

# Rice Straw Diversion Plan

California Air Resources Board

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## **PREFACE**

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<http://www.arb.ca.gov/rice/ricefund/ricefund.htm>

## EXECUTIVE SUMMARY

State legislation requires the Air Resources Board to develop an implementation plan and schedule to find uses for 50 percent of the rice straw from the Sacramento Valley by the year 2000. The burning of rice straw has been phasing down over the last seven years, leaving rice growers with the only available option of plowing the straw into the soil. Some growers object to soil incorporation because it is costly, may be conducive to crop diseases, and presents logistics problems.

In recent years, about 500,000 acres have been annually planted in rice in the Sacramento Valley. When the fields are burned, about 3 tons of straw are burned per acre. However, when the straw is harvested, only about 2.25 tons of straw can be removed from an acre. Thus, the total yield is about 1.125 million tons of straw annually. This Rice Straw Diversion Plan targets finding uses for about 562,500 tons of rice straw, which is 50 percent of the total straw yield on 500,000 acres.

Not all of the straw grown is expected to be available for harvest. Four factors which would limit straw availability are disease burning, preferred incorporation, hunting clubs, and poor straw condition. These four factors could decrease the availability of straw by up to 50 percent.

Since only about 13,500 tons of rice straw are currently used off-field, increasing the use by more than 50-fold will require a tremendous effort. Many issues need to be resolved before a successful market can be created for 50 percent of the straw. A straw infrastructure needs to be created to solve the logistics problems of harvesting, transporting and storing over half-a-million tons of straw within the six-to-eight-week harvest period during the fall. Straw specifications of the end-users of straw also need to be defined.

If additional measures are not implemented, forecasts call for 3 percent use of rice straw in 2000 and about 20 percent use in 2003. If the Legislature were to implement additional measures, the earliest, practical date by which resources could be appropriated would be during late 1999 or early 2000. This would allow only about 9 months to develop and implement programs that could affect the September 2000 straw harvest. There are very few straw usage categories which could be targeted in such a short time frame.

To comply with the SB 318 requirement for a 50 percent diversion plan, the ARB staff has identified two approaches which would achieve the 50 percent goal on the most expeditious schedule possible. One approach is targeted to divert 50 percent in the year 2000, as required in the legislation. However, meeting the diversion goal by this date could be accomplished only with large subsidies and even then would face substantial logistic and technical difficulties. For this 2000 plan, a dairy and cattle feed marketing program could be pursued, which would include a \$20 per ton subsidy, to induce dairy and cattle ranchers to buy rice straw for animal feed. This subsidy, totaling almost \$10 million annually, would need to continue until other uses of rice straw were developed.

Because of the extreme difficulty and high cost of achieving a 50 percent diversion by the year 2000, the ARB also identified an alternative plan targeted at the year 2003. The approaches for diverting 50 percent of rice straw by 2003 include appropriating resources for analyzing straw production, harvest and availability; funding to build straw storage facilities; funding for prospective straw businesses; assisting potential straw businesses in developing viable business plans; directing state agencies to use and promote rice straw products; and modifying the Rice Straw Tax Credit Program.

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## CHAPTER 1 - INTRODUCTION

Senate Bill 318 (1997, Thompson) requires the Air Resources Board to "...develop an implementation plan and a schedule to achieve diversion of not less than 50 percent of rice straw produced toward off-field uses by 2000." This plan and schedule are to be developed in consultation with the Department of Food and Agriculture (CDFA), the Advisory Committee on Alternatives to Rice Straw Burning (Alternatives Committee) and the Trade and Commerce Agency (TCA).

This document, *The Rice Straw Diversion Plan* (the Plan), was written to fulfill the SB318 requirement. The text of SB318 is included as Appendix A. The Plan was developed with the input of many stakeholders, including the three specified by the bill--the CDFA, the Alternatives Committee and the TCA. Other participating stakeholders include representatives of the following groups: rice growers and the rice industry, environmental community and public health advocates, rice straw businesses and entrepreneurs, and local community groups. Numerous meetings and telephone conversations were held with these stakeholders in both developing and reviewing this Plan, and many of their suggestions have been included in this Plan.

Little more than a year ago, the prospect of finding uses for significant amounts of rice straw was bleak. Since that time, however, the forecast has improved significantly. Although only 3 percent of straw is now estimated to be used off-field by the year 2000, about 20 percent is forecasted to be used by 2003, without additional assistance from government. However, to achieve 50 percent diversion, additional measures would be needed. Candidate measures are suggested in this document.

Before a problem can be solved, its constituent parts must first be defined and understood. To this end, background information is first presented, followed by a discussion of the important issues which need to be resolved. Chapter 4 presents estimates of current uses of rice straw and Chapter 5 presents future estimates without instituting additional measures. Chapter 6 presents plans for 50 percent diversion by 2000 and 2003.

## CHAPTER 2 - BACKGROUND

### Rice Production

California holds the second rank among states in the nation in acreage planted to rice. About 95 percent of California's rice is grown in the Sacramento Valley, where it is the most widely planted crop. In recent years, about 500,000 acres of rice have been planted in the Sacramento Valley, producing over a million tons of straw annually. After the rice has been harvested, the straw has traditionally been burned to clear the fields.

### Phase Down Act

With the passage of the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 (the Phase Down Act), rice growers have had to reduce the number of acres burned according to a schedule expressed in terms of progressively declining percentages of planted rice acreage. When the Act was written, it was anticipated that a new market for rice straw would be created that would provide an alternative to burning rice straw. However, seven years into the phase down, when only 32 percent of the rice acreage was allowed to be burned, only about 13,500 tons of straw have found uses off the field. Approximately 98 percent of the straw not burned continues to be incorporated into the soil, a practice that the rice growers object to because they believe it is costly, may be conducive to increased incidence of crop diseases, and causes logistics problems with field management.

In its 1997 status report, the Alternatives Committee estimated that, at the current rate of development, only two percent of the straw produced in the year 2000 would find commercial uses and that little had changed since its previous status report two years prior.

### Tax Credit Program

The Rice Straw Utilization Tax Credit Program was established by Senate Bill 38 (Lockyer) to provide a California state income tax credit of \$15 for each ton of California-grown rice straw purchased and used off-field. The CDFA administers the program, which limits the aggregate amount of tax credits issued to all taxpayers to \$400,000 per year for the 11-year program. This limit represents 26,667 tons of rice straw, or about 12,000 acres. During 1997, the first year of the program, the CDFA issued tax credit certificates for the utilization of 6,034 tons of straw. The primary recipients of the tax credits were from the dairy industry in the San Joaquin Valley, which used the straw for animal feed and bedding. The first year of the tax credit program is described in the CDFA Report to the Legislature and is included as Appendix B.

### Advisory Committee on Alternatives to Rice Straw Burning

The Phase Down Act created the Advisory Committee on Alternatives to Rice Straw Burning "...to assist with the identification and implementation of alternatives to rice straw burning... and ...to develop a list of priority goals for the development of alternative uses of rice straw..." Over the last six years, the Alternatives Committee has identified many potential uses of rice straw, ranging from building materials to electricity generation to animal feed.

In its 1997 status report, the Alternatives Committee evaluated the technological process and constraints, the economic feasibility, and commercial development status of each identified alternative. Technical barriers to developing rice straw products include rice straw's high silica and ash contents. Economic barriers include the high cost of starting up a new facility, the difficulty in attracting investors to a project which may have a relatively low rate of return, and the uncertainty of a steady supply and cost of a new raw material, that is, rice straw. Although technical barriers remain to various degrees for some potential rice straw uses, the primary barrier for most appears to be economic in nature.

#### Senate Bill 318

In 1997, when the Phase Down Act limited rice straw burning to 38 percent of the acreage planted and less than one percent of straw was used off-field, rice growers turned to the California Legislature seeking relief from the phase down. The resulting legislation, Senate Bill 318, authored by Senator Mike Thompson, provided the opportunity for additional burning for three years; created a two-year, \$5 million grant program to help create a market for rice straw; and directed the ARB to develop a plan to use 50 percent of the straw by the year 2000.

#### Rice Fund

The Rice Straw Demonstration Project Fund (Rice Fund) was created by Senate Bill 318 to provide cost-sharing grants for projects which would use significant quantities of Sacramento Valley rice straw. The ARB, who administrates the program, awarded three grants totaling \$2.07 million at its public meeting on May 28, 1998. The three grant recipients are Anderson Hay & Grain, Inc., FiberTech U.S.A., Inc., and MBI International. A summary of the three projects is included in Appendix C. Anderson will work on developing the straw infrastructure, exporting rice straw for cattle feed, and manufacturing erosion control blankets. FiberTech is expected to start manufacturing particle board from rice straw early 1999 and will be the first significant user of rice straw. MBI will work on a pilot plant to produce high-value animal feed which, if successful, will be the precursor to a full-scale plant using very large amounts of rice straw. The second and final round of grant awards is in progress, with 12 grant requests currently being evaluated. The ARB is expected to award grants totaling \$2.25 million at its April 1999 public meeting.

### CHAPTER 3 - IMPORTANT ISSUES

In the ideal situation, rice straw products would have been gradually phased into the marketplace as the burning of rice straw was phased down. Unfortunately, this has not been the case. Since the Phase Down started in 1992, the demand for rice straw has remained low relative to supply, increasing to only about 13,500 tons the last year. Discussed below are the important issues that need to be resolved to achieve the goal of large-scale uses of rice straw.

#### Straw Production/Yield

Each year during the last 18 years, between 300,000 and 550,000 acres of rice have been planted in the Sacramento Valley. During the past several years, it has remained at about 500,000 acres. The Rice Promotion Board estimates either steady or increasing acreage in future years.

The rice industry and rice agronomists generally estimate that for each ton of harvested grain, about one ton of straw is grown, that is a one-to-one ratio of harvested grain to straw grown. The grain harvest (yield) varies yearly and also depends on the variety of rice grown. The grain yield of individual fields ranges from 3 to 4.5 tons per acre, and in recent years the average yield in California has been about 3.75 to 4 tons per acre. Using the one-to-one ratio, about 3.75 to 4 tons of straw would be grown per acre.

Of course, not all of the straw grown would be recoverable. According to a study by the University of California at Davis, Department of Agronomy and Range Science, when the fields are burned, about 3 tons of straw are removed per acre. Harvesting and baling the straw results in 42 to 59 percent removal or about 2 tons per acre. This estimate is close to the yield estimates of three other sources described below.

Under a USDA grant, the University of California at Davis (UCD) has been conducting a five-year study titled, "Rice Straw Harvesting and Handling for Off-Field Utilization" (UCD Project). During the 1997 straw harvest, the project investigators found that the straw yield (amount harvested) from the fields (776 acres) studied varied from 1 to 4 tons per acre, with an average of 2.2 tons per acre. The circumstances explaining such a wide range of straw production are not known. Two Rice Fund grant recipients have recently begun harvesting straw for their projects. FiberTech's and Anderson Hay and Grain's 1998 straw harvest range from 2 to 2.5 and from 2 to 2.75 tons per acre, respectively.

Since extensive, historical data on rice straw harvesting do not exist, only a rough estimate of straw yield can be made at this time. Known factors affecting straw production include weather conditions, rice variety, grain yield, method of harvesting the grain and the method of harvesting the straw.

Further investigation needs to be done to better estimate straw yield. Based on the four sources discussed above, an estimate of 2.25 tons per acre straw yield will be used, until better estimates become available. Therefore, the goal of diverting 50 percent of the straw towards off-field uses

will target using 562,500 tons of straw, which is 50 percent of the 2.25 tons per acre yield on 500,000 acres planted.

### Straw Availability

Although rice straw is grown on about 500,000 acres, not all of the acreage would be available for harvest. Four factors limiting the availability of straw harvest are discussed below.

- **Disease Burning:** The final phase of the modified Phase Down Act permanently allows up to 25 percent of rice acres to be burned for disease management starting September 2001. The rice industry has stated on many occasions that they expect the full 25 percent would be used for burning. Therefore, assuming at least some burning continues to be needed to manage disease, up to 25 percent of straw would not be available for off-field uses.
- **Preferred Incorporation:** A number of rice growers prefer to incorporate their straw because it is less costly or because they follow the organic-farming philosophy of not burning. It is not known how many acres may fall into this category of *preferred incorporation*, but estimates of 5 to 10 percent have been made. It is also unknown how many of these growers would prefer to harvest their straw if the cost for straw disposal changes.
- **Hunting Clubs:** Some growers manage their rice fields for the use of hunting clubs during the winter by leaving the straw standing then flooding the fields which attracts ducks and other aquatic birds. During the spring, the partially decomposed straw is incorporated into the soil. Rough estimates of about 50,000 acres fall into this category, translating to about 10 percent of planted acreage.
- **Poor Straw Condition:** An additional unknown percentage of straw may not be suitable for off-field uses because of its diseased or otherwise poor condition. An estimate of 5 to 10 percent will be used for this report.

**Table 1**  
**Estimates of Unavailable Rice Straw**  
(% of acres planted)

Disease Burning	25%
Incorporation Preferred	5% to 10%
Hunting Clubs	10%
Poor Condition	5% to 10%
Total:	45% to 55%

Using the estimates of reduced straw availability due to the four categories discussed above, 45 to 55 percent of straw may not be available for off-field uses. The goal of achieving diversion of at least 50 percent of the rice straw produced may not be practical, since it might approach, or even exceed, 100 percent of the straw that is available. Some stakeholders have suggested that, because 50 percent of the straw may not be available for harvest, a more realistic goal of the 50 percent diversion plan would be to target using 281,250 tons of straw or 50 percent of the straw available.

### Straw Infrastructure

The lack of a rice straw supply infrastructure is a common concern of rice growers and potential straw users alike. A rice straw supply infrastructure is defined as those activities needed to get the straw from the field to the final end-user of the straw. These activities would encompass harvesting, transporting, distributing and storing the straw. The issues involved with each of these activities are discussed below. Additional activities might include pre-processing the straw to meet end-users' specifications, compressing the straw for greater densification, and the creation of a straw distribution network.

The lack of a long-term contract or other assurances of a steady, stable supply of raw material (rice straw) "creates a big hole" in a business plan, according to many potential straw users. Rice growers have stated that they are reluctant to commit to a long-term contract for the following reasons: if the straw buyer were not successful in starting up his or her business, the rice grower would be left with, perhaps, hundreds or thousands of bales of straw that could not be burned; if the grower's straw production fell short of the contract commitment, the grower would have to purchase straw from another grower and pay for the higher cost; and, the future cost/price of straw may increase, leaving the grower committed to sell the straw at the lower, original contract price.

### Straw Harvesting

The normal rice harvest period is from about mid-September through the end of October, for most of the rice grown in the Sacramento Valley. However, depending on the weather, harvest may begin during late August or continue into December. Harvesting must be done when the fields are drained of water, otherwise the harvesting equipment tends to rut up the fields. It is assumed that rice straw destined for most off-field uses would need to be harvested during the fall, soon after the grain is harvested but before the winter rainy season begins. This creates a very short time frame (six to eight weeks) in which most of the straw would need to be harvested. During those years when early rains abruptly terminate much of the straw harvest, enough straw would have to be stored from previous years to ensure a steady supply for all straw users.

### Straw Harvesting Costs

The UCD Straw Harvesting Project team performed time and motion studies of rice straw harvesting on 766 acres during the first year of its five-year project. The resulting estimates of direct costs of harvesting ranged from \$10.84 to \$30.87 a ton, depending on harvesting method, type of equipment, and bale size. The Alternatives Committee quoted the Foster Report estimate

of \$19.40 per ton (small bale) using the least-cost harvesting options. All the above estimates are for harvesting the straw and stacking the bales by the edge of the field, next to a road, called *road-siding*.

### Straw Transportation

After road-siding, the bales would be either placed in storage located on the rice grower's property, transported to a distribution storage facility, or transported to the end-user's storage facility. Transporting 562,500 tons of straw would require a tremendous amount of transportation resources. Using the estimate of 20 tons of straw-per-truck-load, it would require 28,000 truck loads. If all this straw were to be transported during the four to eight week fall harvest period, it would require 3,500 to 7,000 truck loads per week to transport the 50 percent goal of 562,500 tons of straw. This would amount to 50 to 100 truck-loads-per-hour, at 10 hours per day, 7 days per week. It is not known whether or how this large amount of needed transportation resources could be met. It is unlikely that there is that much excess transportation capacity currently waiting to be used, and, therefore, new transportation resources would need to be developed. This also points to the need for straw storage on or near the rice growers' fields, so that the transportation to the end-users' facilities could be scheduled throughout the year.

Transportation costs within a 10-mile radius are estimated at about \$10 per ton including loading and unloading the straw (Anderson Hay & Grain Co.). Transportation to a location 50 miles away would be about \$20 per ton. If the demand for transportation abruptly increases, greatly out-pacing supply, transportation costs may also abruptly increase, until the supply and demand level off. This points to the need of an analysis of transportation availability and costs and its environmental effects.

### Straw Storage

Potential straw users would need a supply of straw on a year-round basis to produce their rice straw products continuously. Since rice straw would be harvested primarily during the fall months, each potential straw user would need to secure a full year's supply during the fall straw harvest. The straw could be stored either at the user's facility or at the straw supplier's facility (here, the straw supplier could be a rice grower, a broker, or a pre-processor).

In addition, enough straw would have to be stored from the previous year in case of a poor harvest during the upcoming year, such as the case when early rains prematurely terminate the straw harvest. This carry-over would be necessary to ensure a steady, stable supply for the straw users. Individual straw users would have to determine the prudent amount necessary for carry-over.

Most potential straw users need straw to be kept in dry storage, such as pole barns or under tarps. Five years ago storage costs were estimated at \$1 to \$4 per ton of straw stored (Alternatives Report page 57). More recently, Anderson Hay and Grain Company estimated the capital cost of a 2,550 ton capacity straw storage barn to be \$162,500. Anderson also estimated yearly tarping costs at \$1.76 per ton straw. Storage location could be next to a rice field, at the end-user's

facility, or at a distribution or pre-processing center. A cost analysis needs to be performed listing all practical options and the parameters affecting storage costs. Currently, there is very little straw storage available in the Sacramento Valley.

#### Creating a Straw Market

In the ideal situation, rice straw businesses would have phased into the marketplace along the same gradual time line as the mandated 10 percent yearly reduction in straw burning. If this were the case, the rice straw supply infrastructure would gradually develop to meet the gradually increasing demand for rice straw. The availability of harvesting equipment, storage facilities, and transportation options would increase gradually, instead of responding to a sudden surge in demand. The market-determined price of these resources would be determined by the incremental difference in supply and demand.

#### Soil Incorporation Costs

Currently, 98 percent of the straw not burned is incorporated into the soil. With few exceptions, this has been the only alternative to burning. Rice growers object to soil incorporation for several reasons--it is more costly than burning, it may increase plant disease, and it presents problems with field management in terms of timing and logistics. According to a recent study by the University of California Cooperative Extension Service (1997 Report to the Legislature-Appendix E) , it costs an average of about \$36 an acre to incorporate straw into the soil. This is the incremental cost beyond the normal soil management costs. While the costs of incorporation ranged from \$8 to \$77 per acre, 60 percent of the farms studied were in the range of \$18 to \$48 per acre. From this perspective, rice straw is currently considered a liability, with a disposal cost equal to the cost of incorporation.

#### Market Price of Straw

Currently, the available supply of rice straw greatly exceeds the demand. It is unlikely that the market for rice straw would change suddenly so that straw moves from being a liability to an asset. The economic value of straw as a liability can be quantified as the cost of incorporation less the cost of burning, which currently averages \$36 per acre. Because of this, some rice growers are willing to initially pay for some of the straw removal costs, thereby making this new raw material (rice straw) more attractive to potential rice straw enterprises. Some rice growers have stated their goal of making straw disposal *revenue-neutral*. Currently, the market price of rice straw ranges from about \$15 to \$35 a ton. This range does not include smaller sales that are priced at around \$3 per bale, which translates to \$75 per ton.

#### End-user Specifications

Different straw users require different straw specifications. Some users require straw to be chopped to a specific length, or, when harvested, cut at a certain point (above or below the water-line). For many straw uses, the straw must be very clean (no soil contamination) and kept in dry storage. For a few other straw uses, the straw can be harvested and then left out in the open and leached with the winter rains; these straw uses may also be able to utilize spring-harvested straw. The required bale size also differs for the various end-users, and, as previously mentioned, this

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would affect the harvesting cost.

## CHAPTER 4 - CURRENT USES OF RICE STRAW

Two sources were used to estimate current alternative uses of rice straw--the Alternatives Committee 1997 progress report and the CDFA 1998 Tax Credit Program report. The Alternatives Report was based on the 1996 crop year, while the CDFA Report was based on the 1997 calendar year. Table 2 lists the estimates from these two sources and a revised estimate combining the two sources with some adjustments, as listed below.

**Table 2**  
**Current Uses of Rice Straw**  
(tons used)

Use Category	Alternatives Report Estimate (1996)	Tax Credit Program Participation (1997)	Revised Estimate
Animal Bedding		2,967*	2,665
Animal Feed	1,350	2,501*	1,860
Compost/Fertilizer		1,264	1,264
Bale Construction	**	50	200
Erosion Control	7,450	460*	7,450
<b>TOTAL</b>	<b>8,800</b>	<b>6,657</b>	<b>13,439</b>

\* Numbers revised because multiple categories were given for straw usage, resulting in double-counting

\*\* Estimate not quantified

The Tax Credit Program would not include straw used by governmental agencies since they would not have tax liabilities necessary to use the tax credit. A common use of straw by governmental agencies is for erosion control. Therefore, the Alternatives Committee estimate was used for this category.

The actual amount of rice straw currently used may be higher than the estimates shown in Table 2. A comprehensive survey of rice growers, straw balers, straw distributors, and straw end-users would be needed for an accurate estimate of actual rice straw usage.

## **CHAPTER 5 - FORECASTED STRAW USAGE WITHOUT ADDITIONAL MEASURES**

Currently, there are two incentives established to promote rice straw uses: the State Tax Credit Program (expires on December 1, 2008) and the Rice Fund Grant Program (expires at the end of fiscal year 1998-99). Without additional incentives, significant amounts of rice straw are not expected to be used until well after 2003.

In 1997 tax credits were used to purchase 4,525 tons of straw for animal feed and bedding, but future straw use is expected to decline for these categories. According to the CDFA staff report, almost half of all the tax credits issued in 1997 went to the dairy industry. The tax credit offset the transportation costs of transporting the straw from the Sacramento Valley to the San Joaquin Valley, from 50 to 100 miles. In the future, one large-scale straw production facility could use most or all of the annual tax credit, since the annual limit of the tax credit program is \$400,000, or about 26,667 tons of rice straw, and because the tax credit legislation specified that the tax credit certificates be issued on a first-come-first-served basis. When this occurs, small individual users may discontinue using rice straw, especially users who use the tax credit to offset transportation costs, such as the dairies in San Joaquin Valley. Because this potential is likely to occur and because there are fewer dairy and cattle operations in the Sacramento Valley, usage forecasts for these categories were decreased for future years.

Table 3 shows the straw usage forecasts if additional measures are not implemented. The forecasts are for 3 percent usage for the year 2000 and 21 percent usage for 2003.

**Table 3**  
**Straw Usage Forecast**  
**Without Additional Measures**  
 (tons of rice straw)

Straw Usage Category	Year 2000		Year 2003	
	Low	High	Low	High
<b>Energy Alternatives</b>				
Anaerobic Digestion	0	0	0	0
Direct Combustion for Electricity and Heat	0	0	0	0
Ethanol	0	0	0	0
Chemicals	0	0	0	0
<b>Manufacturing/Construction</b>				
Pulp/Paper Mills	0	0	0	20,000
Fiberboard	10,000	20,000	10,000	40,000
Composites/Bricks	0	0	0	0
Bale Buildings	200	1,000	200	1,000
Sound Walls	0	500	0	500
<b>Environmental Mitigation/Compost</b>				
Erosion Blankets	2,000	5,000	6,000	11,000
Bales and Loose Straw	3,000	5,000	3,000	7,000
Compost/Fertilizer	0	1,000	0	1,000
<b>Livestock Utilization</b>				
Domestic Animal Feed	0	500	50,000	100,000
Export Feed	0	0	30,000	40,000
Bedding	0	200	0	1,000
<b>Future Rice Fund Grant Recipients*</b>	0	20,000	50,000	100,000
<b>AVERAGE:</b>	<b>34,200</b>		<b>235,350</b>	
<b>PERCENT OF STRAW PRODUCED:</b>	<b>3%</b>		<b>21%</b>	

\*Unknown usage categories for recipients of fiscal year 1998-99 grants

## CHAPTER 6 - RICE STRAW DIVERSION PLAN

### A. Approaches for Achieving a 50 Percent Diversion by 2000

Even if the necessary funds could be appropriated immediately, an enormous effort would be required to achieve almost 20 times the straw usage that is currently expected for the year 2000. However, because of the lead time required for the legislative process, the earliest, practical date when new funding could be appropriated would be during late 1999 or early 2000. This would allow only about 9 months to develop and implement programs by the September 2000 straw harvest.

There are only a few straw usage categories which could be targeted in such a short time frame, such as animal feed and bedding, erosion control and sound walls. Most of the other categories of straw usage would require about 18 months to build manufacturing facilities which would use rice straw as a raw material.

#### Straw Infrastructure Development

Funds would need to be appropriated to develop the infrastructure needed for using 562,500 tons of straw. Straw storage facilities would have to be built, straw harvesting equipment would have to be purchased, and trucking resources would have to be acquired.

#### Erosion Control

There currently exists a market for rice straw (in the form of bales and loose straw) as erosion control material. This market could be increased ten fold by promoting, or even requiring, state and local agencies to use rice straw for erosion control. Developing a marketing plan targeting the construction industry would also increase the use of rice straw for erosion control. The current lack of straw storage facilities limits this market since rice straw is not available year-round. Funds would need to be appropriated to develop the marketing plan and storage facilities. Use of bales or loose straw for erosion control could be increased to about 15,000 tons annually.

#### Sound Walls

The California Department of Transportation (CalTrans) and the Integrated Waste Management Board have made plans to build a demonstration sound wall using rice straw. If the results of the demonstration project are positive, the State could make a commitment to use rice straw to build a significant percentage of future sound walls, using up to about 3,000 tons of straw annually.

#### Animal Bedding

In 1997, there were 18 dairies which purchased rice straw for animal bedding, using the \$15 per ton State Tax Credit to offset the cost of transporting the straw to the San Joaquin Valley. These dairies used approximately 2,665 tons of rice straw. The demand for animal bedding is limited by each year's meteorological conditions, that is, by the amount of rainfall during the winter (more rainfall would result in greater demand for straw). The most that could be expected to be used by 2000 would be about 10,000 tons, which is four times the amount used during the 1997 extremely wet winter, by promoting rice straw to other dairy and cattle ranchers.

### Animal Feed

The only straw usage category which could possibly be targeted for using the balance of the required 50 percent is for animal feed. In 1997, there were 6 dairy and cattle ranchers who purchased approximately 1,860 tons of rice straw for animal feed, using the \$15 per ton State Tax Credit to offset the cost of transporting the straw to the San Joaquin Valley. To increase this usage over 260-fold, to 490,000 tons, the tax credit may have to be increased to \$20 per ton.

The CDFA estimates the potential market for low-grade feed for cattle at between 1 and 1.3 million tons. Therefore, 490,000 tons of rice straw would have to capture about 50 percent of the market, displacing the feed currently being used. According to the United States Department of Agriculture, the price of alfalfa was \$115 a ton during the past spring. Rice straw has a nutritional value of about 45 percent of alfalfa when used for maintenance. Therefore, the nutritional equivalent cost would be about \$50 per ton. The cost of harvesting rice straw and transporting it to San Joaquin Valley, the location of most of the dairy and cattle ranches, would be about \$50 per ton. It is assumed that additional storage costs would not be incurred, since the rice straw could be stored in the barns which would otherwise store the alfalfa. The \$50 per ton cost and \$50 per ton nutrition equivalency represents the break-even point for rice straw. However, most dairy and cattle ranchers, being skeptical of changing their feed to rice straw, would need a cost incentive to start using rice straw. A \$20 per ton cost advantage, which would represent a 40 percent cost savings, would be a strong incentive for dairy and cattle ranchers to switch to using rice straw for part of their feed requirements.

A marketing plan targeting dairies and cattle feed-lots would also have to be developed to promote the use of rice straw. This would have to include nutritional studies of using rice straw as part of the daily rations. The total tax credit for 490,000 tons of straw would amount to \$9,800,000 per year. This subsidy could be gradually reduced as other, more cost-effective uses of rice straw were developed over time.

### Conclusions

The estimates for using 50 percent rice straw by following the approaches discussed above are shown in Table 4. The ARB staff does not believe that these approaches are practical, since they would not work towards a permanent, long-term solution to using over a half-a-million tons of straw annually.

**Table 4**  
**Straw Usage Forecast**  
**With 2000 Plan Measures**

<b>Straw Usage Category</b>	<b>Tons of Straw</b>
Fiberboard	20,000
Sound Walls	3,000
Bale Buildings	600
Erosion Blankets	3,500
Erosion Control: Bales and Loose Straw	15,000
Animal Bedding	10,000
<b>Future Rice Fund Grant Recipients*</b>	20,000
<b>Subtotal:</b>	72,100
Animal Feed (Balance required for total to equal 50%)	490,000
<b>TOTAL:</b>	<b>562,100</b>
<b>PERCENT OF STRAW PRODUCED</b>	<b>50%</b>

\*Unknown usage categories for recipients of fiscal year 1998-99 grants

## **B. Approaches for Achieving a 50 Percent Diversion for 2003**

Because it would be extremely difficult and costly to implement the recommendations for 50 percent diversion by the year 2000 in such a short time, alternative approaches were developed that could, if fully implemented, meet the 50 percent goal by the year 2003. The ARB staff believes that this target date, 2003, is far more viable than 2000.

To achieve diversion of 50 percent of rice straw produced by 2003, additional measures would need to be taken. The approaches listed below were suggested by stakeholders, the Alternatives Committee, the Department of Food and Agriculture, the Trade and Commerce Agency, and Air Resources Board staff. If these approaches were to be implemented according to the schedule outlined in Table 5, the goal of 50 percent diversion could be achieved. Table 6 lists the low and high estimates for each straw usage category.

### **Measures by Category**

#### Straw Infrastructure

1. Provide resources to perform the following studies: estimates of how much rice straw is actually produced and available for off-field uses; estimates of how much straw is currently being used off-field; evaluation of the options and costs of straw harvesting methods, harvesting equipment, storage, and transportation; evaluation of straw quality characteristics affected by harvesting methods.
2. Provide resources for the following: determine the straw specifications needed by various end-user groups, including length of straw (chopping requirements), quality of straw, bale-size, moisture content, storage requirements, etc.; determine the potential of a secondary straw market, for example, uses for low-quality straw, spring-harvested straw, and straw waste generated by other straw users.
3. Provide financial resources to subsidize the cost of building storage facilities on rice growers' land, central distribution centers, and end-user facilities. The financial incentives could take the form of loan guarantees, low-interest loans, accelerated capital depreciation, 50 percent grants, or tax credits. Provide assistance to rice growers and others to develop straw cooperatives and straw distribution and marketing centers.

#### Incentives for End-users

4. Provide financial resources for end-user straw businesses. The financial incentives could take the form of 30 percent loan guarantees, low-interest loans, accelerated capital depreciation, or 50 percent grants. This financial incentives program could be made self-supporting by requiring the grant recipient to repay the grant, at some multiple, when the business is self-sufficient. The Rice Straw Demonstration Project Fund, which was created for only two years, could be modified to be self-supporting and extended beyond the 1998-99 fiscal year.

5. Provide financial resources for research projects to address the technical barriers of those straw usage categories which could use significant (at least 50,000 tons) quantities of straw. This could be modeled after the Defense Conversion Matching Grant Program, which required that the results of the research be made public.
6. Provide resources to develop a Rice Straw Business Assistance Program which would educate potential rice straw businesses about existing available programs for federal, state, and local financial and educational assistance. Through this program entrepreneurs would be assisted in the following areas: product marketing and marketing analysis; estimating capital costs; seeking private investors and available public and private grants and loans; environmental and building permitting processes;

#### Potential Users of Straw Products

7. State agencies should be encouraged to use and promote rice straw products where such use would be appropriate. State Agencies have the potential of becoming significant users and promoters of straw products, such as paper, building materials and bale buildings, sound walls, and straw for erosion control and compost. Local governmental agencies, especially those in the rice-growing counties, also have the same potential, thereby creating a demand for products made from rice straw. The President's September 14, 1998, Executive Order, titled "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition", could be a model for California. This Executive Order directs federal agencies to use environmentally preferable products including bio-based products which would include products made of rice straw.
8. Modify the Straw Tax Credit Program. Set limit that can be claimed by any one tax payer in order to prevent one large straw user from claiming the entire credit, thereby losing smaller users; do not set a limit on individual users, but, instead, increase the yearly cap to \$8.5 million per year for the first 5 years to cover the entire 562,500 tons, which is 50 percent of the straw produced; allow tax credit trading and marketing to provide incentives to straw users who do not have State tax liabilities.

**Table 5**  
**Proposed Schedule for 2003 Diversion Plan**

<b>Category</b>	<b>Quarter - Year</b>	<b>Activity</b>
For All Categories	Q4 - 1999	Provide resources, identify responsible agencies
Straw Infrastructure Studies	Q1 2000 - Q1 2001	Perform studies
	Q2 2001 - Q2 2002	Implement findings/Develop Infrastructure
Storage Development	Q2 2000 - Q2 2002	Provide financial assistance/Build storage facilities
Financial Incentives for End-users	Q1-Q2 2000	Establish financial assistance program for commercialization projects
	Q1-Q2 2000	Establish financial assistance program for research projects
	Q4 2000 - Q1 2001	Receive, evaluate, and select applications for first round of financial assistance
	Q1-Q2 2002	Receive, evaluate, and select applications for second round of financial assistance
Rice Straw Business Assistance Program	Q1-Q2 2000	Develop program
	Q3 2000 - Q3 2002	Implement program
Rice Straw Financial Assistance	Q1-Q3 2000	Develop program
	Q4 2000 - Q4 2002	Implement program
Tax Credit Program	Q1-Q2 2000	Modify State Tax Credit Program

**Table 6**  
**Straw Usage Forecast**  
**With 2003 Plan Measures**  
 (tons of rice straw)

<b>Straw Usage Category</b>		
	<b>Low</b>	<b>High</b>
<b>Energy Alternatives</b>		
Anaerobic Digestion	5,000	20,000
Direct Combustion for Electricity and Heat	0	20,000
Ethanol	20,000	200,000
Chemicals	0	50,000
<b>Manufacturing/Construction</b>		
Pulp/Paper Mills	75,000	125,000
Fiberboard	30,000	40,000
Composites/Bricks	10,000	60,000
Bale Buildings	5,000	10,000
Sound Walls	4,000	8,000
<b>Environmental Mitigation/Compost</b>		
Erosion Blankets	6,000	11,000
Bales and Loose Straw	10,000	15,000
Compost/Fertilizer	4,000	6,000
<b>Livestock Utilization</b>		
Domestic Animal Feed	100,000	200,000
Export Feed	30,000	55,000
Bedding	6,000	10,000
<b>AVERAGE:</b>		<b>567,500</b>
<b>PERCENT OF STRAW PRODUCED</b>		<b>50%</b>

### **Basis of Forecasted Straw Usage**

It is difficult to predict whether technical and economic barriers can be overcome for these categories of rice straw usage to become operational within the next five years. The basis of the forecasted estimates used in Table 6 are discussed below for each straw usage category. The discussion focuses on the status of each usage category, including the current barriers to success. The barriers summarized here are fully described in the 1997 Alternatives Report. The basic assumption is that the measures listed at the beginning of this chapter are implemented, and that funding is appropriated by January 1, 2000.

### **Anaerobic Digestion**

The economic feasibility of anaerobically digesting rice straw to produce methane as a fuel for generating electricity and heat requires a pilot plant demonstration. This would demonstrate whether this technology could compete with low-cost natural gas. The best market for this technology would be supplying energy to commercial rice straw conversion facilities. The waste or low-quality straw from the conversion facility could be used for the anaerobic digestion process, thus saving costs for both facilities. A one megawatt plant could use 50,000 tons of straw. Funding is needed for the pilot plant demonstration. If the pilot is successful, at least one commercial-size plant could be built by 2003, using 50,000 tons of straw. If a commercial-size plant is found not to be economically feasible, the existing pilot plant would still be able to provide energy at its existing site, using about 5,000 tons of straw annually.

### **Direct Combustion**

There are two technical barriers to using rice straw for direct-combustion: the alkalinity of rice straw creates serious and costly slagging problems in biomass power plant boilers and the high silica content resulting in high ash creates disposal problems. An economic barrier is the low-cost, high-availability of other feedstocks, such as other agricultural byproducts and urban wastes, which can be obtained at a substantially lower cost than rice straw. A permanent subsidy may be required to make rice straw use for direct-combustion economically competitive.

### **Ethanol**

Commercial feasibility of rice straw to ethanol conversion depends on the relatively high ethanol prices in the market. Currently, government subsidies and mandates to add oxygenated compounds to gasoline are needed to sustain the demand and price of ethanol, and the ethanol tax subsidy has recently been renewed for about 10 years. Since the western states currently import about 45 million gallons of ethanol a year, primarily from the Midwest, a rice straw ethanol plant in the Sacramento Valley could have a substantial economic advantage due to its lower transportation costs. One commercial plant could use up to 200,000 tons of straw yearly.

### **Industrial Chemicals**

Industrial chemicals which can be produced from rice straw include diphenolic acid, succinic acid, tetrahydrofuran, silica, and citric acid. There is a large market for these chemicals, although pilot projects would need to be funded to determine the feasibility of using rice straw as the raw material. Additional funding could bring advances to this potentially lucrative usage category, since large amounts of rice straw could potentially be used in this high-value product category.

### Pulp and Paper Mills

Silica sludge, a byproduct in pulping rice straw creates the main technological barrier in this potentially high-usage category. Additional research funding could overcome this barrier, after which a pilot-scale facility could be funded to demonstrate the economic feasibility of pulping rice straw. Government agencies giving preferential consideration to products made of rice straw could create their initial market demand.

### Fiberboard

With a grant from the Rice Fund, FiberTech, U.S.A. is currently in the process of starting up its particle board facility expecting to achieve full scale production before the end of 1999.

Assuming product acceptance in the particle board market, additional funding could enable FiberTech to open a second facility, doubling its projected use of rice straw. Other projects are also looking for funding support to start-up operations to make medium density fiberboard and building panels.

### Composites and Bricks

Rice straw can be combined with other materials to make various products such as roofing tiles and bricks. With additional funding for end-users, some of these projects could be successful in using large amounts of straw.

### Bale Buildings

Most of the counties in the Sacramento Valley have issued permits for the construction of at least one rice straw bale building project. Although a standard residential home uses only about 10 tons of straw, with state and local assistance, the total amount of straw which could be used could total 5,000 to 10,000 tons annually.

### Sound Walls

The California Integrated Waste Management Board (CIWMB) and CalTrans are conducting a pilot project using bales of rice straw to construct a sound wall. The sound wall will be monitored for two years. If the pilot project is successful, future sound walls, especially in and near the Sacramento Valley, could be constructed using bales of rice straw, totaling 4,000 to 8,000 tons annually.

### Erosion Blankets

With a grant from the Rice Fund, Anderson Hay and Grain Inc, has started shipping rice straw to Greenfix, an Anderson-affiliated company in Brawley, to be used in making erosion control blankets. Greenfix believes substituting rice straw for its current use of wheat straw will be acceptable to its existing customers and predicts capture of an additional 10 percent of the straw market for erosion control blankets, for a total 11,000 tons straw annually.

### Bales and Loose Straw

Currently about 7,500 tons of rice straw are used for erosion control in the form of bales or loose straw. If the State Tax Credit Program were modified to allow trading and marketing the tax credits, those organizations which do not have tax liabilities would have an economic incentive to

use rice straw for their erosion control needs. This could double the straw usage to 15,000 tons annually.

#### Compost/Fertilizer

Because of the nature of the final product, low-quality rice straw could be used for compost or fertilizer. This would create an important secondary straw market for using the straw that was unusable to make other products, thus filling a disposal need. In 1997, one company applied for a tax credit for using 1,264 tons of rice straw to produce compost and fertilizer. The State Rice Straw Tax Credit Program would need to be modified to expand this usage category.

#### Domestic Animal Feed

With a grant from the Rice Fund, MBI International is working on a pilot project to make a high-value animal feed for the domestic market. MBI's project includes modifying an existing small plant to produce enough of the feed for running feeding trials and to produce preliminary design specifications for a full-scale commercial plant capable of using 160,000 to 330,000 tons of straw annually. MBI did not receive the full \$1.5 dollars grant request, delaying the project by about one year. Additional funding would enhance MBI's prospect of full-scale production by 2003.

#### Export Animal Feed

Part of Anderson Hay and Grain's Rice Fund project is to develop the required protocols for exporting rice straw to Japan for cattle-feed. Japan currently imports rice straw from other Asian countries to meet its short-fall. Hoof-and-mouth disease in Taiwan, a large rice straw exporter to Japan, has recently created a rice straw shortage. Anderson currently exports other straws and hay to the Asian market for which it helped to develop the export protocols. The company predicts that by 2003, it can export 55,000 tons of rice straw to Japan. A two-year delay in its predicted schedule would reduce that amount to 30,000 tons.

#### Animal Bedding

Dairies, primarily from the San Joaquin Valley, applied for tax credits for using about 2,665 tons of rice straw for bedding material in 1997. If the Tax Credit Program were modified, it could continue to offset the transportation costs of the dairies in the San Joaquin Valley, increasing its use by more dairies. Although there are far fewer dairies in the Sacramento Valley, rice straw should be marketed to these dairies close to the rice counties since the lower transportation costs in addition to the tax credit would create a good incentive for using rice straw.

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