Chapter 2

Proposed Action and Alternatives

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2. PROPOSED ACTION AND ALTERNATIVES

The Department of Energy (DOE or Department) is proposing to provide federal funding of approximately $85 million to Abengoa Bioenergy Biomass of Kansas, LLC (Abengoa Bioenergy) to support the design, construction, and startup of the Abengoa Biorefinery Project (the total anticipated cost of the biorefinery is approximately $300 million). This *biorefinery* would use lignocellulosic *biomass* (biomass) as feedstock to produce *biofuels* and *biopower* at a facility proposed to be located near Hugoton, Kansas (Chapter 1, Figure 1-1). DOE has prepared this EIS to evaluate the potential environmental impacts of the construction, operation, and decommissioning of the biorefinery. The U.S. Department of Agriculture-Rural Development is a cooperating agency in the preparation of this EIS.

FERMENTATION

Ethanol *fermentation* is the biological process of bacteria and yeast breaking down simple sugars for their cellular energy and producing ethanol and carbon dioxide.

In a traditional grain-to-ethanol facility, biofuel producers *ferment* the simple sugars contained in grains such as corn and milo (grain sorghum) to produce ethanol. Instead, in the biorefinery proposed by Abengoa Bioenergy, biomass, such as wheat straw, milo stubble, switchgrass, corn stover, and other available materials, would be harvested as feedstock and fermented to produce ethanol (Figure 2-1).

Abengoa Bioenergy would ferment the simple sugars contained in the cell walls of the feedstock. Roughly two-thirds of the feedstock is present as *cellulose* and *hemicellulose* (the two main components of plants that give them structure), and *lignin* makes up the bulk of the remaining dry mass.

Figure 2-1. Corn stover in the field after corn harvest.

Cellulose hydrolysis involves breaking down the cellulose into simple fermentable sugars. Acids and enzymes are used for cellulose hydrolysis. After the cell walls are broken down into fermentable sugars, yeast or bacteria are mixed with the sugars. Yeast or bacteria feed on the sugars and produce ethanol and carbon dioxide. The ethanol is distilled to remove most of the water and residual solids; the living yeast or bacteria are destroyed as well. Lignin is the major *byproduct* of the fermentation process.

Bioenergy, or biopower, is the use of biomass to generate electricity. Bioenergy system technologies include *direct-firing*, *co-firing*, *gasification*, *pyrolysis*, and *anaerobic digestion*. Direct-firing uses biomass as solid fuel in biomass boilers to produce steam. Gasification occurs when biomass is heated in a low-oxygen environment, producing a biofuel known as *syngas*. Pyrolysis is a special kind of *chemical* breakdown using heat that does not require oxygen the way direct firing does. The result of pyrolysis is syngas. Anaerobic digestion is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen. It is a renewable energy source because the process produces a methane- and carbon dioxide-rich biogas. Most bioenergy plants use direct-fired systems in that they burn biomass *feedstocks* directly to produce steam. This steam drives a turbine, which turns a generator that converts the power into electricity. In some biomass industries, the spent steam from the power plant is used for manufacturing processes or to heat buildings. Such combined heat and power systems greatly increase overall energy efficiency.

The remainder of this chapter describes the *Proposed Action* and Alternatives. *Best management practices* are integral to the design, construction, and startup of the biorefinery. If a best management practice is important to understanding the design of the biorefinery it is described in this chapter.

BEST MANAGEMENT PRACTICES

The practices, techniques and methods, and processes and activities commonly accepted and used throughout the construction and ethanol and energy production industries to facilitate compliance with applicable requirements, and that provide an effective and practicable means of avoiding or reducing the potential environmental impacts of the Proposed Action and Action Alternative.

Best management practices are presented in greater detail in Chapter 6. Section 2.1 discusses the Proposed Action, Section 2.2 discusses the Action Alternative, Section 2.3 discusses the No-Action Alternative, Section 2.4 provides a comparison of the key design features between the Proposed Action and Action Alternative, Section 2.4 summarizes the findings of this EIS, and Section 2.5 discusses alternatives considered but eliminated from detailed consideration.

2.1 Proposed Action

DOE's Proposed Action is to provide federal funding to support the design, construction, and startup of the biorefinery. The biorefinery would use biomass (for example, corn stover, milo stubble, wheat straw, and switchgrass) as feedstock to produce biofuels, such as ethanol [18 million gallons (68 million liters) per year], for sale to the conventional market and bioenergy (92 megawatts of electricity) to meet the electrical needs of the facility and for sale to the regional power grid. The biorefinery would process 2,500 dry short tons (2,300 dry metric tons) per day of feedstock, which would be obtained from producers within 50 miles (80 kilometers) of the *Biorefinery Project site*. Figure 2-2 presents a simplified diagram of the process that Abengoa Bioenergy would use to convert biomass feedstock to biofuel and biopower. Figure 2-3 is a photograph of a biorefinery in York, Nebraska; the proposed biorefinery would have a similar appearance. Figure 2-4 is a conceptual drawing of the current layout of the biorefinery facilities.

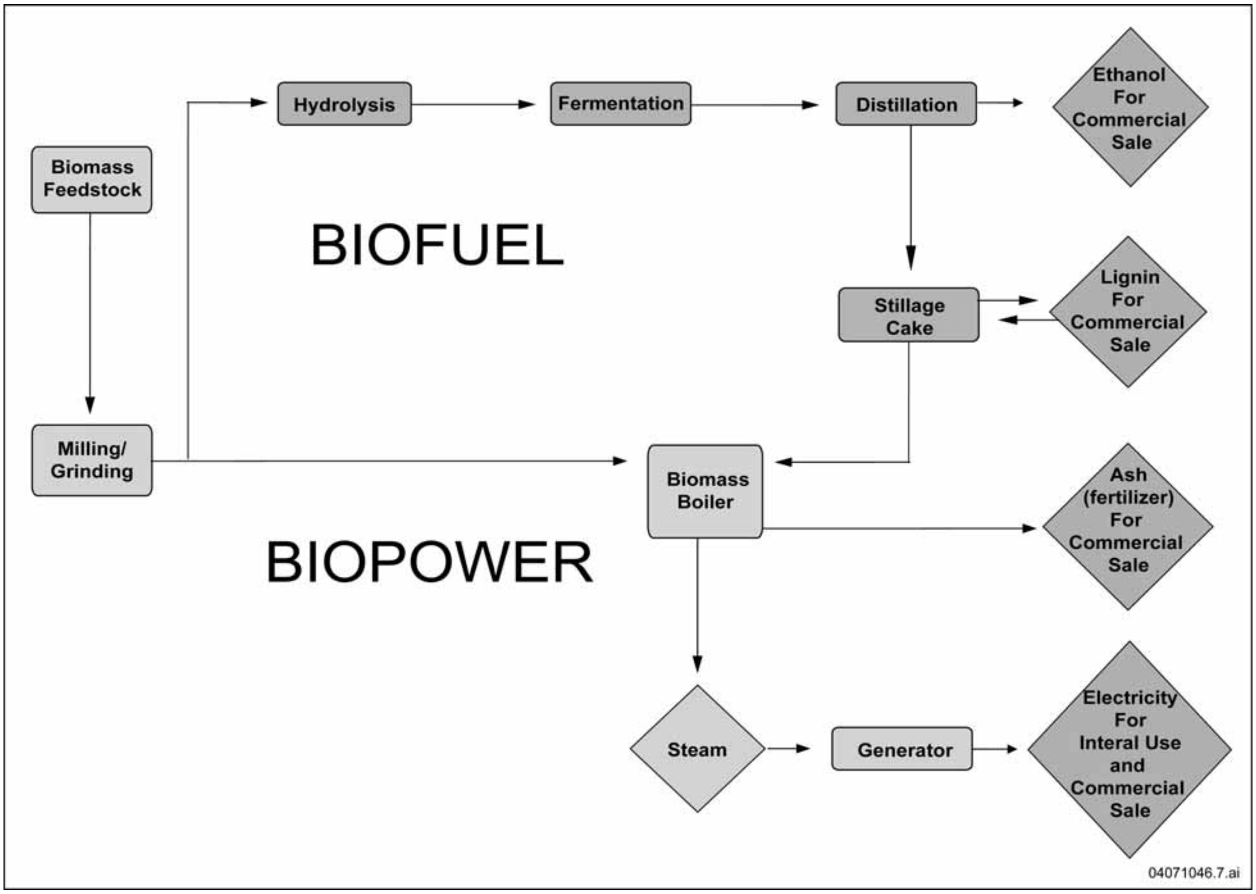

Figure 2-2. Simplified diagram showing conversion of feedstocks to biofuel and biopower under the Proposed Action.

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Figure 2-3. Biorefinery in York, Nebraska.

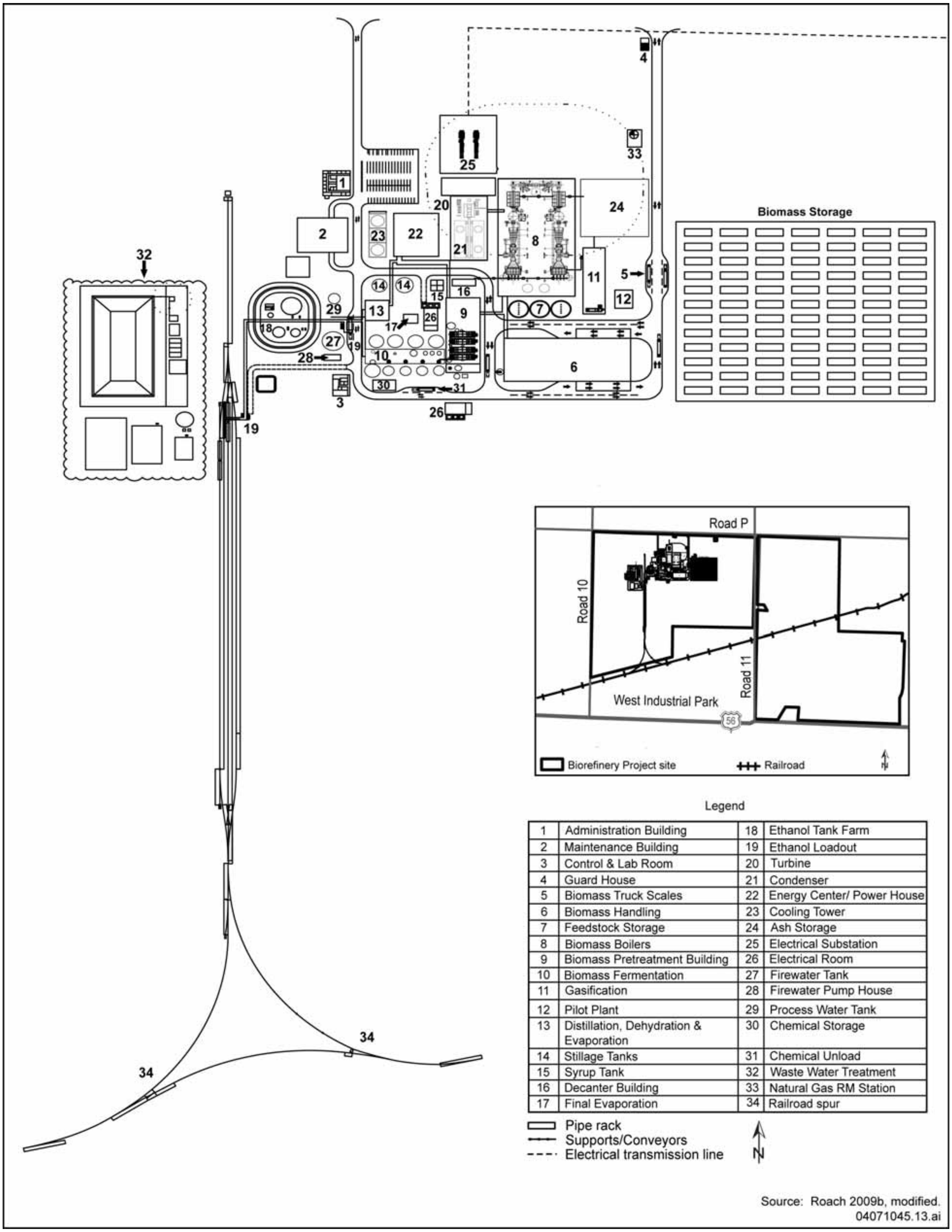

Figure 2-4. Site layout of biorefinery (concept).

2.1.1 CONSTRUCTION

Abengoa Bioenergy would construct the biorefinery on a 385-acre (1.6-square-kilometer) parcel on the west site of the Biorefinery Project site (Chapter 1, Figure 1-2). Abengoa has optioned an additional 425 acres (1.7 square kilometers) immediately east of the *biorefinery parcel*, between the biorefinery and the Hugoton, Kansas, city limits, as a *buffer area*. The optioned parcel would continue to be used as agricultural land and might be used to test production of various feedstocks, such as new varieties of switchgrass. Water from the proposed wastewater treatment facility would be used to irrigate the buffer area. The biorefinery would include commercial, fuel-grade cellulosic ethanol facilities, electricity production facilities, and an onsite 0.5-mile (0.8-kilometer)-long railroad spur for railroad access to receive materials and ship product (Figure 2-4).

Construction of the biorefinery would take approximately 18 months and would include infrastructure improvements, such as construction of site roads that would tie to Rural Road P and a 0.5-mile (0.8-kilometer)-long railroad spur within the Biorefinery Project site that would tie to the Cimarron Valley Railroad as well as installation of new electrical transmission line along County Roads P and 11. Construction activities would include use of heavy diesel-operated equipment, such as trucks, cranes, bulldozers, dumpers, front-loaders, and excavators. Dust control and silt- and erosion-control measures would be implemented for all disturbed areas during the entire construction period. Temporary connections to utilities would include electricity, cable, telephone, and a nonpotable water line. Temporary potable water and sanitary facilities would be provided onsite until construction of permanent, onsite facilities.

Construction activities would start with the removal of vegetation and stripping and stockpiling the topsoil for future use, such as reclamation of areas not covered by permanent structures. Construction crews would grade the site and begin construction of the railway and foundations. Once grading was complete, workers would install underground utilities.

After installation of utilities, permanent roadways would be stabilized and prepared for paving while disturbed but temporary roads and areas would be seeded. Coincident with these activities, crews would install buildings, heavy process equipment, and chemical storage tanks, as shown in Figure 2-5, prior to paving permanent roads. After final grading, paving, and landscaping, all construction silt- and erosion-control measures would be removed from the site. Construction of the facility would be complete when electrical, mechanical, and communications connections were final.

2.1.2 OPERATIONS

The biorefinery would operate 24 hours a day, 350 days a year. Preliminary design and processes are presented in Appendix A of this Abengoa Biorefinery Project EIS. The biorefinery would produce up to 18 million gallons (68 million liters) of denatured ethanol and 92 megawatts of electricity. Seventy megawatts of electricity would be sold commercially. Discussions between Abengoa Bioenergy and the Sunflower Electric Power Corporation concerning the commercial sale of electric power are underway. The following sections describe operations of the biorefinery.

2.1.2.1 Harvesting and Handling Feedstock

The following sections present harvesting and collection, storage, and preparation of feedstock for conversion to biofuels and bioenergy.

2.1.2.1.1 *Harvesting and Collection of Feedstock*

Abengoa Bioenergy would execute contracts with local producers to purchase biomass from locations within 50 miles (80 kilometers) of the Biorefinery Project site. Contracts with biomass producers would reflect resource conservation and agricultural program guidelines to ensure best management practices, such as topsoil protection, are used during harvesting. Initially, the primary feedstock for the biorefinery would be corn stover; other feedstocks would include milo stubble, wheat straw, and switchgrass. Over time, Abengoa would increase the use of switchgrass until it became the primary feedstock. Corn stover, milo stubble, and switchgrass harvesting would begin mid-October and last between 8 and 14 weeks. Wheat straw harvesting would begin mid-June and last approximately 3 weeks. Harvesting of biomass would occur after grain harvesting and would involve use of a windrower to cut stalks; a baler to compress, bale, and bind the bales; bale accumulator to collect the bales; bale squeeze to stack the bales; and flatbed trailers for transport. Bales would be transported to either the biorefinery or *offsite storage locations*. Figure 2-5 shows the kinds of equipment that would be used to harvest and transport the bales of feedstock.

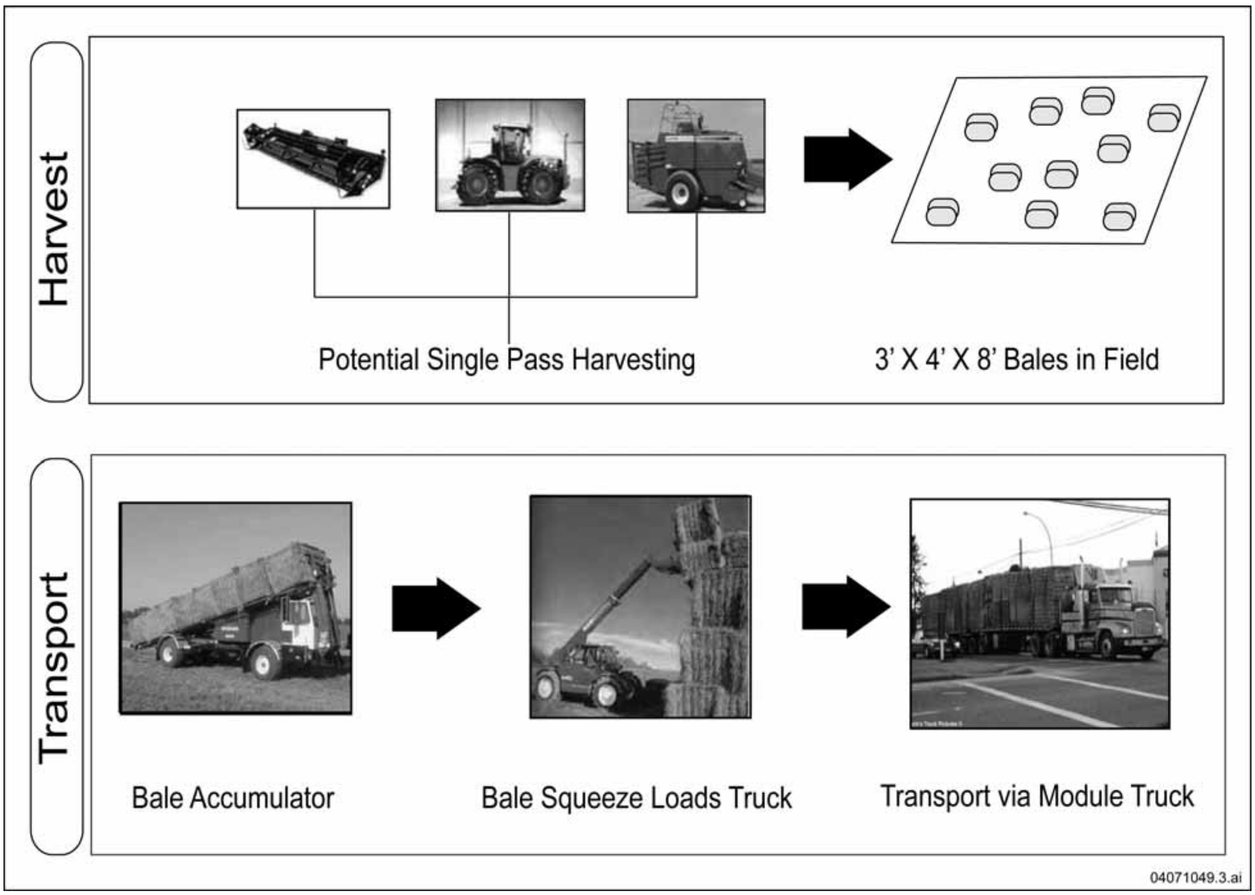

Figure 2-5. Harvesting and transport equipment for biorefinery.

2.1.2.1.2 *Offsite Storage of Biomass Feedstock*

Biomass feedstock would be stored at seven locations within 30 miles (48 kilometers) of the Biorefinery Project site. Although these locations have not yet been identified, they would be areas that:

Do not interfere with crop production or irrigation activities,
Utilize lands that are marginal for crop production, and
Provide truck access.

Each storage location would comprise about 160 acres (0.65 square kilometer) and, together, would accommodate the amount of biomass needed to support biorefinery operations for up to 1 year. At each location, bales would be stacked to accommodate offloading of arriving trucks during the biomass harvesting season and loading of trucks for shipment to the biorefinery. No permanent structures would be needed at these locations to facilitate offloading or loading operations.

2.1.2.1.3 *Onsite Biomass Feedstock Receiving, Grinding, and Storage*

Biomass would primarily be stored offsite. However, Abengoa Bioenergy would store a 2.6-day supply of biomass on 10 acres (0.04 square kilometer) onsite to ensure process continuity in case of a short-term disruption of biomass delivery from offsite locations (due to bad weather, for example).

Handling operations would consist of receiving the biomass bales by truck and unloading them at a bale barn large enough to support a “nearly just in time” operational process. Grinding would be required for both biofuel and bioenergy production. Grinding is a mechanical process that reduces the biomass into useable sizes for feedstock for ethanol production and the biomass boilers. To *attenuate* the *noise* associated with the hammer mills used for grinding, the hammer mills would be housed within the Biomass Handling Building (Figure 2-4, Building 6), where all grinding would take place. Approximately 2,500 dry short tons (2,300 dry metric tons) of biomass a day would be processed for feedstock.

Flatbed trailer-loads of baled biomass would be unloaded via overhead cranes. The cranes would either place the bales in intermediate storage inside the bale barn or onto process in-feed conveyors. Baled biomass would then travel via the conveyer from the bale barn to the grinding lines. Each grinding line would be equipped with a receiving processing unit that grinds and cleans the feedstock. There would be four storage silos (Figure 2-4, Building 7) to store the feedstock that is not sent directly to the process metering bins: one for biomass feedstock supplying the *enzymatic hydrolysis* for ethanol production and three for biomass feedstock supplying the solid biomass boilers.

The biomass receiving, grinding, and storage operations would be an enclosed, high-velocity, positive pressure collection and transfer system to capture and transfer airborne particles to a dirt loadout tank. The loadout tank, grinding activities, and associated transfer points would have fabric filter dust collectors (baghouses).

2.1.2.2 Ethanol Production

This section describes the ethanol production process diagrammed in Figure 2-2. Ethanol would be produced using approximately 670 short tons (610 metric tons) of biomass feedstock a day. The following sections describe the steps/areas, listed below, required for production of ethanol:

enzymatic hydrolysis and fermentation
distillation and dehydration
ethanol denaturant and storage.

The biorefinery would produce up to 18 million gallons of denatured ethanol a year.

2.1.2.2.1 *Enzymatic Hydrolysis and Fermentation*

Once milled, the feedstock would be conveyed to the Biomass Pretreatment Building (Figure 2-4, Building 9).

CONSTITUENTS OF BIOMASS FEEDSTOCK

Cellulose:
An organic compound consisting of a linear chain of several hundred to over ten thousand glucose molecules (polysaccharide). Cellulose is broken down to simple sugars during enzymatic hydrolysis.

Hemicellulose:
Any of several branched polysaccharides present in almost all plant cell walls along with cellulose. Hemicellulose has a random, amorphous structure with little strength. It is easily hydrolyzed by dilute acid or base as well as myriad hemicellulase enzymes. Hemicellulose is broken down to simple sugars during acid pretreatment.

Pectin:
Part of the non-woody parts of terrestrial plants. In the space between plant cells, *pectin* helps to bind cells together. The amount, structure, and chemical composition of the pectin differ between plants, within a plant over time, and in different parts of a plant. Hard parts of a plant contain more pectin than soft parts. Pectin is broken down to simple sugars during acid pretreatment.

Lignin:
A complex chemical compound that is an integral part of the cell wall of plants. Lignin fills the spaces in the cell wall between cellulose, hemicellulose, and pectin components. Lignin is not broken down to simple sugars. Lignin would be recovered from the process as a byproduct or treated as a waste.

The cellulose-rich, lignin-rich feedstock would be treated with enzymes and *genetically modified organisms* (enzymatic hydrolysis) to simultaneously break down the tougher cellulose and ferment the recovered sugars (Figure 2-4, Building 10) resulting in “beer.” At the conclusion of the fermentation process, the beer is between 4 and 5 percent ethanol. Beer would be conveyed to the distiller for purification. *Volatile organic matter* released during processing would be captured in a *vent scrubber*. Liquid from the vent scrubber would be sent to the wastewater treatment facility described later in this chapter.

2.1.2.2.2 *Distillation and Dehydration*

The beers from enzymatic hydrolysis and the fermentation process would be distilled and dehydrated (Figure 2-4, Building 13). Ethanol must be anhydrous (without water) for use as a biofuel. Distillation removes the majority of the water and residual solids from the ethanol. Distillation also destroys all living organisms, including genetically modified organisms.

Soluble and insoluble solids would be recovered from the bottom of the distillation column. The insoluble solids, referred to as *lignin*-rich *stillage cake* would be separated from the soluble solids. The soluble solids would be concentrated to a thin *stillage syrup* in an evaporator and would be combusted in the biomass boilers. Volatile organic compounds released during processing would be captured in a vent scrubber. Liquid from the vent scrubber would be sent to the wastewater treatment facility.

The ethanol production process would produce about 117,000 tons (about 106,000 metric tons) per year of lignin-rich stillage cake. A lignin producer would purchase this lignin-rich stillage cake as crude lignin. The producer would have its processing plant near the biorefinery to reduce transportation costs between the biorefinery and the lignin processing plant. A conveyer would transport the lignin-rich stillage cake the short distance between the biorefinery and the producer's processing plant. After the lignin was extracted, the lignin producer would return the lignin-poor stillage cake and Abengoa Bioenergy would use it as fuel for the solid biomass boiler.

The three main markets for lignin-derived products in North America include resin-based binders and bonding agents, antioxidant agents, and water-soluble derivatives and compounds. The most likely use for the recovered lignin would be as a replacement for phenol used in wood bonding to create such products as plywood and fiberboard. Until the lignin extraction plant is built, Abengoa Bioenergy would burn the lignin-rich stillage cake as solid fuel in the biomass boiler. If lignin extraction is determined not to be commercially viable, lignin-rich stillage cake would be used as solid fuel in the biomass boiler for the life of the biorefinery. Both options for treatment of lignin are discussed in Chapter 4, Section 4.6.

2.1.2.2.3 *Ethanol and Gasoline (Denaturant) Loadout*

The facility design incorporates two shift tanks that would hold the anhydrous ethanol produced during an 8-hour shift (Figure 2-4, Building 18). Each shift tank would have a capacity of 60,000 gallons (230 cubic meters) of ethanol. Ethanol product not meeting required quality control specifications (for example, ethanol containing water) would be stored in a 60,000-gallon tank until transfer back to the distillation, dehydration, and evaporation facility (Figure 2-4, Building 13) for reprocessing.

Gasoline would be added to denature the ethanol to make it unfit for human consumption. A 22,500-gallon (85-cubic-meter) denaturant tank would store gasoline to be used for blending with the ethanol product. The final ethanol product would be approximately 4.9 percent gasoline and would be stored in one 460,000-gallon (1,740-cubic-meter) tank until shipment.

Each tank in the storage area would be built onsite and would have an *internal floating roof* design. Abengoa Bioenergy would provide meters, filters, pumps, and loadout equipment, as required, for loadout into rail tankers. The storage tanks would be enclosed in a bermed area to contain spills that could occur.

Liquid product loadout would involve loading gasoline (denaturant) and denatured ethanol to and from tanker trucks and tanker railcars. The denatured ethanol would ship by rail.

2.1.2.3 Power Generation

Electricity would be produced via the high-pressure, steam-condensing turbine generator (Figure 2-4, Building 20). The gross power produced at the biorefinery would be 92 megawatts. Biomass boilers would be used to produce steam. Steam would be used for ethanol production processes and electricity production.

Figure 2-4 shows the Biomass Boiler Building (Building 8). Approximately 1,900 dry short tons (1,700 dry metric tons) per day of biomass feedstock would supply a solid biomass boiler to produce high-pressure superheated steam for the high-pressure steam-condensing turbine generator. In addition, the biomass boiler would use much of the waste resulting from ethanol production, including particles collected during milling, stillage cake and syrup from the distillation process. The solid biomass boiler would produce almost 80,000 tons (approximately 73,000 metric tons) of ash annually. This ash would contain potassium and phosphorous and would be marketed to local biomass producers as a soil amendment. In the event there is no market for the ash as a fertilizer replacement, the ash would go to landfills. Impacts from both options for the ash are addressed in Chapter 4.

2.1.2.4 Support Facilities and Infrastructure

2.1.2.4.1 *Emergency Equipment*

The facility design incorporates an emergency firewater tank and a separate pump house equipped with two electric pumps and one diesel-powered engine (Figure 2-4, Buildings 27/28). Since the emergency equipment would be diesel-fired, the design includes installation of a diesel storage tank. The facility design also incorporates an emergency power back-up generator equipped with a diesel-powered engine.

2.1.2.4.2 *Chemical Storage Pad*

The chemical storage pad (Figure 2-4, Building 30) would hold a 10,000-gallon (40-cubic-meter) tank for sodium hydroxide (used for pH adjustment), a 13,300-gallon (50-cubic-meter) tank for urea (used for biomass fermentation), a 30,400-gallon (115-cubic-meter) tank for ammonia (used for pH control in the enzymatic hydrolysis process and nitrogen control in the biomass boilers), a 50,400-gallon (191-cubic-meter) tank for sulfuric acid, a 53,600-gallon (203-cubic-meter) tank for hydrolytic enzyme cocktail (*cellulase* and *hemicellulase* that perform the enzymatic hydrolysis of the cellulose and any residual hemicellulose in the pretreated biomass), a 53,000-gallon (201-cubic-meter) tank for corn syrup (used to activate the enzymes for hydrolysis), and a 8,000-cubic-foot (230-cubic-meter) silo for lime storage and storage capacity for 3,000 cubic-foot (85-cubic-meter) storage of limestone (used to neutralize the sulfuric acid). The storage tanks would be enclosed in a bermed area to contain spills that could occur.

2.1.2.4.3 *Wastewater Treatment Facility*

The onsite wastewater treatment facility (Figure 2-4, Building 32) would treat all wastewater generated at the facility and would not discharge any to the Hugoton wastewater treatment system. The biorefinery would produce approximately 250 gallons (950 liters) per minute of wastewater that would be treated onsite and reused in the biorefinery processes. The *aerobic* treatment operation would include a membrane bioreactor. One homogenization basin and one emergency pond are included in the wastewater treatment system design. Treated wastewater would be recycled to the enzymatic hydrolysis process. Abengoa Bioenergy would apply approximately 7.5 to 10 gallons (28.4 to 38 liters) per minute of wastewater treatment facility sludge on the buffer area. The land application of this sludge would require a discharge permit from the Kansas Department of Health and Environment. There would be no discharge of wastewater to surface water.

2.1.2.4.4 *Non-Contact Cooling Tower*

Water circulating through heat exchangers, a chiller, and a cooling tower (Figure 2-4, Building 23) would cool equipment and process material during ethanol production. No water discharged from the processes producing ethanol or generated from the cooling tower would come into contact with the production processes. Non-contact cooling wastewater, including reject water from the reverse osmosis process, softener regeneration water, boiler blowdown water, and cooling-water tower blowdown water (approximately 225 gallons [852 liters] per minute), would not be treated in the onsite wastewater treatment system. Instead, it would be used as irrigation water on the buffer area immediately east of the biorefinery parcel. The land application of non-contact cooling wastewater would require a discharge permit from the Kansas Department of Health and Environment. There would be no direct discharge of wastewater to surface water.

2.1.2.4.5 *Paved Plant Roads*

In-plant haul roads would be paved to reduce air emissions. Process-related materials would be received onsite by truck and would include biomass feedstock, and chemicals and supplies. Process-related materials would be shipped offsite by truck and would include cellulose feedstock cleaning waste, and ash. Abengoa Bioenergy would establish a maximum speed limit of 25 miles (40 kilometers) per hour and develop, maintain, and implement a *fugitive dust* control strategy and monitoring plan to reduce visible emissions.

2.1.2.4.6 *Railroad Spur*

A 0.5-mile (0.8-kilometer)-long railroad spur (Figure 2-4) would be built on the Biorefinery Project site to tie the biorefinery to the Cimarron Valley Railroad to receive materials and ship denatured ethanol. Disturbance during construction of the railroad spur is discussed in Section 2.1.1

2.1.2.4.7 *Transmission Lines*

A new 115,000-volt (115-kilovolt) transmission line would be constructed. The approximately 1.5 mile (2.4-kilometer)-long line would begin at the Pioneer Electric Cooperative, Inc., Hugoton Substation, which is approximately 1 mile (1.6 kilometers) northwest of the Hugoton, Kansas, city limits, and run south along County Road 11 and west along County Road P from the Hugoton Substation to the biorefinery. The location of the transmission line as it would enter the biorefinery substation is shown on Figure 2-4. The transmission line is envisioned to be single-pole design (wood), with three-phase conductors (one per phase) and one steel overhead shield wire.

There would be minimal land disturbance associated with the new transmission line and the expansion at the Hugoton Substation. The permanent disturbance would be the land directly impacted by the placement of poles into the ground. It is anticipated that the poles would be embedded into the ground to a depth from 12 to 15 feet (3.7 to 4.6 meters) with the excavated soil spread aboveground at each pole site. Each pole would be from 2 to 3 feet (0.61 to 0.91 meters) in diameter and 80 feet (24 meters) high. Single-pole transmission lines usually have from 8 to 12 poles per mile. The other land disturbances associated with the transmission line would be those associated with construction and placement of the poles and the movement of equipment from pole location to pole location. A 60-foot-wide (18.3-meter-wide) easement (30 feet [9.1 meters] per side) is required along the power line route. All routing turns would likely need guy wires extending down from poles to the ground at a 30-degree angle.

2.1.2.4.8 *Water Supply*

The biorefinery processes would require water for consumptive uses including direct process water and non-contact cooling water. The water balance for the biorefinery estimates a continuous demand of 1,370 gallons (5,200 liters) per minute of well water (normal demand) averaged over time. Abengoa Bioenergy has optioned to purchase existing irrigation water rights from eight agricultural water supply wells. Water use would be converted from agricultural to industrial use to satisfy the water demand of the biorefinery. Approval would be required by the Kansas Division of Water Resources to change the use from irrigation to industrial purposes.

2.1.3 DECOMMISSIONING AND DESTRUCTION OF THE BIOREFINERY

For the purposes of the analysis in this EIS, the projected life of the biorefinery is 30 years. However, Abengoa Bioenergy has not projected a life for the facility. The bioenergy industry is so new that no bioenergy facilities have been decommissioned. While there are no data on which to base the impacts associated with decommissioning and destruction of the biorefinery, DOE does not anticipate impacts to be greater than the impacts associated with construction of the facilities.

2.2 Action Alternative

For the Action Alternative, DOE would provide federal funding to support the design, construction, and startup of a biorefinery that would use a two-stage process to pretreat and hydrolyze and ferment sugars for bioethanol production and would produce syngas using a gasification system.

A boiler fueled with syngas, as well as a biomass boiler, would produce steam. Steam from both boilers would be used to produce ethanol and electricity. The boilers and associated turbines, which would be smaller than those under the Proposed Action, would generate electricity sufficient to operate the biorefinery only.

SYNGAS

Syngas, a biofuel, is a mixture of carbon monoxide, hydrogen, methane, carbon dioxide, and higher hydrocarbon gases. Syngas results from heating biomass in the presence of about one-third the oxygen necessary for complete combustion. Syngas has been used successfully in natural gas-based, reciprocating internal combustion engines and gas turbines with only small modifications.

The milling process under the Proposed Action and Action Alternative is the same. Once milled, the feedstock would be conveyed to the Biomass Pretreatment Building (Figure 2-4, Building 9) for removal of the hemicellulose and pectin with dilute acid. The pretreatment process disrupts the hemicellulose/lignin sheath that surrounds the cellulose in plant material. The hemicellulose and pectin would be recovered as simple sugars and separated from the water-insoluble, cellulose-rich, lignin-rich fiber. Before fermentation, the simple sugars recovered during pretreatment would be treated with lime to neutralize the acid.

After pretreatment, the cellulose-rich, lignin-rich fiber would be treated with enzymes and genetically modified organisms (enzymatic hydrolysis) to simultaneously break down the tougher cellulose and ferment the recovered sugars (Figure 2-4, Building 10) resulting in beer. Volatile organic matter released during processing would be captured in a vent scrubber.

The simple sugars recovered after pretreatment would be transferred to the fermentation tanks via conveyer and mixed with genetically modified organisms to ferment (Figure 2-4, Building 10). At the conclusion of the fermentation process, the beer is between 4 and 5 percent ethanol. Beer would be conveyed to the distiller for purification. Volatile organic matter released during processing would be captured in a vent scrubber.

The beers from enzymatic hydrolysis and the fermentation process would be combined, distilled, and dehydrated (Figure 2-4, Building 13). Ethanol must be anhydrous (without water) for use as a biofuel. Distillation removes the majority of the water and residual solids from the ethanol. Distillation also destroys all living organisms, including genetically modified organisms.

Approximately 71,000 dry short tons (64,000 dry metric tons) per year of soluble and insoluble solids would be recovered from the bottom of the distillation column. The insoluble solids, referred to as lignin-rich stillage cake would be separated from the soluble solids. The soluble solids would be concentrated to a thin stillage syrup in an evaporator and would be combusted in the biomass boilers. Volatile organic matter released during processing would be captured in a vent scrubber.

The ethanol production process would produce approximately 130 dry short tons (120 dry metric tons) per day of lignin-rich stillage cake. A lignin producer would purchase this lignin-rich stillage cake as crude lignin. The producer would have its processing plant near the biorefinery. A conveyer would transport the lignin-rich stillage cake the short distance between the biorefinery and the producer's processing facility. After the lignin was extracted, the lignin producer would return the lignin-poor stillage cake and Abengoa Bioenergy would use it as fuel for the solid biomass boiler. If recovery of lignin is not economically feasible, lignin-rich stillage cake would be used as fuel in the biomass boiler.

The three main markets for lignin-derived products in North America include resin-based binders and bonding agents, antioxidant agents, and water-soluble derivatives and compounds. The most likely use for the recovered lignin would be as a replacement for phenol used in wood bonding to create such products as plywood and fiberboard. Until the lignin extraction facility is built, Abengoa Bioenergy would burn the lignin-rich stillage cake as solid fuel in the biomass boiler. Denaturing the ethanol produced and load-out are the same under both action alternatives.

Under the Action Alternative, the facility would be used to produce approximately 12 million gallons (45 million liters) per year of denatured ethanol and 19,000 tons (17,000 metric tons) per year of lignin. Syngas produced in the gasification plant under the Action Alternative would operate a fire-tube boiler to produce steam. A small biomass solids boiler would also produce steam to power the biorefinery process operations only. Steam would be used to operate a small turbine that would produce 20 megawatts of electricity. The remaining electrical power needs would be purchased from the grid. Figure 2-6 shows a simplified flow diagram showing the conversion of feedstocks to biofuel and biopower under the Action Alternative.

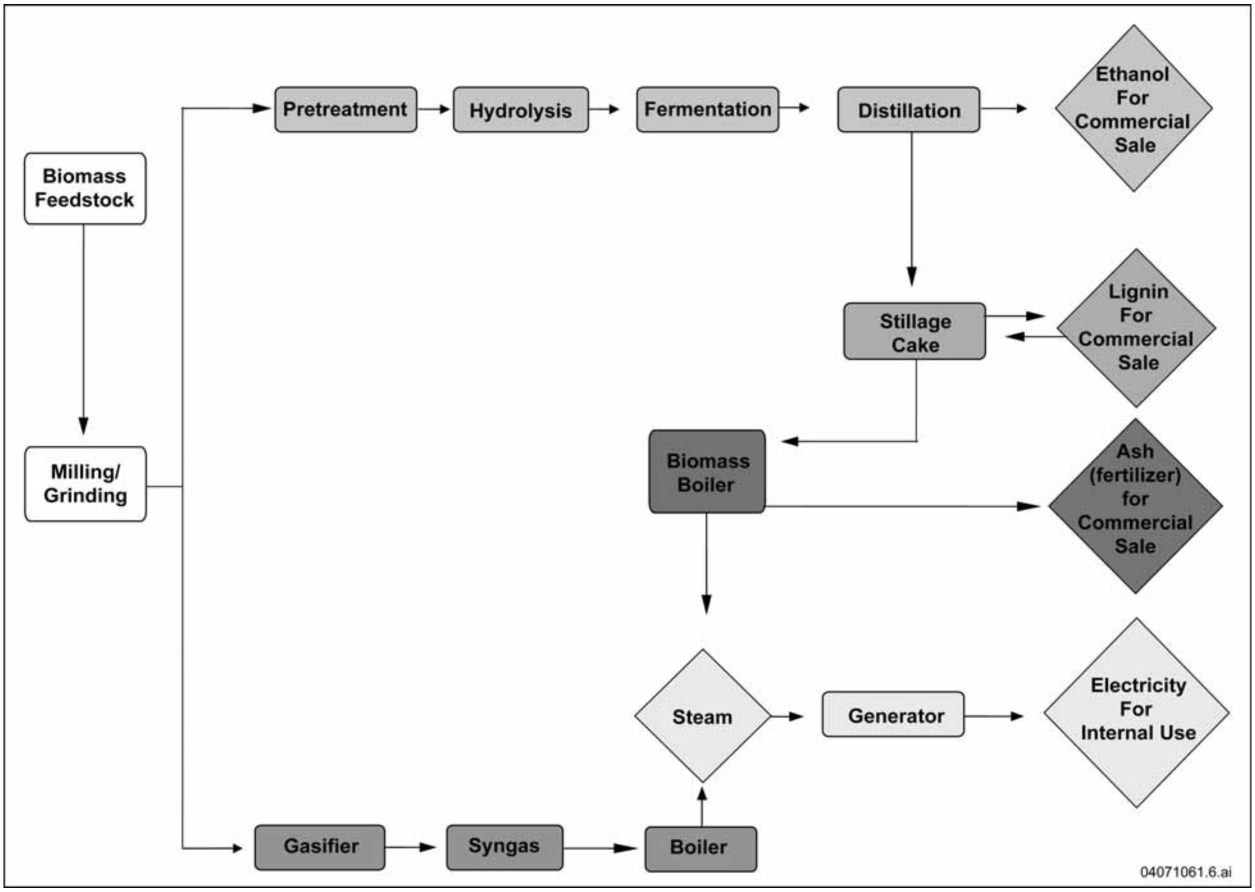

Figure 2-6. Simplified diagram showing conversion of feedstocks to biofuel and biopower under the Action Alternative.

2.3 Comparison of Design Features

Table 2-1 provides a comparative overview of the biorefinery design features and products under the Proposed Action and Action Alternative.

Table 2-1. Comparison of the design features and products of the biorefinery under the Proposed Action and Action Alternative.

Design features/products	Proposed Action	Action Alternative
Biomass feedstock	Approximately 2,500 dry short tons (2,300 dry metric tons) per day	800 dry short tons (700 dry metric tons) per day
Fermentation facility	One step feedstock hydrolysis/fermentation process	Feedstock pretreatment to remove simple sugar molecules followed by hydrolysis/fermentation process on the remaining cellulose
Gasifier	No	Yes, syngas production
Steam production	Larger biomass boiler	Smaller gas boiler and small biomass boiler
Ethanol production	18 million gallons (68 million liters) per year	12 million gallons (45 million liters) per year

Table 2-1. Comparison of the design features and products of the biorefinery under the Proposed Action and Action Alternative (continued).

Design features/products	Proposed Action	Action Alternative
Lignin-rich stillage cake (not including distiller's syrup)	117,000 dry short tons (106,000 dry metric tons) per year	45,000 dry short tons (41,000 dry metric tons) per year
Lignin production	45,000 dry short tons (41,000 dry metric tons) per year	19,000 dry short tons (17,000 dry metric tons) per year
Electricity production	92 megawatts	20 megawatts
Electricity purchase	None	10 megawatts (15 megawatts during peak demand)
Boiler ash	80,000 tons (72,000 metric tons) per year	11,000 tons (10,000 metric tons) per year
Gasifier ash	0	9,000 tons (8,000 metric tons) per year

2.4 No-Action Alternative

Under the No-Action Alternative, DOE would not provide federal funding to Abengoa Bioenergy to support the design, construction, and startup of a biorefinery. Abengoa would not build a biorefinery and the biorefinery parcel would remain agricultural land. The Department recognizes, however, that Abengoa could pursue alternative sources of capital for development of the biorefinery.

2.5 Findings of this EIS

To meet the mandates of the *Energy Policy Act of 2005* and other governing policies, it is in the best interest of DOE to select and fund the most technologically and economically viable alternative. The Proposed Action represents this alternative. DOE has identified the Proposed Action as its preferred alternative.

Table 2-2 summarizes the potential impacts of the Proposed Action, the Action Alternative, and the No-Action Alternative. DOE assessed potential impacts during construction and operation of the proposed biorefinery for 13 resource and subject areas including transportation and accidents. For most resource and subject areas, potential impacts would be small. Potential health and safety impacts indicate the biorefinery could be constructed and operated without significant impacts to workers or the public.

Table 2-2. Comparison of potential impacts under the Proposed Action, Action Alternative, and No-Action Alternative.

Resource area	Proposed Action	Action Alternative	No-Action Alternative
Land use			
	Conversion of 385 acres to non-agricultural production.	Same as Proposed Action.	Land use for the 385 acres (1.6 square kilometers) would remain agricultural.
	No change to land use or agricultural practices to meet demand for biomass feedstock.		
	No changes to land in Conservation Reserve Program, *prime farmland*, *highly erodible* land, or public lands.		
	No change in soil erosion.		
	Minor adverse impact on soil organic content in some fields. No regional impact on agricultural production.		
	Biorefinery consistent with local zoning and land use.		
Air quality			
	Short-term and intermittent emissions during construction.	Same as Proposed Action.	There would be no construction.
	Concentration from operations, along with background concentrations, are about 60% of the *National Ambient Air Quality Standards* for 24-hour PM_{10}, 18% for nitrogen dioxide, and less than 10% of the standards for other pollutants.	Concentration from operations, along with background concentrations, are about 50% of the National Ambient Air Quality Standard for 24-hour PM_{10}, 13% for nitrogen dioxide, and less than 10% of standards for other pollutants.	There would be no changes in air emissions from current background levels.
	Emissions of nitrogen oxide (0.14 pound per million British thermal units) exceed limits specified in EPAct of 2005 (0.08 pound per million British thermal units).		
	Estimated reduction in *greenhouse gas* emissions of 306% by replacing gasoline fuel in vehicles with biomass-derived ethanol.	Estimated reduction in greenhouse gas emissions of 39% by replacing gasoline fuel in vehicles with biomass-derived ethanol.	There would be no reduction in greenhouse gas emissions.
Surface water			
	Minor changes to drainage patterns on the Biorefinery Project site.	Same as Proposed Action.	There would be no changes in drainage patterns on the Biorefinery Project site.

Table 2-2. Comparison of potential impacts under the Proposed Action, Action Alternative, and No-Action Alternative (continued).

Resource area	Proposed Action	Action Alternative	No-Action Alternative
	Runoff and planned releases of wastewater limited to the Project site. No surface waters would be affected by accidental spills. No *floodplain*s or *wetlands* would be affected.		
Groundwater			
	Water Requirements: • Construction phase – 220 acre feet • Operations phase – 2,170 acre-feet annually Net operations water demand is 5,000 acre-feet per year less than permitted for eight supply wells, thus there would be a beneficial decrease in water withdrawals from the High Plains *aquifer*.	Water Requirements: • Construction phase – 210 acre feet • Operations phase – 850 acre-feet annually Net operations water demand is 1,300 acre-feet per year less than permitted for three supply wells, thus there would be a beneficial decrease in water withdrawals from the High Plains aquifer.	Water withdrawal from the affected wells would continue to be used for crop irrigation. There would be no net reduction in water withdrawal from the High Plains aquifer (i.e., 5,000 acre-feet from the Proposed Action or 1,300 acre-feet from the Action Alternative).
Biological resources			
	Minor short-term and long-term impacts to common species from construction and operations within 0.5 mile (0.8 kilometer) of the biorefinery. No *threatened* or *endangered species* would be impacted by the construction and operation of the biorefinery.	Same as Proposed Action	No impacts to biological resources.
Utilities, energy, and materials			
	Maximum domestic and potable water demand about 25% of unused capacity of Hugoton water system. Design capacity of Hugoton sewage lagoons approached during construction, but not exceeded.	Same as Proposed Action	There would be no impact on the Hugoton water system. There would be no increase in the sewage load (beyond current loads) to the Hugoton sewage lagoons.

Table 2-2. Comparison of potential impacts under the Proposed Action, Action Alternative, and No-Action Alternative (continued).

Resource area	Proposed Action	Action Alternative	No-Action Alternative
	Energy: Needs of biorefinery generated onsite, and 70 megawatts of electricity supplied to regional grid (equal to 5.4% of production capacity in western-central Kansas).	Requires electrical power from regional grid, equal to less than 1% of production in local region.	No electrical power would be needed and no electricity would be supplied to the regional grid.
	Construction materials: With possible exception of stainless steel, no availability issues, and needs would not stress regional market for materials.	Same as Proposed Action.	No additional demand (beyond current levels) for construction materials.
Waste, byproducts, and *hazardous materials*			
	Stevens County landfill would not have adequate capacity to receive construction or operations wastes generated and maintain its small arid landfill exempt status. This waste could be split among other landfills and a transfer station in the region.	Same as Proposed Action.	There would be no wastes, byproducts or hazardous materials generated.
	Ash not used as a soil amendment would be disposed of among the landfills and transfer stations in the region.		
	No adverse impacts from land application of wastewater or sludge.		
	No adverse impacts if proposed *hazardous waste* management practices are implemented.		
Transportation			
	32 estimated traffic fatalities from shipments and commuting workers.	13 estimated traffic fatalities from shipments and commuting workers.	There would be no shipments or commuting workers and thus no associated traffic fatalities.
	$680,000 annual cost of pavement damage from biomass shipments.	$210,000 annual cost of pavement damage from biomass shipments.	There would be no shipments or commuting workers and thus no associated pavement damage.
	No adverse impacts to operation of local railroad.	No adverse impacts to operation of local railroad.	
	No roadway improvements required to reduce congestion or improve access to site.	No roadway improvements required to reduce congestion or improve access to site.	

Table 2-2. Comparison of potential impacts under the Proposed Action, Action Alternative, and No-Action Alternative (continued).

Resource area	Proposed Action	Action Alternative	No-Action Alternative
Visual resources			
	Several structures, including a 115-foot-tall structure, visible from surrounding vantage points.	Fewer tall structures than Proposed Action, thus less visible from surrounding vantage points.	No structures would be built on the Biorefinery Project site and visual resources would be unchanged.
	Source of night lighting.	Source of night lighting.	No source of night lighting.
	A 1.5-mile-long transmission line visible from Road P and Road 11.	No new transmission line.	No new transmission line.
Noise			
	Noise exposure to workers would be minimized through implementation of a hearing conservation program.	Same as Proposed Action.	There would be no change in noise from background levels.
	Construction and operations noises would be near background levels at the nearest residences.		
	Nearby residences and a hospital, churches, and other facilities in Hugoton would experience noise from passing trucks about every 9 to 24 minutes, which would interfere with conversations outdoors and cause annoyance indoors.	Trucks would pass residences and facilities in Hugoton every 30 minutes or less, which would interfere with conversations outdoors and cause annoyance indoors.	There would be no trucks passing and thus no interference with conversations outdoors and annoyance indoors.
Odor			
	Odors would not be detectable offsite.	Same as Proposed Action.	There would be no odors.
Socioeconomics			
	Up to 256 workers employed during construction and 43 during operations.	Up to 230 workers employed during construction and 34 during operations.	There would be no increase in employment above current levels.
	1% increase in the population of the region during construction, and 0.1% increase during operations.	0.9% increase in the population of the region during construction, and 0.1% increase during operations.	
	Little impact to public services.	Little impact to public services.	There would be no impact on public services.
	$17 million annual infusion of earnings during construction and $4.4 million annually during operations.	$16 million annual infusion of earnings during construction and $3.4 million annually during operations.	There would be no annual infusion of earnings.

Table 2-2. Comparison of potential impacts under the Proposed Action, Action Alternative, and No-Action Alternative (continued).

Resource area	Proposed Action	Action Alternative	No-Action Alternative
Cultural resources			
	No adverse impacts	Same as Proposed Action.	Same as Proposed Action.
Health and safety			
	Public not affected by industrial hazards.	Same as the Proposed Action.	There would be no hazards to the public.
	Construction workers: 13.5 *total recordable cases*, 7 *days away from work* cases, and 0.026 fatality estimated.	Construction workers: 12.1 total recordable cases, 6.3 days away from work cases, and 0.023 fatality estimated.	
	Operations workers: 2.7 total recordable cases, 0.94 day away from work, and 0.0014 fatality estimated.	Operations workers: 2.3 total recordable cases, 0.68 day away from work, and 0.0011 fatality estimated.	
Accidents			
	Accidents during operation of the biorefinery would be unlikely to impact the general public.	Same as the Proposed Action.	There would be no potential for accidents and thus no hazards to the general public.
Environmental justice			
	No impacts to communities with high percentages of *minority* and *low-income* populations.	Same as Proposed Action.	There would be no environmental justice impacts.
	No unique exposure pathways, sensitivities, or cultural practices that would result in different impacts on minority or low-income populations.		
	Disproportionately high and adverse impacts would be unlikely.		

2.6 Alternatives Considered but Eliminated from Detailed Consideration

2.6.1 ALTERNATIVE LOCATIONS

Abengoa Bioenergy considered a number of locations in Illinois, Iowa, Missouri, Nebraska, Oklahoma, eastern Colorado, and Kansas for the biorefinery. Abengoa Bioenergy used the following site selection criteria:

- Proposed ethanol plant would need to be located adjacent to railroad and/or barge transportation;
- Site should be relatively close (within a 50-mile radius) to large quantities of wheat straw, corn stover, certain varieties of grass, and/or other sources of cellulose;
- Facility will need an adequate long-term water supply;
- A minimum requirement of approximately 400 acres of land would be needed for layout of the biorefinery;
- Potential for adverse meteorological conditions to affect refinery operations;
- Overall potential for efficient and cost effective cellulosic ethanol production potential; and
- Public acceptance of an ethanol plant in its respective community.

Abengoa Bioenergy selected six specific locations for more in-depth analyses. These sites included Imperial, Nebraska; Colwich, Dodge City, Wellington, and Hugoton, Kansas; and Gillman, Illinois.

Abengoa Bioenergy eliminated the Imperial, Nebraska, location because its feedstock was primarily corn stover, negating the design efforts to process multiple feedstocks. Colwich and Wellington, Kansas, both ranked low in corn production and had no large feedlots within a 50-mile (80-kilometer) radius. In its review of Dodge City, Kansas, Abengoa Bioenergy could not identify an adequate long-term water supply. Gilman, Illinois, was eliminated not only because it lacked diversity in biomass feedstock, but it has a rainy season in November, which might interfere with harvesting feedstock. Because of these and other reasons identified during its in-depth review, Abengoa Bioenergy selected Hugoton, Kansas, as its preferred site.

2.6.2 ALTERNATIVE DESIGN

The original application for a cellulosic biorefinery proposed a traditional grain-to-ethanol facility integrated with the biomass facility. Market conditions determined that the grain-to-ethanol facility was not economically viable at this time.

2.6.3 ALTERNATIVE PROCESS ELEMENTS

During the initial review of processes for this EIS, DOE considered wet versus dry storage of the biomass, onsite versus offsite storage, and options for the management of lignin and boiler ash. Initial analysis of wet versus dry storage and onsite versus offsite storage did not identify any meaningful environmental differences. DOE retained the management of lignin and boiler ash for detailed analysis.

REFERENCES

Roach, C. 2009a. "Data Needs #1, 44." Email from C. Roach, Abengoa Bioenergy, to K. Kerwin, DOE-Golden, dated March 6, 2009.

Roach, C. 2009b. "Data Need 42." Email from C. Roach, Abengoa Bioenergy, to E. Harr, S. Walker, R. Tedlock, D. Lechel, and J. Stover, EIS Team, dated March 1, 2009.