



Clean Heat and Power Market Assessment for Agriculture in South Carolina

Prepared by the North Carolina Solar Center at North Carolina State University
and Mississippi State University

March 2009

Charlie Caulder

Jeff Havens



Mississippi State
UNIVERSITY

Disclaimer

"The information in this report is provided by the North Carolina Solar Center as a public service. The Solar Center strives to provide accurate information, but does not warrant or represent the accuracy, usefulness, or reliability of this information. For specific advice, please consult with a qualified professional."

ADVERTISEMENT AND ENDORSEMENT NOTICE

"In effort to achieve the goals set forth by the North Carolina Solar Center, the Southeast CHP Application Center, the North Carolina State Energy Office, and the United States Department of Energy, certain persons, agencies, companies, and manufacturers may be mentioned or addressed in the following report. It is not the intention of the authors of this document to endorse, favor, condone, or give preferential treatment to those listed herein. No listing of any persons, agencies, companies, and manufacturers is intended to be comprehensive or complete. However, if any persons, agencies, companies, or manufacturers wish to be included in any revisions of this report, please contact the authors."

FAIR USE NOTICE

This document may contain copyrighted material, the use of which has not always been specifically authorized by the copyright owner. We are making such material available in our efforts to advance understanding of energy, economic, scientific and related issues, et cetera.

We believe this constitutes a "fair use" of any such copyrighted material as provided for in section 107 of the U.S. Copyright Law. In accordance with Title 17 U.S.C. Section 107, the material in the document is distributed without profit to those who have expressed a prior interest in receiving the included information for research and educational purposes.

See www.law.cornell.edu/uscode/html/uscode17/usc_sec_17_00000107----000-.html for more information on "fair use." If you wish to use copyrighted material from this document for purposes of your own that go beyond "fair use," you must obtain permission from the copyright owner.

This assessment contains the following sections:

Executive Summary

What is Clean Heat and Power?

What Fuel Sources are available to South Carolina Farmers?

Financial Benefits of CHP to South Carolina Agriculture

Potential Applications for CHP in Agriculture

Barriers to CHP Development

Exploring Implementation of CHP

Recommendations

Conclusions

Appendix A: Agriculture Profile of South Carolina

Appendix B: CHP Technologies

Executive Summary

In the beginning of 2008, the Southeast CHP Regional Application Center including Mississippi State University and the North Carolina Solar Center at North Carolina State University commenced work pertaining to Clean Heat and Power (CHP) and the Industries of the Future as designated by the United States Department of Energy (DOE). This report describes the South Carolina agricultural industry and its potential for fostering CHP development.

Clean heat and power (CHP) is an effective way to increase energy efficiency and reduce polluting emissions. CHP applications may reduce consumer costs and provide reliable heat and power to a facility. Favorable scenarios for CHP applications exist near well matched thermal and electrical loads. If a facility uses substantial amounts of both heat and electricity, there is a possibility of implementing CHP.

Crop farmers' fuel source options are limited to wood and/or crop residues, the latter of which are virtually free, but the inexpensive cost of coal derived electricity is more financially advantageous than purchasing and maintenance of traditional gensets to support biomass gasification.

However, CHP does have potential; especially among livestock farms where animal waste can be readily collected and converted to a biogas fuel source. Other food related industries have potential, but are restricted to those which employ steam; primarily for thermal conversion of waste thermal energy.

Barriers to CHP implementation include issues related to interconnection, the prohibition of third party sales of electricity within South Carolina, and the constraining emissions standards.

The state of South Carolina is 34th in agriculture in the United States. With over 24,000 farms and a total value of shipments of \$1.89 billion dollars in 2006, agricultural industry is one of the largest industries within South Carolina. Approximately 10% of operating costs are due to energy consumption in the agricultural industry.¹

If this 10% operating costs could be reduced through CHP implementation, the South Carolina agriculture industry could recoup \$630 million spent on energy consumption (as determined in the **Benefits of CHP to South Carolina Agriculture** below). However, since it is unrealistic to assume all of the operating costs due to energy consumption would be realized, and in the absence of information concerning energy usage within agriculture, a more realistic arbitrary goal of 10% to 30% energy savings (of the 10% operating costs) yields a financial recovery between \$63 million and \$190 million per year.

What is Clean Heat and Power?

Conventional electricity production, as it exists today in the United States, is only about 33% efficient². The waste of approximately two-thirds of internal energy from a fuel is generally accounted for by thermal losses resulting from the thermodynamic cycle used in standard electricity production and losses in the transmission and distribution system. Clean heat and power (CHP) systems capture and utilize these heat losses by applying thermal energy to existing needs.

CHP is an integrated energy system located at or near a facility to provide at least a portion of the electrical or mechanical load while recycling the waste heat from the power application to provide heating, process steam, cooling, and/or dehumidification or the production of electrical power^{2,3}.

Formatted: En

By capturing waste heat, CHP systems, if effectively integrated, can reach up to or greater than 80% efficiency³. An illustrative example of CHP system efficiency can be seen in Figure 1: CHP Efficiency.

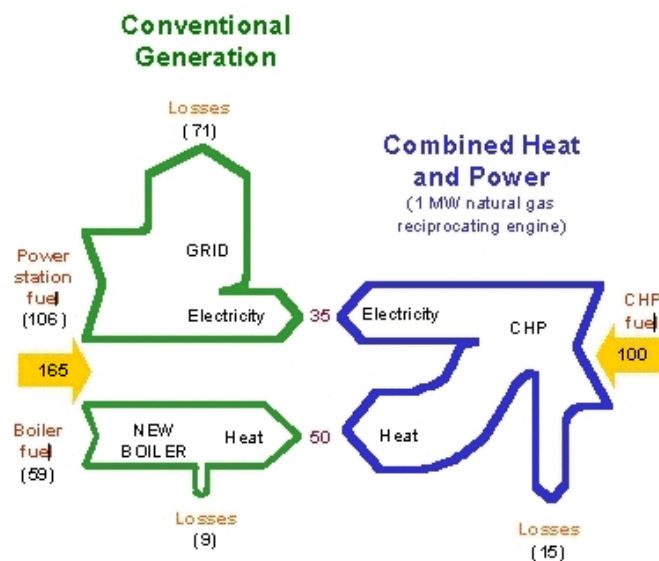


Figure 1: CHP Efficiency

CHP includes the added benefit of power availability and reliability. CHP also alleviates grid overcrowding and costs associated with distribution⁴. If a utility outage occurs, a CHP system can maintain operation and lessen the effect of the outage on a facility⁵.

One estimate reports⁶ that power interruptions cost \$80 billion dollars annually in the United States. The commercial and industrial sectors incur the largest costs associated with power outages. It was also shown that “momentary interruptions” lasting less than five minutes were more expensive than “sustained interruptions⁶.” CHP installations can reduce the effects of power outages in an industrial manufacturing setting. When interconnected with the utility grid, during an outage, power can be obtained from the CHP system without costly interruption.

A CHP system also includes the benefits of reduced emissions due to increased system efficiency. If the potential for CHP in the United States was met, approximately 130GW, the carbon equivalent emissions would shrink by 70 million metric tons **Error!** **Bookmark not defined.**⁷.

Common thermal loads for CHP applications can be cooling, heating, humidity control systems, steam production, and hot water production. CHP can also utilize a variety of opportunity fuels such as landfill gas (LFG), tire-derived fuel (TDF), wood and wood waste, biomass, and digester gas^{7,8}.

What Fuel Sources are available to South Carolina Farmers?

As mentioned above, CHP can use a variety of fuel sources.

Landfill gas (LFG) is burned like natural gas and is similarly priced. LFG is efficient for CHP applications if the facility employing this fuel is close or on-site of the landfill. If the farmer or production facility is close to a landfill, CHP can be implemented. However, this assessment will not make the assumption that South Carolina's farmers are near landfills and as such, LFG will not be discussed within this assessment.

Tire-derived fuel (TDF) is good fuel source which can be burned like coal or cofired with it. TDF is better suited for facilities operating machinery in the 25-50 MW range.⁹ Most agriculture facilities, which are typically smaller farms, will not benefit from TDF since TDF is more expensive than coal. Hence, TDF will not be further discussed in this assessment.

Wood and wood waste (i.e. sawdust, scrap, bark, branch and stump residue, etc.) can be burned as a solid or converted to a biomass gas. Wood is labor intensive and can cost between \$15 and \$45 per dry ton.⁵ Compared to coal, wood is more expensive (unless it can be obtained on site), but burns cleaner.⁵ Wood will continue to be a good fuel source, but its application is well established and will not be further discussed in this paper.

Biomass and digester gases are the most readily available fuel sources to farmers. Biomass can be obtained from crop residues such as rice husks, corn stalks, oat meal husks, bagasse, nut shells, etc. Whereas these crop residues can be burned directly, more energy can be derived, and burned at cleaner emissions content, if used to create a biogas. Similarly, digester gas can be acquired from animal wastes, and like biomass, can be burned directly. Since these two fuel sources are readily available on farms, their potential will be discussed later.

Financial Benefits of CHP to South Carolina Agriculture

Per the American Council for an Energy Efficient Economy (ACEEE), in the conclusion of their paper "Potential Energy Efficiency Savings in the Agriculture Sector" the estimated potential energy savings within the agricultural industry across the USA is 98 trillion BTUs at a potential monetary savings slightly over \$1 billion.¹⁰ Their conclusions indicate that farms and other agriculture centers could save 10% of their energy needs by implementing energy saving techniques.

Although surveying all 24,541 farms in South Carolina was beyond the scope of this market assessment, several agricultural and food related businesses were asked to provide data on their electricity usage; all of whom declined or did not respond. The South Carolina Energy Office was receptive, and via the Energy Office, the Mid-Atlantic Co-operative (Mid-Atlantic), a co-op which coordinates information and contracts between the utilities and the co-op distributors, was contacted.

Mid-Atlantic provided data on the daily energy usage of four undisclosed facilities within South Carolina. These facilities included two feed mills, a poultry processing plant, and a fruit and vegetable processing facility. The data included daily usage for all four facilities throughout 2007. Results found the average energy usage of these facilities was 679 kWh per day. If we assume this to be a reasonable average for South Carolina agricultural facilities, then the total agricultural industry in South Carolina consumes roughly 16,664 MWh of electricity; which equates to 6.1 TWh per annum.

The South Carolina Energy Office could not estimate to what detail the South Carolina agriculture sector implemented CHP, however, the Energy Office believes that the majority of the agriculture sector does not implement CHP. If we assume that ACEEE's estimate at 10% savings is an accurate estimate, then the South Carolina agriculture sector could potentially save 610 MWh per year. In addition to the benefits listed in the **What is Clean Heat and Power** segment above and at energy usage rate of \$0.103638 per kWh (see the section on **Electricity Standby Rates**, table 5), South Carolina could potentially save \$630 million. However, until more studies are conducted on energy usage with the Agriculture market sector, it is unrealistic to expect all of the energy usage could be recovered. A more realistic goal would be a value between 10% and 30%, therefore, a savings between \$63 million and \$190 million.

Although the data acquired of the four South Carolina facilities was thorough, with over 24 thousand farms/facilities in South Carolina four facilities alone will not represent an accurate energy profile. More research is definitely needed. However, a potential between \$63 million and \$190 million in energy savings indicates CHP implementation offers valuable energy savings which could provide an opportunity for increased

economic efficiency.

Potential Applications for CHP in Agriculture

It is believed by South Carolina energy officials that CHP is not being used to its full potential within the agricultural industry. Since there is a lack of information forthcoming from farms and food processing facilities, this is difficult to verify because it is virtually impossible to determine quantitatively and qualitatively to what extent CHP is currently being implemented.

However, CHP can be implemented within agriculture via animal waste or crop residues.

Animal waste could be captured by a digester. A digester produces a methane based biogas which is consumed in generators. (Please refer to Appendix B for the types of generator technology which can be employed.) Depending on the genset, heated air, steam, and/or (in conjunction with a turbine) electricity could be produced for sale or farm usage.

Figure 2 demonstrates how this process would work. In this figure, the steam feeds a heat exchanger to regulate temperatures of water and air. The farmer could use the water for fallowing, and the air could be used to dry crops, heat animal pens, or cultivate a greenhouse. Please note in figure 2, the terms 'cooler' and 'hot' are relative. The exact temperatures would be dependent on the actual needs of the facility.

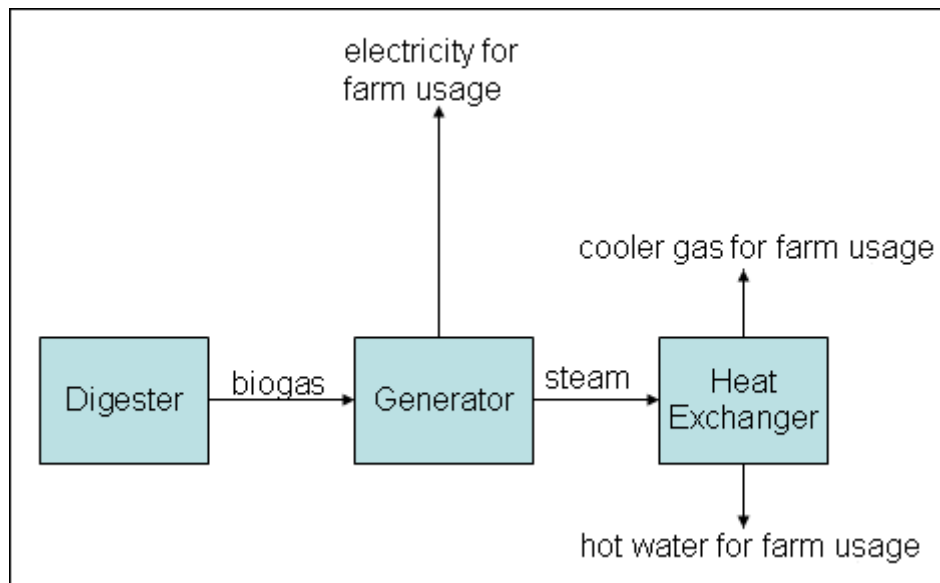


Figure 2: Simple Farm Application

Figure 3 demonstrates how the basic digester/generator CHP could be further modified and adapted from the simple CHP implementation of Figure 2, for more farm applications..

The heat exchanger could be replaced with another engine. Heat processed through a reciprocating engine or a turbine which in turn could provide the power to a digester while still providing hot water for the farm.

By adding a plug flow digester, a separator could be implemented so the solid waste byproducts could become an additional source of income, or a reduction in cost in bedding or compost materials.

The liquid waste could then be returned to the plug flow digester (and associated lagoon) and/or passed to a secondary lagoon for increased waste/odor control or as an additional reservoir for crop/livestock consumption.

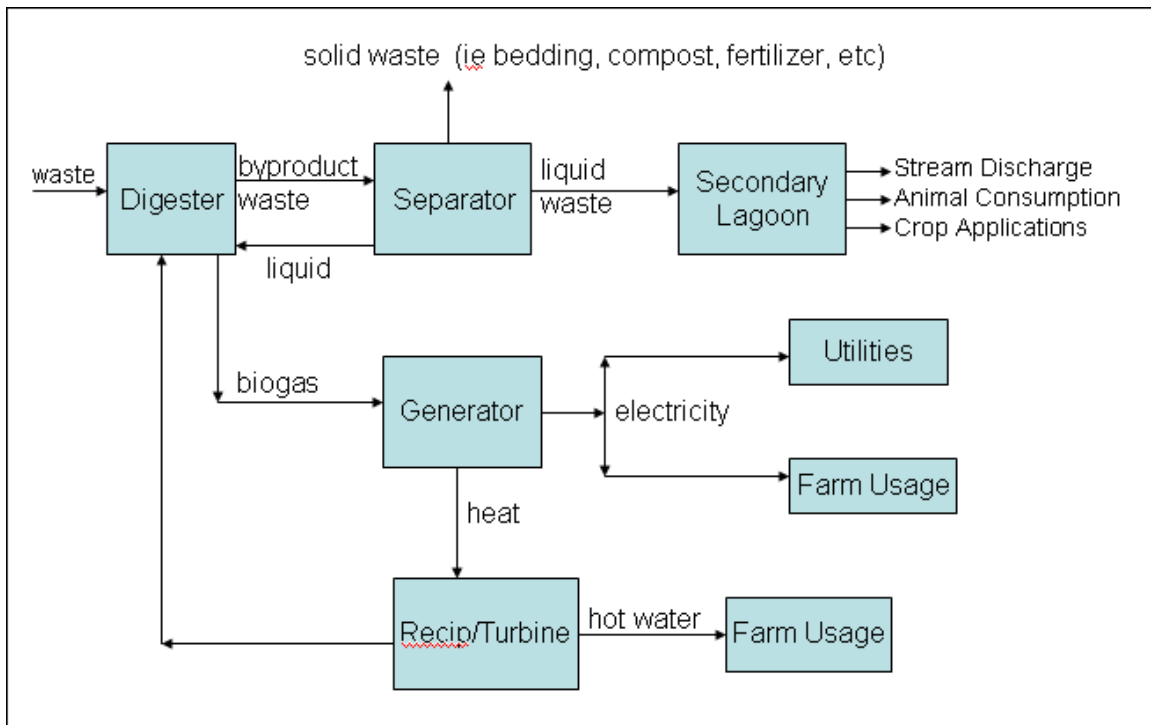


Figure 3: Potential Farm Application

For facilities that do not have animal waste, crop residue could substitute as the fuel for the generator. However, whereas crop residues could be burned directly, higher energy content would be realized if the crop residue were converted to biogas.

This higher energy content is not as high as natural gas, and subsequently, past technologies were not developed to utilize biomasses such as crop residues. However,

with rising energy costs new gasification systems are being developed to burn in smaller combustion turbines. As these systems become more cost effective farms, mills, and processing plants will have alternatives to natural gas. Refer to Appendix B for financial costs of implementing a biomass gasifier.

Barriers to CHP Development

Several barriers prohibit the timely and efficient design, installation, and operation of CHP systems. These barriers include air quality regulations, interconnection issues, the prohibition of third party sales of electricity, and utility rates. These barriers are not specific to CHP, but apply to most distributed generation projects. CHP does have a number of agriculture-specific barriers. These include the amount of small operations, and the inexpensive cost of electricity in South Carolina, and in some cases lack of need for electricity.

Air Quality Regulations

There are six criteria pollutants that the EPA utilizes as indicators of air quality. These pollutants include ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead. For a detailed look at these various pollutants, please refer to the EPA's website Green Book at: <http://www.epa.gov/oar/oaqps/greenbk/o3co.html>

Hazardous Air Pollutants (HAP) adversely affects human health and the environment, resulting in cancer, reproductive defects, birth defects, etc. Currently, there exist 188 pollutants that the EPA defines as HAPs. Nine of these pollutants are related to CHP technologies including benzene, formaldehyde, naphthalene, and toluene. For a comprehensive list of HAPs please visit the EPA's website at <http://www.epa.gov/ttn/atw/188polls.html>

The installation of a CHP system may require a "new source review" or NSR by EPA regulation. The restrictions created by a NSR are dependent upon whether or not the proposed CHP installation will exceed pollution thresholds. These thresholds are set at different levels depending on attainment status. If a specific region is a non attainment area, the thresholds are lower than if the region is located in an attainment area. If the CHP system exceeds pollution thresholds it is considered a "major source." If the CHP system falls short of the thresholds, it is considered a minor source¹¹. Best available control technology is required by a NSR; however, they requirements are based on fuel input, rather than system output. Input criteria do not recognize the efficiency of CHP¹².

Often, heat recovery from a CHP system is not given the appropriate emissions credit. Although offsite utility power generation and onsite thermal energy generation are now combined, the displacement of these sources is not taken into account. Unfortunately, the decrease of emissions for the production of thermal energy is not accounted for in a CHP

system. Smaller sources such as CHP do not receive the “netting” treatment that larger sources do. Netting enables a facility to decrease one source of emissions while increasing another. Additional limitations arise from the prohibitive unit costs of after treatment technology generally applied to larger installations. Standards for emissions limits from large installations are unsuitable for smaller CHP units, however these limits are erroneously applied to mass produced generation equipment, voiding the cost savings yielded from mass production. The savings from mass production are lost because of the high cost per unit of treatment technology. Improper emissions requirements often lead to the difficulty of a CHP installation and therefore should be carefully reviewed before the consideration of a CHP operation¹¹²⁴.

Formatted: E

Air Quality Regulations --- Output Based Regulation

CHP installation can be surrounded by stringent, inappropriate emissions standards. However, relief can be found in using output-based emissions regulations. Instead of traditional “fuel-input” emissions based regulations, output-based regulations focus on the amount of emissions relative to the useful output of a process.¹³

Output-based regulations reduce fuel consumption by fostering new ways to use energy such as CHP. An output-based approach also lends to the use of new energy conversion technologies and opportunity and renewable fuels. By decreased fuel consumption for the same productive output, emissions totals are also decreased. By regulating emissions based on the productive output of the system, different types of technologies may be evaluated on a comparable basis³³.

States such as Connecticut, Massachusetts, and Indiana have already adopted output-based regulations. Output-based regulations are gaining attention and allowing developers to introduce pollution preventing techniques such as CHP without air quality regulation hindrance. Output-based regulations should be used as a tool to overcome the current regulations which do not account for the efficiency of CHP systems.

Interconnection

When a facility installs onsite generation, there are typically three ways which that system may be configured in relation to the utility grid: isolated operation, isolated operation with utility backup, and parallel operation with utility system¹⁴.

Installation of a system with utility backup or parallel operation may yield interconnection issues which pose a barrier to smooth and timely installation. Additional costs and lengthy installation schedules may result as an effect of interconnection boundaries. These barriers may be classified by two categories: technical barriers and regulatory barriers¹⁵.

Technical barriers arise from the utility’s requirement that CHP technology systems be grid compatible¹⁵. Utilities are generally concerned with issues of safety, power quality, equipment protection, and system control¹⁴⁴⁴. Typically, technical issues are addressed

Formatted: E

with thorough engineering analysis and costly equipment; however, this is sometimes unnecessary due to the already present safety devices included in the customer's generation system¹⁵. Comparable to expensive emissions equipment inappropriate for the small scale of CHP, mass production cost savings are reduced via the required equipment and analysis appropriate for a large scale installation where cost per unit is considerably less.

Formatted: E

Regulatory interconnection issues also hinder the successful installation of CHP systems. Many states lack consistent policies, if policies even exist at all¹⁶. However, in February 2008, the EPA reported that 31 States have set policies in place for distributed generation, including South Carolina. South Carolina has adopted standards for residential systems up to 20kW and commercial systems up to 100kW. According to these standards, the owner of a commercial system must have a minimum of a \$300,000 commercial insurance policy¹⁷. Insurance and inconsistencies in regulations create a difficult problem for all interested parties when investigating final monetary costs and time requirements related to a CHP installation. As with technical interconnection barriers and air quality regulations, inconsistent regulations related to interconnection reduces the cost savings of mass manufacture.

Utilities, manufacturers, independent power producers, and end users all benefit from standardized interconnection procedures. Utility duties and responsibilities are more clearly defined. Manufacturers can more efficiently mass produce equipment with clear standards instead of having to tailor equipment produced for different interconnection procedures. Independent power producers benefit from lower interconnection costs and shorter interconnection periods. The end user benefits from lower product costs¹⁸.

Prohibition of Third Party Sales

CHP, along with many other distributed generation projects, face a persistent barrier that arises from policy and regulation regarding the third party sales of electricity. It is suggested that the ban on third party sales is the largest hindrance to distributed generation projects¹⁹. South Carolina title 58, chapter 27, prohibits the third party sale of electricity in South Carolina. Without a legal framework for third party sales, cost savings are difficult to obtain for interested parties due to the "case by case" basis of power purchase agreements between customers and utilities²⁰.

Access to the grid is crucial for CHP growth. It is important that clear established policies and procedures exist so that interested parties can plan and develop new projects with clear cost savings estimates. Grid access policies would allow CHP projects an equal opportunity to compete with centralized generation²⁰. Unbundling of utilities is also related to "open-access" policies. However, costs associated with transmission capacity charges may negatively affect a generating facility.

Formatted: E

Utility and Standby Rates

Many CHP applications utilize the local utility as a source of back up power in the system design. But relying on the utility for back up power creates a large hurdle for CHP applications in South Carolina.

South Carolina rate structures outline certain charges that pertain to owning and operating private power production equipment. Charges known as “back stand” charges or “standby rates” are charges that the consumer must pay in compensation for the utility’s generating capacity. These rates apply to consumers that generate their own power, but still require electrical service from the utility intermittently. The need for this “standby” power arises for periods of predetermined downtime of the consumer’s generation equipment, additional supplemental energy supply from the utility, and the use of the utility as back-up power during unforeseen system downtime¹⁴²⁶. Sometimes the standby rate can be a large enough expense to negate any financial benefit from a CHP system in effect hindering a peak shaving application²¹.

Formatted: E

Of the major utilities that serve South Carolina all have rate structures and riders that address standby charges. For example, Duke Energy’s Parallel Generation (Schedule PG), which can be seen in table 6, applies to generating facilities with a generating capacity of less than eighty megawatts. The standby capacity is determined in one of two ways. Either the generating capacity given by the nameplate of the customers facility is used to calculated standby kW, or at the option of the customer, the standby capacity is based on the maximum demand from the previous twelve month billing period. A charge of \$0.95 per kW of standby capacity is applied to the customer’s bill.

Table 1: Duke Energy Schedule G (SC) General Service

Basic Facilities Charge	\$6.85
Demand Charge	
For the first 30 kW of Billing Demand per month	No Charge
For all over 30 kW of Billing Demand per month	\$3.28 per kW
Energy Charge	
For the First 125 kWh per KW Billing Demand per month:	
For the first 3,000 kWh per month	10.3638 cents per kWh
For the next 87,000 kWh per month	5.4598 cents per kWh
For all over 90,000 kWh per month	3.6940 cents per kWh
For the Next 275 kWh per KW Billing Demand per month:	
For the first 6,000 kWh per month	5.5304cents per kWh
For the next 95,000 kWh per month	5.4684 cents per kWh
For the next 39,000 kWh per month	4.8399 cents per kWh
For the next 60,000 kWh per month	4.8282 cents per kWh
For all over 200,000 kWh per month	4.7649 cents per kWh
For all Over 400 kWh per KW Billing Demand per month:	

For the first 1,000,000 kWh per month	4.6568 cents per kWh
For all over 1,000,000 kWh per month	4.3962 cents per kWh

Negative effects of standby charges have been seen by CHP. An example comes from a nearby state of North Carolina, which has a standby rate of \$1.03 per kW. In a 2007 letter to NC Senator Janet Cowell from Raymond Dubose, director for Energy Services at the University of North Carolina Chapel Hill, Mr. Dubois states that Duke Energy's charge of \$1,030 per megawatt of generation at the Chapel Hill CHP Facility is a large financial burden on the energy department. With a generating capacity of 28 megawatts operating over a twelve month period, the CHP facility pays in excess of \$345,000 a year in standby charges.

Currently, electricity is inexpensive in South Carolina, but rising fuel prices coupled with standby rates could negatively impact the economic return on a CHP system. While standby charges are still present in other states where CHP has been successful, the cost of electricity and fuels is generally higher in those states, thereby creating a tighter profit margin where CHP implementation is generally beneficial.

Table 2: Duke Energy Schedule PG (SC) Parallel Generation

	Interconnected To:	
	Transmission System	Distribution System
Customer Charge per month	\$53.76	\$53.76
On-Peak Demand Charge per On-Peak month	\$13.24 per kW	\$15.77 per kW
Energy Charge		
All On-Peak Energy per month:	3.2955cents per kWh	3.3668 cents per kWh
All Off-Peak Energy per month:	3.1020 cents per kWh	3.1735 cents per kWh
Industrial Service		
All On-Peak Energy per month:	3.2726 cents per kWh	3.3439 cents per kWh
All Off-Peak Energy per month:	3.0791 cents per kWh	3.1506 cents per kWh
Standby Charge per month:	\$0.95 per kW	\$0.95 per kW

Several methods may be used to overcome unfavorable utility rates concerning the installation and operation of a CHP system. The CHP system owner/operator may take certain measure to reduce the negative impacts of utility standby rates. Changes may also be needed for utility policy concerning the application of certain rates related to a CHP or distributed generation project.

A CHP owner/operator may invest in multiple generating units as insurance against system outages. Then standby rates and insurance are purchased for only one of the units. Owners/operators may also identify non-critical loads that may be shed in the event of an outage. Load shedding would decrease demand and lessen penalties applied by the utility in the event of an outage¹⁴²⁶.

Removal of standby charges and exit fees would be a best case scenario for advocates of CHP. Although this event is unlikely, certain steps may be taken by the utility commission to address prohibitive rate and fee practices. Increased testing and analysis should be placed on standby rates. This analysis may prove that exit rates and standby charges are unnecessary. Other rates are subject to a rigorous evaluation and standby rates and exit fees should be no exception. Public interest should also be considered when deciding standby rates. Environmental and economic issues that affect a community at large may outweigh utility profit and the goal of utility service should include society's long term interests²².

Specific Obstacles in Agriculture

Batch Processing

In the best possible scenario, CHP is utilized efficiently where there is a constant supply of thermal energy and a constant load for that thermal energy. However, many agricultural processes are not continuous; often batch or seasonal processes. Therefore the production of waste thermal energy is not constant, and must be applied to a non-constant source.

Batch processing can be improved through the use of a regenerative furnace which utilizes regenerative heat exchangers. These heat exchangers incorporate a thermal energy storage checker which acts to preheat combustion air for the next batch process. CHP proposals have been made which diverts the gas stream after it has left the regenerator to a heat recovery system. The heat recovery system uses a heat exchanger and a working fluid to drive a turbine. The turbine drives an electrical generator **Error!** **Bookmark not defined.**²³.

Proprietary Information

As the Southeast CHP Application Center conducted the market assessment for CHP in agriculture, issues of proprietary information were encountered. While several agricultural experts and officials were contacted to collect information concerning equipment, operational information, and energy and waste heat usage, very little information was received due to the proprietary nature of the data requested. A lack of information and cooperation presents itself as a barrier to the successful implementation of CHP. The situation created by limited access to proprietary information continues to inhibit the development of CHP in an industrial setting. Partnership between industry, government agencies, and research institutions in early discussion and development of CHP is a necessary link for achieving the goals of reduced grid reliance, reduced pollution emissions, and an overall safer, cleaner, electricity market in South Carolina and the United States.

Exploring Implementation of CHP

CHP technologies offer a potential opportunity to increase productivity and economic efficiency within the glass manufacturing process. As such, there are numerous government, trade, and support organizations for the implementation of CHP equipment.

The Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) offers *Quick Plant Energy Profiler (Quick PEP)* software on its website to help determine how energy is currently being used and where opportunity exists to save cost and energy. The Department of Energy also sponsors *Industrial Assessment Centers (IACs)* which provide no-cost energy assessments for small and medium sized manufacturing facilities.

The United States CHP Association (USCHPA) offers links under the resources section of its website including CHP software tools, CHP manufacturing company links, and national case studies for current CHP projects and technologies.

Recommendations

Further Analysis

There is federal information on how energy is created and how much is used within the USA, but during the course of this assessment, no information was obtained from federal or state agencies that would indicate how that energy is being used; and pertinent to this assessment, how CHP was being utilized. The goal of this study was to determine the potential CHP capacity in the South Carolina agricultural industry.

However, due to constraints concerning proprietary data within the agricultural industry, difficulties were encountered in obtaining the pertinent information needed to calculate an accurate potential. Collaboration with industry is needed to correctly assess the true potential CHP capacity within the South Carolina agricultural industry.

There is a process already in place with which information can be attained. The US census, which is taken every 5th year, provides information regarding their yearly production American businesses. The data collected helps the US Census Bureau establish the economic profile of the USA. Similarly, if the US government can insure proprietary information and provided appropriate funding, an energy census could be profiled.

Alternative Markets

It is strongly suggested that a market analysis be completed for the largest Industries of the Future in South Carolina; chemicals and metal manufacturing. The chemical industry

is worth \$12 billion to South Carolina's economy while the metal manufacturing brings in a combine \$7.1 billion from various mills and forges.²³ South Carolina may see a greater energy savings if investments were made to utilize the remaining CHP potential in these two large markets, starting with a market analysis such as the one presented here.

Conclusions

Under the direction of the United States DOE and the North Carolina State Energy Office, the Southeast CHP Application Center has set out to develop market assessments for CHP with respect to specific industries within the southeastern states.

This market assessment was completed for the \$1.89 billion agricultural industry in South Carolina. The South Carolina agricultural industry is a large, energy intensive, multi-billion dollar market that accounts for more than 24,000 livestock ranches, floriculture and crop farms, and many food related industries.

On page four of ACEEE's document "Potential Energy Efficient Savings in the Agricultural Sector," energy savings are estimated to be approximately 10% of the total operating cost in the agricultural industry¹⁰. This 10% value became the target value, since the exact amount of CHP, nor the complete energy profile for the South Carolina agriculture sector, is known.

At a national level, the agricultural industry consumes nearly 98 trillion BTUs of electricity on an annual basis. Traditional farms which have facilities with limited steam operations and are predominantly field applications are viewed as less favorable. However, since CHP is scalable, often has readily available fuel sources, and is usable with existing and attainable technologies, CHP does have potential in agriculture.

Conventional barriers inhibit the installation of CHP as well as distributed generation on a broad spectrum. Environmental regulations, prohibitive interconnection procedures, escalated utility standby rates, and the lack of third party sales for electricity all present themselves as barriers for CHP installation. Difficulty in obtaining local industry data such as energy usage, production rates, and waste heat utilization etc, manifests a barrier in the creation of a market assessment as well as CHP development in general. These barriers do exist, but in time, as energy usage/needs become more mainstream issues, these barriers will be reduced.

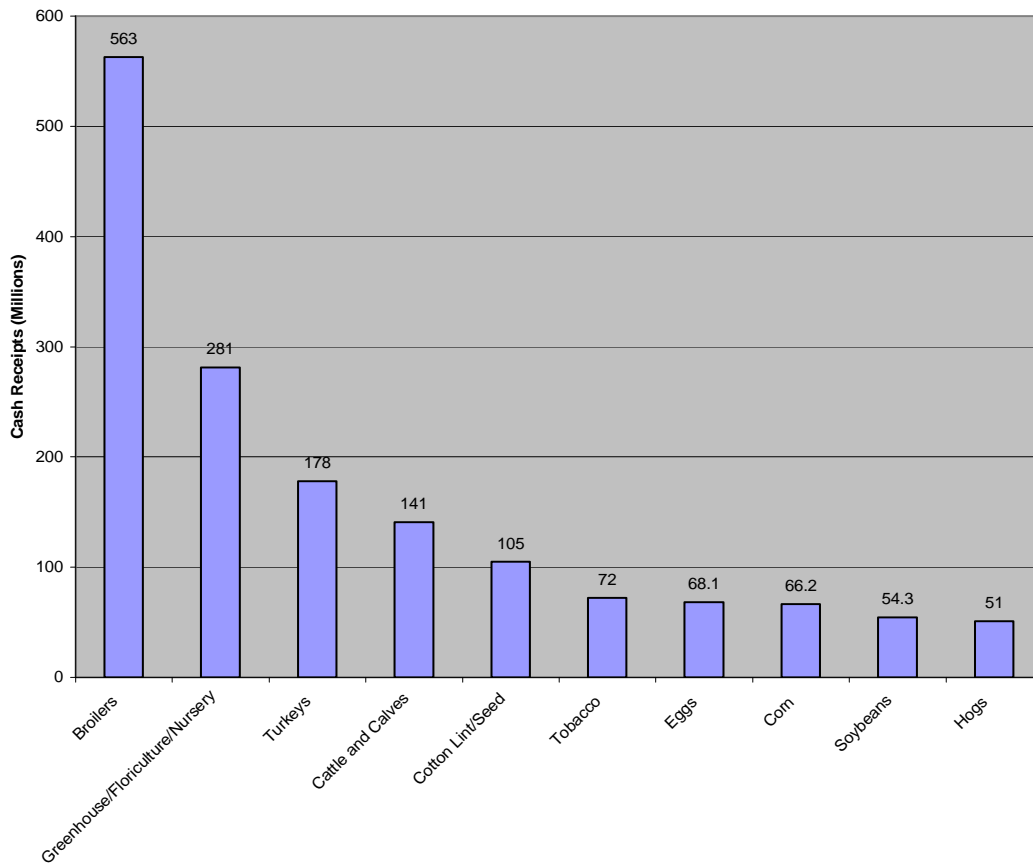
Industry specific barriers may be resolved internally with effective engineering practices. However, barriers that affect CHP and distributed generation projects as a whole should be addressed through policy reformation and modification on a federal, state, and local level. Regulators, officials, and industry and utility representatives must work together to create sound, consistent policies and regulations that give CHP equal or favorable treatment in the world of power generation.

While CHP may provide a cost saving, energy efficient option for farmers and food related manufacturers, change is slow to come in the industry due to the capital and energy intensive nature. For those farmers or food related manufacturers whom are considering CHP implementation, the next step is a feasibility study. The study should provide engineering and economic analysis which will determine if a project using CHP technologies would be profitable to install. While initial costs associated with establishing CHP are viewed as relatively high, rising fuel costs may cast a more appealing light on such proposals²⁴ and subsequently create a large market for CHP applications.

Appendix A: Agriculture Profile of South Carolina

In 2006, South Carolina agricultural sales were \$1.89 billion. Possibly one of the most potential markets within agriculture for CHP is the poultry market, given that it is the second largest poultry market in the USA. Additionally, there are multiple potential uses for CHP when one considers the heating, cooling, and electricity requirements associated with not only the cultivation of poultry, but also the various associated processes such as preparation and packaging. Table A-1 indicates the top ten cash receipts of agricultural products in South Carolina, including both livestock and crops.²⁵

Table A-1: Agriculture Industry Statistics - SC



Figures A-1 and A-2 indicate the spread of divisions of more predominant livestock and crops, respectively.²⁶

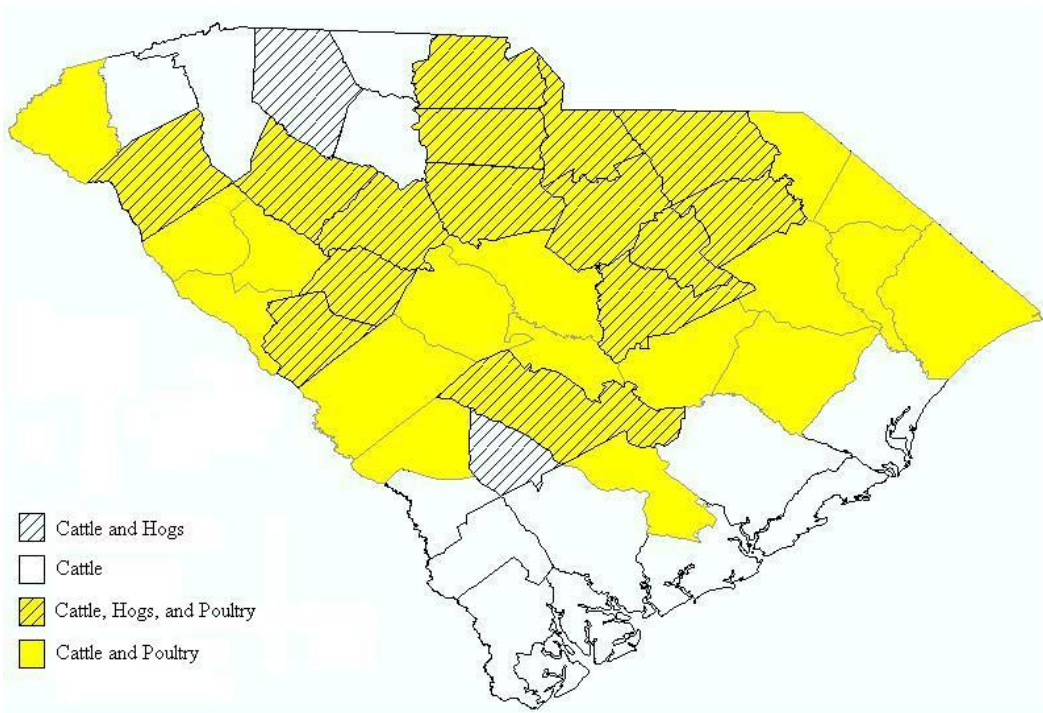


Figure A-1: Livestock Distribution - SC

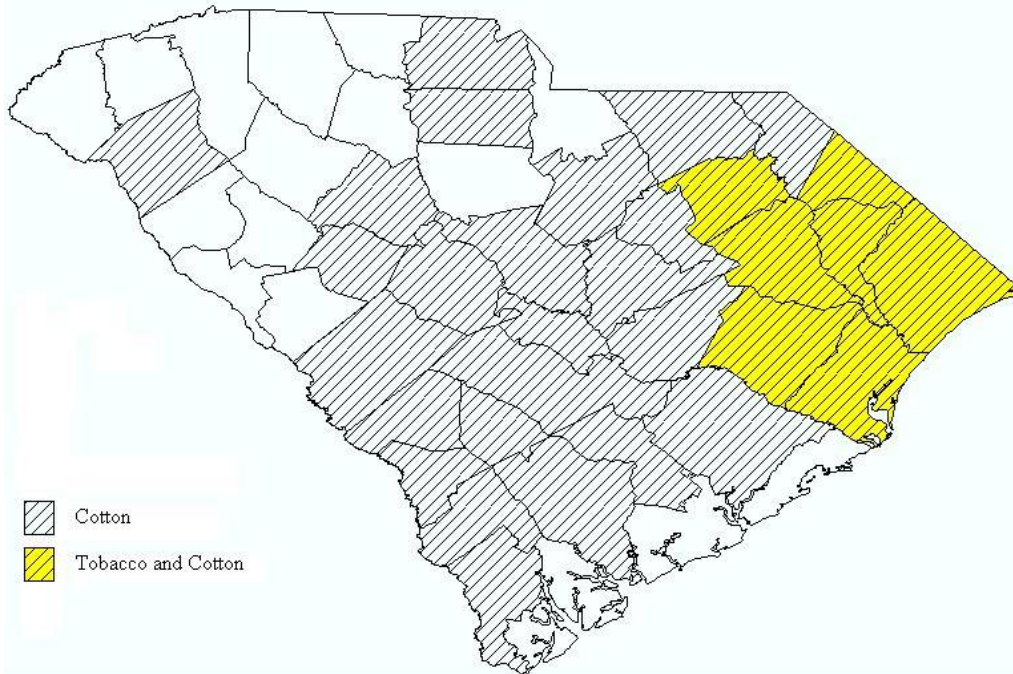


Figure A-2: Crop Distribution – SC

The distribution between the top 10 products can be divided into three principle areas: livestock, crops, and greenhouse.

Livestock

The most dominant form of livestock in South Carolina is poultry which includes broilers, egg producing hens, and turkeys worth \$809 million in cash receipts yearly. The most widespread, however, is cattle (primarily dairy), with a distribution in cattle farming spread across all counties in South Carolina, as evidenced by figure 1. In addition to poultry and cattle, hogs are another livestock in the top 10 agricultural products in South Carolina. [Error! Bookmark not defined.++](#)

Crops

Tobacco and cotton are the two largest crop industries in South Carolina by cash receipts, with \$105 million and \$72 million, respectively. Other crops which place in the top 10 agricultural products in South Carolina include corn and soybeans. [Error! Bookmark not defined.++](#)

Greenhouse/Floriculture/Nursery

The Greenhouse/Floriculture/Nursery sector of South Carolina's agriculture industry is the second largest industry by cash receipts, with \$281 million. [Error! Bookmark not defined.++](#)

Works Cited

- ¹ Brown, Elizabeth., R. Neal Elliot, and Steven Nadel. ENERGY EFFICIENCY PROGRAMS IN AGRICULTURE: DESIGN, SUCCESS, AND LESSONS LEARNED. Jan. 2005. 30 June 2008
<<http://aceee.org/pubs/ie051full.pdf?CFID=846550&CFTOKEN=98779747>>.
- ² "Basics." CHP Basics and Benefits. South East CHP Application Center. 27 July, 2007.
<http://www.chpcenterse.org/03-00_chp.html>.
- ³ Northeast CHP Application Center. What Is CHP? 2005. 12 May 2008
<<http://www.northeastchp.org/nac/CHP/index.htm>>.
- ⁴ Hedman, Bruce. CHP 101: Applications and Benefits of Combined Heat and Power - Las Vegas Nevada. Microsoft Power Point Presentation ed., September 11, 2006.
- ⁵ Korobitsyn, Mikhail. "Industrial Applications of the Air Bottoming Cycle." Energy Conversion and Management 43.9-12 (2002): 1311-22.
<[http://dx.doi.org/10.1016/S0196-8904\(02\)00017-1](http://dx.doi.org/10.1016/S0196-8904(02)00017-1)>
- ⁶ Eto, Joseph H. LaCommare, Kristina H. Understanding the Cost of Power Interruptions to U.S. Electricity Consumers. Ernest Orlando Lawrence Berkeley National Laboratory. Sept. 2004. 8 May 2008.
- ⁷ Crawford, Philip., Tim Lupo, and Keith McAllister. Clean Heat and Power Options for Charlotte Mecklenburg Utilities McAlpine Creek Waste Water Treatment Facility. 11 Oct. 2007. 12 May 2008.
<<http://www.chpcenterse.org/pdfs/McAlpineStudyFinalReport.pdf>>.
- ⁸ Midwest CHP Application Center. Opportunity Fuels. 30 June 2006. 12 May 2008
<http://www.chpcentermw.org/14-00_fuels.html>.
- ⁹ Resource Dynamics Corporation--US Dept of Energy. Combined Heat and Power Market Potential for Opportunity Fuels. Aug. 2004. 18 Dec. 2008
<http://www.eere.energy.gov/de/pdfs/chp_opportunityfuels.pdf>.
- ¹⁰ Brown, Elizabeth., and R. Neal Elliot. Potential Energy Efficiency Savings in the Agriculture Sector. Apr. 2005. 14 July 2008 <<http://www.aceee.org/pubs/ie053full.pdf>>.
- ¹¹ Bluestein, J., M. Eldrige, and S. Horgan. The Impact of Air Quality Regulations on Distributed Generation. Vol. NREL/SR-560-31772. Golden, Colorado: National Renewable Energy Laboratory, 2002.
- ¹² Shipley, Anna, et al. Certification of Combined Heat and Power Systems: Establishing Emissions Standards. Sep. 2001. 20 May 2008
<<http://www.aceee.org/pubs/re014full.pdf>>.

-
- ¹³ U.S. Environmental Protection Agency. Output-Based Regulations. 21 March 2008. 21 May 2008. <http://www.epa.gov/CHP/State-policy/output.html>.
- ¹⁴ Petchers, Neil. Combined Heating, Cooling & Power Handbook: Technologies and Applications. Lilburn, GA: The Fairmont Press, 2003.
- ¹⁵ Alderfer, Eldridge, and Thomas Starrs. [NREL] National Renewable Energy Laboratory. 2000. Making Connections: Case Studies of Interconnection Barriers and Their Impact on Distributed Power on Projects. NREL/SR-200-28053. Golden, Colo.: National Renewable Energy Laboratory.
- ¹⁶ U.S. Department of Energy. CHP Regulatory and Policy Issues. 18 May 2006. 8 May 2008. <http://www.eere.energy.gov/de/chp/chp_applications/regulatory_policy_issues.html>.
- ¹⁷ U.S. Environmental Protection Agency. Funding Resources. 20 June 2008. 25 June 2008. <http://www.epa.gov/chp/funding/funding/pubscinterconnectionstandards.html>
- ¹⁸ O'Neill, Ean. Lack of Simplified Interconnection Capability. California Energy Commission. Power Point. 13 April 1999. 21 May 2008. <http://www.energy.ca.gov/distgen/document/DEPLOYMENT.PPT>
- ¹⁹ Restructuring Today. Casten Paints Picture of DG World, US Waste. 7 June 2005. 27 May 2008 <http://www.recycledenergy.com/documents/articles/tc_restructuring_today.pdf>.
- ²⁰ Beck, Fred., and Eric Martinot. Renewable Energy Policies and Barriers. 2004. 28 May 2008 <http://www.martinot.info/Beck_Martinot_AP.pdf>.
- ²¹ Hoffman, Peter. Personal Interview with Philip Crawford (NC Solar Center). 23 May 2007.
- ²² Casten, Sean. Making the Legal Case for Good Policy on Standby Rate Design. PowerPoint. 2 Aug 2006. 21 May 2008. http://www.masstech.org/renewableenergy/public_policy/DG/resources/2006-08_NARUC_Casten_standby.pdf.
- ²³ US Census Bureau. 2002 Economic Census: Geographic Area Series South Carolina. 7 Oct. 2007. 23 July 2008 <http://www.census.gov/econ/census02/guide/02EC_SC.HTM>.
- ²⁴ ONSITE SYCOM Energy Corporation . The Market and Technical Potential for Combined Heat and Power in the Industrial Sector. Jan. 2000. 4 June 2008 <<http://www.aceee.org/industry/Resources/techpoten.pdf>>.

²⁵ United States Department of Agriculture. South Carolina Fact Sheet: South Carolina. 9 May 2008. 9 June 2008 <
http://www.agcensus.usda.gov/Publications/2002/Rankings_of_Market_Value/South_Carolina/index.asp>.

²⁶ National Agricultural Statistics. Data and Statistics. 13 June 2008. 13 June 2008 <
http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp>.