Thermal	

Dairies	Data Availability / Gaps	Source(s)
Number of operations	• 449 farms with 126,944 Milk Cows – • Gap (not clear how many of these farms would be defined as active dairy; not clear level of concentration)	• 2007 USDA Census of Agriculture
Location of operations	• Primarily northeastern Colorado: Larimer, Morgan, Weld counties with 106,567 milk cows	• 2007 USDA Census of Agriculture
Energy uses	• Pasteurizing • Cooling • Cool storage • Space heating • Hot water heating • Vacuums for pumping • Lighting • Ventilation • Stock water • Conveyor belts	• SWEEP Report • Oregon Department of Agriculture Report
Energy sources	• Not Available - Gap	- GAP-
Energy consumption	• Not Available - Gap	- GAP-

Energy expenses	• Not Available - Gap	- GAP-
Equipment/technology being powered for energy uses	• Not Available - Gap	- GAP-
Renewable energy potential/opportunity	• Methane digesters • Solar Thermal • Geothermal • Solar PV • Small Wind	

Other Animal Feed Operations	Data Availability / Gaps	Source(s)
Number of operations	• Hog operations ○ 1,171 farms with 882,695 (28 operations have 1000+ hogs) • Poultry Operations: 5,981 farms with inventory of about 5 million poultry ○ Layers alone were 3.9 million and 5 operations had over 3.7 million layers	• 2007 USDA Census of Agriculture
Location of operations	• Hogs – Eastern Colorado (county level data not provided for many counties with hog operations) • Poultry Layers – Weld County, 2.8 million layers in that one county	• 2007 USDA Census of Agriculture
Energy uses	• Lighting • Conveyor Belt • Space heating • Hot water	• SWEEP Report • Oregon Department of Agriculture Report
Energy sources	• Not Available - Gap	- GAP-
Energy consumption	• Not Available - Gap	- GAP-
Energy expenses	• Not Available - Gap	- GAP-
Equipment/technology being powered for energy uses	• Not Available - Gap	- GAP-
Renewable energy potential/opportunity	• Methane Digester – one installed on a Hog operation with 5,000+ in Lamar, Colorado. McNeil Technologies conducted study on this operation. • Solar PV • Solar Thermal • Geothermal	

Orchards	Data Availability / Gaps	Source(s)
Number of operations	• 877	• 2007 USDA Census of Agriculture
Location of operations	• 638 located in western and	• 2007 USDA Census of

	southwestern Colorado: Mesa, Delta, Montrose, Montezuma, Garfield, and La Plata counties	Agriculture
Energy uses	• Irrigation	• 2007 USDA Census of Agriculture
Energy sources	• Not Available - Gap	- GAP-
Energy consumption	• Not Available - Gap	- GAP-
Energy expenses	• Not Available - Gap	- GAP-
Equipment/technology being powered for energy uses	• Diverse systems	
Renewable energy potential/opportunity	• Solar PV	

Horticulture	Data Availability / Gaps	Source(s)
Number of operations	• 759 operations with $1,000 or more in production value • 255 operations with $10,000 or more in production value	• 2007 USDA Census of Agriculture • 2009 USDA Census of Horticulture Specialties
Location of operations	• Near front range and western slope counties	• 2007 USDA Census of Agriculture • 2009 USDA Census of Horticulture Specialties
Energy uses	• Heat • Electricity • Irrigation	• SWEEP Report • Oregon Department of Agriculture Report
Energy sources	• Not Available - Gap	- GAP-
Energy consumption	• Not Available - Gap	- GAP-
Energy expenses	• Gasoline, fuel, oils, $6.9 million • Utilities, $6.6 million • Fertilizer and Chemicals, $5.7 million • Total expenses $167,281,000	• 2009 USDA Census of Horticulture Specialties
Equipment/technology being powered for energy uses	• Diverse systems	
Renewable energy potential/opportunity	• Solar PV • Geothermal	

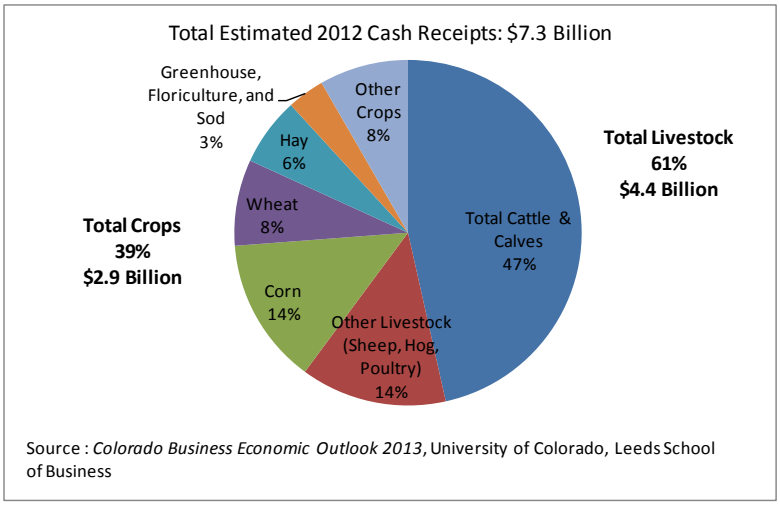
APPENDIX F: COLORADO'S AGRICULTURAL SECTOR ATTRIBUTES

In the U.S. Department of Agriculture's 2007 Census of Agriculture, Colorado's market value of agricultural products sold comprised 2.04% of the national total, ranking 19th among all of the states.[44] The University of Colorado, Leeds School of Business' *Colorado Business Economic Outlook 2013* provides 2012 estimates for Colorado agricultural sector production and an economic forecast for the sector in 2013. Despite a significant drought affecting much of the state in 2012, the agricultural sector still had a strong year, in economic terms, with total cash receipts projected to surpass $7.3 billion. In terms of gross domestic product (GDP), Colorado's agriculture production accounted for 0.8% of the state's total GDP in 2010.[45]

After factoring in government payments and total expenses, the agricultural sector's projected net income of nearly $1.4 billion is the second highest in history. The 2013 forecast has agriculture's net income expanding to a record $1.8 billion; however, reaching this level of income will be difficult if persistent drought conditions continue into the spring and summer months.[46] The Colorado agriculture industry faces stiff competition both domestically and abroad, operating on an average profit margin that has ranged from 10-20% of sales over the past decade, with a margin of 17.1% in 2012.[47] Improving energy security within the sector is an opportunity to create more efficient agricultural operations that will reduce operating costs and continue to improve the economic outlook.[48]

The key driver of Colorado's agricultural economy is the cattle industry, which involves ranching, animal feed operations, and dairies. Cash receipts from the cattle sub-sector alone accounted for 47% of Colorado's total agricultural production. Colorado's total livestock industry accounted for 61% of cash receipts, while total crop production accounted for 39%.[49] These figures do not tell the full story of the livestock industry's role in supporting crop production in other parts of the agricultural sector. A strong linkage exists between a large portion of Colorado's crop production and livestock operations. This is demonstrated by the fact that corn and hay production, which rank 1st and 3rd respectively for crop cash receipts, are produced primarily to provide feed for cattle and other livestock in the region. This linkage between Colorado's livestock industry and crop production has been noted as a symbiotic relationship in a previous report on Colorado's agriculture sector.[50] The proportion of primary crops and livestock to Colorado's total agricultural cash receipts is provided in Figure 5.

FIGURE 5: Colorado Agriculture 2012 Cash Receipts



Source : *Colorado Business Economic Outlook 2013*, University of Colorado, Leeds School of Business

CULTURAL INFORMATION

The agriculture sector's cultural attributes are important to ensuring a full understanding of opportunities and barriers within this sector, and a critical consideration is formalizing how CEO conducts outreach to this sector.

One important feature of Colorado's agricultural sector is the age of farm operators and how age impacts their willingness to invest in projects with a mid- to long-term return-on-investment outlook. **In Colorado, the average principal operator is 57 and only 16% of farmers are under the age of 45.**[51] However, the largest cohort of farmers is the age range 45-54 with 10,449 operators (28%). [52]

The leading informational resource for agriculture producers making changes to their irrigation systems was neighboring farms, according to the USDA's *2008 Farm and Ranch Irrigation Survey*.[53] This could imply that farmers are more likely to trust information from local or familiar sources, and the survey includes questions designed to understand their trust of information from different types of institutions.

Rural areas have been the focus in recent years for the expansion of high-speed internet infrastructure. This lack of digital infrastructure may have limited an agricultural producer's ability to be "connected" and take advantage of energy information monitoring tools that can provide real-time feedback and alerts. However, internet access information collected for the first time in the 2007 Census indicates that a sizable portion of Colorado's agriculture sector is able to use online resources and applications. In 2007, nearly 70% of farms reported having internet access and 48% had high-speed internet access.[54]

ENDNOTES

[1] The U.S. Census Bureau. The 2012 Statistical Abstract: The National Data Book.
[2] U.S. Census Bureau. North American Industry Classification System, http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012. Accessed January 28, 2013.
[3] CU Leeds School of Business. *Colorado Business Economic Outlook 2013*. Data gathered from pages 14-19.
[4] 2007 USDA Census of Agriculture. Colorado County Level Table 1: County Summary Highlights.
[5] 2007 USDA Census of Agriculture. Colorado County Level Table 1: County Summary Highlights.
[6] 2007 USDA Census of Agriculture. Colorado County Level Table 1: County Summary Highlights.
[7] 2007 USDA Census of Agriculture. Colorado State Level Data, Table 11**,** Selected Characteristics of Irrigated and Nonirrigated Farms: 2007 and 2002.
[8] USDA. *2008 Farm Ranch and Irrigation Survey*, Chapter 1 Table 8. . . . . Estimated Quantity of Water Applied Using Only One Method of Distribution: 2008 and 2003.
[9] Potter, Tom. Southwest Energy Efficiency Project, (March 2008). *Rural Electric Efficiency Prospects*. Page 39.
[10] USDA. *2008 Farm Ranch and Irrigation Survey*. Chapter 1, Table 1: Irrigated Farms in the Censuses of Agriculture: 2007 and Earlier Censuses
[11] USDA. *2008 Farm Ranch and Irrigation Survey*. Chapter 1:Table 8. . . . . Estimated Quantity of Water Applied Using Only One Method of Distribution: 2008 and 2003.
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