# COMMERCIAL FEASIBILITY ANALYSIS FOR FUELS FROM PINYON-JUNIPER BIOMASS

## Technical Progress Report

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for

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## INTRODUCTION

This report is a mid-term progress report for the study, *Commercial Feasibility Analysis for Fuels from Pinyon-Juniper Biomass*, being performed by Future Resources Associates, Inc., for the Western Regional Biomass Energy Program under Cooperative Agreement No. DE-FC65-92WA07445. The study involves five major tasks:

- Assessment of the technology available for the production of fuels from Pinyon-Juniper biomass.
- Assessment of the Pinyon-Juniper biomass resources available in the Eastern Nevada Counties of Lincoln and White Pine.
- Analysis of the potential markets for Pinyon-Juniper biomass fuels produced in Eastern Nevada.
- Analysis of the costs of producing fuels from Eastern Nevada Pinyon-Juniper biomass.
- Analysis of the commercial feasibility of fuels production from Eastern Nevada Pinyon-Juniper biomass.

The first two of these tasks have been completed, the third and fourth tasks are substantially in progress, and the fifth task has just been started. This report describes study findings and progress to date, and details the steps that will be taken in order to complete the study.

## WORK COMPLETED

### Current Technology Assessment

A variety of methods exist for the harvesting, processing, and transportation of fuels that can be produced from Pinyon-Juniper biomass. Harvesting technology can vary from manual methods like chain saws to mechanized methods like tractor-mounted fellers. Processing technology options include grinders, chippers, splitters, and pelletizers. Transportation options include conventional trucking options, and rail transportation options. All of the essential technology necessary for the production of fuels from Pinyon-Juniper biomass is available. In the area of harvesting technology, there is room for refinement and adaptation of technology for the Pinyon-Juniper forest type.

*P-J Harvesting and Processing Technology*

Current commercial harvesting of the Pinyon-Juniper woodlands of Eastern Nevada is limited to the production of small quantities of a few traditional products, mainly firewood, Christmas trees, and fence posts. Most of the harvesting is accomplished manually using chain saws and small trucks for hauling. This type of harvesting technology is suitable for small, high-valued applications, but is probably too expensive to be used for the large-scale production of biomass fuels.

Large-scale fuels production from the Pinyon-Juniper woodlands will require mechanized harvesting and processing technologies to be used in order to be able to meet the rigors of market prices. The development of the biomass power industry over the past ten to fifteen years in regions like the Northeast U.S., Scandinavia, and California, has spawned the development of a variety of new technologies for the mechanized harvesting and processing of trees, producing whole-tree wood chips suitable for power-plant use. Technology is available for both selective harvesting and for full land clearing, for a variety of forest types and topographies. In the case of the Pinyon-Juniper woodlands of Eastern Nevada, most of the fuel production probably will involve land-clearing operations.

The first step in harvesting Pinyon-Juniper biomass is to cut the trees. Cutting is usually accomplished using shears mounted near ground level on a tractor. Some operations use feller-bunchers, which both cut the trees and grab them in order to haul the trees to a landing. Other operations simply cut the trees and knock them over, leaving them for later pick-up by other equipment. After cutting, the trees can either be chipped on-site using some type of mobile chipping or grinding equipment, or hauled to a fixed processing facility for chipping.

Trees in the Eastern Nevada Pinyon-Juniper woodlands tend to be fairly short and broad in form, with stiff branches sticking straight out from the trunk. There are few trees taller than thirty feet. Feller-bunchers are best suited for use with tallish, slender trees, and would be very difficult to adapt to use on the Pinyons and Junipers. Thus, the most likely method for cutting the trees will be to cut them in place and leave them for later pick-up and chipping. On-site chipping probably will be desirable. A heavy duty, broad-mouthed chipper will be required, due to the form of the trees. A wide variety of grinding and chipping equipment is commercially available, so finding suitable equipment should not be too difficult.

The size and form of the Pinyon and Juniper trees, as well as their planting density (trunks per acre, tons per acre) is similar to that of many California orchard tree crops, particularly almonds. Modern orchard clearing operations, which have been optimized for fuel production in California over the past five years, provide a better model for the harvesting and processing of Pinyon and Juniper woodlands in Eastern Nevada than, for example, forest-thinning operations in New England do. Figure 1 shows a view of a typical California orchard removal/fuel production operation. Two converted forklifts are being used to pick up the snipped trees and load them onto a conveyor to the chipper.

The chipper is connected directly to a chip van, so fuel chips are blown directly into the van and ready for transport. A tractor slowly pulls the chipper and van down the former rows of the orchard to minimize the distance that the two loaders have to go between the snipped trees and the chipper. After the chipping is complete in the orchard, a stump grinder is used to grind each of the major stumps to a depth of two to three feet below surface level. This latter step probably would not be necessary in the Pinyon-Juniper woodlands.

San Joaquin Bio-Mass Co., which is one of the pioneering developers of technology for the production of fuels from the clearing of almond orchards in California, and currently one of the leading agricultural fuels suppliers in the state, has agreed to contribute to this study by accompanying FRA on its next site visit to Nevada, and performing an assessment of the costs and operational scale that would be necessary to harvest and process the Pinyon-Juniper biomass into a suitable fuel form. Our current estimates are that one full mechanized harvesting crew would be able to produce on the order of 50,000 to 100,000 tons per year of fuel.

*P-J Transportation Options*

Short-range transportation of biomass fuels, which is defined as one-way hauls over distances of less than 200 miles, conventionally is done with trucks with detachable vans. Large chip vans carry loads of approximately 25 green tons, which is equivalent to some 12.5 - 15.0 bone dry tons (BDT). Chip vans would be a suitable option for hauling chips from most of the P-J woodlands in Lincoln County to Las Vegas, but probably would not be a suitable option for hauling chips to the California biomass power-plant market.

Chip vans conventionally are loaded either by blowing the wood chips directly into the van from the chipper, or by pushing the chips into the vans by front-end loaders after being piled on the ground by the chipper. Unloading the vans is more difficult than loading them. Self-unloading vans are available with "walking floors," which allow the vans to unload themselves without any tipping equipment. The walking-floor vans, however, are expensive, and unloading is very slow, often taking 30 to 45 minutes or more.

In the absence of a self-unloading capability, it is necessary to have a tipping device. Most of the major California power plants have full truck-van tippers, which can unload vans without having to disconnect them from the truck. Figure 2 shows two trucks on tippers at the Ultrapower Fresno power plant in Malaga, California. Using truck tippers, a truck can spend less than fifteen minutes at the unloading site, including check-in, weigh-in, unloading, weigh-out, and check-out. This is a very efficient operation.

For long-range transportation, for example to the California biomass power-plant market, conventional trucking options would be prohibitively expensive. Thus it is necessary to consider rail transportation alternatives. The Union Pacific railroad runs through the heart of the Pinyon-Juniper woodlands in

Lincoln County, then through Las Vegas, and on into Los Angeles, California. Connections can be made in Barstow or Mojave with the Southern Pacific railroad to bring the railcars north into the California central valley, or south into the Imperial Valley, both of which areas have large biomass power plants with excellent rail access.

There are three options available for rail transportation of biomass fuels:

- o Conventional chip gondolas
- o Piggy-back hauling of truck vans on flat cars
- o Conventional box cars fitted with removable fiber doors

Chip gondolas are used all over the Western United States for hauling pulp chips. Chip gondolas hold some 6,000 to 6,500 cubic feet of material, which is approximately 150 - 180 green tons of wood chips. Chip gondolas in the Western United States require special lifts for unloading, as they do not have any dumper capability like chip gondolas used in the Eastern United States. The lifts are huge pieces of equipment due to the size of the gondola itself and its load. None of the biomass power plants in California contacted in connection with this study currently has a gondola lift on site, although several of the facilities do have rail sidings available on their sites.

Mr. Michael Shelton of the Union Pacific Railroad, who is currently preparing price quotes for this project, reports that chip gondolas currently are in short supply in the Western United States. Most of the railroads, including UP, are reluctant to shuttle chip gondolas to other railroads, and this may be reflected in the current price of gondola transport of wood chips. More about this will be known when UP delivers its transportation price quotes to FRA.

One alternative to the use of conventional chip gondolas for the transportation of biomass fuels from Nevada to California is to piggy-back truck vans on conventional rail flat cars. Piggy-backing has the advantages of using common flat cars, and simplicity in both loading and unloading from the railroad. However it has the disadvantage that the amount of tonnage hauled per railcar is low.

A second alternative to the use of chip gondolas for the transportation of biomass fuels from Nevada to California is to use conventional boxcars fitted with removable fiber doors as the chip containers. This method currently is being used for hauling wood chips from U.S. sources to Mexico, and could be adapted easily for use entirely within the U.S. The traditional sliding doors are removed from the boxcars, which are outfitted with removable fiber doors that span the entire open area width-wise, and leave a gap of one to two feet of opening at the top. Loading is accomplished by blowing the chips into the boxcar through the opening above the fiber door. Unloading is accomplished by removing the fiber door, and letting the chips spill out at the siding. In Mexican practice, a group of workers then enters the partially empty boxcar and completes the unloading process by manual shoveling and sweeping. In

California, the likely method of choice would be to install a pneumatic vacuum system that could be operated by a single operator.

**P-J Resource Assessment**

Pinyon Juniper is the dominant forest type in Nevada, occurring in most of the state's upland areas. Some forty percent of the 8.8 million acres of Pinyon-Juniper woodlands in Nevada, including some of the most productive, are located in the two Eastern Nevada Counties of Lincoln and White Pine, the regions under investigation in this study. Figure 3 shows the location of these two counties within the state. These counties are very rural, and are composed of long, north-south running valleys bounded by rolling mountains. The Pinyon-Juniper woodlands are located in the mountains, and are concentrated on the Utah boarder.

Lincoln County and White Pine County have approximately equal holdings of Pinyon-Juniper woodlands: 1.75 million acres in Lincoln; 1.9 million acres in White Pine. Almost all of the land in both of these counties is federal land (Lincoln: 95%; White Pine 93%). In Lincoln County the BLM manages nearly all of the land. In White Pine County the BLM manages most of the land, but the U.S. Forest Service also manages a significant portion of the lands, particularly in the highest mountains. In both of these counties the vast majority of the productive Pinyon-Juniper woodlands are under BLM management.

The heaviest concentrations of Pinyon-Juniper forest occur at fairly high elevations, e.g. above 6,500 feet. At the lowest elevations of its occurrence Juniper is the dominant species, and the stands are not very dense, as measured by tons of biomass per acre. At higher elevations Pinyon becomes dominant, and biomass densities of over fifty tons (green) per acre can be found in the most productive areas. The highest-density biomass areas are the subject of greatest concern in this study, both because they are the least costly to harvest in terms of $/ton, and because these are the areas that are most in need of clearing from an environmental perspective in order to improve watershed and wild life values.

A 1991 study by the Intermountain Research Station, U.S. Forest Service, in Ogden, Utah, provides the most comprehensive survey available of Nevada's forest resources. This report classifies woodland biomass densities on the basis of merchantable volume stockings, which includes material down to a diameter of 3 inches. In order to covert this data into total biomass density in terms of tons per acre, it is necessary to estimate the ratio of merchantable volume to total biomass, and to determine the weight-to-volume ratio of the material. Using an average specific gravity of 0.525, the solid wood density for Pinyon-Juniper biomass is 32.8 lb per cubic feet. This is the figure used in this study.

A recent study done by D.C. Chonjnacky and G.G. Moisen, also of the USFS Intermountain Research Station in Ogden, *Converting Wood Volume to Biomass*

*for Pinyon and Juniper*, which is current in press, develops detailed estimates of the relationships between total biomass weight and merchantable volumes for Pinyon-Juniper forests of different densities and ages; and for different merchantable volume definitions (e.g. using the 2, 3, and 5 inch rules). Assuming that our interest is in the denser, more mature stands of biomass, and using the resource data mentioned above, a multiplier of 45 percent is appropriate for converting merchantable biomass to total woody biomass, and 65 percent for converting merchantable biomass to total biomass, including bark and foliage.

Using these multipliers, it is possible to convert the merchantable volume data to estimates of total biomass resources available in Lincoln and White Pine Counties, Nevada. Assuming that fifteen percent of the P-J woodlands are inaccessible to harvesting for environmental or other reasons, each county has a P-J biomass resource base in excess of 3.25 million BDT of total woody biomass in the highest density stands (>24 BDT/ac), and in excess of 8.5 million BDT of total woody biomass in the stands of densities greater than 15 BDT/ac. Annual harvests on the order of 10,000 to 100,000 BDT/year should not be difficult to achieve or sustain from Nevada's P-J biomass resources.

## WORK IN PROGRESS

### Market Assessment

There is no existing market in the Southeastern Nevada region that could absorb the quantities of materials that could be produced from the Pinyon-Juniper woodlands there using modern, efficient, mechanized methods. Several options exist for developing a market for the material that could be produced. The major market options being investigated include:

- The existing, nearly fifteen million ton-per-year biomass fuels market in neighboring California.
- The emerging market for residential pellet fuels in Las Vegas.
- Use of biomass as a blending fuel in a local or regional coal-fired utility power plant.
- Development of a local biomass-fired power plant, either by the local utility company (Nevada Power), or as a private power producer.

The passage of the Federal PURPA legislation in 1978, and the implementation of a variety of policies and incentives in California during the 1980s, promoted the development there of the largest biomass-fueled power generating industry in the world. Almost 900 MW of capacity has been built and placed into service in California, and there are facilities located in all areas of the state, with

concentrations in the north of the state where the lumber industry is centered, and in the state's major agricultural regions. During the peak of the development boom, approximately 1989 - 1990, new capacity was being commissioned at such a high rate that biomass fuel became scarce and prices went very high. More recently the market has had a chance to reach a more stable equilibrium, and fuel prices have come down as much as twenty percent from their peak.

The California biomass fuels market is currently a fairly mature market, with the collection of over fifty power generating facilities commissioned and in operation. Access to the market will require rail transportation of the fuel from Eastern Nevada, so it is relevant to focus on the several facilities with the best rail access. The facilities under active consideration for fuel deliveries of Pinyon-Juniper biomass include:

- Delano Power Company, a 30 MW power plant (expanding to 50 MW in July, 1993) located north of Bakersfield.
- Ultrapower Fresno Power Company, a 25 MW power plant located south of Fresno.
- Sequoia Forestry Industries Sawmill, an 11 MW cogeneration facility located south of Fresno.
- Colmac Energy Power Plant, a 50 MW power plant located near Mecca in the Coachella Valley of Southern California.

The first three of the four facilities, Delano, Ultra Fresno, and Sequoia, are all located in the San Joaquin Valley, and they all purchase fuel from the same, highly competitive market there, although the Sequoia facility derives most of its fuels requirements from the associated sawmill's waste. Current market prices for biomass fuels in the San Joaquin Valley are in the range of $36 - 38 per BDT, with typical fuel sources being orchard removals and wastewood reclaimed from landfills. The high Btu value and low ash content expected of Pinyon-Juniper fuels means that they would probably be able to earn a premium price at these facilities. These prices have been confirmed in interviews with the fuel buyers at each of the three named facilities.

The Colmac power plant is located nearly all by itself in the Coachella Valley, more than 200 miles from the closest San Joaquin Valley facility. This facility does compete for some of its fuel supply with the other facilities, but their market is partially captive. Colmac is currently purchasing fuel for prices on the order of $34 - 36 per BDT. Like the other facilities, Colmac would be willing to pay a quality premium for P-J biomass, but it is unlikely that they would pay quite as much for the fuel as would the other facilities under consideration. This fact, combined with the fact that Colmac alone among the facilities under consideration does not have an existing rail siding, makes Colmac a less likely candidate for purchases of P-J fuels produced in Nevada.

The city of Las Vegas, which is some 150 miles away from the Pinyon-Juniper woodlands of Nevada, has been experiencing rapid growth, with its population currently approaching one million. The city is also experiencing increasing air-pollution problems, and has begun to institute voluntary restrictions on the use of traditional wood-burning appliances, as well as considering banning the installation of traditional appliances in new residential construction. Modern pellet-burning stoves, which produce far less pollution than either fireplaces or air-tight wood stoves, are exempted from all restrictions. Pellet burning stoves increasingly are being installed in Las Vegas, where the market for fuel pellets is growing. A typical household that depends on a pellet stove for heating in the Las Vegas area will consume pellet fuel at the rate of approximately one ton per year. Current prices for pellet fuels in the Las Vegas market are on the order of $250 per ton.

As an alternative to hauling wood chips to the distant California market, it might be feasible to establish a demand for biomass power plant fuels in the Southern Nevada area. Two possibilities are worth investigating: (1) Use of the P-J biomass fuel in blends with coal at an existing coal-fired generating facility in the Nevada Power System. (2) Development of a biomass power plant in Southern Nevada, either by Nevada Power itself, or as a private power producer selling power to Nevada Power. We have initiated contact with Nevada Power in order to explore their interest in these two alternatives.

### Cost Analysis

Commercial fuels production from Pinyon-Juniper biomass involves several distinct steps, each of which can be costed separately. The major fuel-production steps include (not all steps are necessary for all products):

- Biomass harvesting and processing to chip form in the woods.
- Transportation of the wood chips out of the woods, either to a railroad siding, processing facility, or combustion facility.
- Rail transportation.
- Additional chip processing (e.g. pelletization) and marketing.

We are working on producing reliable cost estimates for each of these fuel-processing steps. San Joaquin Biomass Company, one of the leading producers of agricultural fuels in California, is assisting with the cost estimates for the harvesting and in-forest chipping of Pinyon-Juniper biomass, as well as for trucking transportation of chips. Union Pacific Railroad, which is the rail carrier with tracks running through the Pinyon-Juniper country of Eastern Nevada, is preparing a transportation quote for hauling fuel chips from Nevada to the four most promising biomass power plants in California, using several different rail transportation options. A variety of sources are available for cost estimates for processing steps like pelletization.

### Commercialization Analysis

The final major activity to be pursued in this project is an analysis of the potential for the commercialization of biomass fuels production from Pinyon-Juniper biomass in Eastern Nevada. This involves integrating the information developed in the course of this analysis, identifying both entry market opportunities and long-term market opportunities, and developing a plan for producing and delivering the fuel products within the constraints of the relevant markets.

## PLANNED ACTIVITIES

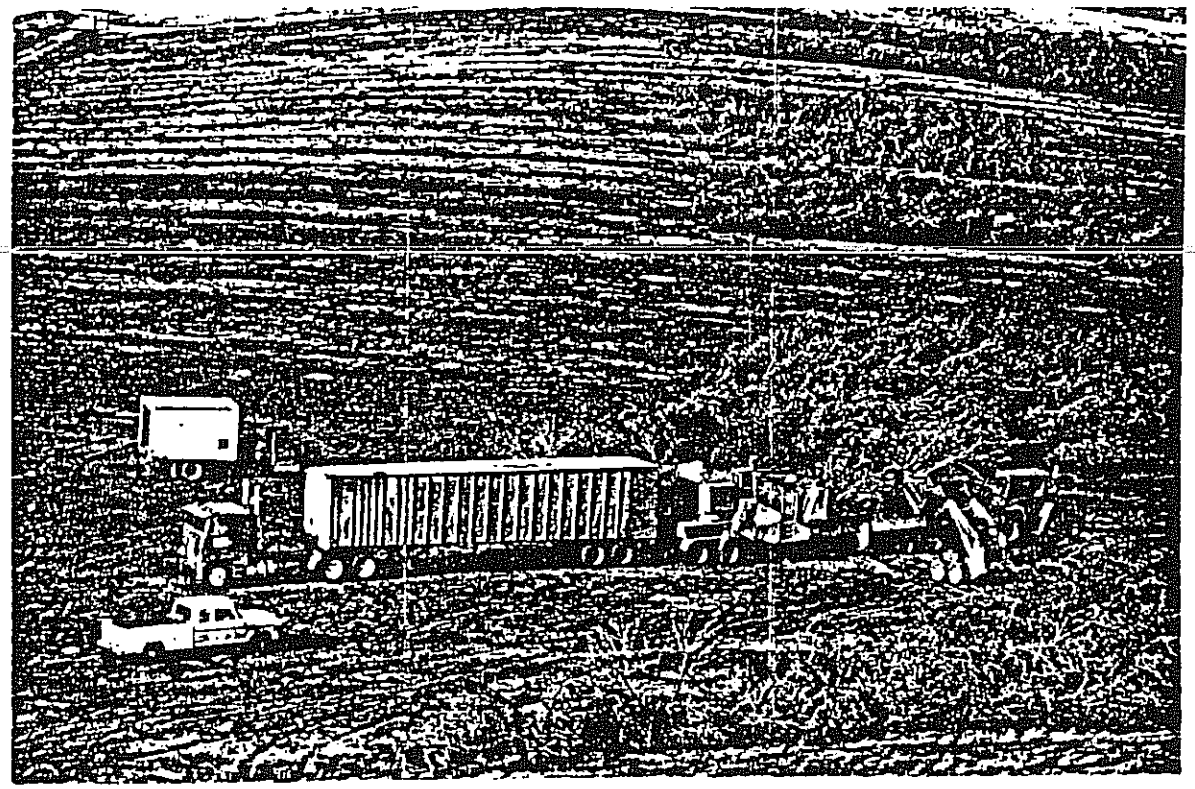
The two major activities still to be done to complete this project are:

- Complete the cost analysis for biomass fuels production and delivery.
- Perform the commercialization analysis to determine the feasibility of establishing a fuels from Pinyon-Juniper biomass industry in Eastern Nevada.

During April, Dr. Gregory Morris will travel to Las Vegas and the Pinyon-Juniper country of Lincoln County. In Lincoln County, he will be joined by Mr. Lee Brown of San Joaquin Biomass Co., who will be making an assessment of the cost of harvesting and chipping the biomass. The work in Las Vegas will also involve assessing the market for residential pellet fuels there, and working with the BLM to determine the terms and conditions under which Pinyon-Juniper biomass harvesting will be allowed, encouraged, and regulated.

Following this second trip to Nevada, and upon completion of the cost estimates for harvesting, processing, and transportation of Pinyon-Juniper biomass, the commercialization analysis will then be pursued in detail. The project is currently progressing on schedule and within budget, and no problems are anticipated in these areas at this time.

# FIGURE 1



The fuel production operation showing the chipper, the chip hauling van, the bobcat loader, and the rows of cut trees waiting to be processed.