Colorado State University

CLEAN ENERGY IN AGRICULTURE

A COLORADO STUDY

April 2018

Overview of this Report

In this report, the Center for the New Energy Economy identifies clean energy opportunities in the agricultural sector and indicates policy changes and programs that will maximize the use of agricultural land in a manner that benefits agricultural producers, electric utilities, and the community. While this report focuses on Colorado's agricultural sector, it can also be used as a model to promote the adoption of clean energy technologies in the agricultural sectors of other states and regions.

Colorado's agricultural sector is a critical driver of the economy. Droughts, low commodity prices, and decreased trade have contributed to the declining net income of agricultural producers in recent years. Since energy is a substantial expense for agricultural producers, clean energy presents an opportunity for savings and stability, and could also be a source of income for agricultural producers.

This report provides background information on Colorado's agricultural sector, considers the relationship between agriculture and energy, discusses previously identified energy efficiency improvements and retrofits, and examines current programs and policies that support greater adoption of clean energy technologies in this sector. We consider policy and program gaps as well as other barriers to clean energy adoption and the report culminates in a set of recommendations, outlining opportunities for policy change and program implementation as well as expansion to improve the uptake of clean energy technologies by Colorado's agricultural sector.

About the Center for the New Energy Economy

Founded in 2011 as a department of Colorado State University, the Center for the New Energy Economy (CNEE) is an initiative led by Colorado's 41st Governor, Bill Ritter, Jr. and assisted by a team of energy and environmental policy experts. The Center works directly with governors, legislators, regulators, utilities and stakeholders by providing technical and strategic assistance to help decision makers create policies that facilitate America's transition to a clean energy economy.

> *"For me, the New Energy Economy has always been about our future, our kids' future, our grandkids' future. I think in order to survive in this created space we inhabit, we need to produce and consume energy differently. If we do not, then our legacy for our children will be a Colorado inferior to the Colorado that we live in."*
>
> – *Bill Ritter, Jr., Director of the Center for the New Energy Economy, CSU*

This report is available online at cnee.colostate.edu

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Source of front page photo: Energy Integrity Project.

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1. The Current State of Colorado's Agriculture

Colorado's diverse topography of majestic mountains and vast plains supports a varied and robust agricultural sector. Farming and ranching in the state began with the discovery of gold in the region, when early prospectors-turned-settlers needed sustenance and wanted a more secure income than gold prospecting could provide. Through irrigation, crops were grown in the semi-arid environment and the open plains supported herds of cattle. Today, agriculture is still a key sector in the state in terms of economic impact, land use, and water use.

1.1. Economic impact

The agricultural sector is a critical driver of Colorado's economy, contributing more than $40 billion annually and providing more than 170,000 jobs in the state. Regardless of how you define the largest industry in the state (for example by the value of the output, the number of the jobs, or the wages paid), agriculture is consistently one of the top industries in Colorado, along with manufacturing, mining, and tourism.

1.2. Land use

Colorado has 33,800 agricultural operations operating on 31.8 million acres of private land. Approximately 10 million acres of federal and state land is used for grazing. Thus, almost 63% of Colorado's total 66.3 million acres of land supports agriculture.

1.3. Water use

Colorado's high-country watersheds supply water to nineteen U.S. states and to Mexico.[1] Within the state, agriculture is the main water user: irrigated agriculture in Colorado accounts for more than 85% of water diversions. Colorado's population is predicted to double by 2050; this growth will naturally increase the demand for water. Furthermore, a protracted and severe drought in the Colorado River Basin is impacting the supply of water. Higher temperatures due to climate change will increase evaporation rates of surface water and snowpack, lowering the water table. With this increasing demand, higher temperatures, and volatile supply, Colorado faces a water shortfall of up to 560,000 acre-feet[2] a year by 2050.[3]

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1 State of Colorado 2016, Report on the Health of Colorado's Forests, page 3.

2 This is approximately 182.5 billion gallons.

3 While crop diversification may assist Colorado farmers, many regions have insufficient water to grow crops different from those usually planted. Leeds School of Business UC Boulder, 2017 Colorado Business Economic Outlook ("**CBEO 2017**"), page 22.

1.4. Commodities

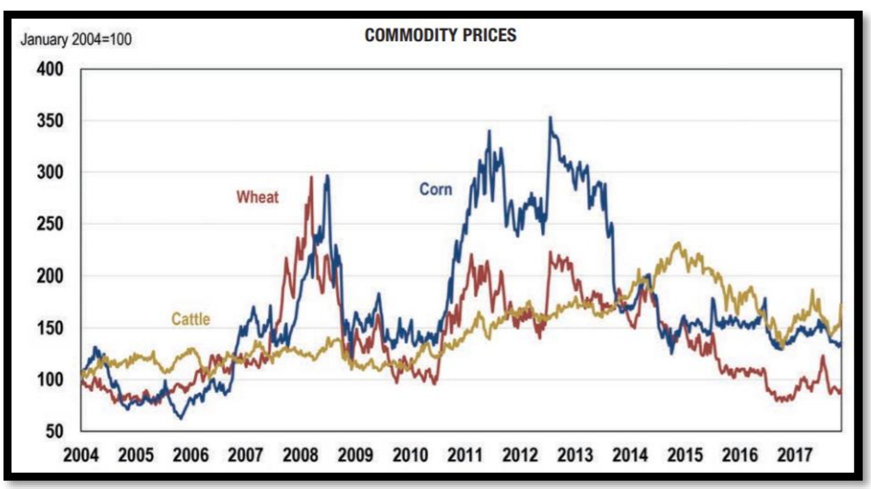
The top commodities in Colorado include cattle, dairy, corn, and wheat. The growing cannabis industry is also discussed below.

Cattle: Livestock makes up the largest share of Colorado's agricultural economy,[4] constituting 65% of cash receipts in 2016.[5] Droughts in 2013 and 2014 decreased the supply of beef and the price consequently increased. Subsequent good weather led to increased supplies, but lower prices. Even though fuel and fertilizer costs have also decreased, these costs are not low enough to offset the low cattle prices. Nationally, cattle farms' average net cash income is forecasted to increase by 6.2% from 2017 to 2018 to $36,100.

Corn: In 2016, corn contributed $496 million in annual cash receipts to Colorado. Prices have decreased by 56% since August 2012 – Chicago Board of Trade futures fell from $8.43 a bushel in August 2012 to $3.67 a bushel in June 2017. This decrease is obviously to the disadvantage of corn producers, but benefits cattle ranchers using corn for feed and increases the demand for corn exports and in the ethanol market. Nationally, corn farms' average net cash income is forecasted to decrease by 7.5% from 2017 to 2018 to $131,500.

Wheat: In 2016, wheat contributed $294.5 million in annual cash receipts to Colorado. National prices have decreased by 54% since September 2012 – Kansas City Board of Trade futures fell from $9.30 per bushel in September 2012 to $4.26 in June 2017. Local Colorado farmers earn $1 to $1.25 less than farmers in other states due to transportation to market costs. Nationally, wheat farms' average net cash income is forecasted to decrease by 21.8% from 2017 to 2018 to $32,000.

Table 1: Commodity Prices, 2004 to 2017



Source: Colorado Business Economic Outlook Committee 2018

4 Leeds School of Business UC Boulder, 2018 Colorado Business Economic Outlook ("**CBEO 2018**"), page 17.

5 CBEO 2017, page 20.

Dairy: In 2016, dairy products contributed $651.5 million in annual cash receipts to Colorado. National prices have decreased by 34% since September 2014 (Chicago Mercantile Exchange futures have fallen from $24.58 per hundred pounds in September 2014 to $16.28 per hundred pounds in June 2017), close to the break-even point for some farmers. Feed costs have also decreased, which stabilizes the price somewhat. Nationally, dairy farms' average net cash income is forecast to decrease sharply by 19.2% from 2017 to 2018 to $215,600, reflecting an anticipated decrease in milk prices; this is in contrast to an increase of 47.2% from 2016 to 2017.

Cannabis: The genus cannabis includes both hemp, a plant containing a tetrahydrocannabinol (THC)[6] concentration of no more than 0.3%, as well as marijuana, a plant with more than 0.3% THC. The Colorado Department of Agriculture has jurisdiction and authority in relation to the cultivation of industrial hemp and the Colorado Department of Revenue has jurisdiction over marijuana. From 2014 to 2015, hemp acreage in Colorado increased ten-fold, and 5,800 acres of industrial hemp was planted in Colorado in 2016, more than double the acreage in peach orchards.[7] Legal medical and recreational marijuana sales in Colorado increased by 120% from 2014 to 2017, and this trend is projected to continue. With such robust growth rates, the hemp and marijuana industries could soon compete with the top commodities in Colorado.

1.5. Farm and Ranch Income and Expenses

The agricultural sector has experienced a rough couple of years. The total net farm and ranch income in Colorado in 2015 was $1.49 billion; it fell to $1.23 billion in 2016 and decreased again to $1.16 billion in 2017.[8] This decrease is attributed to several factors, including low commodity prices, decreased exports,[9] and decreased supply after years of drought. With 33,800 farming and ranching operations in Colorado in 2017, farms earned an average of $34,320 net income for the year.[10] Looking ahead to 2018, the projected net farm income is expected to climb by 18% to $1.37 billion, a level still

The total net farm and ranch income in CO fell from $1.49 billion in 2015 to $1.23 billion in 2016 and dropped even further to $1.16 billion in 2017.

6 THC is the psychoactive chemical in cannabis.

7 CBEO 2017, page 22.

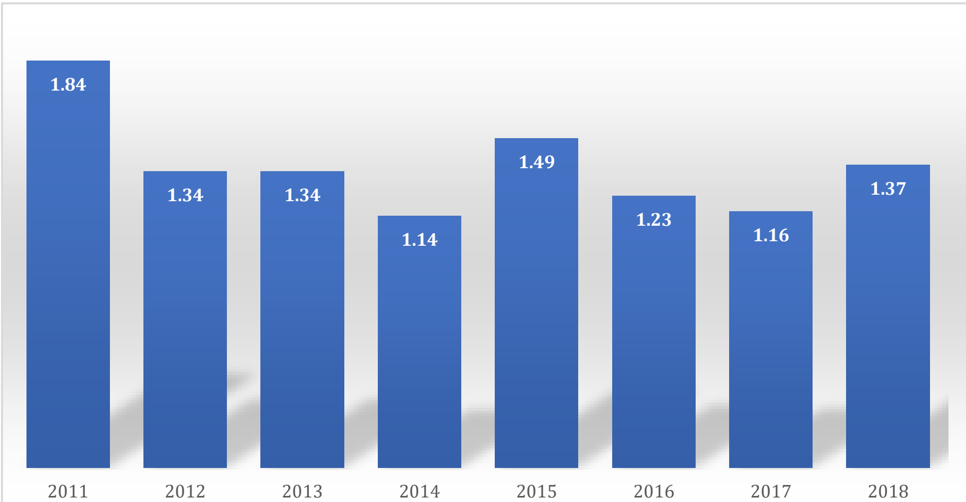
8 CBEO 2018, page 17.

9 In 2014, exports of Colorado's food and other agricultural products reached about $1.8 billion, but this has since declined. Trade agreements could boost exports, as they generally decrease import tariffs and increase access to products. U.S. trade relations are however uncertain at this stage. President Donald Trump formally withdrew from the Trans Pacific Partnership, a decision that affected the agricultural sector. He also signed an executive order directing his administration to review all current U.S. trade agreements. The U.S.-China trade standoff could also affect agriculture adversely.

10 $1.16 billion divided by 33,800 equals $34,320.

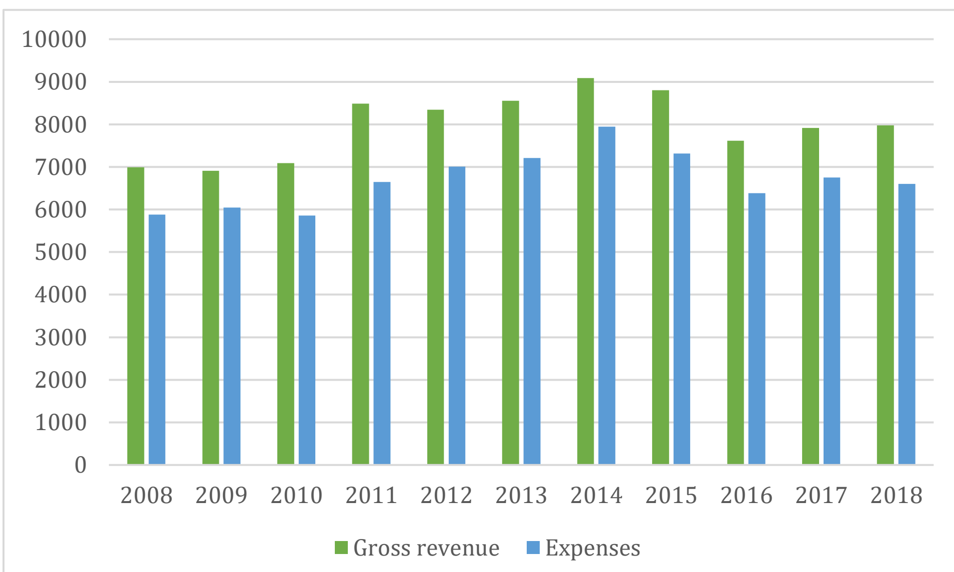
well below the record high of $1.84 billion recorded in 2011 (see Table 2 below). Farm and ranch operating expenses range between 78% and 88% of gross revenue. Table 3 shows the relationship between gross revenue and expenses from 2008 to 2018.

Table 2: CO Net Farm and Ranch Income
In Billions of Dollars



Source: Colorado Business Economic Outlook Committee 2018

Table 3: CO Gross Farm and Ranch Revenue and Expenses
In Millions of Dollars



Source: Colorado Business Economic Outlook Committee 2018

1.6. Clean Energy and the State of Agriculture

The unpredictability of commodity prices (Table 1), decreased net income (Table 2), slight margins (Table 3), decreased exports, and changing weather conditions all adversely affect the agricultural sector in Colorado. Due to the high upfront costs of clean energy technology, these conditions may hinder the adoption of clean energy solutions.[11]

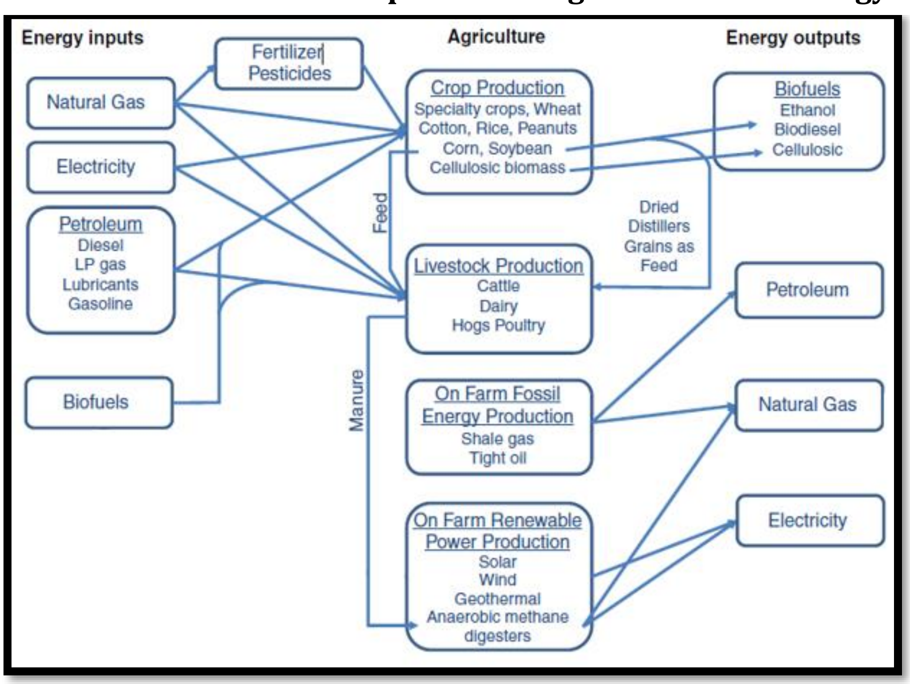
This report identifies clean energy opportunities in the agricultural sector that may assist farmers and ranchers to lower operating expenses, thereby increasing net income and providing more stability. The report also indicates important policy changes and program implementations that will maximize the use of agricultural land in a manner that benefits farmers, electric utilities, and the community.

2. Agriculture and Energy

2.1. Agriculture and Energy

The agricultural sector both uses and produces energy, making energy an expense and source of income. Ranchers and farmers are thus heavily dependent upon and impacted by any changes in the energy sector. Both energy use and energy production are discussed in this report.

Table 4: The Relationship between Agriculture and Energy



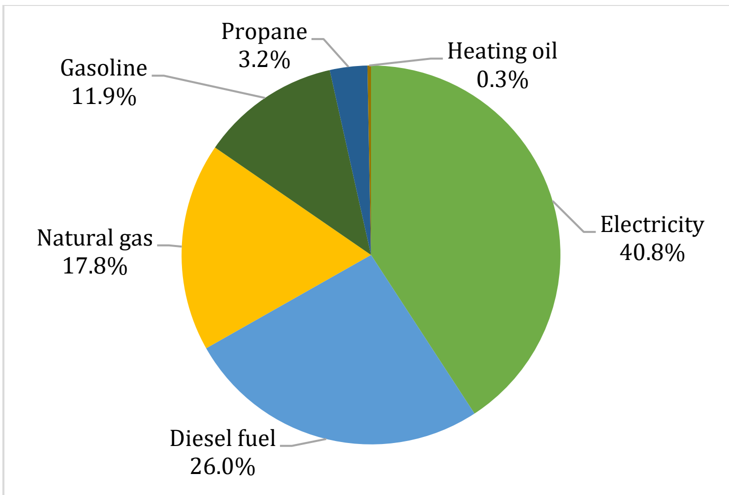
Source: USDA, Economic Research Service

11 In this report, 'clean energy' includes both renewable energy, i.e. wind, solar, hydro, and geothermal energy, and energy efficiency, i.e. the efficient use of any energy source, including oil and gas. It does not include nuclear energy.

2.2. Energy Usage in the Agricultural Sector

The agricultural sector consumed 1.714 trillion British thermal units (Btus) of energy in 2014 – about 1.7% of total U.S. primary energy consumption.[12] Agricultural operations require energy as an input to production, using it to operate equipment and machinery, to regulate the temperature of buildings, and for lighting.[13] These operations consume energy directly in the form of electricity, diesel, gasoline, natural gas, propane, and heating oil, and indirectly in energy-intensive inputs such as fertilizer and pesticides.[14]

Table 5: Colorado Agricultural Sector – Percentage of Total Energy Expenditure by Source



Source: CEO report, page 4

In Colorado, the agricultural sector's energy expenses are approximately 7% of the sector's total operating expenses.[15] Energy consumption is dependent on the focal commodity or commodities of each operation. Generally, electricity makes up 40.8% of energy expenses for agricultural operations, diesel fuels account for 26%, natural gas for 17.8%, and gasoline for 11.9%.[16] Indirect energy expenses, such as fertilizers and pesticides, range from 16% to 36% of total operating expenses for crop producers.[17]

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12 Hitaj, Claudia, and Shellye Suttles. *Trends in U.S. Agriculture's Consumption and Production of Energy: Renewable Power, Shale Energy, and Cellulosic Biomass*, EIB-159, U.S. Department of Agriculture, Economic Research Service, August 2016 ("**Trends in U.S. Agriculture**"), page 4.

13 Congressional Research Service, *Energy Use in Agriculture: Background and Issues*, November 19, 2004. Page 1.

14 Trends in U.S. Agriculture, page 1. Because of measurement difficulties, energy used to produce other inputs for agriculture, such as farm machinery and equipment, is not included in the USDA's definition of indirect energy.

15 Naranjo, R.D. et al., (2013, March). *Colorado Agricultural Energy Phase 2 Market Research Report*, Colorado Energy Office ("**CEO Report**"), page 3.

16 In farming operations, electricity makes up 55.4% of the total energy expenses, diesel fuels 27.2%, and gasoline 13.8%, and natural gas 1.6%. In ranching operations, electricity constitutes a lower portion of the total energy expenses (19.5%), diesel fuels and gasoline a larger portion (45.7% and 22.1% respectively), and natural gas is similar (1.3%).

17 Trends in U.S. Agriculture, page 1.

Irrigation, which requires energy to pump water, is one of the most energy-intensive operations on a farm. The main energy source for irrigation is electricity. Other sources include diesel, biodiesel, natural gas, and propane. Electricity expenses for pumping water for irrigated agriculture in the West total more than $1 billion annually. In 2008, powered irrigation represented approximately 53% of the Colorado agricultural sector's total electric expenses.[18] The operation of field equipment also consumes a great deal of energy on farms. For example, different tillage practices impact energy consumption. Conservation tillage and no-till operations lower fuel consumption, but increase fertilizer and pesticide expenses, which requires energy for application. Conventional tillage requires more fuel but less fertilizer. Planting, cultivation, and harvesting are all practices that consume fuel using heavy machinery.

In the West, electricity expenses in irrigated agriculture for pumping water total more than $1 billion annually.

Most of the energy associated with fertilizers and pesticides is not consumed directly at the agricultural site, but indirectly during its production, packaging, and transportation to the site.[19] Additional energy is used onsite during pesticide and fertilizer application. It is estimated that fertilizer production accounts for 1.2% of global energy use, relying mainly on natural gas for production. Many pesticides are derived from petroleum chemicals, primarily ethylene, propylene, and methane. Electricity and natural gas are also used in manufacturing. Depending on the crop, pesticides account for 5% to 15% of farm energy use.

For ranching operations, transportation accounts for the majority of energy use.[20] Diesel and gasoline costs are higher and electricity costs are much lower than in farming operations. Diesel fuel constitutes approximately 45.7% of ranchers' energy expenses, gasoline 22.1%, and electricity 19.5%. Another substantial expense is propane, constituting 10.6% of ranchers' total energy expenses.

Dairy farms require electricity for vacuum pumps to produce milk, fans for ventilation, lighting for facilities, machinery for feed and waste, space heating, refrigeration, and hot water for sanitation.[21] Cooling systems and milking machines require the most energy, and electricity is the main source of energy used for these operations. Diesel and gasoline are also used for transportation and generators.

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18 CEO Report, page 6.

19 Clark W. Gellings, Kelly E. Parmenter, (2004), *Energy Efficiency in Fertilizer Production and Use*, in 'Efficient Use and Conservation of Energy,' [Eds. Clark W. Gellings, and Kornelis Blok], in Encyclopedia of Life Support Systems (EOLSS), developed under the Auspices of the UNESCO, Eolss Publishers, Oxford, UK, page 8.

20 CEO Report, page 4.

21 CEO Report, page 5.

At hog farms, heating requires the most energy. Feedlots also require energy for field equipment and transportation. Both heating and feedlots use diesel fuel as the primary source of energy.[22]

The marijuana sector, specifically indoor cultivation, is energy-intensive, requiring around-the-clock lighting, ventilation, heating, and dehumidification. Lighting accounts for 80% of electricity use at indoor growing facilities. Denver's electricity use is rising by more than 1% per year, and 45% of that increase is attributed to marijuana facilities in town. In 2014, marijuana facilities consumed more than 2.2% of Denver's total electricity. Growers are experimenting with energy efficient technologies, such as LED lights, but some find that these technologies do not result in the right yield, making it less attractive.

2.3. Energy Distribution in the Agricultural Sector

Many U.S. farms and ranches receive their electricity from rural electric cooperatives.[23] Rural electric cooperatives have a unique relationship with agriculture in the United States. Electric co-ops were formed in the 1930s, and the first Colorado co-op was established in 1936, because 90 percent of farms, ranches, and rural homes in the U.S. did not have access to electricity.

Rural electric cooperatives serve 42 million people in 47 states (approximately 13%[24] of the U.S. population) and 19 million businesses (including farms) across the nation. The cooperatives own and maintain 42% of the electric distribution lines in the U.S. and the service area covers approximately 75% of U.S. land area.[25] Generation and transmission (G&T) cooperatives generate their electricity mainly from coal.[26] Rural electric cooperatives do not always encourage clean energy. For example, Tri-State (a Denver-based G&T cooperative) imposed a penalty tariff on members if they self-generated or sourced more than 5% of their annual electricity use from qualifying power production and cogeneration facilities,[27] thereby requiring distribution cooperatives to purchase 95% of their electricity from Tri-State. In 2016, the Federal Energy Regulatory Commission (FERC) ruled that distribution cooperatives can source local and renewable electricity from qualifying facilities beyond the

Many farms and ranches receive their electricity from rural electric cooperatives.

22 CEO Report, page 5.

23 Trends in U.S. Agriculture, page 23.

24 42 million people served divided by 327 million people in the U.S. as at April 2018.

25 The National Rural Electric Cooperative Association, Comments on Proposed Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units and Notice of Data Availability, December 1, 2014, page 1.

26 Trends in U.S. Agriculture, page 23.

27 Designated as such in terms of the Public Utility Regulatory Policies Act of 1978.

5% limit. This decision will disrupt the G&T business model, as they rely on revenue from members to cover their coal plant[28] and other infrastructure costs.

Furthermore, environmental rules and regulations, like the Cross-State Air Pollution Rule which requires air emission controls on power plants, increase costs at power plants, thus impacting electricity prices. Due in part to a large supply of natural gas, more than 250 coal power plants across the U.S. have retired since 2010, and this trend is set to continue. In Colorado, Xcel Energy plans to retire two coal-fired power plants and to increase its generation from renewable resources from 29% to 55% by 2026.

Other sources of energy, such diesel fuel, gasoline, and natural gas, can be purchased and delivered to farmers and ranchers in bulk. Colorado's oil and gas prices are relatively inexpensive compared to other states in the country.

2.4. Energy Production in the Agricultural Sector

Non-renewable Energy: Farmers and ranchers who own the mineral rights to their land may lease these rights for oil and gas exploration. This may provide many revenue streams, including a large initial 'bonus', paid on a per acre basis, and a royalty, a percentage of the money generated by the oil and gas extracted from the property. It is estimated that 10,000 Colorado farmers and ranchers have oil and gas wells on their property, but it is uncertain how many own the mineral rights.[29] Oil and gas extraction impact agriculture through the placement of drill pads, access roads, pipelines, and other infrastructure on land.[30] Vegetation removal due to oil and gas development between 2000 and 2012 affected about 7.4 million acres of land in North America.[31] Furthermore, the development of mineral rights may increase farmers' risk of soil and water contamination and some forms of development, such as hydraulic fracturing, substantially increase water use.

Renewable Energy: On-farm renewable power production typically relies on solar, wind, hydro, geothermal, biofuel, and biomass resources. For solar and wind energy, Colorado farmland has become particularly lucrative as developers seek treeless, flat areas for expansion.[32] Wind turbines accounted for three quarters of all renewable energy generation in Colorado in 2016, and in March 2017, almost a quarter of the total electricity generated in Colorado was generated by solar and wind power.
Solar: Both solar photovoltaic (PV) and solar thermal technologies can be utilized on farms. The former converts the sun's light directly into electricity and only operates when the sun

28 Tri-State's coal plants are more costly than new renewable energy.

29 CBEO 2017, page 20.

30 Trends in U.S. Agriculture, page 20.

31 47% was rangeland, 37% cropland, and 13% forestland.

32 Though this is mostly positive for farmers, there is concern that solar panels and wind turbines displace crops.

is shining; the latter concentrates sunlight by using mirrors, where the sunlight is either used directly as a source of heat, or to power a generator to make electricity. Farmers and ranchers not only have the opportunity to meet their own energy needs with solar, but can also transfer land use from agricultural production to companies to install large-scale solar projects, such as community solar and investor-owned solar systems. Solar can supplement farm income; solar companies are paying an average of $1,000 per year per acre in Colorado.[33] Colorado's solar power capacity increased by 70% in 2016, the state boasts more than 450 solar companies employing 6,000 people in the state, and approximately $510 million in Colorado solar investments were made in 2016.

Wind: As with solar technology, farmers and ranchers can meet some of their own energy needs with wind turbines. Landowners can also transfer land use to other companies to install utility-scale wind projects. An advantage of wind turbines is that they do not require as much space as solar panels, thus maintaining more arable land on farms. In 2015, Colorado farmers received a total of $9 million in lease payments for turbines. Farmers typically receive $7,000 to $10,000 per turbine per year. Wind is the predominant renewable energy resource in Colorado and the state was the country's seventh largest wind producing state in 2016, accounting for more than 4% of wind generation nationally.

In 2015, Colorado farmers received $9 million in lease payments for wind turbines on their farms.

Hydropower: Hydropower uses flowing water (kinetic energy) to produce electricity. It is one of the least expensive ways to generate electricity. FERC and the state of Colorado implemented a pilot program to streamline procedures for the development of small-scale hydropower projects in the state. Colorado has significant capacity for hydropower development in agriculture, including pressurized irrigation systems and agriculture-related dams.

*Biofuels***:** In some cases, it may be economically feasible for farmers and ranchers to produce their own biofuels. Biofuels are liquid fuels derived from biological matter and are used as substitutes for petroleum products, such as gasoline or diesel. Types of biofuels include ethanol, biodiesel, and cellulosic biofuels. The main biofuel on the U.S. market is ethanol, a type of alcohol derived primarily from the fermentation and distillation of corn, though producers also use sugarcane, sugar beets, and wheat. Biodiesel is a fuel derived from a mix of feedstocks such as soybean oil, recycled cooking oil, and animal fats. Cellulosic biofuel is derived from fibrous plant sources, such as leaves, stems, crop residues, wood wastes, municipal solid wastes, and other fibrous parts of a plant. The Renewable Fuels Standard (RFS) program, created in 2005 and significantly expanded in 2007, is a national policy that

33 Information from Karen Gados, former Chief of Staff at SunShare, and Jon L. Sullivan, Director of Project Development at Microgrid Energy, August 2017.

requires a certain volume of renewable fuel to replace or reduce the quantity of petroleum-based transportation fuel, heating oil, and jet fuel. Agriculture plays a key role in achieving the RFS goals. The Environmental Protection Agency (EPA) predicted that the RFS would expand the market for corn and soybeans for biofuel production.[34]

Biomass: Anaerobic digestion is a biological process in which bacteria breaks down biodegradable material (including agricultural waste, such as manure or crop residues) into a biogas that is composed mostly of methane and some carbon dioxide. In energy production, the methane generated is burned in an engine generator to produce electricity and the waste heat is used for space or water heating.[35] This is particularly suited for dairies, because dairy waste is typically confined to small areas. A 1,000-cow dairy has the potential to develop a 1-MW digester if the manure is combined with other higher-energy organic waste.[36] However, due to Colorado's arid environment, cattle are often kept on dry lots, which is not ideal for anaerobic digestion.[37] Expert guidance is required to ensure the selection of appropriate technologies, especially if cattle are kept on dry lots. The AgSTAR Livestock Anaerobic Digester Database lists only one operational farm-scale digester in Colorado. Alternatives to methane digestion to overcome the barriers created by Colorado's dry lots include gasification, incineration, and pressing.

3. Previously Identified Energy Efficiency Opportunities for the Agricultural Sector

3.1. Irrigation

Increasing Colorado's agricultural irrigation efficiency[38] by only 10% could result in energy savings of more than 90 million kilowatt hours (kWh) annually. Known methods to reduce irrigation energy use include maintaining existing pumps, servicing pumps regularly, retrofitting pumps to increase efficiency,[39] installing new pumps with variable speeds, properly sizing pumps, using soil monitoring data and satellite maps to determine water

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34 Biofuels are somewhat controversial. Those opposed to biofuels argue that the diversion of crops to biofuel could cause more hunger (so-called 'food v fuel' debate). Benefits include that biofuels are a replacement for oil and is theoretically carbon neutral; proponents also say that biofuel co-products can be used as livestock feed.

35 Lazarus, W.F., *Farm-Based Anaerobic Digesters as an Energy and Odor Control Technology Background and Policy Issues*, USDA Report, February 2008, page 14.

36 Weisberg, P & Roth, T. *Growing Oregon's Biogas Industry: A Review of Oregon's Biogas Potential and Benefits*, February 2011, page 5.

37 Cattle kept on dry lots produce waste that is high in solids and inorganic material; anaerobic digestion requires waste with low solids content.

38 CEO Report, pages 7 to 8 of this report.

39 See Advanced Pumping Efficiency Program in California as an example.

requirements, implementing Low Energy Precision Application irrigation, and generally improving irrigation technology and management practices.

3.2. Transportation and On-farm Machinery

Energy use for transportation and machinery[40] can be reduced by purchasing or converting to fuel-efficient and/or alternative-energy-fueled machinery, sizing equipment properly, modifying farm practices to conserve fuel use (e.g. by reducing or eliminating tillage), and implementing fuel-efficient practices such as proper tire inflation and regular vehicle maintenance. Adopting technologies that provide for reduced idling, auto steering, obstacle isolation, and GPS auto-drive to reduce overlapping can also improve fuel efficiencies.

3.3. Fertilizer and Pesticide Production

Energy use in fertilizer and pesticide production can be reduced by replacing process equipment with high efficiency models, improving process controls to optimize chemical reactions, recovering process heat, and maximizing the recovery of waste materials.[41]

3.4. Fertilizer and Pesticide Use

Energy use associated with the application of fertilizers and pesticides can be reduced by testing the soil to determine the level of soil nutrients, maintaining the soil pH, covering crops and using manure, mulching to prevent nutrient loss, composting, crop rotation with legumes, implementing integrated pest management (IPM), and practicing precision farming to reduce overlap. The use of IPM and the determination of economic thresholds of pests can reduce the frequency of using preventative pesticides.[42] Adequate soil fertility, crop rotations, cover crops, proper plant spacing, and optimal planting dates can also reduce the amount of pesticide needed. Substitution of lower energy materials or non-petroleum based pesticides and use of low-volume / low-rate technologies also lower overall energy used.

3.5. Lighting

Common ways to improve lighting energy usage include switching from incandescent lighting to compact fluorescent or high-pressure sodium lighting and installing LED lights

[40] See pages 12 and 13 of the CEO report.

[41] Gellings, page 10.

[42] In heavy-use pesticide situations (e.g. fruits and vegetables) a pesticide use reduction of more than 50% may be realized through IPM.

(but high initial costs can make this less attractive).[43] Outdoor cattle feedlots, which can be used in Colorado, also reduces lighting (and heating) needs.[44]

3.6. Vacuum Pumps

Known methods to reduce the energy use of vacuum pumps used in dairies include using lower horsepower vacuum pumps and installing variable speed technology.[45]

3.7. Ventilation Fans

The energy efficiency of ventilation fans can be improved by using variable speed fans, fans that automatically turn on and off depending on the conditions, building steep ceilings to pull hot air up, reducing the need for fans, ensuring proper configuration of fans within a system, and conducting regular maintenance.[46]

4. Programs and Policies that Support Clean Energy in Colorado

The Appendix to this paper contains a list of current, active programs and policies that support clean energy through direct or indirect funding, and technical assistance and/or education.[47] This list includes local programs, such as the La Plata Electric Association's On-Bill Financing Program, statewide programs, like the Colorado Energy Office's Agricultural Energy Efficiency Program, and federal programs and policies that are applicable in Colorado, such as the USDA's Office of Rural Development's Energy Programs. In the Appendix, local regional and state programs are listed first (programs 1 to 14), followed by federal programs (programs 15 to 22). Below is a brief description of programs in the Appendix that we chose to highlight.

The Colorado Energy Office's Agricultural Energy Efficiency Program (Appendix: program 5), also known as the AgEE Program, has been hailed as a success: to date, 107 producers have been approved for the program and the Colorado Energy Office (CEO) was selected for a $1.1 million USDA award to help finance energy efficiency improvements for Colorado's farmers. The award was matched through a $1.3 million cash and in-kind combined contribution from CEO, the Colorado Department of Agriculture, and utility and industry partners. The funds help finance energy and water saving projects identified through CEO's AgEE Program and can be coupled with existing USDA financial assistance programs. The

43 CEO Report, page 9.
44 CEO Report, page 11.
45 CEO Report, page 9.
46 CEO Report, pages 9 and 11.
47 This includes technical assistance, help applying for funds, audits, feasibility assessments and workshops.

efficiency improvements are expected to achieve over 5,250 megawatt hours (MWh) of electricity savings and 524,000 gallons of water savings annually. CEO aims to expand the program to 200 additional producers over the next two years. CEO's program demonstrates how agency, partner, and producer resources can be strategically leveraged to accomplish significant energy and environmental improvements that will benefit farm operations and the state for the long term.

The Colorado Department of Agriculture's ACRE[3] programs (Appendix: programs 6 to 8) are still in initial stages. ACRE[3]'s Agricultural Hydro program (Appendix: program 6) has secured $3.25 million to assist farmers with upgrading their irrigation systems to save water and energy. This program aims to install 30 integrated hydromechanical or hydroelectric power systems across Colorado over the next four years. Funding has recently opened for solar PV in agriculture as well. ACRE's past projects have been successful, which bodes well for these programs.

Colorado State University's Rural Energy Center's Solar and Wind Assessments for Pivots (SWAP) program (Appendix: program 9) assessed the economic feasibility of installing solar and wind systems in non-irrigated corners of farms that use center pivot irrigation. The assessments concluded that the average farmer who installs these systems on his/her land would achieve an 80% offset of irrigation electricity use per meter, pay $70,000 net upfront costs, gain $185,000 in energy benefits over 25 years, and have a 13 to 20-year payback period. SWAP currently offers economic feasibility assessments to Colorado farmers.

CSU's Rural Energy Center's Feedlot Assessments for Solar Energy (FASE) program (Appendix: program 10) launched on July 1st, 2017. This project, conducted by the same center that was responsible for SWAP, is offering free solar energy assessments for Colorado animal feeding operations and will conduct thirty of these economic feasibility assessments throughout Colorado.

CSU's Climate Smart Agriculture program (Appendix: program 11) provides research-based information to agricultural producers with the aim to improve farms' and ranches' resiliency to climate change and to sustainably increase agricultural productivity and incomes, all while reducing greenhouse gas emissions.

Commercial Property Assessed Clean Energy (C-PACE) (Appendix: program 12) is a financing mechanism that enables commercial property owners, including agricultural producers, to finance up to 100% of the upfront costs of clean energy improvements with repayment terms of up to 20 years. The repayment is facilitated through the county property tax assessment process.

Other financial incentives and rebates offered for clean energy installations and efficiency improvements in Colorado include financial incentives for the installation of renewable energy generation (Appendix: program 3); sales and use tax exemption for systems which produce electricity from a renewable resource (Appendix: program 14); efficiency rebates for lighting, energy efficient motors, variable speed drives, water heaters, and heating and cooling equipment (Appendix: program 4); and tax incentives to encourage businesses to expand to economically distressed areas of Colorado (i.e. areas with high unemployment and low income) (Appendix: program 13). La Plata Electric Association's On-Bill Financing Program (Appendix: program 1), in partnership with 1st Southwest Bank, offers low-interest loans to local farmers from La Plata and Archuleta counties to finance energy efficiency projects. The loans are repaid monthly on farmers' La Plata Electric Associations' electric bill.

The USDA's Office of Rural Development's Energy Programs are a group of programs authorized by the Agricultural Act of 2014. The programs offer funding for energy audits, renewable energy development assistance, energy efficiency improvements, and renewable energy systems installation. Programs 15 to 17 listed in the Appendix form part of this group. USDA's Rural Energy for America Program (REAP) (Appendix: program 15), which started in 2003, provides guarantees on loans to agricultural producers and rural small businesses for renewable energy systems or for energy efficiency improvements. Loans are available for up to 75% of total eligible project costs. Grants are also available, for up to 25% of total eligible project costs. REAP also provides financial assistance for energy audits. The Biorefinery Assistance Program (Appendix: program 16) offers loan guarantees to assist farm cooperatives and associations of agricultural producers in the development, construction, and retrofitting of biorefineries. The Environmental Quality Incentives Program's (EQIP) On-Farm Energy Initiative (Appendix: program 17) provides financial assistance for energy audits of certain farmsteads and irrigation systems. After an audit, qualifying agricultural producers can apply for financial and technical assistance to purchase and install a variety of energy improvements.

The federal Business Energy Investment Tax Credit (Appendix: program 18) administered by the Internal Revenue Service (IRS), provides tax credits (a credit offset against a tax balance) equal to 30% of expenditures for solar PV, solar water heating, solar space heating/cooling, and solar process heat. This percentage will decline gradually to 10% in 2022, with no stated expiration. The IRS further provides tax credits equal to 10% for geothermal property, with no maximum credit limit or expiration. Lastly, the IRS provides tax credits equal to 24% for large wind equipment, gradually declining to 12% in 2019 and expiring in 2020.

AgSTAR (Appendix: program 21), a program established more than 20 years ago and managed by the USDA and EPA, promotes the use of anaerobic digestion systems to reduce emissions from livestock waste. The program assists those who purchase and install digesters, by providing information, identifying benefits and risks, and creating a supporting environment for implementation. There is potential for approximately 8,000 livestock anaerobic digesters in the U.S., but currently there are only 244, only one of which is in Colorado.

5. Program and Policy Gaps and Other Barriers to Clean Energy Adoption

The diverse set of programs and policies listed in the Appendix do a fair job of encouraging implementation of clean energy solutions in the Colorado agricultural sector. However, despite plentiful programs and funding, there are program gaps and other barriers that deter the adoption of clean energy solutions, some of which are discussed below.

One of the key barriers to adopting clean energy solutions is financing. Even though approximately 80% of the 22 programs and policies listed provide direct or indirect financial support, interviews and surveys conducted by CEO found that financing remains a large barrier to adoption due to the high upfront costs of clean energy technology and farmers' low profit margins.[48]

Duration and diversity of policies can also cause uncertainty and confusion for agricultural producers. For example, only a handful of the programs and policies listed in the Appendix have been around longer than five years. Furthermore, agriculture operators can choose from a large assortment of federal and local financial policies. During the abovementioned CEO interviews and surveys, farmers and ranchers expressed their reluctance to implement clean energy solutions due to uncertainty about the continued existence of current policies (such as tax credits or incentives) and the undefined effects of new policies.[49] Short-term policies deter long-term investments and a mixed bag of financial incentives and policies can create confusion, may add complexity, can be time-consuming, and it ultimately deters adoption of clean energy solutions.[50]

Another key barrier to adopting clean energy solutions is farmers' and ranchers' lack of time. Almost 75% of farmers who responded to a recent poll indicated that they work more

48 CEO Report, page 15.

49 CEO Report, page 17.

50 For example: A farmer who wants to install solar panels on his farm may qualify for a local or regional energy efficiency rebate program, renewable energy rebate program, and CEO's AgEE program. He or she may also qualify for C-PACE and a tax refund, as well as sale and use tax exemption. On a federal level, he or she could apply for a REAP grant as well as loan guarantees through the U.S. Department of Energy. This mélange is complex to navigate and may cause confusion. Furthermore, the farmer may be uncertain about the continued existence of some of these policies and possibility of new policies, which could affect his or her financial planning.

than 60 hours per week. This includes running the farm or ranch, preparing products for sale, supervising employees, and performing other commercial and administrative tasks related to their agricultural operation. This leaves very little time to research, find, consider, apply for, and implement clean energy technology.

The comparatively low cost of oil and gas in Colorado also does not encourage clean energy adoption. Because farmers' and ranchers' net income has decreased significantly, there is no financial incentive to switch to clean energy if current energy sources are relatively inexpensive.

Another limitation to clean energy adoption is utility rate design. Conventionally, utility revenues are proportional to sales of electricity and natural gas. Both publicly owned and investor-owned utilities (IOUs) set rates to recover costs and earn a reasonable profit to invest in new facilities; IOUs also need to earn additional revenue as profit for investors. Programs that improve customers' energy efficiency reduce sales and negatively affect profits. This ultimately results in a reduced rate of return, deterring utilities from supporting customer energy-efficiency programs. Furthermore, some utilities' agricultural rates are regressive (i.e. the first block of kWh is the most expensive, and rates decline thereafter) and this incentivizes increased energy use.

The adoption of clean energy technologies in the agricultural sector is relatively new. Social acceptance of clean energy is as important as the technology itself. The well-known triangle of social acceptance requires acceptance on a socio-political, market, and community level.[51] The socio-political aspect entails the acceptance of the technologies and policies by the public, key stakeholders, as well as by policy makers. Market acceptance refers to the market's adoption of an innovation, i.e. consumers need to demand the clean energy technology and investors should be willing to invest in creating the supply. Finally, local stakeholders, such as farmers and local authorities, need to accept the technology. This is not just a general acceptance of clean energy, but also a specific adoption of the technology. Many personal and psychological factors could affect a farmer's willingness to accept clean energy technologies such as age, social class, political belief, environmental concern, perceived fairness, and trust.[52] Additionally, contextual factors of project size, ownership, distribution of benefits, and regional context affect the social acceptance of new technologies.[53] People more readily adopt new technologies if a close acquaintance, such a neighbor, has done so with success. Social acceptance, and specifically community acceptance on a project level, still has room for improvement in Colorado.

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51 Rolf Wustenhagen; Maarten Wolsink and Mary Jean Burer, (2007), *Social acceptance of renewable energy innovation: An introduction to the concept*, Energy Policy, 35, (5), 2683-2691.

52 Devine-Wright, P, (2007) *Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review*, School of Environment and Development, University of Manchester, Oxford Road, Manchester M13 9PL, UK, pages 5-6.

53 Devine-Wright, page 7.

The agriculture sector in Colorado faces many deterring factors when it comes to adopting clean energy technologies. Entrenched in a utility rate design that favors higher energy consumption, agricultural operators are faced with high technology costs and policy uncertainty combined with low fossil fuel prices, paucity of time, and limited social acceptance, making implementation of clean energy solutions difficult.

6. Policy and Program Recommendations

In order to address the abovementioned gaps and barriers, we have identified program, policy, and business opportunities to increase the adoption of clean energy solutions.

6.1. Buying Agent or Concierge Program

In addition to the educational outreach and technical support provided by current programs, a clean energy buying agent or concierge program could further encourage the adoption of clean energy solutions in the agricultural sector in Colorado and elsewhere in the country. The aim of such a program would be to assist farmers and ranchers to navigate the assortment of programs, policies, and financial assistance available for clean energy improvements and technologies and to assist them in making informed purchases. A buying agent / concierge program could significantly reduce the time it takes farmers and ranchers to learn about, find, apply for, purchase, and maintain clean energy solutions. The program could also provide agricultural producers with continued technical and educational guidance by creating a website showcasing relevant resources and practical guidelines, distributing educational mail-outs and exhibits, providing individual support, and hosting workshops, meetings, and conferences. This will not only address the practical barrier of a paucity of information, but also serve to increase social acceptance of clean energy technology and accelerate adoption. Furthermore, program agents could play a key role in advising policy-makers and other program officers on the needs of farmers and ranchers to increase the feasibility, integration, and likelihood of adoption of future programs and policies. Ultimately, a buying agent / concierge can serve as an intermediary and foster collaboration among a diverse set of stakeholders to increase local and social acceptance and adoption of clean energy solutions. An independent organization, such as CNEE, would be suited to drive such a program,[54] or such an organization could partner with another, such as the Rural Energy Center, to build and expand on both organizations' work.

[54] Members of the CNEE team have experience in successfully building and implementing a buying agent program in Colorado.

6.2. Increased Financing Solutions

More financing solutions are needed to overcome the upfront cost barrier for agricultural producers. Legislators and financing companies could enable and implement these solutions to overcome the barrier of high upfront costs of clean energy technologies.

On-bill financing and on-bill repayment are promising mechanisms where capital for clean energy solutions is provided by a utility (on-bill financing) or by another entity (on-bill repayment) and the loan is repaid monthly through the agricultural producer's utility bill. The benefit of this mechanism is that the costs are amortized and combined with utility savings. Bridge financing can provide immediate cash flow to overcome the high upfront costs, and the clean energy technology solution itself could be the collateral for this type of short-term loan.

C-PACE is another financing mechanism that enables commercial property owners, including agricultural producers, to finance up to 100% of the upfront costs of clean energy improvements through their property tax payment. Property owners repay the financing, provided by approved private capital providers, as a special assessment on their property tax bill and the repayment responsibility usually transfers to the new owner when the property is sold. Colorado already has a statewide program with repayment terms of up to 20 years. Counties must opt in to the Colorado program to make C-PACE financing available to agricultural producers in their county. Counties should be encouraged to opt in to this program and promote it to agricultural producers in their region.

Feed-in tariffs (FITs) are a financing mechanism that has not yet been widely implemented in Colorado. This policy provides payment for electricity generated by renewable resources, which can be located on agricultural lands and buildings. FITs have proven successful in Europe and California and have spurred rapid development of clean energy.

6.3. New Utility Business Models

It is imperative that utilities rethink their business models to avoid the so-called "utility death spiral." As Peter Kinds remarked, "[t]o create the clean, efficient, and sustainable energy future that all stakeholders seek, we must revisit the [utility] industry model to ensure alignment with customer and policy goals, while also ensuring that utilities and third-party providers are properly motivated to support their customer, societal, and fiduciary obligations."[55] Some states have already started this process and Hawaii is leading the way. In April 2018, Hawaii enacted the groundbreaking Ratepayer Protection Act which mandates the state's public utilities commission to establish, by 2020, performance

55 Ceres Inc., Pathway to a 21st Century Electric Utility, Nov 2015, page 5.

incentives and penalty mechanisms that link electric utilities' revenues to customer-focused performance metrics and "break the direct link between allowed revenues and investment levels." The metrics include electric service reliability, reduced volatility of electric rates, timely execution of competitive procurements, the rapid integration of renewable energy sources, and the quality interconnection of customer-sited resources such as solar. The Future Energy Jobs Act of Illinois that went into effect on June 1, 2017, allows utilities' clean energy investments to be regarded as regulatory assets. This permits utilities to earn returns on distributed solar and energy efficiency, i.e. utilities can make profit by reducing their sales. California commenced an integrated capacity analysis that will enable utilities to better understand and map where customer-sited distributed solar and storage can be added to the grid to avoid or defer building more costly infrastructure and meet growing energy demand. In New York, the Reforming the Energy Vision proceeding implemented ratemaking changes that allow utilities to earn money through "earnings adjusted mechanisms" (i.e. outcomes-based performance incentives) in addition to their traditional cost-of-service rates. A number of states have implemented decoupling mechanisms, where utility rates are shifted from a cost-per-unit sold basis to a cost-per-customer basis and return on equity is not dependent on volumetric sales. Policy solutions would greatly help publicly owned utilities and IOUs with this transition. Rural electric cooperatives, as independent, non-profit, member-owned businesses, can also work collaboratively with members towards a business model for a distributed energy market.[56]

In sum, a concierge program can assist agricultural producers in navigating the clean energy landscape; increased innovative financing solutions can assist agricultural producers with the high upfront costs of clean energy solutions; and utility business model innovations will enable utilities to design their rates to support and incentivize clean energy adoption by agricultural producers.

7. Future Opportunities

In the next phase, CNEE will engage stakeholders through our AEL Tracker, SPOT for Clean Energy, and Legislative E-book. We will also explore opportunities for collaboration between CNEE, other departments at CSU, and potential partners. This includes collaborating with local Colorado farmers in a full case study, hosting workshops with partners, as well as exploring the possibility for a climate-smart demonstration farm in Colorado.

56 The National Rural Electric Cooperative Association (NRECA) is actively working with RECs to produce energy in more sustainable and renewable ways. Currently, 95% of NRECA's distribution members offer renewable options and RECs plan to add more than 1.3 GW of additional renewable capacity over the next few years.

Appendix: Programs and Policies in Colorado

	Program or Policy	Agricultural Subsector Served	Eligible Technologies	Lead Partners	Funding (direct / indirect)	Education and tech assistance
Local, Regional, and State Programs						
1.	La Plata Electric Association On-Bill Financing Program	All agricultural producers and processors in La Plata and Archuleta counties and who are customers of La Plata Electric Association	Caulking/weather-stripping, insulation, LED lighting, storm or thermal windows and doors, insulating window coverings, water heaters, heat pump systems or other heating or cooling systems that reduce energy consumption	La Plata Electric Association	Yes	No
2.	Energy Efficiency Rebates Program	All agricultural producers and processors who are customers of Mountain View Electric Association	Geothermal Heat Pumps Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Motors, Other EE, LED Lighting	Mountain View Electric Association, Inc.	Yes	No
3.	Renewable Energy Rebate Program	Agricultural producers and processors who are customers of Holy Cross Energy	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Wind (Small), Hydroelectric (Small)	Holy Cross Energy	No	No
4.	Commercial Energy Efficiency Rebate Program	All agricultural producers and processors who are customers of Poudre Valley Rural Electric Association	Water Heaters, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Motors, Motor VFDs, Other EE, Food Service Equipment, LED Lighting	Poudre Valley REA	Yes	No
5.	Colorado Dairy and Irrigation Efficiency Pilot (2014) and Program (2015) converted into Colorado Agricultural Energy Efficiency Program (2017)	Initially, dairy farms and irrigators in Colorado Now, all farmers and ranchers in Colorado with monthly electric bills of $400 or more	Various energy efficiency improvements	Colorado Energy Office (CEO)	Yes	Yes
6.	ACRE Agricultural Hydropower, a Colorado Agricultural Energy Efficiency Program	Irrigators in Colorado	Hydromechanical or hydroelectric power systems	CO Dept. of Agriculture (CDA)	Yes	Yes
7.	ACRE Energy Efficiency, a Colorado Agricultural Energy Efficiency Program	Agricultural producers in Colorado	Dairy farm technology, irrigation technology, greenhouse technology, and cold storage specifically	CDA	Yes	Yes
8.	ACRE Renewable Heating and Cooling, a Colorado Agricultural Energy Efficiency Program	Agricultural producers in Colorado	Heating and cooling systems	CDA	Yes	Yes

Appendix: Programs and Policies in Colorado

	Program or Policy	Agricultural Subsector Served	Eligible Technologies	Lead Partners	Funding (direct / indirect)	Education and tech assistance
9.	CSU Solar and Wind Assessments for Pivots (SWAP)	Irrigators in Colorado	Solar and wind on non-irrigated field corners	CSU Rural Energy Center (REC)	No	Yes
10.	CSU Feedlot Assessments for Solar Energy (FASE)	Livestock operations in Colorado	Solar energy	REC	No	Yes
11.	CSU Climate Smart Agriculture	All agricultural producers and processors in Colorado	Research-based information for all technologies	CSU Office of Engagement	No	Yes
12.	Commercial Property Assessed Clean Energy (C-PACE) for agriculture	All agricultural producers and processors in Colorado	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Wind (Small), Hydroelectric (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies; Lighting, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Building Insulation, Windows, Doors, other energy efficiencies	Sustainable Real Estate Solutions, Inc	Yes	Confirmation of technical projections only
13.	Tax Credit Refund for Renewable Energy Projects	All agricultural producers and processors in Colorado in designated enterprise zones	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas, Anaerobic Digestion Recycled Energy	Colorado Enterprise Zone, State of Colorado	Yes	No
14.	Sales and Use Tax Exemption for Renewable Energy Equipment	All agricultural producers and processors in Colorado	Biomass, Anaerobic Digestion	Colorado Dept. of Revenue	Yes	No
Federal Programs						
15.	Rural Energy for America Program (REAP) Grants, Loan Guarantees, Energy Audits, and Renewable Energy Assistance Grants	Agricultural producers and processors	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Hydrogen, Geothermal Heat Pumps, Combined Heat & Power, Tidal, Wave, Ocean Thermal, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Microturbines	USDA Rural Development	Yes	Yes
16.	Biorefinery Assistance Program	Farm cooperatives or farm cooperative organizations, associations of agricultural producers	Biomass, Municipal Solid Waste, Landfill Gas Renewable Chemicals, Biofuels	USDA Rural Development	Yes	No

Appendix: Programs and Policies in Colorado

	Program or Policy	Agricultural Subsector Served	Eligible Technologies	Lead Partners	Funding (direct / indirect)	Education and tech assistance
17.	Environmental Quality Incentives Program (EQIP)	All agricultural producers and processors	Lighting, plate coolers, ventilation and fans, irrigation pumps, grain dryers, greenhouse improvements, heating and refrigeration units, insulation and building sealing, motor controls and variable speed drives	National Resources Conservation Service	Yes	Yes
18.	Business Energy Investment Tax Credit (ITC)	All agricultural producers and processors	Solar Water & Space Heat, Geothermal Electric, Solar Thermal Electric & Process Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Tidal, Wind (Small), Geothermal Direct-Use, Fuel Cells using Renewable Fuels, Microturbines	U.S. Internal Revenue Service	Yes	No
19.	Modified Accelerated Cost-Recovery System (MACRS)	All agricultural producers and processors	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Microturbines	U.S. Internal Revenue Service	Yes	No
20.	U.S. Department of Energy (DOE) - Loan Guarantee Program	All agricultural producers and processors	Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Tidal, Wave, Ocean Thermal, Daylighting, Fuel Cells using Renewable Fuels, and Efficiency Technologies	U.S. DOE	Yes	No
21.	AgSTAR	Farms that produce manure (cattle, hog, poultry)	Anaerobic digestion	Environmental Protection Agency (EPA) and USDA	No	Yes, through partners
22.	Various Tribal Government Financial Incentives	Various agricultural producers and processors that qualify for support from the Tribal Government	Various	Various	Yes	No