The Colorado Department of Agriculture ACRE Program

An Evaluation, conducted by the StEPP Foundation, of the ACRE Program.
Dec. 30, 2011

Success metrics and recommendations for the future

Evaluation of The Colorado Department of Agriculture ***Advancing Colorado's Renewable Energy (ACRE) Program***

I. Contributors

a. Bruce Dines, M.S., Executive Director of the StEPP Foundation, a 501c.3 specializing in Renewable Energy and Energy Efficiency projects where impact and results can be quantified. www.steppfoundation.org.
b. Abigail Clarke-Sather, PhD., Sustainability Consultant, Clarke-Sather LLC. www.abigailclarke-sather.com
c. Bin (William) Fan, Accountant, Master of Science in Finance candidate, Daniels College of Business, University of Denver.
d. Sam Anderson, Mechanical Engineer and Renewable Energy Expert.

II. Executive Summary

The ACRE grant program has funded 56 projects since its inception in 2007. These projects span many areas of renewable energy (RE) including: anaerobic digestion (biogas), biochar, biofuels, biomass combustion, energy efficiency, energy storage, micro-hydro, solar, and wind. These projects have successfully fulfilled ACRE's mission of: 1) advancing knowledge in the area of RE within the agriculture industry in CO; 2) funding a variety of projects (research, feasibility studies, implementation of known technologies); 3) funding projects across different sectors of the agricultural industry (dryland and irrigation crop development, biofuels, animal husbandry, winter growth, etc.); and 4) diversifying funding across rural Colorado counties (projects have been implemented in thirty-five of Colorado's sixty-four counties).

Measureable impacts of the ACRE program to date include:

- 15 permanent and 229 temporary jobs created by nine of the 56 projects
- 550,000 gallons of diesel saved annually from a single project
- 2,600,000 decatherms of natural gas saved annually by two projects
- 240,600 kilowatt-hours of electricity saved annually by three projects
- over 100,000 tons of CO2 equivalent emissions avoided annually by 5 projects

By any measure, the ACRE program has been successful in fulfilling its charter. The purpose of this report is to provide clear examples of success, and to understand if there are ways to improve on that success even more. In fact, this study concludes that with relatively minor changes, the program could at minimum, double its efficacy in terms of measureable outcomes and impact. Those changes and recommendations revolve around the following areas:

1) Refinement of selection metrics
2) Alignment of selection metrics and evaluation criteria (should be one and same)
3) Broader focus on Energy Efficiency (EE) as a major project contributor
4) Post project evaluation
5) Project categorization and recommended $ allotment by category
6) Consistency in:
    a. Quantifying and measuring results
    b. Formatting and timing of reporting
    c. Project administration and management

Evaluation of The Colorado Department of Agriculture ***Advancing Colorado's Renewable Energy (ACRE) Program***

Contents

1. Overview of the ACRE Program

The Colorado Department of Agriculture's Advancing Colorado's Renewable Energy (ACRE) Program has funded 56 projects since 2007. This program received the focus of its work through Colorado Revised Statute 35-75-205(1.5). For each fiscal year starting in July 2006 through 2012, the Colorado Legislature has appropriated $500,000 for The Colorado Agricultural Value-Added Development Board to promote "the feasibility and development of agricultural energy-related projects (Senator Isgar & et al. 2009)."

In general the projects funded by ACRE encompass the areas of research, feasibility studies, and project participation, which are described on their website as follows:

> Feasibility Studies: Funds will be allocated to eligible applicants in the form of a grant to study the feasibility of establishing an agricultural energy-related project. Feasibility studies may address the market for the product, engineering requirements, economic viability, environmental concerns, legal requirements, management, and other necessary study components. The Board has established a maximum allocation of $25,000 per feasibility study project.
>
> Project Participation: Provided that a feasibility study has been previously conducted demonstrating the likely success of the project, application can be made to the Board to assist with the development of the project. Funds can be used to assist with the purchase or lease of equipment, construction costs, and land costs. A maximum funding allocation of $100,000 has been established by the Board for project participations and may take the form of a grant, loan, loan guarantee or equity interest.
>
> Research: The Board will consider applications for research of agricultural energy-related topics and issues. Research should be tied to a particular issue or problem and the results of such research must advance the potential for further developing agricultural energy projects in Colorado. Funds are provided in the form of a grant with a maximum allocation of $50,000 per project. (CDA 2010)

This program has funded a variety of types of projects across Colorado.

2. Evaluation Process

The Colorado Department of Agriculture (CDA) has contracted the StEPP Foundation to evaluate the success of the ACRE program. The evaluation process consists of several parts: evaluation of projects, review of grantee selection, gathering of feedback from grant recipients, project site visits, and development of tools for improved evaluation and awardee selection. The following sections touch on each of the processes involved in this evaluation.

2.1. Project Evaluation

The StEPP Foundation evaluated projects both categorically and individually, looking primarily at project finances and metrics of success at both levels. Primary project documents such as the application form, interim, and final reports were all considered in the evaluation. Part of the evaluation process included a phone survey to ensure that we received direct responses from as many of the awardees as possible (we received completed surveys from approximately 40%).

2.2. Reviewing the Grantee Selection Process

Grant evaluation and selection criteria were included in the analysis, as well as the process and formulas designed to filter them appropriately. This review included multiple conversations with ACRE grant managers to ensure a thorough understanding of the current process.

2.3. Development of Decision Matrix and Metrics

The review in section 2.2 above led to suggested modifications of some of the selection and evaluation criteria, and the development of a decision matrix to assist in this process. With ACRE's feedback and input, the StEPP Foundation modified the draft into the final form presented in this report.

2.4. ACRE grant recipient feedback

As mentioned above, StEPP conducted telephone interviews (Appendix A) to assist in the overall understanding of the ACRE program, grant management process and project success. 23 out of 56 projects, representing all project categories completed the survey for a response rate of 41%. With this high response rate, we can extrapolate results to the entire awardee group.

2.5. Project Site Visits

In addition to the telephone surveys, we also visited two project sites, enabling us to meet one on one with awardees and see and experience their projects. Please refer to Appendix B for more information.

3. Evaluation Findings

The ACRE program has awarded grants to a total of 56 projects since 2007 (5 grant cycles).

Table 1: Number of funded projects and applicants by funding year

Year	Funded Projects	Applicants	Acceptance Rate
2007	9	9	100%
2008	11	32	34%
2009	13	32	41%
2010	10	47	21%
2011	13	27	48%
Total	**56**	**147**	**49%**

3.1. Current Program Goals

The CAVAD board wants projects to:

- be dispersed geographically across all parts of rural Colorado
- include a mix of research, feasibility, and participation projects
- include a broad variety of renewable energy categories
- migrate ultimately from research to feasibility to participation

We investigated each of these goals in turn.

Figure 1 shows the current distribution of projects throughout Colorado, and Figure 2 shows the project count by county. ACRE projects are located in thirty-five of Colorado's sixty-four counties, and fourteen projects now have multiple locations. Without question, ACRE's goal of geographic distribution has been achieved.

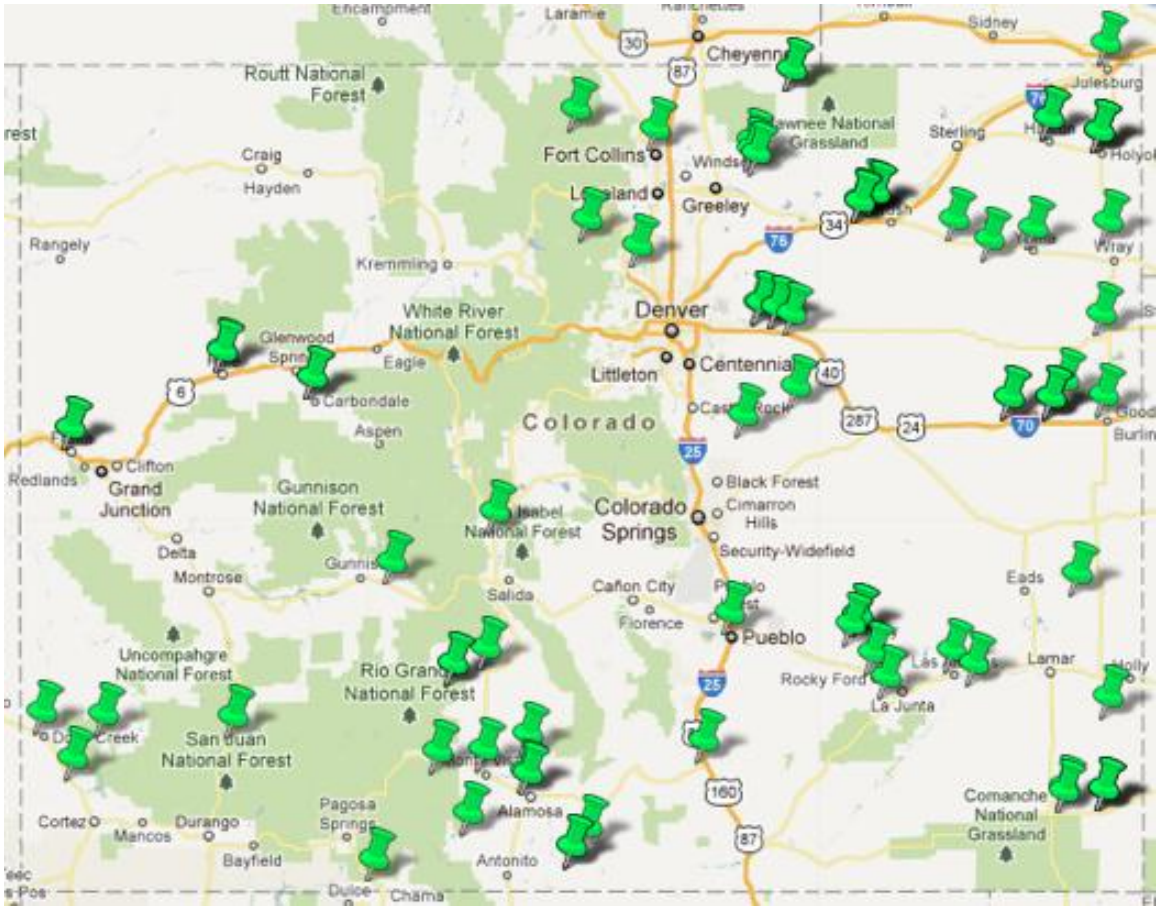

Figure 1: Geographic distribution of projects in Colorado

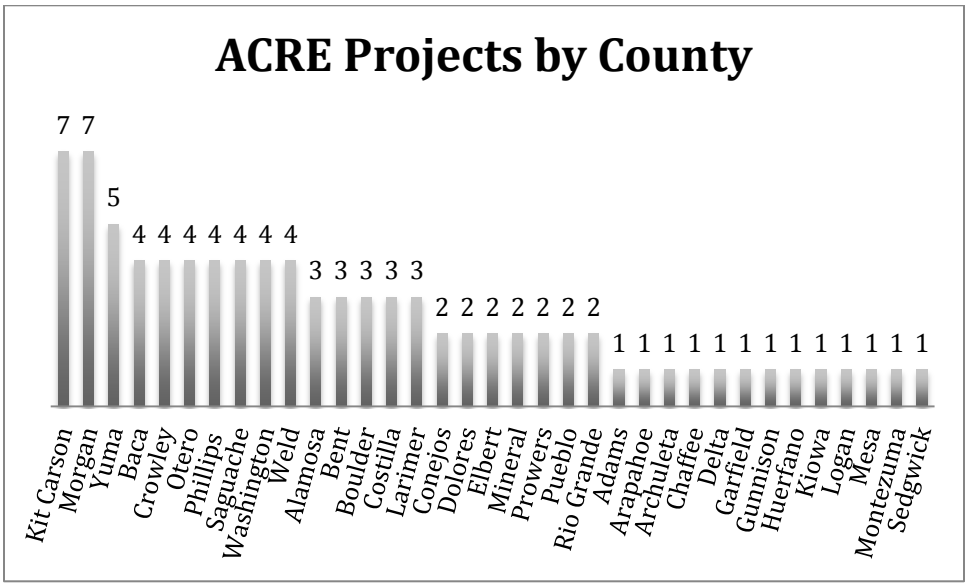

Figure 2: Count of Projects by County

Applicants for the ACRE grant were asked to submit projects in three different areas: research, feasibility, and participation. The initial goal was to have a relatively even distribution across these three categories. Though the ACRE program to date has funded multiple projects in each category, the funded research to date skews heavily towards research. (The category of "other" refers to two projects funded on RE education).

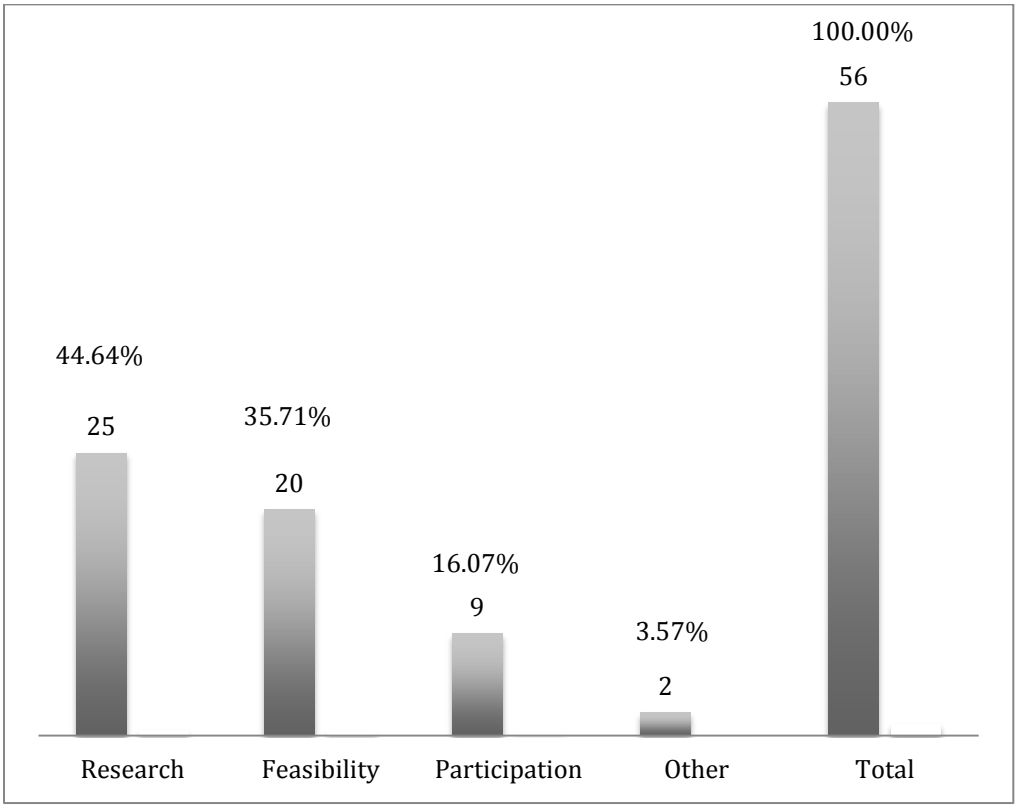

Figure 3: Number and Percentage of Projects by Type

Table 2 shows the number of projects and funding allocated for each type of project. The scope of this project did not include a financial audit, and in that regard, unverified funds for projects are shown in parentheses. A portion of the unverified funds come from projects that were funded in 2011 and are still ongoing. Other projects lacked clear documentation of funds, especially for the final amounts of matching funds and in-kind contributions for the projects. (Please refer to Section 5.5 for recommendations on how to improve transparency here). When final amounts were not available, financial numbers were used from the project applications. As evidenced from Table 2 below, research projects received over half of all ACRE funding.

Table 3 shows the matching funds and in-kind contributions for each project (verified financial numbers without parentheses and unverified numbers in parentheses). Participation projects received the greatest amount of matching funds. This is expected, since participation projects involve equipment installation and typically require larger amounts of capital. As a result, these projects often times bring with them already

existing source(s) of funding. In contrast, the research projects have the lowest amount of matching funds and usually depend on ACRE as their sole source of funding.

The overall program shows considerable success in leveraging ACRE funding with other sources of capital, including Federal level grant programs such as the USDA Rural Energy for America Program (REAP). Other additional funding sources leveraged by ACRE projects include the Department of Energy (DOE) and the US Treasury. In addition, ACRE grants have also leveraged Colorado program sources such as Colorado Water Conservation Board, and the Governor's Energy Office (GEO).

Table 2: Number of Projects by Project Type – ACRE funding only (number of projects with verified funds without parentheses, total number of projects including unverified funds in parentheses)

Project Type	No. of Projects	Grant amount	% of Total ACRE Funds
Feasibility	9 (20)	$211,204 ($446,048)	23% (20%)
Participation	5 (9)	$323,809 ($560,022)	36% (25%)
Research	7 (25)	$300,534 ($1,171,635)	33% (52%)
Other	2	$75,000	8% (3%)
Total	**23 (56)**	**$910,547 ($2,252,705)**	**100% (100%)**

Table 3: Number of Projects by Project Type - No ACRE funding, only shows Matching funds and In-kind donation (number of projects with verified funds without parentheses, total number of projects including unverified funds in parentheses)

Project Type	No. of Projects	Matching Funds	Match % of Grant Award	In-Kind Match	In-Kind % of Grant Award
Feasibility	9 (20)	$414,789 ($548,089)	196% (123%)	$11,307 ($57,557)	5% (13%)
Participation	5 (9)	$802,254 ($12,566,149)	248% (2244%)	$8,873 ($8,873)	3% (2%)
Research	7 (25)	$89,806 ($256,947)	30% (22%)	$0 ($71,057)	0% (6%)
Other	2	$65,631	88%	$42,332	56%
Total	**23 (56)**	**$1,372,480 ($13,436,817)**	**151% (596%)**	**$62,512 ($179,819)**	**7% (8%)**

Figure 4 shows that ACRE has successfully achieved its goal of funding a wide variety of renewable energy types. Within these diverse categories, the largest beneficiary is biofuels. Additionally, some projects funded worked on more than one area of renewable energy. In these instances, that table below splits equally among those areas. For

example, if the project included both biodiesel and straight vegetable oil (SVO) each of those areas was counted as 0.5. The funding amounts in Figure 5 were also allocated in this way.

		No. of Projects						
		2007	2008	2009	2010	2011	Totals	% of Total Projects
	Biochar	1				1	2	4%
Biofuel, 18, 32%	Biodiesel	2	1		1	2	6	11%
	Ethanol		3	2			5	9%
	Oil seeds			1		2	3	5%
	SVO	2.5	1.5				4	7%
	Biogas		1	1	1	2	5	9%
	Biomass combustion	2.5	1.5	2		1	7	13%
	Energy Efficiency			1			1	2%
	Energy Storage			3			3	5%
	Greenhouse improvements			1	1	1	3	5%
	Hydro	1	1		1		3	5%
	Solar			1	1		2	4%
	Wind		2	1	1	1	5	9%
	Other				4	3	7	13%
	Total*	**9**	**11**	**13**	**10**	**13**	**56**	**100%**

*Any apparent discrepancies in totals come from rounding error

Figure 4: Number of projects funded each year by renewable energy type

	Biochar	$20,180 ($33,680)	1% (1%)	
Biofuel	Biodiesel	$135,983 ($260,483)	5% (12%)	$269,457 ($566,358)
	Ethanol*	$200,000 ($308,952)	7% (14%)	
	Oil seeds	$25,000 ($100,000)	1% (4%)	
	SVO	$80,028 ($107,528)	3% (5%)	
	Biogas	$94,472 ($213,184)	3% (9%)	
	Biomass combustion	$165,470 ($186,340)	6% (8%)	
	Energy Efficiency	$25,000 ($25,000)	1% (1%)	
	Energy Storage	$50,000 ($119,943)	2% (5%)	
	Greenhouse improvements	$100,000 ($107,500)	4% (5%)	
	Hydro	$100,000 ($196,200)	4% (9%)	
	Solar	$73,403 ($73,403)	3% (3%)	
	Wind	$41,600 ($191,509)	1% (9%)	
	Other	$278,982 ($328,982)	10% (15%)	
	Total	$1,562,085 ($2,424,671)		

*Any apparent discrepancies in totals come from rounding error

Figure 5: Funding allocated to each renewable energy type (unverified funds shown in brackets)

3.2. Grantee Selection Process

Projects that receive ACRE funding are selected through a multi-step process (Figure 6). First of all, applications are reviewed by an Internal Review Committee (IRC) and scored using a score sheet of selection criteria. The Internal Review Committee consists of members of CDA, the Governor's Energy Office (GEO), and the Rocky Mountain Farmer's Union (RMFU). The criteria for selecting grantees were developed by the CDA and CAVAD Board, and involve scoring and tallying points for each criterion. The total points possible for each area are shown below:

- Completeness and presentation of the proposal (10 Points)
- Project merit, potential for success (including applicant and other assigned personnel experience), and support by city, local government, industry associations, etc. (25 Points)
- Degree to which the project will benefit Colorado's agriculture industry (25 Points)
- Degree to which the project contributes to the topic or technology (25 Points)
- Applicant contribution to the project in terms of cash and in-kind contributions (15 Points).

The participants in the IRC score the projects before meeting as a group. The scores they give projects are then combined and displayed for everyone to see. The IRC meets to review the scores, discuss the projects and, and determine which to fund and why. The narrative summaries for each project and the IRC's recommendations are presented to the CAVAD Board at their December meeting. CAVAD Board members also score each application prior to that meeting. After consideration of the IRC's recommendation and their own evaluation, the CAVAD Board makes a final decision about which applications to fund.

Figure 7 shows a combined general timeline for all projects (only verified dates are included) and is revealing -- projects start, finish, and report at different times and last from 6 months to 2½ years.

Time Period	Action	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Jun-Aug	Request for Proposals is available (starting in June)											
Sept	Applications received											
Sept	Internal Review Committee (IRC) scores projects using score sheet											
Nov	IRC meets and makes recommendations for which projects to fund, narrative summary written of discussion for each application											
Nov	IRC recommendations and narrative summaries sent to The Colorado Agricultural Value-Added Development Board (CAVAD)											
Dec	CAVAD members score applications using score sheet											
Dec	CAVAD members meet, review scores and narrative summaries, and decide which applications to fund.											
Dec	Rejection letters sent											
Jan	Approval letters sent											
Jan-Apr	Contracts with state finalized for each project											
Apr	In general, projects all have started work											
	Grantees carry out project plans	Each project had unique timelines										
	CDA contacts grantees with questions as needed, issues are brought to CAVAD board as needed	Each project had unique timelines										
	CDA reviews final reports and contacts grantees with questions as needed	Each project had unique timelines										

Figure 6: General Timeline of ACRE projects selection process

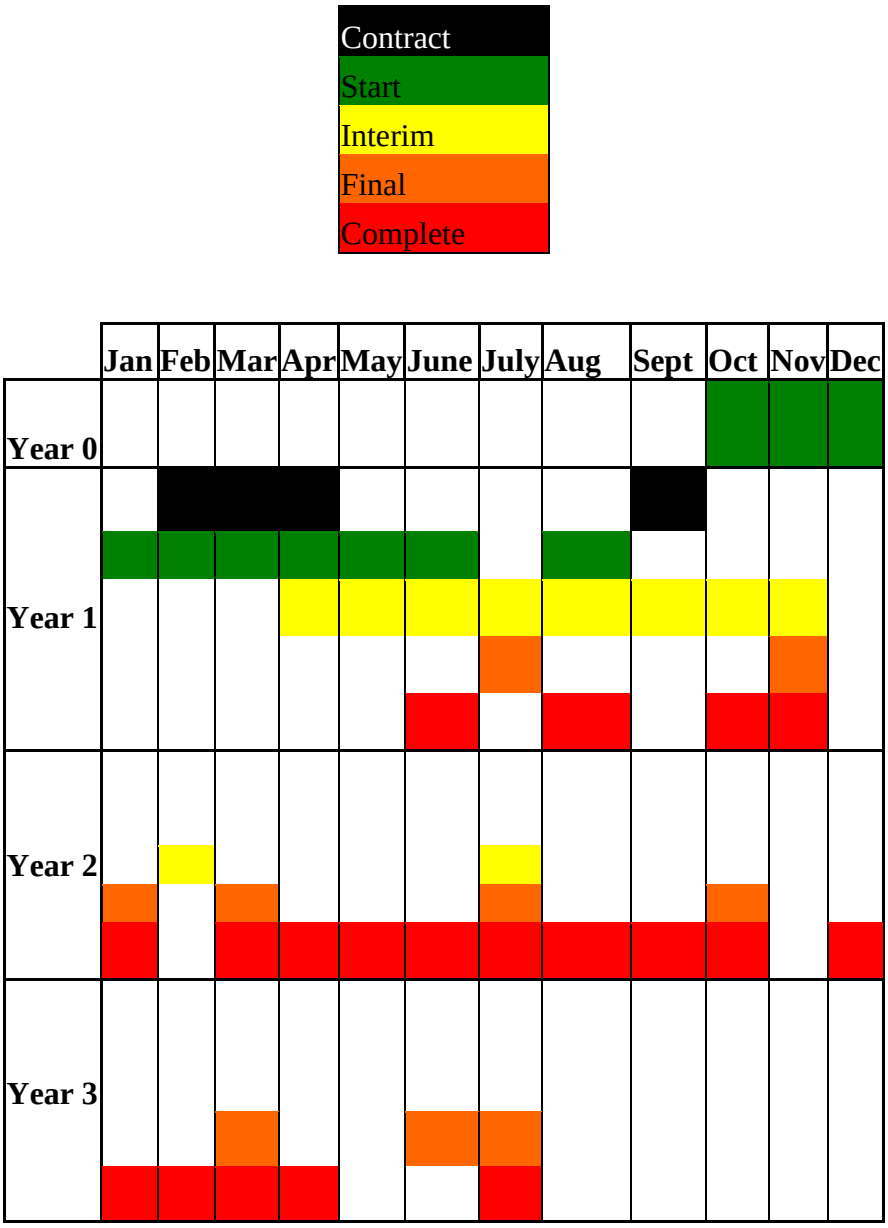

Figure 7: Combined timeline of all verified project dates

3.3. Project Participants

Many different types of organizations receive funding from ACRE, ranging from businesses, consulting firms, farmers, non-profits, to university researchers. Some of these organizations are repeat award recipients. The largest recipient of ACRE grant money is iCAST, probably because of the variety of projects applied for, and the diversity in their grant partners (iCAST is a non-profit based out of Lakewood). iCAST's projects covered a broad range of renewable energy topics including biodiesel, SVO, energy storage, wind power, biomass combustion, and greenhouse improvements.

In contrast to iCast, there were many repeat award recipients working on similar types of renewable energy projects. For example, both of Brink's projects involved wind power.

Table 4: Major Project Participants and their verified awards

Major Project Participant	No. of ACRE Projects (Total Projects)	Verified Awards (Total Awards)
iCAST	4 (8)	$250,000 ($400,000)
San Juan Bioenergy, LLC	2	$150,000
Southeast Colorado Resource Conservation & Development Inc	2	$127,500
Synergistic Building Technologies & Cure Organic Farm	1 (2)	$50,000 ($100,000)
Flux Farm Foundation	(2)	($99,943)
Colorado State University Department of Soil and Crops Sciences	1 (2)	$50,000 ($99,909)
BioVantage Resources	1 (2)	$50,000 ($96,200)
Colorado Corn Growers Association	1 (2)	$21,992 ($81,992)
Stewart Environmental Consultants	2	$75,000
Brink Inc	2 (3)	$41,600 ($49,100)
Living Arts Systems, LLC	2	$31,000

Part of the reason for the original categorization of projects is to encourage research projects to progress to feasibility projects and from there to participation projects. In that regard, repeat award recipients are expected, and there are 5 instances where projects funded by ACRE led to this progression:

1) The 2007 Elbert County feasibility project assessing economic viability for wind turbines at several farmers' operations was followed by a research project by Brink, Inc. in 2009 that measured wind speeds with anemometers. These two projects were followed by a 2011 Brink Inc. participation project where one wind

turbine was installed at a small feedlot and farming operation.

2) The Colorado Corn Growers created a feasibility study for E85 pumping stations that became a participation project for the installation of those stations.
3) San Juan Bioenergy started with a participation project for their biofuel/biomass facility that led to a research project about improving the operation of some of the facility's equipment.
4) Stewart Environmental Consultants performed a statewide resource survey of CAFOs and dairy wastes for use in anaerobic digestion. This project led to a feasibility study for anaerobic digesters.
5) iCAST had two research projects that led to additional research funded by ACRE. The first project focused on energy storage. The second project considered biomass briquetting that subsequently led to a project on biomass torrefaction.

Despite some successes in follow on projects, it is the exception, rather than the rule. ACRE funded projects are not following their designed trajectory (research to feasibility to participation) on a regular basis, and this piece of the program needs some reassessment. (See section 5, "Recommendations", for more information).

3.4. Feasibility Projects

Table 5: ACRE funded Feasibility Projects

Grant Applicant	Project Purpose	Renewable Energy	Funding Year
Rio Grande County	Crushing oil seeds to produce crude vegetable oil	SVO	2007
Washington County	Feasibility study of building a community-scale biodiesel production facility using a variety of producer-identified feedstocks	Biodiesel	2007
Alamosa County	7 feasibility studies, each one of which completely evaluates one energy resource's potential for further development in San Luis Valley.	Multiple technologies considered	2007
Baca County	Feasibility of building wind turbines in Baca County, and scrutinized the impacts of different user types and loads.	Wind Turbines	2007
Elbert County	Feasibility of building wind turbines in Elbert, Yuma and Morgan Counties.	Wind Turbines	2007
Colorado Corn Growers Association	E85 fueling infrastructure	Ethanol	2008
Colorado Farm Bureau	Development of an advanced ethanol facility project near Ft. Morgan, CO and other related by-products, like organic fertilizer and high-quality distiller grain.	Ethanol	2008
Stewart Environmental	A business model to support the installation of regional anaerobic digesters	Anaerobic digesters	2008
Chokecherry Farm	Small scale anaerobic digester for farm use	Anaerobic digesters	2008
Crowley County	Find the best way to dispose of the manure by beef cattle	Multiple ways of disposal	2008

Cochetopa Land & Cattle	Utilizing the wood-chip residues from the owners' lumber mill to power the farm's irrigation energy needs	Heat and electricity produced through gasification of biomass	2008
Feedlot Biofuel	Small ethanol plants in the following Colorado counties: Crowley, Otero, Bent, Prowers, Baca, Kit Carson, and Morgan	Ethanol	2009
Crowley County	Green community plan for the entire county including energy efficiency and renewable energy opportunities for residents, local businesses, and local government entities	Multiple renewable energy types	2009
Costilla County	Small-scale, vertically integrated biodiesel production facility in Mesita, Colorado.	Biodiesel	2010
Northeast Colorado Resource Conservation and Development Council	Hog manure biogas facility	Anaerobic digesters	2010
Boulder County	Development of a supply chain to use local crops as both cooking oil and biodiesel	Biodiesel	2011
Yuma Conservation District	Feasibility of building an oilseed crushing plant and a biodiesel refinery	Biodiesel	2011
Delta County Economic Development	Wood products for renewable energy market applications (e.g. pellets)	Biomass	2011
Painted Sky Resource Conservation and Development Council	Identify locations appropriate for small scale hydro power	Hydro	2011
Arrowpoint Cattle	Feasibility of drying spent grain from brewing with a solar dryer and extruder for use as animal feed	Solar	2011

3.4.1. Feasibility Project Summaries

Of the 15 feasibility projects funded, biofuel accounts for 6 projects, biogas for 4 projects, biomass for 1 project, county wide green development plans for 2 projects and wind energy for 2 projects. Within feasibility, we see a nice diversity among types of projects, renewable energy categories and geographic dispersion.

As might be expected, biofuels and biogas collectively are the most studied and funded fields within feasibility. Biofuel projects seek to utilize crops currently available in Colorado to produce ethanol, biodiesel and other co-products like distillers' grains. Biogas typically focuses on producing methane using different anaerobic digestion technologies. However, one biomass project uses wood chips from a lumber mill using gasification technology to produce biogas which can then be converted to electricity for

irrigation pumping. The two sustainable development planning studies focused on San Luis Valley and Crowley County respectively. Lastly, the two wind projects developed different models evaluating the economic viability of wind turbines for individual farmers. Some of the projects clearly state their important findings and show potential for further development and implementation. For example, the sustainability plan developed for Alamosa by San Luis Valley Resource Conservation & Development (SLV RC&D) Council is a particularly valuable report because of its comprehensiveness, attention to detail, and potential benefit to the public. This project evaluated business plans of multiple energy choices for agriculture in the region under the idea of building a Sustainable Environmental and Economic Development Park (SEED Park). The business plan for each energy choice includes an evaluation of almost all the factors that should be considered during a feasibility study, from the business and industrial environment to marketing and sales strategies to financial forecasts and profitability. If the SEED Park idea is put into action, the Alamosa community is a significant beneficiary through job creation, wage increase, sustainable economic improvement through local money circulation, etc.

Most of the feasibility studies were of average quality, lacking information and/or quantifiable potential impact. For example, the two studies on wind energy did not consider traditional economic viability of the technology within the context of their specific location.

Wind and solar are mature renewable energy technologies. Calculating the economic feasibility by application of these technologies is straightforward. Moreover, neither wind nor solar are great candidates for a feasibility study per se, because of the maturity of each technology and the clear understanding of each variable and assumption that determine feasibility.

Only one feasibility project was followed by a participation project or actual implementation of the business plan. This project selected locations for E85 fuel pumps. Although there are still potential follow on implementation projects outstanding, to date no other feasibility study has led to implementation. There are reasons for this, not the least of which is the difficulty in determining which factors show the most potential for future implementation.

However, there are several criteria in any feasibility study that are critical to successful implementation, and to the extent that any of them are missing, the feasibility project will likely not lead to implementation:

a. Complete business environment and trend analysis

b. Maturity and availability of technologies employed

c. Financial viability and sensitivity/risk analysis

d. Cost-benefit and economic impact analysis

Biofuel, biogas, biomass and wind energy projects are all technically feasible but the

financial viability will differ greatly depending on the scale of the project and current energy prices.

3.5. Participation Projects

Table 6: Acre Funded Participation Projects

Organization	Project Purpose	Renewable Energy	Funding Year
Dolores County \ San Juan Bioenergy	Install an oilseed crushing line for a meal, fuel pellet and biodiesel production facility	Oilseed crushing, fuel pellets and biodiesel	2007
Elk View Ranch	Install plant for hydropower, irrigation and livestock watering	Micro-hydropower and irrigation	2008
Southeast Colorado Resource Conservation and Development Council	Install on-farm wind turbines	Wind turbines	2008
Colorado Corn Growers Association	Install 3 new E85 fueling stations in NE CO	Ethanol	2009
iCAST - Seed Crushing Pilot	Develop 2 new seed crushing plants, one with biodiesel production	Oilseed crushing, oil and biodiesel	2009
Nunatak Alternative Energy Solutions	Install a frost-free, solar-powered water pump for livestock	Solar water pump	2009
Heartland Renewable Energy	Preliminary engineering and permitting of anaerobic digester facility	Anaerobic Digesters	2010

The seven participation projects that were evaluated consisted of three projects related to biofuels (two SVO/biodiesel and one E85), and one in each of the following four categories: 1) anaerobic digestion, 2) micro-hydro, 3) solar and 4) wind. Five of the projects concluded with the commissioning of functioning equipment. Of the other two, the anaerobic digester project comprised project design, development and permitting, while the E85 fueling stations project is currently stalled because of contract negotiations. At this point in time, no construction activities have begun on either of these projects.

Of the seven projects, four of them appear to contribute significant value to the advancement of renewable energy in Colorado in a manner consistent with the objectives of the ACRE program. These include Southeast Colorado Resource Conservation and Development Council (RC&D)'s wind project, the two seed crushing and biodiesel plants developed by iCAST and San Juan Bioenergy, and the anaerobic digester development project by Heartland Renewable Energy.

Southeast Colorado RC&D's wind project documents the experiences of developing five small-scale wind installations, providing valuable information to an industry that suffers from a lack of project experience. The wind industry relies heavily on data that is usually

proprietary, insufficient, or too costly to obtain, and each installation provides new lessons. In this regard, it will be worthwhile to revisit this project by documenting wind turbine performance and client experiences after several years of data have accumulated.

Similarly, the two seed crushing and biodiesel projects and the anaerobic digester permitting project are among the first projects of their kind in Colorado, contributing to the knowledge base for future development of these types of renewables.

The E85 fueling stations project and the micro-hydro project contribute the least value of the participation projects to the ACRE program. The Colorado Corn Growers Association project to install three E85 fueling stations is stalled and likely warranted a more complete business plan (the business plan was funded by ACRE as a feasibility project). In addition, federal sources of funding exist specifically to fund this type of project. ACRE funding may not have been the most appropriate funding source.

The micro-hydro project benefits a single farmer. The turbine is currently generating power to successfully provide water for livestock for this producer. However this project does not provide much economic, social or environmental benefit to Colorado at large. The application of the micro-hydro turbine was straightforward. Additionally, because the appropriate quantification metrics were not required as part of the project, it is not clear whether it is economically viable.

The solar project also benefited a single producer. In contrast to the micro-hydro however, it did show real value. The application of solar was both novel and unique, solving the problem of freezing water tanks for livestock in high altitude winter settings. However, one of the primary takeaways that emerged, despite the functioning technology and unique application, is the lack of economic viability.

Although all seven of the participation projects are technically viable, neither the micro-hydro nor the solar project for single farmers shows a clear economic benefit. The wind turbine installations show mixed economic benefits; some installations perform well and others do not. iCAST's seed crushing and biodiesel installations appear to be viable, while San Juan Bioenergy could not survive the economic downturn and drop in natural gas prices after September, 2008. Likewise, anaerobic digestion for energy production has not proven to be financially viable since the drop in natural gas prices. Lastly, the financial viability of the Colorado Corn Growers Association E85 project is still in question, due to its stalled status.

3.6. Research Projects

Table 7: ACRE funded Research Projects

Organization	Project Purpose	Renewable Energy	Funding Year
Colorado State University	Evaluate viability of on-farm production and use of SVO	SVO (straight vegetable oil fuel as a diesel substitute)	2007
National	Test starch and cellulosic composition of	Ethanol potential of	2007

Sorghum Producers	different genetic variants of sorghum crops	sorghum varieties	
University of Colorado-Boulder	Research and develop a surface-to-aquifer pumped hydro energy storage system to store solar power otherwise used for powering irrigation pumps.	Surface-to-aquifer pumped hydro energy storage (UPHS)	2007
Blue Sun Biodiesel	Production yields of camelina	Oil seed cropping, Biodiesel	2008
iCAST	Evaluate energy storage technologies; design and build a pilot-scale CAES system and control system	Energy storage technologies	2008
Golden Plains	Test the production yields of different crop rotation systems and their economic returns for farmers including agricultural and biofuel markets	Dryland crop rotation including biomass crops and oilseeds for use as biofuel	2009
Stewart Environmental Consultants	Map location, type of operation and waste stream info at Colorado CAFOs, rendering plants, and food processors in a GIS system	Colorado feedstock availability for anaerobic digestion	2009
Flux Farm	Measure effects of biochar sequestration on forage yield, soil chemistry and microbial activity	Biochar sequestration and associated soil properties	2009
iCAST - Briquette	Evaluate viability of a biomass fuel made from manure and other abundant agricultural wastes.	Bioenergy fuel pellet made from agricultural residue	2009
San Juan Bioenergy	Develop capability to sample and test production gas from a biomass gasifier for suitability of use in an IC engine, and develop a production gas monitoring system.	Gasifier production gas monitoring and testing	2009
Synergistic Building Technologies	Reduce fossil fuels used to provide energy for greenhouses by using as much passive solar and insulation as possible	Greenhouses design	2009
Brink Inc	Measure wind speed with anemometers at three cattle feedlots	Wind turbines	2009
Southeast Colorado RC&D	1. Test oil yields for soy, canola, sunflower and camelina in dryland or winter conditions; 2. Engine testing of oil and biodiesel; 3. Test value of meal as feed.	Strategic value of oilseed crops in a reduced water-use regime	2010
BioVantage Resources, Inc	Test a photobioreactor to produce algae used for agricultural wastewater bioremediation.	Algae bioreactor	2010
Flux Farm Foundation	Evaluate perennial plant species and crop inputs for biomass and bioenergy production.	Sustainable biomass and bioenergy production	2010
Colorado State University (CSU)	Assess different types of farmers ability to reduce energy use	Energy Efficiency	2010
iCAST	Research and develop compressed air energy storage system to store on-farm solar or wind.	Compressed air energy storage (CAES)	2010
Synergistic Building Technologies & Cure Organic Farm	Find optimal greenhouse controls for a greenhouse that uses passive solar and heavy insulation	Greenhouse control design	2010
Applegate Group, Inc	Small hydro in irrigation ditches, canals, checks etc.	Small hydropower	2010

BioVantage Resources	Statewide algae survey	Biofuel, Wastewater treatment	2011
CSU Biochar	Test biochar's effect on plants and feasibility in general	Biochar	2011
GeoSynFuels	Investigate and improve process of dewatering and extruding waste from ethanol processing into briquettes for combustion	Biomass	2011
CSU Engine Testing	Test effects of SVO combined with gasoline on farm equipment engines	Biofuel	2011
iCAST-Low Value Biomass Torrefaction	Develop a device to use torrefaction to turn biomass into a fuel or additive for electricity co-firing	Biomass	2011
iCAST-Greenhouses	Retrofit greenhouses to be energy efficient	greenhouse improvements	2011

Twenty research projects and one education project were evaluated, including five biofuel projects (three SVO/biodiesel and two cellulosic ethanol), one biogas (anaerobic digestion for bioenergy), five biomass (one biochar, two bioenergy fuel pellets, one algae, and one cellulosic biomass), one education research (energy policy), one energy efficiency, three energy storage (pumped hydro and two compressed air), two energy options analyses (passive solar greenhouse), one small hydro and one small wind.

Nine of the 20 research projects are providing real value in meeting the objectives of the ACRE program and contributing to the advancement of renewable energy. The two passive-solar greenhouse projects by Synergistic Building Technologies and Cure Farm appear to represent significant advancement in the design and applications of passive-solar technology. The biomass crops research by Flux Farm provides worthwhile research and development with valuable data on perennial crops for cellulosic butanol production. Research by Stewart Environmental Consultants and iCAST provide useful information about the potential capacity and value of bioenergy from animal and agricultural wastes. San Juan Bioenergy research contributes valuable experience in developing a small-scale, vertically-integrated gasification process for heat and power. Research by Southeast Colorado RC&D, Colorado State University and Blue Sun Biodiesel contributes valuable data for growing and using SVO (straight vegetable oil) on the farm as a fuel.

Four of the research projects and the education project do not appear to provide much value to the ACRE program. In particular, two projects did not deliver any information or product of value (May Farms community renewable energy fair and National Sorghum Producers sorghum testing). National Sorghum Producers conducted laboratory testing but did not provide any context or interpretation of the raw data. Golden Plains research on intensive dryland crop rotations, Flux Farms research on bio-char for carbon sequestration, and BioVantage Resources, Inc, research on developing an algae bioreactor were more loosely associated with renewable energy and may not represent as close a fit as to the ACRE charter as others.

Besides these projects, ACRE funded three energy storage projects. Energy storage is a key enabling technology that will eventually have a dramatic impact on the versatility of

renewable energy, but is not directly related to renewable energy itself. An assessment of the severe technical and economic barriers in these three projects indicates that these technologies are not mature enough to be a good use of ACRE funding. Perhaps a smaller grant for exploratory research would be more appropriate for nascent, peripheral technologies such as these.

Based on the 20 research projects reviewed, small hydro, farm- or community-scale wind, energy efficiency and passive solar greenhouses show the best potential for future participation projects based on market readiness and maturity of the technology. These categories are followed by SVO/biodiesel, biomass fuel pellets, gasification, anaerobic digesters and cellulosic ethanol or butanol. Feasibility studies may be warranted for installations of community-scale wind and small hydro, and business feasibility studies for new production of fuel pellets, cellulosic fuels, biogas and SVO/biodiesel. *Note, however, that additional funding sources may be available for wind and hydro, and that fuel pellets, cellulosic fuels, biogas and SVO/biodiesel face severe economic challenges as well as several technical challenges. For example, effusive quantities of agricultural waste exist in northeastern Colorado suitable for anaerobic digestion and energy from biogas, but capitalization and production costs cannot compete in current market conditions.*

3.7. Other Projects

Table 8: Other projects funded by ACRE grants

Organization	Project Purpose	Renewable Energy	Funding Year
May Farms	to create a rural renewable energy fair to educate the public at May Farms in 2009	Renewable Energy education	2008
Colorado Working Landscapes	Policy support for community based renewable energy development in San Luis Valley	Community based renewable energy development	2009

The above two projects did not fit well into the established grant application categories of research, participation, and feasibility projects. These two projects focused on renewable energy education in different forms. The May Farms project goal was to run a renewable energy fair. For a variety of reasons this fair never came to fruition. Colorado Working Landscapes worked on a project to assess the opportunities and barriers to community-based energy development for San Luis Valley with a focus on educating different entities about policy barriers to implementation.

Neither of these projects appear consistent with the ACRE charter and selection criteria. In addition, tangible results were difficult to find from either project. In the future, StEPP's recommendation is that ACRE avoids funding projects where education is the primary focus of the application, unless the education component can show meaningful curriculum development and be coupled with tangible, quantifiable results, which require a high commitment with follow up. An example of this might be the number of farmers who changed their animal waste stream practices to include more recycling as a direct

result of class attendance, coupled with how much waste is being recycled on an annual basis.

3.8. Grantee Feedback

Feedback from ACRE grant recipients was obtained through two methods: 1) a phone interview of recipients and 2) two site visits to ACRE funded projects, each of which have received two grants.

3.8.1. Phone Interviews

Interviews with grant recipients were conducted over the phone to obtain feedback about the effectiveness of grant administration and communication between the CDA and the recipient. All interviews were conducted between November 18th and 23rd, 2011. The interviews helped to gauge the impact of the grant program on the funded projects, and consisted of 18 general questions (focused on the administration of the project) and 11 to 17 questions specific to each of the four categories of project types (feasibility, participation, research, and other projects). A sample interview can be found in Appendix A.

An announcement email was sent to the primary contact for each project to request a time for a phone interview. In response to the email, interviews were scheduled with project managers for 23 of the 56 projects. Several of the projects were overseen by the same organization and had the same contact. In total, we reached and interviewed 14 of the 40 unique contacts. Six of the 40 contacts for projects were unreachable because of changes in email address or phone number. No attempts were made to contact recipients who did not respond to the original email announcement. The phone interviews lasted 20--40 minutes.

The interviewed projects consisted of the following categories: 2 feasibility projects, 4 participation projects, 15 research projects, and the 2 projects in the "other" category. Of the 23 projects, 14 were completed and 9 (2 participation, and 7 research) were still ongoing.

A short summary and analysis of responses follows. Whenever possible quantitative analysis of responses has been completed.

3.8.2. Analysis of Interviews

Grant recipients indicate they learned about the ACRE program through diverse sources, but personal contacts in organizations ranked first, followed by various websites (CDA, GEO, USDA and DSIRE). One respondent learned about the ACRE program through a CDA e-newsletter. Figure 8 represents how each of the 14 awardees (remember – some of the 14 were recipients of more than one grant, enabling these 14 interviews to cover 23 projects) learned about the ACRE program.

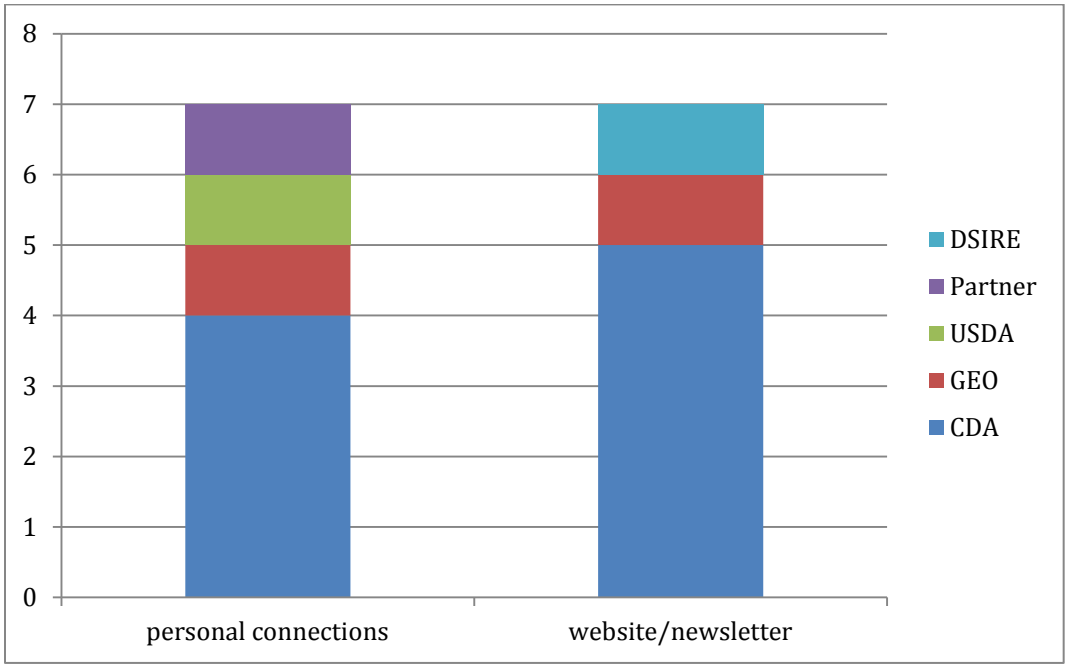

Figure 8: How participants learned about the ACRE program.

With regards to contracting and grant management, nearly all respondents indicated that the application process was clear and straightforward and that they received award notifications and signed contracts in a timely manner, with one notable exception. In this case, the respondent stated that the award notification was received in January, but the contract was not received until September, by which time the project needed to be nearly complete to satisfy timing requirements written in the grant proposal. This situation occurred early on in the grant program and is an obvious exception. Generally speaking, survey participants offered numerous compliments about how Stacy Romero and Tom Lipetzky administered the ACRE program.

Survey participants said they had already begun working on more than 60% (14 of the 23) projects prior to submitting the grant proposal. Only four of the 23 project awardees (17%) waited until after the contract was signed to begin the project. Figure 9 indicates when projects started relative to the contract period. In general, projects that started before a proposal was submitted to the ACRE program were either part of the recipient's core business or were a continuation of a previous ACRE project.

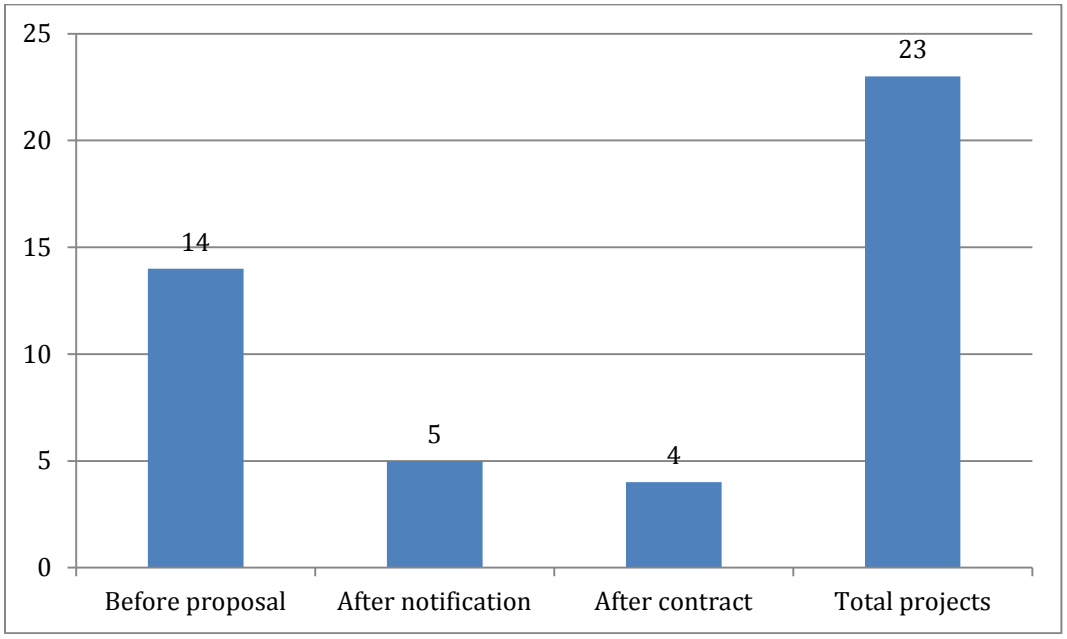

Figure 9: Projects start times relative to ACRE contract start times, by number of projects

Each project application and grant recipient set their own project timelines. Eight of the projects (35%) required or will require a contract extension. Most extension requests were caused by unanticipated project delays such as permitting issues or difficulties with project partners, but most did not indicate that the contract period was too short. In one case, the project goals and scope of work changed significantly during the contract period. One interview participant commented that the contract period should be lengthened by adding a monitoring and validation period at the end of technology implementation projects, which could publicize valuable data and add significant value to the ACRE program.

Most respondents (83%) said they had no issues with reporting requirements. Two project participants indicated the reporting requirements were not clear; in one case, the project was administered through a university. However, poor communication between university administrators and project participants resulted in the participants having no idea what reporting requirements were present in the contract with the University. Decoupling the Scope of Work and reporting requirements from the legal and budgetary requirements of the grant contract will resolve this issue in the future. In addition to the above, three survey participants cited personal time constraints and one person cited partner difficulties as a hindrance in delivering project reports.

Despite most project participants stating that they had a clear understanding of reporting requirements, many different types of reports were sent in compliance with these requirements. Figure 10 shows what types of reports project participants said they submitted. According to respondents, specific reporting requirements varied as described in the histogram below. In part this is true; each project had an individual contract with CDA and in that contract reporting requirements were stated specifically for each project. However, since the reporting requirements varied so greatly from awardee to awardee,

one of our primary recommendations is to devise clear, standardized compliance reporting formats and timelines.

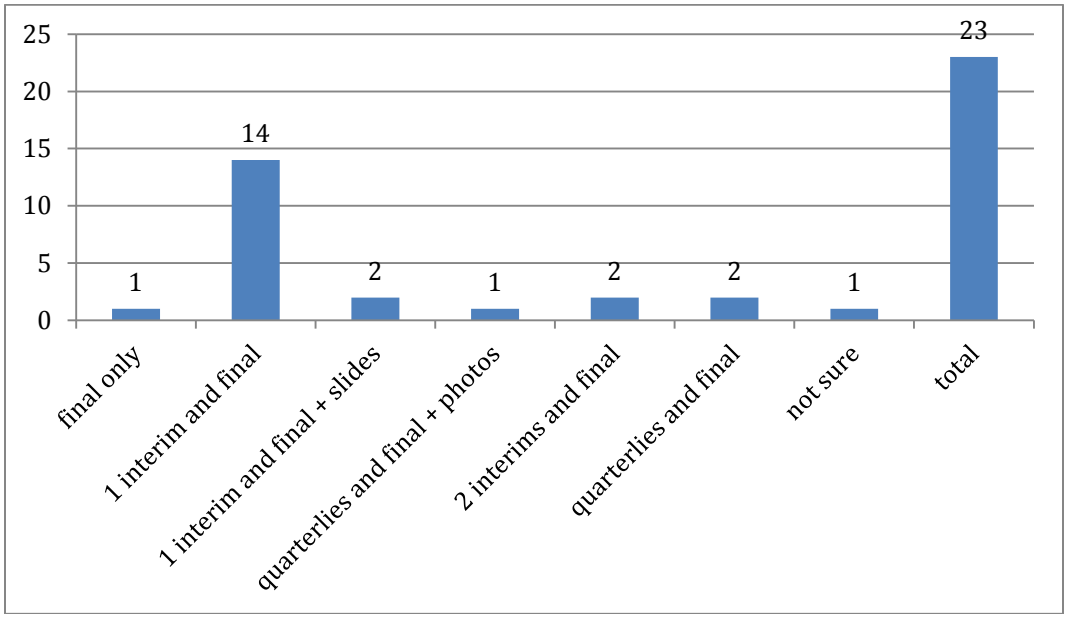

Figure 10: Reporting requirements as described by respondents.

Interviewees did not indicate any significant issues with the grant disbursement process. One project participant noted some frustration about trying to understand funding restrictions. Initial misunderstandings required reallocation of funds from other sources for that particular project.

When asked about the amount and value of the program grants, most of the respondents (78% of projects) stated that the grant was critical to launching their projects. The exact same percentage of projects (18 total) indicated that they successfully leveraged ACRE funds with some combination of additional internal and external funding. For five of those 18 projects, grant recipients said the ACRE project helped qualify them for funding for new projects outside the ACRE program. Other respondents said the grant provided critical seed money, was crucial to funding technical consulting for farm-based projects, or enabled financing for the project in other ways. Three respondents (17% of projects) indicated they likely would have started the project without ACRE funds since the project was part of their core business. While most respondents said they wrote the grant proposal according to the funding guidelines, for eight (35%) of the projects, the grant was not adequate for the scope and needs of their project. In the case of four of these projects, the grant only covered a small portion of project costs. Additionally, the grant stipulations and funding were too restrictive or inadequate to cover labor costs for the other projects. Figure 11 outlines responses to value contributions of the ACRE grants to the projects.

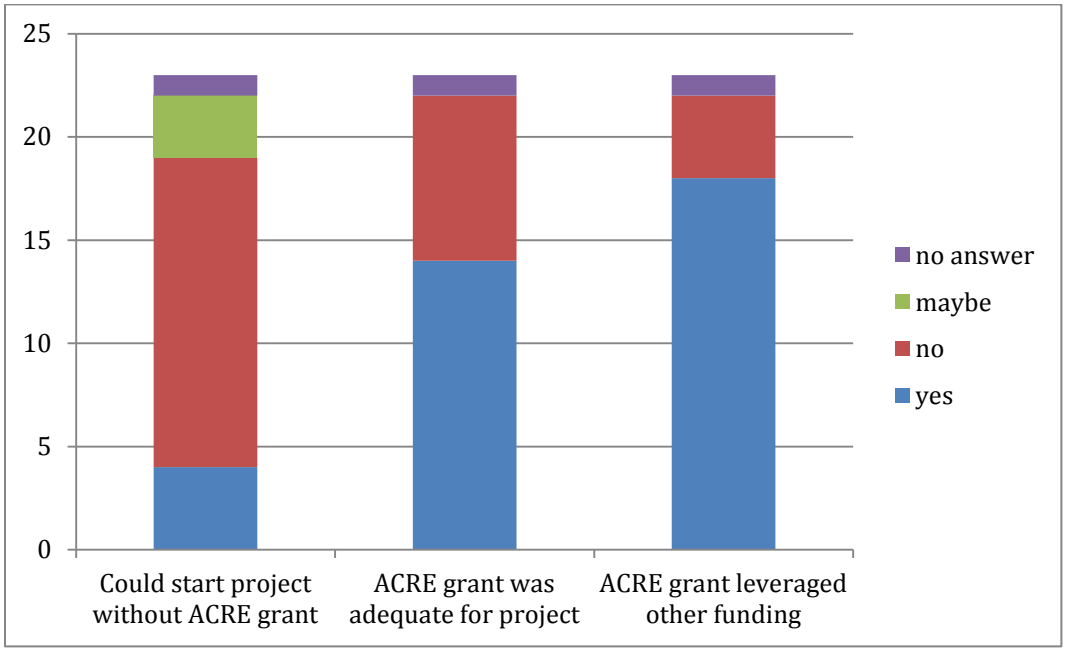

Figure 11: Value contributions of ACRE funding to projects

Based on interview responses, the ACRE program provides a unique source of funding to enable or support agricultural applications (sometimes the only application) of emerging industries and new technologies in alternative energy. In some cases, such as wind and solar installations, other rebate and incentive programs also exist to support the projects.

All but three of the projects interviewed had partners for the project as well as some level of external support. The following chart Figure 12 breaks down the types of partnerships or external support utilized by the projects. External support includes services, financing, or materials provided by someone such as a contractor, bank or agricultural producer who was not considered a partner in the project. Most of the projects (78%) relied on partnerships or external support to provide technical expertise. A minority of the awardees needed other types of partnerships and support, such as agricultural products and/or land. All but two had their partnerships in place before submitting the grant application.

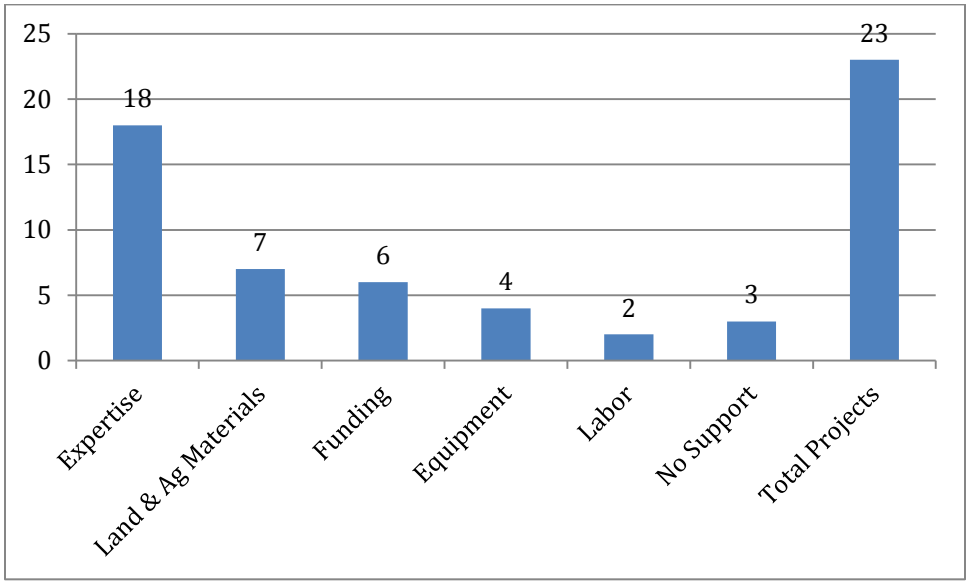

Figure 12: Types of partnerships and project support by number of projects.

The final question asked of the awardees was open ended to allow for more general feedback. Several project participants had interesting comments and recommendations for the ACRE grant program. One participant recommended a change in the way project funding is allocated to provide a monitoring and verification period after projects have been completed. This would allow benefits to be properly documented and published, such as renewable energy equipment performance, energy savings or return on investment. This project participant believes providing funding for project monitoring and verification could significantly leverage the strategic value of the ACRE program.

Others expressed a desire that the ACRE program continues. In particular one respondent said that there are few funding opportunities like the ACRE program that have a specific interest in Colorado. Another contact stressed the importance of CDA retaining a decision-making role in advancing renewable energy in Colorado. Two project contacts made a request for increases in funding to the program. One mentioned that in the future the ACRE grant program could be structured more like Department of Energy grants which are broken up into a first and second phase for project funding. Many participants commented on the ease of working with ACRE grant managers Stacy Romero and Tom Lipetzky.

Of the two feasibility projects interviewed (one on wind and the other on anaerobic digestion), only the wind project moved to implementation. The completion phase was funded by a second participation grant from ACRE, as well as USDA and US Treasury funding. Three temporary jobs were created for erection of the turbine tower. After implementation, the awardee received calls from 15-20 people interested in setting up wind turbines on their land.

The anaerobic digestion project has not made it to implementation due to low natural gas prices. Though the project participants received a USDA grant to design the anaerobic digester system, until such a time as natural gas prices rise again, the commercialization

of this technology will not be financially viable. Only one person contacted this awardee with a follow up interest.

Four participation projects were interviewed. For all but one the renewable energy technology was performing as expected. The fourth project is still ongoing and it is too early to determine its relative success. The three finished projects collectively created 17 temporary jobs and 3 permanent jobs. The two oil seed crushing and biodiesel/SVO facilities created saleable products every year worth an estimated $800,000. The fuel from these facilities is used onsite at the farms, which replaces 550,000 gallons of diesel fuel that would have been purchased. Meal and oil are products that can be sold. An estimated 1200 tons of CO2 equivalent greenhouse gas emission reductions are achieved by this project annually. Biodiesel and SVO facilities may be financially viable but without the grant money from ACRE, it is unlikely these projects would have been built. More than a hundred people have contacted the owner of the biodiesel facility for more information.

The small solar project that kept a cattle water tank free from ice saves on average 90 hours of the producer's time every year. If this producer had to bring electricity to this site it would have cost more than $24,000. This project has avoided electricity use as well as transportation fuel. Unfortunately however, these results were not measured. This project would have taken 5 years to pay the costs if the grant had not been available. A dozen or more producers have contacted the awardee for more information.

The 10 kW wind turbine installed for a producer has created $2000 in energy savings just this year. The turbine produces 19,000 kilowatt-hours of electricity annually. Without the ACRE support and two other grants received, this project has a 30 year payback, and is clearly not economically viable. About fifty people have contacted the awardee about this project.

The fourth project is still ongoing. The awardee had a contract set up for the purchase of natural gas produced from CAFO and dairy waste. This contract fell through so they are now working on finding new buyers for the gas. The awardee estimates that construction of the plant will create about 70 temporary jobs and 8 or more permanent jobs. When this project is operational about 3,000 decatherms of natural gas from renewable sources will be produced each day for about 1 billion cubic feet of natural gas produced annually. They estimate about 20,000 tons of CO2 equivalent greenhouse gas emission reductions could be achieved annually. Economic analysis shows viability. The ACRE grant portion is a small part of their total costs ($35 million), but this grant provides an important start that is helping convince others to provide additional funding.

Awardees were asked if they would undertake this type of project again and recommend that other producers undertake a project of this type as well. All said yes. The biodiesel and SVO facility awardee mentioned that operating these facilities isn't for everyone, and that the right circumstances have to exist for them to work. The natural gas plant awardee mentioned that this type of project has to be run by someone who can focus on operational efficiency and profitability.

The two "other" category projects were both interviewed. The ACRE funded community based energy development project led to other work for the organization regarding community solar gardens. This project did outreach to 350 or more attendees at an agricultural conference. This project also reached 12 industry leaders and 50 government leaders with their work. The project contact mentioned that the organization managing this project held a workshop recently for 25 people who were interested in continuing development of renewable energy in San Luis Valley and working on a distributed energy generation policy for Colorado. The second of the "other" projects was to develop and plan a renewable energy fair. They contacted many media outlets and vendors who wanted to exhibit at the fair. Despite the educational and public relations outreach, the economic conditions in 2008 placed a sufficient amount of strain on the project that the festival was never held. No jobs were created by either project.

Contacts for fifteen research projects were interviewed. Three projects have commercialized findings from their research in some form. Another two projects have potential leads for commercialization projects. So far, on a combined basis, these 5 projects have created one permanent job related to energy storage technology. Three other projects have the potential to create jobs: 1) 3 to 8 permanent jobs per facility that use algae to clean up effluents from agricultural operations, 2) 20 to 33 permanent jobs per facility to create a biomass combustion product, and 3) 4 permanent jobs projected for installing micro hydro turbines in irrigation ditches. 11 of the 15 research projects have been contacted by people wanting more information, and one of these contacts led to an invitation for continued research.

3.8.3. Site Visits

BioVantage Resources and Synergistic Building Technologies both received funding for two research projects each through ACRE. Synergistic Building Technologies has completed both research projects, and BioVantage Resources is still working on the latter, collecting types of algae from all across the state.

BioVantage Resources has developed a bioreactor that grows algae, specifically engineered for wastewater treatment (municipal, agricultural and industrial). The Biovantage team demonstrated their 50-gallon bioreactor prototype. The team believes that, post waste-water treatment, the algae can be used as fertilizer or combusted for use as heat or electricity. The core part of their business is wastewater treatment with limited connection to renewable energy. However, this technology does hold potential benefits for farmers, including cleaning irrigation water, improving fertilizer application, and treating waste from CAFOs and dairies. A BioVantage engineer commented that 2% of all energy used in the U.S. goes to wastewater treatment. Bio Vantage still has much work to build a case that demonstrates how much their system saves over conventional energy technology. Assuming they can achieve their goals, this represents an interesting and relevant technology to the Ag Industry.

Figure 13: Photo of Bioreactor from BioVantage final report

Synergistic Building Technologies is focused on Greenhouse development, and has built a 1000 square foot test environment as a proof of concept. As design engineers, they are hoping to achieve the following: high levels of insulation with low levels of glazing, tight sealing across the entire building envelope, and minimizing temperature fluctuation through increased thermal mass. The single most interesting innovation is the insulated shutters that open and close automatically based on internal temperature sensors. The second leading innovation is the sheer number of temperature sensors throughout the greenhouse; they extend from beneath the soil to the top of the structure. These two innovations combine with insulated greenhouse doors, concrete blocks designed to increase thermal mass, and a fan-pipe system that pumps warm air from the top down into the soil. Synergistic is currently working on two larger commercial greenhouses (2000 and 3000 square feet respectively). Additional research and development is needed on the insulating shutters as well as the automated control system. This opportunity appears to be highly relevant, and could be accelerated with additional funds. Synergistic has now proven that their novel approach to greenhouse design is a dramatic improvement over current state-of-the-art, and is generating interest from other entities as well.

Figure 14: Larry Kinney (President) in front of Synergistic Building Technologies' Greenhouse

4. Impact of ACRE Program

The ACRE grant program has funded a variety of projects that provide clear value to the agricultural industry and the state of Colorado. Benefit to the agricultural industry includes number of jobs created, cost savings to farmers, environmental benefits, types of farming affected, and regions affected. Due to the types of projects funded and the lack of standardization in reporting, not every project has clear, quantifiable benefits. The following assessment is based on those projects where we found them available.

4.1. Matching Funds. The ACRE funding leverage is substantial. Figure 2 shows 23 projects where the match contributed 150% or more of the original ACRE funding . These 23 projects leveraged 1.5 times the value of the ACRE grant. (Because of the variation in reporting requirements, we were unable to verify the match on other projects).

4.2. Job Creation. Table 11 shows that 15 permanent jobs and 229 temporary jobs have been created by nine ACRE projects. For three of these projects salary and benefits of these jobs was estimated at $640,000 (Table 12). Tables 13 and 14 show the jobs that are projected for feasibility and research projects, which have not yet transitioned to implementation.

For two projects (both biofuels) that have been implemented, projected revenue is

$26 million annually (Table 15). One project that has been implemented saved $25,000. Five more projects implemented are estimated to save over $800,000 annually (Table 16). Table 17 shows projected revenues if projects are implemented or facilities built.

Table 11: Jobs created from implemented projects funded through the ACRE program

Permanent	Temporary	No. Projects
15	229	9

Table 12: Salaries and benefits for jobs created from implemented ACRE projects

Permanent	Temporary	Salaries and Benefits	No. Projects
14	190	$640,000	3

Table 13: Potential Jobs if projects are implemented

Potential	
Permanent	No. Projects
186-204	6
31-56 per facility built	3

Table 14: Potential Salary and benefits if projects are implemented

Potential		
Permanent	Salaries and Benefits	No. Projects
41	$2.495 million	3
21-41 per facility built	$1.05 million to $2.07 million	2

Table 15: Projected revenue for implemented ACRE projects

Projected revenue	No. Projects
$26 Million per year	2

Table 16: Avoided cost estimates from implemented ACRE projects

Avoided cost estimates	No. Projects
$819,655 annually	5
$25,000	1

Table 17: Potential revenue if projects are implemented

Potential	
Predicted revenue	No. of Projects
$128 million to $145 million annually	3
$100,000 per facility	1

4.3. Types of Farming Affected and Geographic Distribution of Projects. The ACRE grant program has impacted 20 types of farming and farm products. These areas span dryland and irrigated crops, animal husbandry, forestry, compost, and greenhouse production. Figures 1 and 2 (page 6) show the map and count of projects by county. ACRE has funded initiatives in 35 of Colorado's 64 counties.

4.4. Environmental Benefits. For those projects where we have verifiable data, a total of 550,000 gallons of diesel are saved annually by one project, 2,600,000 decatherms of natural gas are saved annually by two projects, and 240,600 kilowatt-hours of electricity are saved annually by three projects (Table 18). In addition to the above results, 5 implemented ACRE projects estimate that over 100,000 tons of greenhouse gas (GHG) emissions in CO2 equivalents are avoided annually. The cost for these GHG emission reductions ranges widely among the five projects, from $1 per ton CO2 equivalent annual reduction to $1727 per ton (Table 20).

Calculating an environmental return per ACRE $ invested is another primary recommendation, and will be discussed at greater length in Section 5 below. By quantifying an estimated environmental benefit return, the selection committee can more easily take projects that are materially different in scope and implementation, and quickly determine which ones are the most efficient. Though there may be extenuating circumstances, why would ACRE want to fund a project that will cost $1,000 per ton of CO2 saved over a project that will provide the same return for $1.00? This kind of return analysis is not difficult – it just requires some time and someone who is knowledgeable in the field. For those projects which have different systems of measurement (job creation, number of people trained), different decision criteria can be used. Ideally, ACRE will find its "sweet spot" in projects that have a job creation, knowledge advancement, and GHG reduction benefit, all in one. These objectives will be driven by a clearer RFP and application process.

Table 18: Energy reduction estimates for implemented ACRE projects

Gallons diesel annually	ACRE dollar spent per gallons reduced annually	No. of Projects
550,000	$0.18	1
Decatherms Natural Gas annually	ACRE dollar spent per decatherms reduced annually (average)	No. of Projects
2,600,000	$0.06	2

Kilowatt-hours (kWh) annually	ACRE dollar spent per kWh reduced annually (average)	No. of Projects
240,600	$1.47	3

Table 19: Energy reductions possible if projects are implemented

Potential	
Gallons diesel annually	No. of Projects
70,000,000	1
Therms Natural Gas Annually	No. of Projects
643,740	4
Kilowatt-hours (kWh) Annually	No. of Projects
1,314,000	2

Table 20: Greenhouse gas (GHG) reduction estimates for implemented ACRE projects

Estimated GHG reductions (tons CO2 equivalents annually)	ACRE dollar spent per ton GHG reduced annually (range)	ACRE dollar spent per ton GHG reduced annually (average)	No. of Projects
100,358	From $1 to $1727	$616	5

Table 21: Greenhouse gas (GHG) reductions possible if projects are implemented

Potential			
GHG reductions (tons CO2 equivalents annually)	ACRE dollar spent per ton GHG reduced annually (range)	ACRE dollar spent per ton GHG reduced annually (average)	No. of Projects
4,041,300	From $.01 to $1000	$241	6

5. **Recommendations to Improve the ACRE Program.** Before moving to recommendations for improvement, we want to reinforce the fact that the ACRE program is having success in a number of areas: 1) geographic distribution of projects, high correlation of projects to ACRE mandate and charter, relative success of projects as currently defined, reasonably efficient deployment of capital, reporting and follow up. Is there room for improvement in these areas? Absolutely – and we have identified below those areas where some relatively minor changes will yield a big impact on the ongoing development and success of the program.

5.1. Program Selection and Evaluation

5.1.1. Geographic Distribution. A primary goal of geographic distribution of projects throughout Colorado has been met in a very positive way.

5.1.2. Selection and Evaluation Criteria. Although the current selection and evaluation process has well defined criteria, some modifications to those criteria will ensure even more success. By defining clear quantifiable goals in the RFP, application and project scoping documents, and by establishing a reporting process that measures progress towards these goals, ACRE projects will achieve a higher correlation to their charter, have a clearer path to results, and cleaner documentation. Secondly, by following these steps, the quantitative measures will also link the goals to the results, enabling a clear evaluation of project success. Thirdly, ACRE managers and CAVAD Board members will more easily determine which projects merit additional funding. Lastly, by determining results per dollar spent, it will be easier to show actionable progress and secure future CO State funding.

5.1.3. Selection and Evaluation Metrics. Table 9 below shows recommended metrics to evaluate all ACRE projects, and are repeated in Table 10 for applicant selection, with the important goal of aligning selection and evaluation. These revised selection criteria are designed to be used in the same way as the original score sheet criteria. In addition to the changes listed below, we have applied a new weighting schema leaning more heavily towards quantified results. The primary changes are the following: 1) remove the criterion of "Quality of Presentation" (if it is poor, it should not make it to the application pool); 2) the addition of "Impact to Society" in the form of quantifiable environmental benefits (energy savings, water savings, greenhouse gas emission reductions, etc.); and 3) better definitions under the criterion "Benefit to the Agricultural Industry", now stated as the number of jobs created, new revenues created, cost savings to farmers, total types of farming impacted and number of agricultural regions affected by the project; 4) the former criterion "Degree to Which the Project Contributes to the Topic or Technology" has been redefined as the "Novelty of the Project". As before, the novelty criterion seeks advancement of knowledge and innovation, but also asks whether the renewable energy technology is proven. The selection committee will make their judgment here – we simply want clear recognition that unproven renewable energy technologies carry greater risk and are thus less likely to result in success.

We recognize that the role of ACRE is not to simply install renewable energy equipment, but also to drive potentially new agricultural applications of renewable energy in Colorado. In order to balance higher risk associated with funding research, novel projects and early stage feasibility, we also recommend a certain histogram of project types (see figure 16).

5.1.4. The Importance of Energy Efficiency (EE). As an important side-note, one project theme that remained lightly funded, and one component that was missing from many of the projects was energy efficiency. The easiest energy to save is energy that is never used. With that in mind, we highly recommend that ALL ACRE projects include an assessment of base line energy use as a fundamental requirement of participation. This requirement will need to be incorporated into the RFP and application process. This action is particularly relevant to those projects that are interested in installing any renewable energy equipment. An energy audit may reveal that it makes more sense to divert allocated funds to EE, or pursue a different project than to spend it on renewable energy (RE) associated with that particular program.

5.1.5. Post Project Evaluation and Funds Withholding. At least 6 months of data for installed working renewable energy equipment is needed to calculate the actual energy savings and other metrics. In order to ensure project metrics are evaluated, we recommend that a small amount of the total grant money is held back (e.g. 15%) until a final report is received. The final report will include quantified, measured, post project success metrics as well as a schedule showing final financial information about project. With these two components included as a mandatory part of the reporting process, it will be relatively simple to determine the grant dollar per metric achieved. The dollar expended per job created and the dollar expended per energy savings achieved can then be quantified and compared, and provided to the CAVAD board 2x per year.

Table 9: Decision Matrix criteria and weights

	Weight
Matching funds multiplier	**15**
% of funds that are levied by this project (must be >10%)	15
Benefit to the Agricultural Industry	**25**
Number of Jobs created - permanent and temporary	10
Revenue or projected revenue from new products, business expansions, or new markets for products	7
Total cost savings or avoided costs for farmers	3
Types of farming affected (total number of types and list of types)	3
Agricultural regions affected (total number of regions and list of regions)*	2
Likelihood of project success	**15**
Qualifications of applicants	3
Past success of applicants	3
Proven renewable energy technology	3
Number of government partners in place ~i.e. letters of support	3
Number of industry partners in place ~i.e. letters of support	3
Novelty	**20**
Has this type of project been done before (anywhere)? In Colorado? In an agricultural area?	10
Is the technology in question already actively used somewhere? In Colorado and working? In an agricultural area and working?	10
Environmental Impact	**25**
Energy use reductions (e.g. dollar spent per amount of kilowatt, therm, or gallon reduction)	8
Water use reductions (e.g. dollar spent per amount of water use reduction - cubic feet per second or acre foot)	9
Greenhouse (GHG) gas reductions (e.g. dollar spent per amount of GHG reduction)	9
Total:	

Table 10: Project success metrics

Matching funds multiplier
% of funds that are levied by this project
Benefit to the Agricultural Industry
Number of Jobs created - permanent and temporary including total salary and benefits for all jobs created
Revenue or projected revenue from new products, business expansions, or new markets for products
Total cost savings or avoided costs for farmers
Types of farming affected (total number of types and list of types)
Agricultural regions affected (total number of regions and list of regions)*
Environmental Impact
Energy use reductions (e.g. dollar spent per amount of kilowatt, therm, or gallon reduction)
Water use reductions (e.g. dollar spent per amount of water use reduction - cubic feet per second or acre foot)
Greenhouse (GHG) gas reductions (e.g. dollar spent per amount of GHG reduction)

5.2 Project categories

We recommend a new way to categorize the projects (Figure 15). The new categories - technical feasibility, economic feasibility, and implementation – will provide a more aligned focus to our other recommendations. Additionally, Figure 16 shows Statewide Resource Assessments as a 4th category, and also provides examples of previous ACRE projects, and how they would be applied in the new scheme. For instance, technical feasibility projects will consist of both technical feasibility studies and proof of concept testing. One example of a technical feasibility study was iCAST's Briquetting project that explored how biomass briquettes could be co-fired with coal to produce electricity. An example of proof of concept testing is Synergistic Building Technologies' greenhouse project, which set up a test greenhouse that used areas of glazing, heavy insulation and weather sealing atypical for conventional greenhouses.

Economic feasibility studies will focus on the project procurement plan, capital requirements, sales plan, investment and revenue schedules, and payback period. A good example of economic feasibility is The Colorado Farm Bureau project that analyzed the economic viability of a corn-based ethanol plant for Fort Morgan, Colorado. Several feasibility projects under current categories focused more on technical feasibility than economic feasibility. The new category recommendation clarifies this distinction.

The last category of projects is implementation. This category considers large and small-scale single and multi-site demonstration projects. One example of a large-scale single site demonstration project is Heartland Renewable Energy which used ACRE funds to

help with permitting for a facility in Weld County to turn dairy waste into methane for commercial sale. Nunatuk solar water tank project is an example of a small-scale single site project. iCAST's seed crushing project, which created two facilities that made biodiesel and SVO from locally grown vegetables, is a good example of a larger scale multi-site project. Lastly, Southeast Resource Conservation and Development Council's project set up customized wind turbines for five different farms, and is an example of a small scale, multi-site demonstration project.

Within these category suggestions, we also provide some guidance as to how best to allocate funds across categories. Historically, ACRE has spent the bulk of its funding on research projects, which, by nature are inherently more risky than any other types of projects (the viability of the RE technology is still unknown). Our recommendation is to shift the risk profile of ACRE funding towards projects that are known to work and will have quantifiable impacts and benefits to the agricultural industry today. To be clear, we still believe that ACRE should consider some early stage project research (under new categories, this includes technical and economic feasibility), but the % of funds allocated to these types of projects should be no more than 20% of the total spend.

A strong example of an early stage research project that is worth continued consideration are the surveys and resource assessments which is why we recommend setting them up in a category of their own: Stewart Environmental Consultants did a statewide resource survey of CAFOs and dairies to assess the potential of anaerobic digesters statewide. This resource (available online at Colorado State University 2011) has been useful to other ACRE projects working with CAFOs.

We see no reason to change the funding levels by category. Historically, ACRE has granted $25,000 for economic feasibility, $50,000 for technical feasibility, and up to $100,000 for implementation projects. Even though some project participants have requested greater funding levels, we agree that part of ACRE's core mission is to seed multiple projects and enable these projects to leverage other funding.

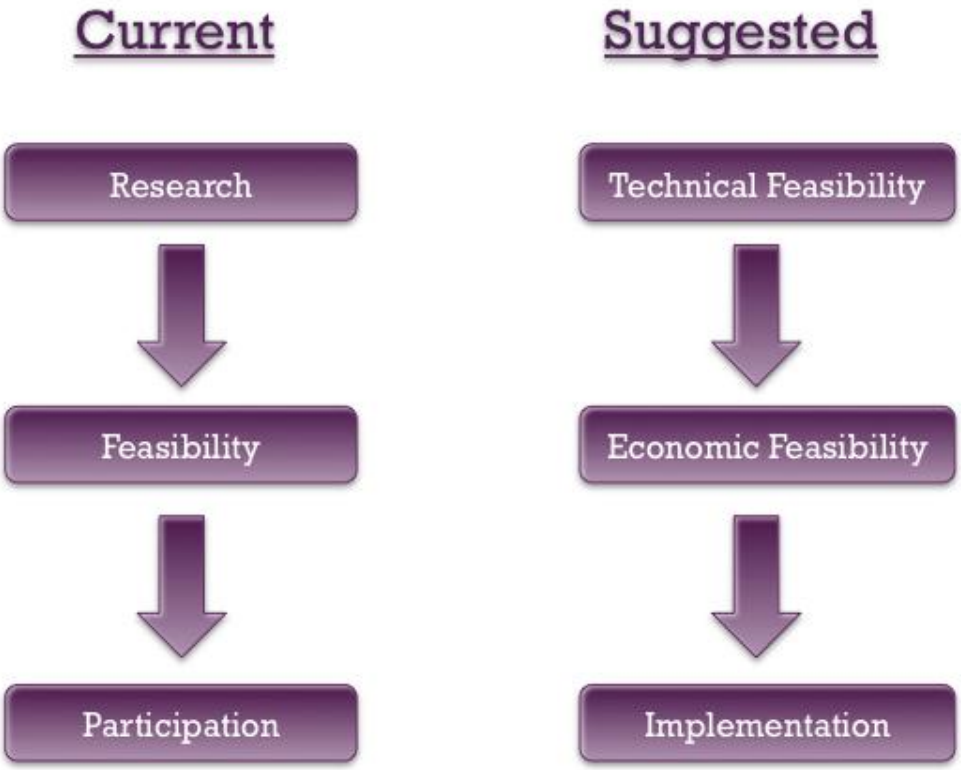

Figure 15: Current categorization of projects and suggested categories

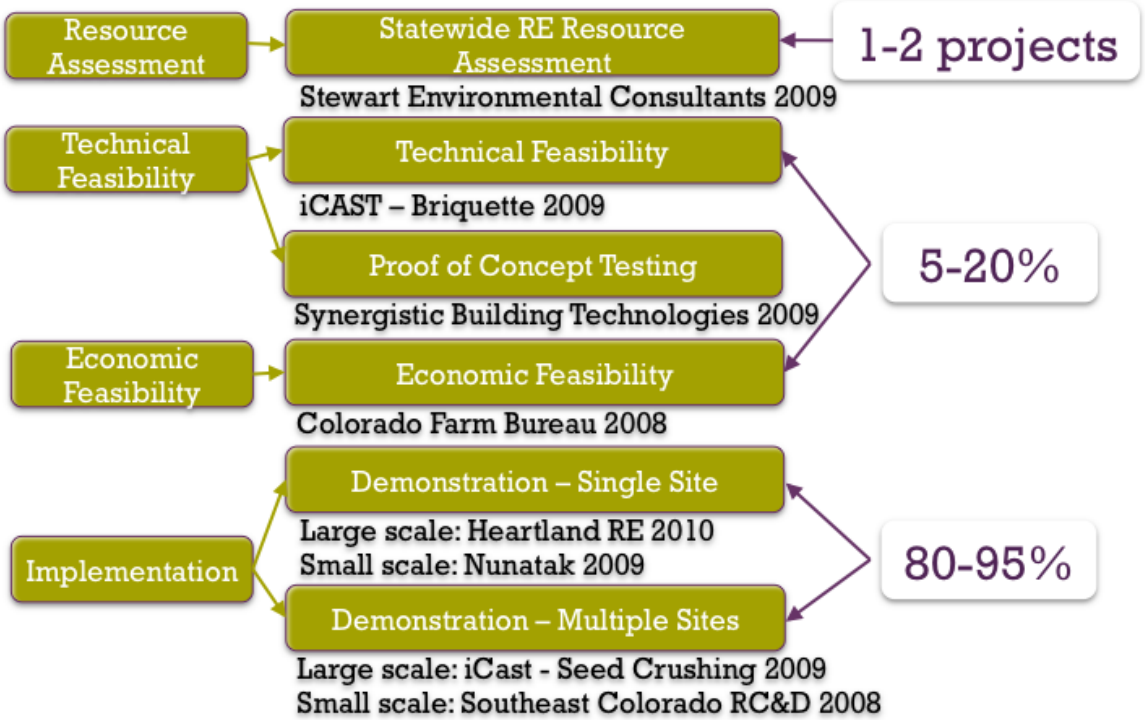

Figure 16: Proposed project categories and suggested funding goals

5.3 Project Risk. As mentioned above, ACRE can improve the risk profile of their project portfolio by allocating a smaller % of funding to research. Because of their early stage, research projects are inherently more risky than later stage implementation projects, and are challenging to quantify and measure return.

5.4 Stay within the category definitions and avoid repetition. The five year history of the ACRE program enables us to see which projects are successful, and which are challenged. In general, educational projects are difficult to quantify, and the two that ACRE has funded have been limited in their success. We recommend that ACRE avoid educational oriented projects in the future, unless they are combined with measureable, quantifiable "capital-in-the ground" components and are built around curriculum development, job development and training.

Interestingly, ACRE funding has paid for multiple biofuel facility and wind turbine economic feasibility studies. These studies applied to different geographic regions and economies, but the payback involved with conventional biofuels and wind turbines are well known. Private consultancies can produce this type of study within weeks and do so on a fairly common basis. We recommend that ACRE no longer fund feasibility studies that are related to well known and mature RE technologies.

It is critical that ACRE consider the end result of the project as well. We noted 2 studies that tested planting methods of oil seed crops, but did not necessarily support biofuel as an end result. The incorporation of quantifiable measures into the RFP and application process will help support this end result focus as well.

Lastly, in the past, ACRE has subsidized several individual farms with known renewable energy technology such as wind turbines, micro hydro turbines, or photovoltaics. We do not see these individual small scale projects, which have limited novelty, scalability or meaningful knowledge gain fitting well with ACRE's charter, and recommend avoiding such "one-off" projects going forward.

5.5. Quantifiable, Measurable Results. The ACRE program has heretofore not had a clear mandate for quantifying and measuring project results/impact. As a result, many of the projects have not provided clear information on success metrics. The charter of ACRE is to advance RE for the benefit of the agriculture industry within the state, and many RE technologies have well known impacts in terms of greenhouse gas reduction, barrels of oil of avoided use, kilowatt hours of avoided use, etc. This is a fairly easy change to implement in the funding process, starting with the application itself, and one that we recommend pursuing immediately. The added advantages of this approach are: align the selection and the evaluation process, make it easier to determine success, and with the appropriate reporting (see next section) enable contingency planning when projects do miss their mark.

5.6. Project Administration and Management. We see room for improvement in ACRE's project administration and management. Initial project scoping, timelines and ongoing reporting processes can be strengthened. Our recommendation is to supplement existing processes and reporting forms with the following: 1) A scoping document that includes quantifiable measurements and outcomes; 2) Quarterly financial reporting and tracking (including in-kind and outside funds); 3) Quarterly reporting that includes activities completed, barriers encountered, management issues, press coverage, budget overview and issues, and major changes in project scope or timelines; 4) A final report that includes a summary, quantified project metrics, photographs, budget overview, press coverage and other supporting material; and 5) A final accounting report that includes all in-kind donations and project leverage. These reports are all contractually required, can generally be done as "one-pagers" (with the exception of the final report), and provide complete documentation over the life-cycle of the project. Lastly, to ensure timeliness of completion of the Final Report, we recommend withholding the final 15% of the total payment commitment until such a time as the Final Report is received and accepted.

5.7. Timing and Reporting. Currently projects are treated on a case by case basis and project participants pick their own timelines for reporting information. With differing durations and timelines, keeping track of a portfolio of projects becomes increasingly complicated. Establishing dates for review of all projects according to a quarterly timeline is critical for project evaluation. Projects will always have differing completion (and likely start) times/goals, but interim reporting can be aligned across projects. We recommend a quarterly reporting timeline (Jan. 15, April 15, July 15 and Oct. 15), which times and frequencies can then be coordinated with CAVAD board meetings. As a matter of principle and contractual obligation, work should not be started before the contract is signed. Since the contracting process takes a couple months, expectations of a January start are unrealistic. To the extent possible, we recommend spending Q1 finalizing all contract agreements, with a target launch month of all projects in April and May, followed by strict adherence to the quarterly timetable suggested above.

During the interviews, most awardees expressed that they knew what was expected in their reports. In practicality, this did not prove true – the variation on both type of information and amount of detail provided is substantial. As previously discussed, a standard reporting format with more detailed guidelines is needed to accurately assess project success and provide early warning signals if the project strays off track. The ultimate goal of these reports is to provide complete documentation on the project, assist in the project management process, and make it easy to measure the success of the project based on agreed to outcomes/goals.

Due to the variation in timing and reporting requirements, the website was also missing information on a number of projects. We recommend updating the website once per year each December.

5.7. Outsourcing the ACRE Program Administration.

ACRE has, up to this point in time, performed the administration of the program in-house, using existing Dept. of Agriculture resources. The above recommendations will, without

fail, improve the results of an already worthy program. The question then becomes how best to implement them? To fully manage the potential of the program with appropriate RFP creation, application administration, review and scoring, project oversight, quarterly reporting and compliance, documentation, board reviews, final reporting and success metrics analysis, requires a dedicated resource with RE, project management and environmental engineering experience.

As mentioned in this report, the lack of standardized reporting and project oversight became increasingly evident as we analyzed the project results, and spoke with the awardees. One consideration for the Dept. of Agriculture and CAVAD board is to outsource the ACRE program administration to a knowledgeable, trusted third party. It may, in fact, be less expensive to perform that function with a knowledgeable 3rd party than to continue an in-house process, particularly if the Board agrees with the recommendations in this report, and wants better tools from which to select, evaluate and analyze projects and their relative success.

6. Conclusion.

The ACRE program is having meaningful success in achieving its overall charter. We can cite projects that have advanced knowledge, directly and indirectly benefited the CO agricultural industry, created jobs in rural communities, effectively leveraged ACRE's seed funding to bring in more $, benefited the environment in measureable ways, included a variety of project types and categories, and shown a broad, geographic distribution. All of this bodes extremely well for the future of the program.

Can the program be improved? Absolutely. We believe that the impacts quantified in section 4 can easily be tripled. To accomplish that goal will require that ACRE implement all of the recommendations in this document. As stated above, this could be done in house, but will likely require hiring someone with expertise in project management, RE and environmental engineering. Another option is to outsource the administration to a third party resource who has expertise in RE, EE, RFP creation and development, application processing and scoring, project management, compliance reporting and environmental engineering. This question of how best to implement change and administer the program merits real consideration on the part of the CAVAD board and the Dept. of Agriculture. To the extent that the StEPP Foundation can be helpful in providing some guidance and options around that decision, we stand ready.

Bibliography

Colorado Department of Agriculture (CDA), 2010. Application Categories. *Advancing Colorado's Renewable Energy Program*. Available at: http://www.colorado.gov/cs/Satellite/Agriculture-Main/CDAG/1215590455358 [Accessed December 8, 2011].

Colorado State University, 2011. eRAMS - Environmental Risk Assessment & Management System. Available at: http://www.eramsinfo.com/erams/resources/ [Accessed December 13, 2011].

Senator Isgar & et al., 2009. *Concerning additional funding for agricultural energy-related projects through the agriculture value-added cash fund,* Available at: http://www.state.co.us/gov_dir/leg_dir/olls/sl2009a/sl_256.htm.

Appendix A: Interview Questions for ACRE Grant Recipients

(Marketing Process) How did you hear about the ACRE Grant opportunity?
(Application Process) Were the application guidelines clear?
(Application Process) Did you have enough time to complete the application?
(Application Process) Were you notified of the grant award in a timely manner?
(Application Process) Did you receive a signed contract in a timely manner?
(Application Process) Did you start working on the project before or after the contract was signed?
(Project Process) Did you have enough time to complete the project?
(Project Process) Did you need to extend the project timeline? Why?
(Project Process) What reporting requirements did you have during the implementation of the project?
(Project Process) Did you have a clear understanding of what those reporting requirements were? (Formatting, content)
(Project Process) Did you have any difficulty meeting those reporting requirements?
(Project Process) Was the reimbursement process clear?
(Project Process) Did you receive payment for your reimbursement requests in a timely manner?
(Project Process) Did you have to make multiple requests for a payment?
(Grant Money) Would you have or could you have started this project without ACRE funds?
(Grant Money) Was the ACRE grant adequate for the scope and needs of your project?
(Grant Money) Did receiving the ACRE grant help leverage other funding?
(Partnering) Did you have project partners?
(Partnering) If so, what types of partnerships or collaborations were essential to the success of your project?
(Partnering) Did you have all partnerships in place before you started work on the project?
(Partnering) What other types of external support were needed for successful completion of your project (for example, funding, labor and expertise) ?
(General) Do you have anything else you would like to add to what has been said?

(Participation Projects) Has the project been completed to your satisfaction? If not, what setbacks or challenges interfered with the project?
(Participation Projects) How many jobs, permanent and temporary, have been created by this project?
(Participation Projects) What revenue from new products, business expansions or new markets was achieved by this project?
(Participation Projects) What cost savings or cost avoidances were achieved by this project?
(Participation Projects) What types of energy savings were achieved or are achievable by this project?
(Participation Projects) How many power savings were achieved or are achievable by this project?

(Participation Projects) How many water use savings were achieved or are achievable by this project?
(Participation Projects) How many greenhouse gas (GHG) reduction were achieved or are achievable by this project?
(Participation Projects) Is this an economically viable application of a renewable energy technology?
(Participation Projects) Would the economics of the project have worked out without the grant money?
(Participation Projects) Has anyone asked about the project with interest in setting up a similar project in a different location?
(Participation Projects) Would you do this project again?
(Participation Projects) Would you suggest to other producers to start a similar type of project?
(General) Would you like to add any other comments about the ACRE program in general, or about your project?"

(Feasibility Projects Only) If the project was determined to be feasible, has the project been built, or is it in the process of being built?
(Feasibility Projects Only) If yes, where did the funding come from to build the project?
(Feasibility Projects Only) If not, why not? Is it no longer considered feasible? Why not?
(Feasibility Projects Only) How much money do you estimate you saved by not continuing to build the project?
(Feasibility Projects Only) How many jobs, permanent or temporary, have been created by this project?
(Feasibility Projects Only) Has anyone contacted you about your feasibility study?
(Feasibility Projects Only) If so, what was their interest?

(Research Projects Only) Did this project lead to other work? If so, what type?
(Research Projects Only) Has this project led to any commercialization or demonstration of the topic researched? If not, why not?
(Research Projects Only) If yes, where did you get the funding for implementation?
(Research Projects Only) How many jobs, permanent or temporary, have been created by this project?
(Research Projects Only) Has anyone contacted you about this research?
(Research Projects Only) If so, what was their interest?

(Other Projects Only) Did this project lead to other work? If so, what type?
(Other Projects Only) How many jobs, permanent or temporary, have been created by this project?
(Other Projects Only) How did you publicize this project? How many media outlets were contacted?
(Other Projects Only) How many ads, articles or other publications were produced? (for example, TV, radio, newspaper or online stories)
(Other Projects Only) How many people did you contact through this project?
(Other Projects Only) How many government or industry leaders responded to your outreach?

(Other Projects Only) Has anyone contacted you about this project?
(Other Projects Only) If so, what was their interest?

Appendix B: Site Visit Questions and Responses

Site visit: BioVantage Resources
Location: 700 Corporate Circle, Ste H, Golden, CO 80401
Date/Time: 11/22/11 12:45-2:15 PM
Attending: 4 people:
Sam Anderson (StEPP Foundation)
Mike Veres (founder and operations manager)
Adam Wolach (administrator)
Matthew Donham (engineer)

Projects:

A. Biovantage Resources: Bioreactor pilot. (Funding Year 2010: Project Completed October 2010)
B. Biovantage Resources: Cataloging indigenous strains of algae. (Funding Year 2011: 2011-ongoing)

1. What notable successes or accomplishments have you achieved? **A. Achieved objectives of refining light rods for efficient distribution of light. Currently marketing photobioreactor. B. Collected and cataloged 30 strains of algae to date.**
2. Please show me and explain what you have accomplished so far with funding from the ACRE program. **Showed me prototypes of light rods from the R&D of their bioreactor; a working 50-gallon unit undergoing testing; a complete prototype unit; working lab where strains of algae are being isolated in small flasks; a growing room where isolated strains are cultivated; a growing room with several small bioreactors undergoing testing with various algae strains.**
3. What types of work is BioVantage Resources involved with? **BioVantage is focused on algae bioreactors and applications of bioreactors and algae for wastewater treatment; developing wastewater treatment applications for municipal, agricultural and industrial facilities with plans to develop applications for biomass derivatives.**
4. How far along was this idea before you heard about the ACRE grant? **The first crude prototype of a bioreactor was completed just before the first proposal was submitted.**
5. How does the amount you won for the ACRE grant compare to your total budget (as a percentage)? **The two ACRE grants have provided about 6-7% of BioVantage's operating budget.**

6. What led you to apply for a second research project from ACRE in this area? Did you consider other funding sources? **BioVantage applies for all available funding including federal grants.**
7. How does this project help to advance renewable energy in Colorado? **The algae biomass is a carbon-neutral way to store solar energy for applications such as CHP and electric power generation.**
8. How does this project help to advance renewable energy applications in Colorado's agriculture industry? **The algae biomass can be used as a fertilizer or for direct combustion for applications such as heat and power for agricultural applications.**
9. Where does your project fit in with other research that has been done or is ongoing in this research area? **In addition to novel applications, the bioreactor is a novel design which has been sold to researchers at several universities. Bids have been submitted to several private and international labs as well.** What is unique about your approach to this research? **This technology is being used at Colorado School of Mines to evaluate its efficacy as a low-cost wastewater treatment method.**
10. How do you see the technology and research you worked on playing out in increasing renewable energy use in Colorado's agricultural industry? **Not clear. Biomass is a form of stored solar energy.**
11. What impact does this project hold for agricultural producers (farmers and ranchers) in Colorado? **The primary benefits to farmers include resource conservation and recovery of agricultural inputs such as irrigation water, more efficient fertilizers and treatment of dairy waste and other effluents from agricultural operations. This technology could also help bring many rural wastewater treatment systems back into compliance with existing and new environmental regulations.**
12. What has the bioreactor been used for since its development? **Testing and growing new algae strains.**
    How much, if any, biofuel or bioenergy has been produced using algae? **None.**
    How much does it cost to produce biofuel from algae with this reactor design? **Withheld comment to avoid disclosure of sensitive/proprietary information.**
    How does that compare to other methods of producing biofuel? **N/A**
13. Based on the current status of your research, is this a technically viable renewable energy technology? **This technology is definitely commercially viable.**
14. What is the expected commercial scale of this technology? (annual production capacity – energy capacity or energy savings) **A large algal wastewater treatment facility might process 30 to 100 million gallons of water per year and result in $100 thousand per year in avoided costs through CHP and environmental fines.**

15. Are there plans for building commercial scale applications of this technology? **BioVantage is ready to do so but regulatory barriers prevent it. China would be more favorable.**
    If not, how soon do you think this technology could be commercialized? **Depends on approval by regulatory agencies and adoption by wastewater treatment industry.**
16. What are the primary barriers to commercializing this technology? (BioVantage as a company) **The bioreactor technology doesn't face any significant barriers but regulatory barriers in Colorado prevent implementation of the wastewater treatment technology. CDPHE would need at least one year (four seasons) to evaluate this technology for wastewater treatment.**
    (and for the industry)? **The wastewater treatment industry is not interested in new, unproven technologies such as algae-based wastewater treatment.**
17. How much venture capital would be required to develop a full-scale working plant in Colorado? **Retrofitting a working municipal wastewater treatment system might cost $300 thousand. A new, full-scale facility could cost $1 million to start up.**
18. How many permanent jobs could be directly created to operate a commercial plant? **One to eight permanent jobs to operate the wastewater plant plus auxiliary jobs.**
19. What impact would a full-scale working plant have for energy savings and water savings in Colorado? **(See Question 14.) May improve removal of toxins from wastewater.**
20. What difficulties or mitigating circumstances are you currently experiencing? **None.**
21. What are your next steps for this project? **A. (first project): the photobioreactor is a stable system and market-ready; currently focused on refinements and optimization.**
    B. (second project): Cataloging isolated strains of algae will be complete by January, 2012 (at least 30 strains). BioVantage is also pursuing applications in aquaculture and industrial wastewater treatment.

Notes and observations:

Comment from Matthew: 2% of all energy used in the U.S. goes to wastewater treatment.

Location:___Cure Organic Farm, Boulder CO_____
Date/Time:__11/11/22 3:35 pm_- 5:02 pm_____
Attending:___Larry Kinney (President Synergistic Building Technologies)
Abigail Clarke-Sather (StEPP Foundation)_____

Evaluation of The Colorado Department of Agriculture ***Advancing Colorado's Renewable Energy (ACRE) Program***

Projects:

A. Synergistic Building Technologies: Practical Green Greenhouse Development I (Funding Year 2009: Project Completed February 2011).
B. Synergistic Building Technologies: Practical Green Greenhouse Development II (Funding Year 2010: Project Completed August 2011).

1. What notable successes or accomplishments have you achieved?

   Created proof of concept greenhouse with good mobile insulation, high thermal mass, good air sealing that uses nearly no fossil fuel input by using only the sun for heating and maintains temperatures of 50 degrees Fahrenheit inside even when it is -18 degrees Fahrenheit outside
2. Please show me and explain what you have accomplished so far with funding from the ACRE program.

   Larry Kinney showcased the automated insulated shutters, the temperature sensors through out the greenhouse – from bottom in the soil, to the top near the fan and window shutters, the insulated greenhouse doors, the concrete blocks used to provide structural support and thermal mass in the greenhouse, the fan-pipe system that pumps warm air from the top of the greenhouse down under the soil the length of the greenhouse
3. What types of work is Synergistic Building Technologies involved with?

   Energy efficiency for buildings, daylighting, insulating shutters. Applied these concepts to greenhouses
4. How far along was this idea before you heard about the ACRE grant?

   The insulated shutters idea had been conceived of for 25-30 years prior. The idea to build a greenhouse and apply for the grant was put together after Larry Kinney heard about the grant program.
5. How does the amount you won for the ACRE grant compare to your total budget (percentagewise)?

   During the time of the ACRE project the grant money was about 50% of Synergistic Building Technologies' budget. Now it is less about 7% of the budget.
6. What led you to apply for a second research project from ACRE in this area? Did you consider other funding sources?

   In order to finish work on the greenhouse more money was needed. Synergistic Building Technologies originally applied for $100,000 but the grant funding amount for a research project was only $50,000. CDA was happy with their previous work so Synergistic Building Technologies put together another proposal to start work on greenhouse controls and sensors. In the extended time period of the project Synergistic was able to do more outreach such as creating a video that the CDA Value Added Ag Products Board was shown.
7. How does this project help to advance renewable energy in Colorado?

This project looks at how to make "renewable food" as well as renewable energy. By this Larry Kinney means food that can be grown locally in Colorado with little energy all year round and travel a short distance and time to get to Coloradans' tables. Thus fossil fuel use and energy costs are reduced,

8. How does this project help to advance renewable energy applications in Colorado's agriculture industry?

   Reduces high energy costs and fossil fuel use by greenhouses using passive solar design, insulation, thermal mass, and high reflection of light instead of high amounts of glazing.

9. Where does your project fit in with other research that has been done or is ongoing about greenhouse energy use? What is unique about your approach to this research area?

   Synergistic Building Technology's research is not based on other greenhouse research. This research takes building science concepts and applies them to greenhouses. Unique approach to greenhouse designs includes (1) low levels of glazing with high levels of reflectivity including light shelves and white interior surfaces (2) high levels of insulation and heavy weather sealing, and (3) high levels of thermal mass. This approach to greenhouse design makes it easier for the greenhouse to maintain interior temperature and keep temperature swings to a minimal range.

10. How do you see the technology and research you worked on playing out in increasing renewable energy use in Colorado's agricultural industry?

    No Response

11. What impact does this project hold for agricultural producers (farmers and ranchers) in Colorado?

    Right now this research only helps one farmer, Anne Cure. In the future this design could be used to help many farmers start plants earlier and extend the growing season.

12. What has the greenhouse grown so far since its construction? What has the yield of those crops been? What are the costs per square meter for the greenhouse (construction and energy use)? How does that compare to a conventional greenhouse?

    1000 tomato starts were grown in the greenhouse last winter and sold for $5/6 a piece. Costs per square meter are difficult to quantify for this greenhouse since labor was mostly donated to build the greenhouse and its value was not quantified. It took 3 months to build the greenhouse. Material costs were $30,000. The second generation design for this type of greenhouse costs about $80 per square foot. The goal for the third generation greenhouse design is $60 per square foot. The greenhouse is 1000 square feet. Conventional greenhouses run from $30 to $100 and up per square foot.

Energy costs for the greenhouse have been $9 since this summer. Conventional greenhouses have energy costs for just heating around $4 per square foot.

13. Based on the current status of your research, is this a technically viable renewable energy technology?

Yes. The sun is not going to run out of energy any time soon.

14. What is the expected commercial scale of this type of greenhouse design and automation technology? (annual production capacity – energy capacity or energy savings)

This type of design compared to conventional greenhouses cuts energy costs by half.

15. Are their plans for building commercial scale greenhouses of this type? If not, how soon do you think this technology could be commercialized?

Right now Synergistic is being asked to work on energy efficiency improvements for a 100,000 square foot greenhouse. There are also plans or construction started on four other greenhouses, one is a 3000 square foot greenhouse used by a Denver area restaurant that grows some of its own food, another is 2300 square feet, the final two are greenhouse additions to houses and 640 and 400 square feet respectively. These greenhouses in planning and under construction represent the second generation of this technology. Synergistic is working on a third generation, which will include improvements to window shutters and the controls with an eye to reduce costs.

16. What are the primary barriers to commercializing these types of greenhouses and greenhouse control technology? (From the perspective of industry/other researchers working on the problem and from Synergistic Building Technologies in particular)?

Primary barrier to continuation of research and improvement of greenhouse design is lack of start up capitol for the business. which would require a more concrete business plan.

The shutters need improvements in mechanics and manufacturing in order to reduce costs. However quality shouldn't and won't be sacrificed just to make the technology cheaper.

17. How much venture capital would be required to develop a full-scale working commercial greenhouse in Colorado?

10 million. Also looking beyond Colorado for market opportunities.

18. How many permanent jobs would be created through the commercialization of this greenhouse design?

Estimates 10 to 15 jobs.

19. What impact would a commercial scale greenhouse have for energy savings and water savings in Colorado?

This greenhouse design hardly uses any energy. This greenhouse design also uses significantly less water, about one tenth the amount of conventional greenhouses. Most greenhouses vent during the day and lose both heat and

moisture. The high amounts of thermal mass in this greenhouse design keep the temperature from reaching extremes, too high or too low, reducing the need for venting and heating. This greenhouse is very well-sealed so heat and moisture do not escape. The system that recirculates heat from the top of the greenhouse to below the soil also moves moisture from the warm air high in the greenhouse into the soil where the water stays and is located near the plants where it is needed.

20. What difficulties or mitigating circumstances are you currently experiencing?

    Trying to run a business with no money. Has not been able to pay himself for his work. Difficult to borrow money, bankers are suspicious of new technology.

21. What are your next steps for this project?

    Improve the greenhouse design, controls, and sensors. Find better ways to move energy. Work on making building the greenhouses more cost-effective while still maintaining quality. Produce second generation greenhouses and do outreach and marketing of these greenhouses with a video. Look for grant funding for further sensor and electronics design. Market the greenhouses more heavily in order to attract private funding. Twelve people have called about the integrated greenhouse design and shutters. Has a proposal out for a demonstration greenhouse.

Notes and observations:

Greenhouse inside temperature was very comfortable even after the sun set. A few starts had come up in the greenhouse but it was largely empty.