Rice Husk to Energy
De la Balle de Riz à l'Energie

A Preliminary Assessment
Une Evaluation Préliminaire

for
pour

The Republic of Mali
La République du Mali

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SECTION 1

Introduction & General Information

Schaffer & Associates International, LLC (SAIL) in association with Louisiana State University Agricultural Center (LSU AgCenter) was awarded Grant Number 688-G-00-04-00049-00 by the U.S. Agency for International Development (USAID) Mission to Mali and West Africa Regional Program, and USAID Energy Washington, D.C. Subsequently, SAIL signed a sub-contract with the LSU AgCenter for their assistance, and both have cost shared the effort.

SAIL has extensive experience in co-generation and electric generation using waste and bio-renewable fuels. SAIL has designed and implemented over 300 agri-industrial projects throughout the world, over 100 of which included co-generation power plants using waste and bio-renewable fuels, ranging in size from 1.0 MW to 70.0 MW (about 85% in the sugar industry). SAIL has a partnering agreement with Agrilectric, a division of the Powell Group, which built, owns, and operates a 13.5 MW and a 1.5 MW power plant near Lake Charles, Louisiana and furnished technology for a 28 MW plant in California, all using rice husks as fuel and producing good quality silica ash. The original 13.5 MW plant has operated for 20 years at over 95% time availability. The LSU AgCenter, a leader in rice production and processing, has extensive experience in education, outreach, and research for the rice industry. The LSU AgCenter has designed, implemented and trained rice industry representatives from many rice producing countries in areas such as post harvest loss prevention, waste utilization and quality control. Office du Niger is a Government of Mali (GOM) agency that operates the irrigation districts and has administrative control of the Niger River water and irrigated land in a large area in Mali.

Work commenced in August, 2004 and the initial meetings for commencement of this assessment were held by the following SAIL staff members during the last week in September, 2004 in Bamako.

Francis C. Schaffer
Mima Nedelcovych
Geralyn Contini

In Mali, the Schaffer team consisting of Harouna Niang and Mario de Matos participated in the meetings and assisted in detailed data gathering. A kick-off meeting was held in the USAID offices with all of the

Schaffer team present. Additionally, meetings were held with the following, where a briefing on the project assessment and the activities to be conducted were made.

H.E. Minister of Agriculture

H.E. Minister of Commerce and Industry

H.E. Minister of Minerals, Energy & Water Resources

USAID Mission Director Pamela White and her staff

It was suggested that initial meetings take place with the General Manager of PRODEPAM, in order to share preliminary information on the rice sector. This meeting also took place during the last week of September, 2004.

The first field visit and report was prepared by Dr. H. Rouse Caffey and Dr. Lakshman Velupillai of Louisiana State University Agricultural Center (LSU AgCenter) based on information they gathered in Mali with assistance by the SAIL team in Mali headed by Mr. Mario de Matos during November 2004. Their report not only discusses co-generation but makes suggestions for quality enhancement and efficiency improvements that could help the rice industry grow, while reducing losses in the processing.

An additional visit was made in January, 2005 by Dr. Mima Nedelcovych, when the field visit report was submitted to USAID in Bamako.

SAIL home office personnel working on this report include Mr. Francis C. Schaffer, Dr. Harold Birkett, Mr. Marlan Mitch, Mrs. Geralyn Contini, Mr. Rafael Espinosa, and Dr. Mima Nedelcovych. LSU AgCenter home office personnel working on this report included Mr. Brett Craig and Dr. Lakshman Velupillai.

General Information

There is considerable agreement that electrical energy availability is a serious constraint to economic development in Mali. Thus off-grid, independent sources of electrical power are encouraged by the authorities. Secondly, the country with no known fossil fuel resources is currently importing 200 million liters of refined petroleum products for power generation, transportation and domestic use. Thus not only capital costs for cogeneration systems but also the corresponding reduction of diesel fuel for power generation needs to be considered.

Rice is an important food staple for over half of the world's population. A major by product of the rice milling process is the rice husk or hull, a fibrous product that comprises approximately 20 to 23% weight of the rough rice. Given recent annual world rice production of about 600 million metric tons (T) of rough rice; rice husk totals over 130 million T annually at present. Annual rice production tends to grow with or exceed population growth and some estimates predict that rice production will double in 30 to 35 years. The electric energy that could be produced from the present amount of rice husks is approximately 100 million MW hours (MWH) per year or about 11,400 MW for each hour of a year. Assuming a diversity factor is 65%, this would require an installed capacity of 17,500 MW, equivalent to 1,750 plants of 10 MW each or 3500 plants of 5 MW each. The preceding assumes efficiencies usual in small (1.5 to 10 MW) fairly efficient plants using about 45 Bars (650 psig) steam boilers and multi-stage steam turbines. Thus, present rice husks production in the world could generate a substantial amount of environmentally friendly energy.

Rice straw constitutes a substantially larger energy source, but is not considered herein, as it is normally left in the field or has alternate uses. However, rice husks are collected and available at rice mills, often having little value and constitute a disposal problem in many areas. In the United States, there are only 5 operating plants (of 5 MW to 28.0 MW capacities and one 1.5 MW demonstration plant). The low price of $0.015 to $0.02 per kWh that the electric utilities will pay for "purchased" electric energy from co-generation plants has limited the use of rice husks and other waste fueled plants in the United States.

Rice is an important food staple providing food for 1/2 to 2/3 of the world's population. The crop ranks second to wheat in terms of area and production. In terms of yield, it is second only to maize. In addition to the crop being a staple food in many countries, it is also important from a trade standpoint to those countries such as Thailand, Vietnam and the United States that export the crop.

The importance of rice has also been looked at from the standpoint of food value in terms of energy contribution to the diet and nutrient value in comparison to other cereals. Luh, in his book *Rice: Production and Utilization* states that rice provides more calories and carbohydrate per hectare than wheat, maize, barley, oats and millet. The yield of protein per unit of land is only second to oats. Assuming a hectare of rice can sustain 2055 persons for a day or 5.63 persons for a year, in 1990, rice provided up to 75 percent of the dietary energy and protein for nearly 2.5 billion people.

The rice crop is grown around the world in a wide variety of physical and cultural environments. These environments have had a profound effect on the crop. Cultural dietary patterns, socioeconomic facts, and government programs have a strong influence on the amount of land devoted to the crop. Although double and even triple cropping in the tropics complicates the estimates of the hectares of land devoted to the production of rice around the world, the land devoted to rice production covers 11 percent of the Earth's entire arable land, or more than 500 million hectares (Maclean, et al., 2002).

The major derivative of the rice milling process is the hull or husk, a fibrous product that comprises approximately 20 percent by weight of the rough rice. Given the present world rough rice production of over 600 million tons in 2000, some 120 million tons of rice hulls are currently available for various forms of utilization. The treatment of rice hulls as a "resource" for beneficial use including the production of energy is a departure from the previous thinking that hulls presented a "disposal" problem. The concept of generating additional revenue by proper utilization of rice hulls holds promise for the rice milling industry worldwide, particularly in those rice producing nations that are primarily dependent on imported oil for their energy needs. With the global increase in oil prices, these nations are experiencing hardships due to scarcity of foreign exchange as well as cost of transporting imported fuel oils within the country. For these nations, the utilization of locally available biomass including rice hulls is of crucial importance.

Present average annual production of rice husk of about 168,000 T in Mali is sufficient to provide fuel to generate electric power of 126,300 MWH or 14.4 MW for every hour of the year (8760 hours). At usual use diversity factors of about 65%, this would require an installed capacity of 22 MW. This is based on 800,000 T paddy rice annually, recent annual production has been 760,000 T to 970,000 T of paddy. Rice production in Mali is increasing as Mali is still a net importer of rice but is nearing self-sufficiency. There is potential for at least doubling rice production in Mali in the near future if Mali decides to become an exporter as neighboring countries in West Africa import over 2.0 million T rice annually. The full potential for exports from Mali to its neighbors can be realized through programs aimed at enhanced production and post harvest operations that promote the processing of quality milled rice. Discussions at various levels indicate that at present even though the imported rice is cheaper than the locally available milled rice, the population prefers the local rice. This implies that a market for local rice exists, and will continue to grow concurrently with increased grain quality.

Environmental Consideration

Rice hulls contain about 20% silica and are extremely slow to degrade. Rice hulls stored in piles present two health hazards. First, they become a food supply for rats, and second they trap water which acts as a breeding ground for mosquitoes, other insects and pests. In addition, the land used to store the rice hulls becomes temporarily sterile.

The combustion of rice hulls to produce both energy and valuable silica ash is an elegant solution for the disposal of stockpiled surplus rice hulls. During the combustion process the organic matter in the hulls (carbohydrate and carbonaceous fractions) is converted to carbon dioxide and water. During the combustion process very minor quantities of carbon monoxide, nitrogen oxides and volatile organic compounds are generated which leave the furnace with the flue gases.

The combustion process is used to generate steam in a boiler, which in turn is used to generate electricity in a turbo-generator. The electricity generated displaces fossil fuels, primarily diesel in the case of Mali, which in turn reduces the pollutants discharged to the atmosphere.

The Draft Final Preliminary Assessment was submitted in March 2005 to USAID-Mali and Washington. Additionally, the Summary was translated and submitted to the Government of Mali. Comments regarding modifications were received in late March/April and have been taken into consideration in the issuance of the Final Preliminary Assessment. Visits to Washington and Mali and further discussions regarding the Preliminary Assessment conclusions took place in March/April for the purpose of moving forward to a roundtable discussion in Mali(under separate proposal) and full feasibility study and its required components.

The Final Preliminary Assessment is submitted at April 2005 and contains the following sections:

1 Introduction & General Information
2 Summary and Preliminary Conclusions
3 Terms of Reference – Future Study
4 Technical Approach
5 Status of Rice Production in Mali
6 SWOT Analysis

7 Physical Infrastructure & Human Resources

8 Project Costs, Development, Implementation and Constraints of the Rice Husk to Energy Project

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Annexes

SECTION 2

Summary and Preliminary Conclusions

The purpose of this assessment is to determine if the establishment of a power plant or plants to utilize rice husks to generate electric power in Mali's growing rice sector should be explored further. If the assessment indicates that conditions in Mali are such that a rice husk power plant should be considered, the next step would be a definitive feasibility study for a plant or plants in a specific location or locations.

Key Findings

Present average annual production of rice husk of about 168,000 T in Mali is sufficient to provide fuel to generate electric power of 126,300 MWH or 14.4 MW for every hour of the year (8760 hours). At usual use diversity factors of about 65%, this would require an installed capacity of 22 MW. This is based on 800,000 T paddy rice annually, recent annual production has been 760,000 T to 970,000 T of paddy. Rice production in Mali is increasing as Mali is still a net importer of rice but is nearing self-sufficiency. There is potential for at least doubling rice production in Mali in the near future if Mali decides to become an exporter as neighboring countries in West Africa import over 2.0 million T rice annually. The full potential for exports from Mali to its neighbors can be realized through programs aimed at enhanced production and post harvest operations that promote the processing of quality milled rice. Discussions at various levels indicate that at present even though the imported rice is cheaper than the locally available milled rice, the population prefers the local rice. This implies that a market for local rice exists, and will continue to grow concurrently with increased grain quality.

The parts of the Ségou and Mopti regions where Office du Niger and Office du Riz offer controlled irrigation water will probably be the major areas of rice expansion. The Ségou and Mopti Regions produces 73-75% of Mali's rice production with the Ségou Region alone producing about 60% or about 500,000 T paddy at reasonably high annual yields of 3,800-4,800 kg paddy/ha, based on information provided.

The first sites to investigate as potential cogeneration plant sites would be the eight existing "large" rice mills of 50 to 150 T/day capacity (see Table 5, Section 5.2). The closure of these mills started in the early 1990's and today only one operates on a regular basis and two or three others have only operated for short

periods in the last several years. Large mills and the small mills and hullers actually only operate six (6) or seven (7) months a year. Most of the 8 "large" mills have paddy storage capacity and at one time operated 10 to 12 months per year. These 8 mills were privatized starting in 1994. There were a number of reasons that the newly privatized mills were not successful including a sharp crop reduction one year, social and political changes in the early 1990's, the long time it took to sell the mills, lack of farmer crop financing, lack of transport to deliver paddy to the mills, etc. The largest single factor is probably that many of the new owners lacked or did not devote sufficient capital to purchasing paddy and employee compensation, resulting in the loss of farmer's production to the smaller mills. Any large new mill or reopening of existing mills will require determination, incentives, capable management, and sufficient capital to avoid similar problems.

Key Challenges

There are many difficulties in developing rice husk based electric production in Mali. The main difficulties include the fragmentation of the industry, the small size of most operating mills, the lack of an overall milling plant program and the lack of operating capital even for existing rice mills and rice hullers. Additionally, annual production in many areas varies from year to year due to dependence on natural flooding instead of proper controlled irrigation in many fields. The parts of the Ségou and Mopti regions where Office du Niger and Office du Riz offer controlled irrigation water will probably be the major areas of rice expansion. The Ségou and Mopti Regions produces 73-75% of Mali's rice production with the Ségou Region alone producing about 60% or about 500,000 T paddy at reasonably high annual yields of 3,800-4,800 kg paddy/ha. Tombouctou produces nearly 3,000 kg/paddy per ha but its total production is small; other Regions have much lower yields of 700 to 2,000 kg/ha. The present area devoted to rice, typically 375,000 to 400,000 ha could double Mali's rice production, if all fields achieved the average rice yield typical for the Ségou Region. This would require controlled irrigation, more inputs, more efficient rice mills and better agricultural management and practices in all areas.

Mali is believed to have one of the lowest per capita energy consumption rates in the world (2). At present only 8% of the population (approximately 100,000 customers) are said to have access to electricity, with a projected additional 7% of the population having electricity by 2010. Installed power in Mali includes hydroelectric (50 MW) and thermal (64 MW) sources. Mali is also stated to possess about 1 MW of solar

power sources serving about 2000 homes, and public buildings including schools and community buildings. Some solar powered water pumps are also used.

Currently, nearly 80% of the energy consumed by the population is estimated to come from fuel wood, albeit without a plan to sustain this renewable resource. Clearly Mali's economic progress requires additional electric power. Last years 2004 household rate was 94 CFA or U.S. 19.2 cents per kWh with social rates of US 20.2 cents per kWh. Last years industrial rates in U.S. cents per kWh at January 2005 exchange rate of 490 CFA to one USD follow:

Time of Day	Price CFA/kWh	Price U.S. Cents/kWh	Price with 18% Tax U.S. Cents/kWh
00.00 hr. to 06.00 hr.	43	8.78	10.36
06.00 hr. to 18.00 hr.	70	14.3	16.9
18.00 hr. to 24.00 hr.	98	20.0	23.6

Future Potential for Cogeneration

Despite the many problems, we believe that Mali has the potential to expand its rice industry and become a substantial rice exporter and producer of electricity from renewable wastes including rice husks. Mali has sufficient farmers, water and irrigation districts to provide controlled irrigation to double its production to 1.8 million T paddy without increasing the total area (400,000 ha) now devoted to rice. Mali is politically stable, a very important factor in Africa. The democratic change in governments 18 months ago was almost seamless, and the GOM has maintained its complete priority commitment to a large Agro-industrial project which SAIL has been developing in Mali for nearly four years.

We will now discuss several approaches that should be discussed for further study leading to a rice electric co-generation project or projects.

1) A large new rice mill/power plant

   An ideal location for a 5 to 15 MW or larger rice husk power plant would be at a large new rice mill to produce export quality rice, several of which are now being discussed.

The power plant could not only utilize rice husks from its own or associated rice mill but could receive rice husks from other nearby rice mills or clusters of small mills and/or ground rice husks from more district mills. A modern rice mill with a modern efficient power plant could be very feasible and could produce valuable silica ash and quality milled rice as an export product earning hard currencies.

2) Reactivation of existing facilities

The reactivation of several of the eight (8) existing "large" mills and the transport of ground rice husk to one in a central location.

a) There are two rice mills in Ségou City just across the road from one another, one of 50 T/paddy/day and the other of 75 T/paddy/ day. These mills are both owned by Mr. Modibo Keita. Mr. Keita, also owns a similar size mill at Savare/Mopti, within hauling distance of ground husk. Near Ségou City at Diero is a mill of 60 or 75 T/day capacity and within hauling distance of unground or ground husks. If one of these mills was reactivated, and the mills operated 24 hrs/day there would be 185 T/day to 200 T/day capacity in or near Ségou City sufficient for a 1.5 MW electric plant, if both were reactivated, there would be 250 T/day capacity that could supply husks for about 2.1 MW. If the mills do not operate the year around, sufficient husks could be obtained from nearby small mills to provide year around operation or to justify a larger power plant. Nearby small mills could provide enough additional husks for a 3.0 MW to 4.0 MW electric plant, perhaps 5 or 6 MW with some additional husks from smaller nearby plants and/or ground husks from the mill at Savare/Mopti.

b) An electric generating plant at one of the other 8 "large" mills that may be reactivated and husks from one or more of the other 8 mills plus husks from nearby small plants that could be considered for use. Perhaps the Molodo/Niono mill, reported to have been the largest mill in Mali and is presently closed, could be considered as a location.

3) Centrally located power plant

Another option that could be implemented soon would be to build an Electric Power Plant in a central location in an area of a large number of the 2 T/hr plants that produce a better quality rice

than the smaller huller type mills. The smaller mills do not usually separate the bran from the rice, the bran and substantial brokens end up in the husk fraction. The non separation of the bran and the loss of brokens and rice powder to the husk portion presently probably represent a loss of about 5.0 billion CFA or USD 10 million per year in Mali. Thus, an increase in the 2T/hr mills with rubber roll shellers and steel polishers that separate the bran and reduce brokens and rice powder incorporated in the husks will probably increase. One group of villages has already purchased and installed 10 of these mills within a 10-15 km radius and is arranging the purchase of 10 more in the same area. The 10 mills could produce sufficient husks to fuel a 4.0 MW electric plant when all 10 mills are operating, or an 8.0 MW when all 20 mills are in operation. The husks from these mills, if burned in a suitable high pressure boiler, could produce a good quality silica ash. The team was informed that these rice mills presently operate or will operate 18 hours/day for 7 months per year. During this time, they should process 151,000 T/paddy, and produce 31,700 T husks which should produce 23,800 MWH per year. If the power plant operates for 350 days/year, 68.0 MWH/day could be produced per operating day. Assuming that the parasitic requirements of the electric plant are 12%, net export power would be 59.8 MWH/day. At a 65% diversity factor, this would require a 4 MW electric plant. If the rice mills operated 7 months at full capacity 24 hrs per day, they would produce 42,300 T husks and could produce 31,700 KWH per year or 90.57 kWh/day, and a net export power of 79.7 kWh/day. This would require (at 65% diversity) a 6.0 MW plant. If the 2 T/hr rice mills operated 350 days a year, they could process 336,000 T paddy that would result in 70,500 T husks per year that could produce 53,000 kWh/year or 151 MWH/day and average net exportable power of 133 MWH/day or 5.56 MWH/hr. that would at 65% diversity, require a 10.0 MW electric plant. Some of the customers for the power could be the participating rice mills together with other rice mills in the area now using imported and expensive diesel oil to fuel their engines.

4) <u>Development of industrial park/agro-industrial complex</u>

An option that should not be overlooked is the development of an industrial park/agro-industrial complex. This plant could serve as the nucleus of an agro-industrial complex / industrial park.

If this project were to be organized as a partnership whereby other industries/partners (stakeholders) were encouraged to locate their industries/processing facilities next to the biomass

energy plant this could be mutually beneficial. Industry located next to the plant would benefit from the plant's infrastructure (water, roads, etc.) as well as an economic steady power supply. Such industries could include rice mills, other grain processing plants, ethanol plants, bottlers, saw mills, slaughter houses, fish processing plants, canneries and others. Transmission costs would be minimal since long transmission lines would not be required to sell the power. Some industries may require steam which could be even more economical to supply than electricity. Industries located in the industrial park which produce fibrous biomass waste could sell that waste to the biomass energy plant to be used as fuel. In this case the fuel collection costs would be very low. Rice husks when available in sufficient quantity would be fired alone to avoid contamination of the ash. When rice husks are not available other fuels would be used, such as:

- Agricultural wastes—collected by large farming groups
- Liquid waste produced by some industries could be used to produce biogases as a supplemental fuel for the biomass energy plant. Waste from ethanol plants are sometimes used to produce biogases for fuel.
- Wood Waste from sawmills, tree pruning of wind breaks or fruit trees and programmed harvesting of cultivated forests. These forests could be used to form green belts to reduce soil erosion and wind blown losses.

The organization of the rice husk/biomass energy plant/industrial park could be an organized effort representing a wide spectrum of local society from industrialist/traders to farmers, representing an integrated productive unit. This option, although not included as part of the preliminary assessment and preliminary financial analysis, should not be overlooked in future studies.

Preliminary Financial Assessment

We favor a medium high pressure steam boiler and multi-stage turbine using steam pressure 31 to 45 bar (450 to 650 psig) with about 100˚ C (180˚ F) superheat. Low pressure boilers and steam engines and gasifier gas engine systems, whilst suitable for providing power and heat for small individual mills would not be an efficient use of the heating value of the husks and the ash would not be an exportable additional product.

The economics of a rice husk co-generation plant varies substantially with size, and the larger plants are much more profitable. Our preliminary estimate of the total installed cost of the plants and their indicated profitability with annual sales of 65% of capacity follow: (We assume that the plants will be income tax free for their first 10 years)

	1.5 MW	3.0 MW	6.0 MW	10.0 MW	20.0 MW
Installed Cost, Mil.	5.25	8.40	12.60	18.38	34.65
Elect. USD 0.11, Ash $ 80 T					
Cash Flow Gross	0.407	1.064	2.58	4.635	9.816
Net Cash Flow	(0.166)	0.146	1.208	2.008	6.030
Payback Years	12.9	7.89	4.87	3.96	3.53
Elect. USD 0.15, Ash 130/T					
Cash Flow Gross	0.853	1.975	4.431	7.710	15.956
Net Cash Flow	0.279	1.056	3.54	5.703	12.170
Payback Years	6.15	4.25	2.84	2.38	2.17

At the above prices, plants of 3.0 MW or larger are fairly attractive. The project's financial return becomes increasingly attractive as plant size increases.

Cash flow projections for a 10 MW plant at lower electric prices (USD 0.07 and USD 0.09/kWh and at lower ash prices (USD 50.00 and USD 65.00/T) was also made for sensitivity purposes. At USD 0.07/kWh and ash at USD $50.00/T net for the ash, the financial results of a 10 MW plant are marginal and the payback is 10 years; at the USD 0.09/kWh electric price and USD $65.00/T net for the ash, the return is feasible but not especially attractive with its 5.77 year payback. Electric prices of USD 0.11 to 0.15 are required to make the projects financially attractive on full commercial basis.

As can be seen, the profitability of the small 1.5 MW plant is marginal and would have too low an internal rate of return unless a suitable second hand factory in good condition could be found or unless a higher price for electric energy could be obtained or the plant could operate at full capacity 24 hrs/day, 350 days/year. Detailed and summarized financial analyses for the purposes of this assessment can be found in Section 8.

In all discussions of plant capacity, we have assumed that only rice husks are burned. The rice straw associated with rice production is usually 2 or 3 times the weight of the husks produced. If rice straw can be economically collected, the potential electric power that could be produced from the amount of rice waste (husks and straw) could increase from about 22 MW to 75 MW or more installed capacity and a future potential of up to 150 MW capacity from an expanded Mali rice industry. The feasibility of collecting and utilizing rice straw along with the husks could be considered in any future feasibility study. Larger plants of 10 MW or more should be very profitable. After a large plant is paid for, they could reduce electric prices substantially and remain profitable. Small plants in remote areas such as Tombouctou could also possibly be feasible if most electric power is furnished by small diesel or petrol fueled plants.

The potential for a profitable rice husk fueled electric plant in Mali is large. A feasibility study should determine the likely – price of electricity and the net ex-factory price for silica ash, which will require location of purchasers of the ash, the cost of delivery to the user and the quality of the silica ash that can be produced by Mali husks. A very important factor is the final location, central to husk production and husk collection methodology. Unground husks have a low density, about 128 kg/cubic meter (8 lbs/cubic foot), and a maximum economic haul distance of about 15 km; ground husks have a density of 385 to 480 kg/cm (24 to 30 lbs/cubic foot). Ground husks can have economic haul distance of more than 100 km. The indicated financial results for the various size plants all assume a 65% diversity factor for 350 days/year or for the annual period of operation. If a user can be found that would reduce combined hourly and seasonal variation to the point where 85% of the net power production of the plant capacity is diversified, financial results will improve substantially <u>or</u> the price received for the electric power could be reduced substantially at a given profitability.

SWOT Analysis and Recommendations

The detailed SWOT Analysis can be found in Section 6.

The SWOT analysis was designed to establish if rice husk to energy was a viable option for Mali. As noted in the matrix, conceptually the strengths that the project brings outweighs any weaknesses and threats. In addition, most of the weaknesses and threats can be managed and manipulated to provide positive input into the overall development of the rice and its by-products industries. The following recommendations are

made based on the SWOT matrix formed through verbal information collected from stakeholders during the period of the preliminary assessment.

- Rice husk to energy systems have the potential to provide rural electrification in the Segou region. Segou provides the largest locally available supply of rice husks in the country.
- The SWOT analysis does recommend that a bankable feasibility study be performed for the Segou Region. This detailed study should include: accurate cost estimates for transporting agricultural commodities and value-added commodities by truck, rail and barge; economic impact of a cogeneration facility on the potential for development of and industrial park/agro-industrial complex, and the MSMEs surrounding the facility; design, construction, and operating costs associated with a cogeneration facility; determine extent of concessionary financing; and identifying potential investors, multilateral funding agencies and multilateral donor agencies.
- Stakeholder participation will be the cornerstone for the success of this project. Engaging the stakeholders in the project and the benefits of the project will play an important role in the design and implementation phase of a project of this nature.
- Maintaining transparency in the project activities will promote the success of the project. Stakeholders should see the potential financial and economic incentives and the benefits through rural electrification provided by the project. Procurement and other business transactions should be done in a way as to increase the trust between the rice farmers and the cogeneration facility.
- This trust will expedite changes away from traditional uses of the rice husks, if the farmers see the potential financial and economic benefits.
- Increasing knowledge and skills of local labor force will help insure success of the project.
- Best management practices at the farm level and best manufacturing practices at the milling level should lead to more competitive pricing and higher quality products. The project could also focus on assisting with post harvest loss prevention through its activities.
- Develop MSMEs and farmers' associations to help concentrate the availability of rice husks, to decrease postharvest losses, to increase buying power for crop inputs, and to provide a forum for value-added raw materials and end products.

Recommendation

The Preliminary Assessment did not include all components that a full bankable feasibility study would address, and was completed in order to ascertain if in fact a bankable study document was justified..

It is the recommendation of the team that a full feasibility study is justified based on the findings of this Preliminary Assessment, and a full terms of reference/scope of work has been prepared and presented in Section 3. Prior to the feasibility study, a stakeholders roundtable discussion should be conducted in Mali for information distribution, and for the purposes of cooperation amongst the potential stakeholders and the enthusiasm and participation required to make this a successful study and ensuing project.

It should be noted that four potential project concepts have been identified for further study and discussion with stakeholders. After the Stakeholders Roundtable, these could be further amended and modified, increased or reduced.

SECTION 3

Terms of Reference – Future Full Feasibility Study

Technical Analysis

a) Geographic suitability for project site
b) Estimation of proposed raw material availability and identify any additional or increased sources of raw materials that could be utilized
c) Develop a plan to improve rice post harvest operations that improve grain quality, decrease losses and provide rice husk free of rice bran/brokens
d) Cost of obtaining and delivering raw materials to the plant

Engineering Analysis: Power Plant and Distribution Network

a) Delivery system for collecting and delivering raw materials
b) Storage and handling system, for raw material
c) Conceptual design for the power plant and any future expansions
d) Preliminary Material and Energy Balances for the facility and potential expanded capability
e) General arrangement and flow diagrams – power plant
f) General delivery diagrams for power distribution at plant battery limits
g) Equipment lists and descriptions
h) Environmental Impact Review

Project Cost Estimates

Capital cost estimates and operations and maintenance costs will be developed. The capital cost requirements will include estimates of the cost for design and engineering, project management, equipment supply, inland and ocean freight and insurance, plus construction and installation. Projected operations and management (O&M) cost data will be developed.

Financial, Economic, and Socio-economic Analysis

Based on projected costs and revenues as outlined above, calculations of the internal and financial rate of return (EIRR), based on a number of scenarios consistent with the economic parameters provided, will be performed. Financial analyses will be performed, using a variety of assumed costs

and revenues, so as to establish an internal break-even level. The financial analysis will include:

(i) Socio-Economic Analysis and Human Resource Development

(ii) Review of potential for concessional loans from international financial institutions or infrastructure funds.

(iii) Estimated capital costs will include estimates of engineering and construction

(iv) Overall annual costs will include annual depreciation and interest on total project investment, annual operating expenses.

Project Financing

Alternatives of project financing will be reviewed throughout the study works, and will be summarized for the final study, after review and discussion with appropriate stakeholders.

Project Implementation Plan/Schedule

An implementation program will define the most effective and viable method of Project implementation based on the overall analysis. A Project schedule will be provided with all major aspects of the overall project outlined. It will also denote, in line with the financing plan, the method of implementation. An overall investment schedule will be provided to organize timely availability of the financing for the Project as well as the disbursement schedule for the Project components.

Final Report

At the end of the study, the team will prepare a Final Report, which will include information pertaining to the tasks mentioned above, as well as conclusions regarding the final project recommended together with the financial criteria to further develop the project.

SECTION 4

4.0 Technical Approach and Work Plan

On 6 August 2004, SAIL in association with the LSU AgCenter was awarded Grant Number 688-G-00-04-00049-00 by the USAID/Mali and West Africa Regional Program. The grant (Annex A) consisted of these terms of reference as they appear in the grant agreement:

4.1. Technical Approach

The SAIL team propose a four step approach to determining the feasibility for the potential of designing, implementing and constructing a small-scale renewable energy system fueled by rice husks that will provide an affordable and reliable alternative to fossil fuels and other traditional energy technologies. These steps include a feasibility report with the following objectives and emphases:

- Identify status of rice production in Mali (concentrating on the The Segou, Markala and other Office du Niger regions) in conjunction with CLUSA
- SWOT (Strength, Weakness, Opportunity and Threats) analysis on current rice production and milling operations
- Identify physical infrastructure and human resources
- Identify potential locations and economic impact to developing energy production systems in those regions.

4.1.1 Identify status of rice production in Mali (concentrating on the Segou, Markala and other Office du Niger regions)

Activities:

- Tour sites in the rice production communities in Segou, Markala, and other Office du Niger regions.
- Meet with potential stakeholders including private and public representatives of the rice growers.

4.1.2 SWOT analysis on current rice production and milling operations

In order to determine the rice industry's ability to support a rice husk to energy system, a SWOT analysis will need to be performed. This analysis is an important step in the development planning process and involves an assessment of strengths, weaknesses, and available opportunities, and threats. The analysis will identify local resources and the capabilities for rice production, marketing, finance, technology, and labor force. It will be used to identify strengths, for instance, help planners set objectives, develop plans for meeting those objectives, and take advantage of marketing opportunities. While strengths and opportunities

afford leverage, weaknesses and threats represent problems, as weaknesses denote constraints and threats denote vulnerabilities.

SWOT analysis, is a method to compare internal organizational strengths and weaknesses with external opportunities and threats. (SWOT is an acronym for strengths, weaknesses, opportunities, and threats). This analysis provides managers and planners with a critical view of the organization's internal and external environments and helps them to evaluate the firm's fulfillment of its basic mission (Boone and Kurtz, 2004).

The following elements will be used to classify the four factors involved in the SWOT analysis:

- Strengths: financial resources, existing network of farmers or farm organizations, physical infrastructure, and managerial skills, low operation cost, reputation.
- Weaknesses: narrow scope of business, lack of management skills or financing, high operation cost, inadequate financing capabilities, weak reputation.
- Opportunities: new areas of advantage to the farmers on their own or through partnerships.
- Threats: entry of new competitors or similar organizations, adverse government policy, changing markets.

4.1.3 Identify physical infrastructure and human resources, potential locations and economic impact to developing energy production systems in those regions.

Because of the importance of understanding the current infrastructure in developing a rural energy production facility, this feasibility study will briefly assess the following:

- Social considerations – how the industry will affect the region proposed at the societal level, i.e., gender, income, cultural acceptability, etc.?
- Infrastructure – will the industry have access to inputs and post harvest handling for outputs, i.e., transportation, roads, handling, market outlets, etc.?
- Property rights – who owns the rights to land, access, etc.? Will property rights be an issue, i.e., common property, land tenure, etc.?
- Geographic suitability – what are the soil types, water resources, topography, etc., of the region proposed for the development of rice and related industries?

Activities:

- Assess current social considerations that may cause constraints to the development of the industry.
- Assess current access to the infrastructure including roads, methods of transportation, etc. to determine viability and recommend needed improvements.
- Assess property rights in region proposed for development.
- Inventory the geographical suitability of the region proposed for the development.

4.2 Work Plan and Project Timeline

Activity	Month 1				Month 2				Month 3				Month 4			
Team Mobilization																
Assess Current Conditions																
Team Travel																
Data Analysis																
Draft Report																
Final Report																

4.3 Outputs

The following would be covered in the assessment and form the Table of Contents of the Assessment Document:

Executive Summary & Conclusions
Terms of Reference
Technical Approach

4.3.1 Status of Rice Production in Mali

a. History Data
b. Current Situation and Production
c. Future Potential Production of Rice and Rice Husk/Power

4.3.2 SWOT Analysis

4.3.3 Physical Infrastructure and Human Resources

a. Social Considerations
b. Infrastructure (Logistics and Transport)
c. Geographic Suitability

4.3.4 Project Costs, Development, Implementation & Constraints of the Rice Husk to Energy Project

a. Capital Requirements
b. Preliminary Financial Analysis
c. Environmental Benefits

4.4 Technical Approach for Assessment

The purpose of this assessment is to determine if the establishment of a power plant or plants to utilize rice husks to generate electric power in Mali's growing rice sector should be explored further. If the assessment indicates that conditions in Mali are such that a rice husk power plant should be considered, the next step would be a definitive feasibility study for a plant or plants in a specific location or locations. To accomplish this goal, SAIL and the LSU AgCenter performed the following activities based on the Terms of Reference (Section 3).

In August 2004, the grant agreement between USAID and SAIL was signed. Immediately following the signing of the grant agreement, the LSU AgCenter completed and signed their subcontract with SAIL for its portion of the project. Shortly after the signing of the contracts, SAIL and the LSU AgCenter began extensive literature and data searches covering historical and contemporary information on the rice industry in Mali. In September 2004, team mobilization began. Travel plans were made for Francis Schaffer, Geralyn Contini, Mima Nedelcovych, Lakshman Velupillai and H. Rouse Caffey. Travel logistics were arranged for trips in September and November 2004 and January 2005.

The initial meetings in Bamako were held by the following SAIL staff members during the last week in September, 2004.

Francis C. Schaffer
Mima Nedelcovych
Geralyn Contini

In Mali, the Schaffer team consisting of Harouna Niang and Mario de Matos participated in the meetings and assisted in detailed data gathering.

A kick-off meeting was held in the USAID/Mali with all of the Schaffer team present. Additionally, meetings were held with the following, where a briefing on the project assessment and the activities to be conducted were made.

H.E. Minister of Agriculture
H.E. Minister of Commerce and Industry
H.E. Minister of Minerals, Energy & Water Resources
USAID Mission Director Pamela White and her staff

It was suggested that initial meetings take place with the General Manager of PRODEPAM, in order to share preliminary information on the rice sector. This meeting took place during the last week of September, 2004.

The first field visit and report was prepared by Dr. H. Rouse Caffey and Mr. Lakshman Velupillai of LSU AgCenter based on information they gathered in Mali with assistance by the SAIL team in Mali headed by Mr. Mario de Matos during November 2004. Their report not only discusses cogeneration but makes suggestions for quality enhancement and efficiency improvements that could help the rice industry grow. The LSU AgCenter team also met with USAID/Mali for a country briefing and follow-up debriefing during their visit.

In December 2004, SAIL and the LSU AgCenter continued to compile data and cost estimates for the development a cogeneration plant. Based on the field visit and report from the LSU AgCenter, SAIL was able to make preliminary cost estimates based on the current production yields and future yields based on the implementation of the LSU AgCenter report recommendations for quality enhancement and efficiency improvements.

An additional visit was made in January 2005, by Dr. Mima Nedelcovych, when the field visit report was submitted to USAID/Mali in Bamako. During this time, SAIL home office personnel (Mr. Francis C. Schaffer and Dr. Harold Birkett) were performing energy balances for different sized plants and developing estimated cost scenarios for these plants.

In February 2005, the SWOT analysis was performed using the total project collected inputs as well as the knowledge of SAIL and the LSU AgCenter teams. The process was completed and is reported in Section 6 of this document. In addition, an environmental analysis based on the information available from existing cogeneration facilities in the U.S. and taking into consideration the local conditions in Segou region was completed by SAIL. In trying to provide a true assessment, SAIL has also provided several scenarios for feasible activities including the development of an agro-industrial complex/park. During this period, the draft final report was organized and written. SAIL home office personnel working on this report include Dr. Harold Birkett, Mr. Marlan Mitch, Mrs. Geralyn Contini, Mr. Francis C. Schaffer, Mr. Rafael Espinosa, and Dr. Mima Nedelcovych. LSU AgCenter home office personnel working on this report included Mr. Brett Craig.

SECTION 5

5.0 Status of Rice Production in Mali

The assessment was undertaken by the LSU AgCenter (see Annex B for complete report). The main purpose of the assessment was to review the rice production and post harvest operations including the milling of rice to gauge the availability and quality of rice hulls for potential cogeneration systems. The premise for the assessment was that the production of electrical power from off-grid and independent sources utilizing a renewable resource will enhance the availability of electricity for the rural population, and reduce the dependence of the country on imported fuels, or its limited wood resources (forests).

The assessment was conducted in November 2004 by two specialists from the LSU AgCenter with expertise in the production and post harvest operations of rice. The staff of SAIL in Mali provided all in-country support to conduct the assessment. Although the main focus of the assessment was the Segou region within the purview of the Office du Niger, the Mopti region where a significant area is under rice cultivation was also visited. Interviews and visits were conducted at ministries, agencies, with rice traders, millers, farmers, and village associations.

5.1 Historical Data

As far back as the Malinke-speaking people who built the Mali Empire, agriculture has been the basis for economic growth in the region. During the colonial period, Mali was not considered a country with resources for exportation but as a country to supply labor for other colonies that did have resources to strip. As a result, agriculture continued to contribute to the local economy. At the time, agricultural production consisted of maize, millet, sorghum and vegetables. The colonial governments provided cheap broken imported rice for the local Malians. With independence in September of 1960, the Malian economy suffered greatly from the lack of stability associated with the withdrawal of the French and the focus on the government toward socialism. The country whose agricultural economy was based on subsistence farming of cereals, primarily sorghum, millet, and maize had grown accustom to have cheap rice as a food stuff. As a result, rice production became part of the agricultural landscape. Rice production has been centered around the Niger River basin and remains a subsistence crop for local farmers. In the recent past, there have been a number of governmental programs focusing on irrigation projects. The oldest and largest of the government-established rice production areas is the Office du Niger, which has historically produced

nearly half of the domestic rice production and the majority of the domestic rice entering the market place (Dembele and Staatz, 1999).

5.2 Current Situation and Production

Rice Production – In seeking to determine the status of rice production in Mali for the recent years, the reports vary according to source. The area under cultivation from the reports ranges from 350,000 to 400,000 hectares. The paddy production is stated from 700,000 tons to over 960,000 tons. The yield per hectare varies from below one ton per hectare, to more than six tons per hectare. The national average is 2.2 to 2.5 tons per hectare. Of the seven production regions, the highest yield per hectare and the highest total production is in the Segou Region (Office du Niger and Office du Riz). The Markala dam constructed many years ago permits the controlled irrigation in much of that area, which probably contributes to increased paddy yields and production. Field yields of 3.8 to 4.7 tons per hectare are produced in the Segou Region, and it is estimated that the production of paddy from that Region is about one-half of the total Malian paddy production. The size of household planting of rice ranges from 0.25 hectares up to 12.0 hectares, with the average about 1 to 3 hectares.

In the two Regions visited, Segou and Mopti, the rice production practices are about the same. Seed beds are planted to obtain plants (seedlings) for transplanting. After transplanting, commercial fertilizer is applied when it is available, with a split application of nitrogen at panicle initiation. Weeding is primarily a hand operation, but a few growers reported using chemical herbicides.

No insecticides or fungicides are applied. The number of days from planting to harvest, range from 120 to 135. When the paddy is matured (moisture level of the grain about 18 to 20 percent), the paddy is harvested by hand in the field, stacked, and allowed to dry for 2 to 3 days, and then threshed with a mechanical thresher. The grain is then spread on drying mats and allowed to dry in the sun until it reaches a safe storage moisture content of about 12-13 percent. The paddy is then sacked into 70 to 80 kg bags, and stored at the grower's home until it is milled by the small fixed location and portable mills. The milled rice from these inefficient machines consists of mostly broken white milled rice, and a mixture of ground hulls and bran which is then used for animal feed.

The Rice Post harvest System – The rice post harvest system is currently handled by a combination of manual means with very little energy use, and small scale threshers and rice mills run by diesel power. The timing of harvesting and threshing practices could be modified to reduce internal breakage of the rice kernels, and subsequent low mill yields and food losses. An awareness program mainly through training of trainers, and low cost rice quality assessment laboratories can be one solution to address past harvest losses, currently estimated to be about 38,000 tons of milled rice equivalent valued at 16 million U.S. Dollars per annum.

The Rice Milling Industry – Since the privatization of the processing and trade in rice in the early 1990s, most of the larger mills with an estimated total annual milling capacity of 115,000 tons have been closed for operations. This situation has been caused by a variety of factors including lack of finance for paddy purchases, competition from the smaller mills for paddy purchases, and possibly lack of management efficiency. Despite this, one miller plans on continuing operations, and has even purchased another government mill, while another company is planning to establish a new large rice mill. Further, groups of villages have invested in improved rice milling systems that are capable of producing quality rice for the local markets.

As far as milled rice quality is concerned, by far the most striking observation was the amount of broken rice, overall about 50%, and in some cases even 100% brokens. Due to the low purchasing power of the rural populations, there is no present recognition for higher quality, and hence a higher price for milled rice. However, there appears to be a growing market for quality milled rice in the major cities, and discussions have revealed that those who can afford it will purchase the higher quality rice at a higher price. Mali currently imports a small quantity of rice from Asia, and this rice is sold at a price that is slightly lower than the locally produced rice. However, it is believed that the local population prefers the Malian rice.

Through an awareness and education effort referenced in subsection (a) above, a focus on rice quality improvement will result in reduction of food loss, which in turn will reduce rice imports. Concurrently, the focus on improved rice quality will encourage a move away from the current milling systems that are largely the cause for the broken rice component. This move will also result in a purer bran component, and rice hulls, more suited for cogeneration systems.

Rice Husk Availability – Given the current status of milling systems in the country, the availability of rice hulls for cogeneration systems is limited. The only operating large mill at Segou city currently produces approximately 2000 tons of rice hulls per annum, while in a group of villages in the Niono area ten 2 t/h mills are currently operating producing 15,000 tons rice husk per annum. This latter group of mills is within a ten to fifteen kilometer radius making husk collection for a cogeneration unit feasible. Further, discussions with this village association revealed that they are planning to add another ten mills of similar capacity, thereby enabling a total husk availability of 30,000 tons per annum. Assuming a 1.2 MW cogeneration unit (consuming 45 tons husk per day) is viable, the present amount of rice husk of 15,000 tons per year will be sufficient to run the power plant for approximately 330 days/year. Other systems of lower capacity, particularly steam engine based systems need to be explored.

Potential for Cogeneration from Rice Hulls – As a backdrop to this assessment, there is considerable agreement that electrical energy availability is a serious constraint to economic development in Mali. Due to funding and maintenance issues, and the delay in the Manatali Power Unit coming on stream, grid power is limited and transmission losses are high, estimated at 25% for a country that can ill afford this loss. Thus off-grid, independent sources of electrical power are encouraged by the authorities. Secondly the country with no known fossil fuel resources is currently importing 200 million liters of refined petroleum products for power generation, transportation and domestic use. Thus not only capital costs for cogeneration systems but also the corresponding reduction of diesel fuel for power generation needs to be considered. While high pressure steam turbine systems are more efficient, smaller capacity cogeneration systems driven by steam engines should not be ruled out.

Rice is a major agricultural crop in Mali, and holds great potential for expansion, enhancement of quality and possibly exports to neighboring nations that are experiencing a deficit in terms of this crop. The most productive region for rice lies along the Niger River basin between Bamako and Mopti, and extends south to the borders of Guinea, Cote d'Ivoire, and Burkina Faso. Rice is grown extensively along the banks of the Niger between Segou and Mopti, and the most significant part of this is found in the areas under the purview of the Office du Niger north of Segou. This region accounts for nearly one third the production of rice in Mali. Table 1 below provides rice production data:

Table 1. Rice Production Data

Region	2002/2003			2003/2004 (forecast)		
	Area (Ha)	Yield (Kg/Ha)	Production (T)	Area (Ha)	Yield (Kg/Ha)	Production (T)
Kayes	979	1,276	1,249	3,890	828	3,222
Koulikoro	17,751	2,193	38,927	12,996	1,365	17,741
Sikasso	62,085	1,624	100,814	63,348	1,170	74,094
Segou	116,315	4,701	546,856	114,970	3,815	438,610
Mopti	134,681	1,281	175,552	107,648	634	68,228
Tombouctou	26,918	2,980	80,204	27,571	2,454	67,662
Gao	27,222	976	26,571	26,188	903	23,646
Totals/Mean	385,952	2,513	970,173	356,611	1,943	693,203

Source: Malian Chamber of Agriculture, Official Bulletin, January 2004

As seen from the above data, Segou region by far has the highest yield on a per hectare basis, and produced approximately 56 and 63 percent of the national production respectively for the two seasons as calculated from the above table. The above data predicted a national decrease of 276,970 T in 2003/2004, and the decrease appears to be due to predicted decreases in all the regions except Kayes. The major reduction seems to be from the Mopti area. The production in T/Ha and land area in hectares of paddy harvested differ greatly as presented from several reports, publications and Internet sources. The variation in the data seems to indicate significant differences in reported yields, production, and harvested area for Mali. However in all cases, there is a consistent relationship. The Segou area has the highest yields and area under paddy production. Although the Mopti area is relatively higher in hectares planted to paddy, the uncertainty of water excesses and droughts result in low yields per hectare. The present and future production of rice in Mali looks promising, and will depend on many factors, but the most important is controlled irrigation.

Although Mali's rice production is close to being sufficient for its own internal use, it still imports some rice from Asia. In like fashion West African countries including Ivory Coast, Senegal, Guinea, Mauritania, Burkina Faso and Niger, all import a total of nearly 2.0 million tons of rice per year (2). Mali's neighbors in

West Africa has a combined deficit of nearly 1.2 million tons per year, providing an opportunity for exports of quality milled rice from Mali. Although Mali's rice production, including its irrigation systems have an

impressive record, the full potential for exports from Mali to its neighbors can be realized through programs aimed at enhanced production and post harvest operations that promote the processing of quality milled rice. Discussions at various levels indicate that at present even though the imported rice is cheaper than the locally available milled rice, the population prefers the local rice. This implies that a market for local rice exists, and will continue to grow concurrently with increased grain quality.

Status of Rice Production in Mali – Rice production areas in Mali are divided into seven (7) regions: Kayes, Koulikoro, Sikasse, Segou, Mopti, Tombouctou and Gao. The land area for rice production is reported to range form 350,000 to 386,000 hectares (depending on the reporting source). Field yields of paddy (rough rice) range from less then one ton per hectare up to more that 5 tons per hectare. The average is 2 to 2.5 tons/ha. Total national production in tons also varies according to different reports (600,000 to 970,000 tons).

Differences in statistical data regarding land area in hectares of paddy (rice); national production data in tons of paddy; and field yields in tons per hectare from Table 1 Rice Production Data are shown in the following seven instances.

- An IRRI (International Rice Research Institute) publication, *Rice Almanac*, published in 2002 listed the following for Mali.

Table 2. Mali Rice Production Data

Year	Area Harvested	Yield T/A	Production (time)
1999	350,000	2.2	809,555
2000	350,000	2.3	869,555

Source: *Rice Almanac*, IRRI, 2002

- A report prepared for USAID/Mali Mission for USAID Global Bureau Center for Environment, Office of Energy and Environment and Technology, November 2001 listed "relevant rice production" as 700,000 tons. The assumption is that this referred to paddy or unmilled rice.

- An internet source (www.irri.org/science/ricestat/index.asp) reported the paddy rice yield for Mali in 2002 as 2.05 tons/ha; and the rice area as 453,000 ha.

- Another internet document, MALI, stated the 1997 rice statistics as 613,965 tons; 400,000 ha (harvested area); and a yield of 1.6 tons/acre. Another internet access for MALI showed 350,000 harvested ha; yield 2.3 tons/ha; and a production of 809,555 tons.

- Still another internet accessed document by WARDA (West Africa Development Association) for 2002 showed Malian rice production as 926,000 tons.

- A paper, *Analyse des Filieres de Production Agricole au Mali: Cas du Riz* October 2004 reported that the highest production regions were as follows: Segou region produced 438,610 tons of paddy in 2002/03; whereas the Mopti region produced 68,228 tons, a decrease from 205,733 tons in 2001/02; the Sikasso region produced 74,094 tons, down from 89,054 tons in 2001/02; and the Tombouctou region 67,662 tons, down from 99,613 tons in 2001/02.

- In a publication, *Recuil des Statistiques du Sector Rural*, Minister du Development Rural, Republique du Mali, March 2001, presented the following information for 1999/2000.

Table 3. Rice Production Data

	Hectares	Production	T/ha
Kayes	3,345	2,638	0.789
Koulikoso	21,779	25,599	1.175
Sikasso	78,695	119,194	1.515
Segou	100,493	396,902	3.950
Mopti	69,799	88,271	1.265
Tombouctou	25,589	78,702	3.078
Gao	25,407	15,834	0.623
MALI	325,107	727,140	2.237

Source: *Recuil des Statistiques du Sector Rural*, Minister du Development Rural, Republique du Mali, March 2001

The present and future production of rice in Mali will depend on many factors, but the first is controlled irrigation. The future looks promising for increased rice production in Mali.

An estimate of the percent of total national land cultivated for rice by the seven regions follows.

Table 4. Percent of the Total National Land Cultivated in Rice

Region	Percentage
Kayes	3.9 %
Khoro	4.7 %
Sikasso	10.8 %
Segou	7.9 %
Mopti	59.2 %
Tombouctou	7.8 %
Gao	6.5 %

The largest region (Mopti) produces much less rice because of low yields, and the Segou region produces the most (almost one-half of the national production) because of high yields.

Again, of the seven rice regions, the highest field yields are produced in the Segou Region. This involves controlled irrigation in the NIONO, MACINO, MOLODA, and N'DEBOUCOU areas (see attached plat, perimeters amenages). The second plat illustrates the ZONE D'INTERVENTION Office Riz Segou and the hectares available for the production of irrigated rice.

The main season rice is planted May to July, and harvested October to December. Off season rice is planted January to March, and harvested May to June. Deep water rice is planted July to August and harvested December to January.

Planted varieties are classified as (1) irrigated; (2) rainfed lowland; (3) upland; (4) deepwater; and (5) tidal wetland. Variety development and testing is done primarily by the Institut d'Economic Rural under the leadership of Dr. Mamadou M'Baré Coulibaly, Chef Programme Riz Iriqué, CRRA, Niono. Dr. Culibaly does have a network of cooperation in receiving germ plasma from WARDA and IRRI. He developed the variety Kogoni 99-1 Gambiaka, now grown on about 80 percent of the areas planted in rice.

Yield performance, by variety and region, was listed in one publication for 15-20 other varieties. The reported yields ranged from 2 to 8 T/ha. We assume that the yields are relative to their yielding ability and small plots, and we expect those listed as 6-8 tons/ha to perform about 20 to 25 percent less under average field production practices.

In another report, fertilizer use of supplied nitrogen, phorphorus (P_2O_5), and potash associated with testing varieties ranged as follows:

0 – 100 kg/ha nitrogen
0 – 163 kg/ha phosphorus fertilizers
0 – 100 kg/ha potash

with resulting yields ranging from 1.9 T/ha to 5.86 T/ha as a result of fertilizer applications levels.

Another report from the irrigated Office du Niger showed nitrogen responses as follows:

0 kg N/ha – 3.26 T/ha
60 kg N/ha – 5.55 T/ha
100 kg N/ha – 5.9 T/ha

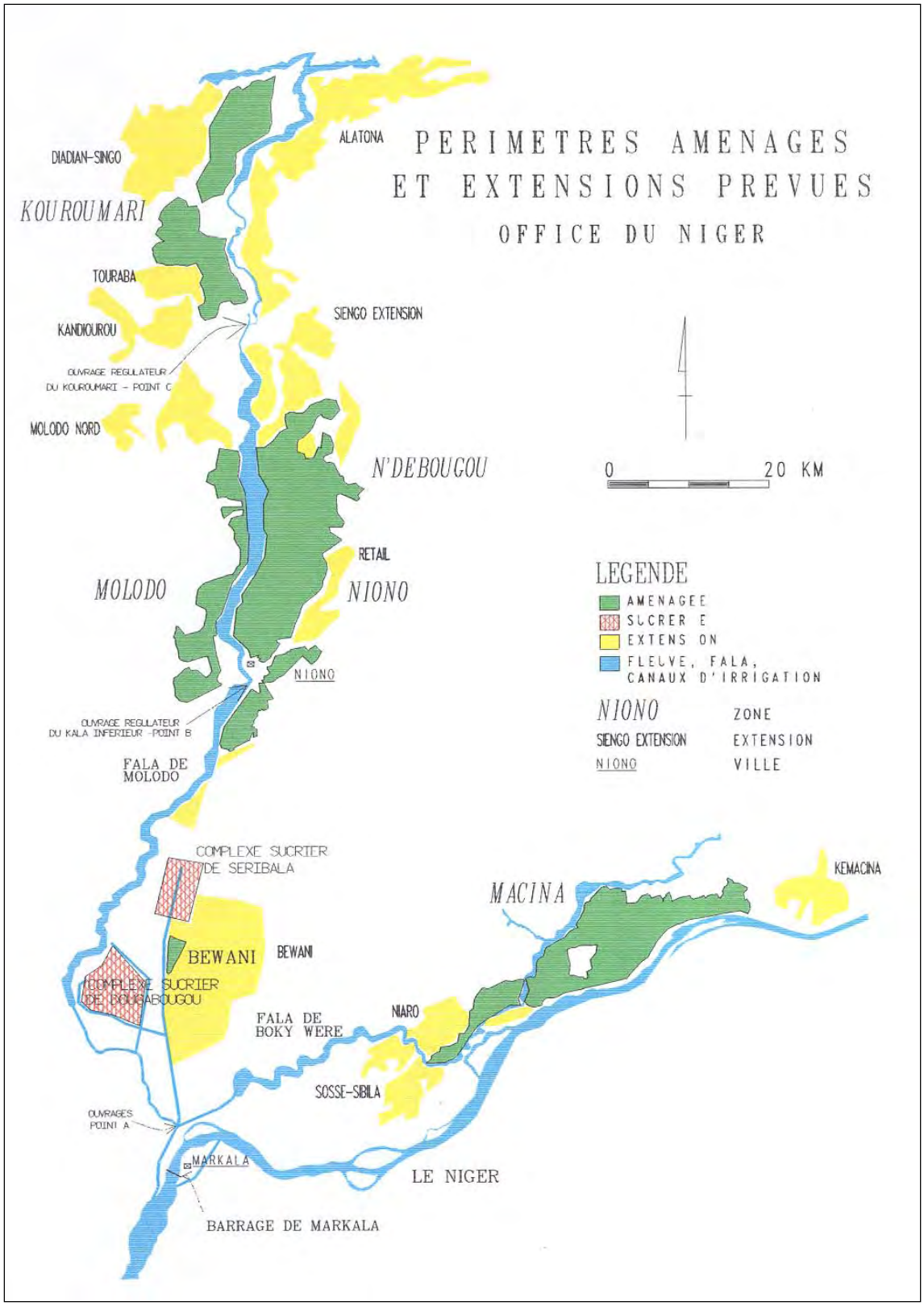

Figure 1. Office du Niger Area of Intervention. Source: Office du Niger, D.A.D.R., May, 1997

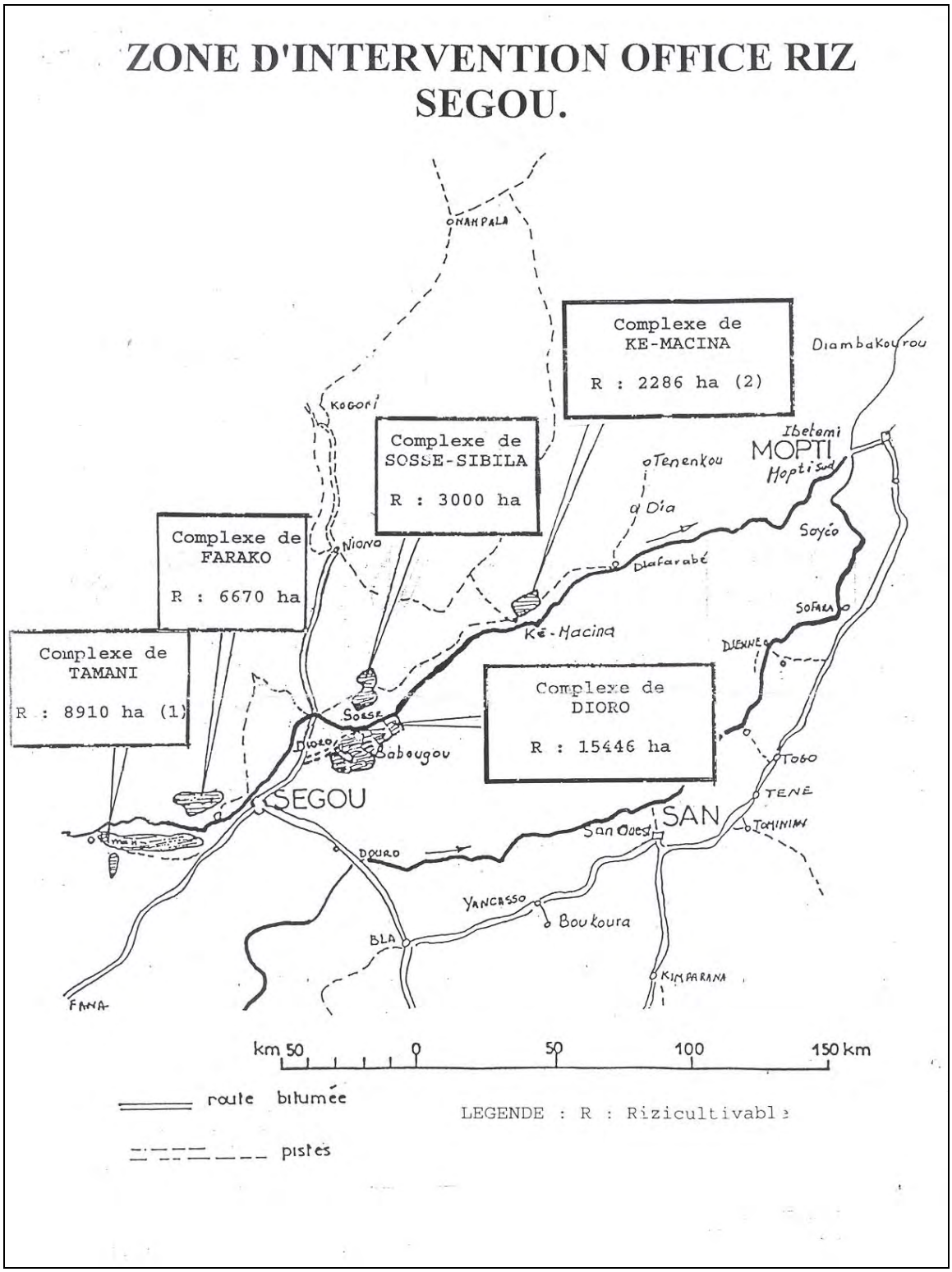

Figure 2. Office du Riz Area of Intervention in Segou. Source: Office du Niger, D.A.D.R.

Most rice farmers use fertilizer if it is available and recognize the increase in yields as a result of applied inorganic (commercial) fertilizers. A few added organic wastes (from animals) to the land planted to rice if it were available. In regard to commercial fertilizer, there were consistent reports about its lack of availability, or the lack of funds to purchase fertilizer. However, from our intensive travel in both the Segou and Mopti regions, we did not detect poor nutrition of the rice plants, or extremely poor yields resulting from lack of fertilizer applications.

According to all reports, insects and diseases of rice in Mali were not of economic importance. We had read 2004 reports of severe infestation of locust in West Africa, including Mali, but I was told that locust destroyed other crops in certain regions, but not rice. So, the use of applied insecticides and fungicides was not a production expense for Malian rice growers.

However, instances of yellow dwarf virus were noted. The decision was then made not to go into the field until harvest so that the virus would not spread.

There were reports of the use of herbicides for weed control, but data on this use was not available to us. Hand weeding is the primary means of removing unwanted weeds and grasses.

Reports of problems in Malian rice production were listed as:

a. Low temperatures during off-season in irrigated areas.
b. Drought/flooding in some regions.
c. Shortage of water in the dry season.
d. Weeds.
e. Lack of maintenance of irrigation facilities.
f. Production costs.
g. Inadequate production inputs.
h. Transportation.
i. The need for more research and extension.

Of the seven regions of rice production, the highest “average” yields were in the Office du Niger region, ranging from 3.26 tons/ha to 5.9 tons/ha. This greatly contrasted with yields of 1.72 to 2.63 T/ha in the Mopti-South region.

The Office due Niger and the Office du Riz offer the best potential for the proposed rice cogeneration project if it can be designed using the small, fixed location 2 ton mills in a designed series.

There are no large scale rice mills now active in Mali except for the 50 ton mill at Segou, which operates at 30 percent capacity. Actually, there is another 75 ton mill "across the street" from that mill but it is not operating now. Neither mill uses rice husks for energy. The mill owner reported power cost at 4,000,000 CFA/month to operate.

In those two regions (Niger and Riz), there is an express desire to expand rice cultivation to an area of 240,000 hectares. Land is available, but first, they wish to attempt increased production per hectare of the existing paddy (rice) before expanding land areas.

The goal of rice production increase in the Segou Region (Office du Niger) will require high yielding varieties, agricultural extension, involvement of the private sector, and policies for energy in the agricultural sector. But, we would hasten to add that the future planned development for increased rice production will be limited unless there is an increase in controlled irrigation.

With available water resources for the dry season, the increase in rice production could easily double by planting two crops per year. However, we were informed that the water flow is too low from the Niger River in the dry season, and subsurface water sources are not known, nor could be easily produced without power for the pumps and subsurface wells.

The days from rice planting to harvest in the irrigation areas range from 125 to 140 days, thus providing ample time for two crops if irrigation is available during the dry season. Unfortunately, the information in the preceding paragraph makes that difficult to achieve.

The Milling Industry – The rice milling industry in Mali underwent major changes after the sociopolitical events in 1991. Eight large mills with a total estimated capacity of 115,000 tons per annum that were in operation at the time were privatized. By 'privatized' it is meant that these mills were sold on tender and some were bought mainly by traders engaged in the imports and distribution of sugar and rice (Mali still imports a small quantity of rice despite being fairly close to self sufficiency). Table 5 shows data gathered during the study on all of the 'large' mills in Mali – six of the eight were visited during the study. At the present time (November 2004), only two mills at Segou city located across the street at the same location were operational.

Table 5. Large Rice Mills in Mali (in the Segou and Mopti Areas)

Location	Owner	Year Built	Capacity	Distance to Segou	Notes
1. Dioe/Segou	Bakore Silla	(?)	(?)	50 Km	Closed[1]
2. Segou City	Modibo Keita	(?)	50 T/day	0 Km	Working[2]
3. Segou City	Modibo Keita	(?)	75 T/day	0 Km	Closed
4. Kolongo du Macina	Aliou Boubacas Diallo	1948	1200 T/yr	91 Km	Closed
5. Molodo/Niono		1950	30,000 T/yr	113 Km	Closed[3]
6. Dogoferi/Diabali		1968	21000 T/yr	80 Km	Closed
7. Debougou		1976	21000 T/yr	120 Km	Closed
8. Sevare/Mopti	Modibo Keita	1973	6 ~ 9000 T/yr		Not working[4]

Notes: 1. This plant has a low pressure steam cogeneration system utilizing rice hulls from the mill. The mill is currently closed due to owner not being able to purchase paddy caused by competition from small huller millers in the area; lack of funds for paddy purchases, etc.

2. The owner says 30 % of the combined capacity of the mills in item 2 and 3 above. These mills are located across the street. He also says that most of the milling is done at the 50 T/day mill. Conclusion – 30% of the combined capacity (50 + 75) is 37.5 T/day at mill in item 2 above.

3. This mill, now long closed, had a Chinese rice hull gasifier system to produce power for milling operations. A gasifier plant was located inside the building, and another abandoned gasifier and diesel engine was found outside the premises.

4. This mill was recently purchased by Mr. Modibo Keita in November 2003. Officials of the government at Sevare, Mopti say that he has not turned up at the site yet. Mr. Keita says he bought it "at a very low price". An estimate would be that the price paid was much less than $ 400,000.

Rice hulls based cogeneration systems were installed at two of the mills (Bakore Silla mill at Segou city, and Molodo mill at Niono) that are presently not operating. One mill had a steam boiler/turbine system coupled to a generator for the needed electrical power, while the other had utilized a Chinese gasifier unit coupled to a diesel generator set to produce the required power.

Of all the mills visited during the study, all but one (Kolongo du Macina location) showed that the facilities could be upgraded and renovated if large scale operations in milling rice were to be given consideration by investors. The mill and premises at the Kolongo du Macina location appeared to be in disrepair. This comes from visual observation by the postharvest specialist who while looking through the windows noticed that the equipment was deteriorated or missing altogether. Given this status of rice milling in the country, most rice processing is left largely to the smaller mill operators who utilize the Engleberg type huller units

with small hourly throughput, powered by diesel engines. These mills were fairly common in the village setting, and were either available to producers as portable units (the diesel engine/mill were skid mounted and drawn by a donkey, or fixed at a central location in the village for use on a custom milling basis. In one group of villages (Seriwala, KM 30 in the Niono area) the village association has invested in ten mills (each of 2 tons per hour capacity, totaling an estimated 7500 tons per annum) that were more advanced (in terms of producing a better quality milled rice) than the Engleberg type huller mills referenced earlier. These are of the rubber roll sheller/steel polisher type mills, and are capable of producing a better quality of milled rice (less brokens), while at the same time producing two by products – hulls and bran.

Given the above scenario, by far the most striking feature was the quality of the milled rice. The better samples of rice seen during the visit at best showed nearly 50 to 60 percent brokens, while in some cases, the rice from the portable smaller units appeared to be nearly 100 percent broken. There are several points to note in this regard. The sale price of broken rice is generally half that of unbroken rice; when rice breaks in the mill, not only is the quality lowered, but also the total yield is reduced. This is caused by the fact that a significant part of the brokens also are abraded in the mill producing in effect rice flour that goes to the bran/hulls mixture the mill produces. The result is economic and food loss estimated at between 5 to 7 percent to the farmers. Using the annual production in the Segou are as 473,000 tons, the above loss translates to about 23,000 tons of milled rice per year valued at about 5.0 billion CFA or about 10 million dollars per year. This estimate increases to about 38,000 tons of milled rice for the nation valued at about 16 million dollars per annum (an annual production of 800,000 tons was used for this estimate).

A secondary issue is the quality of the byproducts produced by the smaller mills. Due to the nature of the design of these small huller mills, they produce two outputs – a) milled rice and brokens, and b) a mixture of partially ground hulls and bran. A considerable amount of small brokens were also noted in the second output from these mills confirming the notion that there is at present food loss (lower total milled rice yield). While at the present the by product (mixture of bran and ground hulls) is returned to the farmers for use as animal feed, as production increases, a focus on mills that produce a purer bran component may be necessary. This will result in a higher value by product in comparison to the present mixture of rice bran and ground hulls. Of course a move in this direction will also result in pure rice hulls that are suited for energy production (the current mixture of bran and ground rice hulls is unsuitable for cogeneration purposes).

The closure or non-operation of most of the larger mills in the country prompted an exploration of the reasons for closure by speaking to many representatives of the milling industry. The key issues/reasons are: a) Socio-political events in 1991, and a dry spell at the time caused a reduction of paddy available to the large mills; b) the privatization process took some time and in this period the mills closed operations; c) competition from small millers - they offered a better price than was possible for the larger mills at the factory gate (the large mills can compete if they went to the villages to collect and purchase paddy), and small millers gave back the bran-hull mixture to the farmers for use as animal feed; and d) lack of capital to purchase paddy. In addition to these reasons, it was felt that good management, or the lack there of, could also be a cause for the closure of most of the large mills in the country.

5.3 Future Potential Production of Rice and Rice Husk/Power

Energy Production ~ Sources and Use – To obtain an understanding of the energy production and use in Mali, several meetings and visits were conducted during this study. Further, reports available from USAID and other sources were also consulted. Meetings with the Minister of Energy, at the offices of Energie du Mali (EDM), and Agence Malienne pou le Developpement de l'Energie Domestique et de l'Electrification Rurale (AMADER) in Bamako and Segou were conducted. Mali is believed to have one of the lowest per capita energy consumption rates in the world (2). At present only 8% of the population (approximately 100,000 customers) are said to have access to electricity, with a projected additional 7% of the population having electricity by 2010. Installed power in Mali includes hydroelectric (50 MW) and thermal (64 MW) sources. Mali is also stated to possess about 1 MW of solar power sources serving about 2000 homes, and public buildings including schools and community buildings. Some solar powered water pumps are also used.

Currently, nearly 80% of the energy consumed by the population is estimated to come from fuel wood, albeit without a plan to sustain this renewable resource. Due to the absence of any source of fossil fuel in the country, Mali currently imports 3800 bbl/day (200 million liters per year) of refined petroleum products for the purpose of power generation, transportation needs and domestic use (lighting and cooking).

It is reported that both the quality of power supply and distribution are major issues that contribute to the mismatch between supply and demand (2). There are several causes for this mismatch: a) the delay in the availability of the Manatali plant (100 MW) , b) the decommissioning of some of the thermal power plants in

the urban areas without replacement, and c) the inefficiency of transmission with losses amounting to about 25% of the generated amount (an amount that Mali can ill afford). Some factors that cause this high transmission loss are long distances of power lines, low transmission voltage, and possibly low quality transmission equipment and maintenance.

Given the above situation, future development will likely emphasize distributed power generation. This notion was confirmed when discussions were held at the Ministry, AMADER and EDM offices. Distributed power generation will help provide power to rural consumers faster than currently possible with the national grid, and improve transmission efficiency by producing the electricity close to the consumers. Off-grid, independent sources of electrical power including from rice hull based systems were welcomed and encouraged by all agencies visited during the study.

Energy prices, particularly for electricity for use in the rural setting for rice mills and home use were investigated. These cost values will be important when considering rice hull powered systems. Electricity is supplied at three rates: social, normal and industrial. Both the social and normal rates are based upon the amount of use per month by the consumer; the higher the use, the greater the cost of a unit (kWh). The industrial rates are generally based upon the time of day (peak, regular and off peak). Prices also vary by region. Data from a USAID study conducted in 2001, and data obtained during this study are shown in Table 6 below:

Table 6. Electricity Prices in Mali

		August 2001 Study		November 2004 Study
Electricity	Social Rate	Use < 50 kWh/month	- 64 CFA/kWh	68 CFA/kWh
		Use 50 to 100 kWh/month	- 99 CFA/kWh	
	Industrial Rate	Off Peak (0h-6h)	- 43 CFA + 18% TVA	43 CFA/kWh w/o tax
		Regular (6h-18 h)	- 70 CFA + 18% TVA	70 CFA/kWh w/o
		Peak (18h-24h)	- 98 CFA + 18% TVA	98 CFA/kWh w/o tax
	Household Rate	-	-	94 CFA/kWh
Fuel Oil	Diesel	344 CFA/liter		

Source: Reference (2), USAID 2001 Report; Present study data

Utilization of Rice Hulls and Availability – Given the present methods of rice milling in the country, the amount of rice hulls available for cogeneration is not significant. Given that only one large mill is currently operating at about 10,000 tons of paddy per annum, this translates to about 2000 tons per annum of rice hulls. In addition, there are an estimated ten 2 tons/hour mills (producing pure husk as opposed to a rice husk-bran mixture) operating 18 hours per day for 30 days per month, for seven months per year. These mills produce a total of approximately 15,000 tons of husk per annum. Discussions at the village association which owns these ten mills revealed that they are planning to add another ten mills of the same type and capacity. When these plans are completed, it is likely that these 20 mills will be located within a 15 to 20 KM radius, permitting husk collection for any centralized cogeneration system. Rice hulls have a low bulk density, and thus transporting this by product over long distances (greater than 15 to 20 KM) is not economically viable. Thus in summary, presently a total of about 17,000 tons of rice hulls appear to be available for cogeneration for production of electrical power. Assuming that a high pressure steam turbine system is feasible in terms of cost of production of electricity (compared to the mostly diesel based systems in the rural areas of Mali), such a system producing 1.2 MW will have sufficient husk to run at 45 tons husk per day throughout the year. Since the mills only run for 7 months in the year, the cogeneration system can supply a limited excess during the seven months, and a much larger excess power to the villages for the balance 5 months in the year. Smaller systems using the low pressure steam engine configuration are also a possibility. However the low pressure systems that normally are less efficient (in converting rice hulls to electrical energy) than the high pressure systems, may not have sufficient excess power for rural use.

Given the current situation, the best option seems to be to organize groups of villages where the rubber roll type mills are in operation to collect the needed rice hulls for pilot cogeneration system. A second option would be to seek the support and participation of the larger mill owners to consider the addition of the cogeneration system to produce sufficient power to run the mills. There are two possibilities in this regard. The owner of the Segou mills, Mr. Modibo Keita showed interest in this approach, and inquired about costs for cogeneration systems. A second possibility is the new rice mill being planned by the Aiglon Group in Bamako, whose owners are currently in the cotton business. Incorporating a cogeneration system may be an option for this company.

Initiating cogeneration using locally available rice hulls has several implications for the rural population. These include the avoided cost for diesel fuel currently being used for running the mills; the possibility of

locally generated off grid power for domestic use; the possibility of employment for a local organization charged with the task of collecting and delivering the rice hulls to the cogeneration plant; eliminating a disposal problem for the rice hulls; and finally, revenue from the sale of ash from the cogeneration system.

Gasification/Combustion Technologies Previously Used in Mali – Two of the larger rice mills now closed for nearly ten years used a cogeneration system based on the rice hulls produced by the mills. The mill at Molodo had utilized a Chinese rice hull gasifier cogeneration system. At the time of the visit to this mill the premises were closed, but the gasifier system was visible, and the data reported here are mainly drawn from the past experience of the authors from visiting and examining similar systems in China. In essence, the system uses a digester which produces the gas from the rice hulls, and in turn this gas is fed to a modified diesel engine driving the electric generators. One complete unit was seen out side the premises, and appears to have been abandoned. A newer unit Digester/diesel engine/ generator set were seen inside the premises. The following are pertinent data based on the Chinese experience, and can be considered representative of the system used at this mill:

- Capacity of generator was 160 to 200 KW
- Ash from the digester was sold as poultry litter
- Approximately 33 to 55% of rice hulls were unused
- Electric power consumed by mill and cogeneration about 50 KW/ton of paddy
- Cost of electricity generated at mill ranged from 33 to 60% of cost of grid power. This was specific to the Chinese mill based on cost of grid power and time of operation (price at night was cheaper than during the day)

While the above data are specific to the Chinese mills gathered in 1995, there are some useful inferences to be drawn for the Malian case. The mill saves on electric power costs, producing all the power needed for its operations; and makes additional income from the sale of the ash. The drawback, however is that some rice hulls are still left over at the mill premises and need to be disposed.

The second mill located at Segou and owned by Mr. Bakore Silla has utilized the low pressure steam system to generate power for running the mill. The data obtained at this mill, while incomplete, are as follows:

Boiler output:	400 Kg/h
Husk Consumption:	400 – 500 Kg/h
Turbine/generator set rated at:	400 KVA

One important inference to be drawn from the above two cases is that apparently the cogeneration systems did not fail, rather the mills ceased to operate due to a variety of reasons including the lack of paddy for milling.

Technology Choices and Opportunities – To identify opportunities for cogeneration systems, several factors need to be considered, foremost amongst which is the availability of husk, as discussed in the previous sub-sections. Capital costs of systems capable of generating electric power from rice hulls, and even the importance of avoiding the use of diesel fuel need to be considered. This latter reason may be an important consideration for Mali that currently imports diesel fuel. To enable the formulation of appropriate strategies in this regard, data and a discussion of previous research are provided below.

In a study by Twente University in the Netherlands (3), the capital costs of three types of systems capable of producing electric power from rice husk, at three sizes of mills was compared as shown in Table 7 below:

Table 7. Capital Costs of Three Types of Systems Producing Electric Power from Rice Husk

Mill size	Power	Diesel Plant	Gasifier System	Steam Engine System
1 t/h	30 kW	$ 10,500	$ 24,000	$ 42,000
2 ½ t/h	70 kW	$ 21,000	$ 42,000	$ 70,000
6 t/h	160 kW	$ 40,000	$ 72,000	$ 104,000

Source: Velupillai, et al.

Among other factors, the weight of conventional steam engines contributes to the higher capital cost of such systems. The use of more modern light weight alloys and standard parts designed for internal combustion engines can help reduce the capital costs for the steam engines. In comparing the costs as shown above, the cost of diesel fuel, the cost of rice hulls at the cogeneration site and other factors need to be considered. In the above table the cost of diesel used was $ 0.25/liter (the current cost of diesel at the rural setting in Mali is about 410 CFA/liter or at an exchange rate of 500CFA to the dollar, about $ 0.82). Another consideration in this regard is the extremely durable nature of steam engines that can normally operate for 30 to 40 years with minimal maintenance.

Despite high capital costs and low efficiency of steam engines they may still be a viable choice when the price and availability of diesel and rice hulls are taken into consideration. In like fashion, the cost of electric power produced at an off grid site needs to be examined. To enable a discussion, the following Table 8 illustrates a study conducted by Twente University in 1992:

Table 8 Comparative power costs (US cents per kWh)

Mill size	Power	Diesel Plant	Gasifier System	Steam Engine System
1 t/h	30 kW	18.4	21.9	29.9
2 ½ t/h	70 kW	13.6	11.9	19.3
6 t/h	160 kW	11.1	7.9	14.0

Source: Velupillai, et al.

The above study assumed that the mills were at off-grid locations, the cost of diesel was $ 0.25/liter. The above data illustrates that there is a considerable economy of scale for both the gasifier and steam engine systems as the size of the mill increases (or the available rice hulls increases).

It is also worth noting that in another study conducted by the International Development and Energy Associates Inc. (IDEA) in Washington, DC in 1989 to look at the commercialization of rice hull powered gasifier systems of 20 kW capacity in India. This study concluded that the capital cost of the system was less important in determining the economic viability of the system than the percentage of diesel fuel displacement, the annual number of operating hours, and the price of diesel fuel in comparison to the price of rice husk.

In summary, the above analyses are provided to support any analyses for economic viability of cogeneration systems in Mali. The status at the time of this assessment includes key issues that need to be taken into consideration:

- There is an urgent need for off-grid power generation
- Diesel fuel is imported at considerable cost
- Rice production is poised to increase to take advantage of capturing an export niche
- A focus on increased production and rice quality enhancement will mean that an appropriate quality and quantity of rice husk will become available

SECTION 6

6.0 SWOT Analysis

6.1 Approach

SAIL and the LSU AgCenter as part of the grant requirements performed the following SWOT analysis based on an overview of the rice industry in Mali, to determine the rice industry's ability to support a rice husk to energy system. The SWOT analysis was performed over the period of the contract which included in-country data collection, plant inspections, first hand observations of rice production and processing, stakeholder interviews, discussions with rice producers and traders, discussions with Malian government agencies, and discussions/inputs from USAID officials. In essence, this SWOT analysis is based on the immediate term, development impacts through GOM and donor activities have not been taken into account, and are perceived by the contractor and subcontractor as a direct weakness or threat to implementation of a rice husk to energy project

The following elements were used to classify the four factors involved in the modified SWOT analysis for this project:

- Strengths: financial resources, existing network of farmers or farm organizations, physical infrastructure, and managerial skills, low operation cost, reputation.
- Weaknesses: narrow scope of business, lack of management skills or financing, high operation cost, inadequate financing capabilities, weak reputation.
- Opportunities: new areas of advantage to the farmers on their own or through partnerships.
- Threats: entry of new competitors or similar organizations, adverse government policy, changing markets.

6.2 Analysis

As we approached the stakeholders in Mali during the assessment, there was reluctance to discuss information on current business activities. The assumptions were that many of the rice mill owners were also rice importers. Current demand for rice in Mali overshadows domestic supplies. Rice brokers are making profits from importing low quality rice from the global market and selling it at higher prices to domestic consumers. Our project, though it would benefit the rice brokers and millers by providing two

sellable goods (electricity and ash), may have been seen as an immediate threat to the merchants status quo thereby reducing the likelihood of informative discussions.

In terms of rice husk to energy applications, current governmental and industry strengths are its resources and capabilities that can be used as a basis for developing a competitive advantage. The following list of strengths were identified in the field work as factors that illustrate the ability to develop a rice husk to energy system for certain regions in Mali.

- Mali's rich riziculture history
- 400,000 hectares of rice under cultivation
- Herbicides, insecticides and fungicides are typically not needed
- Fertilizers are easily assessable
- Seven rice producing regions (total annual yields estimated at 700,000 tons of paddy rice) in Mali: Gao, Kayes, Koulikoro, Mopti, Segou, Sikasso and Tombouctou.
- Of the seven regions, the highest yield per hectare and the highest total production is in the Segou Region (Office du Niger and Office du Riz).
- The Segou Region produces almost one-half of the national rice production.
- Field yields of rice in the Segou Region are estimated at 3.8 to 4.7 tons per hectare
- The Markala dam permits controlled irrigation in the Segou Region (Office du Niger and Office du Riz).
- Three large rice mills (50 T/day and 75 T/day) in Segou Region
- Large rural workforce with competitive wages
- Reasonably good road system
- Navigable rivers systems for husk and potential export transportation
- Rail and road connections to port facilities for export transportation
- Port facilities available in St. Louis, Senegal and Tema, Ghana
- Existing land routes from Bamako, Mali to Dakar, Senegal and Tema, Ghana
- Stable political and business climate
- National investment code
- Access to available concessionary financing from Arab funds, multilateral banks, and multilateral donor agencies
- Provide rural electrification
- Provide an environmentally sound disposal solution for rice husks
- Provide environment for the development of micro, small and medium sized industries
- Increase quality agricultural and value-added products for domestic and international markets

Common industry weaknesses are defined as the absence of certain requirements or the contradiction of the strengths. The following list of weaknesses identified in the field work as factors that limit the ability to develop a rice husk to energy system for certain regions in Mali.

- Fragmentation of the rice industry
- Unconsolidated micro/movable milling operations
- Of the three large rice mills, only one (50 T/day) is in operation.
- Lack of operating and purchasing capital
- Significant variations in field yields throughout the seven rice producing regions
- Lack of production management and utilization of Best Management Practices (BMPs)
- Lack of flood and irrigation controls in most regions.
- Unskilled labor market
- Low milling standards (broken rice)
- Poor milling efficiencies (post harvest losses)
- High transportation costs for transporting husks

The opportunities to the development of a rice husk to energy system in the rice producing regions of Mali can have major impacts on rural economic development. Currently, the Segou Region, which has the greatest potential for supplying rice husk for a cogeneration system, would be able to increase the production and quality of agricultural products and to develop small industries based on value-added agricultural products. The economic opportunities, that a steady supply of electrical power which can be utilized by micro, small and medium enterprises (MSMEs), will boost rural economic development as well as meet the national rural electrification goals and potentially provide exportable commodities.

- Increase rural electrification
- Increase rural economic development
- Increase rural employment
- Increased the number of MSMEs
- Increase production and quality of agricultural commodities for MSMEs through steady supply of electricity for cold storage and small manufacturing
- Increase production of value-added products
- Increase the potential for foreign currency through an exportable by-product
- Increase rice production through Best Management Practices (BMPs)
- Maintain low chemical inputs
- Access to long-term project financing
- Increase yield of Mali grown rice
- Increase export of Mali grown rice
- Decrease reliance on rice imports
- Develop farmer/processor cooperatives
- Consolidate and improve efficiency of rice milling industry
- Improve environmental conditions including water quality

The SAIL and LSU AgCenter team have identified several threats to the success of this project. However, through proper management these threats can be overcome or minimized. These threats are divided into two categories: immediate and future. The immediate threats include:

- Property rights issues
- Access to land
- Project ownership
- Corruption
- Cultural and social traditions in riziculture – Change in agriculture is always viewed initially as a threat to the status quo. Thus, when we talk about change, it is important to keep in mind that changes takes time and can be a threat to the sustainability and success of our project.

The future threats include:

- Skilled labor force
- Inefficient rice milling practices
- Transportation costs associated with moving the rice husks from one locations to another

6.3 Matrix

SAIL and the LSU AgCenter team have constructed a matrix with all of the identified strengths, weaknesses, opportunities and threats to the development of a rice husk-to-energy/rural electrification project for Mali. The matrix is utilized in this case to assess the competitive advantage for developing the industry and to determine if the project will require more study in the form of a bankable feasibility study to attract investors.

SWOT Analysis Rice Husk to Energy for Mali		Internal	
		Strengths • Mali's rich riziculture history • 400,000 hectares of rice under cultivation • Herbicides, insecticides and fungicides are typically not needed • Fertilizers are easily assessable • Seven rice producing regions (total annual yields estimated at 700,000 tons of paddy rice) in Mali: Gao, Kayes, Koulikoro, Mopti, Segou, Sikasso and Tombouctou. • Of the seven regions, the highest yield per hectare and the highest total production is in the Segou Region (Office du Niger and Office du Riz). • The Segou Region produces almost one-half of the national rice production. • Field yields of rice in the Segou Region are estimated at 3.8 to 4.7 tons per hectare • The Markala dam permits controlled irrigation in the Segou Region (Offices du Niger and Riz). • Three large rice mills (50 T/day and 75 T/day) in Segou Region • Large rural workforce with competitive wages • Reasonably good road system • Navigable rivers systems for husk and potential export transportation • Rail and road connections to port facilities for export transportation • Port facilities available in St. Louis, Senegal and Tema, Ghana • Existing land routes from Bamako, Mali to Dakar, Senegal and Tema, Ghana • Stable political and business climate • National investment code • Access to concessionary financing from Arab funds, multilateral banks, and donor agencies • Provide rural electrification • Provide an environmentally sound disposal solution for rice husks • Provide environment for the development of micro, small and medium sized industries • Increase quality agricultural and value-added products for domestic and international markets • Louisiana partners' (SAIL and the LSU AgCenter) expertise in design, construction, implementation and managing international projects • Louisiana partners' (SAIL and Agrilectric) expertise in engineering design and construction and management of cogeneration facilities.	Weaknesses • Fragmentation of the rice industry • Unconsolidated micro/movable milling operations • Of the three large rice mills, only one (50 T/day) is in operation. • Lack of operating and purchasing capital • Significant variations in field yields throughout the seven rice producing regions • Lack of production management and utilization of Best Management Practices (BMPs) • Lack of flood and irrigation controls in most regions. • Unskilled labor market • Low milling standards (broken rice) • Poor milling efficiencies (postharvest losses) • High transportation costs for transporting husks
External	Opportunities • Increase rural electrification • Increase rural economic development • Increase rural employment • Increased the number of MSMEs • Increase production and quality of agricultural commodities for MSMEs through steady supply of electricity for cold storage and small manufacturing • Increase production of value-added products • Increase the potential for foreign currency through an exportable by-product • Increase rice production through Best Management Practices (BMPs) • Maintain low chemical inputs • Access to long-term project financing • Increase yield of Mali grown rice • Increase export of Mali grown rice and decrease reliance on rice imports • Develop farmer/processor cooperatives • Consolidate and improve efficiency of rice milling industry • Improve environmental conditions including water quality	SO Alternatives • Design and implement the financing and construction cogeneration power plant fueled by agricultural wastes (specifically rice husks) • Develop training programs to improve production efficiency • Develop farmer/producer associations • Create and train workforce industry associated jobs • Provide training in business/management for MSMEs • Assist in the development of value-added products for MSMEs • Work with GOM to identify areas for infrastructure improvements (e.g., power grid, roads, rails, and shipping) • Determine extent of concessionary financing • Identify investors • Maintain transparency in relationships with GOM, investors and donor agencies. • Improve/consolidate existing large rice mills to meet husk requirements • Produce environmentally sound electrical energy for rural communities • Provide value-added opportunities (e.g., aquaculture) for MSMEs	WO Alternatives • Evaluate the feasibility of consolidating the rice milling industry • Develop and implement business and financial plans required to operate a large rice mill and cogeneration facility • Investigate alternative to a large rice mill(s) and look at small/medium rice mill consolidation • Provide training in BMPs in order to increase yields • Work to improve flood and irrigation controls • Develop training to improve workforce skills • Provide training programs to improve milling efficiencies • Develop grading standards and pricing based on grading standards
	Threats The immediate threats • Property rights issues • Access to land • Project ownership • Corruption • Cultural and social traditions in riziculture The future threats • Skilled labor force • Inefficient rice milling practices • Shipping of exports via the Niger River to southern seaports • Transportation costs associated with moving the rice husks from one locations to another	ST Alternatives • Included stakeholders* in project implementation • Maintain transparency in project activities • Focus awareness campaign on the benefits of rural electrification and the economic impacts associated with co-generation to rural communities • Focus on developing skills of the rural workforce and MSMEs • Promote BMPs for postharvest production and processing – concentrating efforts on developing better milling effiencies • Assess the efficiencies for exporting of agricultural commodities by truck, rail and barge • Assess and minimize costs associated with moving rice husks to the cogeneration facility • Assess the economic impact of a cogeneration facility on the development of MSMEs surrounding the facility • Use the history and culture of Mali to build a stronger rice industry	WT Alternatives • Engage stakeholder* in project implementation • Maintain transparency in project activities, purchasing and financial reporting • Train workforce • Promote BMPs for postharvest production and processing • Develop grading standards and pricing • Minimize transportation costs

* Stakeholders – rice farmers, rice millers, rice brokers, GOM agencies & officials, NGOs, donor agencies, etc.

6.4 Recommendations

Despite the many problems, we believe that Mali has the potential to expand its rice industry and become a substantial rice exporter and producer of electricity from renewable wastes including rice husks. Mali has sufficient farmers, water and irrigation districts to provide controlled irrigation to double its production to 1.8 million T paddy without increasing the total area (400,000 ha) now devoted to rice. Mali is politically stable, a very important factor in Africa. The democratic change in governments 18 months ago was almost seamless, and the GOM has maintained its complete priority commitment to a large Agro-industrial project which SAIL has been developing in Mali for nearly four years.

We will now discuss several approaches to starting a rice electric co-generation project or projects.

1

- Rice husk to energy systems have the potential to provide rural electrification in the Segou region. Segou provides the largest locally available supply of rice husks in the country.
- The SWOT analysis does recommend that a bankable feasibility study be performed for the Segou Region. This detailed study should include: accurate cost estimates for transporting agricultural commodities and value-added commodities by truck, rail and barge; economic impact of a cogeneration facility on the potential for development of and industrial park/agro-industrial complex, and the MSMEs surrounding the facility; design, construction, and operating costs associated with a cogeneration facility; determine extent of concessionary financing; and identifying potential investors, multilateral funding agencies and multilateral donor agencies.
- Stakeholder participation will be the cornerstone for the success of this project. Engaging the stakeholders in the project and the benefits of the project will play an important role in the design and implementation phase of a project of this nature.
- Maintaining transparency in the project activities will promote the success of the project. Stakeholders should see the potential financial and economic incentives and the benefits through rural electrification provided by the project. Procurement and other business transactions should be done in a way as to increase the trust between the rice farmers and the cogeneration facility.
- This trust will expedite changes away from traditional uses of the rice husks, if the farmers see the potential financial and economic benefits.

- Increasing knowledge and skills of local labor force will improve the successfulness of the project.
- Best management practices at the farm level and best manufacturing practices at the milling level should lead to more competitive pricing and higher quality products. The project will focus on assisting with post harvest loss prevention through its activities.
- Develop MSMEs and farmers' associations to help concentrate the availability of rice husks, to decrease postharvest losses, to increase buying power for crop inputs, and to provide a forum for value-added products.

The SWOT analysis was designed to establish if rice husk to energy was a viable option for Mali. As noted in the matrix, conceptually the strengths that the project brings, outweighs any weaknesses and threats. In addition, most of the weaknesses and threats can be managed and manipulated to provide positive input into the overall development of the rice and its by-products industries. The following recommendations are made based on the SWOT matrix formed through verbal information collected from stakeholders during the period of the project.

- Rice husk to energy systems have the potential to provide rural electrification in the Segou region. Segou provides the largest locally available supply of rice husks in the country.
- This assessment recommends that a bankable feasibility study be performed for the Segou Region. This detailed study should include: accurate cost estimates for transporting agricultural commodities and value-added commodities by truck, rail and barge; economic impact of a cogeneration facility on the potential for development of and industrial park/agro-industrial complex, and the MSMEs surrounding the facility; design, construction, and operating costs associated with a cogeneration facility; determine extent of concessionary financing; and identifying potential investors, multilateral funding agencies and multilateral donor agencies.
- The inclusion of Stakeholder participation as a cornerstone will assure the success of this project. Engaging the stakeholders in the project and the benefits of the project should play an important role in the design and implementation phase of a project of this nature.
- Maintaining transparency in the project activities will promote the success of the project. Stakeholders should see the potential financial and economic incentives and the benefits through rural electrification provided by the project. Procurement and other business transactions should:

- Be done in a way to increase the trust between the rice farmers and the cogeneration facility. This trust will expedite changes away from traditional uses of the rice husks, if the farmers see the potential financial and economic benefits.
- Increasing knowledge and skills of the local labor force will improve the potential success of the project.
- Best management practices at the farm level and best manufacturing practices at the milling level should lead to more competitive pricing and higher quality products. The project will focus on assisting with post harvest loss prevention through its activities.
- Develop MSMEs and farmers' associations to help concentrate the availability of rice husks, to decrease postharvest losses, to increase buying power for crop inputs, and to provide a forum for value-added products.

SECTION 7

7.0 Physical Infrastructure and Human Resources

Local and cultural traditions have a major impact on all development activities. As indicated in the SWOT analysis, many of these traditions can be mitigated through appropriate awareness and compensation. The following section reviews some of the local and cultural traditions that may have an impact on the project.

7.1 Social Considerations

Social considerations, especially when dealing with agricultural commodities that are produced in a subsistence-based agricultural society, can have major impacts on the project's success.

In terms of rice production, currently the rice hulls are used for other purposes, such as, animal feed and bedding. In addition, questions like what impact will the project have on women?, what impact will the project have on local economies and incomes? The breadth of this project did not allow for complete understanding of these impacts on social considerations. However, social considerations from an economic standpoint improve incomes and rural electrification were considered as benefits for social consideration. A more defined feasibility study needs to take these issues and expand their impact on the social considerations in designing and implementing a project of this nature.

From a health standpoint, disposal of the hulls will provide for decreased health risks in the traditional areas of the piles.

7.2 Information (Logistics and Transport)

One major impact that a project like this one can provide is the potential for the development employment opportunities at the rural level. Labor is an available resource in Mali that is under utilized in the rural areas. By providing rural electrification, this project will provide the opportunity for MSMEs to evolve around the power source resulting in larger labor markets for the rural communities. As a result, MSMEs will have the ability to market and export value-added products thereby increase rural incomes and rural jobs. By providing an incentive through sustainable and reliable income in rural communities, Mali will see a decrease in transmigration to its urban centers.

The project will also provide opportunities for commercial transportation. The need to transport rice husks from mills to a cogeneration facility will provide a new labor market. In addition, the silica ash by-product will provide cargo for outbound transports by truck, rail, and barge from Segou to Bamako, Bamako to Dakar, Senegal, Bamako to St. Louis, Senegal, and Segou to Tema, Ghana. Currently, there is very little outbound cargo from Mali to the ports in Senegal and Ghana.

7.3 Geographic Suitability

The geographic suitability for the rice cogeneration facility will be dominated by the supply/availability of rice hulls in the area. Due to the concentration of rice production and processing in the Segou region (Figures 1 and 2), the likely location of the cogeneration plant would be in that area.

SECTION 8

8.0 Project Costs, Development, Implementation and Constraints of the Rice Husk to Energy Project

8.1 Capital Requirements

The capital requirements for rice husk co-generation projects of various sizes are outlined in this section and in the following section entitled Preliminary Financial Analysis. The total capital requirements include the installed cost of the project, interest during construction and operating capital. This section includes indicative installed cost estimates for plants of 1.5 MW, 3.0 MW, 6.0 MW, 10 MW and 20 MW capacity plants. Other aspects of capital requirements appear in the Preliminary Financial Analysis section.

The indicative estimated installed costs, excluding interest during construction, for the various sized power plants are as follows (rounded):

Plant Capacity (MW)	Cost in U.S. Dollars (000,000)
1.5 MW	5.00
3.0 MW	8.00
6.0 MW	12.00
10.0 MW	17.50
20.0 MW	33.00

The cost estimates are only indicative based on SAIL's experience in building many agro-industrial projects throughout the world including many co-generation plants of 1.0 MW to over 50.0 MW capacity. The estimates are only rough and are based on 2003/04 prices. More accurate estimates would be part of a feasibility study and would depend upon specific locations in Mali, soil conditions at the site, site location in relation to roads, rivers, infrastructure and housing, etc.

We have assumed that the location will be close enough to a populated area where there are facilities for skilled construction personnel and sufficient local labor and semi-skilled labor are available, thus the estimates do not include the cost of construction camps and messing facilities.

Freight is another variable that will depend on location. We assumed that suitable rock and sand for concrete will be available within one hours haul distance of the site. We assume that the facility will obtain an exemption from all import tax and duty and that expat supervisors and consultants will be exempt from income tax. The cost estimates were made without the benefit of design drawings. The cost estimates

were made in USD and assume an exchange rate of 480 to 500 CFA to one USD. The cost estimates, whilst only indicative, are fairly accurate in reflecting the variation of costs with plant size.

8.2 Preliminary Financial Analysis

This section contains a preliminary financial analysis for rice co-generation plants of various sizes from 1.5 to 20.0 MW. To perform this preliminary analysis, we made various assumptions. Whilst we would hope that some environmental groups and international development funds would make some grants to or offer some concessionary financing to these projects, we did not assume the use of such grants or concessionary financing. Similarly, we did not assume that the project would benefit from carbon credits, etc. which could be available.

The assumptions made include:

- All assumptions listed in the Capital requirements section
- Construction will require 18 months for smaller plants, 24 months for 10 MW plants and larger
- Interest during construction would increase the installed cost of all facilities by 5%, thus, the installed costs used in this section are 5% higher than in the capital costs section.
- Equity would be 25% of installed cost, debt 75% of installed cost
- Debt interest at 7.5%
- Amortization of debt over 10 years with equal annual payments
- Annual operating capital requirements to be about 2/3% of annual expense but varies somewhat with plant size
- Interest on operating capital of about 18% per annum for about 7 months/year
- Ex plant price of electric power as shown (USD 0.11 and 0.15/kwh for all size plants. Also shown at 0.07 and 0.09 for 10 MW plant)
- Net price received for product ash as shown (USD 80/ton and USD 130/ton ex-factory and also at USD 50 and USD 65 for 10 MW plant)
- Plant efficiency (overall) 1.33 T hulls/MWH produced and about 1.5 T husk per MWH for the net power sold.
- Net power sold per year of 2/3% of plant's annual capacity
- No income tax on the project's profits. The matter of income tax will have to be negotiated with GOM. It is usual to obtain an exemption from income tax until at least the cost of the plant is recovered.
- The total cost of the husks at the factory will be USD$ 15.00/T. Only the 20.0 MW plant capital cost includes provisions for transport equipment costs.

We believe the cash flow projections are self explanatory and that the financial viability of the various sized plants are representative. An additional cash flow projection was made for the small 1.5 MW plant assuming use of second hand equipment. Cash flow projections for the 10 MW plant were made at lower electric and silica prices. More detailed cash flow projections should be made in a detailed feasibility study once a location or locations have been selected.

FINANCIAL ANALYSIS/CASH FLOW At U.S. Cents 11/kwh, USD 80/metric ton Ash Net	MALI RICE HULL COGENERATION				
Assumptions	1.5 MW Unit	3.0 MW Unit	6.0 MW Unit	10.0 MW Unit	20.0 MW Unit
Constructed Cost (incl interest during construction), $	5,250,000	8,400,000	12,600,000	18,375,000	34,650,000
Equity, $	1,312,500	2,100,000	3,150,000	4,593,750	8,662,500
Debt Financed, (7.5% for 10 years)	3,937,500	6,300,000	9,450,000	13,781,250	25,987,500
Operating Days per Year	355	355	355	355	355
Plant Full Capacity, KW	1,500	3,000	6,000	10,000	20,000
Diversity Factor, %	75	75	75	75	75
Gross Power Output, KW	1,125	2,250	4,500	7,500	15,000
Net Power for Sale, KW @ 66.67% Capacity	1,000	2,000	4,000	6,667	13,334
Rice Hulls Consumed, metric tons/yr	12,878	25,756	51,512	85,853	171,706
Ash Produced, metric tons/yr	2,575	5,150	10,300	17,166	34,332
Ash Selling Price, $/metric ton (gross)	180	180	180	180	180
Revenues					
Electricity, $ (KW x 24 x 355 x price)	937,200	1,874,400	3,748,800	6,248,312	12,496,624
Ash, $	463,500	927,000	1,854,000	3,089,880	6,179,760
TOTAL REVENUE	1,400,700	2,801,400	5,602,800	9,338,192	18,676,384
TOTAL ESTIMATED OPERATING EXPENSE	993,270	1,737,440	3,018,280	4,703,162	8,860,824
Cash Flow Before Debt Service	407,430	1,063,960	2,584,520	4,635,030	9,815,560
Average Annual Interest	179,888	287,821	431,732	629,609	1,187,263
Average Annual Principal Repayment	393,750	630,000	945,000	1,378,125	2,598,750
TOTAL	573,638	917,821	1,376,732	2,007,734	3,786,013
Net Cash Flow	-166,208	146,139	1,207,788	2,627,296	6,029,547

FINANCIAL ANALYSIS/CASH FLOW At U.S. Cents 15/kwh, USD 130/metric ton Ash net	MALI RICE HULL COGENERATION				
Assumptions	1.5 MW Unit	3.0 MW Unit	6.0 MW Unit	10.0 MW Unit	20.0 MW Unit
Constructed Cost (incl interest during construction), $	5,250,000	8,400,000	12,600,000	18,375,000	34,650,000
Equity, $	1,312,500	2,100,000	3,150,000	4,593,750	8,662,500
Debt Financed, (7.5% for 10 years)	3,937,500	6,300,000	9,450,000	13,781,250	25,987,500
Operating Days per Year	355	355	355	355	355
Plant Full Capacity, KW	1,500	3,000	6,000	10,000	20,000
Diversity Factor, %	75	75	75	75	75
Gross Power Output, KW	1,125	2,250	4,500	7,500	15,000
Net Power for Sale, KW @ 66.67% Capacity	1,000	2,000	4,000	6,667	13,334
Rice Hulls Consumed, metric tons/yr	12,878	25,756	51,512	85,853	171,706
Ash Produced, metric tons/yr	2,575	5,150	10,300	17,166	34,332
Ash Selling Price, $/metric ton	230	230	230	230	230
Revenues					
Electricity, $ (KW x 24 x 355 x price)	1,278,800	2,557,600	5,115,200	8,520,426	17,040,852
Ash, $	592,250	1,184,500	2,369,000	3,948,180	7,896,360
TOTAL REVENUE	1,871,050	3,742,100	7,484,200	12,468,606	24,937,212
TOTAL ESTIMATED OPERATING EXPENSE	1,018,270	1,767,440	3,053,280	4,758,162	8,980,824
Cash Flow Before Debt Service	852,780	1,974,660	4,430,920	7,710,444	15,956,388
Average Annual Interest	179,888	287,821	431,732	629,609	1,187,263
Average Annual Principal Repayment	393,750	630,000	945,000	1,378,125	2,598,750
TOTAL	573,638	917,821	1,376,732	2,007,734	3,786,013
Net Cash Flow	279,142	1,056,839	3,054,188	5,702,710	12,170,375

FINANCIAL ANALYSIS/CASH FLOW 10.0 MW PLANT At U.S. Cents 7 and 9/kwh, USD 50 and 65/metric ton Ash net	MALI RICE HULL COGENERATION	
Assumptions	7 cents	9 cents
Constructed Cost (incl interest during construction), $	18,375,000	18,375,000
Equity, $	4,593,750	4,593,750
Debt Financed, (7.5% for 10 years)	13,781,250	13,781,250
Operating Days per Year	355	355
Plant Full Capacity, KW	10,000	10,000
Diversity Factor, %	75	75
Gross Power Output, KW	7,500	7,500
Net Power for Sale, KW @ 66.67% Capacity	6,667	6,667
Rice Hulls Consumed, metric tons/yr	85,853	85,853
Ash Produced, metric tons/yr	17,166	17,166
Ash Selling Price, $/metric ton (gross)…	150	165
Revenues		
Electricity, $ (KW x 24 x 355 x price)	3,976,199	5,112,256
Ash, $	2,574,900	2,832,390
TOTAL REVENUE	6,551,099	7,944,646
TOTAL ESTIMATED OPERATING EXPENSE	4,703,162	4,758,162
Cash Flow Before Debt Service	1,847,937	3,186,484
Average Annual Interest	629,609	629,609
Average Annual Principal Repayment	1,378,125	1,378,125
TOTAL	2,007,734	2,007,734
Net Cash Flow	-1,589,797	1,178,750

FINANCIAL ANALYSIS/CASH FLOW USING SOME SECONDHAND EQUIPMENT At U.S. Cents 11 and 15/kwh, USD 80 and 130/T Ash Ex-Factory	MALI RICE HULL COGENERATION	
Assumptions	11 cents	15 cents
Constructed Cost (incl Interest during construction), $	4,200,000.00	4,200,000.00
Equity, $	1,050,000.00	1,050,000.00
Debt Financed, (7.5% for 10 years)	315,000.00	315,000.00
Operating Days per Year	355.00	355.00
Plant Full Capacity, KW	1,500.00	1,500.00
Diversity Factor, %	75.00	75.00
Gross Power Output, KW	1,125.00	1,125.00
Net Power for Sale, KW @ 66.67% Capacity	1,000.00	1,000.00
Rice Hulls Consumed, metric tons/yr	12,878.00	12,878.00
Ash Produced, metric tons/yr	2,575.00	2,575.00
Ash Selling Price, $/metric ton	180.00	230.00
Revenues		
Electricity, $ (1000 KW) x 24 x 355 x price)	937,200.00	1,278,800.00
Ash, $	463,500.00	592,250.00
TOTAL REVENUE	1,400,700.00	1,871,050.00
TOTAL	993,270.00	1,018,270.00
Cash Flow Before Debt Service	407,430.00	852,780.00
Average Annual Interest	143,910.00	143,910.00
Average Annual Principal Repayment	315,000.00	315,000.00
TOTAL	458,910.00	458,910.00
Net Cash Flow	-51,480.00	393,870.00

INDICATIVE COST ESTIMATE

	1.5 MW	3.0 MW	6.0 MW	10.0 MW	20.0 MW
One (1) Turbo Generator, with Condenser	500,000	730,000	1,250,000	1,725,000	3,450,000
One (1) Boiler and accessories	650,000	950,000	1,750,000	2,700,000	4,800,000
Two (2) Feed Water Pumps	50,000	98,000	140,000	170,000	350,000
One (1) Deareator	25,000	25,000	31,000	50,000	80,000
Cooling Tower & Pumps	92,000	148,000	222,000	325,000	525,000
Water Treatment Plant	27,000	43,000	65,000	95,000	150,000
Rice Husk Handling	50,000	80,000	120,000	175,000	300,000
Rice Husk Collecting Trucks and Storage Facilities	- -	- -	- -	- -	1,000,000
Rice Husk Grinding	120,000		300,000	430,000	750,000
Ash Handling	64,000	102,000	154,000	225,000	400,000
Ash Pelletizina	125,000	230,000	300,000	400,000	800,000
Compressor, Pumps, Tanks, Utilities and Misc.	93,000	149,486	224,000	327,000	500,000
Piping	150,000	240,000	360,000	525,000	900,000
Electrical, including Switchgear	415,000	800,000	1,100,000	1,600,000	2,800,000
Instrumentation	100,000	100,000	100,000	125,000	200,000
Buildings	71,000	114,000	171,000	250,000	450,000
Foundations	57,000	91,000	137,000	200,000	350,000
Insulation and Painting	21,000	34,000	51,000	75,000	140,000
Freight & Insurance	500,000	800,000	1,080,000	1,575,000	3,000,000
Erection	550,000	830,000	1,440,000	2,000,000	3,800,000
Supervision	425,000	600,000	1,150,000	1,300,000	2,200,000
G & L and Other Insurance	52,000	84,000	126,000	183,000	350,000
Engineering	52,5000	880,000	950,000	1,800,000	3,200,000
Contingency	33,5000	765,000	800,000	1,225,000	2,500,000
Total	4,997,000	7,893,486*	12,021,000*	17,480,000*	32,995,000*

* Does not include Interest during Construction

8.3 Environmental Benefits

Rice hulls are generated from the milling of rice. In Mali, in the larger rice mills, the rice hulls are considered to be a waste stream and simply stored in piles on land close to the rice mill. In some of the smaller milling operations, the rice hulls generated are returned to the grower along with his milled rice. Small growers use some of the rice hulls as animal feed or for bedding. Unless the rice husks contain the bran and a substantial amount of broken kernels of rice and rice powder (wasteful), the husks have little nutritional value. It should be noted that the high silica content of the rice hulls severely limits the quantity that can be used in animal feed. Even moderate levels irritate the stomach lining and lead to weight loss in the animal.

Rice hulls contain about 20% silica and are extremely slow to degrade. Rice hulls stored in piles present two health hazards. First, they become a food supply for rats, and second they trap water which acts as a breeding ground for mosquitoes, other insects and pests. In addition, the land used to store the rice hulls becomes temporarily sterile.

The combustion of rice hulls to produce both energy and valuable silica ash is an elegant solution for the disposal of stockpiled surplus rice hulls. During the combustion process the organic matter in the hulls (carbohydrate and carbonaceous fractions) is converted to carbon dioxide and water. During the combustion process very minor quantities of carbon monoxide, nitrogen oxides and volatile organic compounds are generated which leave the furnace with the flue gases.

The combustion process is used to generate steam in a boiler, which in turn is used to generate electricity in a turbo-generator. The electricity generated displaces fossil fuels, primarily diesel in the case of Mali, which in turn reduces the pollutants discharged to the atmosphere.

Comparison of Pollutants for Rice Hulls and Diesel

Basis: 10 MW for 355 days
Rice Hulls Required = 143,390.86 short tons/year
= 130,083.33 metric tons/year
Small diesel engine requires 9383 Btu/kwh

Emission Factors

Pollutant	lb/short ton rice hulls	lb/MMBTU Diesel
NOx	2.4	4.41
CO	2.0	0.95
PM10	1.5	0.31
VOC	0.4	0.36
SO2	0.0	0.29

Green House Gas

CO2	2,436.13	164.00

Annual Emissions for 85,200 MWH

Pollutant	from Rice Hulls	from Diesel
NOx	172.07	1762.75
CO	143.39	379.73
PM10	107.54	115.92
VOC	28.68	123.91
SO2	0.00	143.90

Green House Gas		
CO2	174,659.12	65,553.39

The above emissions indicate that pollutant emissions for the equivalent quantity of net power generated are much less when using rice hulls than they are for diesel. In particular, for the criteria pollutants, rice hulls yield one tenth of the NOx emissions, no SO2 emissions and lower emissions for CO, PM10 and VOC.

In the case of CO2 emissions (green house gas), the rice hulls cause zero additional emissions as an equivalent quantity of CO2 was absorbed from the atmosphere during the growing of the rice. On the other hand, the CO2 emissions for diesel combustion represent a net increase to the CO2 in the atmosphere.

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U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
MISSION TO MALI AND THE WEST AFRICA REGIONAL PROGRAM
Acquisition & Assistance Office

Schaffer & Associates, Int'l
1020 Florida Boulevard
Baton Rouge
Louisiana 70802

Reference: Rice husk study

Subject: Grant Number: 688-G-00-04-00049-00

Dear Mr. Schaffer:

Pursuant to the authority contained in the Foreign Assistance Act of 1961, as amended, the U.S. Agency for International Development (USAID) hereby awards to Schaffer and Associates (hereinafter referred to as the "Recipient"), the sum of $194,809.00 to provide support for a program in conducting a study in using rice husk for energy as described in the Schedule of this award and in Attachment 2, entitled "Program Description."

This award is effective and obligation is made as of the date of this letter and shall apply to expenditures made by the Recipient in furtherance of program objectives during the period beginning with the effective date and ending 02-28-2005. USAID will not be liable for reimbursing the Recipient for any costs in excess of the obligated amount.

This award is made to the Recipient on condition that the funds will be administered in accordance with the terms and conditions as set forth in Attachment 1 (the Schedule), Attachment 2 (the Program Description), and Attachment 3 (the Standard Provisions), all of which have been agreed to by your organization.

Please sign the original and all enclosed copies of this letter to acknowledge your receipt of the award, and return the original and all but one copy to the undersigned.

Sincerely yours,

Bettie F. Bowles
Regional Agreement Officer

Attachments:
A. Schedule
B. Program Description
C. Standard Provisions

ACKNOWLEDGED: Schaffer and Associates

BY: _____
TITLE: _____
DATE: _____

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Grant No. 688-G-00-04-00049-00

A. GENERAL

1. Total Estimated USAID Amount: $194,809.00
2. Total Obligated USAID Amount: $194,809.00
3. Cost-Sharing Amount (Non-Federal): $124,706.00
4. Activity Title: Assessment of rice husk for energy
5. USAID Technical Office: Accelerated Economic Growth SOT
6. Tax I.D. Number: 721460490
7. DUNS No.: 119095151
8. LOC Number: HHS-A8668P

B. SPECIFIC

Budget Fiscal Year: 2004
Operating Unit: USAID/Mali
Strategic Objective: 0009
Team/Division: AEG SO
Benefiting Geo Area: 688
Object Class:

STRATEGIC OBJECTIVE 688-0009
MAARD: 688-0009-683
APP: 723/41021
BPC: GDV30321688KG13 $94,809
RCN: R306566
ECN: E406865
PE: 01

FUNDS AVAILABLE
DATE: 08/02/2004
INITIALS: Kaa
AUTHORIZED BY: [illegible]

C. PAYMENT OFFICE

M/FM/CMP-LOC
USAID
Ronald Reagan Building, Room 7.07-095
1300 Pennsylvania Avenue, N.W.
Washington, D.C. 20523

SCHEDULE

A.1 PURPOSE OF AGREEMENT

The purpose of this Agreement is to provide support for the program described in Attachment 2 to this Agreement entitled "Program Description."

A.2 PERIOD OF AGREEMENT

1. The effective date of this Agreement is August 1, 2004. The estimated completion date of this Agreement is February 28, 2005.

A.3 AMOUNT OF AWARD AND PAYMENT

1. USAID hereby obligates the amount of $94,809.00 for program expenditures during the period set forth in A.2.2 above and as shown in the Budget below. The recipient will be given written notice by the Agreement Officer if additional funds will be added. USAID is not obligated to reimburse the recipient for the expenditure of amounts in excess of the total obligated amount.

2. Payment shall be made to the Recipient by Letter of Credit in accordance with procedures set forth in 22 CFR 226.

A.4 BUDGET

The following is the Agreement Budget, including local cost financing items, if authorized. Revisions to this budget shall be made in accordance with 22 CFR 226.

Line Items	USAID	SAIL
Salary & wages	$34,200	$56,960
Fringe Benefits	10,368	12,960
Travel & Per diem	16,946	4,200
Other Direct Costs	3,450	
Subcontracts	65,185	14,976
Facilities & Administrative Costs	55,660	35,630
Total	**$194,809**	**$124,706**

A.5 REPORTING AND EVALUATION

1. Financial Reporting

The Recipient shall submit one original and 2 copies quarterly. Financial Reports shall be in keeping with 22 CFR 226.52.

In accordance with 22 CFR 226.52, the SF 269 and SF 272 will be required on a quarterly basis. The recipient shall submit these forms in the following manner:

1) The SF 272 and 272a (if necessary) must be submitted via electronic format to the U.S. Department of Health and Human Services (http://www.dpm.psc.gov) within 45 calendar days following the end of each quarter. A copy of this form shall also be submitted at the same time to the Cognizant Technical Officer.

2) The SF 269 or 269a (as appropriate) must be submitted to the Cognizant Technical officer.

3) In accordance with 22 CFR 226.70-72, the original and two copies of all final financial reports shall be submitted to M/FM/CMP-LOC Unit. The electronic version of the final SF 272 or 272a shall be submitted to HHS in accordance with paragraph (1) above.

2. Program Reporting

The Recipient shall submit a draft report to USID/Mali Cognizant Technical Office for review and comments.

3. Final Report

The Recipient shall submit the original and one copy to the CTO and one copy to USAID Development Clearinghouse 8403 Colesville Road, Suite 210, Silver Spring, MD 20910 Fax Number (301) 588-7787 or via email: docsubmit@dec.cdie.org

The final performance report shall comply with Program Description Section 3 – Outputs.

Recipients shall list each country included in the program and the total amount expended for each country under the award for the reporting period in the "Remarks" block on the "Financial Status Report" SF-269 or SF-269A, or on a separate sheet of paper with the "Request for Advance or Reimbursement" SF-270.

A.6 INDIRECT COST RATE

Pending establishment of revised provisional or final indirect cost rates, allowable indirect costs shall be reimbursed on the basis of the following negotiated provisional or predetermined rates and the appropriate bases:

Description	Rate	Base	Type	Period
Overhead	26.32	1/	1/	1/
G&A	47.25	2/	2/	2/

1/Base of Application: Direct labor
Type of Rate: Provisional
Period: Life of award

2/Base of Application: Other Direct Costs
Type of Rate: Provisional
Period: Life of award

A.7 TITLE TO PROPERTY

Property Title will be vested with the Cooperative Country.

A.8 COST SHARING

The Recipient agrees to expend an amount not less than 39.02 percent of the total activity costs. The overall amount of contributions and leveraged resources are anticipated to be equal to the amount of the cost share in the time line and amount of cost share in support of the development objectives of this award.

A.9 PROGRAM INCOME

The Recipient shall account for Program Income in accordance with 22 CFR 226.24 (or the Standard Provision entitled Program Income for non-U.S. organizations). Program Income earned under this award shall be added to the project.

A.10 AUTHORIZED GEOGRAPHIC CODE

The authorized geographic code for procurement of goods and services under this award is 935.

A.11 EXECUTIVE ORDER ON TERRORISM FINANCING

The Contractor/Recipient is reminded that U.S. Executive Orders and U.S. law prohibits transactions with, and the provision of resources and support to, individuals and organizations associated with terrorism. It is the legal responsibility of the contractor/recipient to ensure compliance with these Executive Orders and laws. This provision must be included in all subcontracts/subawards issued under this contract/agreement.

A.12 REPORTING OF FOREIGN TAXES

(a.) Final and Interim Reports. The Schaffer & Associates, Int'l must annually submit:

(i) an interim report on or before November 17, and
(ii) a final report on or before April 16,
for each foreign country on the amount of foreign taxes, as of the date of each report, charged by a foreign government on commodity purchase transactions valued at USD500 or more financed with U.S. foreign assistance funds under this [contract/grant] during the prior U.S. fiscal year, and the amount reimbursed by the foreign government.

(b.) Terms. For purposes of this clause:

(i) "Agreement" includes USAID direct and country contracts, grants, cooperative agreements and interagency agreements;
(ii) "Commodity" means any material, article, supplies, goods, or equipment;
(iii) "Foreign government" includes any foreign governmental entity;
(iv) "Foreign taxes" means value-added taxes and custom duties assessed by a foreign government on a commodity. It does not include foreign sales taxes.

(c.) Where. Submit the reports to USAID/Mali Executive Office, Bamako, Mali .BP.34.

(d.) Contents of Report. The reports must contain:

(i) contractor/grantee name;
(ii) contact name with phone, fax and email;
(iii) agreement number(s) if reporting by agreement(s);
(iv) amount of foreign taxes assessed for each foreign government.
(v) amount of any foreign taxes reimbursed by each foreign government.

(e.) Subagreements. Schaffer & Associates, Int'l must include this reporting requirement in all applicable subcontracts, subgrants and other subagreements.

A.13 RESOLUTION OF CONFLICTS

Conflicts between any of the Attachments of this Grant shall be resolved by applying the following descending order of precedence: Schedule, 22 CFR 226, Standard Provisions and Program Description.

PROGRAM DESCRIPTION

An Assessment for the Potential of Using Rice-Husk for Energy: Schaffer & Associates, LSU AgCenter, and Agrilectric

Introduction

Rice is an important food staple providing food for 1/2 to 2/3 of the world's population. In addition to the crop being the staple food in many countries, it is also important from a trade standpoint for many countries. The Ségou, Markala, and other Office du Niger regions are major rice producing regions in southern Mali that produce in excess of 400,000 tons of rice per year. It is ranked as one of the major rice producing regions in Mali.

The major derivative of the rice milling process is the hull or husk, a fibrous product that comprises approximately 20 percent by weight of the rough rice. Given the present world rough rice production of over 510 million metric tons, some 100 million metric tons of rice husks are currently available for various forms of utilization. In Mali, rice hulls are estimated at around 100,000 tons per year, which in turn causes a major environmental disposal problem for rice millers. Typically, rice husks have been heaped in piles along side the rice mills with no intended users or uses. They are slow to decompose naturally, providing harborage for pests and breeding grounds for mosquitoes and other insects. Rice husks, themselves, have no intrinsic value except to be used as animal bedding and as a source of energy in a limited scale in some rural settings.

Co-generation provides an alternative use for rice husks. By burning the rice husks under the right conditions, this environmentally challenging waste product can be converted into two high valued and highly demanded products. For in country use, the rice husks can be converted into electricity that is in high demand. This electrical energy can be utilized in the running of local rice milling operations and can also be sold to the national power grid for countrywide distribution. Small scale power generation systems that utilize a renewable .resource such as rice hulls will complement/enhance existing rural electrification systems. This in turn will serve to attract light industry to rural areas providing opportunities for employment and overall economic enhancement of rural areas. The by-product of the controlled burning process is a high silica ash that is used in the steel manufacturing industry. This by-product is a highly valued commodity that can be exported to a number of steel producing countries, to earn hard currency.

Implementation of aquaculture production by utilization of the water ponds associated with the power plant should not be overlooked in the overall project concept. The additional industry would provide a basic food product with the potential of an eventual export market. Additionally, water filtration and sanitation potential should be incorporated into the scheme, adding very little cost, however, a crucial health benefit for the region.

The SAIL team consisting of Schaffer & Associates International, LLC, Louisiana State University Agricultural Center, and Agrilectric, have joined together in a public/private partnership to address the environmental issues associated with the disposal of rice husks in Mali.

The SAIL team, in conjunction with the Ministry of Commerce and Industry, have foreseen the importance of this project in generating the potential for economic development which will reduce poverty in the Office du Niger region. Economic development will provide not only local currency but also value added products and potential industrial development for other exportable goods. The project will potentially provide energy in a rural region and promote a cleaner environment for the region. The successful implementation of this project will in turn provide a model to be used throughout the African region.

The SAIL team has identified several immediate results that the project will accomplish. These include:

- Disposal of rice husks, a major environmental concern
- Production of energy for rural electrification

- Provision for water sanitation systems
- High Value-Added By-Products for export (Silica Ash)
- Economic export opportunities
- Increased agricultural and aquaculture production
- Creates employment – direct and indirect and trickle down industry

PROJECT IMPLEMENTATION:

The SAIL team envisions a four phase project. The four phases of the project are as follows:

PHASE 1A: Assessment for Viability of Converting Agricultural Waste to Energy;
PHASE 1B: Feasibility Study

To perform an assessment of the basic parameters and viability for Mali. Further, a determination would be made to ascertain if further study is warranted. A complete feasibility study would then be performed in bankable form on the identified regions that show potential viability.

PHASE 2: Rice/Husk Production

Increase rice production and milling efficiency in the identified regions

PHASE 3: Power Plant Project – Design, Project Management and Implementation

Project Design, Management and Implementation and begin operation of power facilities

PHASE 4: Additional By-Product Utilizations

Continued assessment and development of peripheral industries for value-added processing

This concept paper outlines the steps for the initial assessment for converting rice husks to energy and providing a solution to environmental aspects.

Assessment:

Technical Approach and Work Plan

1. Technical Approach

The SAIL team proposes a four step approach to determining the feasibility for the potential of designing, implementing and constructing a small-scale renewable energy system fueled by rice husks that will provide an affordable and reliable alternative to fossil fuels and other traditional energy technologies. These steps include a feasibility report with the following objectives and emphases:

- Identify status of rice production in Mali (concentrating on the Ségou, Markala and other Office du Niger regions) in conjunction with CLUSA
- SWOT analysis on current rice production and milling operations
- Identify physical infrastructure and human resources
- Identify potential locations and economic impact to developing energy production systems in those regions.

1.1 Identify status of rice production in Mali (concentrating on the Ségou, Markala and other Office du Niger regions):

Activities:

- Tour sites in the rice production communities in Ségou, Markala, and other Office du Niger regions.
- Meet with potential stakeholders including private and public representatives of the rice growers.

1.2 SWOT Analysis on Current Rice Production and Milling Operations:

In order to determine the rice industry's ability to support a rice-husk-to-energy system, a SWOT analysis will need to be performed. This analysis is an important step in the development planning process and involves an assessment of strengths, weaknesses and available opportunities, and threats. The analysis will identify local resources and the capabilities for rice production, marketing, finance, technology, and labor force. It will be used to identify strengths, for instance to help planners set objectives, develop plans for meeting those objectives, and take advantage of marketing opportunities. While strengths and opportunities afford leverage, weaknesses and threats represent problems, as weaknesses denote constraints and threats denote vulnerabilities.

SWOT analysis, is a method to compare internal organizational strengths and weaknesses with external opportunities and threats. (SWOT is an acronym for strengths, weaknesses, opportunities, and threats). This analysis provides managers and planners with a critical view of the organization's internal and external environment and helps them to evaluate the firm's fulfillment of its basic mission (Boone and Kurtz, 2004).

The following elements will be used to classify the four factors involved in the SWOT analysis:

- Strengths: Financial resources, existing network of farmers or farm organizations, physical infrastructure, and managerial skills, low operation cost, reputation.
- Weaknesses: Narrow scope of business, lack of management skills or financing, high operation cost, inadequate financing capabilities, weak reputation.
- Opportunities: New areas of advantage to the farmers on their own or through partnerships.
- Threats: Entry of new competitors or similar organizations, adverse government policy, changing markets.

1.3 Identify physical infrastructure and human resources, potential locations and economic impact to developing energy production systems in those regions.

Because of the importance of understanding the current infrastructure in developing a rural energy production facility, this feasibility study will briefly assess the following:

- Social Considerations – How will the industry affect the region proposed at the societal level, i.e., gender, income, cultural acceptability, etc.?
- Infrastructure – Will the industry have access to inputs and post harvest handling for outputs, i.e., transportation, roads, handling, market outlets, etc.?
- Property rights – Who owns the rights to land, access, etc.? Will property rights be an issue, i.e., common property, land tenure, etc.?
- Geographic suitability – What are the soil types, water resources, topography, etc., of the region proposed for the development of rice and related industries?

Activities:

- Assess current social considerations that may cause constraints to the development of the industry.
- Assess current access to infrastructure including roads, methods of transportation, etc. to determine viability and recommend needed improvements.
- Assess property rights in region proposed for development.
- Inventory the geographical suitability of the region proposed for the development.

2. Work Plan and Project Timeline:

Activity	Month 1				Month 2				Month 3				Month 4			
Team Mobilization																
Assess Current Conditions & Requirements																
Team Travel																
Data Analysis																
Draft Report																
Final Report																

3. Outputs

The following would be covered in the assessment and form the Table of Contents of the Assessment Document:

Summary & Preliminary Conclusions
Terms of Reference
Technical Approach

3.1 Status of Rice Production in Mali

a. Historical Data
b. Current Situation and Production
c. Future Potential Production of Rice and Rice Husk/Power

3.2 SWOT Analysis

3.3 Physical Infrastructure and Human Resources

a. Social Considerations
b. Infrastructure (Logistics and Transport)
c. Geographic Suitability

3.4 Project Costs, Development, Implementation & Constraints of the Rice Husk to Energy Project

a. Capital Requirements
b. Preliminary Financial Analysis
c. Environmental Benefits

PROPOSED PERSONNEL:

Team Leader/ Investment Specialist – Mima Nedelcovych
Project Engineer/ Environmental Specialist – Francis C. Schaffer
Rice Agronomist – Dr. H. Rouse Caffey
Rice Postharvest Specialist – Dr. Lakshman Velupillai

CAPABILITIES:

Schaffer & Associates International, LLC (SAIL) (Schaffer)

Schaffer & Associates and predecessor companies have offered complete services to the worldwide sugar and agri-process industries since 1955. Schaffer is recognized worldwide as an expert with over 48 years experience in all aspects of the sugar industry .SAIL is completely independent of any equipment supplier or manufacturer. SAIL possesses an excellent staff of experienced, practical personnel, many of whom have been with the company since inception. The company offers a complete scope of services in the areas of:

- Sugarcane Cultivation, including irrigation and drainage
- Sugarcane Harvesting and Transportation
- Raw Sugar Factories
- Cane and Beet Sugar Refineries
- Utilization of by-products for cogeneration or other products
- Ethanol production from molasses, sugar juice or syrup, sweet sorghum, cassava and grains
- Aquaculture Systems
- Rice Production

Demonstrated capability exists to develop a project from start to finish, including feasibility studies, project financing, engineering and design, field planning and trials, equipment and material procurement, construction supervision, personnel training, harvest and transport operations, and operations management. Based in Baton Rouge, Louisiana, the company maintains branch offices in Washington, D.C., and Honduras. Field Offices are located in Ethiopia, Mali and Florida, and representative offices are to be found throughout Central America, West Africa, East Africa and Southern Africa.

An overview description of the Schaffer organization and its capabilities is presented below.

Consultancy/Technical Assistance – Schaffer acts as consultants to agri-process industries and to Governments, major cane sugar producers and sugar refiners worldwide. It also acts as consultants to banks, insurance companies, chemical companies and other manufacturers. Services rendered to clients include analysis of operations, recommendations for improvements in efficiency and design, modification, rehabilitation, expansion and modernization of facilities and personnel evaluations, together with privatization and restructuring of existing industries.

Appraisals/Valuations/Privatization Studies – Schaffer renders complete appraisal and evaluation services to investor groups and the financial sector in general. Appraisals may be for the purpose of salvage value, replacement cost or fair market value of industrial and/or agricultural sector facilities. In today's world of privatization, appraisals of operating facilities play a major role in these efforts. SAIL's services, in privatization efforts, have been utilized by governments, private and potential private owners, and financial institutions worldwide.

Cogeneration – Power Facilities – Energy production is a necessity in developing countries as are energy savings in developed countries. Schaffer's designs are energy efficient and utilize by-products as a source of power generation. The company has completed over 100 projects in cogeneration, utilizing waste products, and steam and electric generation plants.

Feasibility Studies – Schaffer provides complete feasibility studies, which include projection of future economic trends, market surveys and analysis, agricultural data and requirements and combined engineering/economic studies of new and existing plant facilities and equipment and estates. The company has performed over 300 studies of this nature.

LSU AgCenter:

Research and educational institutions in Louisiana, a major rice producing state in the U.S., have long had a great interest in the development of rice related technologies around the world. As the premier research institution, Louisiana State University System has been involved internationally in the training of professionals from, and providing technical assistance to, many nations around the world.

Since the late 1980s, the LSU AgCenter has conducted studies nationally and internationally on the use of, and technologies for the conversion of rice hulls, as waste product, to various forms of energy for beneficial use. Some of these efforts by the university were linked to the Louisiana private sector that had developed technologies for the conversion of rice hulls to electrical energy. Interest was initially focused on identifying and assessing market potential for the Louisiana-based technology and other processes in the rice producing countries around the world. In 1997, a study by the LSU AgCenter conducted for the U.S. Department of Energy focused on Vietnam together with two other Asian countries and one European rice producing country in terms of rice hull availability, uses and technologies available. The results of this study indicated the need for technology sizing and identified potential areas and market opportunities for U.S. technology use in the future.

To facilitate the marketing of energy by-products from the rice milling process, the 1992 EPA Act, Title 12, Section 1206, requested the U.S. Department of Energy to conduct a worldwide study. The Midwest Research Institute, which had a contract with the Department of Energy for the operation and management of the National Renewable Energy Laboratory (NREL), requested proposals for such a project entitled "Study of Marketing of Rice Milling Energy By-Products" through NREL. The main purpose of the solicitation was to develop a strategy for the marketing of rice mill by-product-to-energy processes and technologies in the context of both industrialization as well as developing countries. The LSU AgCenter was awarded this contract and as a result a book was published by the LSU AgCenter. The book provides a global review of rice production, husk utilization, and husk-to-energy technologies and case studies of rice husk availability and utilization in five countries – the U.S., Italy, China, Thailand, and Sri Lanka. Field assessments were made in three countries – Italy, China, and Thailand. Information, generalizations, and conclusions were made and are based on data gathered in the field studies through direct communication; and subsequent written communications.

STANDARD PROVISIONS FOR U.S., NONGOVERNMENTAL RECIPIENTS

C.1 APPLICABILITY OF 22 CFR PART 226 (APRIL 1998)

(a) All provisions of 22 CFR Part 226 and all Standard Provisions attached to this agreement are applicable to the recipient and to subrecipients which meet the definition of "Recipient" in Part 226, unless a section specifically excludes a subrecipient from coverage. The recipient shall assure that subrecipients have copies of all the attached standard provisions.

(b) For any subawards made with entities which fall outside of the definition of "Recipient" (such as Non-US organizations) the Recipient shall include the applicable "Standard Provisions for Non-US Nongovernmental Grantees" except for the "Accounting, Audit and Records" Standard Provision. Recipients are required to ensure compliance with subrecipient monitoring procedures in accordance with OMB Circular A-133 and shall insert an appropriate provision on accounting, audit and records.

C.2 INELIGIBLE COUNTRIES (MAY 1986)

Unless otherwise approved by the USAID Agreement Officer, funds will only be expended for assistance to countries eligible for assistance under the Foreign Assistance Act of 1961, as amended, or under acts appropriating funds for foreign assistance.

C.3 NONDISCRIMINATION (MAY 1986)

No U.S. citizen or legal resident shall be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity funded by this award on the basis of race, color, national origin, age, handicap, or sex.

C.4 INVESTMENT PROMOTION (JANUARY 1994)

No funds or other support provided hereunder may be used in a project or activity reasonably likely to involve the relocation or expansion outside of the United States of an enterprise located in the United States if non-U.S. production in such relocation or expansion replaces some or all of the production of, and reduces the number of employees at, said enterprise in the United States. No funds or other support provided hereunder may be used in a project or activity the purpose of which is the establishment or development in a foreign country of any export processing zone or designated area where the labor, environmental, tax, tariff, and safety laws of the country would not apply, without the prior written approval of USAID. No funds or other support provided hereunder may be used in a project or activity which contributes to the violation of internationally recognized rights of workers in the recipient country, including those in any designated zone or area in that country.

C.5 NONLIABILITY (NOVEMBER 1985)

USAID does not assume liability for any third party claims for damages arising out of this award.

C.6 AMENDMENT (NOVEMBER 1985)

The award may be amended by formal modifications to the basic award document or by means of an exchange of letters between the Agreement Officer and an appropriate official of the recipient.

C.7 NOTICES (NOVEMBER 1985)

Any notice given by USAID or the recipient shall be sufficient only if in writing and delivered in person, mailed, or cabled as follows:

To the USAID Agreement Officer, at the address specified in the award.

To recipient, at recipient's address shown in the award or to such other address designated within the award Notices shall be effective when delivered in accordance with this provision, or on the effective date of the notice, whichever is later.

C.8 SUBAGREEMENTS (JUNE 1999)

Subrecipients, subawardees, and contractors have no relationship with USAID under the terms of this agreement. All required USAID approvals must be directed through the recipient to USAID.

C.9 OMB APPROVAL UNDER THE PAPERWORK REDUCTION ACT (APRIL 1998)

Information collection requirements imposed by this grant are covered by OMB approval number 0412-0510; the current expiration date is 11/30/2000. Identification of the Standard Provision containing the requirement and an estimate of the public reporting burden (including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information) are set forth below.

Standard Provision	Burden Estimate
Air Travel and Transportation	1 (hour)
Ocean Shipment of Goods	.5
Patent Rights	.5
Publications	.5
Negotiated Indirect Cost Rates - (Predetermined and Provisional)	1
Voluntary Population Planning	.5
Protection of the Individual as a Research Subject	

22 CFR 226	Burden Estimate

22 CFR 226.40-.49 Procurement of Goods and Services	1
22 CFR 226.30 - .36 Property Standards	1.5

Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Procurement, Policy Division (M/OP/P) U.S. Agency for International Development, Washington, DC 20523-7801 and to the Office of Management and Budget, Paperwork Reduction Project (0412-0510), Washington, DC 20503.

C.10 USAID ELIGIBILITY RULES FOR GOODS AND SERVICES (APRIL 1998)

(a) Ineligible and Restricted Goods and Services: USAID's policy on ineligible and restricted goods and services is contained in ADS Chapter 312.

(1) Ineligible Goods and Services. Under no circumstances shall the recipient procure any of the following under this award:

(i) Military equipment,

(ii) Surveillance equipment,

(iii) Commodities and services for support of police or other law enforcement activities,

(iv) Abortion equipment and services,

(v) Luxury goods and gambling equipment, or

(vi) Weather modification equipment.

(2) Ineligible Suppliers. Funds provided under this award shall not be used to procure any goods or services furnished by any firms or individuals whose name appears on the "Lists of Parties Excluded from Federal Procurement and Nonprocurement Programs." USAID will provide the recipient with a copy of these lists upon request.

(3) Restricted Goods. The recipient shall not procure any of the following goods and services without the prior approval of the Agreement Officer:

(i) Agricultural commodities,

(ii) Motor vehicles,

(iii) Pharmaceuticals,

(iv) Pesticides,

(v) Used equipment,

(vi) U.S. Government-owned excess property, or

(vii) Fertilizer

Prior approval will be deemed to have been met when:

(i) the item is of US source/origin;

(ii) the item has been identified and incorporated in the program description or schedule of the award (initial or revisions), or amendments to the award; and

(iii) the costs related to the item are incorporated in the approved budget of the award.

Where the item has not been incorporated into the award as described above, a separate written authorization from the Agreement Officer must be provided before the item is procured.

(b) Source and Nationality: The eligibility rules for goods and services based on source and nationality are divided into two categories. One applies when the total procurement element during the life of the award is over $250,000, and the other applies when the total procurement element during the life of the award is not over $250,000, or the award is funded under the Development Fund for Africa (DFA) regardless of the amount. The total procurement element includes procurement of all goods (e.g., equipment, materials, supplies) and services. Guidance on the eligibility of specific goods or services may be obtained from the Agreement Officer. USAID policies and definitions on source, origin and nationality are contained in 22 CFR Part 228, Rules on Source, Origin and Nationality for Commodities and Services Financed by the Agency for International Development, which is incorporated into this Award in its entirety.

(1) For DFA funded awards or when the total procurement element during the life of this award is valued at $250,000 or less, the following rules apply:

(i) The authorized source for procurement of all goods and services to be reimbursed under the award is USAID Geographic Code 935, "Special Free World," and such goods and services must meet the source, origin and nationality requirements set forth in 22 CFR Part 228 in accordance with the following order of preference:

(A) The United States (USAID Geographic Code 000),

(B) The Cooperating Country,

(C) USAID Geographic Code 941, and

(D) USAID Geographic Code 935

(ii) Application of order of preference: When the recipient procures goods and services from other than U.S. sources, under the order of preference in paragraph (b)(1)(i) above, the recipient shall document its files to justify each such instance. The documentation shall set forth the circumstances surrounding the procurement and shall be based on one or more of the following reasons, which will be set forth in the grantee's documentation:

(A) The procurement was of an emergency nature, which would not allow for the delay attendant to soliciting U.S. sources,

(B) The price differential for procurement from U.S. sources exceeded by 50% or more the delivered price from the non-U.S. source,

(C) Compelling local political considerations precluded consideration of U.S. sources,

(D) The goods or services were not available from U.S. sources, or

(E) Procurement of locally available goods and services, as opposed to procurement of U.S. goods and services, would best promote the objectives of the Foreign Assistance program under the award.

(2) When the total procurement element exceeds $250,000 (unless funded by DFA), the following applies: Except as may be specifically approved or directed in advance by the Agreement Officer, all goods and services financed with U.S. dollars, which will be reimbursed under this award must meet the source, origin and nationality requirements set forth in 22 CFR Part 228 for the authorized geographic code specified in the schedule of this award. If none is specified, the authorized source is Code 000, the United States.

(c) Printed or Audio-Visual Teaching Materials: If the effective use of printed or audio-visual teaching materials depends upon their being in the local language and if such materials are intended for technical assistance projects or activities financed by USAID in whole or in part and if other funds including U.S.-owned or U.S.-controlled local currencies are not readily available to finance the procurement of such materials, local language versions may be procured from the following sources, in order of preference:

(1) The United States (USAID Geographic Code 000),

(2) The Cooperating Country,

(3) "Selected Free World" countries (USAID Geographic Code 941), and

(4) "Special Free World" countries (USAID Geographic Code 899).

(d) If USAID determines that the recipient has procured any of these goods or services under this award contrary to the requirements of this provision, and has received payment for such purposes, the Agreement Officer may require the recipient to refund the entire amount of the purchase.

This provision must be included in all subagreements which include procurement of goods or services which total over $5,000.

C.11 REGULATIONS GOVERNING EMPLOYEES (AUGUST 1992)

(a) The recipient's employees shall maintain private status and may not rely on local U.S. Government offices or facilities for support while under this grant.

(b) The sale of personal property or automobiles by recipient employees and their dependents in the foreign country to which they are assigned shall be subject to the same limitations and prohibitions which apply to direct-hire USAID personnel employed by the Mission, including the rules contained in 22 CFR Part 136, except as this may conflict with host government regulations.

(c) Other than work to be performed under this award for which an employee is assigned by the recipient, no employee of the recipient shall engage directly or indirectly, either in the individual's own name or in the name or through an agency of another person, in any business, profession, or occupation in the foreign countries to which the individual is assigned, nor shall the individual make loans or investments to or in any business, profession or occupation in the foreign countries to which the individual is assigned.

(d) The recipient's employees, while in a foreign country, are expected to show respect for its conventions, customs, and institutions, to abide by its applicable laws and regulations, and not to interfere in its internal political affairs.

(e) In the event the conduct of any recipient employee is not in accordance with the preceding paragraphs, the recipient's chief of party shall consult with the USAID Mission Director and the employee involved and shall recommend to the recipient a course of action with regard to such employee.

(f) The parties recognize the rights of the U.S. Ambassador to direct the removal from a country of any U.S. citizen or the discharge from this grant award of any third country national when, in the discretion of the Ambassador, the interests of the United States so require.

(g) If it is determined, either under (e) or (f) above, that the services of such employee should be terminated, the recipient shall use its best efforts to cause the return of such employee to the United States, or point of origin, as appropriate.

C.12 CONVERSION OF UNITED STATES DOLLARS TO LOCAL CURRENCY (NOVEMBER 1985)

Upon arrival in the Cooperating Country, and from time to time as appropriate, the recipient's chief of party shall consult with the Mission Director who shall provide, in writing, the procedure the recipient and its employees shall follow in the conversion of United States dollars to local currency. This may include, but is not limited to, the conversion of currency through the cognizant United States Disbursing Officer or Mission Controller, as appropriate.

C.13 USE OF POUCH FACILITIES (AUGUST 1992)

(a) Use of diplomatic pouch is controlled by the Department of State. The Department of State has authorized the use of pouch facilities for USAID recipients and their employees as a general policy, as detailed in items (1) through (6) below. However, the final decision regarding use of pouch facilities rest with the Embassy or USAID Mission. In consideration of the use of pouch facilities, the recipient and its employees agree to indemnify and hold harmless, the Department of State and USAID for loss or damage occurring in pouch transmission:

(1) Recipients and their employees are authorized use of the pouch for transmission and receipt of up to a maximum of .9 kgs per shipment of correspondence and documents needed in the administration of assistance programs.

(2) U.S. citizen employees are authorized use of the pouch for personal mail up to a maximum of .45 kgs per shipment (but see (a)(3) below).

(3) Merchandise, parcels, magazines, or newspapers are not considered to be personal mail for purposes of this standard provision and are not authorized to be sent or received by pouch.

(4) Official and personal mail pursuant to a.1. and 2. above sent by pouch should be addressed as follows:

Name of individual or organization (followed by letter symbol "G") City Name of post (USAID/_____) Agency for International Development Washington, D.C. 20523-0001

(5) Mail sent via the diplomatic pouch may not be in violation of U.S. Postal laws and may not contain material ineligible for pouch transmission.

(6) Recipient personnel are NOT authorized use of military postal facilities (APO/FPO). This is an Adjutant General's decision based on existing laws and regulations governing military postal facilities and is being enforced worldwide.

(b) The recipient shall be responsible for advising its employees of this authorization, these guidelines, and limitations on use of pouch facilities.

(c) Specific additional guidance on grantee use of pouch facilities in accordance with this standard provision is available from the Post Communication Center at the Embassy or USAID Mission.

C.14 INTERNATIONAL AIR TRAVEL AND TRANSPORTATION (JUNE 1999)

(a) PRIOR BUDGET APPROVAL

In accordance with OMB Cost Principles, direct charges for foreign travel costs are allowable only when each foreign trip has received prior budget approval. Such approval will be deemed to have been met when:

(1) the trip is identified. Identification is accomplished by providing the following information: the number of trips, the number of individuals per trip, and the destination country(s).

(2) the information noted at (a)(1) above is incorporated in: the proposal, the program description or schedule of the award, the implementation plan (initial or revisions), or amendments to the award; and

(3) the costs related to the travel are incorporated in the approved budget of the award.

The Agreement Officer may approve travel which has not been incorporated in writing as required by paragraph (a)(2). In such case, a copy of the Agreement Officer's approval must be included in the agreement file.

(b) NOTIFICATION

(1) As long as prior budget approval has been met in accordance with paragraph (a) above, a separate Notification will not be necessary unless:

(i) the primary purpose of the trip is to work with USAID Mission personnel, or

(ii) the recipient expects significant administrative or substantive programmatic support from the Mission. Neither the USAID Mission nor the Embassy will require Country Clearance of employees or contractors of USAID Recipients.

(2) Where notification is required in accordance with paragraph (1)(i) or (ii) above, the recipient will observe the following standards:

(i) Send a written notice to the cognizant USAID Technical Office in the Mission. If the recipient's primary point of contact is a Technical Officer in USAID/W, the recipient may send the notice to that person. It will be the responsibility of the USAID/W Technical Officer to forward the notice to the field.

(ii) The notice should be sent as far in advance as possible, but at least 14 calendar days in advance of the proposed travel. This notice may be sent by fax or e-mail. The recipient should retain proof that notification was made.

(iii) The notification shall contain the following information: the award number, the cognizant Technical Officer, the traveler's name (if known), date of arrival, and the purpose of the trip.

(iv) The USAID Mission will respond only if travel has been denied. It will be the responsibility of the Technical Officer in the Mission to contact the recipient within 5 working days of having received the notice if the travel is denied.

If the recipient has not received a response within the time frame, the recipient will be considered to have met these standards for notification, and may travel.

(v) If a subrecipient is required to issue a Notification, as per this section, the subrecipient may contact the USAID Technical Officer directly, or the prime may contact USAID on the subrecipient's behalf.

(c) SECURITY ISSUES

Recipients are encouraged to obtain the latest Department of State Travel Advisory Notices before travelling. These Notices are available to the general public and may be obtained directly from the State Department, or via Internet. Where security is a concern in a specific region, recipients may choose to notify the US Embassy of their presence when they have entered the country. This may be especially important for long-term posting.

(d) USE OF U.S.-OWNED LOCAL CURRENCY

Travel to certain countries shall, at USAID's option, be funded from U.S.-owned local currency. When USAID intends to exercise this option, USAID will either issue a U.S. Government S.F. 1169, Transportation Request (GTR) which the grantee may exchange for tickets, or issue the tickets directly. Use of such U.S.-owned currencies will constitute a dollar charge to this grant.

(e) THE FLY AMERICA ACT

The Fly America Act (49 U.S.C. 40118) requires that all air travel and shipments under this award must be made on U.S. flag air carriers to the extent service by such carriers is available. The Administrator of General Services Administration (GSA) is authorized to issue regulations for purposes of implementation. Those regulations may be found at 41 CFR part 301, and are hereby incorporated by reference into this award.

(f) COST PRINCIPLES

The recipient will be reimbursed for travel and the reasonable cost of subsistence, post differentials and other allowances paid to employees in international travel status in accordance with the recipient's applicable cost principles and established policies and practices which are uniformly applied to federally financed and other activities of the grantee. If the recipient does not have written established policies regarding travel costs, the standard for determining the reasonableness of reimbursement for overseas allowance will be the Standardized Regulations (Government Civilians, Foreign Areas), published by the U.S. Department of State, as from time to time amended. The most current subsistence, post differentials, and other allowances may be obtained from the Agreement Officer.

(g) SUBAWARDS.

This provision will be included in all subawards and contracts which require international air travel and transportation under this award.

C.15 NEGOTIATED INDIRECT COST RATES - PROVISIONAL (NONPROFIT) (APRIL 1998)

(a) Provisional indirect cost rates shall be established for each of the recipient's accounting periods during the term of this award. Pending establishment of revised provisional or final rates, allowable indirect costs shall be reimbursed at the rates, on the bases, and for the periods shown in the schedule of the award.

(b) Within the earlier of 30 days after receipt of the A-133 audit report or nine months after the end of the audit period, the recipient shall submit to the cognizant agency for audit the required OMB Circular A-133 audit report, proposed final

indirect cost rates, and supporting cost data. If USAID is the cognizant agency or no cognizant agency has been designated, the recipient shall submit four copies of the audit report, along with the proposed final indirect cost rates and supporting cost data, to the Overhead, Special Costs, and Closeout Branch, Office or Procurement, USAID, Washington, DC 20523-7802. The proposed rates shall be based on the recipient's actual cost experience during that fiscal year. Negotiations of final indirect cost rates shall begin soon after receipt of the recipient's proposal.

(c) Allowability of costs and acceptability of cost allocation methods shall be determined in accordance with the applicable cost principles.

(d) The results of each negotiation shall be set forth in a written indirect cost rate agreement signed by both parties. Such agreement is automatically incorporated into this award and shall specify (1) the agreed upon final rates, (2) the bases to which the rates apply, (3) the fiscal year for which the rates apply, and (4) the items treated as direct costs. The agreement shall not change any monetary ceiling, award obligation, or specific cost allowance or disallowance provided for in this award.

(e) Pending establishment of final indirect cost rate(s) for any fiscal year, the recipient shall be reimbursed either at negotiated provisional rates or at billing rates acceptable to the Agreement Officer, subject to appropriate adjustment when the final rates for the fiscal year are established. To prevent substantial overpayment or underpayment, the provisional or billing rates may be prospectively or retroactively revised by mutual agreement.

(f) Failure by the parties to agree on final rates is a 22 CFR 226.90 dispute.

C.16 TITLE TO AND CARE OF PROPERTY (COOPERATING COUNTRY TITLE) (NOVEMBER 1985)

(a) Except as modified by the schedule of this grant, title to all equipment, materials and supplies, the cost of which is reimbursable to the recipient by USAID or by the cooperating country, shall at all times be in the name of the cooperating country or such public or private agency as the cooperating country may designate, unless title to specified types or classes of equipment is reserved to USAID under provisions set forth in the schedule of this award. All such property shall be under the custody and control of recipient until the owner of title directs otherwise or completion of work under this award or its termination, at which time custody and control shall be turned over to the owner of title or disposed of in accordance with its instructions. All performance guarantees and warranties obtained from suppliers shall be taken in the name of the title owner.

(b) The recipient shall maintain and administer in accordance with sound business practice a program for the maintenance, repair, protection, and preservation of Government property so as to assure its full availability and usefulness for the performance of this grant. The recipient shall take all reasonable steps to comply with all appropriate directions or instructions which the Agreement Officer may prescribe as reasonably necessary for the protection of the Government property.

(c) The recipient shall prepare and establish a program, to be approved by the appropriate USAID Mission, for the receipt, use, maintenance, protection, custody and care of equipment, materials and supplies for which it has custodial responsibility, including the establishment of reasonable controls to enforce such program. The recipient shall be guided by the following requirements:

(1) Property Control: The property control system shall include but not be limited to the following:

(i) Identification of each item of cooperating country property acquired or furnished under the award by a serially controlled identification number and by description of item. Each item must be clearly marked "Property of (insert name of cooperating country)."

(ii) The price of each item of property acquired or furnished under this award.

(iii) The location of each item of property acquired or furnished under this award.

(iv) A record of any usable components which are permanently removed from items of cooperating country property as a result of modification or otherwise.

(v) A record of disposition of each item acquired or furnished under the award.

(vi) Date of order and receipt of any item acquired or furnished under the award.

(vii) The official property control records shall be kept in such condition that at any stage of completion of the work under this award, the status of property acquired or furnished under this award may be readily ascertained. A report of current status of all items of property acquired or furnished under the award shall be submitted yearly concurrently with the annual report.

(2) Maintenance Program: The recipient's maintenance program shall be consistent with sound business practice, the terms of the award, and provide for:

(i) disclosure of need for and the performance of preventive maintenance,

(ii) disclosure and reporting of need for capital type rehabilitation, and

(iii) recording of work accomplished under the program:

(A) Preventive maintenance - Preventive maintenance is maintenance generally performed on a regularly scheduled basis to prevent the occurrence of defects and to detect and correct minor defects before they result in serious consequences.

(B) Records of maintenance - The recipient's maintenance program shall provide for records sufficient to disclose the maintenance actions performed and efficiencies discovered as a result of inspections.

(C) A report of status of maintenance of cooperating country property shall be submitted annually concurrently with the annual report.

(d) Risk of Loss:

(1) The recipient shall not be liable for any loss of or damage to the cooperating country property, or for expenses incidental to such loss or damage except that the recipient shall be responsible for any such loss or damage (including expenses incidental thereto):

(i) Which results from willful misconduct or lack of good faith on the part of any of the recipient's directors or officers, or on the part of any of its managers, superintendents, or other equivalent representatives, who have supervision or direction of all or substantially all of the recipient's business, or all or substantially all of the recipient's operation at any one plant, laboratory, or separate location in which this award is being performed;

(ii) Which results from a failure on the part of the recipient, due to the willful misconduct or lack of good faith on the part of any of its directors, officers, or other representatives mentioned in (i) above:

(A) to maintain and administer, in accordance with sound business practice, the program for maintenance, repair, protection, and preservation of cooperating country property as required by (i) above, or

(B) to take all reasonable steps to comply with any appropriate written directions of the Agreement Officer under (b) above;

(iii) For which the recipient is otherwise responsible under the express terms designated in the schedule of this award;

(vi) Which results from a risk expressly required to be insured under some other provision of this award, but only to the extent of the insurance so required to be procured and maintained, or to the extent of insurance actually procured and maintained, whichever is greater; or

(v) Which results from a risk which is in fact covered by insurance or for which the grantee is otherwise reimbursed, but only to the extent of such insurance or reimbursement;

(vi) Provided, that, if more than one of the above exceptions shall be applicable in any case, the recipient's liability under any one exception shall not be limited by any other exception.

(2) The recipient shall not be reimbursed for, and shall not include as an item of overhead, the cost of insurance, or any provision for a reserve, covering the risk of loss of or damage to the cooperating country property, except to the extent that USAID may have required the recipient to carry such insurance under any other provision of this award.

(3) Upon the happening of loss or destruction of or damage to the cooperating country property, the recipient shall notify the Agreement Officer thereof, shall take all reasonable steps to protect the cooperating country property from further damage, separate the damaged and undamaged cooperating country property, put all the cooperating country property in the best possible order, and furnish to the Agreement Officer a statement of:

(i) The lost, destroyed, or damaged cooperating country property;

(ii) The time and origin of the loss, destruction, or damage;

(iii) All known interests in commingled property of which the cooperating country property is a part; and

(iv) The insurance, if any, covering any part of or interest in such commingled property.

(4) The recipient shall make repairs and renovations of the damaged cooperating country property or take such other action as the Agreement Officer directs.

(5) In the event the recipient is indemnified, reimbursed, or otherwise compensated for any loss or destruction of or damage to the cooperating country property, it shall use the proceeds to repair, renovate or replace the cooperating country property involved, or shall credit such proceeds against the cost of the work covered by the award, or shall otherwise reimburse USAID, as directed by the Agreement Officer. The recipient shall do nothing to prejudice USAID's right to recover against third parties for any such loss, destruction, or damage, and upon the request of the Agreement Officer, shall, at the Governments expense, furnish to USAID all reasonable assistance and cooperation (including assistance in the prosecution of suits and the execution of instruments or assignments in favor of the Government) in obtaining recovery.

(e) Access: USAID, and any persons designated by it, shall at all reasonable times have access to the premises wherein any cooperating country property is located, for the purpose of inspecting the cooperating country property.

(f) Final Accounting and Disposition of Cooperating Country Property: Within 90 days after completion of this award, or at such other date as may be fixed by the Agreement Officer, the recipient shall submit to the Agreement Officer an inventory schedule covering all items of equipment, materials and supplies under the recipient's custody, title to which is in the cooperating country or public or private agency designated by the cooperating country, which have not been consumed in the performance of this award. The recipient shall also indicate what disposition has been made of such property.

(g) Communications: All communications issued pursuant to this provision shall be in writing.

C.17 PUBLIC NOTICES (AUGUST 1992)

It is USAID's policy to inform the public as fully as possible of its programs and activities. The recipient is encouraged to give public notice of the receipt of this award and, from time to time, to announce progress and accomplishments. Press releases or other public notices should include a statement substantially as follows:

"The U.S. Agency for International Development administers the U.S. foreign assistance program providing economic and humanitarian assistance in more than 80 countries worldwide."

The recipient may call on USAID's Office of External Affairs for advice regarding public notices. The recipient is requested to provide copies of notices or announcements to the cognizant technical officer and to USAID's Office of External Affairs as far in advance of release as possible.

C.18 COMMUNICATIONS PRODUCTS (OCT 1994)

(a) Definition - Communications products are any printed material (other than non-color photocopy material), photographic services or video production services.

(b) Standards - USAID has established standards for communications products. These standards must be followed unless otherwise specifically provided in the agreement or approved in writing by the agreement officer. A copy of the standards for USAID-financed publications and video productions is attached.

(c) Communications products which meet any of the following criteria are not eligible for USAID financing under this agreement unless specifically authorized in the agreement schedule or in writing by the Agreement Officer:

(1) Any communication products costing over $25,000, including the costs of both preparation and execution. For example, in the case of a publication, the costs will include research, writing and other editorial services (including any associated overhead), design, layout and production costs.

(2) Any communication products that will be sent directly to, or is likely to be seen by, a Member of Congress or Congressional staffer.

(3) Any publication that will have more than 50 percent of its copies distributed in the United States (excluding copies provided to PPC/CDIE and other USAID/W offices for internal use).

MODIFICATION OF ASSISTANCE

PAGE 1 OF 1

1. MODIFICATION NUMBER	2. EFFECTIVE DATE OF MODIFICATION	3. AWARD NUMBER	4. EFFECTIVE DATE OF AWARD
001	August 25, 2004	[illegible]	08-01-2004

5. GRANTEE:
Schaffer & Associates, Int'l
1020 Florida Boulevard
Baton Rouge
Louisiana 70802

DUNS NO.: 119095151
TIN NO.: 721460490 LOG NO.: [illegible]

6. ADMINISTERED BY:
USAID/Mali
Acquisition and Assistance Office
Bamako, Mali
BP.34

7. FISCAL DATA: Amount Obligated: $100,000.00

Budget Fiscal Year: 2004
Operating Unit: USAID/Mali
Strategic Objective: 0009
Team/Division: AEG SO
Benefiting Geo Area: 688
Object Class:

8. TECHNICAL OFFICE:

9. PAYMENT OFFICE:
M/FM/CMP/LOC
USAID
Ronald Reagan Building Room 7.07-025
1300 Pennsylvania Avenue N.W.
Washington, DC. 20523

10. FUNDING SUMMARY:

	Obligated Amount	Total Est. Amt.
Amount Prior to this Modification:	$94,809.00	$194,809.00
Change Made by this Modification:	$100,000.00	
New/Current Total:	$194,809.00	$194,809.00

11. DESCRIPTION OF MODIFICATION:
The purpose of this modification is to provide the amount of $100,000.00 as incremental funding, thereby increasing the total obligated amount to $194,809.00 to fully fund the agreement.

Specific changes are as follows:

Cover Page
B. SPECIFIC:
Add the following fiscal data:
*Strategic Objective 905-111
APP: 7241021; BPC: KDV4-29688-KG59 -$100,000; PHOENIX CODE: EGAT 04
RCN: A406933 04

FUNDS AVAILABLE
DATE: 08/26/2004
INITIALS: [illegible]
AUTHORIZED BY: [illegible]

12. THIS MODIFICATION IS ENTERED INTO PURSUANT TO THE AUTHORITY OF THE FOREIGN ASSISTANCE ACT OF 1961, AS AMENDED, EXCEPT AS SPECIFICALLY HEREIN AMENDED, ALL TERMS AND CONDITIONS OF THE GRANT REFERENCED IN BLOCK #3 ABOVE, AS IT MAY HAVE HERETOFORE BEEN AMENDED, REMAIN UNCHANGED AND IN FULL FORCE AND EFFECT.

13. GRANTEE: ☐ IS ☒ IS NOT REQUIRED TO SIGN THIS DOCUMENT TO RECEIVE ITS AGREEMENT WITH THE CHANGES EFFECTED HEREIN

14. GRANTEE:

BY: _____

_____ (Name Typed or Printed)

TITLE: _____

DATE: _____

15. THE UNITED STATES OF AMERICA
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

BY: [signature]

[illegible] (Name Typed or Printed)

TITLE: Agreement Officer

DATE: 08/30/04

MODIFICATION OF ASSISTANCE

1. MODIFICATION NUMBER	2. EFFECTIVE DATE OF MODIFICATION	3. AWARD NUMBER:	4. EFFECTIVE DATE OF AWARD:
001	August 25, 2004	688-G-00-04-00049-00	08-01-2004

5. GRANTEE:
Schaffer & Associates, Int'l
1020 Florida Boulevard
Baton Rouge
Louisiana 70802

DUNS NO.: 119095151
TIN NO.: 721460490 LOC NO.: HHS-A8668P

6. ADMINISTERED BY:
USAID/Mali
Acquisition and Assistance Office
Bamako, Mali
BP.34

7. FISCAL DATA: Amount Obligated: $100,000.00

Budget Fiscal Year: 2004
Operating Unit: USAID/Mali
Strategic Objective: 0009
Team/Division: AEG SO
Benefiting Geo Area: 688
Object Class:

8. TECHNICAL OFFICE:

9. PAYMENT OFFICE:
M/FM/CMP/LOC
USAID
Ronald Reagan Building Room 7.07-095
1300 Pennsylvania, Avenue N.W.
Washington, DC. 20523

10. FUNDING SUMMARY:

	Obligated Amount	Total Est. Amt.
Amount Prior to this Modification:	$94,809.00	$194,809.00
Change Made by this Modification:	$100,000.00	
New/Current Total:	$194,809.00	$194,809.00

11. DESCRIPTION OF MODIFICATION:
The purpose of this modification is to provide the amount of $100,000.00 as incremental funding, thereby increasing the total obligated amount to $194,809.00 to fully fund the agreement.

Specific changes are as follows:

Cover Page
B. SPECIFIC:
Add the following fiscal data:
"Strategic Objective 905-111
APP: 7241021; BPC: KDV4-29688-KG59 -$100,000; PHOENIX CODE: EGAT 04 DVBBFY:2004".

12. THIS MODIFICATION IS ENTERED INTO PURSUANT TO THE AUTHORITY OF THE FOREIGN ASSISTANCE ACT OF 1961 **AS AMENDED. EXCEPT AS SPECIFICALLY HEREIN AMENDED, ALL TERMS AND CONDITIONS OF THE GRANT REFERENCED IN BLOCK #3 ABOVE, AS IT MAY HAVE HERETOFORE BEEN AMENDED, REMAIN UNCHANGED AND IN FULL FORCE AND EFFECT.**

13. GRANTEE: ☐ IS ☒ IS NOT REQUIRED TO SIGN THIS DOCUMENT TO RECONFIRM ITS AGREEMENT WITH THE CHANGES EFFECTED HEREIN

14. GRANTEE:

BY: _____

_____
(Name Typed or Printed)

TITLE: _____

DATE: _____

15. THE UNITED STATES OF AMERICA
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

BY: _____

Bettie F. Bowles
(Name Typed or Printed)

TITLE: Agreement Officer

DATE: _____

ASSISTANCE NO.	MODIFICATION NO.		
688-G-00-04-00049-00	001		

11. DESCRIPTION OF MODIFICATION (CONTINUED)

A.3. AWARD AMOUNT AND PAYMENT

1. Delete the paragraph in its entirety and substitute in lieu thereof the following:
"USAID hereby obligates the amount of $194,809.00 for program expenditures during the period set forth in A.2.2."

[End of Modification # 001]

Rice Husk Study

Cooperative Agreement Grant No: 688-G-00-04-00049-00
Funded by
The United States Agency for International Development
Mission for Mali, and the West Africa Regional program

Under Sub agreement with
Schaffer & Associates International, L.L.C.
1020 Florida Blvd.,
Baton Rouge, LA 70802

Mali Assessment Report

November 2004

Submitted by

International Programs
Louisiana State University Agricultural Center
Baton Rouge, Louisiana

Prepared by

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LSU AgCenter
and

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LSU AgCenter

Acknowledgements

Drs. Caffey and Velupillai wish to thank all those who assisted in the preparation for the assignment, the conduct of the assignment and the compilation of this report. They wish to thank Schaffer and Associates International, L.L.C., for the award of the sub agreement, and the USAID Mission in Mali for awarding the parent agreement to Schaffer and Associates International, L.L.C. Many individuals provided their time and assistance both in the U.S. and Mali for completing the study, and compilation of the data. Special thanks are due to Mr. Mario de Matos, representative for Schaffer and Associates International; Mr. Harouna Niang, and Dr. Amadou Coulibaly. The assistance of International Programs staff at the LSU AgCenter for preparations for the assignment, and post assignment activities are recognized. Finally, the authors of this assessment report wish to recognize and thank the many farmers, village leaders, government of Mali officials, the Ministers of Agriculture, Energy, and Industry and Commerce, and others who met with us to provide valuable insight.

Rice Husk Study ~ Mali Assessment Report

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Part I Summary

This assessment was undertaken by the LSU AgCenter as a part of the requirement for the Cooperative Agreement Grant No: 688-G-00-04-00049-00 funded by the United States Agency for International Development Mission for Mali, and the West Africa Regional program, under sub agreement with Schaffer & Associates International, L.L.C. 1020 Florida Blvd., Baton Rouge, LA 70802. The main purpose of the assessment was to review the rice production and post harvest operations including the milling of rice to gauge the availability and quality of rice hulls for potential cogeneration systems. The premise for the assessment was that the production of electrical power from off-grid and independent sources utilizing a renewable resource will enhance the availability of electricity for the rural population, and reduce the dependence of the country on imported fuels.

The assessment was conducted in November 2004 by two specialists from the LSU AgCenter with expertise in the production and post harvest operations of rice. The staff of Schaffer & Associates International in Mali provided all in-country support to conduct the assessment. Although the main focus of the assessment was the Segou region within the purview of the Office du Niger, the Mopti region where a significant area is under rice cultivation was also visited. Interviews and visits were conducted at ministries, agencies, with rice traders, millers, farmers, and village associations. A summary of the key findings are provided below, organized under 1) Rice Production, and 2) Rice Milling/Rice Hulls Utilization for Energy.

1) Rice Production

In seeking to determine the status of rice production in Mali for the recent years, the reports vary according to source. The area under cultivation from the reports range from 350,000 to 400,000 hectares. The paddy production is stated from 700,000 tons to over 960,000 tons. The yield per hectare varies from below one ton per hectare, to more that six tons per hectare. The national average is 2.2 to 2.5 tons per hectare. Of the seven production regions, the highest yield per hectare and the highest total production is in the Segou Region (Office du Niger and Office du Riz). The Markala dam constructed many years ago permits the controlled irrigation in much of that area, which probably contributes to increased paddy yields and production. Field yields of 3.8 to 4.7 tons per hectare are produced in the Segou Region, and it is estimated that the production of paddy from that Region is about one-half of the total Malian paddy production. The size of household planting of rice ranges from 0.25 hectares up to 12.0 hectares, with the average about 1 to 3 hectares.

In the two Regions we visited, Segou and Mopti, the rice production practices are about the same. Seed beds are planted to obtain plants (seedlings) for transplanting. After transplanting, commercial fertilizer is applied when it is available, with a split application of nitrogen at panicle initiation. Weeding is primarily a hand operation, but a few growers reported using chemical herbicides.

No insecticides or fungicides are applied. The days from planting to harvest ranges from 120 to 135. When the paddy is matured (moisture level of the grain about 18 to 20 percent), the paddy is harvested by hand in the field, stacked, and allowed to dry for 2 to 3 days, and then threshed with a mechanical thresher. The grain is then spread on drying mats and allowed to dry in the sun until it reaches a safe storage moisture content of about 12-13 percent. The paddy is then sacked into 70 to 80 kg bags, and stored at the growers home until it is milled by the small fixed location and portable mills. The milled rice from these inefficient machines consists of mostly broken white milled rice, and a mixture of ground hulls and bran which is then used for animal feed.

Suggested recommendations:

- Maintain and improve controlled irrigation in the Markala dam areas of rice production.
- Seek advanced technology for rice production from the Institut D=Economie Rurale, including high yielding varieties, cultural practices and plant protection.
- Continue the development of farmer cooperatives/associations to promote better production and milling.
- Make an effort to stress higher quality in both paddy and milled rice.
- Search for means to increase production on existing land used for paddy production by the proper use of applied chemical fertilizers, and perhaps the growing of a second crop during the dry season if water is present for controlled irrigation.

2) Rice Milling/Rice Hulls Utilization for Energy

a. The Rice Post harvest System

The rice post harvest system is currently handled by a combination of manual means with very little energy use, and small scale threshers and rice mills run by diesel power. The timing of harvesting and threshing practices could be modified to reduce internal breakage of the rice kernels, and subsequent low mill yields and food losses. An awareness program mainly through training of trainers, and low cost rice quality assessment laboratories can be one solution to address past harvest losses, currently estimated to be about 38,000 tons of milled rice equivalent valued at 16 million U.S. Dollars per annum.

b. The Rice Milling Industry

Since the privatization of the processing and trade in rice in the early 1990s, most of the larger mills with an estimated total annual milling capacity of 115,000 tons have been closed for operations. This situation has been caused by a variety of factors including lack of finance for paddy purchases, competition from the smaller mills for paddy purchases, and possibly lack of management efficiency. Despite this, one miller plans on continuing operations, and has even purchased another government mill, while another company is planning to establish a new large rice mill. Further, groups of villages have invested in improved rice milling systems that are capable of producing quality rice for the local markets.

As far as milled rice quality is concerned, by far the most striking observation was the amount of broken rice, overall about 50%, and in some cases even 100% brokens. Due to the low purchasing power of the rural populations, there is no present recognition for higher quality, and hence a higher price for milled rice. However, there appears to be a growing market for quality milled rice in the major cities, and discussions have revealed that those who can afford it will purchase the higher quality rice at a higher price. Mali currently imports a small quantity of rice from Asia, and this rice is sold at a price that is slightly lower than the locally produced rice. However, it is believed that the local population prefers the Malian rice.

Through an awareness and education effort referenced in subsection (a) above, a focus on rice quality improvement will result in reduction of food loss, which in turn will reduce rice imports. Concurrently, the focus on improved rice quality will encourage a move away from the current milling systems that are largely the cause for the broken rice component. This move will also result in a purer bran component, and rice hulls, more suited for cogeneration systems.

c. Rice Husk Availability

Given the current status of milling systems in the country, the availability of rice hulls for cogeneration systems is limited. The only operating large mill at Segou city currently produces approximately 2000 tons of rice hulls per annum, while in a group of villages in the Niono area are currently operating ten 2 t/h mills currently producing 15,000 tons rice husk per annum. This latter group of mills is within a ten to fifteen kilometer radius making husk collection for a cogeneration unit feasible. Further, discussions with this village association revealed that they are planning to add another ten mills of similar capacity, thereby enabling a total husk availability of 30,000 tons per annum. Assuming a 1.2 MW cogeneration unit (consuming 45 tons husk per day) is viable, the present amount of rice husk of 15,000 tons per year will be sufficient to run the power plant for approximately 330 days/year. Other systems of lower capacity, particularly steam engine based systems need to be explored.

d. Potential for Cogeneration from Rice Hulls

As a backdrop to this assessment, there is considerable agreement that electrical energy availability is a serious constraint to economic development in Mali. Due to funding and maintenance issues, and the delay in the Manatali Power Unit coming on stream, grid power is limited and transmission losses are high, estimated at 25% for a country that can ill afford this loss. Thus off-grid, independent sources of electrical power are encouraged by the authorities. Secondly the country with no known fossil fuel resources is currently importing 200 million liters of refined petroleum products for power generation, transportation and domestic use. Thus not only capital costs for cogeneration systems but also the corresponding reduction of diesel fuel for power generation needs to be considered. While high pressure steam turbine systems are more efficient, smaller capacity cogeneration systems driven by steam engines should not be ruled out.

Part II Rice Production

1. Overview of agricultural development and rice production in Mali

a. Country Background and Agricultural Production

The production of agricultural commodities, livestock and fisheries in the agricultural sector, and the continued development of the mining sector are key to Mali's wealth and economic well being. About 70% of the labor force in Mali is engaged in agricultural activities contributing about 42% of the nation's GDP. Agricultural production in Mali is dominated by small producers using traditional farming methods, particularly to produce cereals, including rice, sorghum, millet and maize (1).

b. The Rice Industry in Mali – An Overview

Rice is a major agricultural crop in Mali, and holds great potential for expansion, enhancement of quality and possibly exports to neighboring nations that are experiencing a deficit in terms of this crop. The most productive region for rice lies along the Niger River basin between Bamako and Mopti, and extends south to the borders of Guinea, Cote d'Ivoire, and Burkina Faso. Rice is grown extensively along the banks of the Niger between Segou and Mopti, and the most significant part of this is found in the areas under the purview of the Office du Niger north of Segou. This region accounts for nearly one third the production of rice in Mali. Table 1 below provides rice production data:

Table 1. Rice Production Data

Region	2002/2003			2003/2004 (forecast)		
	Area (Ha)	Yield (Kg/Ha)	Production (T)	Area (Ha)	Yield (Kg/Ha)	Production (T)
Kayes	979	1276	1249	3890	828	3222
Koulikoro	17751	2193	38927	12996	1365	17741
Sikasso	62085	1624	100814	63348	1170	74094
Segou	116315	4701	546856	114970	3815	438610
Mopti	134681	1281	175552	107648	634	68228
Tombouctou	26918	2980	80204	27571	2454	67662
Gao	27222	976	26571	26188	903	23646
Totals/Mean	385952	2513	970173	356611	1943	693203

Source: Malian Chamber of Agriculture, Official Bulletin, January 2004

As seen from the above data, Segou region by far has the highest yield on a per hectare basis, and produced approximately 56 and 63 percent of the national production respectively for the two seasons as calculated from the above table. The above data predicted a national decrease of 276,970 Tons in 2003/2004, and the decrease appears to be due to predicted decreases in all the regions except Kayes. The major reduction seems to be from the Mopti area. The production in Tons/Ha and land area in hectares of paddy harvested differ greatly as presented from several reports, publications and Internet sources. The variation in the data seems to indicate significant differences in reported yields, production, and harvested area for Mali. However in all cases, there is a consistent relationship. The Segou area has the highest yields and area under paddy production. Although the Mopti area is relatively higher in hectares planted to paddy, the uncertainty of water excesses and droughts result in low yields per hectare. The present and future production of rice in Mali looks promising, and will depend on many factors, but the most important is controlled irrigation.

Although Mali's rice production is close to being sufficient for its own internal use, it still imports some rice from Asia. In like fashion West African countries including Ivory Coast, Senegal, Guinea, Mauritania, Burkina Faso and Niger, all import a total of nearly 2.0 million tons of rice per year (2). Mali's neighbors in West Africa have a combined deficit of nearly 1.2 million tons per year, providing an opportunity for exports of quality milled rice from Mali. Although Mali's rice production, including its irrigation systems have an impressive record, the full potential for exports from Mali to its neighbors can be realized through programs aimed at enhanced production and post harvest operations that promote the processing of quality milled rice. Discussions at various levels indicate that at present even though the imported rice is cheaper than the locally available milled rice, the population prefers the local rice. This implies that a market for local rice exists, and will continue to grow concurrently with increased grain quality.

c. Status of Rice Production in Mali

Rice production areas in Mali are divided into seven (7) regions: Kayes, Koulikoro, Sikasse, Segou, Mopti, Tombouctou and Gao. The land area for rice production is reported to range form 350,000 to 386,000 hectares (depending on the reporting source). Field yields of paddy (rough rice) range from less then one ton per hectare up to more that 5 tons per hectare. The average is 2 to 2.5 tons/ha. Total national production in tons also varies according to different reports (600,000 to 970,000 tons).

Differences in statistical data regarding land area in hectares of paddy (rice); national production data in tons of paddy; and field yields in tons per hectare from Table 1 Rice Production Data are shown in the following seven instances.

- An IRRI (International Rice Research Institute) publication, ***Rice Almanac***, published in 2002 listed the following for Mali.

Table 2. Mali Rice Production Data

Year	Area Harvested	Yield T/A	Production (time)
1999	350,000	2.2	809,555
2000	350,000	2.3	869,555

Source: Rice Almanac, IRRI, 2002

- A report prepared for USAID/Mali Mission for USAID Global Bureau Center for Environment, Office of Energy and Environment and Technology, November 2001 listed "relevant rice production" as 700,000 tons. The assumption is that this referred to paddy or unmilled rice.

- An internet source (www.irri.org/science/ricestat/index.asp) reported the paddy rice yield for Mali in 2002 as 2.05 tons/ha; and the rice area as 453,000 ha.

- Another internet document, MALI, stated the 1997 rice statistics as 613,965 tons; 400,000 ha (harvested area); and a yield of 1.6 tons/acre. Another internet access for MALI showed 350,000 harvested ha; yield 2.3 tons/ha; and a production of 809,555 tons.

- Still another internet accessed document by WARDA (West Africa Development Association) for 2002 showed Malian rice production as 926,000 tons.

- A paper, ***Analyse des Filieres de Production Agricole au Mali: Cas du Riz*** October 2004 reported that the highest production regions were as follows: Segou region produced 438,610 tons of paddy in 2002/03; whereas the Mopti region produced 68,228 tons, a decrease from 205,733 tons in 2001/02; the Sikasso region produced 74,094 tons, down from 89,054 tons in 2001/02; and the Tombouctou region 67,662 tons, down from 99,613 tons in 2001/02.

- In a publication, ***Recuil des Statistiques du Sector Rural***, Minister du Development Rural, Republique du Mali, March 2001, presented the following information for 1999/2000.

Table 3. Rice Production Data

	Hectares	Production	Tons/ha
Kayes	3,345	2,638	0.789
Koulikoso	21,779	25,599	1.175
Sikasso	78,695	119,194	1.515
Segou	100,493	396,902	3.950
Mopti	69,799	88,271	1.265
Tombouctou	25,589	78,702	3.078
Gao	25,407	15,834	0.623
MALI	**325,107**	**727,140**	**2.237**

Source: Recuil des Statistiques du Sector Rural, Minister du Development Rural, Republique du Mali, March 2001

The variation in the data seem to indicate significant differences in reported yields, production, and harvested areas for Mali. However, in all cases, there is a consistant relation. The Segou area has the highest yields and area in paddy production. Although the Mopti area is high in hectares planted to paddy, the uncertainty of water excesses and droughts result in low yields per hectare.

The present and future production of rice in Mali will depend on many factors, but the first is controlled irrigation. The future looks promising for increased rice production in Mali.

According to one report downloaded form the internet, the percent of the total national land cultivated for rice by the seven regions was as follows.

Table 4. Percent of the Total National Land Cultivated in Rice

Region	Percentage
Kayes	3.9 %
Khoro	4.7 %
Sikasso	10.8 %
Segou	7.9 %
Mopti	59.2 %
Tombouctou	7.8 %
Gao	6.5 %

Source:

The largest region (Mopti) produces much less rice because of low yields, and the Segou region produces the most (almost one-half of the national production) because of high yields.

Again, of the seven rice regions, the highest field yields are produced in the Segou Region. This involves controlled irrigation in the NIONO, MACINO, MOLODA, and N'DEBOUCOU areas (see attached plat, perimeters amenages). The second plat illustrates the ZONE D'INTERVENTION Office Riz Segou and the hectares available for the production of irrigated rice.

The main season rice is planted May to July, and harvested October to December. Off season rice is planted January to March, and harvested May to June. Deep water rice is planted July to August and harvested December to January.

Planted varieties are classified as (1) irrigated; (2) rainfed lowland; (3) upland; (4) deepwater; and (5) tidal wetland. Variety development and testing is done primarily by the Institut d'Economic Rural under the leadership of Dr. Mamadou M'Baré Coulibaly, Chef Programme Riz Iriqué, CRRA, Niono. He does have a network of cooperation in receiving germ plasma from WARDA and IRRI. I am informed that he developed the variety Kogoni 99-1 Gambiaka, now grown on about 80 percent of the areas planted in rice.

Yield performance, by variety and region, was listed in one publication for 15-20 other varieties. The reported yields ranged from 2 to 8 T/ha. We assume that the yields are relative to their yielding ability, and small plots, and we expect those listed as 6-8 tons/ha to perform about 20 to 25 percent less under average field production practices.

In another report, fertilizer use of supplied nitrogen, phorphorus (P_2O_5), and potash associated with testing varieties ranged as follows:

0 – 100 kg/ha nitrogen
0 – 163 kg/ha phosphorus fertilizers
0 – 100 kg/ha potash

with resulting yields ranging from 1.9 T/ha to 5.86 T/ha as a result of fertilizer applications levels.

Another report from the irrigated Office du Niger showed nitrogen responses as follows:

0 kg N/ha – 3.26 T/ha
60 kg N/ha – 5.55 T/ha
100 kg N/ha – 5.9 T/ha

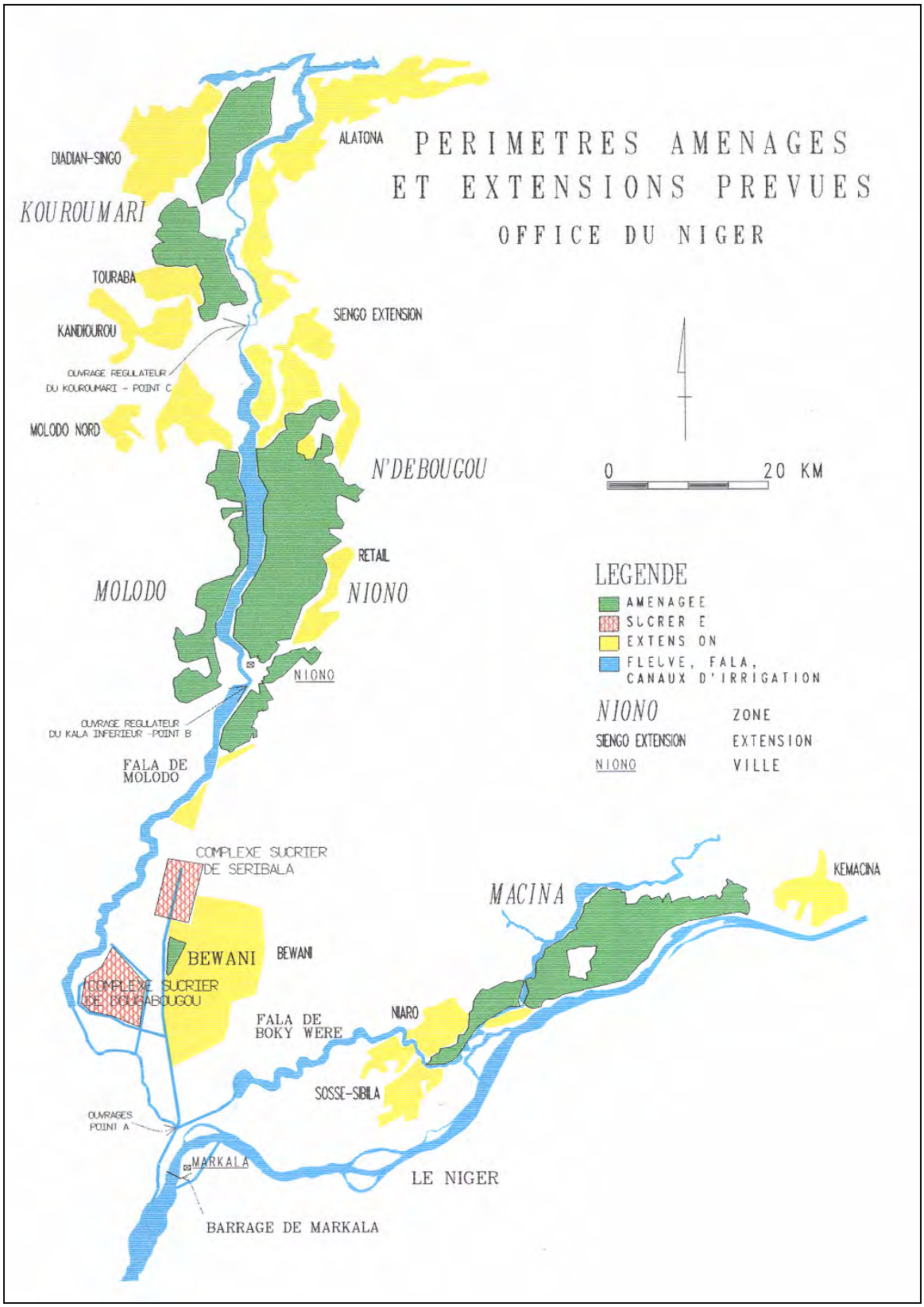

Figure 1. Office du Niger Area of Intervention. Source: Office du Niger, D.A.D.R., May, 1997

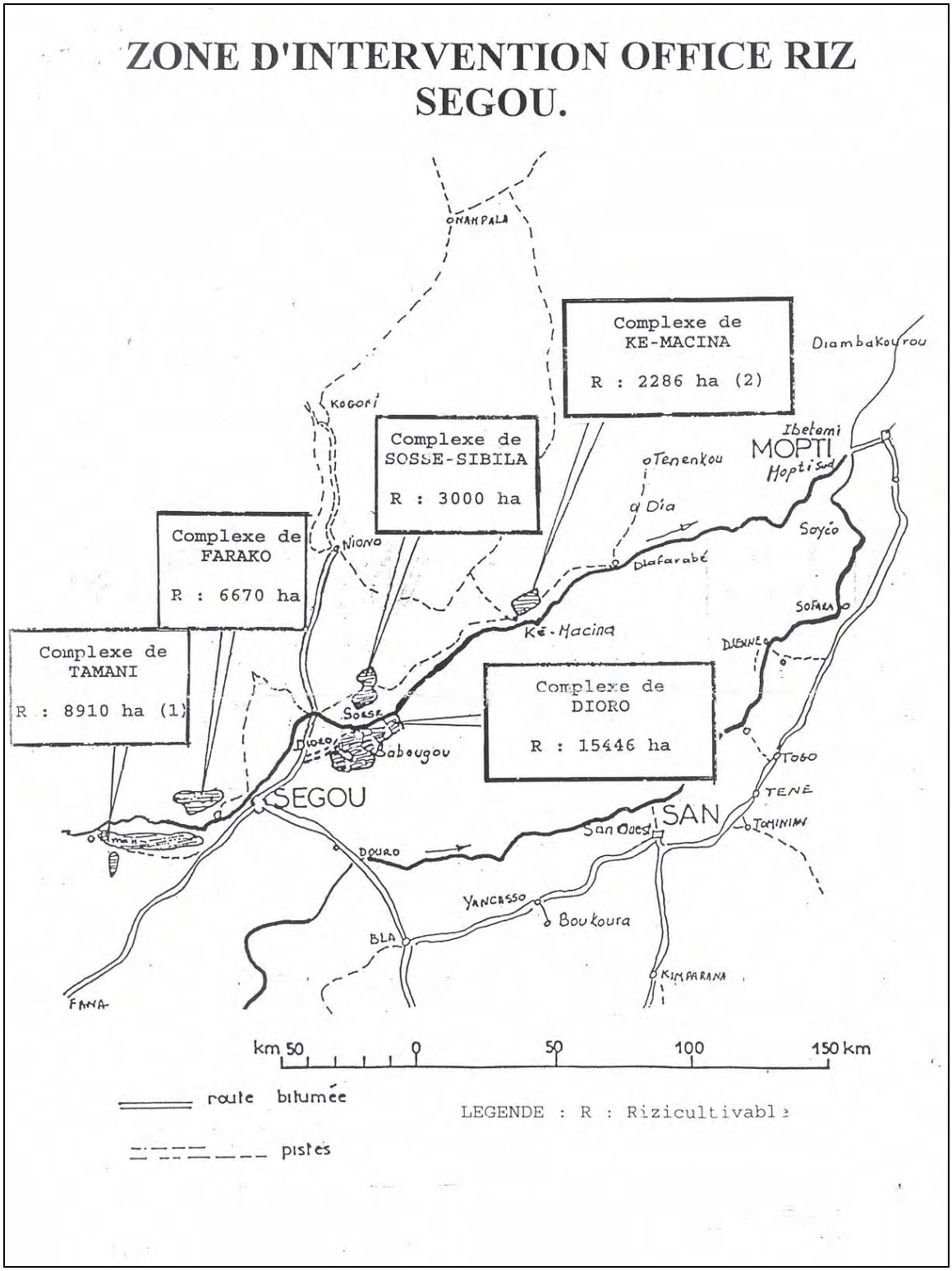

Figure 2. Office du Riz Area of Intervention in Segou. Source: Office du Niger, D.A.D.R.

Most rice farmers use fertilizer if it is available and recognize the increase in yields as a result of applied inorganic (commercial) fertilizers. A few added organic wastes (from animals) to the land planted to rice if it were available. In regard to commercial fertilizer, there were consistent reports about its lack of availability, or the lack of funds to purchase fertilizer. However, from our intensive travel in both the Segou and Mopti regions, we did not detect poor nutrition of the rice plants, or extremely poor yields resulting from lack of fertilizer applications.

According to all reports, insects and diseases of rice in Mali were not of economic importance. We had read 2004 reports of severe infestation of locust in West Africa, including Mali, but I was told that locust destroyed other crops in certain regions, but not rice. So, the use of applied insecticides and fungicides was not a production expense for Malian rice growers.

However, instances of yellow dwarf virus were noted. The decision was then made not to go into the field until harvest so that the virus would not spread.

There were reports of the use of herbicides for weed control, but data on this use was not available to us. We suspect that hand weeding is the primary means of removing unwanted weeds and grasses.

Reports of problems in Malian rice production were listed as:

a. Low temperatures during off-season in irrigated areas.
b. Drought/flooding in some regions.
c. Shortage of water in the dry season.
d. Weeds.
e. Lack of maintenance of irrigation facilities.
f. Production costs.
g. Inadequate production inputs.
h. Transportation.
i. The need for more research and extension.

Of the seven regions of rice production, the highest "average" yields were in the Office du Niger region, ranging from 3.26 tons/ha to 5.9 tons/ha. This greatly contrasted with yields of 1.72 to 2.63 T/ha in the Mopti-South region.

The Office due Niger and the Office du Riz offer the best potential for the proposed rice cogeneration project if it can be designed using the small, fixed location 2 ton mills in a designed series.

There are no large scale rice mills now active in Mali except for the 50 ton mill at Segou, which operates at 30 percent capacity. Actually, there is another 75 ton mill "across the street" from that mill but it is not operating now. Neither mill uses rice husks for energy. The mill owner reported power cost at 4,000,000 CFA/month to operate.

In those two regions (Niger and Riz), there is an express desire to expand rice cultivation to an area of 240,000 hectares. Land is available, but first, they wish to attempt increased production per hectare of the existing paddy (rice) before expanding land areas.

The goal of rice production increase in the Segou Region (Office du Niger) will require high yielding varieties, agricultural extension, involvement of the private sector, and policies for energy in the agricultural sector. But, we would hasten to add that the future planned development for increased rice production will be limited unless there is an increase in controlled irrigation.

With available water resources for the dry season, the increase in rice production could easily double by planting two crops per year. However, we were informed that the water flow is too low from the Niger River in the dry season, and subsurface water sources are not known, nor could be easily produced without power for the pumps and subsurface wells.

The days from rice planting to harvest in the irrigation areas range from 125 to 140 days, thus providing ample time for two crops if irrigation is available during the dry season. Unfortunately, the information in the preceding paragraph makes that difficult to achieve.

The production practices in the Segou region are discussed in the trip report, but presented here in summary form:

1. Seed beds from broadcast rice seeds.
2. Transplant, by hand, on 20 cm x 20 cm spacing.
3. Apply fertilizer in split applications (two).
4. Harvest at about 18 – 20 % grain moisture by hand in the field and tie in bundles to dry.
5. Wait 2 to 3 days for available machine thresher.
6. Spread grain on drying floor for sun drying to safe moisture for storage (about 12%).
7. Bag the paddy in 70 to 80 kg bags.
8. Store at home.
9. Mill as needed, and/or sell any of the production not needed for household food consumption.
10. Mill 1 to 3 bags as needed using primarily small, portable mills or fixed location small mills. The problem with the latter is transportation even though the quality (percent broken grains) is better in the fixed location mills than the portable mills.
11. Use the bran/hull mixture for animal feed.

Part III Rice Post Harvest System and Rice Husk Utilization

1. Rice Post harvest System

a. Overview

Most rice is hand harvested at maturity, and at a grain moisture level of 18% to 20%. The farmer then leaves the harvested panicles in bundles in the field to dry for 2 to 3 days and then based on the availability of mechanical threshers the paddy is threshed. The paddy is then taken to the farmer's home and sun dried by spreading on the ground directly or on woven mats (Figures 3 ~4). The farmer then sells a portion to a large mill or has it milled at a small huller type mill for sale at the local market. Depending on the area, family size and other considerations, some farmers may not have sufficient paddy for sale. In this case they mill the paddy on an as needed basis, keeping the rest of the grain at home. Storage at the farmer's home is generally in mud structures (Figure 5).

Figure 3. Hand Harvesting Paddy

Figure 4. Hand Harvesting/Threshing

Figure 5. Paddy Storage Structure

Observing the rice quality at various mills and markets, it is apparent that by far the most visible aspect is the large number of brokens. For example, rice from a mobile huller mill run by a diesel engine in Sasendang town near the Macina area, appearedto be nearly all broken, and the bran-hull mixture had many small brokens. In general rice samples revealed a greater than 50% Observing the rice quality at various mills and markets, it is apparent that by far the most visible aspect is the large number of brokens. For example, rice from a mobile huller mill powered by a diesel engine in Sasendang town near the Macina area appeared to be nearly all broken, and the bran hull mixture had many small brokens. In general rice samples revealed a greater than50% breakage. At the same time, the grains appeared to be very sound, and devoid of any heat damage, insect damage, or otherwise discolored. This indicates that if the issue of breakage is addressed, then the quality of the rice would be good.

Since 1994, when the government of Mali privatized rice processing and trading, there has been a trend for the closure of the few large rice mills and the growth of a large number of small huller type mills. Of the eight large rice mills, six were visited. At present only one mill at Segou city is functioning albeit at about 30% capacity. Most of these large mills have been closed for 10 or more years. The smaller mills are of two types. The most common is the huller type in which paddy enters at one end, and two products, a) milled rice and brokens, and b) bran and hulls leave the machine. A second type of mill recently introduced in the Niono area is the combination of the rubber roll sheller (to remove the rice hulls) and steel polisher to remove the bran. The

former huller type mill is generally powered by diesel engines, and is either a mobile unit going to various locations in a village to mill farmers' paddy, or exists in a fixed location where farmers bring the paddy for processing. Some farmers believe that the fixed mill produces better results in terms of rice quality.

b. The Milling Industry

The rice milling industry in Mali underwent major changes after the sociopolitical events in 1991. Eight large mills with a total estimated capacity of 115,000 tons per annum that were in operation at the time were privatized. By 'privatized' it is meant that these mills were sold on tender and some were bought mainly by traders engaged in the imports and distribution of sugar and rice (Mali still imports a small quantity of rice despite being fairly close to self sufficiency). Table 5 shows data gathered during the study on all of the 'large' mills in Mali – six of the eight were visited during the study. At the present time (November 2004), only two mills at Segou city located across the street at the same location were operational.

Table 5. Large Rice Mills in Mali (in the Segou and Mopti Areas)

Location	Owner	Year Built	Capacity	Distance to Segou	Notes
1. Diore/Segou	Bakore Silla	(?)	(?)	50 Km	Closed[1]
2. Segou City	Modibo Keita	(?)	50 T/day	0 Km	Working[2]
3. Segou City	Modibo Keita	(?)	75 T/day	0 Km	Closed
4. Kolongo du Macina	(?)	1948	1200 T/yr	91 Km	Closed
5. Molodo/Niono	(?)	1950	30,000 T/yr	113 Km	Closed[3]
6. Dogoferi/ Diabali	(?)	1968	21000 T/yr	80 Km	Closed
7. Debougou	(?)	1976	21000 T/yr	120 Km	Closed
8. Savare/Mopti	Modibo Keita	1973	6 ~ 9000 T/yr		Not working[4]

Notes:
1. This plant has a low pressure steam cogeneration system utilizing rice hulls from the mill. The mill is currently closed due to owner not being able to purchase paddy caused by competition from small huller millers in the area; lack of funds for paddy purchases, etc.
2. The owner says 30 % of the combined capacity of the mills in item 2 and 3 above. These mills are located across the street. He also says that most of the milling is done at the 50 T/day mill. Conclusion – 30% of the combined capacity (50 + 75) is 37.5 T/day at mill in item 2 above.
3. This mill, now long closed, had a Chinese rice hull gasifier system to produce power for milling operations. A gasifier plant was located inside the building, and another abandoned gasifier and diesel engine was found outside the premises.
4. This mill was recently purchased by Mr. Modibo Keita in November 2003. Officials of the government at Sevare, Mopti say that he has not turned up at the site yet. Mr. Keita says he bought it "at a very low price". An estimate would be that the price paid was much less than $ 400,000.

Rice hulls based cogeneration systems were installed at two of the mills (Bakore Silla mill at Segou city, and Molodo mill at Niono) that are presently not operating. One mill had a steam boiler/turbine system coupled to a generator for the needed electrical power, while the other had utilized a Chinese gasifier unit coupled to a diesel generator set to produce the required power.

Of all the mills visited during the study, all but one (Kolongo du Macina location) showed that the facilities could be upgraded and renovated if large scale operations in milling rice were to be given consideration by investors. The mill and premises at the Kolongo du Macina location were in a poor state of repair. Given this status of rice milling in the country, most rice processing is left largely to the smaller mill operators who utilize the Engleberg type huller units with small hourly throughput, powered by diesel engines. These mills were fairly common in the village setting, and were either available to producers as portable units (the diesel engine/mill were skid mounted and drawn by a donkey, Figure 6), or fixed at a central location in the village for use on a custom milling basis. In one group of villages (Seriwala, KM 30 in the Niono area) the village association has invested in ten mills (each of 2 tons per hour capacity, totaling an estimated 7500 tons per annum) that were more advanced (in terms of producing a better quality milled rice) than the Engleberg type huller mills referenced earlier. These are of the rubber roll sheller/steel polisher type mills, and are capable of producing a better quality of milled rice (less brokens), while at the same time producing two by products – hulls and bran.

Figure 6. Moveable Engleberg Type Huller Mill

Given the above scenario, by far the most striking feature was the quality of the milled rice. The better samples of rice seen during the visit at best showed nearly 50 to 60 percent brokens, while in some cases, the rice from the portable smaller units appeared to be nearly 100 percent broken. There are several points to note in this regard. The sale price of broken rice is generally half that of unbroken rice; when rice breaks in the mill, not only is the quality lowered, but also the total yield is reduced. This is caused by the fact that a significant part of the brokens also are abraded in the mill producing in effect rice flour that goes to the bran/hulls mixture the mill produces. This results in economic and food loss estimated at between 5 to 7 percent to the farmers. Using the annual production in the Segou are as 473,000 tons, the above loss translates to about 23,000 tons of milled rice per year valued at about 5.0 billion CFA or about 10 million dollars per year. This estimate increases to about 38,000 tons of milled rice for the nation valued at about 16 million dollars per annum (an annual production of 800,000 tons was used for this estimate).

A secondary issue is the quality of the byproducts produced by the smaller mills. Due to the nature of the design of these small huller mills, they produce two outputs – a) milled rice and brokens, and b) a mixture of partially ground hulls and bran. A considerable amount of small brokens were also noted in the second output from these mills confirming the notion that there is at present food loss (lower total milled rice yield). While at the present the by product (mixture of bran and ground hulls) is returned to the farmers for use as animal feed, as production increases, a focus on mills that produce a purer bran component may be necessary. This will result in a higher value by product in comparison to the present mixture of rice bran and ground hulls. Of course a move in this direction will also result in pure rice hulls that are suited for energy production (the current mixture of bran and ground rice hulls is unsuitable for cogeneration purposes).

The closure or non operation of most of the larger mills in the country prompted an exploration of the reasons for closure by speaking to many representatives of the milling industry. The key issues/reasons are: a) Sociopolitical events in 1991, and a dry spell at the time caused a reduction of paddy available to the large mills; b) the privatization process took some time and in this period the mills closed operations; c) competition from small millers - they offered a better price than was possible for the larger mills at the factory gate (the large mills can compete if they went to the villages to collect and purchase paddy), and small millers gave back the bran-hull mixture to the farmers for use as animal feed; and d) lack of capital to purchase paddy. In addition to these reasons, it was felt that good management or the lack there of could also be a cause for the closure of most of the large mills in the country.

c. Rice Milling Facilities

In this section, data on mills representative of the different categories are presented. As discussed previously, there are three major categories of mills in Mali. The first category is the now largely non operational large mills; the second category is the rubber roll type mills; while the third category is the most common Engleberg huller type mill.

i) Modibo Keita Rice Mill, Segou City

There are two mills located across the road from each other at this location, and are both owned by Mr. Modibo Keita, a prominent sugar and rice trader in Bamako. Last November Mr. Keita also purchased on tender the Savare Mill in the Mopti area for a "very low price", but has not taken any interest to begin operations at this location. The following are pertinent data on the Segou mill and its operations:

Mill capacity – the mills are stated to have a capacity of 50 tons/day and 75 tons/day respectively as stated by the owner. As daily operations were stated to be either 18 or 24 hours, the hourly capacity ranges from 2.0 to 2.7 tons/h for the 50 ton mill, and from approximately 3 to 4 tons/h for the 75 ton mill. All indications are that the 75 ton mill is currently not in operation. A feature of the monthly operational capacity was that it varied according to the availability of funds from the owner. Data from the books on

monthly capacity revealed that from April through August of 2004 they milled on average 1200 tons per month (see Table 6 below), equivalent to about 40 tons/day on a 30 day per month basis. The persons at the mill premises stated that the mill normally operates about 7 months per year and mills about 20,000 tons. For example, this year, they have milled about 9000 tons thus far for a 6 month period.

Electrical energy use – the owner stated that he spent on average about 4.0 million CFA per month on electricity. The actual data on consumption is provided below, and shows an average of 3.36 million CFA per month:

Table 6. Electricity consumption at Modibo Keita Mill, Segou city

Month		Paddy milled(tons/month)	Electric bill for the month (million CFA/month)
April	2004	1622	4.48
May	2004	1210	3.57
June	2004	1232	3.48
July	2004	1192	2.61
August	2004	985	2.68

Mill type – The above mill consists of paddy cleaners, two rubber roll shellers, two paddy separators, abrasive type polishers and rice graders (Figures 7 and 8). This configuration is capable of producing quality rice, pure bran, and pure rice hulls. The operator claimed that their final rice product contained about 25% broken rice. The bran is sold as animal feed and the rice hulls are mainly unused and left in the adjoining field (Figure 9).

Figure 7. Modibo Keita Mill, Segou City

Figure 8. Rubber Roll Shellers, Modibo Keita Mill, Segou City

Figure 9. Rice Hulls Left Unused

Paddy purchases - The availability of paddy for the larger rice mills is a concern and has a bearing on the closure of most of the larger mills in Mali as discussed earlier. At this mill, for example, paddy is obtained by purchases at the 'factory gate' from farmers, or purchased through buyers who on behalf of the mill travel to the villages to purchase/collect paddy for the mill. The furthest point of purchase was stated as 160 KM. Quality checks at the 'factory gate' or when purchased by buyers appeared to be limited to a visual inspection. Price is said to vary by 'quality', and the Gambiaka variety fetched the highest price. Purchase price data was not available.

ii) Bakore Silla Rice Mill, at Diorra

This mill, also located in the Segou area (Figure 10), was one of the large mills now closed for operations. According to the factory manager this mill was built in 1980 and ran as a government mill until 2000. Due to the absence of grid power in the area, the mill also had a low pressure steam cogeneration system run on rice hulls to produce power for the mill operations. The following are pertinent data on this mill:

Figure 10. Bakore Silla Mill, Diorra

Mill capacity – The manager stated that the mill ran at between 2 and 3 tons/h for 24 hour per day for 6 months of the year. This translates at the higher 3 tons/h rate to an annual capacity of 12,960 tons per annum. The mill also has paddy storage (rectangular silos) of 6000 tons and milled rice storage of 2000 tons. The surrounding area (within a 20 Km radius) produces sufficient paddy for the mill, and it was stated that almost 20,000 tons of paddy could be available for this mill. Since 2000 when operations at the mill were stopped, the smaller mills have taken over the milling in the area. When inquired about the quality of the rice produced at this mill versus the quality of the rice from the smaller mills, it was stated that the quality of rice produced at this mill was better than from the smaller mills. However, the mill did not command a higher sale price consistent with rice quality as the population at the present did not care about the quality and was only willing to pay the lowest price. During the time of operations, the government had used the rice for hotels and restaurant use. The manager did state that they can ask for a higher price at other locations.

Figure 11. Part of Cogeneration System

Electrical energy use – The mill, as referenced earlier is located in an area without grid power, thus it was installed with a rice cogeneration system (Figure 11) primarily of Italian manufacture. Although details of specifications were not readily available, it appears that the system had a fire tube boiler fueled by rice hulls using a gravity fed step grate system for combustion. They used straw and cotton waste for start up before switching to rice hulls after the boiler system reached steady state operation. The boiler capacity was stated to be 400 Kg/h, and husk use was stated to be between 400 and 500 Kg/h. The boiler provided steam for a single 400 KVA steam turbine generator set. This power was used for the running of the mill, lighting for the premises and for electricity use by three houses for staff at the same location. In addition to the cogeneration system, they also had installed three diesel generator sets of 400, 250 and 50 KVA respectively. Data on power use by the mill was not available. It was only stated that the diesel based operation of the mill was more expensive that the cogeneration system running on rice hulls.

Mill type - The mill was essentially of the rubber roll sheller type (Figure 12) with equipment supplied from Italy and China. The rubber roll shellers used were of Italian make with 250 mm diameter x 250 mm long rolls, the paddy separator (Figure 13) was of the "Satake" design made in China, and the polishing (bran removal) operations used a 4-stage vertical cone (1500mm diameter x 600 mm height) polishers (Figure 14) of Italian manufacture. To grade the milled rice, there were two oscillating sieve type graders and a single trieur cylinder type grader. Rice quality was estimated at about 65% total milled rice output with an estimated 50% whole kernels based on 100% paddy.

Figure 12. Rubber Roll Shellers

Figure 13. Paddy Separators

Figure 14. Vertical Cone Polishers

<u>iii) Rubber Roll Sheller/Polisher Combination Mills, Seriwala village, KM 30, Niono Area</u>

This group of villages have a village association that is stated to operate 10 of these fixed location mills (as opposed to the moveable mills found in the villages), with plans for introducing another ten units in the near future. As discussed elsewhere in this report, this group of villages and other like this group offer possibilities for organized rice husk collection and the generation of electrical power from rice hull based cogeneration systems in the near term for Mali.

The unit is a rubber roll sheller that dehulls the paddy, mounted atop a steel polishing unit to remove bran. The capacity of these units (Figure 15) are stated to be 2000Kg paddy per hour, and use an 200 mm diameter x 150mm and 250 mm long rollers. The information on motor power used to run the unit (a single motor drives the entire unit) varied, but a figure of 40 kW was taken as the average. All of these units are run by electricity produced by a 40 kW diesel engine alternator set (Figure 16) using about 5 to 6 liters per hour of diesel. Inquiries at one location revealed that these mills generally run 18 hours per day, 30 days per month, for 7 months per year. This translates to about 7560 tons of paddy per annum. For this duration, the mill requires 22,680 liters of diesel valued at 9.2 million CFA per annum (U.S. $ 18,400 at 500 CFA/$).

A variation of the unit described above was a separate rubber roll sheller and steel huller type polisher with a lower throughput capacity of about 800 kg per hour. In one village, it was estimated that about 30 such units mill paddy in comparison to at least 500 huller type mills of the fixed and moveable variety.

These mills purchase paddy at a price range of between 100 and 120 CFA/kg based on 'quality', variety, and season (or time of year – at harvest time price is low, and at other times in the year the price could be higher). The charge for milling is around 750 CFA per bag of 70 kg. The rice hulls are not utilized for any specific purpose (in some villages there is some use for brick making, as a fuel for cooking and the use of ash for horticultural production), while the pure bran (with some small rice brokens in it) is sold at 2500 CFA per bag of 70 kg. The milled rice is said to be sold at 225 CFA per kg (with approximately 50% brokens), and sold at 275 CFA per kg after grading to reduce the brokens. Information on how much brokens were present in this 'graded' rice was not available. The imported rice in Mali was said to be sold at prices close to the 225 CFA per kg level.

A discussion on willingness to participate in a cogeneration project was welcomed by the above referenced association, although the association head stated that the opinion of the association members will have to be considered. He realized that at present,

there was no value associated with rice hulls, and that once people realize that rice hulls have value, they would be willing to consider the collection and use in a cogeneration system.

iv) Small Portable and Fixed Huller Mills

As discussed elsewhere in this report, by far, these mills were most common in all villages in the rice producing area in Mali. To obtain an overview of these mills, discussions were held in one village in the Office du Niger area near Macina. The discussions held with the leaders of the town administration for Sasendang Town revealed that at least 80 mobile units and about 30 fixed units are operational in their area to handle the paddy produced from approximately 10,000 ha under rice production. Farmers are said to keep most of the rice crop as paddy stored in their homes, and mill the grain on an as needed basis. The charge for the processing at these small mills varies from 1 bag of paddy for every 12 bags or 14 bags of paddy processed. In general the villagers are said to prefer the rice quality from the fixed mills as compared to the mobile units, but that transport to and from the fixed mills was a consideration. These small mills are all of the Engleberg huller type, and produce two outputs: a) milled rice and brokens, and b) a mixture of ground hulls and bran with some small quantity of small broken rice particles.

Figure 15. Rubber Roll/Polisher Unit

One such mill visited (figures 17 and 18) in Sasendang village was powered by a small diesel engine of Chinese manufacture (Yangdang Company). This engine, model S 195 had a maximum horse power rating of 13, and ran at 1200 RPM. The diesel consumption was estimated at between 2 and 3 liters per hour. The capacity of the huller was stated to be ten 70 Kg bags of paddy or approximately 700 Kg paddy per hour. A visual examination of the milled rice output indicated that nearly 100 % of the kernels were broken.

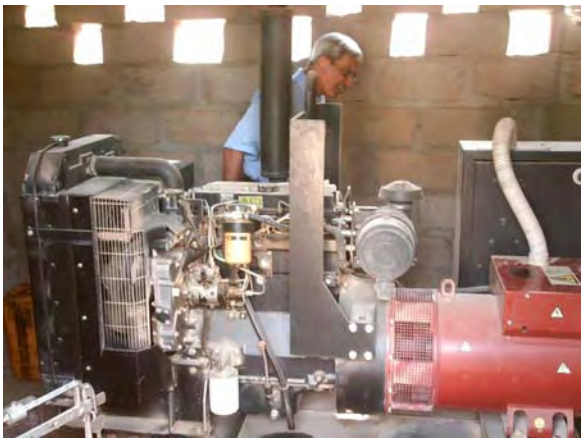

Figure 16. Diesel Generator Set

Figure 17. Portable Mill, End View

d. Rice Quality Issues

As discussed previously, rice quality appears to be a major consideration if post harvest losses are to be reduced. While it now appears that rice quality may not be a consideration for the majority of the people, inquiries revealed a price differential for milled rice (225 CFA to 300 CFA/Kg) based on quality (amount of brokens), particularly in the Bamako market. Secondly, it was found that while imported rice is available in the market (landed price approximately FOB price at sale point plus $ 100/ton transportation

plus 18% import duty versus local rice at $ 520/ton) the people generally prefer the locally produced rice. Further it was found that those who can afford will pay a slightly higher price for better quality.

Figure 18. Portable Mill, Side View

The situation described above is not unlike the situation in other rice producing countries where as one approaches self sufficiency and look to exports of any excess production, then rice quality issues become important. Mali is in fact poised to move in this direction. At the same time, Mali can seize the current opportunity of exporting to neighbors who collectively have a current estimated deficit of 1.2 million tons milled rice per annum (2). To move in this direction producing export quality rice, Malian processing facilities need to focus on improved rice quality. This has the added advantage of reduced food losses in general for the country. To absorb any increased production, increased milling capacity, particularly for export oriented businesses, it would be normal to invest in larger capacity mills that produce rice of acceptable standards. This has an implication on availability and quality of rice hulls for cogeneration purposes, in that the rice hulls of an appropriate quality (for cogeneration) will be available at the sites (of the mills), thus removing and collection and transport costs, and the cogeneration unit will provide power to run the mill and associated facilities, and based on the cogeneration system installed, produce excess power for the locality.

Given the above discussion, consideration should be given to an awareness program focusing on post harvest operations, losses (in the field, at storage, and through the milling process). This program should be oriented to general awareness for the producers, capacity building through training programs for Office du Niger and Office du Riz personnel, local NGOs and village leaders. The LSU AgCenter has conducted similar programs and has the capacity to develop and implement such programs in-country. In addition to the capacity building effort, paddy/rice quality assessment needs to be addressed. One way to accomplish this is to establish small low cost quality assessment laboratories in key locations in the main rice producing areas. The added advantage of these small laboratories is that they will be appropriate sites for conducting the training programs.

2. Electrical Energy Production and Use

a. Energy Production ~ Sources and Use

To obtain an understanding of the energy production and use in Mali, several meetings and visits were conducted during this study. Further, reports available from USAID and other sources were also consulted. Meetings with the Minister of Energy, at the offices of Energie du Mali (EDM), and Agence Malienne pou le Developpement de l'Energie Domestique et de l'Electrification Rurale (AMADER) in Bamako and Segou were conducted. Mali is stated to have one of the lowest per capita energy consumption in the world (2). At the present only 8% of the population (approximately 100,000 customers) are said to have access to electricity, with a projected additional 7% of the population having electricity by 2010. Installed power in Mali includes hydroelectric (50 MW) and thermal (64 MW) sources. Mali is also stated to possess about 1 MW of solar power sources serving about 2000 homes, and public buildings including schools and community buildings. Some solar powered water pumps are also used.

At the present time, nearly 80% of the energy consumed by the population is estimated to come from fuel wood, albeit without a plan to sustain this renewable resource. Due to the absence of any source of fossil fuel in the country, Mali currently imports 3800 bbl/day (200 million liters per year) of refined petroleum products for the purpose of power generation, transportation needs and domestic use (lighting and cooking).

It is reported that both the quality of power supply and distribution are major issues that contribute to the mismatch between supply and demand (2). There are several causes for this mismatch: a) the delay in the availability of the Manatali plant (100 MW) , b) the decommissioning of some of the thermal power plants in the urban areas without replacement, and c) the inefficiency of transmission with losses amounting to about 25% of the generated amount (an amount that Mali can ill afford). Some factors that cause this high transmission loss are long distances of power lines, low transmission voltage, and possibly low quality transmission equipment and maintenance.

Given the above situation, future development will likely emphasize distributed power generation. This notion was confirmed when discussions were held at the Ministry, AMADER and EDM offices. Distributed power generation will help provide power to rural consumers faster than currently possible with the national grid, and improve transmission efficiency by producing the electricity close to the consumers. Off-grid, independent sources of electrical power including from rice hull based systems were welcomed and encouraged by all agencies visited during the study.

Energy prices, particularly for electricity for use in the rural setting for rice mills and home use were investigated. These cost values will be important when considering rice hull powered systems. Electricity is supplied at three rates: social, normal and industrial. Both the social and normal rates are based upon the amount of use per month by the consumer. The higher the use, the greater the cost of a unit (kWh). The industrial rates are generally based upon the time of day (peak, regular and off peak). Prices also vary by region. Data from a USAID study conducted in 2001, and data obtained during this study are shown in Table 7 below:

Table 7. Electricity Prices in Mali

		August 2001 Study		November 2004 Study
Electricity	Social Rate	Use < 50 kWh/month	- 64 CFA/kWh	68 CFA/kWh
		Use 50 to 100 kWh/month	- 99 CFA/kWh	
	Industrial Rate	Off Peak (0h-6h)	- 43 CFA + 18% TVA	43 CFA/kWh w/o tax
		Regular (6h-18 h)	- 70 CFA + 18% TVA	70 CFA/kWh w/o tax
		Peak (18h-24h)	- 98 CFA + 18% TVA	98 CFA/kWh w/o tax
	Household Rate	-	-	94 CFA/kWh
Fuel Oil	Disel	344 CFA/liter		

Source: Reference (2), USAID 2001 Report; Present study data

b. Energy Use in Rice Mills

In assessing the use of rice hulls for energy, it is useful to estimate the energy consumption by the rice mills that produce the hulls. The following are pertinent data (Table 8) from a previous publication (3):

Table 8. Electric Power Use by Rice Mills

Maximum Power Demand	kW	Source
½ ton/h hullers, India	7 ½	IIT, Bombay, 1989
½ ton/h shellers, India	22	IIT, Bombay, 1989
2 ton/h mills, India	100	Assoc. Engineering, 1995
3 ½ ton/h mill, Molodo, Mali	125	German Ag. For Tech. Coop., 1987
kWh per ton of paddy	**kW**	**Source**
1 ton/h mills, Indonesia	25	ITB, Bandung, 1994
1 ton/h mills, world wide (maximum)	65	FAO, 1978
2 ton/h mills, world wide (maximum)	50	FAO, 1978
3 ½ ton/h mill, Molodo, Mali	32	German Ag. For Tech. Coop., 1987

Source: Reference (3), Velupillai et al, 1996

The above data are consistent with the data obtained from some of the mills in Mali during the study. The smaller huller type mills found most commonly in the rural settings in Mali are all driven by diesel engines and consume an estimated 7.5 to 10 KW. The diesel consumption for these ranged from 2 to 3 liters per hour. The capacity of these hullers were approximately 700 Kg/h

The next type of mill found in Mali was the rubber roll sheller with the steel polisher. These mills had a capacity of approximately 2 tons per hour and were driven by a 35 HP electric motor powered by a diesel engine/generator set. The diesel set used about 5 to 6 liters of diesel per hour. Data on the larger mills was more difficult to obtain or estimate.

It needs to be pointed out that any discussion of the power consumed by a rice mill needs to consider the quality of the rice output and the components of the mill. At the one end, paddy can be milled in a single pass, one operation mill such as the Engleberg huller which produces two outputs – milled rice and brokens, and a mixture of partially ground husk and bran. This mill is known to produce the lowest quality of milled rice as found in the case of most small mills now in operation in Mali. Given the current conditions – state of economy, buying power of the populace, availability of energy etc., this quality appears adequate for the people. Inquiries have revealed, however that those who can afford it will purchase the better quality (primarily less brokens) rice. Indeed, some mentioned the fact that there is some grading of the rice to separate brokens at some locations in Bamako, and the sale of better quality rice to the hotel/restaurant industry.

The next step in the configuration of milling systems is to step up to a separate sheller (to remove the rice husk) and a 'polisher' to remove the bran. For the sheller, there are two common types of machines, a) the under-runner disc huller (an older design, still in use in some countries), and b) the rubber roll sheller. This system generally produces three outputs, milled rice and brokens, bran, and rice hulls. In general this system produces rice of higher quality (than the Engleberg Huller type one-pass mill), produces pure bran and rice hulls as by products. This implies that the rice bran is of higher quality (hence capable of fetching a higher price) and pure rice hulls suitable for use in cogeneration systems. Additional improvements in milling systems are mainly enhancements of the rubber roll sheller/polisher combination. Improvements include the addition of a paddy pre-cleaner; a paddy separator (rubber roll shellers do not dehull 100% of the paddy, rather shell about 85% at optimum setting (a trade off between the percent shelled and the breakage of milled rice) requiring that a separator remove the unhulled grains for rehulling, and the brown rice to be sent for polishing); and rice graders to separate brokens rice from whole kernels to achieve a certain grade for the market.

As seen from Table 8 above, rice mills that have a combination of components to produce milled rice of good quality generally require increased power as the capacity (tons per hour of paddy) increases, but require less power per ton of paddy as the mill capacity increases.

3. Husk Utilization and Technologies in Use

a. Utilization of Rice Hulls and Availability

Given the present methods of rice milling in the country, the amount of rice hulls available for cogeneration is not significant. Given that only one large mill is currently operating at about 10,000 tons of paddy per annum, this translates to about 2000 tons per annum of rice hulls. In addition, there are an estimated ten 2 tons/hour mills (producing pure husk as opposed to a rice husk-bran mixture) operating 18 hours per day for 30 days per month, for seven months per year. These mills produce a total of approximately 15,000 tons of husk per annum. Discussions at the village association which owns these ten mills revealed that they are planning on adding another ten mills of the same type and capacity. When these plans are completed, it is likely that these 20 mills will be located within a 15 to 20 KM radius, permitting husk collection for any centralized cogeneration system. Rice hulls have a low bulk density, and thus transporting this by product over long distances (greater than 15 to 20 KM) is not economically viable. Thus in summary, presently a total of about 17,000 tons of rice hulls appear to be available for cogeneration for production of electrical power. Assuming that a high pressure steam turbine system is feasible in terms of cost of production of electricity (compared to the mostly diesel based systems in the rural areas of Mali), such a system producing 1.2 MW will have sufficient husk to run at 45 tons husk per day throughout the year. Since the mills only run for 7 months in the year, the cogeneration system can supply a limited excess during the seven months, and a much larger excess power to the villages for the balance 5 months in the year. Smaller systems using the low pressure steam engine configuration are also a possibility. However the low pressure systems that normally are less efficient (in converting rice hulls to electrical energy) than the high pressure systems, may not have sufficient excess power for rural use.

Given the current situation, the best option seems to be to organize groups of villages where the rubber roll type mills are in operation to collect the needed rice hulls for pilot cogeneration system. A second option would be to seek the support and participation of the larger mill owners to consider the addition of the cogeneration system to produce sufficient power to run the mills. There are two possibilities in this regard. The owner of the Segou mills, Mr. Modibo Keita showed interest in this approach, and inquired about costs for cogeneration systems. A second possibility is the new rice mill being planned by the Aiglon Group in Bamako (contact: Ms. Aissa Diallo) whose owners are currently in the cotton business. Incorporating a cogeneration system may be an option for this company.

Initiating cogeneration using locally available rice hulls has several implications for the rural population. These include the avoided cost for diesel fuel currently being used for running the mills; the possibility of locally generated off grid power for domestic use; the possibility of employment for a local organization charged with the task of collecting and delivering the rice hulls to the cogeneration plant; eliminating a disposal problem for the rice hulls; and finally, revenue from the sale of ash from the cogeneration system.

b. Gasification/Combustion Technologies Previously Used in Mali

Two of the larger rice mills now closed for nearly ten years used a cogeneration system based on the rice hulls produced by the mills. The mill at Molodo had utilized a Chinese rice hull gasifier cogeneration system. At the time of the visit to this mill the premises were closed, but the gasifier system was visible, and the data reported here are mainly drawn from the past experience of the authors from visiting and examining similar systems in China. In essence, the system uses a digester which produces the gas from the rice hulls, and in turn this gas is fed to a modified diesel engine driving the electric generators. One complete unit was seen out side the premises, and appears to have been abandoned. A newer unit Digester/diesel engine/ generator set were seen inside the premises. The following are pertinent data based on the Chinese experience, and can be considered representative of the system used at this mill:

- Capacity of generator was 160 to 200 KW
- Ash from the digester was sold as poultry litter
- Approximately 33 to 55% of rice hulls were unused
- Electric power consumed by mill and cogeneration about 50 KW/ton of paddy
- Cost of electricity generated at mill ranged from 33 to 60% of cost of grid power. This was specific to the Chinese mill based on cost of grid power and time of operation (price at night was cheaper than during the day)

While the above data are specific to the Chinese mills gathered in 1995, there are some useful inferences to be drawn for the Malian case. The mill saves on electric power costs, producing all the power needed for its operations; and makes additional income from the sale of the ash. The drawback, however is that some rice hulls are still left over at the mill premises and need to be disposed.

The second mill located at Segou and owned by Mr. Bakore Silla has utilized the low pressure steam system to generate power for running the mill. The data obtained at this mill, while incomplete, are as follows:

Boiler output:	400 Kg/h
Husk Consumption:	400 – 500 Kg/h
Turbine/generator set rated at:	400 KVA

One important inference to be drawn the above two cases is that apparently the cogeneration systems did not fail, rather the mills ceased to operate due to a variety if reasons including the lack of paddy for milling.

c. Technology Choices and Opportunities

To identify opportunities for cogeneration systems, several factors need to be considered, foremost amongst which is the availability of husk, as discussed in the previous sub sections. Capital costs of systems capable of generating electric power from rice hulls, and even the importance of avoiding the use of diesel fuel need to be considered. This latter reason may be an important consideration for Mali that currently imports diesel fuel. To enable the formulation of appropriate strategies in this regard, data and a discussion of previous research are provided below.

In a study by Twente University in the Netherlands (3), the capital costs of three types of systems capable of producing electric power from rice husk, at three sizes of mills was compared as shown in Table 9 below:

Table 9. Capital Costs of Three Types of Systems Producing Electric Power from Rice Husk

Mill size	Power	Diesel Plant	Gasifier System	Steam Engine System
1 t/h	30 kW	$ 10,500	$ 24,000	$ 42,000
2 ½ t/h	70 kW	$ 21,000	$ 42,000	$ 70,000
6 t/h	160 kW	$ 40,000	$ 72,000	$ 104,000

Source: Velupillai, et al,

Among other factors, the weight of conventional steam engines contributes to the higher capital cost of such systems. The use of more modern light weight alloys and standard parts designed for internal combustion engines can help reduce the capital costs for the steam engines. In comparing the costs as shown above, the cost of diesel fuel, the cost of rice hulls at the cogeneration site and other factors need to be considered. In the above table the cost of diesel used was $ 0.25/liter (the current cost of diesel at the rural setting in Mali is about 410 CFA/liter or at an exchange rate of 500CFA to the dollar, about $ 0.82). Another consideration in this regard is the extremely durable nature of steam engines that can normally operate for 30 to 40 years with minimal maintenance.

Despite high capital costs and low efficiency of steam engines they may still be a viable choice when the price and availability of diesel and rice hulls are taken into consideration. In like fashion, the cost of electric power produced at an off grid site needs to be examined. To enable a discussion, the following Table 10 illustrates a study conducted by Twente University in 1992:

Table 10. Comparative power costs (US cents per kWh)

Mill size	Power	Diesel Plant	Gasifier System	Steam Engine System
1 t/h	30 kW	18.4	21.9	29.9
2 ½ t/h	70 kW	13.6	11.9	19.3
6 t/h	160 kW	11.1	7.9	14.0

Source: Velupillai, et al,

The above study assumed that the mills were at off-grid locations, the cost of diesel was $ 0.25/liter. The above data illustrates that there is a considerable economy of scale for both the gasifier and steam engine systems as the size of the mill increases (or the available rice hulls increases).

It is also worth noting that in another study conducted by the International Development and Energy Associates Inc. (IDEA) in Washington, DC in 1989 to look at the commercialization of rice hull powered gasifier systems of 20 kW capacity in India. This study concluded that the capital cost of the system was less important in determining the economic viability of the system than the percentage of diesel fuel displacement, the annual number of operating hours, and the price of diesel fuel in comparison to the price of rice husk.

In summary, the above analyses are provided to support any analyses for economic viability of cogeneration systems in Mali. The status at the time of this assessment includes key issues that need to be taken into consideration:

12. There is an urgent need for off-grid power generation
13. Diesel fuel is imported at considerable cost
14. Rice production is poised to increase to take advantage of capturing an export niche
15. A focus on increased production and rice quality enhancement will mean that an appropriate quality and quantity of rice husk will become available

Part IV Conclusions

Based upon the pre-assessment research, the assessment conducted in Mali in November 2004, and post assessment discussions, the following general conclusions are presented.

1. Rice Production

- Maintain and improve controlled irrigation in the Markala dam areas of rice production.
- Seek advanced technology for rice production from the Institut D=Economie Rurale, including high yielding varieties, cultural practices and plant protection.
- Continue the development of farmer cooperatives/associations to promote better production and milling.
- Make an effort to stress higher quality in both paddy and milled rice.
- Search for means to increase production on existing land used for paddy production by the proper use of applied chemical fertilizers, and perhaps the growing of a second crop during the dry season if water is present for controlled irrigation.

2. Rice Milling/Rice Hulls Utilization for Energy

a. The Rice Post harvest System

The rice post harvest system is currently handled by a combination of manual means with very little energy use, and small scale threshers and rice mills run by diesel power. The timing of harvesting and threshing practices could be modified to reduce internal breakage of the rice kernels, and subsequent low mill yields and food losses. An awareness program mainly through training of trainers, and low cost rice quality assessment laboratories can be one solution to address past harvest losses, currently estimated to be about 38,000 tons of milled rice equivalent valued at 16 million U.S. Dollars per annum.

b. The Rice Milling Industry

Since the privatization of the processing and trade in rice in the early 1990s, most of the larger mills with an estimated total annual milling capacity of 115,000 tons have been closed for operations. This situation has been caused by a variety of factors including lack of finance for paddy purchases, competition from the smaller mills for paddy purchases, and possibly lack of management efficiency. Despite this one miller plans on continuing operations, and has even purchased another government mill, while another company is planning to establish a new large rice mill. Further, groups of villages have invested in improved rice milling systems that are capable of producing quality rice for the local markets.

As far as milled rice quality is concerned, by far the most striking observation was the amount of broken rice, overall about 50%, and in some cases even 100% brokens. Due to the low purchasing [power of the rural populations, there is no present recognition for higher quality, and hence a higher price for milled rice. However, there appears to be a growing market for quality milled rice in the major cities, and discussions have revealed that those who can afford it will purchase the higher quality rice at a higher price. Mali currently imports a small quantity of rice from Asia, and this rice is sold at a price that is slightly lower than the locally produced rice. However, it is believed that the local population prefers the Malian rice.

Through an awareness and education effort referenced in subsection (a) above, a focus on rice quality improvement will result in reduction of food loss, which in turn will reduce imports. Concurrently, the focus on improved rice quality will encourage a move away from the current milling systems that are largely the cause for the broken rice component. This move will also result in a purer bran component, and rice hulls, more suited for cogeneration systems.

c. Rice Husk Availability

Given the current status of milling systems in the country, the availability of rice hulls for cogeneration systems is limited. The only operating large mill at Segou city currently produces approximately 2000 tons of rice hulls per annum, while in a group of villages in the Niono area are currently operating ten 2 t/h mills currently producing 15,000 tons rice husk per annum. This latter group of mills is within a ten to fifteen kilometer radius making husk collection for a cogeneration unit feasible. Further, discussions with this village association revealed that they are planning to add another ten mills of similar capacity, thereby enabling a total husk availability of 30,000 tons per annum. Assuming a 1.2 MW cogeneration unit (consuming 45 tons husk per day) is viable, the present amount of rice husk of 15,000 tons per year will be sufficient to run the power plant for approximately 330 days/year. Other systems of lower capacity, particularly steam engine based systems need to be explored.

d. Potential for Cogeneration from Rice Hulls

As a backdrop to this assessment, there is considerable agreement that electrical energy availability is a serious constraint to economic development in Mali. Due to funding and maintenance issues, and the delay in the Manatali Power Unit coming on stream, grid power is limited and transmission losses are high, estimated at 25% for a country that can ill afford this loss. Thus off-grid, independent sources of electrical power are encouraged by the authorities. Secondly the country with no known fossil fuel resources is currently importing 200 million liters of refined petroleum products for power generation, transportation and domestic use. Thus not only capital costs for cogeneration systems but also the corresponding reduction of diesel fuel for power generation needs to be considered. While high pressure steam turbine systems are more efficient, smaller capacity cogeneration systems driven by steam engines should not be ruled out.

For the near -term prospects for cogeneration, there are three areas that need to be investigated, particularly for financial viability. These possibilities are based on the present availability of rice hulls and the potential interest of investors in the milling sector. The areas that need to be looked at are:

(i) The possibility for organizing husk collection and cogeneration in the group of villages in the Niono area (KM 30). This group of villages currently produce approximately 15,000 tons of husk per annum. The village association has indicated that they will invest in an additional 10 mills with the potential to double the quantity of rice hulls.

(ii) Mr. Modibo Keita who currently owns two mills in the Segou area and has recently purchased another in the Seuare/Mopti area has indicated interest in a cogeneration system. This needs to be explored.

(iii) The Aiglon Group in Bamako that is currently in the cotton business is planning to build a large rice mill in the Niono area. Discussions with this group to incorporate a cogeneration system may prove useful.

Part V References

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