Final Report

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NRCS Agreement Number: NRCS 68-3A75-6-125

Grant Title:
"Utilizing Wind and Solar Power for Alternative Water Supply for Cattle in Coastal Georgia"

Date Submitted:
8 April 2011

NRCS CIG Agreement Number NRCS 68-3A75-6-125
Final Report Submitted to USDA NRCS CIG Program on Behalf of The University of Georgia

The following materials are submitted as the final report for the original grant agreement number NRCS 68-3A75-6-125 which was granted to The University of Georgia.

Summary:

Livestock located in remote pastures and grazing areas need water. As programs through NRCS and other agencies are working to protect water sources from pollution, one of side effects is that livestock are removed from these water sources. These sources of water may in some cases be the only source of water for livestock in remote locations. The removal of livestock from waterbodies is a good thing to produce better water quality; however, the livestock still need water and hence the purpose of this CIG project. Hybrid wind/solar systems were installed (where applicable) to provide a source of water for livestock that have been removed from natural sources of water (ponds, creeks, streams). The project installed systems in locations including Georgia and South Carolina. The systems as installed are functional in providing water. Multiple workshops, displays and information dissemination opportunities have been used to promote the use of solar for providing water to livestock in remote locations. The cost of the systems varies as based on the pump type and size used, the number of panels required for producing the required power, water storage and add-ons to provide a source of back-up power as needed by the farmer due to cloudy days or extended low solar radiation. Overall the installed systems have and continue to work as designed and will provide water for livestock in remote locations.

Introduction:

The use of alternative energy sources has been of increasing importance over the past 5-10 years and specifically the past 6 years. One of these minor alternative energy sources is the use of solar photovoltaics for the production of electricity. Generally solar is considered to only provide 0.1 percent of the BTUs of energy in 2008 (Figure 1) and is the same as the 2005 year as reported by the Department of Energy.

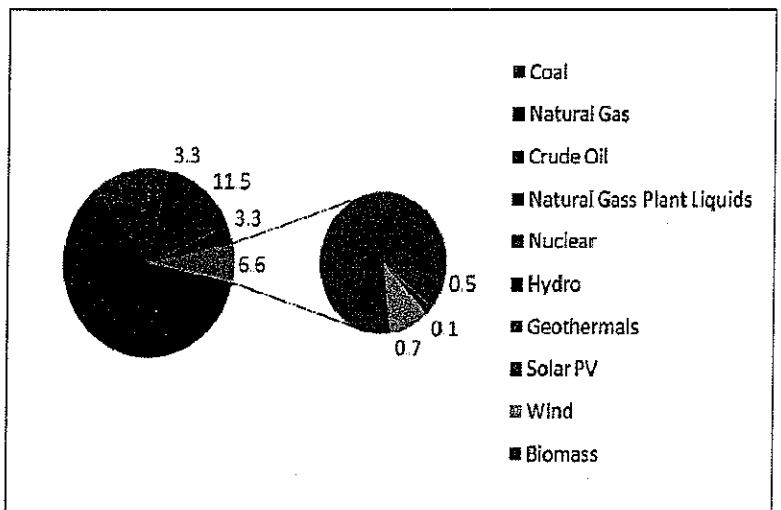


Figure 1. Energy produced in 2008 by type. Graph produced from data reported by Dept of Energy

However, solar has potential in various operations and the use of solar is increasing for agricultural uses. One use of solar is in the transfer of water for providing drinking water to livestock in remote locations without electricity.

Reason for Project and Objectives:

Solar as mentioned has a place in providing electricity for livestock watering where power is not readily available. As farmers practice rotational grazing to promote better livestock weight gain, better land management and better water management the use of smaller grazing areas are needed. Some of these grazing areas have natural water sources such as streams or ponds whereas some have no source of natural water. In the Southeastern states (GA, SC, FL, AL, NC, TN), water quality is an issue that gets a lot of attention as it relates to agricultural production. One source of this potential water pollution in these waterbodies is livestock access for drinking.

NRCS and other agencies have been working with farmers on two main issues as it relates to livestock and BMPs. These are exclusion from waterbodies and rotational grazing. Both programs are very beneficial for both the farmer and the environment. However, when livestock are removed from waterbodies for water quality purposes, they are also removed from their only source of drinking water. And added to that, when the grazing area is separated into smaller paddocks for the use of rotational grazing, the livestock is removed from any source of water and generally is located in areas where electricity is not available or is available but the closest power pole is a distance away (> ¼ mile). This distance maybe cost prohibitive based on the electric provider.

Therefore, this project was drafted to accomplish the following objectives:

- Demonstrate that wind power in combination with solar power can be used to economically supply water to livestock in remote regions of coastal Georgia where line electricity may be limited.
- Explore the possibility of other uses of hybrid systems and agro-tourism for the rural regions of Coastal Georgia.

As the project advanced, and due to movement of urban areas into traditionally agricultural regions on the coast of Georgia, the project was slightly modified (with approval from NRCS) to accomplish the following objectives:

- Demonstrate that wind power in combination with solar power can be used to economically supply water to livestock in remote regions of coastal Georgia where line electricity may be limited.
- Demonstrate the use of hybrid systems (where applicable) to economically provide a water supply to livestock in Georgia, South Carolina and Alabama.

Project Location and Size:

The location(s) for this project were in Georgia and South Carolina. The locations of the farms can be seen on the map in Appendix A.

What was done to meet project:

Design of system:

Each system was designed specifically for the situation and the farm of interest. The general design consisted of working with the farmer on the following points:

- Number of cows in current herd and any potential expansion (number includes all cows)
- Static water level in well
- Depth of well
- Location and distance of water trough from well location
- Size of pipe proposed for use to transfer water
- Height differential for water trough location and well location

Once this information was determined, a system was designed to find a DC solar pump that would meet the water requirements of the livestock. The pump was sized and the solar panels specified. Once a general design was determined, the specifications were sent to a company involved in the design and sale of solar livestock watering systems. The company then either confirmed or changed the design to meet the requirements of the proposed system. Once a system was finalized, it was purchased and installed at the farmer's field.

As would be expected, each system was different and consisted of various pump models, solar panel array sizes and control box specifications. Two of the installed systems also have wind turbines installed to determine and demonstrate the use of wind to power the system.

Two of the systems (the two wind turbine systems) have a battery system installed. The battery is needed to store the wind turbine power as well as to store solar energy for use later. These two systems also have a pressurized tank system to help "push" water to the cattle watering stations since the elevation difference from the holding tank is negligible.

One of the systems has a pressurized tank and a AC Power pack interface. The power pack interface is provided to demonstrate the use of such a system to get away from a battery bank. If the solar array does not provide ample power due to multiple days of cloud cover, the power pack will allow a small generator to be connected to the system for pumping water to the watering locations.

One of the systems has a non-pressurized tank and an AC Power Pack. The tank is 1500 gallons and is located at an elevation at least 10 feet above the watering station. The tank will hold enough water to supply the herd with water while also having at least a two day supply in case of bad weather or cloud cover. The AC Power Pack is also attached to demonstrate the use of a system that can be installed to provide power from a small generator in case of extended low solar power.

Operation of the Solar System:

The installed systems have operated as expected from time of installation. The systems were designed with multiple safety features. Some of these include: 20 gallons per cow per day of water requirement, extra head pressure to account for well drawdown, pipe friction, any future restrictions in water lines, extra head to account for unforeseen head pressures not realized during design.

With the design of the system being based off of the above information (in "Design of System" section above) and the little extra design parameters listed in the previous paragraph, all systems are working as expected and designed.

Some unique aspects to the project are:

- Farmers with batteries have to check for water levels in batteries monthly.
- Farmers with storage tanks have to make sure tanks are clean of algae.

Overall, the demonstration sites have been installed and are working as designed.

Education and Outreach:

The Conservation Innovation Grant (CIG) Program is designed to demonstrate innovative use of technology on farm. Part of the CIG is also designed to disseminate information to other farmers. To accomplish the dissemination of information various activities have been accomplished. These include:

- articles in popular press
- solar workshops for farmers and citizens in non-farming roles
- multiple displays at a National Farm Show
- multiple presentations to school age kids
- trainings and presentations to NRCS personnel
- presentations to professional organizations
- display at meetings
- NRCS and Extension bulletin (scheduled)

Articles in Popular Press:

Multiple articles have been written in popular press magazines to disseminate information on the use of solar and wind where available to provide water for livestock in remote locations. One of these articles is presented in Appendix B-1.

Solar Workshops:

Two workshops have been conducted. One was organized by the local NRCS personnel and Extension Agent and the second was organized by the project director and Extension agent. Both were geared towards farmers and the use of this technology for providing water to livestock in remote locations. Both workshops also provided additional contacts of persons interested in installing systems on their farms. Flyers and presentation covers can be seen in Appendix B-2.

Multiple displays at a National Farm Show:

The solar watering system was displayed at the Sunbelt Agricultural Expo two different years. The purpose of the display was to demonstrate the use of the solar watering system for remotely located livestock. Both years, the project director discussed the system with over 300 farmers over the three day event. The interested farmers were from locations across the US. As the discussions proceeded, there were a few farmers that wanted to buy the system that day for installation on their farm. This means of disseminating information to the public can't be directly measured, but is one very visible means to discuss the use of this technology with the farming community as well as others interested in solar power. Pictures can be seen in Appendix B-3.

Multiple presentations to school age kids:

This means of outreach does not directly interface with farmers, but it provides education to the next generation of farmers, land owners and educators. The presentations were designed to make the students aware of how solar panels work, how they can be used, used solar panels and pumps to demonstrate how the system works and used small panels to explain how panels can be combined to provide the power needed to do various operations. This form of outreach has reached over 600 students from the second grade to high school FFA/Agricultural students.

Trainings and presentations to NRCS personnel:

The dissemination of information to NRCS personnel has occurred at the State level in regional trainings as well as National Trainings. The result of the training was the two workshops listed in the "Solar Workshops" section above. Additional trainings and presentations have been at National Trainings for NRCS State Level Staff. These were for both the Northeast and Southeast regions of NRCS. As a result of this project, additional training is being planned to train Georgia NRCS personnel on the design and installation of solar powered systems for livestock watering. Presentation covers can be seen in Appendix B-4.

Presentations to professional organizations

Information has been disseminated to National and local professional organizations such as Soil and Water Conservation Society, American Society of Agricultural and Biological Engineers and National Association of Natural Resource Extension Professionals. Presentation covers can be seen in Appendix B-5.

Display at meetings

The solar powered pump system has been displayed at meetings such as the Annual Georgia Farm Bureau Commodity Committee Meeting and the Annual Georgia Soil and Water Conservation District Supervisor Meeting. These meetings and others like them provides a visual display of the use of solar power to provide water for livestock. Pictures can be seen in Appendix B-6.

NRCS and Extension bulletin (scheduled)

Plans are being made to produce a NRCS and Extension bulletin on the design and use of solar power to provide water for livestock. These publications will be available to all interested in designing and installing such a system.

Presentations:

Presentations were given at the following locations to disseminate information on the solar powered irrigation system:

1. 2009 CIG projects across Georgia. GA NRCS State Technical Committee Meeting. 23 July 2009.
2. 2009 Georgia Environmental Conference. "Farming with Alternative Energies – Solar, Wind, Anaerobic Digestion". 26 August 2009.

3. 2009 Northeast Technology Workshop. Solar Pumps for Irrigation and Other CIG Projects. Avalon, NJ. 14 October 2009.
4. 2010 UGA Winter School. 2010 Energy Update: Busting Myths about Alternative Energy. UGA Extension Agent Training 2010.
5. 2010 Solar Power workshop. How to use Solar Power for Livestock Watering. Ben Hill County, 20 August 2010.
6. 2010 Growing Power Conference. Innovative Tools and Best Practices for Regenerating Small Scale "On the Farm Energy" Projects. Milwaukee, WI. 11 September 2010.
7. 2010 South Central Georgia Solar Workshop. Solar power 101; The Basics of Solar energy. 25 September 2010.
8. 2010 Southeast Technology Workshop. Energy as a Resource Concern: Opportunities and Challenges Practical Uses of Solar Energy on the Farm. Tifton, GA. 2 November 2010.
9. The solar panels and information gained has and will also be used in college level classes of students majoring in some form of agriculture.

Cost of System:

The cost of each system varied based on the design of the system. The systems ranged in cost from $4000 to $8000. These systems were based on the cost of the pump used, the cost and number of panels and the control system used. During the project three different pumps have been used, all with a different cost. The three types of pumps used were Lorentz, Grundfos and Sun Pumps. Additionally, the pumps used required different voltages and therefore different number of solar panels based on the power requirements. Therefore, as the solar system is designed, the price is not constant from system to system and should be accounted for when designing a solar system either for purchase or in the case of NRCS cost-share of a renewable energy practice or part of a standard.

Benefits and Drawbacks:

The systems as installed have both benefits and drawbacks as you would expect. Some of these are listed below:

Benefits:

1. The system can be designed to pump water from shallow depths (0 feet of head) to very large depths (at or slightly above 600 feet of total dynamic head),
2. The system can be used in very remote locations if solar power is available,
3. The system can be used with or without batteries,
4. The system can be used with a storage tank,
5. The use of a similar solar system will provide "free' electricity for 20-30 years.

Drawbacks:

1. A system, as installed, if placed within close proximity of an AC power source will not pay for itself within the useful life of the system unless you can get greater than 50% of the system paid,

2. There is a limit of the DC pumps to provide large volumes of flow at medium or large total dynamic heads (greater than 100 feet),
3. If the system is used without a battery bank, the potential of intermediate cloud cover can cause problems with the pumping volumes,

Lessons Learned:

Some of the lessons learned from the installation of the solar system for providing water for livestock are:

1. REMEMBER – Solar Panels are ACTIVE as soon as the sun hits the panel!!!!!!!!!!!,
2. The weight and size of solar panels should be accounted for when designing the support structure,
3. If a building is being used, then the roof line, if possible, should be designed to capture maximum solar radiation,
4. The head pressure including all forms of friction should be accounted for when designing the pumping system,
5. There should be a "safety" factor included in the design for unexpected problems that may arise – these may include but are not limited to static water depth, depth of well drawdown, pipe friction, size of pipe and number of livestock, and
6. The number of livestock should be based on the number of expected cows in future years not the current number of cows (or at best the larger of the two numbers),
7. When buying solar panels, it is best to keep the same size panels if at all possible. By doing this, voltages and amperage outputs will match and cause less problems,
8. To insure proper voltage and amperage for the pump, the panels need to be installed in proper series and parallel configuration to get desired output,
9. When a battery system is used, be careful that a breaker system is used not just a disconnect switch in case of short circuit,,
10. The maximum power from the solar panels will occur in the middle to early afternoon. The sun will be shinning in the early morning and late afternoon, but the maximum solar radiation will occur around noon, and
11. Check with insurance company to determine if system will be covered in case there is a lighting strike or other reasons that the system may get damaged.

I expect there are others, but these are the main lessons that we learned from the installation and operation of the system.

Other Locations and Conditions of Technology Application:

This technology should have very few places where it would not be appropriate to use. By that I mean, if there is a clear area from early morning to late afternoon then the solar system will produce power. However, some of the things that needs to be accounted for in such a system is the angle of the panels to the sun, the potential of shadows crossing the panels and the amount of radiation in the area of interest for

installation. In areas where the solar radiation is low, then the panels will produce power, but they may not provide the rated power. On that same line, the number of solar day light hours is important in the amount of power that can be produced. The lower the number of solar daylight hours the lower the daily output of power.

In terms of limits on the watering pumping system as described here, the only limits would be the head and flow rates from the pump. The solar panel array can be designed to provide the needed watts. The pump however has a limit on the pressure head it can produce and the flow at various pressure heads. Therefore, the only limit with livestock is the amount of water needed, the number of solar daylight hours, and the pressure head and the flow rate required.

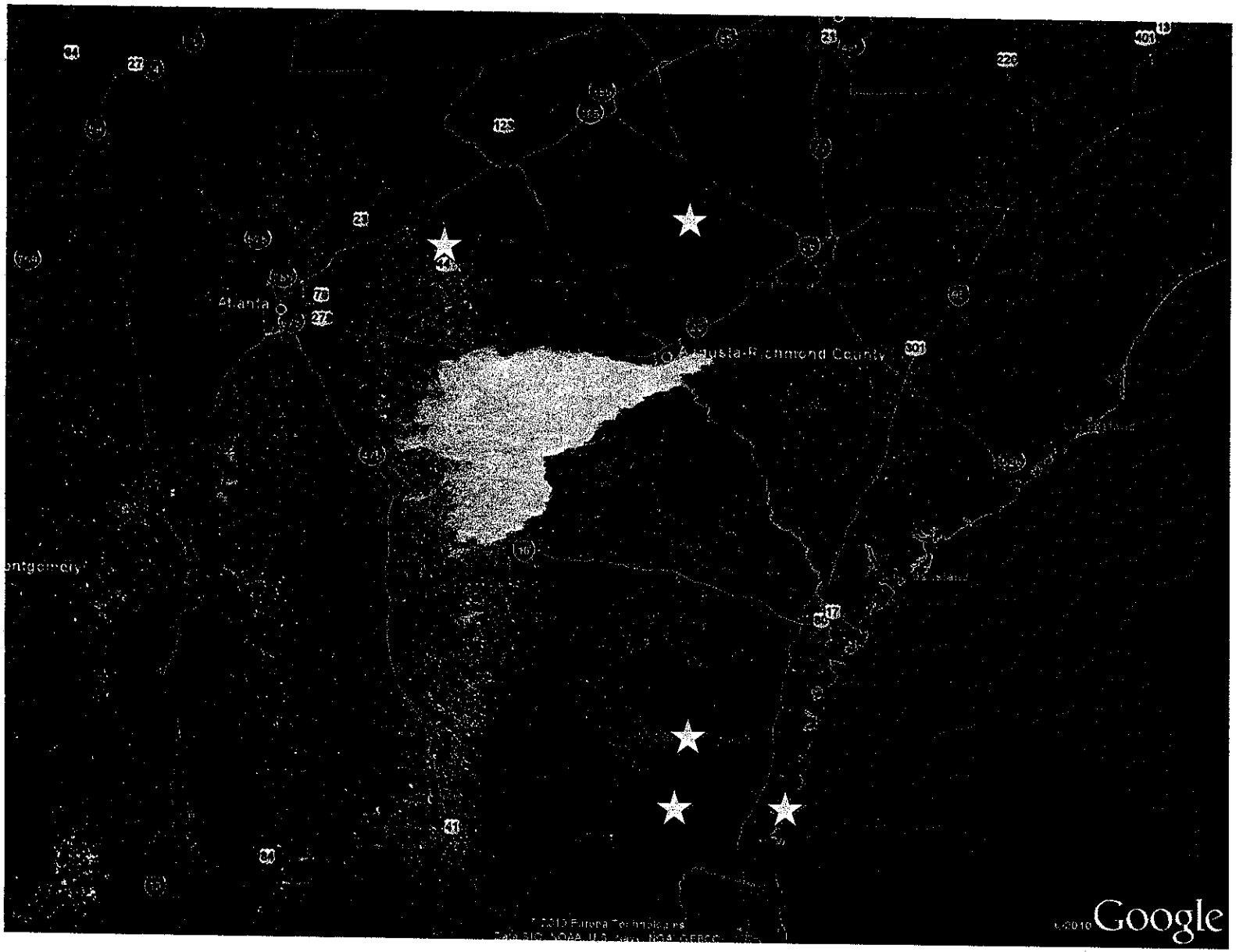
Conclusions:

The installation of these livestock watering systems has occurred for various installations with pressure heads varying from 30 feet to over 600 feet. Based on the pump chosen, the pressure head for the pumping system will vary. Therefore; when designing the solar pumping system, the total dynamic head should be accounted for, the number of current and future animal numbers and potential expansion of the system. The price of the system depends on the pump name brand purchased, the dealer from where the pump and panels are purchased, the type and number of panels, any additional add-ons to the system such as an AC Power Interface pack. Based on the location of the pumping system, a low water level sensor should be included to protect the pump from running dry and overheating.

The systems as installed were designed to handle the amount of animals recommended by the farmers, the depth of the wells installed or planned for installation, the storage method and the run and size of pipe for delivering water to the livestock. As these systems go, if the system design is known, the amount of water needed is known, then a water pumping system can be designed to provide water for livestock in remote locations.

Appendix A

Map of Installation Locations


Atlanta
Augusta-Richmond County
Google

Appendix B-1

Articles in Popular Press

Article in Gulf Coast Cattleman Magazine October 2007

Research News

Sun, Wind Help Pump Water to Cattle

by Brad Haire

Cattle sometimes go to streams and rivers to drink because there is no other place they can get water. But they can pollute that water downstream. A University of Georgia (UGA) expert is setting up sites near Georgia's coast to show cattlemen how to use wind and sun to take the water to the cattle.

Using solar panels and wind turbines to produce electrical power is nothing new, said Gary Hawkins, a water specialist with the UGA College of Agricultural and Environmental Sciences. But using them to power water pumps in Georgia is. They are more common in the Midwest and western United States.

"The goal of this project is to provide cattlemen who are already involved with other conservation and grazing management programs a sustainable alternative for getting their cattle the water they need," Hawkins said.

Five farms will be picked this fall to participate in the three-year project. The Natural Resources Conservation Service Conservation Innovation Grants Program will pay for it.

The project is a collaboration with the Seven Rivers and the Coastal Georgia Resource Conservation and Development Inc. The systems will be installed and running by spring.

The water pumps will be powered by a hybrid system, one that uses both wind and solar energy, said Hawkins, the project's coordinator.

Georgia isn't considered a windy state. But the wind blows consistently along the coast during cooler months when days are shorter. The wind dies off in the summer when the days are longer.

The hybrid system will use wind turbines for power in cooler months and the solar panels in summer. Both sources are enough to provide power to pump as much as 3,000 gallons a day. This is enough water to easily sustain a herd of up to 150 head of cattle.

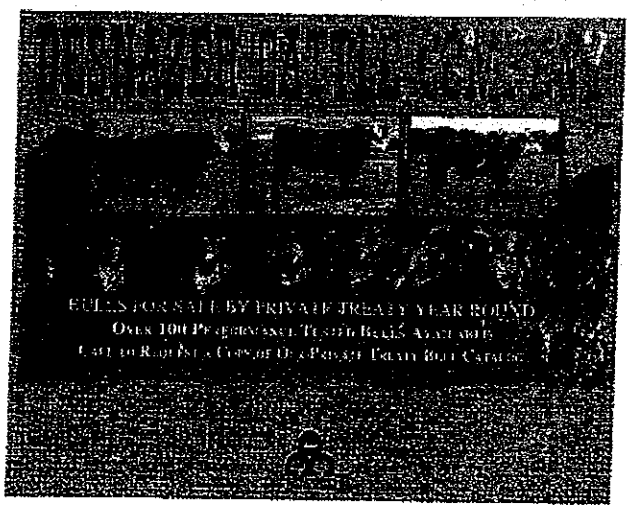
The cattlemen get the power systems free but must agree to take data and open their farms for field days so others can learn about the technology, too, he said.

Traditionally, cattlemen have used electricity or diesel to fuel pumps. Diesel prices have more than doubled in the past five years to more than $2 a gallon. In some remote pastures, electricity is not available. It costs between $2.50 per foot and $3 per foot to install electrical line, depending on the location and company.

But the biggest limiting factor for the hybrid system technology is the price, he said. It varies depending on the configuration needed. The systems in this project cost about $12,000. But solar panels and wind turbine prices are coming down.

Hawkins will study the economic benefit of the hybrid system, too. Considering current prices for electricity and diesel, a hybrid system may pay for itself in a decade. Instructional publications will be created for other cattlemen to use to build similar systems on their farms.

Hawkins set up a solar powered irrigation system on a farm in Pierce County two years ago to see if it could pump water adequately from a holding pond to a five-acre pecan orchard. It worked. The farmer was pleased, he said. Seventy people came to a field day on the farm to learn more about that system earlier this year.

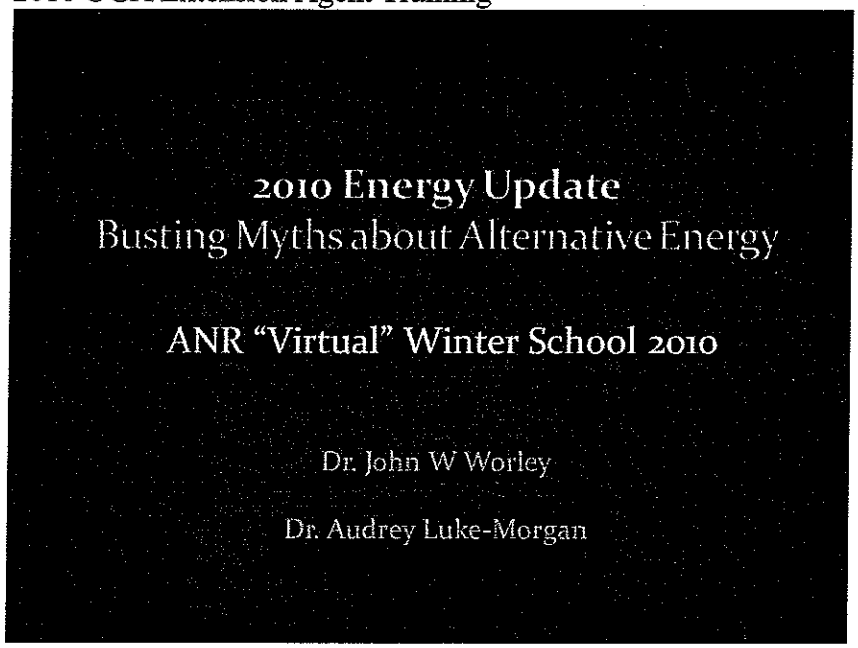


"And then I thought, what would be more romantic than a jug of perfume for your birthday?"

Appendix B-2

Posters and First Slides of Presentations

2010 UGA Extension Agent Training



2010 Growing Power Conference

Innovative Tools and Best Practices for Regenerating Small Scale "On The Farm Energy" Projects

Solar And Anaerobic Digestion for On-Farm Energy

Gary L. Hawkins, Ph.D
University of Georgia
2010 Growing Power's National-International Urban & Small Farm Conference
Milwaukee, WI
10-12 September 2010

University of Georgia
Biological and Agricultural Engineering

2010 South Central Georgia Solar Power Workshop – Flyer

SOUTH CENTRAL GA

SOLAR POWER

WORKSHOP

September 25, 2010

8:30 AM – 2:00 PM

University of Georgia – Tifton Campus

NESPAL Building

2356 Rainwater Road, Tifton

8:30 → Registration

9:00 → Introductions → Scott Carlson

9:10 → Solar Power Basics—How does it work? → Gary L. Hawkins

9:50 → Break

10:00 → Designing a small solar power system → Gary L. Hawkins

10:30 → Components of a solar power system → Brad Buchanan

11:00 → Designing a Home solar power system → Charlie Pepper

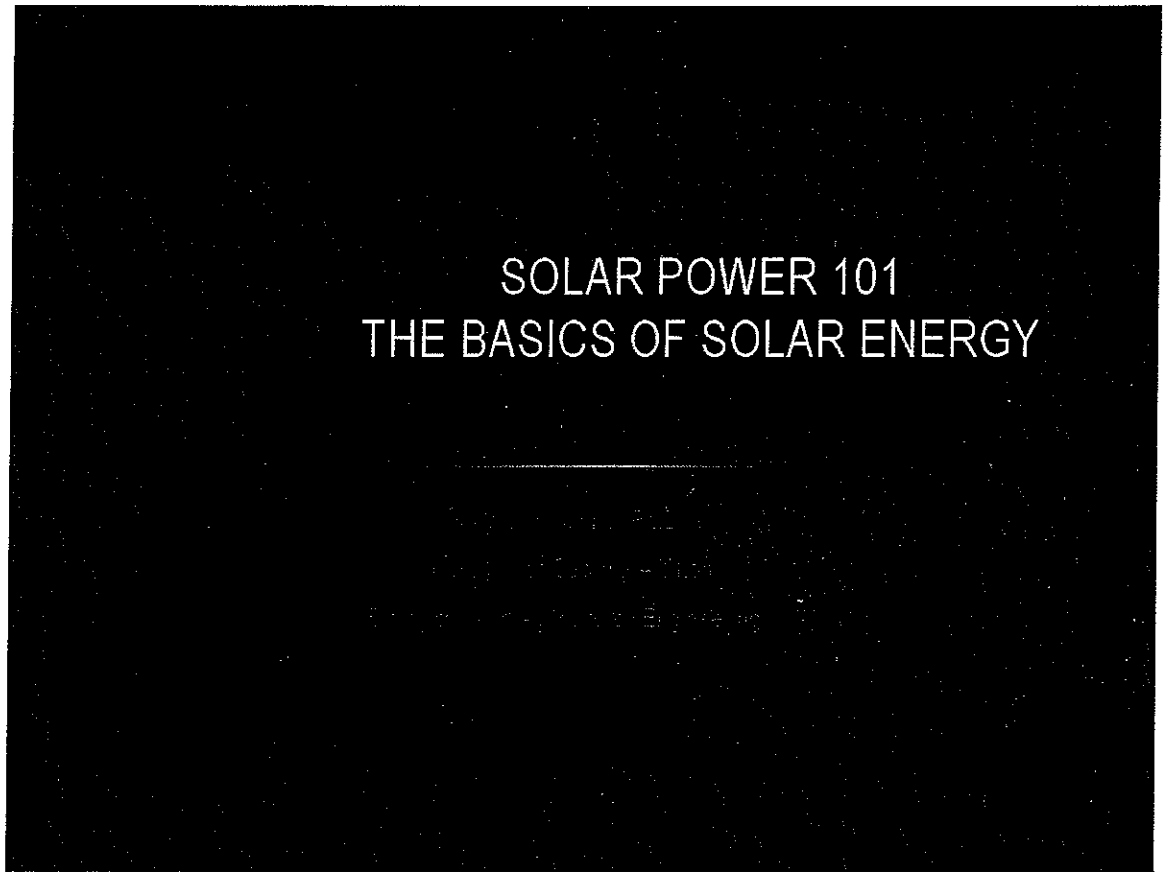
11:30 → Installing a Home solar power system → Charlie Pepper

11:50 → Rebates, Tax relief, etc. related to Renewable energy → Gary, Charlie

GEORGIA DEPARTMENT OF NATURAL RESOURCES
SUSTAINABILITY DIVISION

THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION

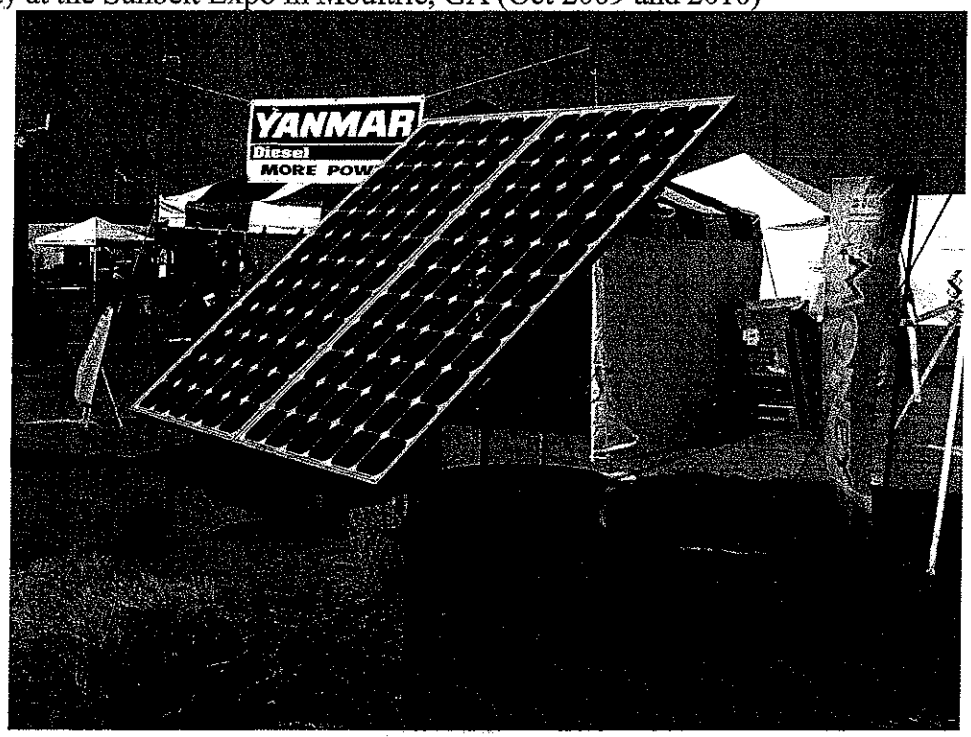
Learning for Life


SOLAR POWER 101
THE BASICS OF SOLAR ENERGY

Appendix B-3

Displays at National Farm Shows

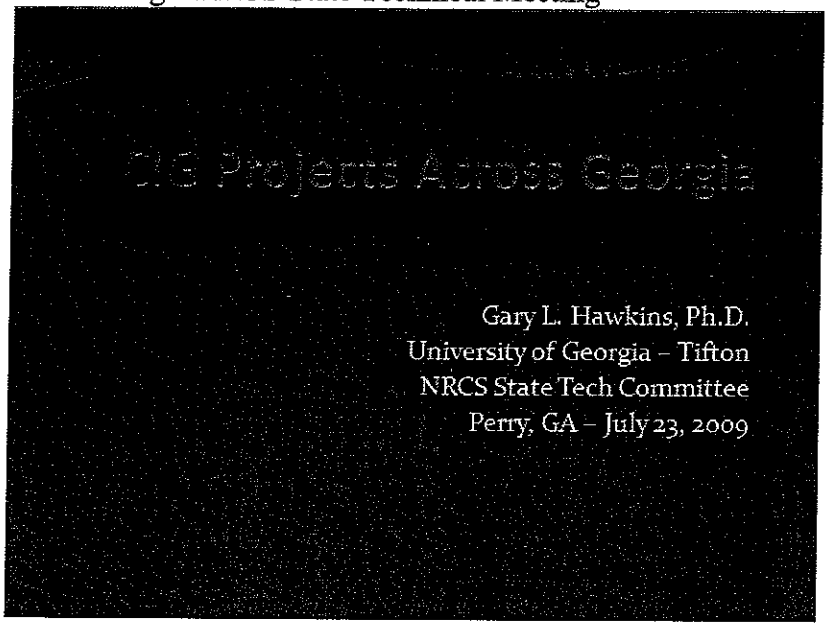
Display at the Sunbelt Expo in Moultrie, GA (Oct 2009 and 2010)



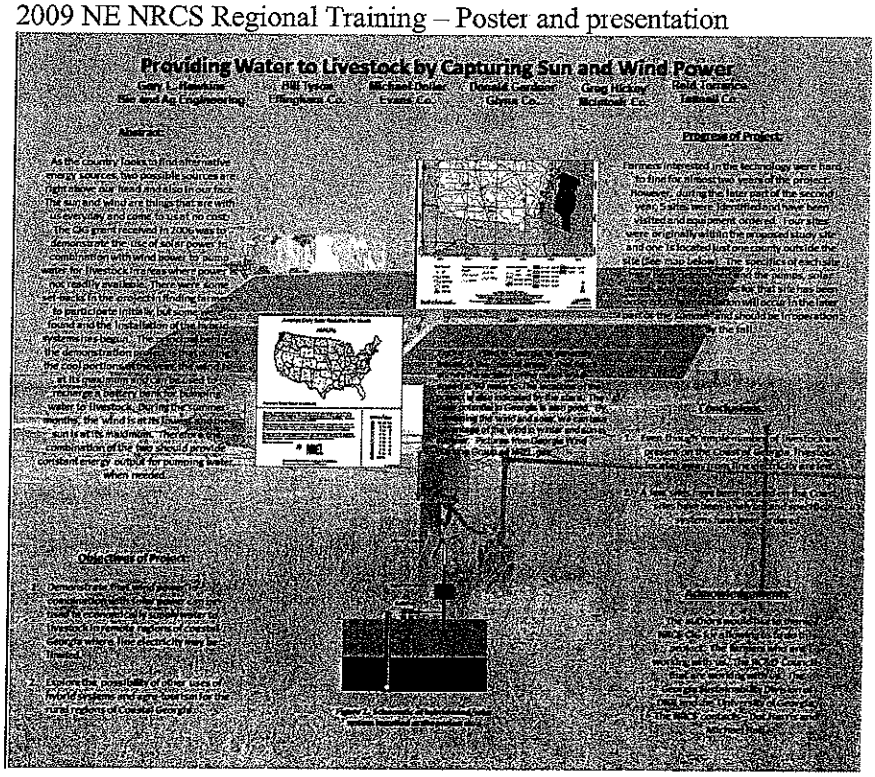
Appendix B-4

Poster and First Slides of Presentations for NRCS

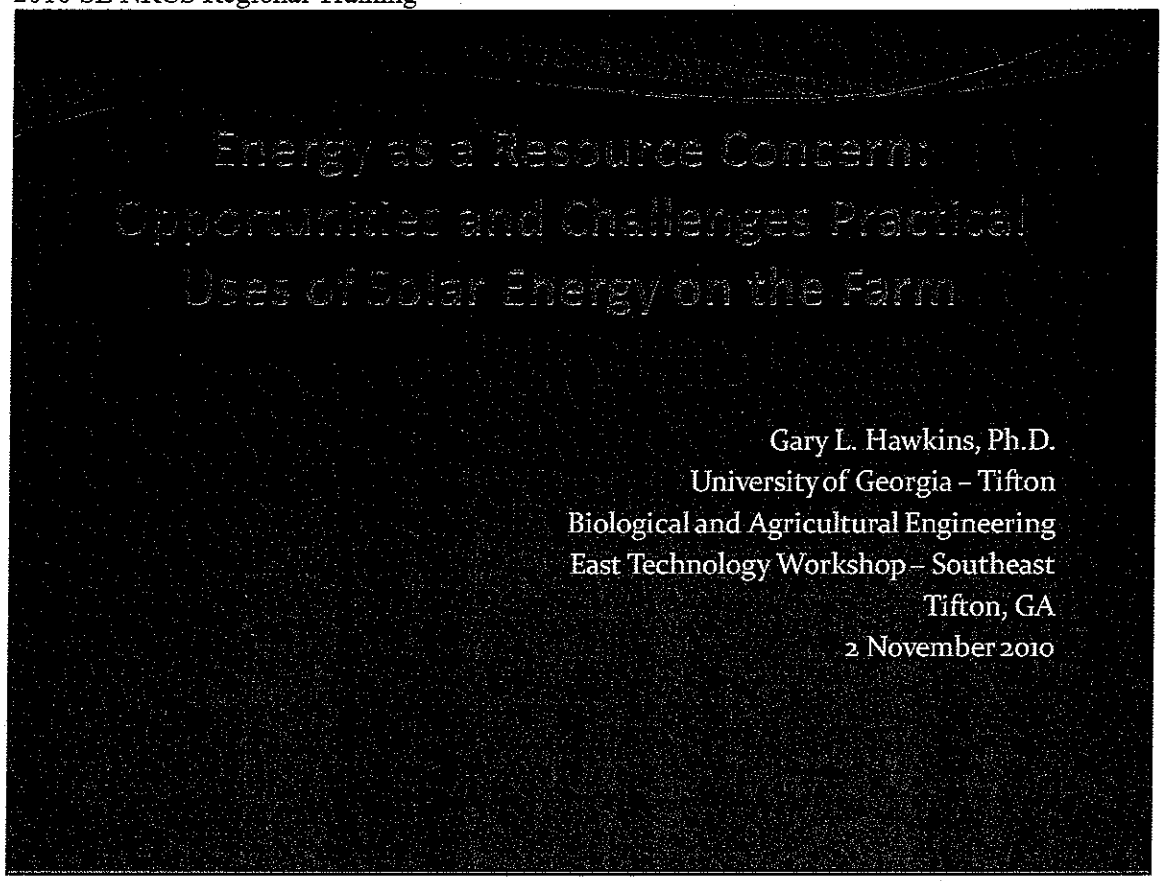
2009 Georgia NRCS State Technical Meeting



2009 NE NRCS Regional Training – Poster and presentation



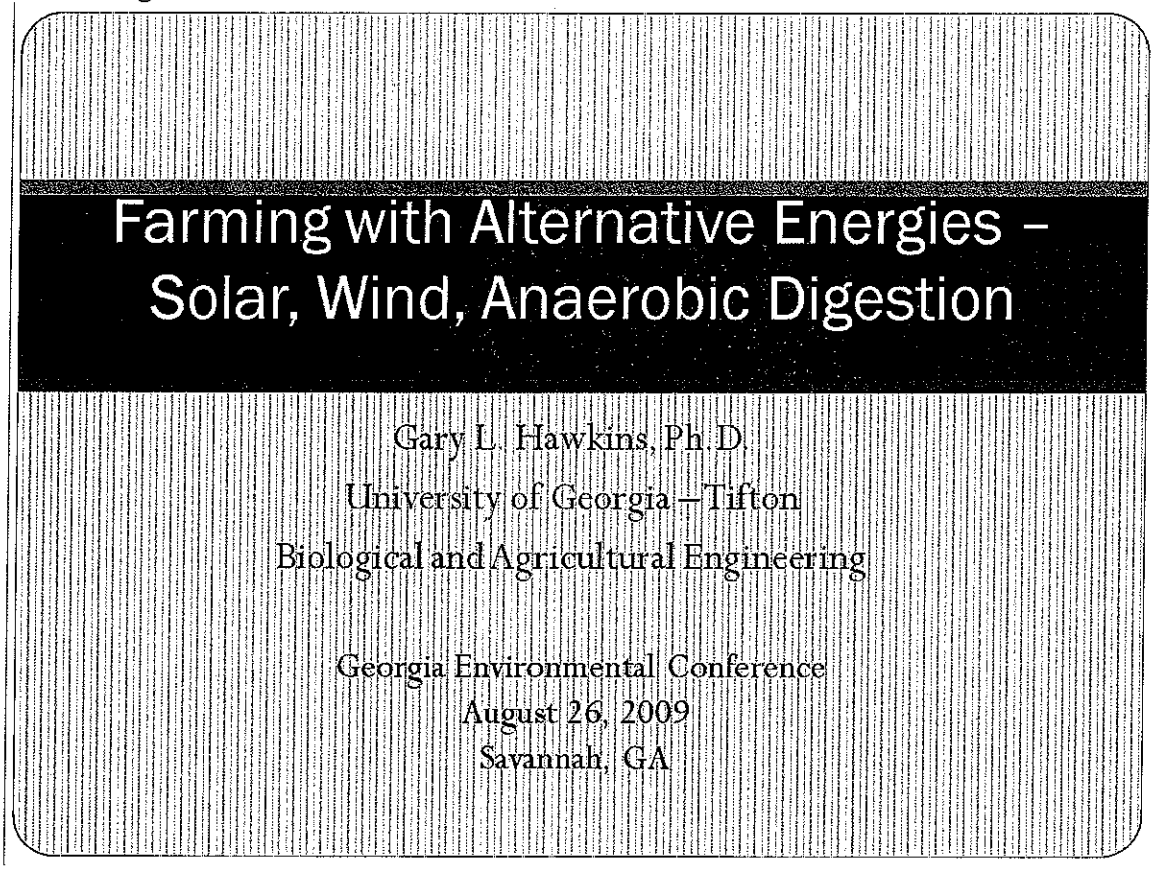
2010 SE NRCS Regional Training



Appendix B-5

Posters and First Slides of Presentations for Professional Organizations

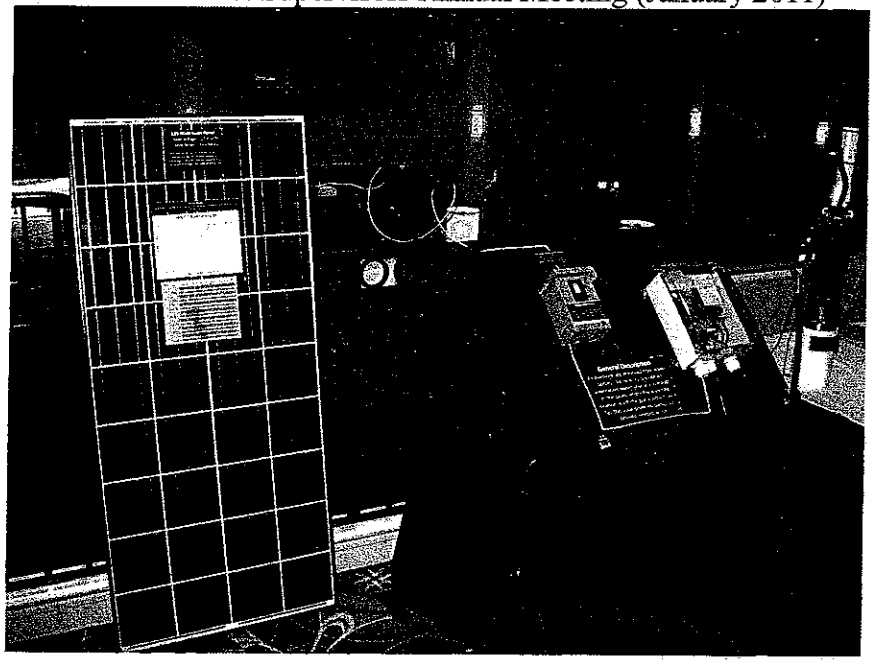
2009 Georgia Environmental Conference



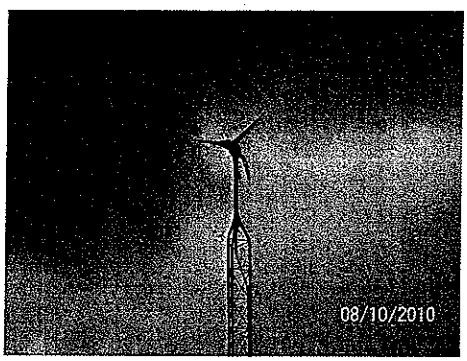
Appendix B-6

Display at Meetings

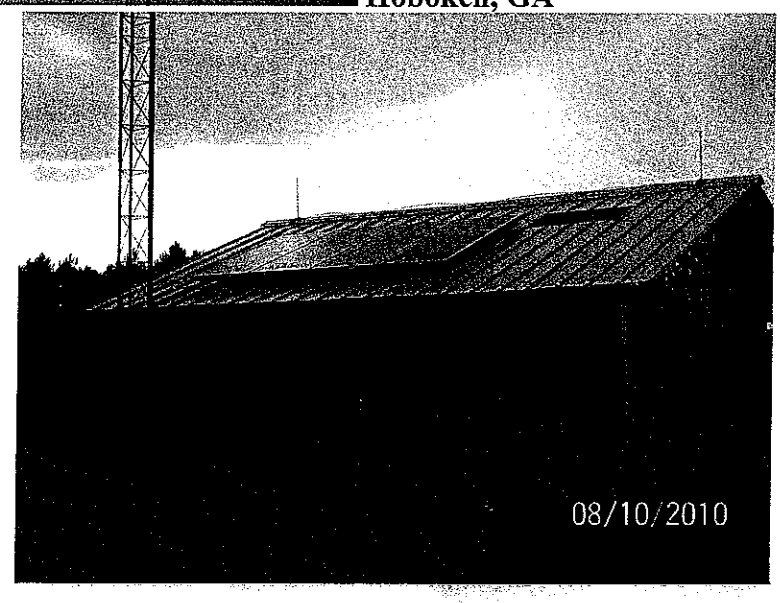
Georgia Conservation District Supervisors Annual Meeting (January 2011)



Shots of installations

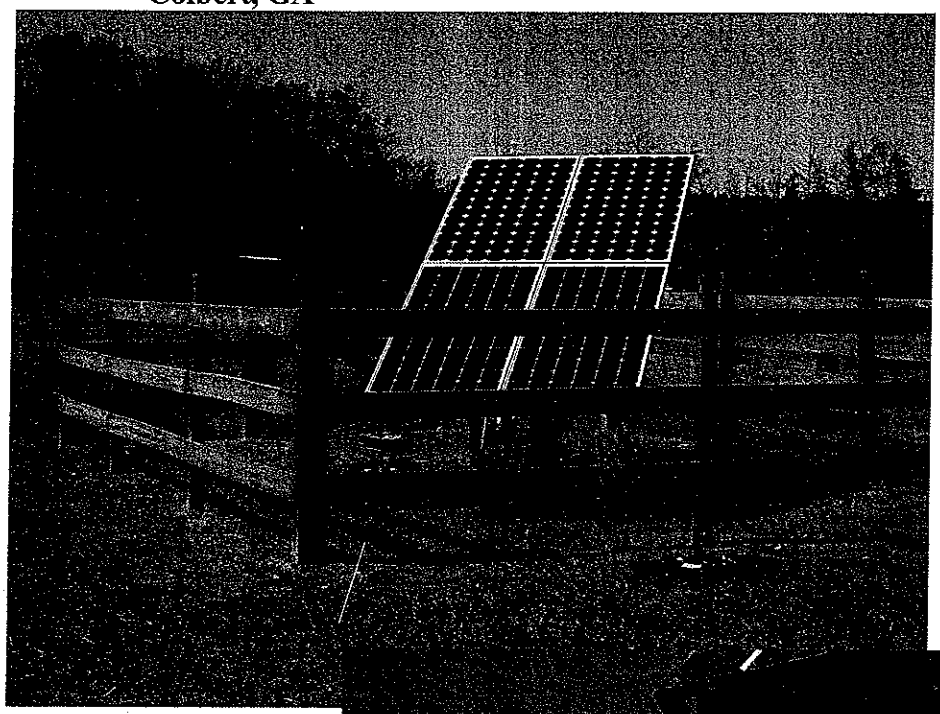


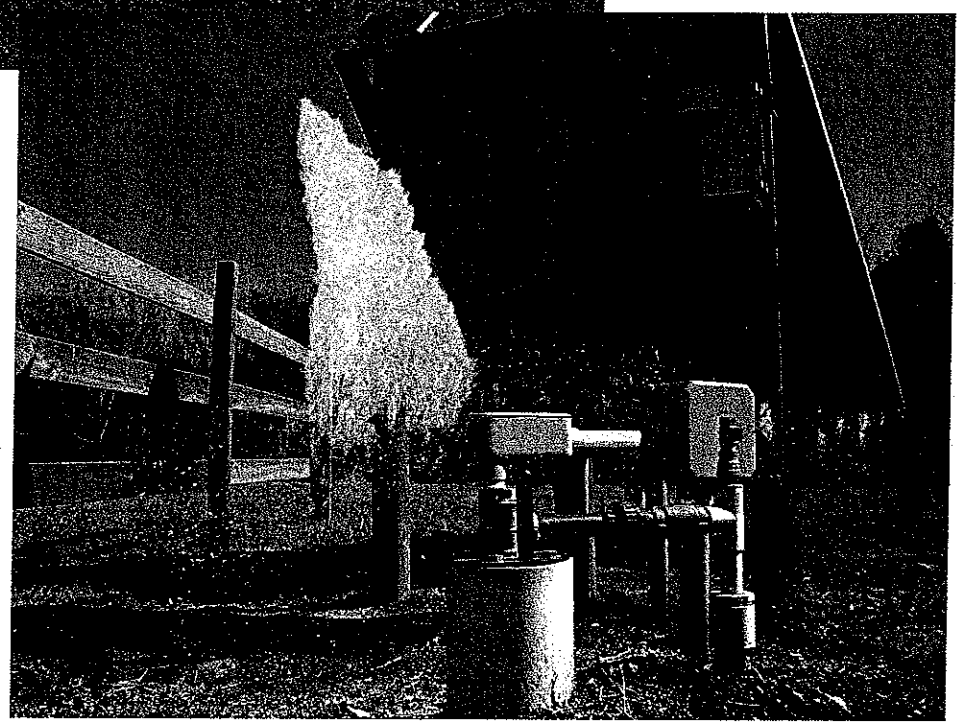
Hoboken, GA



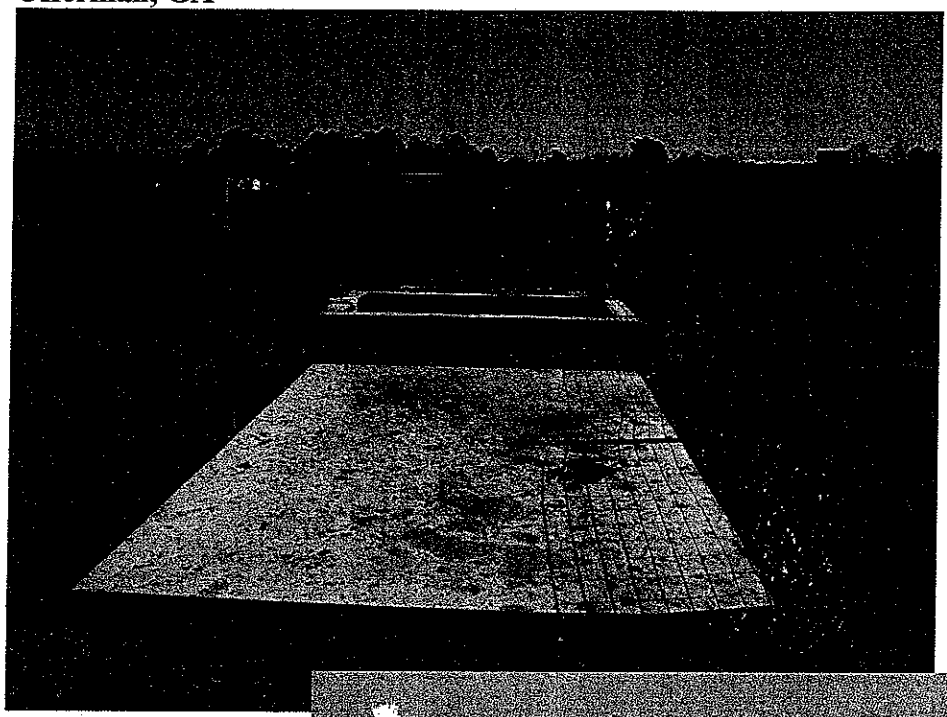
Shellman Bluff, GA

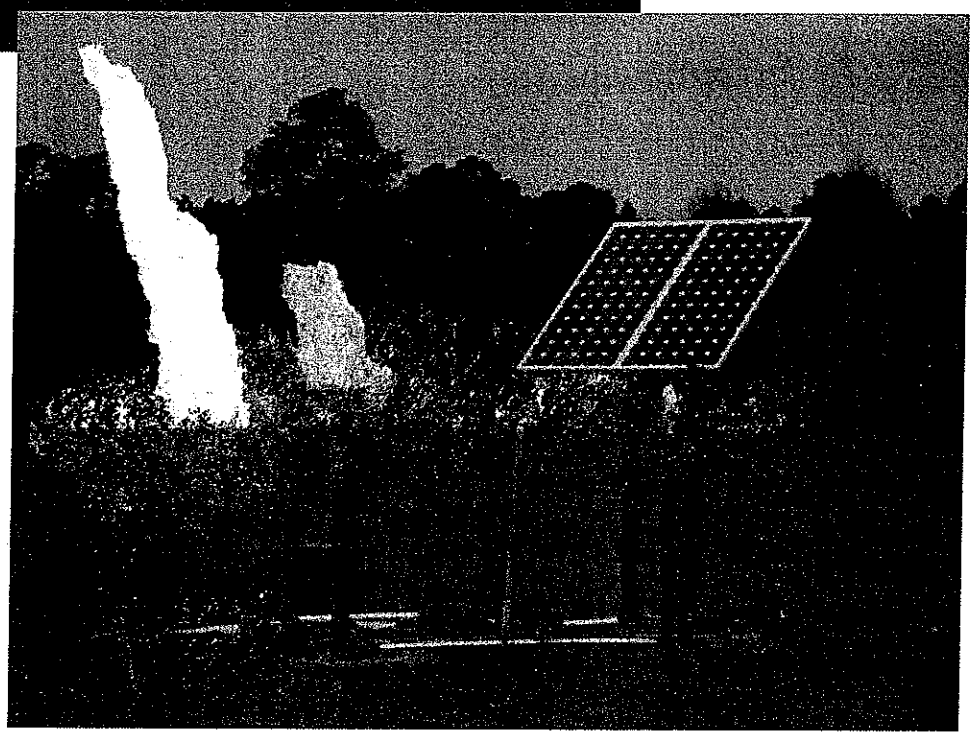
Colbert, GA





Offerman, GA





1785
The University of Georgia

Department of Biological & Agricultural Engineering

College of Agricultural and Environmental Sciences
TIFTON CAMPUS

Coastal Plain Experiment Station
Tifton, GA 31793-0748-USA

8 April 2011

Gregorio Cruz-CIG
1400 Independence Avenue, SW
Room-5233-S
Washington, DC 20250

Dear Mr Cruz,

Enclosed is a copy of the final report for NRCS CIG Agreement number 68-3A75-6-125 (UGA Acct Number 2631RE676259), "Utilizing Wind and Solar Power for Alternative Water Supply for Cattle in Coastal Georgia". It is my opinion as project director that we completed a successful project. From the installation and location of the wind/solar systems themselves, the personnel contacts, dissemination through articles and the dissemination at various local, state, national and international meetings. As a result of the project and the dissemination of information, more farmers in Georgia as well and South Carolina, Florida and other states are interested in the use of solar specifically to be installed for purposes of providing water for livestock located in remote locations. Additionally, I have provided and will continue to provide trainings for NRCS personnel on the design, installation and use of solar power for watering remotely located livestock.

The grant has been completed, but planning has begun for additional presentations, school education, farmer meetings, NRCS trainings, workshops and NRCS Technical and Extension publications. These outreach events will include a wide array of constitutes interested in solar power from the school age kids wanting to know about solar and its potential use in furthering their education to the farmers who are interested in installing solar to promote and advance their rural businesses.

If you have any questions or need additional information feel free to contact me at 229-386-3914 or ghawkins@uga.edu.

Sincerely,

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