July 2004 • NREL/SR-510-36403

Subcontractor Report

Gridley Ethanol Demonstration Project Utilizing Gasification Technology: Feedstock Supply Plan

March 15, 2004

TSS Consultants
Rancho Cordova, California

National Renewable Energy Laboratory
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Operated for the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
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NREL Technical Monitor: M. Ruth

Prepared under Subcontract No. ZCO-2-32065-01

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1. EXECUTIVE SUMMARY

- **Purpose of this Report**
  This Report is in response to Task 1 of the National Renewable Energy Laboratory (NREL) Subcontract **No. ZCO-2-32065-01,** requiring an updated assessment of the rice straw available for the proposed Gridley Project. The report describes a Feedstock Supply Plan for the proposed Gridley Ethanol Demonstration Project to be located in the City of Gridley Industrial Park in Gridley, California. This report also includes information on the establishment of the required infrastructure required for collecting approximately 113,000 Bone Dry Tons (BDT) annually for the proposed facility.

- **Description of the Gridley Ethanol Project Feedstock Requirement**
  Using the Pearson Technology from Aberdeen, Mississippi, and the related engineering assumptions for required feedstock, it is estimated that the proposed Gridley Ethanol Project will use approximately 113,000 BDT of rice straw to produce approximately up to 20 million gallons of ethanol annually, and/or process steam and or electricity.

- **Rice Straw Burning Reduction Act**
  Approximately 500,000 acres of rice are harvested annually in California, resulting in approximately 1 million dry tons of rice straw that is available to be collected each year. Beginning in 2001, the phase-down of rice straw burning limits acreage burned to 25 percent of the total acres planted or 125,000 acres, whichever is less. However, this burning can occur only for disease control purposes. Growers unable to use this disposal method must either incorporate the remaining rice straw back into the field or remove it completely. Last year, because of other regulations limiting agriculture residue burning, rice growers burned approximately 15% of the planted acreages.

- **Report Findings**

  1. **Feedstock Availability**

     Based on TSS's survey of planted rice acreage in the Sacramento Valley, a total of 379,765 acres of rice are grown within a 30-mile radius of the Gridley site and that 759,530 BDT of recoverable rice straw are generated annually. This volume of rice straw is 6.7 times the 113,000 BDT of total feedstock needed by the proposed Gridley facility.

2. Collection Infrastructure

Sufficient infrastructure exists with additional market potential for further private market infrastructure expansion in California and the Northwest (Oregon, Washington and Idaho) to collect the annual feedstock requirement of 113,000 BDT for the proposed Gridley Ethanol Demonstration Project.

3. Projected Feedstock Costs

The projected feedstock cost for 113,000 BDT of rice straw delivered annually to the Gridley facility is approximately $35.00/BDT.

FEEDSTOCK SUPPLY PLAN

2. FEEDSTOCK SUPPLY PLAN PURPOSE & APPROACH

The purpose of this Feedstock Supply Plan Report is to:

1. Assess the availability of rice straw.
2. Determine a Feedstock Supply Plan to meet the proposed Gridley Ethanol Demonstration Project annual raw material needs.
3. Assess the required infrastructure for rice straw collection, storage and transportation to the proposed Gridley facility site.
4. Estimate the feedstock cost for delivery of the projected 113,000 BDT needed annually for the proposed Gridley facility.

The geographic area covered in this Feedstock Supply assessment includes part or all of the Counties of Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Tehama, Yolo, and Yuba. Because there are large quantities of rice straw near the proposed Gridley facility site, TSS gathered data on the availability of rice straw feedstocks within a 30 - mile radius of the project, including all or part of the Counties of Butte, Colusa, Glenn, Sutter and Yuba.

TSS used its database of planted agriculture crops, updated annually from the respective County Agriculture Commissioners. The California County Agriculture Commissioners annually report acreages of crops planted by County to the State Food and Agriculture Agency. TSS uses the County and State sources to determine planted acreages. Then using TSS data on biomass yields from various crops, TSS calculates the projected agriculture residues available from specific crops in specific geographical areas. TSS also conducts and monitors field trials for collecting or actual vendor operations gathering the residues to evolve the actual yields from different crops.

Working with rice farmers, TSS has also done extensive field rice straw collection trials and evaluations to determine available rice straw yields by soil type, variety of rice planted, harvesting equipment, timing of harvesting and height of rice straw harvested above the waterline. TSS has assisted rice growers in the Butte County area in harvesting extensive volumes of rice straw, covering and storing the rice straw, and obtaining laboratory samples to evaluate the chemical analyses related to organic and inorganic composition, moisture content, Btu energy value and deterioration from long term storage. TSS also reviewed numerous studies in rice straw production, uses and harvesting techniques to identify the alternatives for harvesting, collection, storing, processing and transporting the rice straw to satellite storage, grower site storage and the proposed Gridley facility site.

3. BACKGROUND

3.1 Rice Straw Burning Reduction Act of 1991

Approximately 500,000 acres of rice are harvested annually in California, resulting in approximately 1 million BDT of rice straw available annually. The Rice Straw Burning Reduction Act of 1991 (AB-1378) mandated a reduction in rice straw burning by the year 2000 to no more than 25% of the planted acreage. The rice straw burning phase-down has proceeded as required in the statutes, with growers burning less than the statute limitations. Other open field burning laws and regulations further limit the actual rice straw acreage burned annually. The total rice acreage burned annually has declined from 303,000 acres in 1992, the first year of the phase-down, to slightly less than 72,000 acres in 2002.

In 1997 the State of California enacted legislation (SB 318) Rice Straw Demonstration Project, to modify existing law to provide a pause in the phase down of rice straw burning. This legislation was necessary because anticipated commercial technologies that could utilize significant amounts of rice straw had not developed. This legislation established a fund to provide cost-sharing grants for the development by demonstration projects for new rice straw technologies. Since its establishment in 1997, the ARB has awarded $5 million in funds to 10 recipients for demonstration and commercialization projects through the Rice Straw Demonstration Project Grant Fund.

The Gridley Ethanol Project through the efforts of the Rice Straw Cooperative was able to take advantage of the program and received $380,000 as a 50% cost sharing grant to collect, transport and store 18,000 BDT of rice straw for this project during 2000 and 2001. This grant allowed the Rice Straw Cooperative the opportunity to gain valuable experience in developing and operating a rice straw collection infrastructure.

These grants were intended to support diversion of 50 % or more of rice straw produced toward off-field uses by 2000, the legislative goal. Off-field uses could include, but were not limited to, the production of energy and fuels, construction materials, pulp and paper, and livestock feed. New technologies have not yet sufficiently developed to achieve this goal. The California Air Resources Board reports that only 3 – 5 % (approximately 18,000 tons) of the rice straw grown in California is currently used off-field. The primary uses to date have been for cattle feed and for erosion control.

3.2 The Proposed Gridley Ethanol Project

The City of Gridley is located in the heart of California's rice growing area and its economy is uniquely dependent on rice production and markets. In addition, Gridley operates a municipal utility, with responsibility for delivering electrical power to the

community. The Gridley community, including local rice growers, initiated the Gridley Ethanol Project to solve a major rice straw disposal problem and help maintain the economic viability in Butte County and the greater Sacramento Valley. The proposed Gridley Ethanol Project will utilize rice straw to produce ethanol for the transportation fuel markets.

A viable market alternative to dispose of rice straw will reduce the alternative disposal costs of the phase-down of rice straw burning for rice growers. One of the more promising technologies for producing a high value product is to convert rice straw into ethanol. The current technology utilized by Pearson Technologies, Inc. (Pearson) has the potential to annually produce 20 million gallons of ethanol from 113,000 BDT of rice straw, co-host process heat and/or electricity.

In the fall of 1997, a group of Butte County rice growers, the City of Gridley Mayor Pro Tem Tom Sanford and TSS Consultants began to evaluate the feasibility of a rice straw-to-ethanol facility. During March 1998, the Butte County rice growers formed the Rice Straw Cooperative to provide supplies of rice straw to potential commercial users. The goal of this Cooperative was to find a reliable market for the rice straw in Butte County and to develop the infrastructure and methods to collect and transport the rice straw to an end use. To date, members of the Rice Straw Cooperative have baled over 45,000 tons of rice straw over a six-year period to gain knowledge and evolve the infrastructure and techniques needed to collect rice straw.

The site for the proposed Gridley Ethanol Project is within the City of Gridley's newly established Gridley Industrial Park. A parcel located in the northeastern portion of the industrial park totaling 14.74 acres has been selected for siting this facility. Given the anticipated footprint of the ethanol production facility and associated infrastructure, it is estimated that approximately one month's rice straw feedstock will be stored on this site. The supply plan envisions rice grower site storage at a few locations within the Butte County area.

3.2.1. Gridley Ethanol Project Objectives:

(a) Help preserve the Community's agriculture economy in Butte County and adjacent areas.
(b) Comply with the environmental legislative mandates to phase out most of the open field rice straw burning.
(c) Annually produce 20 million gallons of ethanol, a clean transportation fuel to reduce air emissions from California's vehicles.

3.2.2. Project Benefits

a) Supports continued rice farming in the Sacramento Valley by providing a practical straw disposal alternative to burning.
b) Creates jobs, new tax base and economic development in the Sacramento Valley.

4. RICE STRAW FEEDSTOCK AVAILABILITY

TSS assessed the availability of rice straw feedstock within the Sacramento Valley. The following section identifies and discusses the availability of rice straw as a feedstock for the proposed Gridley Ethanol Project.

4.1. Current Supply

TSS gathered and analyzed the rice harvest data by county throughout the Sacramento Valley. Table 4-1 shows the acreage by county and total rice straw estimated available annually.

A review of the crop data from County Agricultural Commissioners' Crop Reports indicates, approximately 511,300 acres of rice is currently grown annually in the Sacramento Valley. This is 96% of the total rice grown in California.

TSS estimates that approximately 3 bone dry tons (BDT) of rice straw are generated per acre, totaling over 1.5 million BDT of rice straw on an annual basis. Based upon the assessments accomplished during the rice straw baling by the Rice Straw Cooperative from 1998 – 2003, TSS estimates that the average volume of rice straw that was economically removed was found to be 2.0 BDT/acre. The Table below summarizes the resultant rice straw availability.

Table 4-1. Rice Acreage and Rice Straw Supply in the Sacramento Valley

County	Rice Acreage*	Rice Straw (BDT)
Butte	99,000	198,000
Colusa	137,000	274,000
Glenn	86,500	173,000
Placer	12,000	24,000
Sacramento	8,200	16,400
Sutter	100,700	201,400
Tehama	900	1,800
Yolo	31,200	62,400
Yuba	35,800	71,600
Total	**511,300**	**1,022,600**

* Rice acreage based on County Agricultural Commissioner Crop Reports for 2002.

The Gridley area is located within heart of the rice-growing region of California. Approximately 74% of the rice grown in the Sacramento Valley is within a 30-mile radius of the project site located in Gridley.

Table 4-2 shows that 379,765 acres of rice are grown within a 30-mile radius of the proposed Gridley site and that 759,530 BDT of recoverable rice straw are generated annually.

Table 4-2. Rice Acreage and Straw Availability Within a 30-Mile Radius of Gridley

County	Rice Acreage*	Rice Straw (BDT)
Butte	99,000	198,000
Colusa	109,600	219,200
Glenn	64,875	129,750
Sutter	70,490	140,980
Yuba	35,800	71,600
Total	**379,765**	**759,530**

* Rice acreage based on County Agricultural Commissioner Crop Reports for 2002, adjusted for the portion of the county falling within the 30- mile radius.

This volume of rice straw is 6.7 times the 113,000 BDT of total feedstock needed by the proposed Gridley facility.

Figure 4-1 on the next page illustrates that the location of the proposed Gridley is within the concentration of rice straw acreage in the Northern Sacramento Valley.

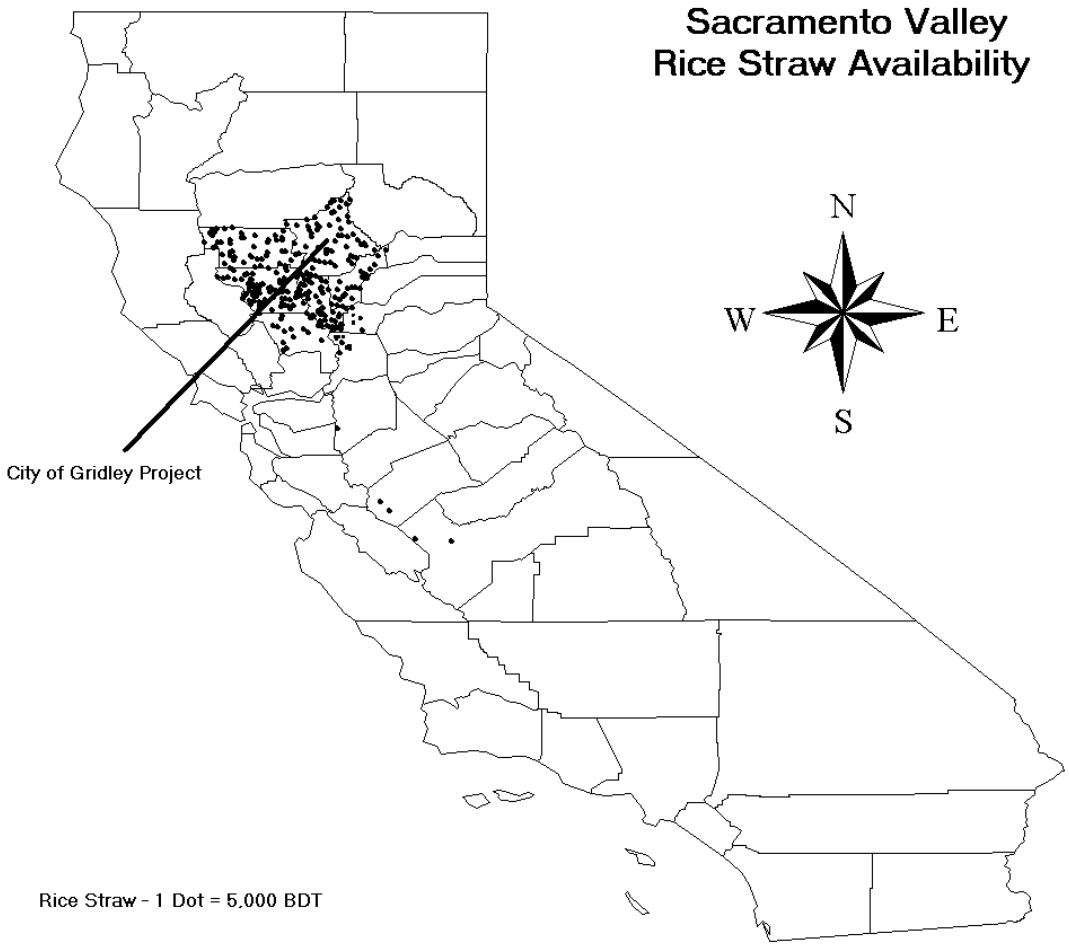

Figure 4-1. Map depicting concentration of rice straw in the Northern Sacramento Valley.

PROPOSED GRIDLEY GASIFICATION TO ETHANOL DEMONSTRATION PROGRAM

FEEDSTOCK SUPPLY AREA

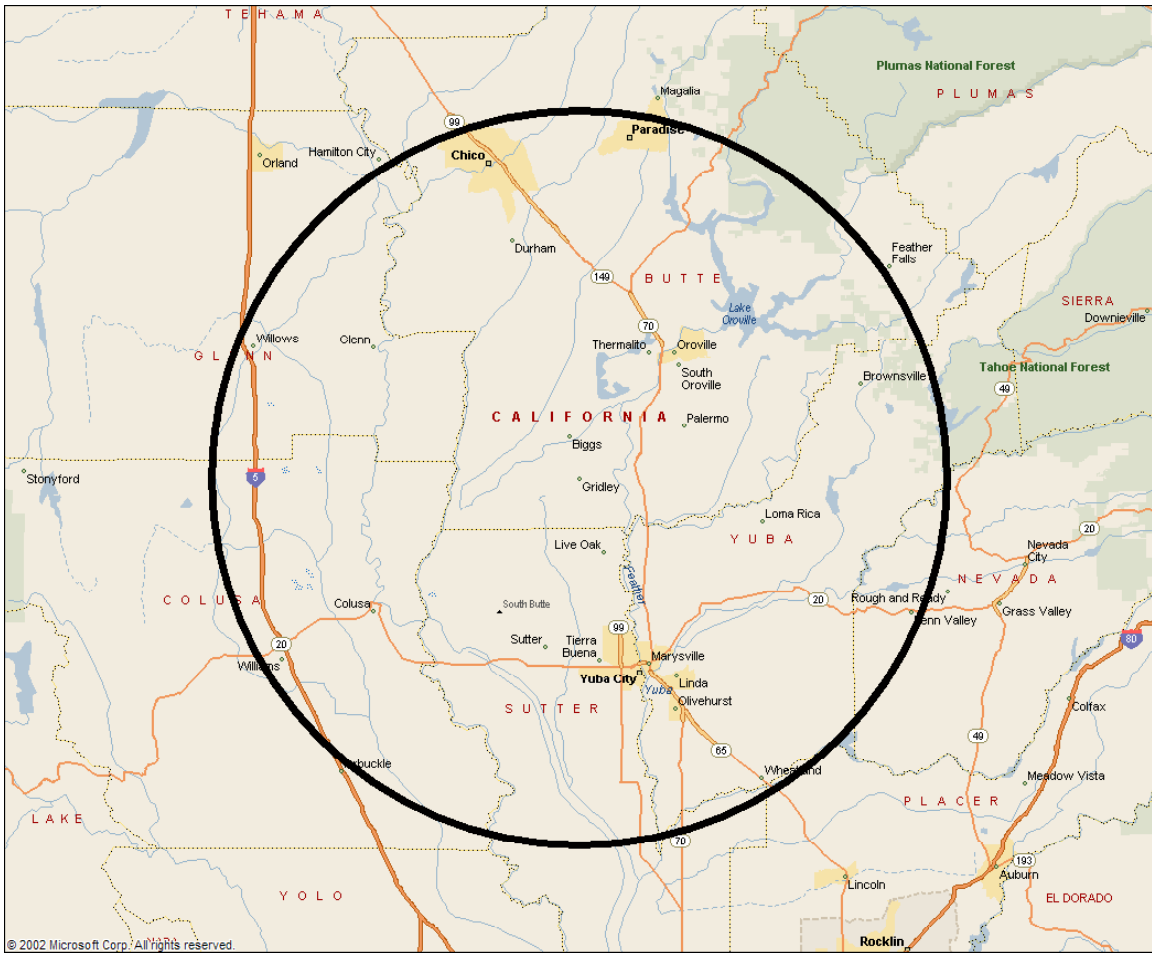

Figure 4-2. Map depicting a 30-mile radius feedstock supply area surrounding Gridley.

4.2. Trends and Projections

Much of the Sacramento Valley rice growing soils are heavy clay with high water tables that cannot economically grow other crops except rice. Of the approximately 500,000 acres of rice growing lands in the Sacramento Valley, it is estimated that 300,000 acres are the heavier clay soils that have not been successful growing alternative crops. The remaining lands are silty clay and silty clay loams that, depending on the other crop markets, can grow other crops such as alfalfa, oats and barley.

Unlike most of California, water is readily available in the Gridley area, from the high water table and farmer access to extensive surface water supplies. Water availability, along with rice commodity prices, has resulted in historical rice planted acreage of 360,000 to 548,000 acres annually as shown in Table 4-3.

Table 4-3. California Rice Acreage Harvested, 1986 – 2002

Year	Acres
1986	360,000
1987	370,000
1988	425,000
1989	410,000
1990	395,000
1991	350,000
1992	394,000
1993	437,000
1994	485,000
1995	465,000
1996	500,000
1997	516,000
1998	458,000
1999	505,000
2000	548,000
2001	471,000
2002	528,000

The California Agricultural Statistics Service reports that 2003 plantings were down approximately 12% to 470,000 acres due to a wet spring causing delayed plantings as well as decisions of some growers to sell water and fallow land.

4.3. Collection, Processing and Transportation of Rice Straw

Equipment to collect rice straw includes rakes, swathers, balers, stackwagons and loaders. Equipment is available from a variety of manufacturers and each type comes in various configurations, with varying capacities, speeds and range of costs. Based on TSS's experience in managing and monitoring rice straw collection efforts in California from 1991 – 2003, TSS recommends the following mix of equipment to efficiently collect and deliver the required rice straw to the proposed Gridley facility.

Swather

The following Figure 4-3 shows a self-propelled rotary swather cutting stripper header harvested rice straw. After rice harvest, the swather can also cut the remaining stubble by a conventional header harvester to maximize the volume of straw per acre collected. Swathing rice straw is expensive, approximately $10 per acre or $5/BDT for stripper header straw.

Figure 4-3. Rotary swather cutting stripper header rice straw.

Figure 4-4. Raking rice straw in preparation for baling.

Rakes

Rakes are used for windrowing rice straw prior to baling. This is done when the rice harvester has spread the straw for drying, or when the windrow left by the harvester does not dry in sufficient time for baling without turning. Raking is also used to combine multiple windrows after swathing to increase baler throughput.

Balers

The most cost effective bales in current commercial use are:

1) Small rectangular bales of conventional type made by a variety of machines and having dimensions of 16”x24”x48”;
2) Large rectangular bales (Hesston balers) with nominal dimensions of 36”x48”x96”; and
3) Large rectangular bales (Freeman balers) with nominal dimensions of 48”x48”x96”.

Based on numerous field trials and TSS’s experience, using the nominal 36” x 48” x 96” foot bales or the 48” x 48” x 96” bales are the most cost effective in terms of delivered cost/BDT. Baling capacities are consistently higher for the large rectangular balers compared with the small rectangular balers, with the large balers averaging about twice the material production capacity.

Figure 4-5 shows a Hesston large bale baler making 36”x48”x96” bales weighing from 975 to 1025 pounds, with 11 – 15% moisture contents.

Figure 4-5. Baling rice straw utilizing a large bale baler.

Roadsiding

Roadsiding consists of moving bales from the interior of a rice field to the edge of the field where the bales are accessible for loading onto trucks. In some cases, the roadsiding operation may include transport of up to a mile or more to a local storage area, with no additional interim stacking and loading operations. Typically, roadsiding operations involve either stacking bales at the edge of the field for later retrieval and loading on trucks, or directly loading bales on trucks during the roadsiding operation.

The following Figure 4-6 shows one method of retrieving large bales from the field. This machine has the capability to pick up 8 bales per load.

Figure 4-6. Freeman Stackwagon retrieving bales from field.

The following Figure 4-7 shows another piece of equipment for picking up large rice straw bales from the field. This machine can pick up 12 bales per load for stacking roadside.

Figure 4.7. Retrieving 12 large bales per load from the rice field.

The following Figure 4-8. shows rice straw bales stored at a roadside location, awaiting transport to a user.

Figure 4-8. Stacking large bales at a grower's roadside site.

The following Figure 4-9 shows the loading of a truck for transportation to the facility. This equipment, commonly know as a squeeze, can efficiently load and unload rice straw and stack bales for storage.

Figure 4-9. A squeeze loading rice straw for transportation to a user.

Transportation

Transportation of rice straw is usually done using either semi-trucks with double flat bed combinations, or semi-trucks with double drop-bed trailer combinations. Drop-bed trailers can haul larger volumes by adding bales between the wheel axles. The drop-bed trailers are used only with the larger 48" x 48" x 96" foot Hesston bales. Flat-bed trailer combinations typically carry 460 – 512 small bales, 42 – 48 Freeman-type large rectangular bales, or 28 – 30 Hesston-type large rectangular bales. Payloads on flat-bed trailers with Freeman bales are about 10% higher than with Hesston bales due to utilization of an additional 9 foot load height in stacking 3 bales high without exceeding maximum legal height. On flat-bed trailers, the Hesston bales can only be transported in stacks 2 bales high. Highest payloads are obtained using the drop-bed trailers with 36 – 38 Hesston bales.

The following Figure 4-10 shows a truckload of 36" x 48" x 96" foot bales of rice straw on its way to the storage area. Note that the bales can be stacked three high.

Figure 4-10. A truck loaded with rice straw arriving at a satellite storage area.

The following Figure 4-11 shows rice straw in storage on prepared pads. These stacks were constructed 32 feet wide and 30 feet high at the peak. Each stack contains approximately 1,000 BDT.

Figure 4-11. Uncovered rice straw in storage.

The following Figure 4-12 shows tarped rice straw stored on a rice grower's property. Tarping is effective for short-term storage. Tarping costs range between $5 - $8/BDT depending upon how extensively the stacks are covered.

Figure 4-12. Tarped rice straw in storage on growers site.

The following Figure 4-13 shows rice straw stored in a barn. This type of storage is recommended for longer-term storage (more than one year). The initial cost of a barn is approximately $50/BDT for a barn that will store approximately 2,000 BDT. In this case, the cost is approximately $7/BDT on an annual basis. Barn storage provides the best protection for rice straw, eliminating losses due to water entering the stack either when tarps become separated during bad weather or when water seeps up from the bottom of a stack.

Figure 4-13. Rice straw stored in a barn on grower's property.

4.4. Economics of rice straw collection and transportation

Based on TSS cost studies and actual rice straw contract negotiations conducted during the past few years, TSS projected the costs of rice straw collection and transportation to the proposed Gridley Ethanol Facility site.. For the proposed Gridley facility, TSS estimates costs of $26.74/BDT to bale and roadside rice straw (as shown in Table 4-4). This assumes that up to 20% of the total rice straw annual supply is harvested by a

stripper header harvester, requiring the straw to be swathed. The remaining 80% would be harvested by traditional harvesters that cut the rice stalk above the water line, separate the rice from the straw and disperse the rice straw on the ground. The following Table shows the TSS estimated costs to collect and deliver large quantities of rice straw to the proposed Gridley facility.

Table 4-4. Estimated Rice Straw Feedstock Costs

Cost Item	Cost/ton	Cost/BDT
Bale and Roadside	$23.00	$26.74
Load & Transport to Facility	$7.00	$8.14
Total	$30.00	$34.88

Transportation is a significant cost of rice straw, second only to baling and roadsiding costs. Transportation costs can be significantly increased in part or all of the rice straw have to be loaded, unloaded and transported twice: first to a satellite storage site and then from the satellite storage site to the user facility. Thus, the alternatives for rice storage are a key economic part of the transportation planning and resulting costs.

There are three alternatives for storing rice straw:

1. *Storage at the proposed Gridley facility site*. This is limited to approximately 30 days supply.
2. *Satellite rice straw storage sites* that are really transfer stations. These require loading rice straw onto trucks and unloading at the satellite storage sites. Then reloading and transporting the rice straw to the eventual user facility, which increases the total delivered costs of the raw material.
3. *Rice grower site storage*. These are sites close to the rice field where the rice straw is collected. The rice straw can be delivered from the rice fields for temporary storage without loading on to a truck.

The plan for the Gridley facility is to use rice grower storage sites to avoid double handling and trucking. This will result in eventual transportation from the growers' sites to the facility with only one trucking cost.

Use of rice grower storage sites, will allow up to a years supply of rice straw to be stored during the short window of harvesting the rice straw; usually late August through October. Thus the significant benefit to grower-sited storage near the harvested field, is that it eliminates the double handling that would be required if the rice straw had to be moved to satellite storage areas. In addition to maximizing the weight of straw on each load – the cost is a function of the amount of time required to load a truck in the field, travel to the facility, unload and return to pick up another load.

The following Table 4-5 shows TSS's estimated transportation costs based on the distance the rice straw must be transported. It is important that this project is located in the heart of the rice growing region and that most of the rice straw will be from growers lands that are relatively close to the proposed Gridley facility.

The data in Table 4-5 reflects the costs per load for the various distances as well as the costs per ton based on the most recent data where loads averaged 20.8 tons, or 17.9 BDT at an average of 14% moisture content.

Table 4-5. Estimated Rice Straw Transportation Costs

Mileage	Cost/Load	Cost/ton	Cost/BDT
0-10	$83	$3.99	$4.64
11-25	$129	$6.20	$7.21
26-40	$156	$7.50	$8.72

Transportation costs have the potential to be reduced by increasing load size by increasing the allowable truck length and increasing bale density to increase load weights. Improvements have been made in bale density as the baling equipment has been improved. Average weights for a 36" x 48" x 96" bales ranged from 975 to 1,025 pounds/bale during the 2001 season. This is an increase of 5% from the 900 to 975 pounds/bale of rice straw collected during the 2000 season.

There has been new legislation passed to increase the allowable truck length within the primary rice growing area of California. In 1999, Assembly Bill (AB) 1489 amended the California Vehicle Code to allow a front extension on the first trailer and a back extension on the last trailer in a combination of trailers used for hauling straw. The front extension, however is not allowed on national or federal highways. If only state or local highways are used for transporting rice straw, this law allows larger loads of rice straw to be transported to a user facility.

In 2002, AB-2051 amended the California Vehicle Code to provide that a combination of vehicles designed and used to transport agricultural biomass, (such as a truck tractor, a semitrailer, and a semitrailer or trailer), may extend to a total combined length of 75 feet, if the length of the front trailer does not exceed 32 feet, and the length of the rear trailer does not exceed 28 feet 6 inches. The bill authorizes operation of these vehicles within the Counties of Butte, Colusa, Glenn, Placer, Sutter, Tehama, Yolo, and Yuba, but would not apply to highways designed as national network routes, as specified. Again, the impact of this legislation was to reduce the hauling costs by authorizing larger rice straw loads.

This statute makes it possible to transport up to 48 – 36" x 48" x 96" rice straw bales, compared with 42 large bales under previous state statute. This could effectively increase the truckload averages of rice straw from the 17.9 BDT/truckload to 20.5 BDT/truckload. This could further reduce the rice straw transportation costs to the proposed Gridley facility.

AB-2051 also requires the California Highway Patrol, in consultation with the California Department of Transportation, to conduct a study on the effect of this act on public safety, and to report the findings to the Legislature on or before July 1, 2005. This bill also provides that provisions of this act will sunset on July 1, 2006, and must be extended to allow the variation in the allowable truckloads of rice straw.

4.5. Technical Barriers to Rice Straw Collection

The primary technical barriers to collection of rice straw in the Sacramento Valley are (1) the limited weather period for rice straw collections and (2) scaling up of rice straw collection to an industrial level for the proposed Gridley Ethanol Project.

TSS Consultants conducted an analysis of the weather limitation and the infrastructure needs for scaling up to produce large volumes of rice straw annually. Under worse case analysis, there is a 45-day calendar period during the fall when the entire annual rice straw needs must be collected. TSS determined the infrastructure needed for that worst case weather-limited window.

Rice straw collection cannot be done until the rice is harvested and the rice straw dried. As noted earlier, rice harvesting in the Sacramento Valley usually starts during late August and continues until the first heavy rains, usually by the end of October. The weather factors limiting rice straw collection during this approximately 75-day period are occurrence, frequency and volume of rainfall during the rice straw collection period. An occasional rain of ¼ to ½ inch causes some delays, but when a rainfall totals 1 inch or more the ground becomes too wet to operate equipment.

Rice straw dries best when spread behind the rice harvester and was the slowest to dry when cut with a swather because the straw is placed in a wide windrow closer to the ground. High moisture in the straw can limit the number of operating hours available each day. For example, higher value rice straw export markets require that the rice straw be baled at 14% or less.

During the past years, to gain experience with baling that will meet some market moisture content specifications, the upper moisture content limit on the balers was initially set at 12%, but this proved to be too restrictive. This upper moisture content limit was moved up to 14%. Normally, baling can begin after the night time dew dissipates, around 10-11 am and continue until about 10-11 pm. However, during some years the moisture levels will stay high due to the weather, limiting the baling hours to an average as low as 7 hours per day.

Further experimenting was done to increase the number of baling hours by increasing the upper moisture limit to 18%. During the same weather patterns, the average baling time was increased to 9 hours per day. However, this moisture level proved to be high for optimum rice straw storage. So for baling purposes, the upper moisture limit was set to 16% to be more appropriate for baling rice straw for conversion to ethanol.

The following Table 4-6 reflects the rice straw collection equipment required during the limited 45-day collection period. This projection is based on what was learned from several years of rice straw collection.

Table 4-6. Estimated Collection Infrastructure Requirement

Equipment	Number
Tractor rake unit	18
Tractor baler unit (big bale)	36
Stack wagon	18

In TSS's opinion, there is adequate rice straw infrastructure equipment to support the short window of rice straw collection under the 45-day worst-case weather limited season. This is based on TSS's previous experience and work with vendors harvesting hay, fescue, rye grass and rice straw that could be used for collecting rice straw for the proposed Gridley facility. Sufficient infrastructure is available and can be expanded in California and in the Northwest (Oregon, Washington and Idaho) to collect the annual feedstock requirement of 113,000 BDT for the proposed Gridley facility.

Although rice straw collection has a limited weather season, that season immediately follows rice harvest, so that the rice grower, the rice transportation equipment and personnel are available for the rice straw collection. Second, the rice straw collection season also follows the summer harvests and collection of hay, grass straws and other grain straws in California and the Northwest. This allows that existing equipment, personnel and infrastructure to be shifted to the Sacramento Valley for the rice straw collection season.

4.6. Incentives for Increased Utilization of Rice Straw

In an effort to promote alternatives to rice straw burning, the Legislature funded several programs. These programs are:

- California Air Resources Board's (CARB) Rice Straw Demonstration Project Grant Fund
- California Department of Food & Agriculture's (CDFA) Rice Straw Utilization Tax Credit Program
- CDFA's Biomass Utilization Grant Fund

The only program still in place is the Rice Straw Utilization Tax Credit Program. The Rice Straw Utilization Tax Credit Program was established by Senate Bill (SB) 38 during 1996. This law provides that for each taxable year, between 1997 and 2008, the end

users of rice straw can qualify for a $15 per ton state tax credit up to a $400,000 program cap. The CDFA has administered the program since 1997 and issued tax credits for over 90,000 tons of rice straw. The program has been utilized primarily by small businesses utilizing rice straw for animal feeding and erosion control products. The tax credit program cap of $400,000 needs to be increased to effectively encourage large-scale uses of rice straw.

4.7. Competition for Rice Straw

Competition for rice straw is limited due to lack of progress in developing markets for off-field uses of rice straw. According to the September 2003 Progress Report on "The Phase-Down of Rice Straw Burning in the Sacramento Valley Air Basin", despite the State subsidized grant and tax credit programs, significant off-field uses of rice straw have not materialized. Soil incorporation is the alternative straw management practice for rice acreage not burned. Off-field uses of rice straw continue to be slow to develop; with an estimated 3 – 5% (18,000 tons) of the rice straw grown in California is used off-field. The primary uses have been cattle feed and erosion control.

CARB's Rice Straw Demonstration Project Grant Fund has funded two projects to investigate the potential to export rice straw. Should this market become viable, it could utilize significant quantities of high quality rice straw (TSS estimates up to 125,000 BDT annually), increasing demand on the infrastructure to collect and store the rice straw.

Anderson Hay & Grain Co., Inc. received a CARB grant for $500,000 to develop a disease treatment protocol acceptable to the Japanese government for exporting rice straw to Japan. Anderson is still pursuing the potential to export rice straw from California.

Kuhn Hay received a CARB grant for $402,311 for a rice straw export project. The purpose of the CARB grant was also to develop a disease treatment protocol to satisfy the Japanese government for exporting rice straw to Japan.

4.8. Avoided Grower Disposal Costs

A key factor in providing rice straw at an acceptable cost to the ethanol facility is the increasing straw disposal costs to rice growers, caused by the statutory phase down of open field burning on 75% of the planted acreage. Based on previous studies by the University of California Cooperative Extension Service and field studies by TSS and others, a derived average cost for incorporating rice straw into the soil versus burning, is $36/acre. This cost averages the use of various incorporation techniques for a range of soils and a variety of rice straw species. It also takes account of other factors such as weather and volumes of rice straw per acre, both of which vary annually.

Although there are approximately 3 BDT/acre of rice straw remaining after harvest to incorporate in to the soil, the net volume rice straw available for collection averages approximately 2 BDT/acre. Growers that have opted to utilize baling and removal as a means of disposing of their rice straw have experienced costs of $50 - $60/acre. In addition, they can have significant transportation and storage costs to deliver their rice straw to a market as referenced earlier in this report.

With the long-term trend of increasing statutory and regulatory limitations on disposal of agriculture residues, the alternative disposal costs continue to increase. This trend of increasing disposal costs makes the conversion of the agriculture residues to a raw material more economically inviting to farmers, such as the rice growers.

4.9. Feedstock Storage and Management

It is anticipated that the available space for rice straw storage at the facility will be limited to approximately 6,500 BDT, or about a 20-day supply. Rice straw collection will begin within a few days after rice harvesting begins, typically by late August. Rice harvesting historically continues through October, or until there is significant rain, making the fields inaccessible. Assuming that the facility will require 113,000 BDT of rice straw on an annual basis, the rice straw flow is projected to be as summarized in Table 4-8. The rice straw requirement is based upon operating the facility an estimated 330 days per year. For this inventory plan it is assumed that there will be a major outage for the month of August. TSS recommends that the project carry over approximately 10% of the annual rice straw requirement, or 11,300 BDT to protect against supply shortfalls caused by early rains during the fall harvesting season. This additional inventory carry over will need to be placed in inventory on grower's storage sites.

Rice straw permanent storage facilities are currently inadequate. Most rice straw storage has utilized tarps. The University of California at Davis conducted research into the various impacts of different storage alternatives. Their research indicates the cost to construct a barn is approximately $50 per ton of rice straw. Annual costs of storage range from $7 to $9.50 per ton.

Rice straw that can be scheduled for delivery during the harvest season and prior to the end of December can likely be left uncovered on grower's storage pads, then transported to the facility. This amounts to approximately 41,000 BDT. The remaining rice straw, approximately 72,000 BDT, should either be covered with tarps or stored in barns to protect the integrity of the bales for transportation. If this volume of rice straw were stored in barns the amount of capital required to construct these barns would be approximately $3,600,000. It is anticipated that this cost of some form of covering will be born by the grower in exchange for offsetting his current rice straw disposal costs. It is TSS's opinion that this approach is necessary, based upon the experience in collecting and storing rice straw by the Rice Straw Cooperative during the past few years.

Table 4-8. Rice Straw Delivery and Inventory Plan

Time Period	Baled (BDT)	Delivered to Facility (BDT)	Available at Facility (BDT)	Consumed at Facility (BDT)	Inventory at Facility (BDT)	Offsite Inventory (BDT)
Existing Inv.					6,500	4,500
9/1 - 30	37,500	10,250	16,750	10,250	6,500	31,750
10/1 - 31	75,500	10,250	16,750	10,250	6,500	97,000
11/1 - 30	0	10,250	16,750	10,250	6,500	86,750
12/1 - 31	0	10,250	16,750	10,250	6,500	76,500
1/1 – 31	0	10,250	16,750	10,250	6,500	66,250
2/1 – 28	0	10,250	16,750	10,250	6,500	56,000
3/1 – 31	0	10,250	16,750	10,250	6,500	45,750
4/1 – 30	0	10,250	16,750	10,250	6,500	35,500
5/1 – 31	0	10,250	16,750	10,250	6,500	25,250
6/1 – 30	0	10,250	16,750	10,250	6,500	15,000
7/1 – 31	0	10,250	16,750	10,500	6,500	4,750
8/1 - 31	0	250	7,000	0	6,500	4,500
Total	113,000	113,000		113,000		

5. CONCLUSIONS

Following are the conclusions of this Report:

- There is sufficient rice straw available in the area to supply the proposed Gridley Ethanol Demonstration Project. A total of 379,765 acres of rice are grown within a 30-mile radius of the Gridley site. 759,530 BDT of recoverable rice straw are generated annually. This volume of rice straw is 6.7 times the 113,000 BDT of total feedstock needed by the proposed Gridley facility.

- Sufficient infrastructure is available and more can be developed in California and in the Northwest (Oregon, Washington and Idaho) to collect the annual feedstock requirement of 113,000 BDT for the proposed Gridley facility. Rice straw collection has a short collection season, immediately following rice harvest. The rice straw collection season can be as short as 45 calendar days. However the rice straw collection season follows the harvest and collection of rice, hay, grass seed straws and other grain straws in California and in the Northwest, making much of that equipment available for collecting rice straw during a limited weather window for collection.

- The projected feedstock cost for rice straw delivered to the facility is approximately $35.00/BDT.

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14. ABSTRACT *(Maximum 200 Words)*

This report describes a Feedstock Supply Plan for the proposed Gridley Ethanol Demonstration Project to be located in the City of Gridley Industrial Park in Gridley, California. This report also includes information on the establishment of the required infrastructure required for collecting approximately 113,000 Bone Dry Tons (BDT) annually for the proposed facility. Using the Pearson Technology from Aberdeen, Mississippi, and the related engineering assumptions for required feedstock, it is estimated that the proposed Gridley Ethanol Project will use approximately 113,000 BDT of rice straw to produce approximately up to 20 million gallons of ethanol annually, and/or process steam and or electricity. Based on TSS's survey of planted rice acreage in the Sacramento Valley, a total of 379,765 acres of rice are grown within a 30-mile radius of the Gridley site and that 759,530 BDT of recoverable rice straw are generated annually. This volume of rice straw is 6.7 times the 113,000 BDT of total feedstock needed by the proposed Gridley facility. Sufficient infrastructure exists with additional market potential for further private market infrastructure expansion in California and the Northwest (Oregon, Washington and Idaho) to collect the annual feedstock requirement of 113,000 BDT for the proposed Gridley Ethanol Demonstration Project.

15. SUBJECT TERMS
biofuels; ethanol; fuels; chemicals; synthesis gas; syngas; feedstock; biomass

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