Colorado Agricultural Energy Market Research
Phase II: Market Research Report

Colorado Energy Office

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Table of Contents

Executive Summary i
Introduction 1
Importance of Agriculture to Colorado 3
Energy Use in Colorado's Agricultural Sector 3
Opportunity Analysis: Energy Use on Colorado Farms 5
Barriers to Energy Improvement On the Farm 15
Colorado Agricultural Energy Recommendations 17
Renewable Energy and Energy EFficiency Policies and Regulation 24
Leveraging Existing Programs & Policies 27
Appendix A: Talking Points Memo 30
Appendix B: State and Regional Best Practices—Programmatic Approaches 31
Appendix c: Survey Results 45
Endnotes 46

Table of Figures

Figure 1: Types of Colorado Agricultural Operations Providing Survey Responses 2
Figure 2: Average Annual Agricultural Energy Expenditures by Survey Respondents 4
Figure 3: Recommended Steps for Program Design 19
Figure 4: Energy Efficiency Program Options 21
Figure 5: Policy Recommendation to Support Agricultural Energy Projects 25
Figure 6: Leverage Points for Supporting Agricultural Energy Projects in Colorado 27

EXECUTIVE SUMMARY

This report is the final phase of a Colorado Energy Office (CEO) project that focuses on energy opportunities in the State of Colorado's agricultural sector. Prior to completion of this report, a gaps analysis and market survey were conducted, which gathered input from secondary research sources and 138 farms across the state.

In Colorado, agriculture is a $7.3 billion[1] industry that represents approximately 86.0%[2] of the state's water use, covers 62.0% of the state's 66.3 million acres of land, and faces direct energy expenses of more than $400 million annually.[3,4] Within this sector, there are a number of opportunities for achieving greater energy efficiency and implementing renewable energy systems. The Colorado agriculture sector's primary energy improvement opportunities can be captured through the use of efficient electric-powered pumps and reduced consumption of petroleum fuels (diesel and gasoline) for on-farm machinery and vehicles. Additional opportunities exist for renewable energy development—including methane digesters, wind energy, small hydropower and solar photovoltaic, and solar thermal—that can be used to provide distributed on-farm energy production. Based on analysis and synthesis of the energy data identified throughout both phases of this project, it is reasonable to estimate that over the next 10 years, existing agricultural operations in Colorado have the potential to reduce electric usage by more than 90 million kilowatt hours annually and install more than 10 megawatts of on-farm renewable energy capacity.*

In order to capture this opportunity, key barriers facing agricultural operators need to be overcome. The largest of these barriers is the upfront investment. Many farmers are hesitant to invest their profits in energy projects, especially in a business environment with unpredictable risks (i.e., weather) that can impact their margins from year to year. Farmers also identified parties that they had existing relationships with (other farms and agricultural organizations) as their first source for energy information—making CEO partnerships with organizations such as Colorado State University Extension and Rural Electric Associations very critical.

Based on research and survey results, this report provides recommendations in the following areas:

Energy Efficiency Programs

- Online Irrigation Efficiency Resources Center
- Colorado Irrigation Decision Support Tool
- Dairy Audit/Assessment with Prescribed Equipment Incentives
- Rural Business Energy Support Program
- Online Farm Machinery/Vehicle Efficiency Resources Center

Renewable Energy Programs

- Renewable Energy Resource Assessment Assistance
- USDA Energy Efficiency and Renewable Energy Programs

Renewable Energy Policies and Regulation

- Public Benefit Funds for Agriculture and Rural Areas
- State Tax Incentive Programs for On-farm Energy Improvements
- Group Metering/Aggregated Metering
- Distributed Generation Requirement
- Annual Agriculture Sector Energy Reporting

*Electric savings potential of more than 90 million kilowatt hours (kWh) was limited to information from the U.S. Department of Agriculture's (USDA's) *2008 Farm and Ranch Irrigation Survey,* indicating that there are 13,021 electric-powered irrigation systems in Colorado, and the average on-farm irrigation well is using 67 horsepower for pumps operating 1,519 hours per year. This data was used to estimate that total electric consumption from irrigation is more than 900 million kWh per year; and it was assumed that statewide adoption of energy efficiency technologies and practices could improve the state's overall irrigation efficiency by 10% to achieve more than 90 million kWh of annual energy savings. In addition, the California Center for Irrigation Technology's Advanced Pumping Efficiency Program reports that between 2002 and 2012 repairs and retrofits to 1,750 irrigation pumps resulted in 108 million kWh in annual savings. Powered irrigation represents approximately 53% of the Colorado agriculture sector's electric expenses. Several other opportunities exist to increase electric efficiency savings across the entire agriculture sector and can contribute to greater overall savings; however, a lack of data did not allow for savings estimates in those areas.

The potential for more than 10 megawatts (MW) of new on-farm renewable energy capacity is based on an assumed continuation of deployment trends, coupled with anticipated policy shifts that will expand development opportunities. USDA's 2009 *On-Farm Energy Production Survey* indicated that approximately 1 MW of capacity was installed over a 10-year period on Colorado farms from 2000–2009, and a recent Colorado policy called "community solar gardens" has demonstrated that aggregating meters for net metered projects results in more than 6 MW annually of new installed capacity from distributed generation. In addition, recent pending legislation (likely to pass) may advance small hydropower projects under 5 MW on existing water conduits, which will create new opportunities for the agriculture sector. Moreover, opportunities exist for the installation of multiple methane digesters on the state's dairies and other animal feed operations that could result in projects more than 1 MW in capacity.

Establishing a near-term fuel consumption savings target is difficult due to variety of factors, including lack of consumption or expense data for specific fuel types (e.g., diesel only or natural gas only) for the Colorado agricultural sector, and a lack of information to indicate the potential across the state for farms to switch to enhanced conservation practices (e.g., reduced till farming).

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.

Purpose Statement:
The market research report represents Phase II of the CEO agricultural market study, which builds on the research results of Phase I and includes the results of a statewide agricultural survey.

> *Phase I—Gaps Analysis:* *The purpose of the 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.*
>
> *Phase II—Market Research Report:* *The purpose of this 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.*

Survey:
In order to bolster secondary research, a survey of agricultural producers from across the State of Colorado was conducted. The survey was designed to yield energy data from across key agricultural market segments, and to determine Colorado farmers' awareness of and openness to energy opportunities. Respondents identified their agricultural operations type, energy systems, energy costs, concerns, and interests. The survey included a number of open-ended, multi-select, ranking, and Likert-scale questions to ensure that the appropriate information was collected. The survey was distributed to several hundred farmers via agricultural organizations that included the Rocky Mountain Farmers Union (RMFU), the Colorado Agricultural Council, the Colorado Association of Conservation Districts, the Colorado Farm Bureau, and cooperatives and rural electric associations.

The survey yielded 138 complete responses. With approximately 37,000 agricultural operations in the State of Colorado, the survey achieved a confidence level[*] of 95% with an 8.33 confidence interval[†].[5]

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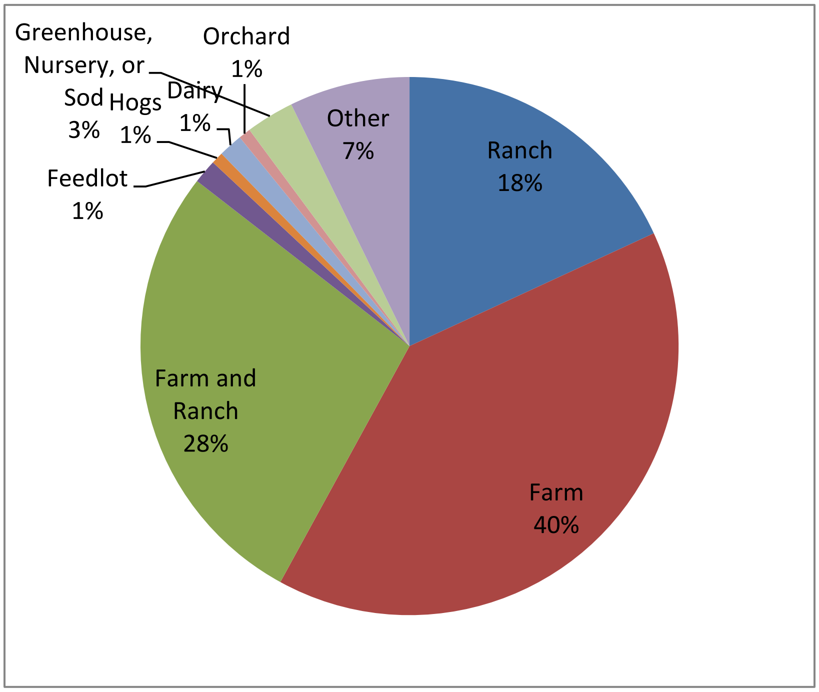
[*] **Confidence level** is expressed as a percentage and represents how often the true percentage of the population who would pick an answer lies within the confidence interval. A 95% confidence level means you can be 95% certain that the sample is representative of the whole. Source: http://www.surveysystem.com/sscalc.htm#one.

[†] A **confidence interval** (also called margin of error) is the figure typically reported in newspaper or television opinion poll results. For example, if 47% percent of your sample selects the same response under a confidence interval of 4, you can confidently surmise that if you had asked the question of the entire relevant population, between 43% (47 minus 4) and 51% (47 plus 4) would have picked that same answer. Source: http://www.surveysystem.com/sscalc.htm#one.

In addition to the known confidence level, the survey respondent types accurately reflected a proportionate response from each key agricultural market segment. Percentage of respondents by type is shown in Figure 1. Also reflective of the actual population, roughly half of the survey respondents operate in the Northeast area of Colorado, which is the state's most active region for agricultural production.

FIGURE 1: Types of Colorado Agricultural Operations Providing Survey Responses



Operation of field equipment was ranked highest by respondents in terms of its contribution to overall energy use, with irrigation and harvesting also ranking high. Survey respondents indicated that they were most interested in lowering energy costs associated with their electricity consumption, diesel use, and gasoline—particularly through equipment rebates, technical assistance, and support in conducting cost-benefit analyses. Of the 138 respondents, 114 (82.6%) had already implemented at least one energy improvement, with 20% of those having implemented a renewable energy project. Eighty-six (62.3%) of the respondents indicated an interest in implementing an energy efficiency project within the next five years. Interestingly, the respondents indicated that they are most likely to seek out information from other agricultural producers and utility providers.

Additional information was received through seven in-depth, one-on-one phone interviews with Colorado farmers. BCS worked closely with RMFU to identify farmers within the largest sub-sectors (ranchers, crop farmers, feedlots, dairies and an orchard) that were willing to discuss their operations and energy use in more detail. The interviews collected anecdotal information about typical energy use, energy projects they have completed, equipment they use and their operation processes, and whether any other producers' operations might be different and why. The interviews also allowed for further discussion about their level of interest in energy projects, what barriers they see, and where and why they get information from the sources they seek out.

The results of these surveys, coupled with the in-depth interviews, were utilized in combination with the secondary research to help inform recommendations for CEO. The following report will provide a brief overview of agriculture and agricultural energy opportunities in Colorado, as well as the barriers currently facing those opportunities. Finally, the report will present recommendations for CEO to support energy projects by the state's farmers.

IMPORTANCE OF AGRICULTURE TO COLORADO

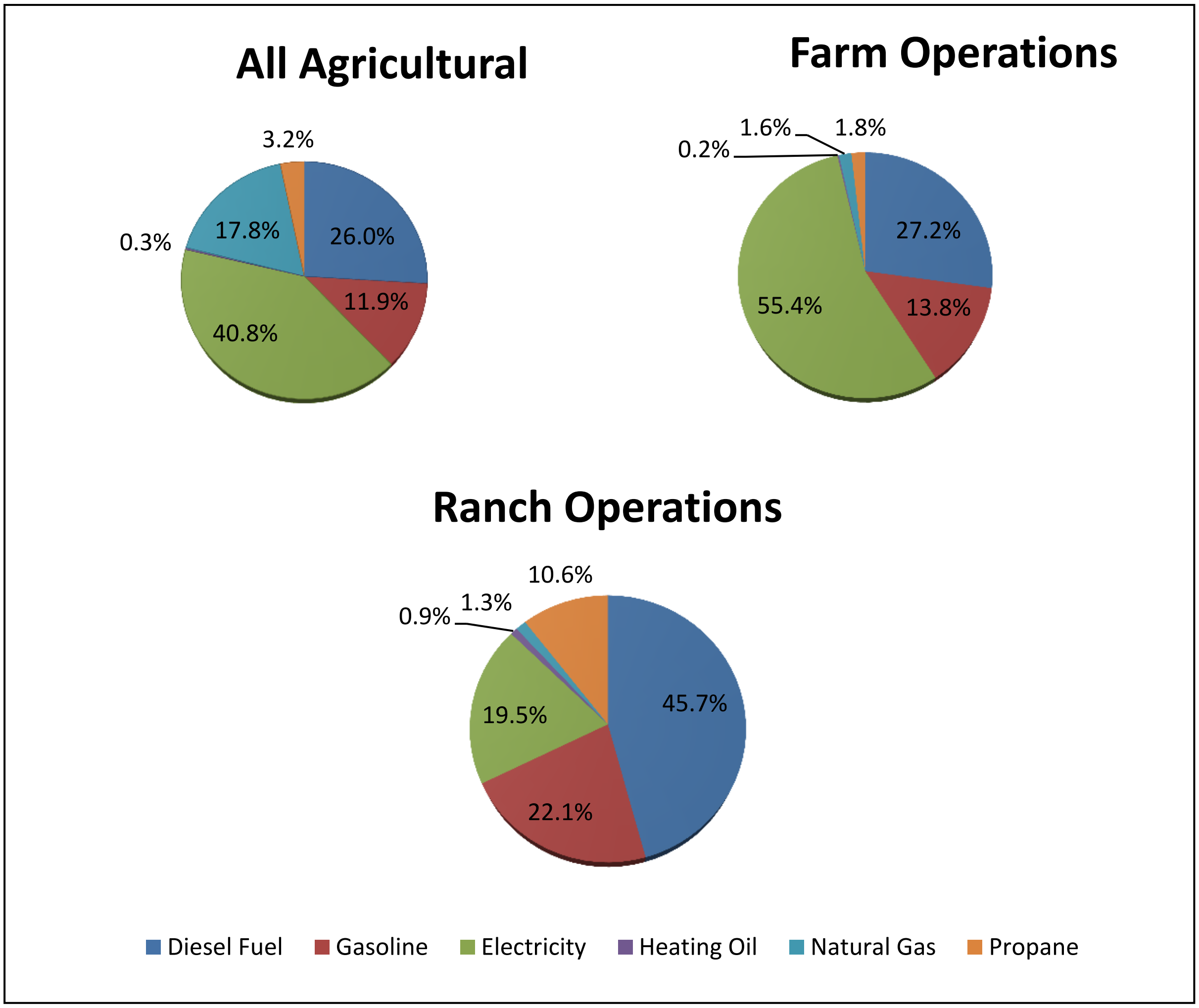
Agriculture is a very important market sector within Colorado in terms of land use, water use, and economic impact. Colorado's agricultural sector represents approximately 86% of the state's water use.[6] In terms of land, more than 31.0 million acres of private land was used for farming or ranching in 2011, which equates to 47.2% of Colorado's total 66.3 million acres.[7] In addition, another 10 million acres of federal and state land is typically used for grazing, which raises the percentage of Colorado land used for agriculture to more than 62%.[8]

Significant agricultural activity, as measured by the U.S. Department of Agriculture's (USDA's) *2007 Census of Agriculture*, is occurring in 63 of Colorado's 64 counties.[9] In the USDA's *2007 Census of Agriculture*, the market value of agricultural products sold in Colorado comprised 2.04% of the national total, ranking 19th among all U.S. states.[10] Despite a significant drought that affected much of the state in 2012, the agricultural sector still had a strong year in terms of economics—total cash receipts were projected to surpass $7.3 billion; up from $7.1 billion in 2011.[11]

ENERGY USE IN COLORADO'S AGRICULTURAL SECTOR

Both the survey results and the secondary research indicate that the agricultural sector uses energy in different ways than other end-use sectors, and that different agricultural operations consume energy differently. The Colorado agriculture sector's energy expenses are generally about 7% of the sector's total operating expenses;[12] however, the level of energy expense is not uniform across the sector and varies greatly for each market segment and operation. For example, farms with electric-powered irrigation systems make up more than 50% of total electric expenses in the agriculture sector, despite only making up about 11% of the state's 37,000 farms.[13] The survey provided insight into energy expenditures for the agricultural sector in Colorado, which Figure 2 highlights. Survey results revealed that electricity constitutes the largest portion of energy expenses for agricultural operations in Colorado at 41%, with costs averaging nearly $23,000 annually. With current prices for a bushel of corn or wheat near $7, a farm would have to sell more than 3,000 bushels to match that annual cost in revenue. Diesel costs were the second largest energy expense, averaging $14,589 annually and accounting for 26% of energy expenditures.[14]

FIGURE 2: Percentage of Average Annual Energy Expenditures by Type



Source: Colorado Energy Office, Agricultural Market Survey.

(*Note*: Data for average annual energy expenditures of the other agricultural subsectors—like feedlots, dairies, greenhouses, and orchards—were not included in the chart above due to the small number of survey respondents in those categories. This aims to maintain respondent confidently, as well as reflect that those few respondents may not have energy expenditures that are representative of the subsector as a whole.)

The following sections provide a more in-depth look at some of the most significant agricultural sectors in Colorado, including valuable insights on energy use yielded from the survey.

Farming Operations: Irrigation and its associated electricity costs is one of the largest areas of energy consumption on a farm. Survey participants identified the operation of field equipment as another primary source of energy consumption on the farm. Farming respondents reported spending an average of approximately $33,000 per year on electricity, while spending an average of $16,000 on diesel, and just over $8,000 on gasoline.[15]

Ranching Operations: In contrast, ranching respondents indicated that energy costs associated with transportation was the largest point of consumption in operation. Ranchers reported spending an average of more than $8,300 per year on diesel, more than $4,000 per year on gasoline, and about $3,500 per year on electricity.[16] In comparison, the average Colorado household spent $2,828 on gasoline in 2010.[17] In-depth interviews with ranchers revealed that most of their annual energy expenditures are the result of fuel costs for transportation equipment. One interviewee noted that it did not have any electricity costs associated with its ranching operation because water stocks were powered by onsite wind and solar systems.[18]

Dairy: Dairy farms' indicated that their primary energy use is for milking machines and milk-cooling systems, with electricity costs averaging $5,000 annually.[19] Diesel and gasoline also represented significant costs, averaging about $4,000 per year for each fuel type—not only for transportation use, but also for other diesel-fueled machines and generators in use at the dairy.[20] In an interview of a dairy with over 4,000 cows, monthly energy costs were reported to be nearly $14,000 for electricity, $2,265 for natural gas, and $519 for propane.[21] Assuming these monthly expenses are consistent throughout the year, this dairy's annual electric costs are over $160,000 annually

Greenhouse / Nursery: Energy costs for greenhouses and nurseries vary, with one survey respondent reporting $1.3 million in annual natural gas costs and more than $600,000 on electricity. This operation, which grows annual and perennial bedding plants, indicated that heating was the aspect of its operation that consumed the most energy. Two other respondents reported no natural gas costs, but relatively high diesel and propane costs.[22] In those instances, it is likely that propane was used for heating in place of natural gas, and some respondents had outdoor operations that required no heating, but higher costs for diesel to run farm machinery. Some of the largest areas of energy use in greenhouses and nurseries include lighting and heating in order to provide the plants with the proper amount of light in the right temperature setting.

Feedlots and Hog Farms: Survey results and additional research have shown that diesel fuel for farm machinery, heating systems and ventilation systems are typically the largest areas of energy use in these sub-sectors. Heating costs were identified as the largest area of energy consumption in hog operations. One hog farm survey respondent indicated that heating costs were the largest area of energy consumption in the operation. The survey respondent reported spending $2,000 per year on electricity for a 120-hog operation.[23] A feedlot survey respondent with a 5,000-head feedlot operation indicated that his annual energy expenses included $65,000 on diesel, $27,000 on electricity, $20,000 on gasoline, and $7,000 on propane. This respondent noted that operation of field equipment and transportation costs were the largest areas of energy consumption in the operation.[24]

OPPORTUNITY ANALYSIS: ENERGY USE ON COLORADO FARMS

The Colorado agriculture sector's primary energy improvement opportunities are found in the areas of electric-powered pumps and use of petroleum fuels (diesel and gasoline) for on-farm machinery and vehicles. Energy sources for heating uses—while a significant use for dairies and other animal feed operations—will have less of an impact for the agriculture sector in reducing on-farm energy consumption and expenses. This section provides an overview of the primary opportunity areas for CEO's Agricultural Energy Program. Based on analysis and synthesis of the energy data identified throughout both phases of this project, it is reasonable to estimate that ***over the next 10 years, existing agricultural operations in Colorado have the potential to reduce electric usage by more than 90 million kilowatt hours (kWh) annually; install more than 10***

megawatts (MW) of on-farm renewable energy capacity; and reduce diesel fuel consumption through conservation practices, fuel efficiency, and use of alternative fuels, including natural gas.

IRRIGATION

Of Colorado's 31 million acres of farmland, only about 3 million acres is irrigated annually for crop production and pastureland.[25] A review of USDA Agriculture Census data back to 1982 indicates a downward trend in the state's irrigated land. Prior to 2002, total irrigated land was greater than 3 million acres; however, it has fallen below 3 million acres in the last two USDA Census' of Agriculture.[26] Figures from recent USDA Agriculture Censuses—from 1997 to 2002—indicate the amount of irrigated farmland has ranged from 3.37 million acres in 1997 to 2.59 million acres in 2002; in 2007, the state's irrigated farmland was 2.86 million acres.[27] More than 55% of the state's irrigated land in 2007 was found in 10 contiguous counties in northeast Colorado[‡] and the 5 counties that make up the San Luis Valley.[28] Two counties alone in northeast Colorado—Weld County and Yuma County—combine for more than 591,000 irrigated acres, which is more than 20% of the state's total.[29]

Even though irrigated land is less than 10% of the state's farmland, the electricity costs to power irrigation made up more than 50% of the total electric expenses in 2008 for Colorado's agriculture sector. In 2008, electricity expenses for the entire agriculture sector were estimated to be $137 million.[30] In the same year, the cost of powering irrigation pumps with electricity was $73.3 million, or 53.0% of total electric expenses.[31] Total expenses to power irrigation included an additional $4.8 million for pumps powered by natural gas and diesel engines.[32] USDA's *2008 Farm and Ranch Irrigation Survey* provides the following irrigation cost per acre data from the different energy sources:

- Electric-powered irrigation pumps were $54.83 for water from well and $34.24 from surface water
- Natural-gas-powered pumps were $57.44 for water from wells and $50.06 from surface water
- Diesel-powered pumps were $28.99 for water from wells and $46.18 from surface water.[33]

Although diesel-fuel-powered irrigation costs were lower for water well pumps in 2008, it should be noted that these fuel cost trends are hard to predict from year to year due to fluctuating commodity prices.[34] Fuel source tradeoffs to consider, in addition to price stability, include operational and convenience factors. Electric-powered irrigation provides a farmer with low maintenance requirements and less noise during operation,[35] whereas using natural gas or diesel may provide an advantage in avoiding utility interruptible power supply periods.[36]

One additional tradeoff to consider when evaluating electricity use for irrigation is the amount of losses experienced by the electric generation, transmission, and distribution systems. The inefficiency in generation is quite large for fossil fuel power plants, with coal plants operating

[‡] The 10 northeast Colorado counties are Weld, Yuma, Kit Carson, Logan, Morgan, Phillips, Larimer, Sedgwick, Washington, and Boulder. Irrigation acres for all Colorado counties found in *Colorado Agricultural Energy Market Research Phase I: Gaps Analysis*, Appendix C, pp. 26–28.

around 33% efficiency and natural gas plants operating near 42% efficiency.[37] Additional losses are then experienced through transmission and distribution (T&D), with losses accounting for 8.5% of total electric generation in Colorado in 2008.[38] By looking at the $73.3 million spent on irrigation electricity in Colorado in 2008, along with the average 2008 Colorado industrial electricity price of 6.65 cents per kWh, it is possible to estimate that 1.1 billion kWh were used in irrigation by Colorado farmers. (Given that some farmers may pay the commercial rate or another rate lower than the industrial, this consumption estimate aligns very closely with the estimates calculated in the next paragraph of 974 million kWh that used number of pumps and associated efficiencies). Given an average T&D loss of 8.5% for Colorado in 2008, it is then possible to estimate that more than 100 million kWh are lost annually just through T&D systems. Thus, depending on the power source, irrigation pumps may yield varying energy-consumption-based emissions.

More than 15,000 farms in Colorado report a portion of their land as being irrigated; however, the primary opportunity for energy improvements can be defined as involving approximately 4,100 farms that have 13,021 pumps powered by electricity.[39] Other farms in the state power 740 irrigation pumps with diesel fuel (375) and natural gas (365). The remaining farms use irrigation methods that do not have powered pumps (such as gravity flow systems), or they went unreported. Additional data from USDA indicates that Colorado's irrigation well pumps run on average 1,500 hours each year using a pump, with an average of 67 horsepower (hp) per pump.[40] Applying this average system and operation data to the 13,021 electric-powered pumps indicates approximately 974 million kWh of electricity consumed annually by irrigation in Colorado.[§] The Colorado State University (CSU) Extension reports that recent field tests in Colorado indicate that irrigation pumps are operating at 45% efficiency on average.[41] By testing the pumps every 1–3 years and conducting maintenance, they should operate at 65% efficiency, with a range of 72%–77% efficiency being achievable.[42] The Advanced Pump Efficiency Program in California provides energy savings data that can serve as an indicator of the potential for Colorado to achieve similar energy savings outcomes through improvements to irrigation pumps. In California, the Center for Irrigation Technology (CIT)—located at California State University, Fresno—operates an Advanced Pumping Efficiency Program. CIT has provided incentives between 2002 and 2012 that total $6.9 million for 1,750 irrigation pump repairs and retrofits. These upgrades have resulted in 108 million kWh in annual savings.[43] In Colorado, efficiency improvements for 1,750 irrigation pumps would make up 13% of the state's total electric powered irrigation pumps. Increasing the efficiency of the existing inventory is a near-term, low-cost opportunity to achieve energy savings in Colorado's agriculture sector. Additionally, more advanced precision agriculture technologies for irrigation create significant opportunities for both energy and water savings.[44] Enhanced irrigation techniques take advantage of soil monitoring data and satellite imagery to map fields that will then allow farmers to indentify which sections of their fields require more or less water. A 2008 report by the Southwest Energy Efficiency Project (SWEEP) on rural electric efficiency opportunities in Colorado and other Southwestern states found that, "Improved irrigation technologies and management practices have consistently provided up to 40% savings of both electricity and water …"[45] The SWEEP report cites a demonstration project conducted in Yuma County, Colorado, starting in 2001 showed a payback period of three to four years to convert a center pivot irrigation system to Low Energy Precision Application (LEPA) irrigation.[46] LEPA irrigation is a term used to describe systems with both improved irrigation technologies and management practices. The demonstration project was

[§] Estimated consumption is based on a reasonable assumption of average pump operation at the full 67 hp during operation hours; and conversion of the 67 hp pump usage to a 49.96 kilowatt (kW) of load capacity (1 hp = 0.745699872 kW).

conducted by the U.S. Department of Energy's (DOE's) Denver Regional Office and included other local partners.

With the implementation of irrigation efficiency programs (described later in this report), Colorado could achieve a 10% efficiency gain or greater over a 10-year period that would result in energy savings of more than 97 million kWh annually—enough energy to power over 8,000 homes each year.[**] This opportunity to increase energy efficiency in irrigation is based partly on an irrigation initiative in four Northwestern states with a goal of achieving 20% efficiency over an eight-year period (2012–2020).[47] It is also based on an understanding that Colorado's farms are not currently using variable speed drive pumps or regularly testing their pumps to ensure higher efficiency ratings.[48] Additional efficiency gains would result—in part—from improved operational practices that are likely to increase yield, resulting in a significant reduction of energy intensity (i.e., the amount of energy required per unit of production). Achieving a 10% irrigation efficiency gain would involve maintenance of existing pumps to increase pump efficiency; installation of more efficient pumps with variable speed drives; application of new technologies that use precision water applications based on soil readings; and more efficient water application and disbursement technologies involving efficient, low-pressure sprinkler heads.

DAIRIES

Although the USDA's *2007 Census of Agriculture* indicates that more than 450 farms in Colorado have milk cows, the actual number of dairies producing milk in the state is between 130–160.[49,50] These dairy operations range in size from 20 cows to more than 5,000 cows, and are concentrated in northeast Colorado (Weld, Morgan, and Larimer counties have more than 80% of the state's milk cows).[51] Although dairy operations make up less than 1% of Colorado farms, dairy milk production generates more than $590 million in sales, ranking third highest among the state's agricultural products.[52] Dairies in Colorado are operating 24 hours per day and 7 days per week. Dairies are energy-intense operations that require electricity for vacuum pumps to produce milk and high-powered fans for ventilation. Dairies have three lighting areas: (1) the milking facility, for cows and staff; (2) outdoor lighting; and (3) the facility where the cows are housed. Other energy uses include the following:

- Powering on-farm machinery and vehicles for feed handling and waste management
- Hot water for washing and sanitizing equipment
- Space heating
- Refrigeration.

Dairies can reduce electric energy use by 10%–35%, depending on the current state of equipment installed.[53] The Innovation Center for U.S. Dairy reports that, on average, U.S. dairies spend $40 per cow per year on electricity.[54] If these electric expenses are similar for Colorado dairies, the opportunity currently exists to save $520,000–$1.82 million annually on electricity expenses from the approximately 130,000 milk cows in the state; these potential savings are equivalent to the amount of electricity required to power 539–1,905 homes each year.[††] Efficiency opportunities

[**] In 2010, the average annual electricity consumption for a U.S. residential utility customer was 11,496 kWh. Source: http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3.

[††] Estimate is based on a Colorado average retail electric price of 8.31 cents per kWh, coupled with an assumption of dairy energy saving resulting in 6.2–21.9 million kWh annually.

exist for reducing the electricity consumption of vacuum pumps, lighting, ventilation fans, and refrigeration. Using lower horsepower vacuum pumps, coupled with the use of variable-speed technology, could reduce the pumps' electricity consumption by 50%–65%.[55] Switching from T-12 lamps to T-8 or T-5 fluorescent tubes for indoor lighting could save more than 20% in electricity consumption, and they will also last longer than T-12 bulbs. Additionally, a Colorado dairy recently reported installation of an outdoor light-emitting diode (LED) light that has proven to be very effective for the operation's lighting needs; although, the dairy views the single LED light bulb as a test case for further consideration due to its high initial cost.[56] Other efficient lighting options include high-pressure sodium lights can be installed to replace incandescent light bulbs in barnyards. High-pressure sodium lights for barnyards are more efficient and have an expected life of about 24,000 burning hours, or six years, for photo-controlled fixtures.[57]

Variable speed ventilation fans with sensors that can auto-detect when conditions require that they be turned on could save electricity compared to older ventilation technologies.[58] In addition, new dairy facilities can be designed to completely eliminate fan loads by installing steep ceilings that will pull the hot air up quickly and out of the facility. The installation of a refrigeration heat recovery unit can pull and recover 20%–60% of the energy in the form of heat from milk that is in the cooling process. This process typically uses a technology called a plate heat exchanger and serves to both lower refrigeration energy costs by precooling the milk and warms water that can be used for washing and providing drinking water for the herd.[59]

Finally, the installation of methane digesters and solar thermal systems are important energy opportunities for dairies. Dairy waste is confined to relatively small areas compared to other cattle operations, making dairies uniquely suited for the use of methane digesters. A methane digester can generate electricity, heat, or both electricity and heat. The U.S. Environmental Protection Agency's (EPA's) AgStar tracks the development of methane digester on farms in all 50 states. As of September 2012, AgStar indicates that throughout the United States there are a total of 158 dairy methane digesters out of a total of 192 manure-based methane digesters.[60] Currently, not one dairy in Colorado has installed a methane digester. A 2011 report from the Energy Trust of Oregon found that a 1,000-cow dairy has the potential to develop a 1-MW digester if the manure waste is combined with other higher-energy organic waste.[61] The additional organic waste for an effective co-digestion mix was found to include annual ryegrass straw.[62] In addition to combining higher-energy organic waste, Colorado dairies will see improved energy production by combining "wastewater generated onsite or by nearby facilities, such as food processing plants or domestic wastewater treatment plants."[63,64] According to CSU Extension, a dairy cow will provide 16,000 British thermal units (Btu) of energy per animal per day.[65] Using this Btu value, a dairy cow's electric generation potential can be converted to 4.68 kWh per day. In 2009, CSU's Department of Soil and Crop Science conducted an economic feasibility study of methane digesters, finding that Colorado dairies with fewer than 3,500 dairy cows would not be cost-effective according to technology providers.[66] USDA's 2007 Census of Agriculture indicates there are 11 dairies in Colorado with more than 2,500 cows.[67] These 11 dairies may create an opportunity to develop more than 10 MW of total installed capacity with sufficient co-digestion waste and water. In addition to electric power production, methane digesters can produce a fertilizer co-product.[68] The current opportunity for energy use from methane digesters will be negatively influenced in Colorado by local net metering rules in some areas that limit renewable energy systems to 25 kW and by a lack of utility power purchase options for mid-size renewable energy projects. Moreover, the ability to reach this potential will require the availability of water and co-digestion feedstock, which could be challenging for future development.

Solar thermal systems can reduce hot water expenses for dairies that require large quantities of hot water for cleaning cases and equipment. Solar thermal systems installed on dairies have demonstrated simple payback periods of eight years, as shown in a recent case study from a dairy in Maine that installed a system with 72 panels in 2008 and received a $10,500 incentive payment and a $60,000 federal tax credit.[69] With many businesses seeking payback periods of less than three years, financial incentives that can reduce payback periods may be necessary to advance the solar thermal market among dairies in the state.

Kraft Dairy: Energy Efficiency Upgrades and Renewable Energy Considerations

Kraft Dairy owns and operates two dairies in Morgan County near Fort Morgan, Colorado. The first dairy is older, has 1,200 cows, and largely operates outdoors. The second dairy opened in 2007 and houses 4,300 cows under 13 acres of roof space. The operation runs 24 hours per day, 7 days per week.

Kraft has made several energy improvements with its dairies over the years, including adding computer-controlled variable speed drives to its vacuum pumps. On its newer diary, Kraft addressed ventilation issues by installing a steeply pitched roof that creates a vacuum and sends air up and through the building. Additionally, Kraft installed compact florescent light bulbs and is currently looking into the opportunity to use LED lights for its outdoor lighting, which has an associated installation cost of $500.

Kraft also installed storage tanks with added insulation to help the milk remain cooler for longer. Furthermore, Kraft is utilizing a heat exchanger for cold drinking water coming in for the cows. The heat exchanger uses the cold water to help cool the milk storage rooms. Kraft noted that this type of heat exchange process is common with larger dairies, but less common in dairies with fewer than 400 cows.

Kraft has considered the installation of methane digesters and solar photovoltaic panels, but has not implemented either. Kraft noted that it did not know of a methane digester installed on any dairy in Colorado, indicating that developers soliciting these projects seem to be pursuing federal dollars associated with the projects. Regarding solar power, Kraft stated that it is looking into concerns surrounding the structural integrity of its roofs being able to support solar panels.

Source: Interview with Chris Kraft on February 27, 2013.

ANIMAL FEED OPERATIONS

In addition to dairies, Colorado has a number of other animal feed operations (AFOs) for cattle, layers (chickens that produce eggs), and hogs. There are approximately 231 (non-dairy) AFOs in the state that are of a significant size:

- *Cattle Feedlots*—186 operations, with several having inventories of more than 100,000 cattle[70]
- *Hog Farms*—33 with 500 or more hogs in inventory (27 with 2,000 or more hogs)[71]
- *Layers* (egg production)—12 with 400 or more (7 with 20,000 or more).[72]

Cattle Feedlots (operations with an inventory of 1,000 to more than 100,000 cattle) utilize outdoor feeding areas that have fewer requirements for electric lighting or heating needs compared to other concentrated AFOs. Electricity is used in the pumping of stock water and running augers that move feed to the cattle. Additional electric uses are for outdoor lighting. Feedlots with more than 15,000 cattle may use natural gas to run steam systems that break the grain for feed. However, the major energy consumption use, and cost, is for diesel fuel to run equipment that moves feed into the feedlot area, and to remove waste.

Hog Farms are characterized by swine housing facilities with mechanical ventilation systems that use multiple fans to address rising temperatures in a facility. Generally, the systems are staged to begin with small fans, with larger fans becoming active later to support greater air delivery. In Colorado, there are 27 operations with more than 2,000 hogs. A hog farm's energy efficiency can be increased in three ways through improvements to the mechanical ventilation system: (1) installing highly efficient fans; (2) ensuring the proper configuration or staging of fans within a system; and (3) conducting regular maintenance on ventilation equipment.[73] More efficient fans and systems will also potentially result in greater animal production benefits by reducing the number of stressed animals that "are more susceptible to disease and also have less-than-optimal animal growth and feed conversion." In addition, other maintenance to systems' discharge cones and motor belts can increase fan efficiency by 15% and 50%, respectively. Moreover, regular maintenance that cleans dirty shutters and blades will improve air delivery. Other energy efficiency improvements to consider on a hog farm operation include lighting, space heating, and hot water.

Layer Operations: There are more than 4 million animals in layer operations that produce eggs. These operations have an extremely high concentration of animals per farm, with several operations in Colorado holding more than 20,000 animals. There is at least one layer operation in Colorado with more than 1 million animals. This large operation has multiple buildings in one location that require electricity for automated ventilation, feeding, and water operations. A recent report from the American Council on an Energy-Efficient Economy (ACEEE) documents that poultry operations "make heavy use of lighting. One poultry house…could have 50 light bulbs that burn all day—conventional poultry houses have no natural lighting so that the grower can keep the light levels at the optimum for maximum growth."[74] ACEEE reports that a layer operation that switches from all-incandescent lighting to all-compact fluorescent lighting can obtain energy savings up to 80%; however, there are concerns that modifications to light color may negatively impact egg production.[75] In addition to lighting, a layer operation will have hot water requirements for cleaning equipment and facilities. Space heating for layer operations is minimized by the high concentration of animals within one building that generate heat.

Similar to dairies, hog and layer operations are viable sites for solar thermal projects and methane digesters. Like dairies, the future development of digesters for other AFOs will be dependent upon technology advances that address Colorado's dry climate and constrained water resources. To date, only one AFO in Colorado has an on-farm methane digester—installed in 1999 with a capacity to produce more than 100 kilowatts (kW) of power, it is located on a hog farm in Lamar.[76]

H2O Farms

H2O Farms Farm and Ranch is located in Baca County, the southeastern-most county in Colorado. H2O Farms grows approximately 1,000 acres of corn; 1,000 acres of wheat; and 2,100 acres of milo. H2O Farms indicated that electricity costs for its operation are around $225,000 annually, with both gasoline and natural gas costs at $12,000 and diesel costs at $14,000 annually. Irrigation was identified as consuming the most electricity throughout the operation.

With regard to implementing energy improvements, H2O Farms adopted no-till farming practices to save money. H2O Farms also installed two wind turbines near the irrigation wells to generate electricity for irrigation. Both turbines produce 200,000 kilowatt hours per year, saving H2O Farms around $7,000 annually in electricity costs. H2O Farms estimates a payback period of seven years from both electricity cost savings and revenue from the sale of renewable energy credits. The wind projects were supported by two grants that included a U.S. Department of Agriculture, Natural Resources Conservation Service's Environmental Quality Improvement Project grant.

H2O Farms installed GPS Autotrack steering on its tractors and sprayer, resulting in an estimated $10,000 in energy cost savings on diesel fuel and chemicals annually from reduced "overlapping" on the field. H2O Farms also installed a pivot track system to remotely monitor sprinklers, saving an estimated $8,000 annually in combined energy costs from more efficient use of electricity, diesel, and gasoline. The pivot track system has eliminated the need to manually check the system twice a day with vehicles.

ON-FARM MACHINERY AND TRUCKS

USDA's *2007 Census of Agriculture* provides a statewide inventory of on-farm machinery for Colorado's agriculture operations. The data provided by the Census indicates that Colorado farms have 73,350 trucks (including pickups); 61,571 tractors; and additional machinery equipment that includes combines (4,322), forage harvesters (2,437), and hay balers (11,282).[77] Based on the results of the survey and the in-depth interviews conducted for this report, that equipment is primarily powered by diesel fuel, with some trucks running on gasoline. Addressing the agriculture sector's highest energy cost—fuels—requires pursuing opportunities for on-farm machinery and trucks in four areas:

1. *Modifying farm practices to conserve fuel use*
   CSU Extension provides estimates of diesel fuel usage and expenses per acre based on different farming practices. Farmers implementing practices that minimize or reduce tillage can see significant diesel savings of several gallons per acre.[78,79] It is estimated that approximately 35% of U.S. cropland is being farmed using no-till practices, and that percentage is increasing.[80]

2. *Installing GPS auto-drive technology to reduce "overlapping"*
   Interviews with two field crop farmers in Morgan County indicated that GPS auto-drive systems on field machinery can reduce diesel use by as much as 10% for pre-harvest and harvest activities, including tillage and planting.[81] The GPS system can also eliminate

unnecessary equipment use, providing detailed records of past applications to specific areas of the farm.

3. *Purchasing fuel-efficient machinery*
The Nebraska Tractor Testing Center conducts tests for fuel efficiency on agricultural tractors that allow a farmer to determine improvements in efficiency. In addition to the type of engine, tractor efficiency is determined by how it is set up and operated. For example, correctly inflated tires can improve performance by as much as 6%.[82] In addition, tractors can be operated in a manner that may only use 70% of their rated engine power to produce fuel efficiency gains of 13%–20%.[83]

4. *Purchasing or converting to alternative-energy-fueled machinery*
Currently, the availability of compressed natural gas (CNG) vehicles is limited to trucks that manufacturers are producing as on-road vehicles. CNG tractor equipment for field operations is not currently commercially available. In addition, farmers indicated during in-depth interviews that running tractors on CNG, unlike road vehicles, will require onsite storage capabilities that create a barrier for use in many field operations, such as tilling, planting, and harvesting.[84] However, the first CNG tractor is being developed by a subsidiary of Fiat and is scheduled for market release in 2015.[85] It should be noted that fuel switching to natural gas vehicles—given the current prices of natural gas compared to diesel fuel—has the potential to reduce a farm's fuel expenses, but not reduce energy consumption. However, natural gas delivers 25% lower carbon dioxide emissions and 95% less nitrous oxide when compared to diesel combustion.[86] Additionally, biodiesel blends can be used on existing on-farm diesel equipment that will not void the warranties of most engine manufacturers. Common blends used in the market today include B2 (2%), B5 (5%), and B20 (20%). Benefits of biodiesel, although not necessarily increasing fuel efficiency, include enhanced lubricity, longer equipment life, lower maintenance costs and less equipment downtime, and a cleaner burning fuel.[87]

CROSS-CUTTING RENEWABLE ENERGY OPPORTUNITIES

USDA's *2009 On-Farm Renewable Energy Survey* indicates a low saturation rate for the installation of renewable energy systems on Colorado Farms. The survey indicates that less than 1% of the state's agricultural producers had an operating solar photovoltaic (PV), solar thermal, or small wind system.[88] Total capacity installed for on-farm energy production was just greater than 1 MW over a period of approximately 10 years, with the average small wind system being 3 kW and the average solar PV system being 1.65 kW.[89] With significant drops in recent years to the price of renewable energy equipment, and with statewide net metering standards for systems up to 25 kW in capacity, the potential exists to increase small wind and solar PV installations significantly over the next several years. Interestingly, the USDA survey also showed that nine farms in Iowa each installed a single large wind turbine with an average nameplate capacity of 1.4 MW. [90] With Colorado's high-quality wind and solar resources, opportunities to install large on-farm projects should be considered. Other onsite renewable energy technologies that provide opportunities for farms to address facility heating costs include geothermal and solar thermal systems.

Small Hydro: The Colorado Department of Agriculture's (CDA's) Advancing Colorado's Renewable Energy Program (ACRE) recently completed research to assess the opportunity for low-head, small hydro development on Colorado's irrigation ditch companies. Colorado has more than 250 irrigation companies, along with streams and rivers, in close proximity to farms and ranches, which provide opportunities for small hydropower development. The research study for ACRE identified more than 20 low-head small hydro technologies, but did not provide an assessment of the statewide potential capacity for development from existing irrigation infrastructure; however, it did hypothesize that future research in this area would likely indicate a number of prime locations with significant elevation drops for implementation of projects. The report's examination of Grand Valley Irrigation Company's system identified eight potential projects as small as 4 kW to more than 400 kW in capacity.[91] Additional research involving funding from the Hydropower Research Foundation and CSU's Department of Civil and Environmental Engineering has collected GIS data for low-head hydropower development in Western states, including Colorado.[92] The GIS data has the potential to be applied across the state to estimate the power potential at low-head sites using elevation data from digital elevation models.

Recent policy developments at the federal level are providing encouraging signs for the future growth of small hydropower in Colorado. In February 2013, the U.S. House of Representatives passed the *Hydropower Regulatory Efficiency Act* (HR 267), co-sponsored by Representative Diana DeGette (D-Denver), on a 422–0 vote that would exempt water conduit projects less than 5 MW in size from costly Federal Energy Regulatory Commission permitting requirements.[93] The legislation still must be passed in the U.S. Senate before being signed into law.

In considering small hydroelectric projects for agricultural operations, electric infrastructure barriers can also lead to higher project costs, negatively impacting the overall economics and feasibility. In a collection of case studies put together by Flux Farm Foundation on small hydro projects for agriculture in western Colorado, three of the four projects were identified as having infrastructure challenges related to electrical interconnection or the availability of a penstock.[94] Additionally, securing funding through rural banks that are unfamiliar with the economics of small hydro projects was noted as a barrier.[95]

CROSS-CUTTING ENERGY EFFICIENCY TECHNOLOGIES

The agriculture sector includes a unique opportunity for increased deployment of energy efficiency technologies that are also applicable to the residential, commercial, and industrial sectors. A large share of the state's farms, ranches, and orchards are operated out of farm homes that would benefit from the energy efficiency improvements of a residential property, including enhancements to the thermal seal, insulation, lighting, and more efficient appliances. AFOs have opportunities for improvements to commercial lighting technologies and industrial pumps, along with space heating and cooling loads that are similar to industrial and commercial properties. Moreover, horticulture operations, including greenhouses and nurseries, present opportunities for commercial type improvement in lighting and heating, ventilation, and air conditioning equipment.

SMART GRID / TRANSMISSION

Additional on-farm energy opportunities include the advancement of smart grid technologies and emerging farmer-led business models to support the development of new transmission lines. Smart metering technologies have undergone significant growth over the last five years, including advanced metering infrastructure ("smart meters"), which is forecasted to be deployed to more than 50% of the homes in the United States by 2015. In addition, a recent program announcement by USDA will provide more than $8 million in low-interest loan funds for smart grid and electrification projects to a rural electric association in the Southeastern region of Colorado.[96] The Southeast Colorado Power Association will use more than $7 million to expand its distribution line network by 130 miles and apply $600,000 to a number of smart grid projects in its service territory. Smart grid research on other sectors, including commercial and residential, indicate that the agricultural sector could see efficiency gains and cost savings from the use of smart grid applications, such as advanced metering infrastructure.[97] Advanced metering infrastructure could provide real-time energy consumption data and pricing that would allow a farmer to make more informed energy-use decisions that could reduce overall consumption and avoid high demand charges by better managing multiple energy-using systems.

BARRIERS TO ENERGY IMPROVEMENT ON THE FARM

A number of key barriers that inhibit the agricultural sector from pursuing energy improvements have been identified through secondary research, survey results, and in-depth interviews. The *2007 USDA Census of Agriculture Farm and Ranch Irrigation Survey* asked farmers and ranchers about the top barriers to making improvements to "reduce energy use or conserve water." The top barriers identified include: (1) investigating improvements was not a priority; (2) respondents were unable to finance improvements; and (3) improvements would not reduce costs enough to cover installation costs.[98] Similarly, two-thirds of respondents to the CEO Agricultural Market Research Survey conducted for this project identified "cost/availability of financing" as a primary barrier to pursuing energy improvement projects.[99] In addition, approximately one-third of CEO survey respondents selected "availability/understanding of technical information" and "refit cycle (current equipment does not need to be upgraded yet)" as primary barriers.[100] It should be noted that although barriers exist, nearly 88% of survey respondents who had implemented energy improvements noted that the projects met their expectations.[101] This indicates that once the barriers have been overcome, there is a high level of satisfaction with the resulting energy improvement project.

COST / FINANCING

As noted above, availability of funds or financing for energy project implementation is a significant barrier for agricultural producers. The survey results are on par with the results of a survey conducted by Oregon's Department of Agriculture, which confirmed "up-front costs are one of the main barriers to additional energy projects" among agricultural producers in the state.[102] The Colorado agricultural sector operates with profit margins that have ranged from 10%–20% of sales over the past decade, with an average profit margin of 17.1% in 2012.[103] These profit margins limit the amount of cash available to producers to reinvest in their businesses for energy improvements, including when in competition with other non-energy farm improvement needs.

Of the survey respondents, 65% listed "Cost/Availability of Financing" as a primary reason they have not already made an energy improvement.[104] In other open-ended questions, as well as during some of the in-depth interviews, respondents expressed reluctance in using financing (loans) for *anything* related to their businesses, let alone energy improvements. They noted the impact that outside variables, such as weather, can have on their profit margins from year to year,[105] reducing interest in long-term financing. This implies that it is more the upfront cost, as opposed to availability of financing that is preventing farmers and ranchers from pursuing energy improvements. Projects—such as switching water stocks to a solar-powered system (costing on average $10,000–$12,000)[106] or installing GPS guides on tractors (costing on average $10,000–$15,000[107])—are viewed positively, but the cost is often high enough to cause hesitation.

In addition to upfront costs, the payback period of an investment in energy improvements is an important factor that can influence an agricultural producer's decision making. If survey respondents had implemented an energy improvement and indicated that it had not met their expectations, the survey inquired why they were disappointed. Just more than 57% of respondents stated that the energy improvement did not meet their expectations because it was not cost-effective or that the payback period was undesirable.[108]

For transportation fuels, infrastructure considerations affect the cost-effectiveness of switching from diesel to CNG or biodiesel, including whether there is a CNG or biodiesel filling station nearby. For Colorado producers, there are 17 CNG filling stations in the state, primarily around metropolitan areas.[109] With no CNG filling stations nearby rural communities, the cost can become prohibitively high, with compressors costing close to $10,000; installation costing around $30,000 or more; and maintenance costing about $1,600 annually.[110] Also, some farmers and ranchers indicated an interest in using biodiesel in their vehicles, but the interviews revealed that there was a barrier with regard to whether any biodiesel filling stations were nearby. The DOE Alternative Fuels Data Center, which reports filling station locations for alternative fuels, indicates that there are only 12 biodiesel filling stations in Colorado, with 9 of the stations in or near large metro areas like Denver, Colorado Springs, Fort Collins, and Boulder.[111]

For farmers and ranchers interested in switching their vehicles from diesel to CNG, there are conversion kits available on the market. The cost of the kits and the required natural gas tanks total approximately $10,000.[112] Within the past few years, CNG bi-fuel heavy-duty pickup trucks have become available by Ford, General Motors, and Dodge. When purchasing a new heavy-duty pickup truck, the upgrade cost to have a CNG bi-fuel system is around $10,000–$11,000.[113] Although the cost of CNG is less and the fuel burns more cleanly, resulting in fewer oil changes, the CNG tank accounts for about half of the cargo space in the bed of the truck, which is often of utility to farmers.[114] There are currently no CNG tractors on the market.

AVAILABILITY OF TECHNICAL INFORMATION

Another key barrier to energy improvements in the Colorado agricultural sector is availability and awareness of technical information on energy opportunities. One-third of survey respondents stated that this was a primary reason why they had not pursued an energy project yet.[115]

Approximately 80% of survey respondents stated that they would look for assistance from another organization before planning an energy project.[116] This indicates a general need, and recognition of the need, by farmers for outside assistance on energy projects. The survey indicated that agricultural producers are most likely to seek out information from other farmers above any other source.[117] Nearly all of the in-depth interviewees noted that they rely on their local equipment suppliers and dealers to learn about available technologies, and that they seek out neighbors and other farmers to gain an understanding of performance issues surrounding specific pieces of equipment.[118]

Survey respondents also ranked their utility provider, the CSU Extension, and USDA as likely secondary sources for information. County/local government and state government tied as the lowest-ranking information resources—respondents indicated that they are "neutral" or "somewhat unlikely" to seek information from the government. This could be translated into a lack of familiarity and trust on the part of the respondents, suggesting an important barrier for CEO to overcome when marketing new programs, policies, or strategies. An important consideration is whether CEO is best served by working with partner organizations that have existing relations with agricultural producers.

REFIT CYCLE

Nearly 30% of survey respondents identified "refit cycle (current equipment does not need to be upgraded yet)" as a primary barrier to implementation of energy projects.[119] While this barrier was not as prominent as financial concerns, it nonetheless indicated reluctance to upgrade any equipment that was still working properly. The in-depth interviews provided more details on this, with some interviewees expressing reluctance in paying the cost of upgrading equipment from the 1980s that is still working, while others expressed their preference for upgrading certain trucks every two years at a high cost ($15,000 annually) to the operation. In this case, the interviewee's preference for upgrading so frequently was tied to the harsh and demanding environment in which the trucks were used.[120]

POLICY UNCERTAINTY

Another barrier that surfaced throughout the in-depth interviews, as well as within the open comment sections of the surveys, was hesitance by agricultural producers to make long(er)-term investments in energy improvement projects when they feel there is uncertainty regarding related policies. This includes uncertainty regarding the availability of tax credits or incentives, and concerns about the unknown impacts of new, emerging policies and regulations that could accompany urban sprawl. As cities and suburbs begin to border agricultural operations, they could pass legislation and/or change existing laws that potentially have negative impacts on agricultural producers in order to pacify the new residential areas.[121]

COLORADO AGRICULTURAL ENERGY RECOMMENDATIONS

Survey results indicate that agriculture producers are most interested in energy efficiency projects that will lower their consumption of diesel, gasoline, and electricity; at least 80% of participants are "very interested" or "somewhat interested" in addressing those energy sources. In addition, 63% of agriculture producers using propane indicated that they are "very interested" or "somewhat interested" in lowering consumption of that fuel. When asked about the type of programs they would like to have available to support energy improvements, participants indicated that they are most interested in equipment rebates (71%), technical assistance (63.7%), cost-benefit analysis (63.1%), and energy audits (52.1%). Of the 83% of participants that had made previous energy improvements, most indicated they had not received technical assistance, but nearly 80% said they would look for technical assistance in the planning of future energy improvements.

In addition to analyzing the survey responses and taking into account information provided during the in-depth interviews, secondary research was conducted to identify current and past agriculture energy programs run by state agencies, including state energy offices and agriculture departments. The research identified 31 energy programs at the state government level that are either solely focused on supporting agriculture, or offer farms the opportunity to participate in a larger program involving other industry sectors. Information on program successes, where available, was generally limited to the number of program participants; however, a small number of programs—e.g., the Maryland and Maine programs mentioned previously—included data on energy and cost savings. Additional research was conducted on regional energy efficiency organizations with agricultural energy programs. The Northwest Energy Efficiency Alliance (NEEA) recently launched an agriculture irrigation efficiency initiate that may be replicable for Colorado. Other sources for agriculture energy program best practices and case studies are available from such organizations as ACEEE, 25x'25, Energy Trust of Oregon, and CSU Extension, among others. Appendix B provides a detailed index of state and regional best practice agricultural programs.

In the following sections, recommendations are provided that will support the State of Colorado and the agriculture sector in taking advantage of achievable near-term energy improvements. The recommendations are divided into four sections that include energy efficiency programs, renewable energy programs, program development, and renewable energy policies and regulations. The recommendations suggest great value in collaboration and partnership with multiple stakeholders that are directly involved with the agriculture community. Throughout the program recommendations section, a number of partner organization are listed that will be critical to ensuring that effective programs are developed with measurable participation and energy improvements. The policy recommendations section should be considered in terms of the unknown level of support for changes among farmers and other stakeholders in the state. Like many state-level policies, the development of new energy policies will need to recognize the principle of "local control" held highly by agricultural communities. In developing these recommendations, particular attention was given to pathways that could result in Colorado capturing the opportunity to (1) save more than 90 million kWh of electricity over the next 10 years, and (2) develop more than 10 MW of on-farm renewable energy capacity. Establishing a near-term fuel consumption or cost-savings target is difficult due to variety of factors, including the lack of diesel-only or gasoline-only expense data for the agriculture sector, as well as the inability to determine the practical potential for farmers to switch to no-till farming or other conservation practices (the 2007 Census of Agriculture an expense category for "gasoline, fuels, and oils").[122]

ENERGY EFFICIENCY PROGRAMS

In 2005, ACEEE conducted a review of local, state, regional, and federal agriculture energy efficiency programs with available information and identified the most successful strategies for supporting the agriculture sector to make energy improvements. ACEEE's report recommended that successful agriculture energy efficiency programs will have the following three elements:[123]

- Cleary defined goals and objectives that combine energy-savings benefits with other top priorities of the agriculture sector (e.g., improved water utilization)
- Program implementer is known and trusted in the agriculture community
- Program evaluation tools are developed with the understanding that baseline information for energy use on farms is not available from other sources.

ACEEE details success factors for state agricultural energy efficiency programs:

First, the program implementer should be familiar with the community where the program will be conducted.

Second, the program should be delivered in a way that is realistic about the costs and benefits without creating unreasonable or lofty expectations; given that "the agriculture community in general is skeptical regarding people they perceive to be salesman, and a very knowledgeable and honest program implementer can combat the skepticism."

The third, and potentially most important, is the need for program implementers to foster an environment where participants can communicate their success to potential participants. Additionally, the report found that including the agriculture sector in a broader program involving industrial or commercial sectors does not by itself make a significant difference to the outcomes for agriculture participants.

Source: Energy Efficiency Programs in Agriculture: Design, Success, and Lessons Learned, 2005.

The Importance of Setting a Baseline to Report Program Achievements

State agricultural energy programs in Maine and Maryland provide a model for measuring energy savings early in the participation process. In both the Maine and Maryland programs, energy-savings data estimates are collected *prior* to distribution of incentive payments, enabling the programs to report annual energy savings.

Efficiency Maine requires that farms complete an application in order to receive incentive payments for prescribed agriculture energy improvement technologies. The application requires that the farm applicant provide details on the existing system being replaced in order to estimate the energy savings associated with the proposed equipment upgrade.

Maryland's Farm Energy Audit Program has a contractor conduct a farm energy audit to determine the energy-savings potential of a specific project that could be implemented. The program provides incentive payments for energy efficiency projects to the farm based on the amount of future energy savings estimated from the audit.

Program Implementation

Figure 3 offers recommended program design steps that should be followed to ensure that programs are successfully deployed and that they are evaluation-ready.

FIGURE 3: Recommended Steps for Program Design

Identify Target Market Segments (e.g., Dairies)
Identify Core Technology Focuses *Develop programs that are tailored to address technologies that can have an impact across energy-intense market segments.* (e.g., Lighting, Tractors and Trucks, Stock Watering, Renewable Energy Systems, Space Heating)
Set Program Goals *Set program goals that are S-M-A-R-T (Specific, Measureable, Achievable, Realistic, and Time-Bound).*

Develop Program Evaluation Tools *In the program enrollment process, require that energy specifications on existing systems and equipment that is being replaced are provided.*
Identify Program Implementation Partners *Develop partnerships with organizations that are familiar with the target market segments to support program implementation.*
Measure Program Impacts at Set Intervals *Quarterly, Annual, 5-year, and 10-year goal checks.*

Program Funding Strategies

The development of future CEO programs for agricultural energy improvements will be enhanced through strategies that take advantage of funding opportunities from multiple resources, including potential funding from local governments, utilities, the federal government, and private foundations. An important first step in pursuing agricultural funding opportunities involves outreach and collaboration with key organizations that will provide information and opportunities for developing funding proposals in the future. The following organizations could be considered as resources and partners for developing funding proposals:

- Colorado Counties, Inc.
- Regional county organizations, including Progressive 15, Action 22, and Club 20
- CSU Extension
- Colorado Rural Electric Association
- Xcel Energy
- Black Hills Energy
- USDA Rural Development
- USDA Natural Resources Conservation Service
- DOE, Office of Energy Efficiency and Renewable Energy
- Sustainable Agriculture Research & Education and its grant program
- The Energy Foundation and its network of foundations with a focus on energy programs in Western states
- Community Resource Center and its network of Colorado foundations.

Program Options

As a result of the survey, in-depth interviews, and the best practice research, a set of recommendations for CEO's agricultural energy efficiency programs are shown in Figure 2 below. The recommended programs are designed to offer sustained education and awareness of energy opportunities, coupled with timely updates on emerging technologies and services. The programs are also scalable; if CEO has funding available for financial incentives, best practice approaches are provided.

FIGURE 4: Energy Efficiency Program Options

Online Irrigation Efficiency Resources Center
Develop a website—in partnership with key stakeholders—that provides up-to date information and trends for making irrigation efficiency improvements. The center would provide information on all current technologies, methods, services, and incentive programs available from such organizations as local utilities, county extension offices, conservation districts, and USDA farm bill programs. The center would provide a pre-approved list of organizations/vendors that can provide testing of pump efficiency for different regions of the state. In addition, the center could provide incentive payments with available funding for conducting pump efficiency testing, making pump improvements, and improving other equipment to support more efficient irrigation methods. Action Items: • Identify stakeholders and partners for developing website content. Currently, CSU Extension and the CSU Engineering Department manage the Center for Agriculture Energy, which includes a Web page with information and resources for irrigation audits.[124] The Center could be a partner for the state in delivering comprehensive information about irrigation technologies, practices, and efficiency results from demonstration projects, as well as financial resources, to farmers. • Provide an online forum for agriculture producers to submit questions, feedback, and comments on irrigation issues to support the development of an online agricultural community. • Ensure that the center periodically provides an updated irrigation efficiency fact sheet that can be distributed to county extension offices, rural electric associations, and local farm organization chapters. • Partner with farm organizations to help promote the resources available though the online resource center.
Colorado Irrigation Decision Support Tool
Develop a Colorado Irrigation Decision Support Tool that integrates data inputs (e.g., current weather, moisture sensors) with more efficient irrigation equipment and techniques to achieve a 10% irrigation efficiency goal. CEO has an opportunity to leverage the work performed by NEEA on this tool, taking into consideration the variables specific to Colorado's needs. NEEA is working with the agriculture irrigation market and Oregon State University to provide a user-friendly, portable software interface to the region's farms that will accelerate market adoption of more energy-efficient irrigation. Action Items: • Contact NEEA to initiate a partnership that allows for use of its irrigation decision support tool in Colorado. • Establish a committee that assesses necessary modifications for the tool so that it can be applied to Colorado. • Partner with farm organizations and other trusted partners to promote and conduct outreach to the agricultural community to make them aware of the resource.
Dairy Audit/Assessment with Prescribed Equipment Incentives
Recent dairy audit and incentive programs in Maryland, Maine, California, and other states have shown that prescribed, low-cost incentives for multiple dairy energy uses can have a significant impact on annual energy savings. With low-cost incentive payments totaling about $60,000 over a short period of time, the state could expect annual energy savings from dairy operations of more

than 800,000 kWh annually, as demonstrated in the case of Maine's program involving 12 dairies. If a goal of identifying and implementing energy improvements on 10% of Colorado's dairies (more than 30) were established, electricity savings potential could be greater than 2.4 million kWh annually.

Action Items:

- Contact states with successful dairy efficiency programs to obtain recommendations for developing a future program involving energy audits or assessments, as well as prescribed efficiency equipment.
- Provide low-cost incentive payments for conducting audits and for prescribed equipment installations.

Rural Business Energy Support Program

Coordinate with the state's USDA Rural Development and USDA Natural Resource Conservation Service to conduct informational workshops and provide state letters of support to farms submitting grant applications to the USDA Rural Energy for America Program (REAP) and the Environmental Quality Incentives Program (EQIP). REAP and EQIP provide grants to support both on-farm renewable energy and energy efficiency projects. Additionally, this program could be expanded to support a suite of business energy efficiency incentives for the agriculture sector, including tax incentives, rebates, and low-interest loans.

Action Item:

- Contact state USDA offices to establish a role for supporting on-farm energy improvement applications.
- Develop a timeline for coordinated outreach to the state's farms and farm organizations.

Online Farm Machinery/Vehicle Efficiency Resources and Demonstration Center

Currently, information that would support on-farm fuel efficiency and fuel switching is dispersed across several online resources. In performing research for this report, it was found that there was no centralized source of information, and that the most informative and valuable information often came directly from retailers of conversion kits or vehicle manufacturers, which reinforces the tendency of agricultural producers' to seek information from local retailers. A Colorado farm fuel efficiency website that brings this dispersed information together, coupled with direct outreach to the agriculture community, could result in fuel savings. The CSU Extension's Center for Agriculture Energy and the state's major farm organizations could be considered as key partners for developing the online tool and conducting direct outreach. It would also be important to familiarize the local USDA NRCS offices with the site to ensure that they point to it when interacting with farmers and ranchers, as the survey indicated that 15% of those seeking information included the NRCS in the sources they utilized.

Critical information and resources for an effective resource center may include the following:

- Nebraska Tractor Testing Laboratory's data on individual tractor fuel efficiency
- CSU Extension information on fuel-use savings from different farm practices and technology deployed on farm equipment
- DOE's Alternative Fuel Data Center with information for use of biofuels, natural gas, and electric vehicles.

In addition, the resource center could be used to engage farm equipment dealers located in the state to hold events and demonstrations of fuel-efficient equipment and other precision agriculture technologies.

Action Item:

- Identify stakeholders and partners for developing website content.
- Contact the Nebraska Tractor Testing Laboratory to provide an annual summary of the most fuel-efficient tractors in the market.
- Collaborate with a key partner to determine the Web content and outreach activities.
- Contact major farm equipment dealers to establish partnership for future outreach events.
- Develop online forum capability for questions, feedback, and comments from the farm community.
- Periodically provide an updated machinery/vehicle fact sheet that can be distributed to local extension agents, rural electric association, and local farm chapters.
- Partner with farm organizations and other trusted partners to promote and conduct outreach to the agricultural community to make them aware of the resource.
- Future consideration should be given for the resource center's role in encouraging tractor and truck manufacturers to develop commercially available alternative fuel vehicles, including CNG tractors.

RENEWABLE ENERGY PROGRAMS

In the recommendations provided in Figure 2, USDA's REAP and EQIP programs are described as providing both renewable energy and energy efficiency grants. REAP is administered by USDA Rural Development and EQIP is administered by USDA NRCS. Several states have demonstrated how local state agencies and other organizations can support farms in applying for REAP grants and guaranteed loans. State and local support can include workshops and outreach about REAP. Additionally, support can include the development of an application template that is replicated by multiple farms in the state that are seeking the same renewable energy technology. Moreover, applications will benefit with a letter from a state agency that indicates the proposed renewable energy project aligns with state and local environmental goals.

REAP Program Supports Solar PV Projects at High Country Orchards

In 2011 and 2012, High Country Orchards in Palisade, Colorado, received two REAP grants that covered 25% of the cost for two solar photovoltaic (PV) projects with a combined capacity of 39.6 kilowatts. The projects match 100% of the electric load, eliminating almost all of the orchard's electric costs—from a packing facility, coolers, and wine tasting facility. In addition, the Orchard received solar rebate funds from its local utility, Xcel Energy, which lowered the up-front installation costs and enabled net metering of the systems. The 126-acre orchard produces premium peaches and wine grapes, and is always seeking new ways to be more efficient. The Orchard owner learned about REAP in 2007 during a presentation at the Western Colorado Horticulture Conference.

Source: Interview with Theresa High, Owner, High Country Orchards, on February 27, 2013.

Other states have successful programs for renewable energy development that involve conducting onsite assessments of the renewable energy resource at the farm. For example, Wisconsin's Focus on Energy has provided onsite small wind energy assessment services for farms in the recent past.

RENEWABLE ENERGY AND ENERGY EFFICIENCY POLICIES AND REGULATION

Several states have implemented policies that either create financial incentives or modify state energy regulations to advance on-farm energy improvements in rural areas. Research indicates that these policies create an important mechanism to expand market development opportunities and funding for energy projects that include both energy efficiency and renewable energy technologies.

Several states have Public Benefit Funds (PBFs) that provide broad support for multiple business sectors, including agriculture. States with PBFs that benefit the agriculture sector include, among others, Oregon, Wisconsin, Minnesota, New York, Maine, and Vermont. State PBF funds are being applied to both energy efficiency and renewable energy projects. A unique PBF that applies to rural areas is found in New Mexico and involves funds that are locally controlled and managed by rural electric associations. New Mexico's Renewable Energy and Conservation Fee is included within the state's Renewable Portfolio Standard, allowing distribution cooperatives to collect from their customers a fee of no more than 1% of a customer's bill to support local energy improvement projects, such as energy efficiency, load management, and renewable energy. A PBF allowing for a greater degree of local involvement and application of funds by rural electric associations may be important to the future adoption of such a program in Colorado, incentivizing energy efficiency projects and rebates for the agriculture sector.

Other policies include targeted tax incentives for agriculture energy efficiency or renewable energy technologies. Currently, at least 12 states have corporate tax incentive programs that explicitly list agriculture as an applicable sector for energy efficiency and/or renewable energy incentives. These tax incentives include tax credits, deductions, and exemptions for qualifying technologies.[125] For example, the State of Georgia's Corporate Clean Energy Tax Credit program lists agriculture as a qualifying sector and provides tax credits for such improvements in lighting, whole building efficiency measures, and solar water heating.[126] Another example includes the State of Oregon's biomass tax credit that provides a $5 per ton of manure tax credit for projects that produce power from methane digesters.[127] With financial support from the tax credit, Oregon's installed capacity of anaerobic digesters on dairies may grow from 0.85 MW to 7.00 MW installed (indicated by a recent estimate of projects under development).[128] Iowa's ¢0.01 production tax credit for wind projects has reached its full allotment of 50 MW of installed capacity, enabling energy production for the farm and for sale to a utility.[129]

Another policy area for consideration deals directly with on-farm renewable generation potential. Several recent policies at the state level are seeking to address current limits for the development of on-farm distributed energy generation systems. In Colorado, statewide net metering standards that apply to public utilities provide for systems up to 25 kW for businesses that include agricultural operations. These statewide rules do not provide for net metered projects to be sized as a percentage of a farm's total electricity load like the state's investor-owned utilities (IOUs) are required to provide. Energy-intense agricultural operations, such as farms with powered irrigation or dairies, will have multiple electric meters and a significant energy load that could be cost-effectively matched with a single renewable energy system that is larger than 25 kW in capacity. Several "group metering" or "aggregated metering" policies that have been enacted or are under development allow for the installation of a single, larger renewable energy project that can be applied to multiple meters on a farm, or among several farms. The future market growth of such rural projects as mid-size wind, small hydropower, and methane digesters will be dependent on expanded opportunities for farms to develop generation capacity beyond 25 kW.

Two state examples pertaining to net metering that Colorado could use as models are from California and Vermont. These examples are similar to Colorado's community solar gardens policy—Xcel Energy has called its program Solar Rewards Community Program—that allows for aggregation of meters up to 2 MW, encouraging customers to combine meters to develop solar PV projects.[130] However, the California and Vermont policies differ from Colorado's policy in allowing for a broader range of renewable energy technologies that are suitable for rural areas. In California, a bill passed in September 2012 that allowed customers to combine the electrical load of their meters for the purposes of installing a single, larger project. California's previous net metering rules prohibited the power generated from an onsite renewable facility to be counted against other meters. California's Senate Bill 594 addressed this issue by allowing for additional renewable energy projects to be eligible for net metering and eliminated the need for multiple facilities at each meter by allowing the aggregation of their meters.[131] Implementation of the bill is contingent upon the California Public Utilities Commission (CPUC) determing that the bill would not result in costs being shifted to non-participating ratepayers.[132] CEO could support Colorado in pursuit of a similar policy that would allow farmers and ranchers to more easily realize the benefits of renewable energy systems.

Another example comes from Vermont, where a group net metering policy allows farms and neighbors to join a "group" for renewable generation. This law provides for offsite generation up to 500 kW as long as group members are part of the same utility.[133] In addition, utilities are required to bill all customers of the group individually.[134] This policy stands out in its value because it prevents renewable generation sites from being limited to less-than-ideal sites within the confines of one group member's property. It allows the installers, investors, and customers to choose the best possible site for a renewable energy system from all of the group members.[135]

Figure 4 identifies policy and regulatory recommendations that would allow for expanded onsite renewable energy projects and provide financial incentives for farms in Colorado to implement other energy efficiency improvements.

FIGURE 5: Policy Recommendation to Support Agricultural Energy Projects

Public Benefit Funds for Agriculture Efficiency in Rural Areas
Establishing a PBF in Colorado that included a focus on agriculture and rural areas could financially support energy improvements and propel the market. Several states have a statewide PBF that includes agriculture-specific programs. New Mexico's PBF is administered locally by REAs. *State Example:* New Mexico, Oregon, Vermont, Maine, Wisconsin, Minnesota, California, and New York.
State Tax Incentive Programs for On-Farm Agriculture Energy Efficiency and Renewable Projects
More than 12 states provide corporate tax incentives for energy efficiency and renewable energy that list agriculture as a qualifying sector. States' providing energy-efficiency-focused tax incentives for agriculture include Georgia, Kentucky, and Vermont. Several other states provide tax incentives for renewable energy technologies, including Iowa, Nebraska, and North Carolina. Iowa has provided a ¢0.01/kWh corporate tax credit for energy that is used onsite or sold to the grid; the wind project must be at least 2 MW in size to qualify for the incentive. Future state tax incentives for Colorado could consider irrigation efficiency technologies, dairy and

animal feed operation efficiency technologies, small hydropower projects, and solar thermal. *State Examples:* Arizona, Georgia, Iowa, Kansas, Maryland, Massachusetts, Nebraska, New Mexico, Oregon, and Vermont.
Group Metering / Aggregated Metering
Energy-intense farms have multiple facilities and applications requiring multiple meters. States have passed legislation requiring utilities to offer group metering of multiple meters on a farm or from multiple farms to allow for the installation of a larger, single renewable energy project that will be applied to offset a farm's total electric bill. Other policies allow farms with multiple properties in close proximity to one another with high-quality renewable resource to be developed to offset total energy demand across the properties. *State Examples:* Vermont, California, and Pennsylvania.
Distributed Generation Requirement
In Colorado, IOUs have a distributed generation requirement of 3% of retail sales by 2020 for all qualifying renewable energy resources in the state's renewable energy standard. However, this distributed generation requirement does not apply to rural electric associations. Legislation has been considered in the Colorado General Assembly to create a distributed generation requirement that applies to public utilities that serve a greater portion of the state's rural areas. *State Example:* Colorado (IOUs only).

The success of future agricultural energy programs will be dependent on the availability of energy consumption and energy expense data for the agriculture sector on an annual basis in order to evaluate program effectiveness and to track measures of energy intensity over time (i.e., amount of energy per unit of production). The state could work with the Public Utilities Commission (PUC) and utility organizations, including CREA, to assess the potential for assembling and making current data available on the agriculture sector for energy consumption and expenses. Following the PUC's review of available data, future legislation and regulatory rules could focus on making data available on an annual basis to the state energy office, as well as the public, to support baselining and measurement of energy impacts in the agriculture sector. Data transparency has also been shown to expand the energy services marketplace, creating an economic impact and enhanced energy benefit. The following data and information would support the state in developing future programs and policies:

- Aggregated irrigation rate data for the agriculture sector
- Reporting agricultural sector energy consumption data currently within existing industrial and commercial rates
- Identification and reporting of the number of agricultural customers by each utility.

In addition, PUC could re-evaluate utility irrigation rates, in conjunction with the state's agricultural organizations, to ensure rate models that encourage energy efficiency.

LEVERAGING EXISTING PROGRAMS & POLICIES

The state has several opportunities to partner with federal, state, and local entities that operate existing programs to support Colorado's agriculture sector on energy issues. Table D offers a summary of those recommendations.

FIGURE 6: Leverage Points for Supporting Agricultural Energy Projects in Colorado

Become an AgSTAR State Partner

One national-level program that CEO could become involved with is EPA's AgStar. This program is a voluntary outreach and education program that is designed to reduce methane emissions from livestock waste management operations by promoting the use of biogas recovery systems. The program is a collaborative effort with USDA and DOE. AgStar also collaborates with state agencies, agricultural extension offices, universities, and other statewide non-governmental organizations. Its current partners include other states and state energy/agriculture agencies, such as the Energy Center of Wisconsin, New Hampshire Department of Environmental Services, the State of Wisconsin, and the Vermont Agency of Agriculture.[136]

Action Item:
To become a partner, CEO only needs to submit a partnership form (http://www.epa.gov/agstar/about-us/partners/index.html), establishing a mutually beneficial, cost-free partnership that would include CEO in certain policy discussions with EPA going forward.

Support an ENERGY STAR® Specification for Rural Applications

ACEEE recommends (in its "Energy Efficiency Policies for Agriculture and Rural Development" fact sheet) that states work collaboratively with EPA to develop an ENERGY STAR® specification for rural applications.[137]

Conduct Outreach for USDA Farm Bill Energy Title REAP Program

REAP, within the Farm Bill's Energy Title, provides grants and guaranteed loans for on-farm energy efficiency and renewable energy projects. REAP is administered by USDA Rural Development, including through an office in Colorado. First established in the 2002 Farm Bill, several states have demonstrated successful models for helping farms receive funds from this program. States with a high number of awardees in the past have included Iowa, Minnesota, and Mississippi. Funding for the program in the future is uncertain due to the 2012 Farm Bill's passage currently being delayed in the U.S. Congress.

Action Item:
Coordinate outreach and communication on REAP with the state's USDA Rural Development Office.

Conduct Outreach for USDA Farm Bill Conservation Title EQIP Program

EQIP, within the Farm's Bill's Conservation Title, provides grant funds for energy audits that support energy efficiency improvements that include improvement to irrigation and tilling practices. The program has developed a specialized agricultural audit called AgEMP (Agricultural Energy Management Plan) that provides a farmer with energy improvement options and a cost-effective assessment for each option. EQIP is administered by the USDA Natural Resources Conservation Service, including through an office in Colorado.

Action Item:
Coordinate outreach and communications on EQIP with the state's USDA Natural Resources Conservation Office.

Determine DOE Better Buildings Program's Applicability to the Colorado Agriculture Sector

In 2012, the Maryland Energy Administration (MEA) received $600,000 in funds from DOE's Better

Buildings Program to support the Kathleen A. P. Mathias Agriculture Energy Efficiency Program. MEA worked in partnership with the Maryland Department of Housing and Community Development to obtain the funds. MEA is using the funds to provide up to 15 grants to farms that must demonstrate 15% energy savings for the projects implemented. *Action Item:* Contact the Better Buildings Program Manager to determine the potential for Colorado's agriculture sector to participate in the program and potentially receive funds for energy improvements.
Partner with CDA ACRE
Since 2007, CDA has supported more than 50 renewable energy demonstration and research projects through the state-funded ACRE. CDA is currently restructuring ACRE to focus on a set of technologies and project types that can be deployed across a number of farms in the state. CEO could partner with CDA to coordinate future programs and outreach to support the deployment of cost-effective projects that best support the agriculture community. *Action Item:* Develop programs and incentives with CDA that complement each other and align with state goals for increasing energy efficiency and renewable energy development from farms.
Partner with ACEEE
ACEEE holds a biannual Forum on Energy Efficiency in Agriculture. The forum is described by ACEEE as a "conference that brings together a diverse group of participants to raise awareness, share information, form new collaborations, and establish new visions regarding policy and program opportunities to increase energy efficiency on farms and ranches and in rural communities. The Ag Forum focuses on advancing programs and policies that can help the agricultural and rural community realize the benefits of more efficient energy use, as well as issues related to increasing the sustainability of farms and rural communities."[138] *Action Item:* Contact ACEEE to suggest Colorado as the next location for its Forum.
Utility Program Collaboration
Colorado's farms are customers of the state's rural electric associations, IOUs, and municipal utilities. Currently, the state's more than 50 utilities provide the agricultural sector with a wide diversity of rate classes, energy services, and incentives. For example, among Colorado's 22 REAs, 12 REAs have irrigation rates that are each unique in terms of energy, demand and service charges, Collaboration and communication between the state's utilities, agricultural organizations, and CEO will support the development of model utility rates and programs across the agriculture sector. *Action Item:* Identify key staff from utilities with a significant number of customers who are irrigation farms and dairies to communicate on future development of programs. A focus could be on utilities in the Northeastern part of the state.
CSU Extension Collaboration
CSU Extension has field offices supporting agriculture producers in all of Colorado's 64 counties on multiple issues, including energy improvements. In addition, CSU Extension and the CSU College of Engineering are part of a joint initiative that manages the Center for Agricultural Energy (CAE), which includes an advisory board composed of representatives from farm organizations, USDA, utilities, and individual farms.[139] The mission of CAE is to empower agricultural producers in Colorado to make environmentally and financially sound energy decisions. Affiliated faculty with CAE conduct agricultural energy audits, outreach, and research to this end.

Action Item:
Continue to have CEO representation on CAE's advisory board and implement future CEO agriculture programs with support from county extension offices.

Participate in the 25x'25 Alliance's Energy for Economic Growth Initiative

The 25x'25 Alliance is a national nonprofit that supports the nation's farmers and ranchers in the goal of producing 25% of the nation's energy from renewable energy resources by 2025. In 2011, 25x'25 launched the Energy for Economic Growth Initiative, which is working with leaders from rural electric associations to determine how local incentive policies might be used to accelerate economic development and distributed renewable energy generation through rural electric utilities and other power providers that serve rural communities.

Action Item:
State agencies can sign up to receive 25x'25 news or become an endorser by submitting online forms, which are available online at www.25x25.org.

APPENDIX A: TALKING POINTS MEMO

- Agriculture is a very important market sector within Colorado in terms of land use, water use, and economic impact:
  - Colorado's agricultural sector represents approximately 86% of the state's water use.
  - More than 31 million acres of private land was used for farming or ranching in 2011, totaling 47.2% of Colorado's total 66.3 million acres. In addition, another 10 million acres of federal and state land is typically used for grazing, pushing the percentage of Colorado land used for agriculture to more than 62%.
  - Colorado's market value of agricultural products sold comprised 2.04% of the national total, ranking 19th among all U.S. states.
  - Faces direct energy expenses of more than $400 million annually.
- Over the next 10 years, existing agricultural operations in Colorado have the potential to reduce electric usage by more than 90 million kWh annually and install more than 10 MW of on-farm renewable energy capacity.
- The cost of powering irrigation on 4,098 farms represents 53% of total electric expenses for the agricultural sector.
- Increasing the state's agriculture irrigation efficiency by 10% could result in energy savings of more than 90 million kWh annually.
- Colorado's 130 dairies have the potential to reduce electric energy use by 10%–35%, with the potential to result in up to $1.82 million dollars in annual savings.
- Small hydro technologies are available for use in the state's irrigation ditches to develop a number of projects with capacities ranging from 1 kW to more than 400 kW.
- Opportunities to reduce fuel expenses for on-farm machinery are found in four areas:
  - Modifying farm practices to conserve fuel use
  - Installing precision agriculture equipment, such as GPS auto-drive technology, to reduce "overlapping"
  - Purchasing fuel-efficient machinery
  - Purchasing or converting to alternative-energy-fueled machinery.
- Several states are implementing group and aggregated net metering policies that allow farmers to install cost-effective renewable resources based on the farm's total energy use.
- Measuring the impact of future agriculture energy programs will be dependent on making energy consumption data available at the state level, which will involve utilities and the Colorado PUC.

APPENDIX B: STATE AND REGIONAL BEST PRACTICES—PROGRAMMATIC APPROACHES

Program Identifiers		Description	Key Results
State:	CA	DEEP provides energy efficiency incentives to dairies that are PG&E customers. Incentives are either a fixed amount based on a specific piece of equipment installed or calculated based on the volume of milk produced. The program also provides $1.00 per therm of gas saved.	• 129 Participants • Average electric savings near 13,000 kWh per participant
Program Type:	Dairy		
Name:	Dairy Energy Efficiency Project (DEEP)		
Program Sponsor:	Pacific Gas and Electric (PG&E)		
Year Began:			
State:	CA	APEP is an educational and incentive rebate program, managed by the Center for Irrigation Technology (CIT), to improve overall pumping plant efficiency and encourage energy conservation. The program is currently funded by PG&E through 2012 using the Public Purpose Programs Fund under the auspices of the California PUC. CIT is located on the campus of California State University, Fresno, but functions as an independent testing laboratory, applied research facility, and educational resource to both the public and private sectors. The twin goals of APEP are to:	From 2002 through 2012, CIT provided California water pumpers with: • 1750 pump retrofit / repair rebates • $6,900,000 in incentive rebates for those projects • 108,000,000 kilowatt-hours saved annually as a result of those projects • 373,000 therms saved annually as a result of those projects • 27,600 subsidized pump
Program Type:	Irrigation		
Name:	Advanced Pumping Efficiency Program (APEP)		
Program Sponsor:	Pacific Gas & Electric (PG&E) / California PUC		

Year Began:	2011	• Get highly-efficient hardware in the field, including pumping plants, irrigation systems, and water distribution systems • Ensure that this hardware is managed correctly.	efficiency tests • $4,560,000 in pump test subsidies • 180 educational seminars
State:	ID	A five-year effort began in 2000 to educate the dairy and livestock industries on anaerobic digestion processes and help them incorporate these technologies into their operations. This is a two-phase program. Phase I identifies barriers to implementing the technology, including markets for generated power and direct project funding. DOE funding for Phase II of the project supports installation of the technology at dairies.	Direct state funding enabled a small number of Idaho dairies to transition to anaerobic digestion technology; however, program success was limited. The results indicated that dairymen are not likely to incorporate the process into their operations unless renewable energy production has a greater value in the state, they're facing greater regulation to treat their wastes, or both.
Program Type:	Digester		
Name:	Anaerobic Digestion Program		
Program Sponsor:	Idaho Office of Energy Resources		
Year Began:	2000		
State:	ID	The Idaho Office of Energy Resources' State Energy Loan Program offers low-interest loans to make building improvements, including agriculture facilities that will conserve energy and increase energy efficiency projects in Idaho. Loans are leveraged by utility incentives and federal and state tax credits and deductions. Loans are 4% interest with five-year terms for $1,000 to $100,000. Applications are evaluated on the basis of credit; all loans must be secured with real estate and/or equipment.	
Program Type:	Loan Program		
Name:	State Energy Loan Program		
Program Sponsor:	Idaho Office of Energy Resources		

Year Began:			
State:	KY	The Department for Energy Development and Independence partnered with the Governor's Office of Agriculture Policy to make American Recovery and Reinvestment Act of 2009 (ARRA) funding available to farmers. One million dollars was provided to implement an On-Farm Energy Efficiency and Production Assistance Program. The funding was used to supplement tobacco settlement funding to provide grants to farmers for on-farm energy improvements.	
Program Type:	Grant		
Name:	2011 ARRA On-Farm Energy Efficiency and Production Assistance Program		
Program Sponsor:	Department for Energy Development and Independence/ Governor's Office of Agriculture Policy		
Year Began:	2011		
State:	KY	One million dollars in stimulus funding was provided to encourage farmers to seek energy-efficient solutions. Farmers are able to use grant funds to pay for professional services or equipment, to expand renewable energy crop production, or to prepare grant applications for USDA to	
Program Type:	Grant		

Name:	2011 ARRA Multi-County Agricultural Energy Program	obtain additional funding. This initiative provided a 1:1 match with ARRA funds and state Agricultural Development Funds for agriculturally related renewable energy projects.	
Program Sponsor:	Department for Energy Development and Independence/ Governor's Office of Agriculture Policy		
Year Began:	2011		
State:	ME	The Efficiency Maine Business Program provides agriculture businesses with prescriptive incentives. Each business is eligible for incentives up to $50,000 per business, per calendar year. The program is funded through the system benefit charge included in electricity rates, as well as through the Regional Greenhouse Gas Initiative and various other funding sources. Efficiency Maine has calculated fixed or "prescriptive	Fiscal year 2011 agriculture sector results: • 41 projects with 33 participants • 453 MWH Ex Ante Gross Energy Savings Dairy Farms

Program Type:	Incentive Payment	incentives" for certain types of equipment that generate consistent savings for agriculture equipment. Prescriptive incentive areas include: Dairy Equipment: • Plate heat exchanger • 7.5/10/15 hp vacuum pump with adjustable speed drive package Potato Storage House Equipment: • 3-5/7.5/10/15/20 hp adjustable speed drive on a ventilation fan motor Lighting Equipment: • Vapor-tight high-performance T8 lighting fixture Other Equipment: • High-volume, low-speed fans (14, 16, 18, 20, 24 foot diameter) • 2/3/5/6 hp new scroll compressor The Efficiency Maine Business Program uses a data collection and information form to support evaluation. The form requires information to be provided on existing equipment being replaced.	• 18 dairies receiving benefits between $500–$12,575 • Total incentive payment of $59,850 • Saving 836,292 kWh annually • Saving more than $125,443 annually
Name:	Efficiency Maine Business Program		
Program Sponsor:	Efficiency Maine		

Year Began:	2002		
State:	MD	**This program is no longer active.* This program began as a pilot program that originally ran in two phases for Maryland's eastern shore counties, and then for Maryland's western counties. This is a collaborative cost-share program funded by the Maryland Energy Administration. The program refunds the cost for a $300 energy audit if one or more of the resulting recommendations are implemented. The program offers incentives of $0.06 per kWh of electricity you save in the first year for any qualifying lighting projects; $0.08 per kWh saved in the first year for all other eligible electric projects; and $1.50 per gallon of propane saved for any eligible propane projects. The incentives cannot exceed 50% of the total project cost. There are a wide range of pre-qualified technologies/improvements for all farm types that reduced	Pilot Program results: • 76 farm audits • $38,800 in incentives • Saves 635,000 kWh annually Dairy: • $22,860 saved • 372,738 kWh saved Poultry: • $14,314 saved • 227,754 kWh saved • 897 gallons of propane saved Nursery: • $1,200 saved • 28,379 kWh saved Orchard:
Program Type:	Audit Incentive Payments		

Name:	Maryland Statewide Farm Energy Audit Program	electric and heating costs. Audits are conducted by a contractor highly qualified to perform farm audits. There are 10 other partners at the federal and local levels.	• $404 saved • 6,679 kWh saved Winery: • $22 saved • 277 kWh saved
Program Sponsor:	Maryland Energy Administration		
Year Began:	2007–April 2009 Pilot Program April 2009–2012 Statewide Energy Audit Program		
State:	MS	Farms and rural businesses are provided credible energy technical guidance through this program. This initiative distributes educational tabloids through mail-outs, exhibits, and workshops, and provides meetings and conferences to help farmers and rural businesses accelerate energy savings and clean-energy efforts. Financing options are provided to emerging and advanced renewable projects.	Tabloid on Energy Produced • Targeted small/medium-sized agricultural operations • Addressed solar, anerobic digestion, alternative fuels, biodiesel, and financial incentives • Distributed through direct mail, exhibits, workshops, and agency websites Information Meetings with Agricultural Organizations
Program Type:	Education Financing		
Name:	Energy's Rural Business Opportunity Project		
Program Sponsor:	Development Authority Energy Division		

<table>
<tr><td>Year Began:</td><td></td><td></td><td>Developed Partnerships with:
Cooperative Extension Service
USDA Rural Development
Soil and Water Conservation Commission
Small Business Administration</td></tr>
<tr><td>State:</td><td>MO</td><td rowspan="3">Using ARRA funds, the Missouri Department of Natural Resources’ Division of Energy developed a Field Day Energy Training Program and a Cost-Share Grant Program focused on the agricultural sector.

Field Days help provide energy-efficiency education and workshops to Missouri Farmers for the purpose of providing information to farmers that will help them reduce operational energy costs. At each Field Day, farmers were provided with information on how to identify opportunities for increasing energy efficiency, how to conduct an energy assessment, and how to calculate energy savings and simple payback. Field Days also highlighted tools and resources that will help farmers and agricultural operators on their individual farms.

This was a cost-share grant program developed to reimburse farmers up to 75% of the cost of 12 eligible energy-saving equipment and systems, up to a maximum of $5,000 per applicant. Farmers received grants to purchase energy-saving equipment.</td><td rowspan="3">Field Day Results:
1,100 people attended over 40 sessions held across the state
Cost-Share Grants:
1,535 farms
$5,756,617 disbursements
$3,750 average grant
Projects Funded:
811 GPS/auto-steer equipment for tractors and applicators
296 insulated waters for livestock
237 solar-powered fencers
119 grain dryers
113 tillage
96 irrigation improvements
59 solar-powered water systems</td></tr>
<tr><td>Program Type:</td><td>Education

Incentives</td></tr>
<tr><td>Name:</td><td>Energize Missouri Agriculture</td></tr>
</table>

Program Sponsor:	Department of Natural Resources' Division of Energy		• 53 lighting upgrades • 40 biomass • 23 poultry facility improvements • 21 motors • 16 dairy facility improvements • 2 swine facility improvements
Year Began:	June 2009–October 2011		
State:	NE	The Nebraska Energy Office and the state's lending institutions provide energy-saving loans for farm and ranch operations at simple interest rates of 2.5%, 3.5%, and 5%—for loan amounts up to $750,000. Loans of 2.5% interest rates for wind, PV, and fuel cell projects up to $125,000, and solar hot water heating up to $14,000. Loan terms range from 3 to 15 years. Initially capitalized with oil overcharge funds, later augmented with ARRA funds, and re-charged with loan repayments from borrowers.	From 1990 to June 2012, 580 agriculture sector projects have been financed with $11.25 in total loans; $5.5 million Nebraska Energy Office share. Loans have financed such improvements as low-pressure irrigation systems, replacement of irrigation pumps and motors, replacement of grain dryers, and well modifications.
Program Type:	Loan Program		
Name:	Nebraska Dollar and Energy Saving Loans		
Program Sponsor:	Nebraska Energy Office		
Year Began:	1990		
State:	NV	Short-term bridge financing with a focus on anaerobic digesters at dairies and small hydro at farms/dairies. The minimum amount that can be applied for is $100,000, and	More than $8 million budgeted in 2011 that supported 15 projects, including 6 solar projects, 4 wind projects, 3 anaerobic digesters, and 2
Program Type:	Loan		

Name:	Revolving Loan Program	the maximum amount that can be applied for is $1 million	small hydro projects.
Program Sponsor:	State Energy Office		
Year Began:	2011		
State:	NY	Funded through a systems benefit charge, the AEEP program will fund up to 75% of a project's total cost up to $250,000. Farmers are expected to contribute at least 25% of the total project cost in cash. The program will fund energy audits up to $1,500. Funding is granted on a first-come, first-served basis. The program closed in March 2011, but is expected to reopen with funding approved until 2015. NYSERDA contracted with EnSave to assist farms during the application process.	• Average incentive payments per farm of $18,000. • Average savings of 44,000 kWh per project.
Program Type:	Incentive Payment		
Name:	Agriculture Energy Efficiency Program (AEEP)		
Program Sponsor:	New York State Energy Research and Development Authority (NYSERDA)		
Year Began:			
State:	TX	This program helped agricultural producers complete Energy Assessment Reports (EARs) for farm buildings and facilities. EARs identify and recommend opportunities to save on energy costs, such as electricity, propane, and diesel	
Program Type:	Technical Assistance		

Name:	Agriculture Technical Assistance Program	fuel within farm operations.	
Program Sponsor:	State Energy Conservation Office		
Year Began:	2005–2006		
State:	VA	Provides grants to waste-to-energy projects.	Provided funding to develop and implement the state's first anaerobic digester, processing waste from nearly 1,000 cows to make electricity and heat. The digester was designed to have a 450 kW generating capacity, as well as being capable of producing gas for heating water and in-floor heating.
Program Type:	Grants		
Name:	Waste-to-Energy Grants		
Program Sponsor:	Virginia Division of Energy		
Year Began:			
State:	IA	The Office of the Governor seeks nominations of farmers that have taken significant steps to serve as local leaders in environmental stewardship on their farms by utilizing a variety of techniques and best management practices. This award seeks to not only recognize farmers for their responsible choices, but also to encourage other farmers to follow in their footsteps by building success on success.	
Program Type:	Awards		
Name:	Iowa Farm Environmental Leader Awards		

Program Sponsor:	Office of Governor		
Year Began:	2012		
State:	MA	This program provides $25,000 grants for on-farm energy efficiency or renewable energy projects. Priority projects have included precoolers, variable speed vacuum pumps, thermal blankets, reverse osmosis, and high-efficiency refrigeration.	
Program Type:	Grant		
Name:	Agricultural Energy Grant Program		
Program Sponsor:	Massachusetts Department of Agricultural Resources		
Year Began:			
State:	WA, OR, MT, and ID	This initiative is developing integrated management solutions on farms using center pivot irrigation systems. The goal is to obtain an agricultural economic enhancement through 20% irrigation energy efficiency by 2020.	In 2012: completed field demos, baselines, and an initial database; developed application program interfaces, standards, and profitability tools.
Program Type:	Irrigation		
Name:	Agriculture Irrigation Energy Efficiency Initiative		

Program Sponsor:	Northwest Energy Efficiency Alliance (NEEA)		
Year Began:	2012–2014		
State:	OR	A web site that provides information and grant writing resources for the USDA REAP program.	
Program Type:	Information		
Name:	Grants and Business Resources		
Program Sponsor:	Oregon Department of Agriculture		
Year Began:			
State:	WI	Provides site assessments that result in recommendations for customers considering solar electric, solar water heating, and wind electric systems. Focus on Energy requires a site assessment to qualify for wind electric system incentives and recommends site assessments for all renewable energy system installations. A certified site assessor directory is provided and assessments range in cost from $300-$1,000. The assessment will do the following:	
Program Type:	Assessment		
Name:	Renewable Energy Site Assessment		
Program Sponsor:	Focus on Energy		

Year Began:		• Review your system goals • Review how systems work • Complete a basic analysis of your energy needs • Make energy efficiency improvement recommendations • Evaluate the resource at your site • Recommend a system size and setting to meet your energy goals • Estimate the system's production • Provide a rough cost estimate for the system • Overview the incentives for which the system is eligible • Provide a preliminary economic analysis of the system	
State:	WI	The program will provide incentives (10-40% of total project cost) for cost-effective renewable energy systems installed at eligible Wisconsin businesses including: • Biomass - incentive up to $500,000 per project • Biogas - incentive up to $500,000 per project • Geothermal technologies - incentive up to $200,000 per project • Solar Photovoltaic (PV) - incentive up to $100,000 per project • Solar Thermal - incentive up to $100,000 per project • Wind - incentive up to $100,000 per project	
Program Type:	Incentive Payment		
Name:	Renewable Energy Competitive Incentive Program		
Program Sponsor:	Focus on Energy		
Year Began:			

APPENDIX C: SURVEY RESULTS

Please see the separate attachment for Appendix C.

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