Chapter 2. Proposed Action and Alternatives

2 PROPOSED ACTION AND ALTERNATIVES

This chapter describes DOE's Proposed Action and No Action Alternative, and it describes Summit's proposed TCEP and alternatives considered by Summit but eliminated from further consideration. Along with an overview of the TCEP, this chapter provides detailed technical information on the proposed project that forms the basis for the analyses in this EIS. This information includes detailed descriptions of the polygen plant, linear facility options, CO_2 capture and sequestration methods, resources required for the proposed project, by-products and wastes, construction and operation plans, measures to reduce potential impacts, and post-operation activities. The chapter also describes the operational options considered by the project.

2.1 Introduction

The TCEP would be located approximately 15 miles (mi) (24 kilometer [km]) southwest of the city of Odessa in Ector County, Texas. The proposed 600-ac (243-ha) polygen plant site is located in the community of Penwell, just north of Interstate (I)-20 and a Union Pacific Railroad (UPRR) line. The land has historically been used for ranching and limited oil and gas activities.

As proposed by Summit, the TCEP would consist of the polygen plant and the linear facilities that would be constructed and operated to serve the plant. The polygen plant would use a commercial IGCC system and would be integrated with CO_2 capture and geologic sequestration through EOR. The proposed linear facilities would consist of an electric transmission line, one or more process waterlines, a natural gas pipeline, a CO_2 pipeline connector, a rail line connector, and two access roads that would connect the plant to existing roads.

Figure 2.1 shows the plant site and associated linear facilities, which consist of the four waterline options (WL1–WL4), six transmission line options (TL1–TL6), the CO_2 pipeline connector (CO_2), natural gas pipeline (NG1), two access roads (AR1–AR2), and one rail spur (RR1).

> **EOR** refers to techniques that allow increased recovery of oil in partially depleted or high viscosity oil fields. CO_2 flooding (CO_2 EOR) has the potential to not only increase the yield of residual or high viscosity oil, but also to sequester CO_2 that would normally be released to the atmosphere.
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> In general terms, CO_2 is injected into an oil field through injection wells drilled near producing wells. The CO_2 and oil mix together and form a mixture that more easily flows to the production well. To sweep out residual oil, CO_2 is cycled through the oil field one or more times, with each cycle resulting in a part of the CO_2 becoming trapped in the spaces that were previously occupied by oil. The CO_2 that comes up the well with the oil is recovered and re-injected into the field. Maturing oil fields and rising oil prices have made this method of resource recovery increasingly attractive to industry. Currently, CO_2 EOR comprises approximately 37 percent of all EOR being performed in the United States (water is also used). The United States has been a leader in developing and using technologies for CO_2 EOR by performing approximately 96 percent of worldwide CO_2 EOR.
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> CO_2 EOR has been used by the oil and gas industry for more than 40 years, but only recently has its potential as a CO_2 sequestration method been realized and investigated. The CO_2 used to increase oil production is an expensive commodity, and for this reason, oil companies are highly motivated to ensure that CO_2 does not escape to the atmosphere.

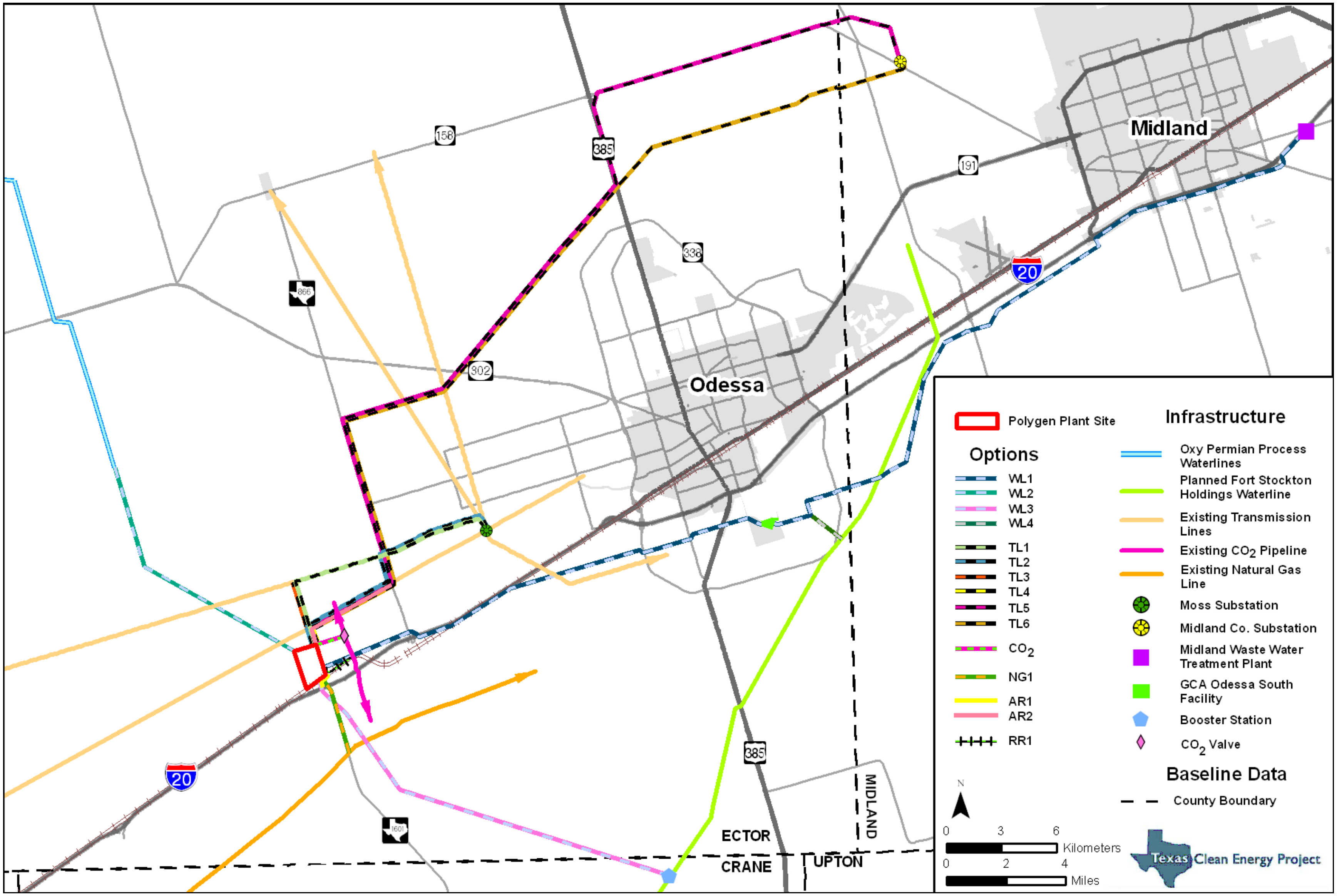

Figure 2.1. Polygen plant site and associated linear facilities.

The polygen plant is being designed to use low-sulfur, Powder River Basin sub-bituminous coal from Wyoming as the feedstock for the gasification island, which would use two Siemens gasifiers to convert that feedstock into syngas for downstream use. After further cleaning, chemical conversion and processing of the syngas, followed by capture and removal of CO_2, the H_2-rich syngas would be used in the power island to generate 400 MW (gross) of electrical power.

The TCEP would contribute approximately 213 MW net (1.7 billion net kilowatt-hours) of electricity per year to the electric grid system, which would help meet future demand. The remainder of the gross generation would be used to run the plant. In addition, the polygen plant would be designed to capture, as CO_2, 90 percent or more of the total carbon in the fossil fuel used in the plant under almost all operating conditions. The captured CO_2 would be sold under binding commercial contracts and subsequently injected deep underground for EOR. The plant would also produce urea for fertilizer. Argon and H_2SO_4 would be by-products of the gasification and syngas cleanup processes and would be made available for commercial sale. Slag (an inert by-product of the gasification process) could be sold as a raw material for manufacturing cement and other products.

Interconnections for supplies of natural gas and process water would all be required. Potable water would be trucked to the site. The TCEP generating facilities would connect with existing transmission lines. Captured CO_2 would be transported from the plant site by pipeline to an existing Kinder Morgan CO_2 pipeline. Coal would be delivered to the plant site by the UPRR line adjacent to the site. Chemical products produced by the plant would be transported off-site by rail or by truck.

Waste water would be managed through on-site processes to minimize overall water demand. Disposal of final brine water effluent would be through a zero liquid discharge (ZLD) system or by on-site deep well injection. Slag that could not be sold for commercial use would be sent by truck or rail to a licensed off-site landfill. Sanitary wastes would be collected and discharged directly to an on-site septic system.

The primary access to the plant would be from Farm-to-Market Road (FM) 866 at the northern border of the plant site, with emergency vehicle, plant administrative workforce, and visitor access from FM 1601 at the southeastern border of the plant site. Use of FM 1601 to access the plant site would require construction of an underpass, overpass, or at-grade intersection with the UPRR line.

2.2 DOE's Proposed Action

DOE's Proposed Action is to provide a total of approximately $450 million in financial assistance for Summit's proposed TCEP through a cooperative agreement. The money would be provided on a cost-share basis for the planning, design, construction, and demonstration-phase testing and operation of the project. Under the terms of the cooperative agreement, DOE has made available approximately $37 million on a cost-share basis for the project definition phase, which includes completion of the EIS. This is 80 percent of the estimated $46.3 million cost of the project-definition phase. The activities eligible for cost sharing during this phase include preliminary design and environmental studies that provide the basis for this EIS. Making these funds available does not prejudice DOE's ultimate decision on the Proposed Action and is consistent with DOE and Council on Environmental Quality regulations (10 C.F.R. § 1021.211 and 40 C.F.R. § 1506.1, respectively), which restrict DOE from taking action that would have an adverse environmental impact or limit the choice of reasonable alternatives until the Record of Decision has been issued.

Summit's application for DOE financial assistance indicated that the TCEP "is readily expandable with gasifiers and other components in modules" (Summit 2009). However, Summit has no plans for expansion at this time. Thus, such activities are speculative and not within the scope of this EIS. Any future expansion, were it to occur, would remain in the current 600-ac (243-ha) site, and no modifications to any linear facilities would be required. If a future expansion involved federal funds or federal lands or required a federal permit or approval, the potential impacts of such an expansion would be subject to the appropriate level of NEPA analysis and disclosure.

2.3 Development of Summit's Proposed Project

2.3.1 Technology Selection

Summit's primary business is the development of power projects having low- to zero-CO_2 emissions, including wind power projects, solar power projects, and combined-cycle gas-fueled power plant projects. Summit has more than $5 billion in commercially operating projects, most of them using Siemens power-generation equipment.

In the early 2000s, Summit began considering the development of an IGCC plant with the intention of providing CO_2 capture when the technology became available. In 2007, Siemens acquired and began testing a gasification technology. Subsequently, the TCEP began as a joint Summit and Siemens concept, building on the development of the proposed REC project in Butte, Montana. The REC project was conceived as a means of supplying electric power, H_2, argon, and other chemicals to REC Silicon, a large manufacturer of polysilicon for solar power and computer applications. Fluor was selected as the REC project's design engineer. Fluor began work under Summit's direction in the configuration and preliminary design engineering of the two-gasifier Siemens reference plant that is the model for the TCEP.

The TCEP's size was based on technology considerations and transmission limitations in West Texas. Summit and Siemens selected a two-gasifier configuration using Siemens SFG-500 gasifiers, with one combustion turbine and one steam turbine. Siemens has designed these gasifiers into a "twin pack" with all the surrounding feedstock, waste water, and product processing equipment to maximize efficiency. However, with two gasifiers and one combustion turbine, the polygen plant would produce excess syngas but not enough to support two combustion turbines (one gasifier would be insufficient for one combustion turbine). Although the excess syngas could be used to make several types of products, market research revealed that the production of urea for fertilizer would have the most financial benefit. A three-gasifier and two combustion turbine configuration was eliminated from consideration because the amount of electricity that would be generated as a result would likely exceed the transmission capacity available in the area.

While the basic configuration of the plant and its technology selections were specified in Summit's proposal submitted to DOE and accepted under the CCPI Round 3 program, two technology options remain under consideration by Summit. For the disposal of brine water from the reverse osmosis system, Summit is considering: 1) a brine concentrator and filter press system, 2) a solar evaporation pond system, or 3) a deep injection well located onsite. To meet the cooling needs for the chemical process portion of the plant, Summit is considering either wet or dry cooling towers, depending on the degree of cooling required and on system economics. These technology options are described in subsequent sections of Chapter 2, and their potential impacts are described where appropriate in Chapter 3.

2.3.2 Alternative Sites

Because of its desire to integrate IGCC technology with CO_2 capture, Summit focused its siting efforts in Texas, which has both a market for CO_2 for use in EOR and existing infrastructure for transporting CO_2 to oil fields. Oil producers in Texas have used CO_2 for many years, and the Texas Bureau of Economic Geology was willing to assist the project.

Summit considered several sites in Texas, including Oak Grove, Corpus Christi, Big Brown, and the two sites—Jewett and Odessa—that had been considered for DOE's FutureGen project, which also would have used IGCC with CO_2 capture. Summit ultimately selected the Odessa site primarily because of its proximity to an existing CO_2 pipeline and multiple EOR sites. The Odessa site also has close access to rail, natural gas, transmission lines, and available sources of water, which the other Texas sites lacked in varying degrees. Finally, the Odessa site enjoys significant community support for the TCEP.

2.3.3 Linear Facility Options

Summit selected options for its required linear facilities based on the most direct routes from the polygen plant site to the closest interconnection points, taking into account the need to minimize adverse impacts to residences and the environment and to minimize construction issues. The linear facilities selected would use existing linear facilities or ROWs to the fullest extent possible.

With respect to the process water needed for the plant, Summit sought to avoid water sources that would cause a conflict with municipal drinking water needs. Thus, Summit is considering the use of some of the city of Midland's waste water effluent blended with city of Odessa waste water with additional processing at the Gulf Coast Waste Disposal Authority (GCA) Odessa South Facility in Odessa. This may be supplemented by the use of brackish (highly saline and nonpotable) ground water from the Capitan Reef Complex Aquifer through an existing pipeline system owned by Oxy USA-W Texas Water Supply (Oxy Permian). In addition, FSH has proposed the development of a water pipeline to provide raw water for municipal use in Midland and Odessa. Should such a pipeline be constructed, Summit would also consider it as a potential process water source.

2.4 Summit's Proposed Project

2.4.1 Process Description

The TCEP would integrate coal gasification, combined-cycle power generation, CO_2 capture, and urea production. These four processes are described below, and a diagram of how these technologies are integrated is shown in Figure 2.2. Unless otherwise noted, the source for the process description is the *Texas Clean Energy Project Initial Conceptual Design Report* dated September 2010 (Summit 2010a).

2.4.1.1 COAL GASIFICATION, SYNGAS PROCESSING, AND CARBON DIOXIDE CAPTURE

Gasification is a thermo-chemical process that converts carbon-based materials, such as coal, into syngas, which is composed primarily of H_2 and carbon monoxide (CO). The conversion occurs in a reduced oxygen (O_2) atmosphere and at temperatures up to 3,000 degrees Fahrenheit (1,648 degrees Celsius). For the TCEP, coal feedstock would be pulverized and transferred to two Siemens gasifiers along with limited amounts of nearly pure O_2 gas. In the gasifiers, controlled reactions would take place, converting the coal into syngas. Along with the H_2 and CO, varying amounts of CO_2, nitrogen (N_2), sulfur species, methane, volatilized metals, and PM would also be in the raw syngas. The syngas would then be cooled and cleaned of PM.

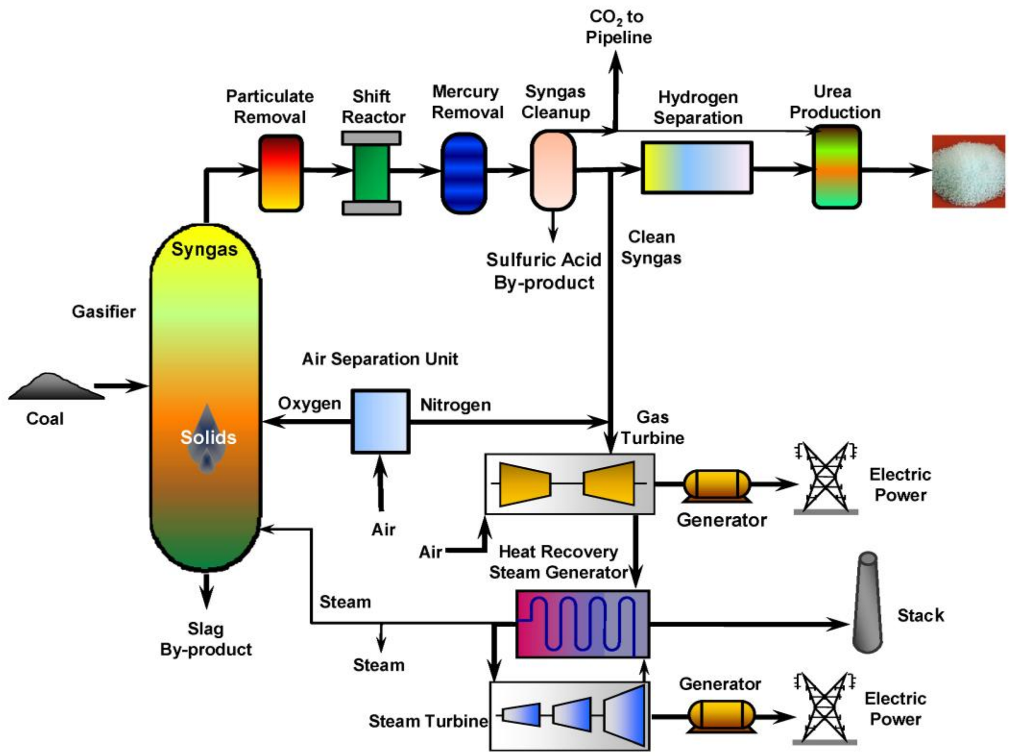

Figure 2.2. TCEP gasification, power generation, and urea production.

Next, the syngas would flow through a water-gas shift reactor. In that system, steam would be injected in the syngas over a catalyst bed, initiating a reaction where the CO in the syngas would be converted to CO_2 and the steam would be converted to additional H_2 in the syngas stream. This would provide a syngas stream that is concentrated in both CO_2 and H_2. Subsequently, the syngas would pass through a Hg removal system and then an acid gas removal system where first the sulfur species would be removed. Next, the CO_2 would be removed, creating a clean, H_2-rich concentration syngas upon exiting the acid gas removal unit. The captured CO_2 would be further cleaned and compressed, and then transported by a short pipeline to an existing regional CO_2 pipeline or, potentially, to a nearby EOR field. A portion of the captured CO_2 would also be used to produce urea. The H_2-rich syngas stream would be split, where part would be used to produce electricity and the other part would be used to produce urea for fertilizer.

Argon and H_2SO_4 are by-products of the gasification process and would be made available for commercial sale. Inert slag, another by-product of the gasification process, would be sold for manufacturing and construction uses or disposed of off-site.

2.4.1.2 POWER GENERATION

For the TCEP, the clean, H_2-rich, low-CO_2 syngas would be combusted in a combustion turbine-generator, generating electricity. Combustion of the H_2-rich fuel gas would produce water vapor and a low-CO_2 exhaust gas with significantly lower CO_2 emissions than would occur if the coal itself, or the raw syngas, had been combusted. The exhaust gas would be ducted through an HRSG, which would generate high-temperature, high-pressure steam. This steam would be piped into a steam turbine-generator, which would generate additional electricity. This integration of the combustion turbine-generator, HRSG, and steam turbine-generator is known as a combined-cycle power plant, and is presently one of the most efficient means for generating electricity because two opportunities are used to produce electricity from coal, instead of one steam turbine-generator alone.

The combined power generation from the combustion turbine-generator and the steam turbine-generator would be approximately 400 MW (gross) with 213 MW sent to the grid, on average, and the remainder being used to run the plant's equipment. The electricity sold would be transmitted to the regional electrical grid by a high voltage transmission line system. Natural gas would be used to start up the polygen plant and as a backup fuel (natural gas would also be used during operations to heat drying gases, supply an auxiliary boiler, and provide burner pilot flames such as for flares).

2.4.1.3 Fertilizer Production

With two Siemens gasifiers, the TCEP would produce more syngas than could be used for electricity production. The additional syngas produced would be converted to NH_3 using the Haber process. In that process, the H_2 in the syngas is reacted with N_2 from the air separation unit, forming NH_3. Downstream, the NH_3 is reacted with a portion of the CO_2 from a syngas cleanup system, thereby forming urea in a Bosch-Meiser process. The urea is produced as a granular product common in the fertilizer industry.

2.4.2 Process Components and Major Equipment

The site layout of the polygen plant is shown in Figure 2.3. A process flow diagram for the TCEP is shown in Figure 2.4. The process components and major equipment shown in the process flow diagram are described below.

2.4.2.1 COAL RECEIVING, STORAGE, AND HANDLING SYSTEM

At full load, the TCEP would consume approximately 5,800 tn per day (5,262 t per day) of Powder River Basin sub-bituminous coal, which would be delivered to the site by rail from Wyoming. A single system for receiving, storing, and handling coal would feed both gasifiers. The coal handling system would consist of a railcar unloading facility, a coal storage system, a reclaim system, a coal crushing system, and a silo fill system. The function of this system would be to unload coal from unit trains, convey it to the active storage pile, recover the coal from the storage pile, crush the coal, and convey it to the coal silos in the coal grinding and drying building.

The railcar unloading system would consist of rapid-discharge, bottom-dumping railcars with an automatic continuous dumping system. The rail unloading hopper would be capable of unloading coal from the railcars at a rate of 4,000 tn (3,628 t) per hour. Belt feeders would transfer coal from the unloading hoppers to a conveyor, which would transfer coal to the coal storage piles.

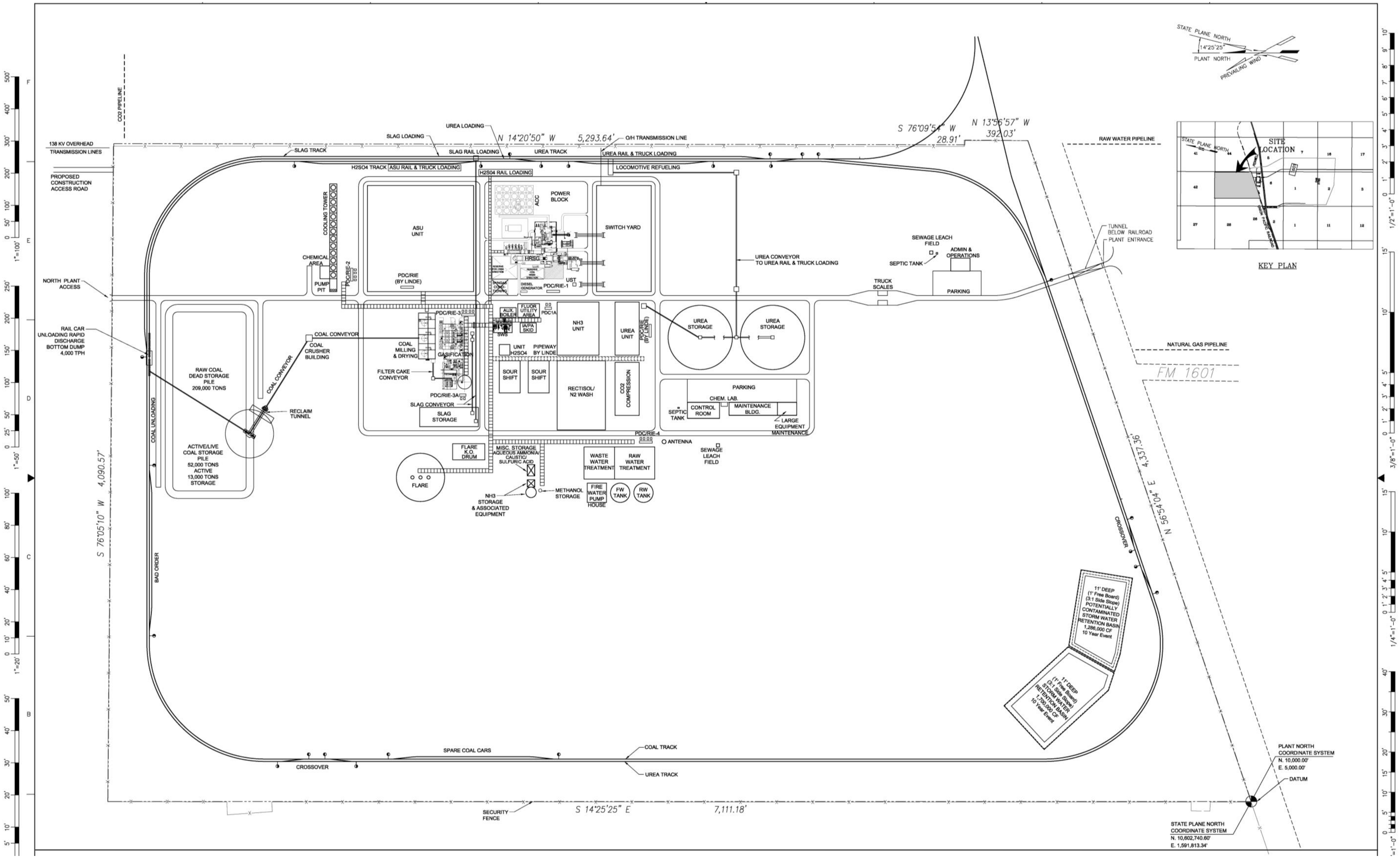

Figure 2.3. Polygen plant layout.

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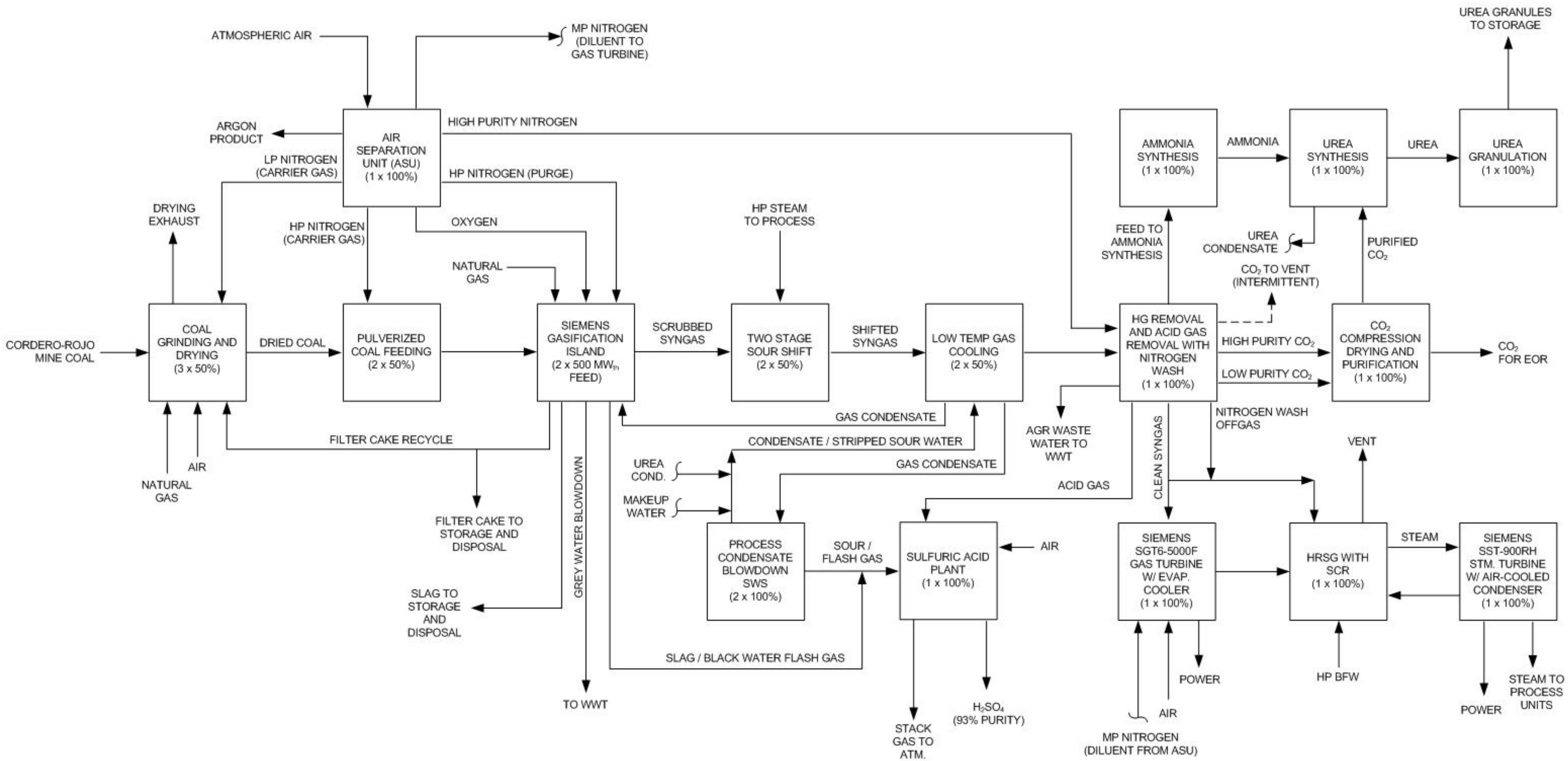

Figure 2.4. TCEP process flow diagram (Summit 2010a).

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From the coal pile, coal would be gravity-fed into the reclaim hoppers located below the pile. Reclaim belt feeders would transfer coal from the reclaim hoppers at a rate of 1,000 tn (907 t) per hour, to the crusher feed conveyors, which would transfer coal to the surge bin in the crushing system. From the surge bin, coal would be transferred to crushers by the crusher belt. Two crushers, each sized to process 1,000 tn (907 t) of coal per hour, would be used. A series of conveyors would transfer crushed coal from the crushers to the coal grinding and drying feed silos. All conveyors would be completely enclosed to reduce noise, and all coal handling buildings would be fully enclosed with dust suppression sprays and collection systems used to control dust and noise.

2.4.2.2 COAL DRYING AND GRINDING SYSTEM

The coal would be simultaneously dried to approximately 8 weight percent moisture and ground to less than 200 micrometers in diameter in two bowl mills. A traveling trip conveyor would feed each of the three grinding trains, distributing the coal into feed bins serving each train. Hot drying gases (heated by combusting natural gas) would also enter the mill from the bottom, and then carry the dried, crushed coal and gases out of the mill and to a cyclone classifier, which would return particles larger than the desired size to the mill. A portion of the spent hot drying gas would be purged through a dust collector (fabric filter) and vented to the atmosphere. Collected dust would be combined with the coal from the cyclone. The dry, ground coal would then be pneumatically conveyed (using N_2 gas) to the individual storage bins that serve each gasifier.

2.4.2.3 AIR SEPARATION UNIT

A single air separation unit would provide O_2 gas and N_2 gas for the entire TCEP plant. The air separation unit would produce 99.5 percent pure O_2 gas for use as an oxidant in the gasifiers, and 99 percent pure N_2 gas for use as a diluent in the combustion turbine and for producing urea fertilizer. In addition, N_2 gas at various pressure levels would also be used as a carrier gas for feeding the dried, pulverized coal to the gasifiers and for purging purposes in the gasification island. Producing high-purity O_2 gas in the air separation unit would also allow for a high-purity stream of argon gas to be recovered. This is a commercially marketable product.

For startup and shutdown purposes, and to enhance overall plant availability, liquid O_2 and liquid N_2 storage would be provided for 12 hours of plant operation.

2.4.2.4 GASIFICATION ISLAND

The gasification island would use two Siemens SFG-500 entrained flow, O_2-blown gasifiers to produce a raw syngas from the pulverized coal. The gasification island includes a pulverized coal feeding system, two gasifiers (including the quench sections), raw syngas scrubbers, black water treatment, and a slag discharge unit. The Siemens gasification island is shown in Figure 2.5.

Gasifiers

The coal feeding system would receive the pulverized and dried coal from the drying and grinding system described above, and feed it into the gasification reactors where the gasification reactions would take place. The coal would be almost totally gasified in this high-temperature environment to form raw syngas consisting principally of H_2, CO, CO_2, and water. The inorganic materials in the coal would be converted to a hot, molten slag. The hot raw syngas and the molten slag would leave the gasifier (shown as the reactor in Figure 2.5) and flow downward into the quench section. There, the raw syngas would be cooled by the injection of water, and the molten slag would solidify in the bottom of the quench section.

The mixture of granulated slag, quench water, and some unreacted char forms a mixture referred to as *black water*. The black water stream would be removed from the quench chamber and treated in the black water treatment plant. A portion of that stream would be recycled for use as quench water, with the remainder being cleaned further for use in other areas of the plant. The slag removed from the quench sump would be dewatered and conveyed to the slag handling, storage, and loadout system (see description below). Water carried out of the slag discharge system would be collected and pumped to the black water treatment plant. Water needed in the slag discharge system would be recycled from the black water treatment plant.

The raw syngas from the quench section would be sent to a Venturi scrubber system for removal of fine ash, chlorides, and char. A portion of the scrubber water would be directed to the black water treatment plant. To reduce fine particles in the raw syngas, a partial condenser would be installed downstream of the scrubber unit. A flash flare port with emergency depressurization would be located immediately downstream of the separator. During startup and in emergency situations, the raw syngas would be burned in a flare, with the exhaust gases vented to the atmosphere.

Black Water Treatment Plant

The black water treatment system would include one flash vessel for each of the two gasifiers, chemical dosing (for precipitation and flocculation to remove suspended solids), a settling basin, the waste water vessel, and a sludge filter press.

Liquid effluents from the quench chambers, the slag discharge units and overflow scrubbing water from the syngas scrubbers, as well as remaining syngas condensate, would contain fine PM, soot, salts, and condensed heavy metal sulfides removed from the syngas stream. The pressurized black water would be sent to the flash vessels to remove excess gases and to cool the black water.

The pretreated black water would then pass through the precipitation and flocculation steps, where flocculants would be added to stimulate coagulation and settlement of soot and fines. Fine slag and precipitate would be removed in a settlement basin, thickened and dewatered using a fabric filter to separate the precipitate (solids) from the black water stream. Most of the dried filter cake (containing a large fraction of carbon) would be mixed with coal and recycled in the gasifiers to produce more syngas, and the remainder would be containerized for appropriate off-site disposal. A portion of the clear effluent of the settlement basin (< 0.1 percent dry solids) and the filtrate of the filter unit would be collected and mixed with softened water for recycle to the gasification island for use in the quench and slag discharge systems. The remaining effluent, which would contain a high concentration of chloride salts, would be piped to the ZLD brine water treatment system for further treatment.

Slag Handling, Storage, and Loading

This system would remove and collect inert gasifier slag and convey it to storage for the loadout system. The inert slag would be collected in the slag trough and conveyed to a covered storage area. The storage area would be periodically emptied by front-end loaders moving the slag to chain reclaimers. The chain reclaimers would convey the slag onto belt conveyors that transfer the slag to a loadout for rail or truck.

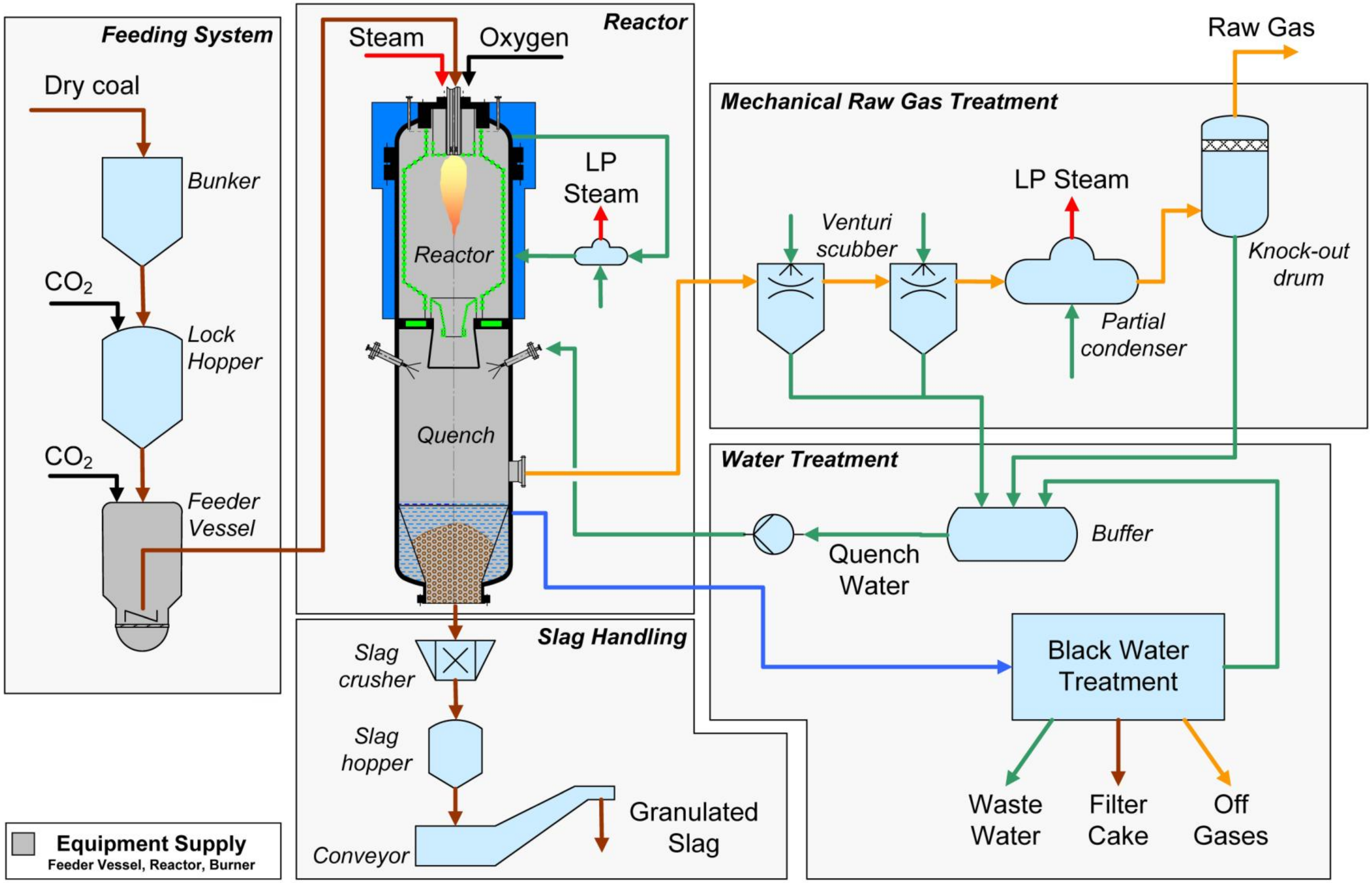

Figure 2.5. Siemens gasification island (Siemens 2010).

Slag from coal gasification and IGCC plants can be used in the manufacture of cement, as a road base, for manufacturing roofing tiles, as an asphalt filler, and as a sandblasting agent. The TCEP plans to sell the slag for such uses. Should the slag not be sold, it would be trucked or sent by rail to a permitted off-site solid waste landfill.

2.4.2.5 WATER-GAS SHIFT, LOW-TEMPERATURE GAS COOLING, AND MERCURY REMOVAL UNITS

The hot raw syngas would be further cooled and cleaned for use downstream for power generation and urea production. The main process units are described below.

Water-gas Shift Unit

To increase the H_2 content and decrease the CO content of the syngas for low-CO_2 power generation and for production of urea, the water-gas shift reaction would be used to shift the syngas composition. In the shift process, CO present in the raw syngas from the gasification island would react with steam over a catalyst bed to produce CO_2 and H_2. Once the syngas is shifted to a high concentration of CO_2, the CO_2 could be efficiently removed downstream, thereby removing most of the carbon from the syngas used in the combustion turbine.

The water-gas shift unit is also called a sour shift unit because the water-gas shift reactions would be accomplished prior to the acid gas removal, meaning that the syngas would still contain large amounts of hydrogen sulfide (H_2S) and carbonyl sulfide (COS). Because the shift reaction would release energy in the form of heat, the reaction equilibrium would favor high CO conversion at lower temperatures, and low CO conversion at higher temperatures. The heat from the shift reaction would be used to generate steam for use in other areas in the polygen plant.

In addition to converting CO, the shift catalyst would convert COS in the syngas to H_2S, which would be much easier to remove in the acid gas removal system than COS. After H_2S removal, there would be a low-sulfur syngas, which would minimize sulfur dioxide (SO_2) emissions in the combustion turbine exhaust and would reduce sulfur in the feed stream sent to the urea plant.

Low-temperature Gas Cooling Unit

Effluent from the water-gas shift unit would be cooled further in the low-temperature gas cooling unit. Water would condense from the syngas as it was cooled. This condensate would be collected, heated, and returned to the gasification island for use in the syngas scrubber. The cooled scrubber gases, which would contain sulfur gases, would be sent to the H_2SO_4 plant. The cooled syngas would be sent to the Hg removal unit.

Mercury Removal Unit

Hg removal would be accomplished by passing the syngas through sulfur-impregnated activated carbon beds, where the Hg compounds would be adsorbed and converted to stable mercuric sulfide. The system is expected to achieve greater than 95 percent Hg removal from the syngas, based on the performance of this technology in other coal gasification plants. At the end of their useful life, the carbon beds would be removed and transported off-site to appropriate facilities for disposal or recovery of the Hg compounds.

2.4.2.6 ACID GAS REMOVAL

The clean, shifted syngas stream would be sent to a Rectisol® acid gas removal system, which would use concentrated methanol (greater than 99 percent by weight) as a solvent in a recirculating wash column to physically dissolve and remove the acid gas components (H_2S, COS, and CO_2), produce two syngas streams of different qualities for downstream use, and produce concentrated streams of H_2S and CO_2 for downstream processing.

The H_2S and COS would be removed in the lower section of the Rectisol® wash column, with the CO_2 being removed in the upper section. Clean syngas streams would exit the Rectisol® system for downstream use. The first syngas stream would be rich in H_2 with a very low content of CO_2 and a total sulfur concentration of less than 0.1 parts per million by volume (ppmv). Approximately 75 percent of the syngas would be sent to the power block as a fuel for the combustion turbine. The remainder of the H_2-rich syngas would be sent to the N_2 wash unit for final purification before going to NH_3 synthesis and production of urea. The second syngas stream would contain a very low concentration of CO_2 in a range of 0.5 to 1 percent by volume, and would be used as a fuel gas in the duct burners in the power block. The sulfur-containing gases that are captured and removed would be sent to the H_2SO_4 plant.

The captured CO_2 would exit the acid gas removal system in low-purity and high-purity streams. The high-purity CO_2 stream would be sent to the urea synthesis plant. The low-purity stream and the remaining part of the high-purity CO_2 stream that could not be used in the urea production plant would be combined, dried, and compressed for off-site use in EOR.

The methanol storage tank for the Rectisol® system would be designed to store about 535,000 gallon (gal) (2,025,195 liters [L]), which is the total liquid methanol inventory of the Rectisol® unit plus the solvent make-up requirement for a minimum of three months. The methanol storage tank would be equipped with an appropriate fire protection system.

2.4.2.7 SOUR WATER TREATMENT

The coal gasification process would generate the following sour (sulfur-bearing) waste water streams:

- Gray water effluent from the black water clarifiers
- Black water clarifier sludge from the gasification block
- Syngas condensate from the raw syngas stream in the piping and in the syngas coolers upstream of the acid gas removal unit

The TCEP would incorporate a sour water stripper to treat sour waste water streams from the gasification process. The sour water stripper column would remove both H_2S and NH_3 from the sour water stream and return the treated water back to the gasification island for reuse.

The combined feed (from the sources listed above) would first enter a degassing drum, where dissolved gases would be released, and entrained oil and solids would be removed. The overhead from the degassing drum would be combined with the overhead from the downstream sour water stripper and sent to the H_2SO_4 plant. After degassing, the water temperature would be increased by heat exchange with the stripped sour water from the sour water stripper. The heated sour water would be fed to the steam reboiled sour water stripper. Most of the NH_3 in the sour water feed would be removed in this column. Sodium hydroxide would be injected as needed to facilitate the release of NH_3 from the condensate. Stripped sour water would then be sent to the ZLD system for cleaning.

2.4.2.8 SULFURIC ACID PLANT

Acid gas streams from the acid gas removal and sour water treatment units, along with flash gas from the gasification island, would be sent to the H_2SO_4 plant (a single 100-percent capacity unit). The H_2SO_4 plant would be recovered using a catalytic process to generate commercial-grade, concentrated H_2SO_4. The feed streams would be combusted with air to convert the sulfur compounds to SO_2. Natural gas would be used in normal operations for startup, support, and burner pilot flames.

Flue gas from the burner would be cooled by generating superheated steam in a waste heat boiler. The cooled process gas would be sent to a selective catalytic reduction system to reduce nitrogen oxides (NO_X) formed during combustion. After NO_X reduction, the gas would enter a catalytic SO_2 converter, where SO_2 would be oxidized to sulfur trioxide. Between each stage of the converter, the gas would be cooled through inter-bed coolers to maximize the conversion in each reactor. Heat from the gas exiting the SO_2 converter would be used to boil water, thereby cooling the effluent gas. During the cooling, most of the sulfur trioxide would react with water in the process gas to form gaseous H_2SO_4. Cooled process gas would condense in the form of concentrated H_2SO_4, and the remaining cleaned gas would exit as tail gas. Hot acid leaving the condenser would be cooled prior to being sent to storage. Concentrated H_2SO_4 product would be stored in a carbon steel tank coated with a fluorinated polymer. The on-site storage tank would hold approximately 36,000 gal (136,275 L) of H_2SO_4, or about four days of production. The product would be pumped from the storage tank to either rail tank cars or trucks for transportation off-site.

The tail gas from the condenser section would be routed to a tail gas scrubbing system consisting of a quench tower, scrubber column, mist filter, and clean gas blower. The gas would first enter a quench tower, where the temperature of the stream would be reduced by evaporating water into the gas. After being cooled, the gas would be routed to a packed scrubber tower to be treated with hydrogen peroxide to remove any residual SO_2. Finally, the overhead vapor would pass through an electrostatic mist filter to remove entrained acid mist. The cleaned gas would be sent to the H_2SO_4 plant stack.

2.4.2.9 CARBON DIOXIDE COMPRESSION AND DRYING

The CO_2 captured by the Rectisol® process would be dried, compressed, and split into two streams. The acid gas removal system would provide CO_2 at several pressure levels. CO_2 recovered at lower pressure would be routed to a low-pressure CO_2 compressor to be compressed in multiple stages with cooling between each stage. After exiting the low-pressure CO_2 compressor, the compressed gas would be mixed with the flash gas recovered from the high-pressure drum and sent to a drying package. Residual water would then be removed using molecular sieve technology. This CO_2 stream would be further compressed in the high-pressure CO_2 compressor. Some of the intermediate-pressure CO_2 would be passed through two catalytic reactors to remove residual H_2S and COS. After purification, this stream would be compressed and the majority of the CO_2 would be transported off-site for EOR, whereas the remainder would go to the urea facility.

2.4.2.10 LIQUID NITROGEN WASH

The H_2-rich syngas stream exiting the Rectisol® acid gas removal system, along with high-pressure N_2 from the air separation unit, would be fed to the liquid N_2 wash unit. Traces of water, CO_2, and acid gas removal solvent (methanol) would be removed in the adsorber unit. Both incoming streams of H_2-rich fuel gas and high-pressure N_2 would be cooled against product gas. The syngas stream would be fed to the bottom of the N_2 wash column, and high-pressure N_2 would be fed at the top of the column. Trace components (offgas) would be removed and separated at the bottom of the column as a fuel that would be used in the duct burners (direct fired gas burner located in the combustion turbine exhaust stream) in the combined-cycle power block (see Section 2.4.2.14). The pure H_2 product gas would exit at the top of the column, then through the heat exchanger (against the incoming H_2-rich fuel gas and high-pressure N_2).

2.4.2.11 AMMONIA SYNTHESIS UNIT

The hydrogen stream from the N_2 wash would be compressed and cooled, then mixed with N_2 from the air separation unit. This combined hydrogen and N_2 stream would be sent to a multi-bed catalytic reactor in which the NH_3 concentration would be increased using an iron-based catalyst. Liquid NH_3 from the bottom of the separator would be fed to another separator operating at a lower pressure. The liquid recovered from this vessel would be sent directly to a receiver in the refrigeration section of the NH_3 synthesis plant. Liquid NH_3 would enter the receiver, where it would be split into two streams. Multiple heat exchangers would be used to cool the liquid streams before routing them to one of two separators. Vapor from these separators would combine with the compressed NH_3 vapor from the storage tank and would be recycled back to the receiver at the front of the refrigeration section. Liquid NH_3 product from the bottom of the separators would be pumped to storage.

2.4.2.12 UREA SYNTHESIS UNIT

The urea synthesis unit would take the NH_3 product and convert it to urea. CO_2 from the acid gas removal unit would be compressed and sent to a urea reactor where it would combine with liquid NH_3 from the NH_3 synthesis unit. Ammonium carbamate would be formed and then would be allowed to decompose to urea.

The concentrated urea solution would be sprayed by a liquid jet into a granulator bed. The bed of particles would be fluidized with fluidization air. When the particles reached a desired size, they would fall through a bottom grid on the bed. The urea granules would be subsequently cooled. A fraction of the particles leaving the granulation bed would be sent to a crusher. The finer particles would act as seeds for growing urea granules in the granulation bed. The air exiting the granulator would be scrubbed with water to remove traces of urea before being directly vented to the atmosphere. The plant would include storage facilities for 40 days of urea production, not including railcars. The urea synthesis unit would produce 1,485 tn (1,347 t) per day of urea, requiring the input of 1,080 tn (980 t) per day of CO_2.

2.4.2.13 UREA HANDLING

The urea handling system would transfer urea from the urea synthesis unit to the rail loadout. A transfer conveyor would deliver urea from the plant to the tripper conveyor, which would transfer the urea to four storage domes at a rate of 150 tn (136 t) per hour. Another conveyor would pick up and transfer the urea from the storage domes to the urea loadout conveyor, which would then carry the urea to the loadout bin. Urea would be loaded into railcars for shipment to market at a rate of 400 tn (362 t) per hour, using a telescoping chute. The conveyors would be fully enclosed for weather protection and to control fugitive dust. All urea handling buildings would be fully enclosed or would have dust collection or control systems.

2.4.2.14 COMBINED-CYCLE POWER BLOCK

The IGCC power block would consist of a Siemens SGT6-5000F3 combustion turbine-generator configured to use either H_2-rich syngas or natural gas (as a startup and backup fuel), an HRSG, a duct burner using a mixture of syngas and liquid N_2 wash system offgas as a fuel, a reheat steam turbine-generator, an air-cooled condenser, flash drums, condensate pumps, and boiler feed water pumps.

The combustion turbine would be specially designed to combust a preheated H_2-rich syngas as the primary fuel with natural gas as the startup and backup fuel. The H_2-rich syngas would be diluted with high-pressure N_2 from the air separation unit. The addition of N_2 to the syngas, along with injection of additional N_2 at certain locations in the combustion zone inside the combustion turbine, would accomplish two key goals: 1) cooling the combustion flame which reduces the formation of thermal NO_X, and 2) increasing the mass flow through the combustion turbine, boosting the combustion turbine power output. The combustion turbine would have a nominal electric generating capacity of 230 MW.

The HRSG would convert the heat in the combustion turbine exhaust to steam, which would then be piped to the steam turbine, where it would be used to generate additional power. This configuration, which integrates the combustion turbine with the HRSG and a steam turbine-generator, is called a combined-cycle power plant and is one of the most efficient technologies for generating electricity. When conditions required additional power-generation capacity, duct burners fired with syngas and offgas would augment the energy contained in the combustion turbine exhaust, producing additional steam for the steam turbine.

The feed water system would move and control water flow through the HRSG to generate steam. The steam system would consist of three sections: high-pressure steam, reheat steam, and low-pressure steam. Some steam would be transferred to other locations in the plant to support functions other than driving the steam turbine. Superheated high-pressure steam would be supplied to the high-pressure section of the steam turbine by the HRSG. The exhaust from the high-pressure section of the steam turbine is called cold reheat steam because it is reduced in temperature and pressure. This steam would be returned to the HRSG, then reheated and combined with additional intermediate-pressure steam produced in the HRSG, and then sent to the intermediate-pressure section of the steam turbine as hot reheat steam. Exhaust from the intermediate-pressure section of the steam turbine (low-pressure steam) would be combined with low-pressure steam from the HRSG to supply the low-pressure portion of the steam turbine. Exhaust from the low-pressure portion of the steam turbine would be cooled in the air-cooled condenser.

2.4.3 Plant Utility Systems

The following plant facilities would also be components of the TCEP.

2.4.3.1 COOLING SYSTEM

Two types of cooling systems would be used at the polygen plant, wet and dry cooling. An air-cooled condenser would be used for the combined-cycle power block. For the chemical process portion of the polygen plant, units requiring cooling to temperatures less than 140 degrees Fahrenheit (60 degrees Celsius) may use wet cooling if other chilled process fluids are not available for heat transfer cooling. Air cooling (using the dry cooling tower) may be used for the chemical process portions of the polygen plant where less cooling is required. Makeup water for the wet cooling tower would be obtained from treated municipal waste water or, under some options, ground water. Cooling tower blowdown from the wet cooling tower would be directed to the ZLD system. The cooling tower would be equipped with a drift eliminator designed to limit drift losses to 0.001 percent of the circulation rate.

2.4.3.2 FLARE SYSTEMS

Flare systems would be provided to allow for the safe venting of gases produced during startup, shutdown, and upset conditions. Two flares, each approximately 200 feet (ft) (61 meters [m]) high, would be provided. The gasification island flare would be designed to burn 1) syngas associated with process operations and purges associated with normal gasifier operation, 2) nonspecification syngas generated during unit startup, 3) syngas generated during short-term combustion turbine outages, and 4) syngas released from pressure-relief valves used to protect against overpressure of individual pieces of process equipment.

Syngas sent to the flare during normal flaring events would be filtered, water-scrubbed, and further treated in the acid gas removal system to remove regulated contaminants prior to flaring. Flaring of untreated syngas or other streams would only occur as an emergency safety measure during unplanned plant upsets or equipment failures.

As part of the design of the flare systems, a natural gas–fueled pilot would remain lit on each flare during normal operation to ensure the flares are available if needed. During normal operation, heat input to each flare would include 300 standard cubic ft (ft^3) per hour (27.8 cubic m [m^3]) of natural gas used for pilot lights. The maximum estimated air pollutant emissions (in pounds per hour) are based on flaring the entire raw syngas flow from one gasifier operating at 60 percent capacity. This peak flaring rate would occur during planned gasifier startups. Annual emissions are based on the equivalent of 60 startups and shutdowns per gasifier each year, and three hours of flaring at the maximum hourly flow rate to the flare. The total raw syngas flow during a flaring event could either go to one flare or it could be split between the two flares.

The primary air contaminants in the raw syngas stream would be CO and H_2S, with trace amounts of COS and NH_3. Estimated CO emissions from the flares are based on 98 percent destruction of the CO (by combustion with air) in the flared stream. NO_X emissions are based on the TCEQ-approved factor for flares plus 50 percent conversion of the NH_3 to NO_X. H_2S and SO_2 emissions are based on 98 percent conversion of the H_2S and COS in the stream being converted (by combustion with air) to SO_2.

2.4.3.3 AUXILIARY BOILER

An auxiliary boiler using natural gas for fuel would be included. The boiler would have a maximum firing capacity of 250 trillion British thermal units (Btu) per hour (higher heating value). The boiler would be primarily used during startup and shutdown. The auxiliary boiler would be equipped with ultra-low NO_X burners and flue gas recirculation to control NO_X emissions.

2.4.3.4 BRINE WATER SYSTEMS

Brine water discharges would be handled by either the ZLD system or deep well injection, as follows.

Zero Liquid Discharge System

The primary brine water sources for the TCEP would be the oil water separator, urea condensate, gasification gray water purge, acid plant tail gas scrubber effluent, shift stripper purge, Rectisol® waste, cooling tower blowdown, contact and noncontact storm water and miscellaneous IGCC plant washdown wastes. The largest volume of brine water would be generated by the wet cooling tower blowdown, which would be treated using lime softening and reverse osmosis to recover most of the water for reuse at the plant site. All brine water would be treated on-site by the ZLD system with no liquid wastes being discharged. The polygen plant is being designed to optimize water reuse through recycling of process waste streams, thus minimizing the overall volume of process water required for the project and the volume of brine water to be treated by ZLD system. The primary ZLD system proposed for the project would consist of a brine concentrator and/or crystallizer, which would evaporate the reverse osmosis stream, thus forming a solid cake. A filter press or centrifuge may also be required to remove water from the ZLD unit. The solid filter cake would be transported to a licensed landfill for final disposal. The cake is expected to be nonhazardous but would be tested to confirm its characteristics.

An alternative option for the ZLD system is being considered for the TCEP. This option would use solar evaporation pond(s) in place of the brine concentrator and filter press system. The concentrated liquid wastes would be placed in the solar evaporation ponds that would be constructed with multiple individual cells that would facilitate the removal of the concentrated solids for disposal at an existing approved landfill. A minimum of two evaporation ponds would be constructed under this option. The size of the evaporation ponds would be dependent upon the final volume and source of the process water.

Deep Well Injection of Nonhazardous Brine Water

Another alternative option to the ZLD system described above would be the use of deep well injection of the reverse osmosis brine water. Under this option, the reverse osmosis brine water would be disposed of using up to three deep injection wells. The maximum instantaneous injection rate would be 126 gal (126 L) per minute, with an average rate of 85 gal (321 L) per minute over the 30-year design life of the polygen plant.

The injection wells would deliver the reverse osmosis brine water from the surface to the underground geologic Queen Formation through tubing, in conformance with requirements for Class I injection wells. The injection casing would be perforated in the Queen Formation at intervals selected using the results of geophysical logging.

Class I injection wells are used for deep injection and are regulated by the TCEQ.
Class II injection wells are related to energy by-products and are regulated by the Railroad Commission of Texas (RRC).
Class III injection wells are used to extract minerals other than oil and gas and are regulated by the TCEQ or the RRC, depending on the type of well.
Class IV injection wells are generally banned but may be authorized by the TCEQ or EPA in certain environmental cleanup operations.
Class V injection wells are used for many different activities and are regulated by either the TCEQ or the RRC, depending on the type of well.

The injection well pumping station would be capable of pumping the peak flow estimated to be 126 gal (126 L) per minute with one pump out of service. This would provide 100 percent pumping redundancy. In addition, the polygen plant would have a redundant power supply and automatic transfer switch along with redundant programmable logic controllers to help ensure the polygen plant was always available for service. The overall system design would provide flexibility to operate over a wide range of flows and pressures up to 950 pounds (lbs) (431 kilograms [kg]) per square inch (in^2). The piping configuration would allow both pumps to pump to the injection well header and into all of the injection wells. Typically only one pump would be operated at a time.

2.4.3.5 EMERGENCY DIESEL ENGINES

One 350-horsepower, diesel-fueled fire-water pump and two 2,205-horsepower, diesel-fueled emergency generators would be located at the TCEP. The pumps and generators would only operate during emergencies and on regularly scheduled intervals for testing. It is estimated that these engines would be operated a maximum of 52 nonemergency hours per year each for testing. The engines would not operate during normal polygen plant operations.

2.4.3.6 STORM WATER MANAGEMENT

Storm water runoff would be directed to on-site retention/settling ponds to control peak discharge. The ponds would be sized based on the area of impervious surface on the polygen site and the maximum design storm-flow volumes. There would be no discharge from the storm water runoff ponds.

Any storm water runoff that came into contact with an area that had the potential for the presence of oil (such as water runoff from parking lots) would be directed to a separate retention pond and then on to an oil/water separator.

2.4.3.7 CONTROL SYSTEMS

The TCEP control system would allow monitoring and control of the plant to be accomplished from a central control room. From work stations, operators would monitor the plant processes and manipulate controls as needed to maintain efficient and safe plant operations. Engineering work stations would give the plant engineering workforce the ability to monitor plant operations and update software and control schemes as needed.

2.4.4 Disposition of Carbon Dioxide

2.4.4.1 PIPELINE NETWORKS

The TCEP's captured CO_2 up to a maximum of approximately 3 million tn (2.7 million t) per year would be transported by a 12-inch (in) (30-centimeter [cm]) steel pipeline to an interconnection with the existing Kinder Morgan Central Basin pipeline, which is located approximately 1.0 mi (1.6 km) east of the proposed plant site. From there, the CO_2 would be comingled in the pipeline with CO_2 from other sources and then transported through the existing and extensive CO_2 pipeline system in the Permian Basin where it would be sold and used for EOR.

The TCEP interconnection to the Kinder Morgan pipeline would be buried approximately 4 ft (1.2 m) below the ground surface. The interconnection would deliver the CO_2 at a pressure of approximately 2,000 lbs (907 kg) per in^2. The CO_2 delivered to the Kinder Morgan pipeline would meet the following specifications:

- Contain at least 95 mole percent of CO_2
- Contain no free water and no more than 30 lbs (14 kg) of water per 1 million ft^3 in the vapor phase
- Contain no more than 20 ppmv of H_2S
- Contain no more than 35 ppmv of total sulfur
- Not exceed a temperature of 120 degrees Fahrenheit (49 degrees Celsius)
- Contain no more than 4 mole percent of N_2
- Contain no more than 5 mole percent of hydrocarbons and the dew point would not exceed −20 degrees Fahrenheit (−29 degrees Celsius)
- Contain no more than 10 parts per million (ppm) by weight of O_2
- Contain no more than 0.3 gal (1.1 L) of glycol per 1 million $ft^{3,}$ (2.8 million m^3) and at no time would such glycol be present in a liquid state at the pressure and temperature conditions of the pipeline

All of the potential CO_2 purchasers under consideration at this time are or can be connected to the Kinder Morgan CO_2 pipeline system, and there is no requirement for any other CO_2 pipelines to be constructed other than the proposed connecting pipeline to the Kinder Morgan system. However, there may be commercial reasons to prefer a direct pipeline connection from the TCEP to a CO_2 offtaker in some circumstances, although no such direct pipelines are currently anticipated. Should a direct pipeline be proposed in the future, the possible pipeline route (or routes) could require new ROW(s) and additional environmental analysis. A direct pipeline would not be expected to exceed 10 mi (16 km) in length. Because no direct pipelines are proposed at this time, no further analysis of that option is included in this document.

2.4.4.2 CARBON DIOXIDE MARKETS

Summit plans to sell most of the CO_2 captured by the TCEP for EOR in the Permian Basin of West Texas, with the remainder used to produce urea as discussed in Section 2.4.2.12. This commercially proven and long-established use of CO_2 is for tertiary production of oil (i.e., the third stage of production) at existing oil-producing fields. Primary production follows initial drilling and results from natural pressure in the oil reservoir or pumping of wells and gravity-induced flow in the reservoir toward producing wells. Secondary production comes from injection of water, which sweeps residual oil toward producing wells and helps bring additional oil to the surface. Injection of CO_2 is typically used to enhance production when production by water injection declines below economical levels. The use of CO_2 as a tertiary method of recovery usually produces an incremental 10 to 20 percent of the original oil in place, depending on the rock qualities.

The most likely potential buyers would be producers who already use CO_2 for EOR. Such producers may want more CO_2 than they are currently able to obtain (e.g., to expand their current CO_2 EOR), or they may want to buy Texas-generated CO_2 to obtain state tax benefits. It is likely that the TCEP's captured CO_2 would be sold to buyers that already use CO_2 for EOR, although other buyers could be oil producers that wish to commence using CO_2 to continue production at existing fields.

2.4.4.3 MONITORING, VERIFICATION, AND ACCOUNTING

Monitoring, verification, and accounting (MVA) measures provide an accurate accounting of stored CO_2 and a high level of confidence that the CO_2 is not being released or leaked to the surface. Such measures include EOR system material balance accounting, modeling, plume tracking, and leak detection.

Material balance accounting compares total injected CO_2 and CO_2 being recovered from oil production. Modeling involves putting field data into a representation of the CO_2 storage system. Usually computer models are used, and these provide helpful mathematical-numerical analysis and visualization of the system. The computer models provide a representation of the underground conditions that influence the behavior of CO_2 that has been injected into geologic formations and characterize the resulting pressure changes and fluid flow throughout the system. They may also provide a representation of certain types of geomechanical changes to the reservoir. Underground plume tracking provides the ability to map the injected CO_2 and track its movement and fate through a reservoir. Usually this is done by mapping pressure data from various wells in the field, although it may also be accomplished with repeat seismic surveys. CO_2 leak-detection systems provide critical measures of whether CO_2 is escaping from the storage reservoir at points or areas of monitoring.

A monitoring program for CO_2 injected in a reservoir for EOR serves the following purposes:

- Supports management of the injection process
- Identifies leakage risk or actual leakage and offers another layer of protection for drinking water aquifers located above the zones of injection. It provides early warnings if the CO_2 is migrating out of the intended reservoir zone
- Provides regulatory assurance that the injected CO_2 ultimately remains confined in the reservoir
- Meets monitoring requirements that may be required by carbon registries to verify carbon credits
- Verifies and provides input into reservoir models

The TCEP monitoring program would be specifically designed for each oilfield using CO_2 from the TCEP and would include one or more of the following approaches:

- Measuring to determine the mass of CO_2 injected, principally derived from the fluid pressure, temperature, flow rate, and gas composition at the wellhead
- Monitoring of the storage reservoir's pressure during the injection process using well gauges
- Using well data and seismic survey results, monitoring of the migration and distribution of CO_2 in the subsurface formation, focusing on the intended storage reservoir but including any unintended migration out of the storage reservoir
- Monitoring of the shallow subsurface through shallow wells to detect and quantify any CO_2 migrating out of the storage reservoir toward the ground surface
- Monitoring of the ground surface and atmosphere to detect and quantify CO_2 leaking into the biosphere

- Measuring and monitoring of the CO_2 that is produced with the oil, separated in the surface facilities, and reinjected into the storage reservoir

An operator implementing an EOR project with CO_2 is highly motivated to track and contain all the CO_2 purchased because it is expensive. If the CO_2 is lost out of the producing zone or vented into the atmosphere, the operator must purchase additional CO_2. This means that the operator is motivated to design the EOR project to minimize the loss of CO_2, either in the oil reservoir or in the surface facilities.

As part of the TCEP, Summit would work with EOR operators in the target field (or fields) to develop appropriate MVA measures, even though the CO_2 captured from the TCEP would be co-mingled with CO_2 from other sources. This effort would include coordination with the EOR field operators and the Texas Bureau of Economic Geology, which also functions as the State Geological Survey. Furthermore, all CO_2 injected for EOR in Texas is regulated by the RRC, which has been delegated Clean Water Act enforcement authority by EPA.

Summit has prepared a generic monitoring plan for the EOR sequestration of CO_2 that would be captured from the TCEP, and presented this plan for review to the Texas Bureau of Economic Geology (Summit 2010b). In the plan, Summit provided a suite of proposed monitoring technologies and noted that the final choice of specific monitoring technologies would be based on site-specific conditions taking into account the EOR site's geologic characterization and risk assessment. Table 2.1 describes these proposed MVA requirements.

Table 2.1. Summit's Proposed Monitoring, Verification, and Accounting for Carbon Dioxide Enhanced Oil Recovery Sequestration

Technology	Potential for Use
Baseline Monitoring	
Geochemical sampling*	Sampling of nearest aquifers and underground sources of drinking water zones would be conducted at least monthly for a year prior to CO_2 injection and more frequently if required by future regulations. Sensitivity analysis will determine which constituents will be sampled, sampling method, and frequency.
Mechanical integrity testing†	Mechanical integrity testing would be conducted by the operator in compliance with RRC regulations prior to initial injection of CO_2,
Pressure monitoring*	Pressure histories above the confining system will be monitored for one year prior to injection to determine trends from production and water disposal pre-injection.
Pressure testing†	Testing as required per RRC regulations prior to initial injection.
Operational Monitoring	
Geochemical sampling*	Sampling of nearest aquifers and underground sources of drinking waterzones would be conducted semiannually and more frequently if required by future regulations.
Mechanical integrity testing†	Mechanical integrity testing would be conducted by the operator prior to the initial injection of CO_2, and once every five years as required by the RRC. This frequency of testing may be increased if required by future regulations (EPA has proposed annual testing).
Pressure monitoring†	Pressure inside the injection tubing string and inside the annulus of the well would be measured continuously. Monitoring would also be performed periodically in the nearest underground sources of drinking water zones.

Table 2.1. Summit's Proposed Monitoring, Verification, and Accounting for Carbon Dioxide Enhanced Oil Recovery Sequestration

Technology	Potential for Use
Injection rate†	Injection rates would be measured continuously and reported monthly.
Pressure testing†	Testing is required prior to initial injection and once every five years thereafter. The frequency would conform to any change in regulations.
Material balance†, *	Material balances would be performed on a monthly basis on each injection pattern, comparing total injected CO_2 and CO_2 being recovered from oil production. The results would be compared to reservoir models for the injection pattern under review.

* Additional monitoring that EPA may require.

† Monitoring considered "business as usual" by industry.

2.4.5 Resource Requirements

Resource requirements for the TCEP include coal, land area, water treatment chemicals, natural gas, potable water, process water, transmission facilities, and transportation. These requirements are summarized in Table 2.2 and are described more fully below.

Table 2.2. TCEP Resource Requirements

Resource	Description
Coal	TCEP would use 5,800 tn (5.262 t) per day or 2.1 million tn (1.9 million t) per year of sub-bituminous coal from the Powder River Basin in Wyoming. The coal pile would be sized for about 45 days of total storage capacity, with approximately nine days of active storage and 36 days of inactive storage.
Natural Gas	2 trillion Btu (average annual use for startup, pilot burners, heating drying gases and other uses)).
Process Water	Annual peak water usage: up to 5.5 million gal (20.8 million L) per day.
	Annual minimum water usage: 3.5 million gal (13.2 million L) per day.
Potable Water	Peak construction (1,500 workers): 45,000 gal (170,000 million L) per day.
	Operation (150 workers): 4,500 gal (17,000 L) per day.
Electric Power	Construction power would be provided by connecting to a distribution line owned by Oncor Energy near the site.
Transportation	
Rail	The TCEP would require rail delivery of coal and some construction materials and equipment. The project may require rail transport off-site of construction and operational wastes and commercial products including argon, H_2SO_4, urea, and slag.
	Coal: maximum of up to five 135-car unit trains per day; average of up to three 135-car unit trains per week.
	Argon: Argon gas would be transported in rail tank cars.
	H_2SO_4: Up to one-half railcar per day would be filled and sold.

Table 2.2. TCEP Resource Requirements

Resource	Description
	Slag: up to five railcars per day.
	Urea: up to 15 railcars per day or an average of twenty 25-tn (23-t) trucks per day.
Truck (other materials [in and out])	The TCEP would require truck delivery for potable water, operations chemicals, and some construction materials and equipment. The project may also require truck transport off-site of construction and operational wastes and commercial products including argon, H_2SO_4, urea, and slag.
	Potable water (construction): forty-two 25-tn (23-t) trucks per week.
	Potable water (operations): five 25-tn (23-t) trucks per week.
	Slag: average of twenty 25-tn (23-t) trucks per day.
Land Area	
Polygen Plant	The polygen plant site would be constructed on 600 ac (243 ha). It is assumed that 300 ac (121 ha) of the site would be permanently developed.
Linear Facilities	All linear facility options are estimated to have a 100-ft (30-m) construction ROW and 50-ft (15-m) operational ROW. Temporary impacts during construction could range from 249 to 1,119 ac (101–453 ha), whereas permanent impacts from operations could range from 134 to 576 ac (54–233 ha), based on the smallest combination (WL2, TL4, CO_2, NG1, AR1, AR2, RR1) and largest combination (WL1, TL5, CO_2, NG1, WL4, AR1, AR2, RR1) of the linear facility options. Impact area details can be found in each linear facility description below.
Natural Gas Pipeline	
NG1	2.7-mi (4.3 km), 12-in (30-cm) diameter interconnection pipeline along FM 1601 from an existing 20-in-diameter main line operated by ONEOK located south of the polygen plant site; 100-ft (30-m) construction ROW and 50-ft (15-m) operational ROW; 32.7 ac. (13.2 ha) temporary impact and 16.4 ac. (6.6 ha) permanent impact.
Process Waterlines	
WL1	A 41.2-mi (66.3-km), 20- to 24-in (51- to 61-cm) diameter pipeline would be constructed south of I-20 from the City of Midland Wastewater Treatment Plant to the GCA Odessa South Facility and from there to the polygen plant site. A maximum of 501.9 ac (203.1 ha) of temporary impacts and 252.4 ac (102.1 ha) of permanent impacts could occur.
WL2	A 9.3-mi (15.0-km), 16-in (41-cm) diameter pipeline would be constructed to connect to an existing Oxy Permian pipeline northwest of the polygen plant site. A maximum of 113.5 ac (45.9 ha) of temporary impacts and 56.3 ac (22.8 ha) of permanent impacts could occur.
WL3	A 14.2-mi (22.9-km), 16-in (41-cm) diameter pipeline would be constructed to connect to the proposed FSH main waterline project southeast of the polygen plant site. A maximum of 172.4 ac (69.8 ha) of temporary impacts and 86.6 ac (35.0 ha) of permanent impacts could occur.
WL4	A 2.7-mi (4.3-km), 16-in (41-cm) diameter pipeline would be constructed from the proposed FSH main waterline to the GCA Odessa South Facility. A maximum of 34.3 ac (13.9 ha) of temporary impacts and 18.1 ac (7.3 ha) of permanent impacts could occur.
Transmission Lines	
TL1	A 9.3-mi (15.0-km) transmission line would be constructed to connect to the ERCOT grid. 75 percent of the line would parallel a section line and existing 138-kilovolt (kV) line. A maximum of 116.6 ac (47.2 ha) of temporary impacts and 60.6 ac (24.5 ha) of permanent impacts could occur.

Table 2.2. TCEP Resource Requirements

Resource	Description
TL2	An 8.6-mi (13.8-km) transmission line would be constructed to connect to the ERCOT grid. 90 percent of the line would parallel a section line, FM 866, and existing 138-kV line. A maximum of 117.8 ac (47.7 ha) of temporary impact and 65.5 ac (26.5 ha) of permanent impacts could occur.
TL3	A 2.2-mi (3.5-km) transmission line would be constructed to connect to the ERCOT grid. The line would require new ROW. A maximum of 31.5 ac (12.7 ha) of temporary impacts and 18.0 ac (7.3 ha) of permanent impacts could occur.
TL4	A 0.6-mi (1.0-km) transmission line would be constructed to connect to the ERCOT grid. The line would require new ROW. A maximum of 11.7 ac (4.7 ha) of temporary impacts and 8.1 ac (3.3 ha) of permanent impacts could occur.
TL5	A 36.8-mi (59.2-km) transmission line would be constructed to connect to the Southwest Power Pool (SPP) grid. The line would parallel a section line, existing transmission lines, roads, and would partially require new ROW. A maximum of 459.2 ac (185.8 ha) of temporary impacts and 236.2 ac (95.6 ha) of permanent impacts could occur.
TL6	A 32.8-mi (52.8-km) transmission line would be constructed to connect to the SPP grid. The line would parallel a section line, existing transmission lines, roads, and would partially require new ROW. A maximum of 455.5 ac (184.3 ha) of temporary impacts and 212.0 ac (85.8 ha) of permanent impacts could occur.
Access Roads	
AR1	A 0.6-mi (1.0-km) access road would be constructed from the eastern corner of the polygen plant site to County Road (CR) 1216 (Avenue G) and would be improved from CR 1216 and FM 1601 to I-20). A maximum of 7.2 ac (2.9 ha) of temporary impacts and 4.0 ac (1.6 ha) of permanent impacts could occur.
AR2	A 3.7-mi (6.0-km) access road would be constructed from FM 866 along an existing 138-kV transmission line to the northeast corner of the polygen plant site. A maximum of 58.0 ac (23.5 ha) of temporary impacts and 35.5 ac (14.4 ha) of permanent impacts could occur.
Railroad Line	
RR1	A 1.1-mi (1.8-km) rail spur would be constructed to connect the existing UPRR line to the on-site rail loop. A maximum of 13.4 ac (5.4 ha) of temporary impacts and 6.7 ac (2.7 ha) of permanent impacts could occur. Attendant features would include a maintenance shop, refueling station, on-site engine yard.
CO_2 Pipeline	
CO_2	A 1.0-mi (1.6-km), 12-in (30-cm) CO_2 pipeline would be constructed to connect plant facilities to the existing Kinder Morgan Central Basin pipeline east of the polygen plant site; a maximum of 12.2 ac (4.9 ha) of temporary impacts and 6.1 ac (2.5 ha) of permanent impacts could occur.

2.4.5.1 COAL

The TCEP would use low-sulfur, sub-bituminous Powder River Basin coal. The plant would use approximately 2.1 million tn (1.9 million t) of coal annually, assuming operation at 100 percent capacity.

Coal would be received by rail in dedicated unit trains from a coal mine. Unit trains would contain up to 135 railcars, with the average unit train shipment containing 115 cars. Each railcar would carry up to 120 tn (109 t) of coal. A maximum of five unit trains per day could be received and unloaded at the plant site, based on an unloading rate of four hours per train. Coal would be stored on-site in coal piles, which would be sized for about 45 days of total storage capacity, with approximately nine days of active storage and 36 days of inactive storage.

The UPRR, which has a rail line at the southern border of the plant site, has agreed to provide coal transportation services to the TCEP. Rio Tinto, a coal producer, has provided a letter of support for the TCEP and is willing to provide sufficient quantities of coal from its Cordero Rojo Mine complex in Wyoming at standard market terms. Although Cordero Rojo coal is being used for purposes of preliminary design engineering, the TCEP would not be dependent on access to Cordero Rojo coal.

2.4.5.2 NATURAL GAS

Although the primary fuel source for electric power production would be coal-derived syngas, the TCEP would require up to 2 trillion Btu of natural gas annually for polygen plant startup and as a backup fuel for the power island. Natural gas would also be used during operations for heating drying gases, fueling an auxiliary boiler, and providing burner pilot flames (see Section 2.4.3.2 for pilot usage). Using the access to natural gas, Summit could decide to install the combined-cycle power island early in the construction process (that is, before the gasification island), which would allow for electricity production from natural gas until the gasification island could be installed and the TCEP began full operation. This would also result in permanent job creation earlier than expected. Use of natural gas for full electricity dispatch would require 17.5 trillion Btu annually.

The plant would tap an existing natural gas pipeline for access to natural gas. Natural gas would be obtained through a proposed 2.7-mi (4.3-km), 12-in-diameter (30-cm-diameter) pipeline that would connect with the ONEOK 20-in-diameter (50-cm-diameter) mainline south of the proposed plant site (NG1). The location of the NG1 is identified in Figure 2.6.

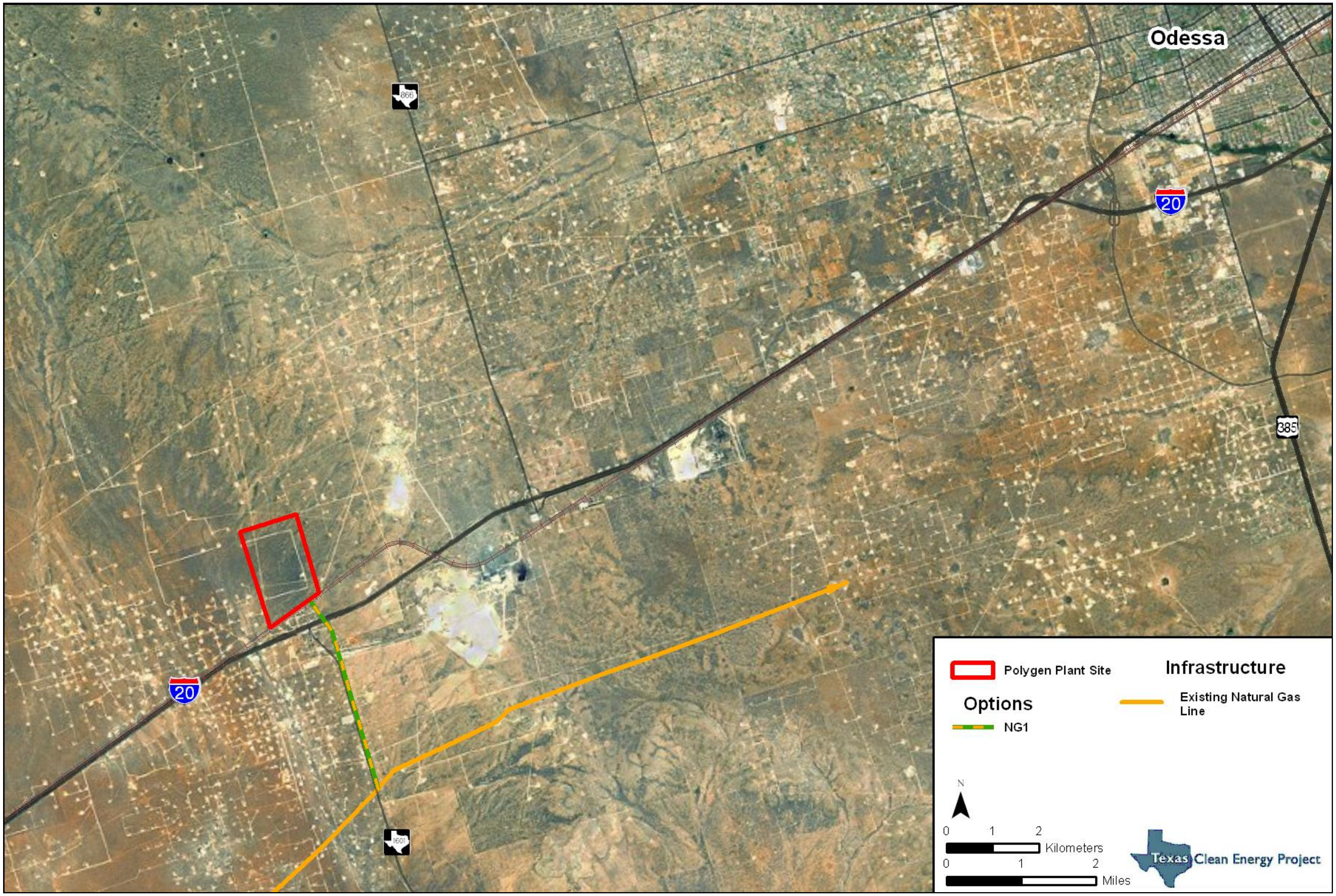

Figure 2.6. Proposed natural gas pipeline interconnection route (NG1).

2.4.5.3 PROCESS WATER

The TCEP would require a minimum of 3.5 million gal (13.2 million L) per day and a maximum of 5.5 million gal (20.8 million L) per day of water for all polygen plant uses. Water used for steam production in the HRSG must be of very high quality and, for economic reasons, would be condensed and reused rather than vented to the atmosphere as steam. Water for the plant would be supplied by a pipeline from one or more of the three sources as described below. WL1 is the preferred process water option. The locations of the four waterline options for providing water from the three sources are shown in Figure 2.7.

Gulf Coast Waste Disposal Authority

The GCA owns and operates the Odessa South Facility, an existing facility in Odessa that treats municipal sewage from the city of Odessa and industrial waste water from nearby industries. GCA's current capacity (as limited by their discharge permit) is 7.0 million gal (26.5 million L) per day; on average, the plant treats 2.0 million gal (7.5 million L) per day (Summit 2010c). GCA has a minimum required discharge rate of approximately 2.0 million gal (7.5 million L) per day into Monahans Draw. GCA currently has no water reuse customers.

For WL1, GCA would provide raw water to the TCEP from treated water from the Odessa South Facility. This facility would continue to receive waste water from the existing sources and would also receive waste water from the city of Midland. Untreated waste water from the city of Midland would be piped to the GCA Odessa South Facility for treatment. GCA would then pipe it to the TCEP as needed for use as raw water. WL1 would require the construction of a 20- to 24-in-diameter (51- to 61-cm-diameter) pipeline from the City of Midland Wastewater Treatment Plant to the GCA Odessa South Facility and from the GCA Odessa South Facility to the polygen plant site. The pipeline would be approximately 41.2 mi (66.3 km) long, of which approximately 20 mi (32 km) would require new ROW.

The specific quantity of waste water to be transferred from the city of Midland to the GCA Odessa South Facility is currently being negotiated by those two entities. The city of Midland has expressed an intention to supply, at a minimum, an amount that would allow GCA to supply the TCEP while not decreasing GCA's current discharge into Monahans Draw. The city of Midland is considering two approaches.

Under the first approach, the city of Midland would transfer its entire flow of untreated waste water to the GCA Odessa South Facility. The waste water is currently being treated (primary treatment only) and disposed of through agricultural irrigation. The city of Midland provides the waste water, fertilizer, and seed base to the selected bidders and collects a small percentage of the profit. This current practice of irrigation of hay or other crops as a means of disposal would be terminated.

The size of the pipeline between the City of Midland Wastewater Treatment Plant and the GCA Odessa South Facility might be larger than what is currently proposed by Summit. However, the width of the proposed ROW would not be increased. Treated water in excess of that used by TCEP would be either supplied for reuse by GCA or discharged into Monahans Draw. It is assumed that the quality of the treated waste water discharged into Monahans Draw would be at least the same as the currently discharged water; water quality details would be determined by a Texas Pollutant Discharge Elimination System (TPDES) permit. The sanitary sewer system for the city of Midland is separate from its storm water sewer system so no storm water from the city of Midland would be transferred to GCA. With this approach, GCA would need to construct additional handling and treatment capacity at its existing facility and existing, but currently unused, systems would be refurbished and put into service.

Under the second approach, the city of Midland would transfer less than all of its waste water to the GCA Odessa South Facility. The amount transferred would allow GCA to meet the TCEP needs and to maintain GCA's current discharge to Monahans Draw. Under this approach, the size of the pipeline between the City of Midland Wastewater Treatment Plant and the GCA Odessa South Facility would be 20–24 in (50–61 cm) in diameter. Waste water would continue to be sent from the City of Midland Wastewater Treatment Plant to irrigate croplands, although at a reduced level compared to current levels. GCA's current discharge rate of treated waste water into Monahans Draw would be maintained. It is assumed that the quality of the treated waste water discharged into Monahans Draw would be at least the same as the currently discharged water; water quality details would be determined by a TPDES permit. Under this approach, GCA would refurbish existing but unused systems at the GCA Odessa South Facility, but new construction at the GCA Odessa South Facility would be less than required for the first approach.

Oxy Permian

Oxy Permian operates a network of pipelines that provide brackish (highly saline and nonpotable) ground water from the Capitan Reef Complex Aquifer. The Oxy Permian Waterline option (WL2) would provide process water to the TCEP from the existing pipeline system through a new 9.3-mi (15.0-km), 16-in-diameter (41-cm-diameter) pipeline. Of the 9.3-mi (15.0-km) length, approximately 8.7 mi (14.0 km) of new ROW would be required. Process water from Oxy Permian would require treatment to meet gasifier manufacturer specifications.

Fort Stockton Holdings

Currently in the developmental stages, the FSH waterline project has been proposed to provide drinking water to the cities of Midland and Odessa. Under this option, FSH would provide water to the TCEP from one of two potential waterlines (WL3 and WL4). The viability of the main FSH waterline project would be independent of the TCEP. If it were built, the TCEP could use approximately 10 percent of the total water that would be available through the FSH waterline. The FSH water source would be ground water from the Edwards-Trinity (High Plains) Aquifer located near the city of Fort Stockton, which is approximately 66 mi (106 km) southwest of the proposed TCEP. Process water from the FSH option would require treatment to meet the gasifier manufacturer's specifications.

WL3 would require construction of a 14.2-mi (22.9-km) connector pipeline from the plant site to the FSH pipeline using 9.2 mi (14.8 km) of new ROW. As a backup to WL1, a 2.7-mi (4.3-km), 16-in-diameter (41-cm-diameter) pipeline (WL4) could be constructed from the main FSH waterline to the existing GCA Odessa South Facility where water would be treated and piped from the GCA Odessa South Facility to the polygen plant site using WL1. Approximately 1.3 mi (2.1 km) of WL4 would require new ROW.

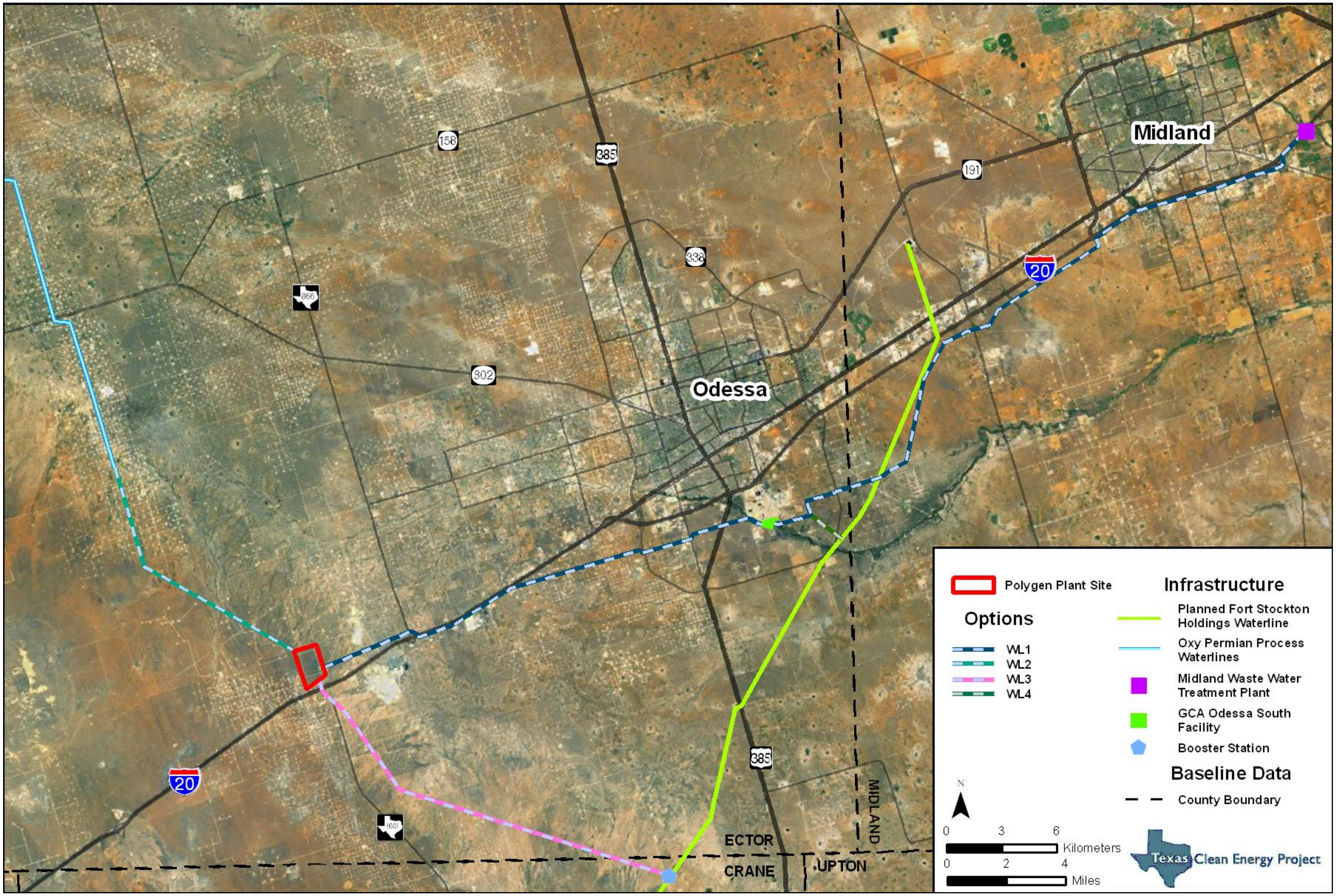

Figure 2.7. Proposed routes for the process water pipeline options (WL1–WL4).

2.4.5.4 POTABLE WATER

Potable water demand would be generated by construction and operations personnel. Approximately 30 gal (113 L) per day per person would be required. During construction peak employment, water demand would be approximately 45,000 gal (170,343 L) per day based on a peak construction workforce of approximately 1,500 workers. Once operational, water demand would decrease to 4,500 gal (17,034 L) per day based on approximately 150 workers on-site.

During construction, potable water would be delivered to the plant site by truck, requiring approximately six 25-tn (23-t) trucks per day (forty-two 25-tn [23-t] trucks per week). Potable water during TCEP operation would also be supplied by truck. Summit estimates that a seven-day operational workweek would require approximately five trucks per week.

2.4.5.5 ELECTRIC TRANSMISSION

Two large generator step-up transformers would be located next to the generators that they serve in the plant, and they would connect to a smaller transformer in an on-site switchyard. The switchyard would also include an 86-ft-tall (26-m-tall) dead-end structure, which would connect the transmission line to the off-site interconnection on a series of 86-ft-tall (26-m-tall) monopoles in 600-ft (183-m) spans. Transmission lines themselves would range from 20 to 80 ft (6–24 m) in height, depending upon the temperature (e.g., heat expansion) and mounting position on the monopoles. Interconnection studies may require upgrades to existing infrastructure. Potential infrastructure upgrades may include new and/or upgraded switch stations, upgraded substation at the point of interconnection, upgrading conductors and/or structures on existing transmission lines and other system infrastructure.

The TCEP would tie into the existing transmission grid at one of the six options described below. The proposed routes for the transmission line interconnection options are identified in Figure 2.8. TL4 is the preferred interconnection option. Maximizing the use of existing infrastructure facilities, Summit identified the following potential transmission line routes that would connect to the ERCOT market:

- TL1 would connect the TCEP with the existing Moss Substation. It would have a total length of 9.3 mi (15.0 km), with segments running parallel to a section line and an existing 138-kV transmission line. This route would require new ROW, although approximately 75 percent of the proposed transmission line would parallel existing linear facilities.
- TL2 would connect the TCEP with the existing Moss Substation. It would have a total length of 8.6 mi (13.8 km), with segments running parallel to a section line, FM 866, and an existing 138-kV transmission line. This route would require new ROW, although more than 90 percent of the proposed transmission line would parallel existing linear facilities.
- TL3 would have a total length of 2.2 mi (3.5 km) and would follow a section line north to a point where it would interconnect with the existing Oncor 138-kV transmission line. This route would require new ROW. This alternative may require the reconductoring of the existing 138-kV transmission line between the point of interconnection with the TCEP and the Moss Substation. The need for reconductoring would be determined by the ongoing interconnection studies currently being conducted by Oncor. Construction of a 5- to 10-ac (2- to 4-ha) switchyard would be required at the intersection point of the existing 138-kV transmission line and the new 2.2-mi (3.5-km) TL3. The switchyard would be used for the physical interconnection between the polygen plant site and the existing transmission

system and would include a ring bus, circuit breakers, lightning arrestors and a small single story building. The switchyard would be graded level and would be surrounded by a chain link fence, while the ground area around the equipment would be covered with gravel.

- TL4 would have a total length of 0.6 mi (1.0 km) and would follow a section line north to a point where it would interconnect with a second existing Oncor 138-kV transmission line. This route would require new ROW and may require the reconductoring of the existing 138 kV transmission line from the point of interconnection with the Moss Substation. The need for reconductoring would be determined by the ongoing interconnection studies currently being conducted by Oncor. Construction of a 5- to 10-ac (2- to 4-ha) switchyard would be also be required at the intersection point of the existing 138 kV transmission line and the new 0.6-mi (1.0-km) TL4.

Summit may determine that, from a power marketing standpoint, it is beneficial to connect to the SPP market instead of or in addition to the ERCOT market. The following two options would support the connection to the SPP:

- TL5 connect the TCEP with the existing Midland County Substation. It would have a total length of 36.8 mi (59.2 km), with segments running parallel to a section line, existing transmission lines and existing roads. This route would require new ROW.
- TL6 would connect the TCEP with the existing Midland County Substation. It would have a total length of 32.8 mi (52.8 km), with segments running parallel to a section line, existing transmission lines and existing roads. This route would require new ROW.

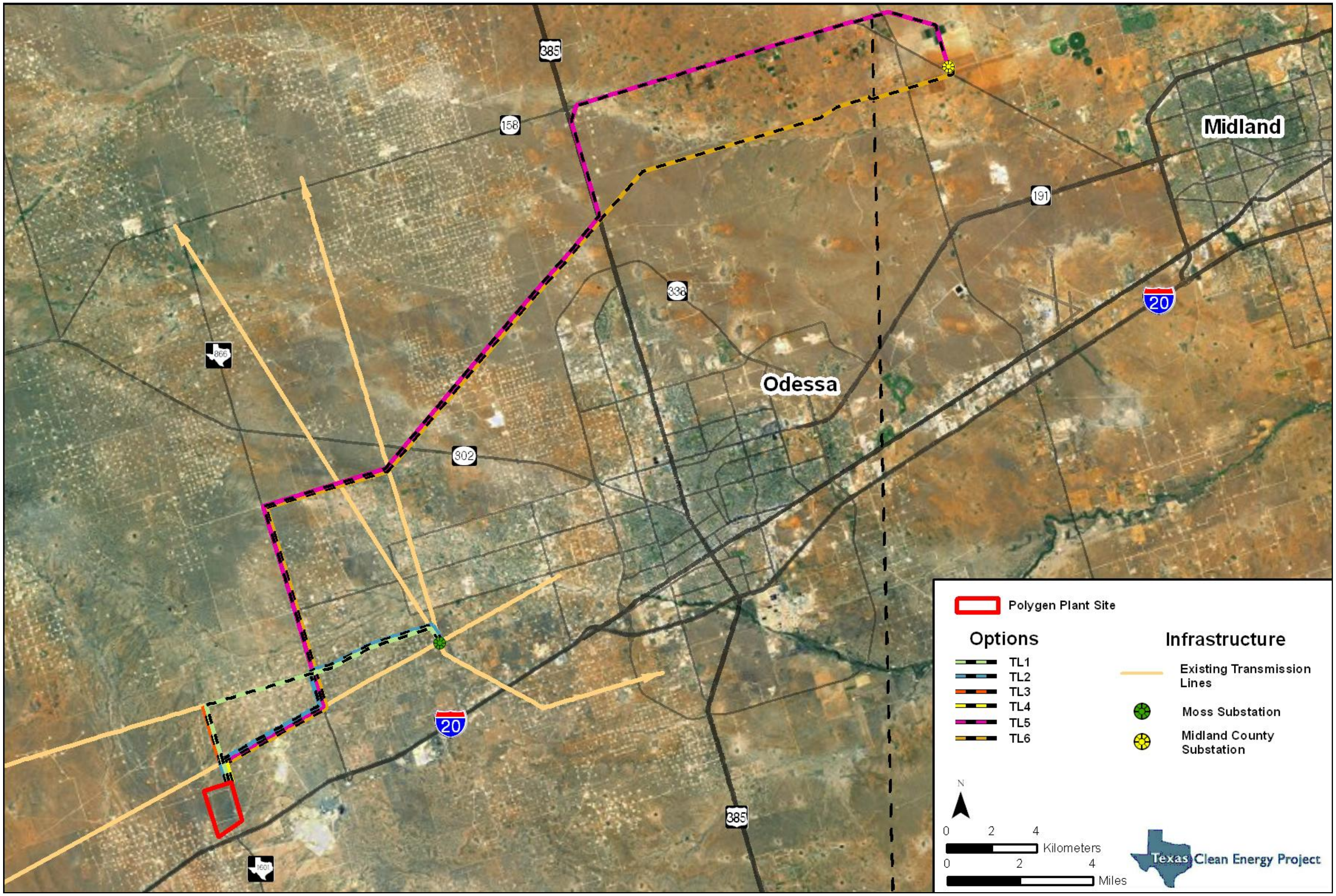

Figure 2.8. Proposed routes for the transmission line interconnection options (TL1–TL6).

2.4.5.6 CARBON DIOXIDE PIPELINE

As discussed in Section 2.4.4.1, captured CO_2 would be transported from the TCEP by pipeline to connect with an existing Kinder Morgan CO_2 pipeline located approximately 1.0 mi (1.6 km) east of the plant site. Figure 2.9 shows the proposed route for the CO_2 pipeline. All of the potential CO_2 purchasers under consideration at this time are or can be connected to the existing Kinder Morgan CO_2 pipeline system. However, there may be commercial reasons in the future to prefer a direct pipeline connection from TCEP to a local CO_2 offtaker. No such direct pipelines are currently under consideration.

2.4.5.7 TRANSPORTATION

Figure 2.10 identifies the two proposed access road and rail spur locations for the TCEP. Access to the polygen plant would be primarily by FM 866 (AR2) connecting to the northeast corner of the site. Approximately 95 percent of the construction and operations vehicle traffic would use AR2. This option would require the construction of approximately 3.7 mi (6.0 km) of a new county road, which Ector County has proposed to build. The new county road would intersect with existing FM 866 and would parallel an existing 138-kV transmission line for approximately 3.1 mi (5.0 km), then turn south for approximately 0.6 mi (1.0 km), where it would terminate at the northeast corner of the polygen plant site. Additional details regarding the access road off FM 866 are currently being developed by Ector County.

Access from FM 1601 (AR1) would be primarily for emergency vehicle access, plant administrative workforce, and visitors (anticipated 5 percent use). AR1 would require the construction of approximately 0.04-mi (0.06-km) underpass, overpass, or at-grade intersection with the UPRR line, which would connect the southeast corner of the plant site to CR 1216. Although details have not been finalized, for purposes of this analysis DOE assumed improvement of approximately 0.56 mi (0.9 km) may be required along CR 1216 and FM 1601 to I-20. Therefore, AR1 totals approximately 0.6 mi (1.0 km) for both construction and potential improvements. Figure 2.10 shows the proposed routes for the access road options.

A railroad line or *rail spur* (RR1) would be constructed from the UPRR line to the polygen plant site. This rail spur would connect to a rail loop within the site boundary that would facilitate the unloading of coal, the loading of H_2SO_4, urea, and slag, as well as the loading and unloading of construction and operations materials. Track layout design has not yet been finalized but would include the 1.1-mi (1.8-km) rail spur at the southeast corner of the plant site, on-site tracks to accommodate at least two coal train sets and two urea unit trains, a locomotive refueling location and road access for a tank truck, and an area for railcar maintenance (including a maintenance building) with access for a railcar repair contractor. Features associated with rail maintenance and refueling would include the plant's own small railcar pusher engine, aboveground fuel storage tanks and/or tanker trucks, lubricants, engine oils, hydraulic fluids, and other equipment necessary to ensure equipment remains in safe operating conditions. To minimize environmental risks, all attendant features will comply with applicable rules and regulations for their storage and handling, as well as implement spill and pollution controls.

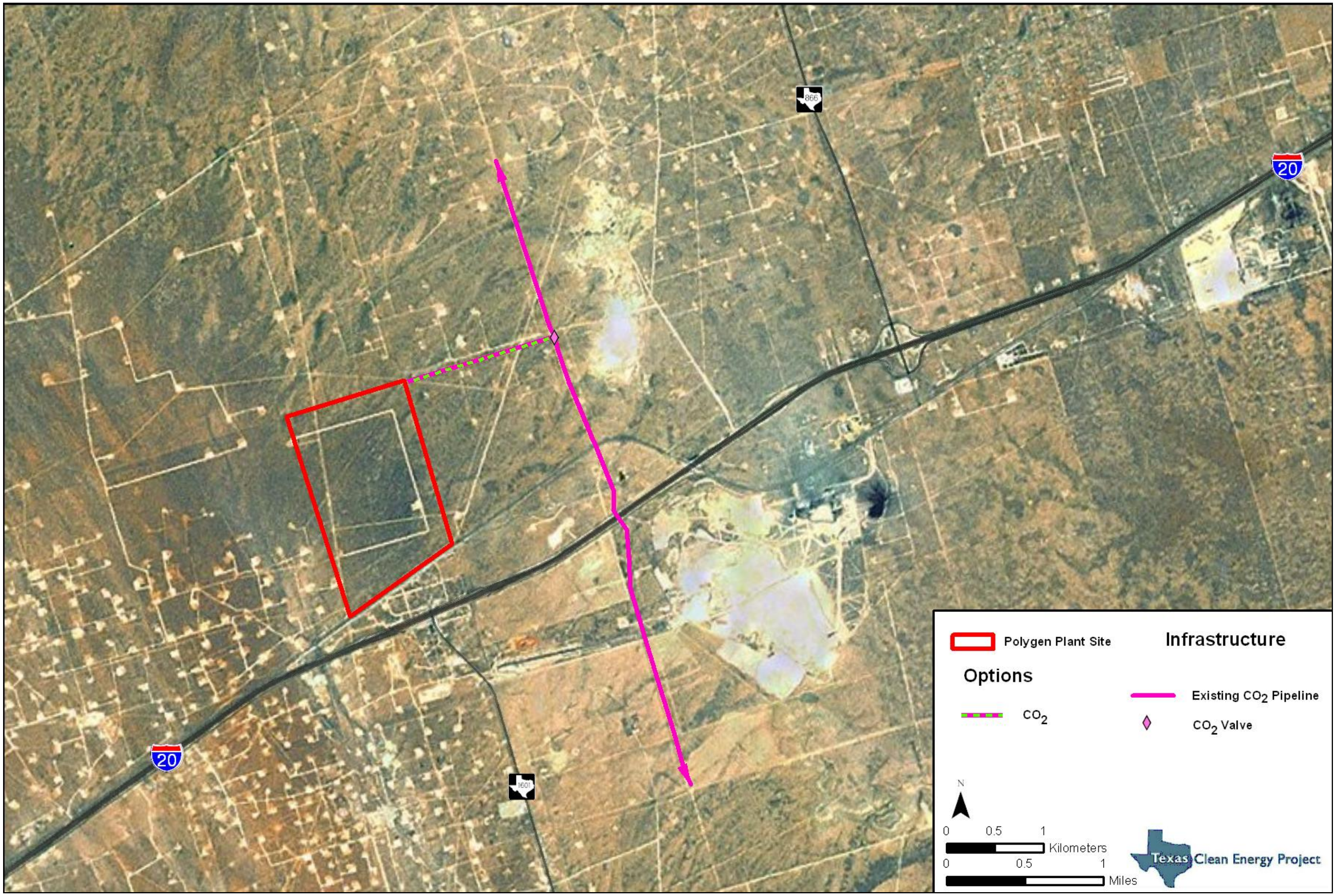

Figure 2.9. Proposed carbon dioxide pipeline route (CO_2).

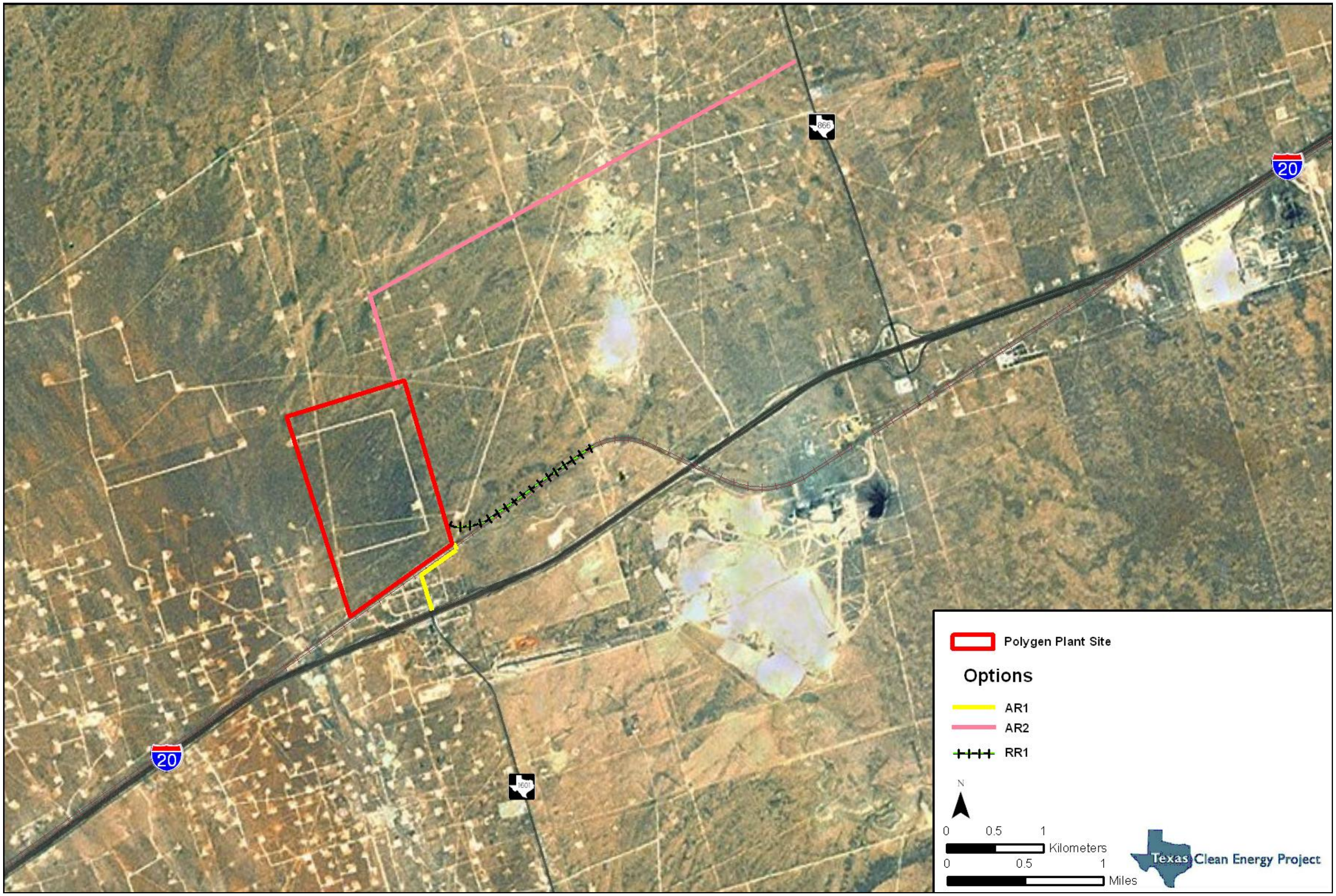

Figure 2.10. Proposed routes for TCEP access roads (AR1 and AR2) and the rail spur (RR1).

2.4.5.8 LAND AREA

The proposed plant site is approximately 600 ac (243 ha) in size, of which approximately 300 ac (121 ha) would be permanently affected by construction and operation of the proposed TCEP. Construction of the various off-site pipelines, transmission line, road access, and rail spur would also require commitments of land resources (see Table 2.2). All linear facility options would have an estimated 100-ft-wide (30-m-wide) construction ROW and a 50-ft-wide (15-m-wide) operational ROW. Temporary impacts during construction could range from 249 to 1,119 ac (101–453 ha), whereas permanent impacts from operations could range from 134 to 576 ac (54–233 ha) based on the smallest combination (WL2, TL4, CO_2, NG1, AR1, AR2, RR1) and largest combination (CO_2, NG1, WL1, WL4, TL5, AR1, AR2, RR1) of the linear facility options.

2.4.5.9 TOXIC AND HAZARDOUS MATERIALS

Hazardous materials that would be used or stored for TCEP operations include relatively small quantities of petroleum products, liquid O_2 and N_2, sulfur, catalysts, flammable and compressed gases, methanol, water treatment chemicals, and minor amounts of solvents and paints (see Table 2.2).

Natural gas and H_2-rich fuel gas (i.e., clean syngas), which are flammable fuels, would be used in the TCEP, specifically for the power block. Natural gas would be used as a startup and backup fuel and would also provide support during operations; it would be utilized directly from the on-site pipeline (connecting to the off-site main pipeline) and would not be stored on-site. H_2-rich fuel gas would be the primary fuel for the combustion turbine. It would be generated on site and not stored.

Bulk quantities of liquid O_2 and N_2 would be stored in tanks in the air separation unit to provide capacity for startups and continued plant operation during short-duration air separation unit system outages. Other gases stored and used at the polygen plant would include those typically used for maintenance activities such as shop welding, emissions monitoring, and laboratory instrument calibration. These gases would be stored in approved standard-sized portable cylinders kept at appropriate locations.

Water treatment chemicals would be required and stored on site. Bulk chemicals such as acids and bases for pH control would require storage in appropriately designed tanks, with secondary containment and monitoring. Hypochlorite bleach is expected to be used for biological control of the various circulating and cooling tower water streams. Other water treatment chemicals would be required as biocides and for pH control, dissolved O_2 removal, and corrosion control for boiler feed water, cooling tower treatment, and cooling water treatment.

For raw water treatment, coagulants and polymers could also be used. Chemicals used for these purposes are generally specified by the water treatment provider and are available under a number of trade names. Stored quantities of these materials would be small, ranging from 55-gal (208-L) drums to 500-gal (1,892-L) tanks.

Diesel fuel would be used for the emergency generator and for the fire-water pump. The expected stored quantity (2,000 gal [7,570 L]) was based on approximately eight hours of operation of the diesel generators at full output (approximately 3 MW). This limited storage would require the plant to have contracts with fuel providers specifying that deliveries of diesel fuel could be provided in fewer than eight hours in an emergency. Appropriate containment and monitoring for spillage control would be provided.

Other petroleum-containing hazardous materials include the combustion and steam turbine lube oils, steam turbine hydraulic fluid, transformer oils, and miscellaneous plant equipment lube oils. These materials would be delivered and stored in approved containers in areas with appropriate secondary containment and would be used in curbed areas that only drain to internal drains connected to an oil-water separator system. Oil reservoirs, containment areas, and the separators would be checked regularly to identify potential leaks and to initiate appropriate actions. The on-site switchyard, which would be the main connection between the polygen plant and the associated transmission line to the transmission grid, would include one small transformer that will require 250 gal (946 L) of mineral-based insulating oil. Two larger generator step-up transformers, which will also require about 18,000 to 20,000 gal (68,137–75,705 L) of mineral-based insulating oil, will be located next to the generators that they serve in the plant. Design of the switchyard and the area containing the larger transformers would include curbing to contain any potential spills, as well as a fire protection system.

Toxic and hazardous materials that would be used or stored for project operations include those used for general plant usage, gasification, raw water treatment, waste water treatment, cooling tower, urea synthesis, sour shift, power block, and fuel, as shown in Table 2.3.

Table 2.3. Toxic and Hazardous Materials and Estimated Storage at the Polygen Plant Site

Chemical	Estimated Storage on Polygen Plant Site	
	Volume (gal [L])	Mass (lbs [kg])
General Plant Usage		
Anhydrous NH_3	1,365,988 (5,170,827)	7,249,454 (3,288,297)
Aqueous NH_3	31,231 (188,222)	232,529 (105,473)
Caustic	29,802 (112,813)	301,153 (136,601)
H_2SO_4 (raw water treatment use)	54,062 (204,647)	815,176 (369,759)
H_2SO_4 Plant		
Hydrogen peroxide	9,725 (36,813)	89,700 (40,687)
H_2SO_4	36,408 (137,819)	558,817 (253,475)
Gasification		
Hydrochloric acid	13,981 (52,924)	131,637 (59,710)
Raw Water Treatment		
Anti-scalant	157 (594)	1,342 (609)
Calcium hydroxide (dry)	n/a	225,927 (102,479)
Ferric chloride	898 (3,399)	10,491 (4,759)
Hydrochloric acid	16,779 (63,515)	159,003 (72,123)
Nalco 7341 (sodium hypochlorite [bleach])	516 (1,953)	5,109 (2,317)
Sodium bisulfite	142 (538)	1,560 (708)
Sodium carbonate (dry)	n/a	409,968 (185,958)

Table 2.3. Toxic and Hazardous Materials and Estimated Storage at the Polygen Plant Site

Chemical	Estimated Storage on Polygen Plant Site	
	Volume (gal [L])	**Mass (lbs [kg])**
Waste Water Treatment		
Acetic acid	11,011 (41,681)	97,500 (44,225)
Ferric chloride	22 (83)	273 (124)
Hydrochloric acid	875 (3,312)	8,323 (3,775)
Nalco 7341 (sodium hypochlorite)	52 (197)	507 (230)
Organo sulfide	52 (197)	429 (195)
Phosphoric acid	90 (341)	1,248 (566)
Cooling Tower		
Nalco 3DT120	3,463 (13,109)	29,452 (13,359)
Nalco 3DT177	1,070 (4,050)	11,781 (5,344)
Nalco 7341 (sodium hypochlorite)	4,960 (18,776)	49,177 (22,306)
Nalco 90005	254 (961)	2,003 (909)
Nalco 71D5	524 (1,984)	3,640 (1,651)
Urea Synthesis		
UF85 (formaldehyde/urea/water)	23,863 (90,331)	260,000 (117,934)
Sour Shift		
Dimethyl Disulfide	591 (2,237)	5,200 (2,359)
Power Block*		
Hydrazine	875 (3,312)	7,377 (3,346)
Ammonium-Ethylenediaminetetraacetic acid disodium salt (dry)	n/a	18,200 (8,255)
Antifreeze (propylene glycol or ethylene glycol)	5,057 (19,143)	43,409 (19,690)
Ethylenediaminetetraacetic acid	778 (2,945)	6,500 (2,948)
Sodium borate (dry)	n/a	30 (14)
Trisodium phosphate	524 (1,984)	4,335 (1,966)
Fuel		
Coal dust suppression polymer	TBD	TBD
Diesel	1,997 (7,559)	16,000 (7,257)

Note: n/a = not available and TBD = to be determined.

*The power block consists of the electric generation unit, combustion turbines, HRSG, and associated equipment.

2.4.6 Emissions, Discharges, and Wastes

2.4.6.1 AIR EMISSIONS FROM PLANT OPERATIONS

The TCEP is being designed with state-of-the-art emissions-control systems that would allow for the conversion of coal to a H_2-rich syngas, which would burn with substantially less air pollution as compared to other fuels. H_2 would combust to produce water vapor. Because H_2 constitutes most of the fuel, much of the exhaust from the combustion-turbine would be water vapor.

> House Bill 469, passed by the Texas Legislature in 2009, requires the use of best available control technology by requiring that IGCC projects meet or improve upon the most stringent emissions limits that have been set for a U.S. coal-based plant. The emissions must be comparable to or better than those of a natural gas–fueled combined-cycle plant. The TCEP's air permit includes even lower emissions limits than those required by House Bill 469.

Summit's design team estimated the maximum and average emission quantities from each emission point using

- equipment supplier data;
- test results for similar equipment at other IGCC facilities;
- engineering calculations, experience, and professional judgment; and
- published and accepted average emission factors such as the EPA Compilation of Air Pollutant Emission Factors (AP-42).

The maximum air pollutant emissions from the polygen plant are shown in Table 2.4.

Table 2.4. TCEP Permitted Air Pollutant Emissions

Type	Emissions (tn [t] per year)
Criteria Air Pollutants	
NO_X	225.00 (204.10)
Volatile organic compounds	39.60 (35.90)
SO_2	251.10 (227.80)
CO	1,173.00 (1,064.10)
PM	416.10 (377.50)
PM_{10}	380.00 (344.30)
$PM_{2.5}$	367.00 (332.90)
Lead	0.02 (0.018)
Hazardous Air Pollutants (HAP)	
COS	2.61 (2.37)
Hg	0.01 (0.01)
Hydrochloric acid	1.39 (1.26)
Hydrofluoric acid	0.83 (0.75)
Formaldehyde	2.96 (2.69)

Table 2.4. TCEP Permitted Air Pollutant Emissions

Type	Emissions (tn [t] per year)
Other Air Pollutants	
H_2S	3.20 (2.90)
Total reduced sulfur	5.80 (5.26)
H_2SO_4	15.00 (13.60)
NH_3	363.00 (329.3)

Source: Summit (2010a).

Note: PM_{10} = PM with aerodynamic diameters equal to or less than 0.00039 in (10 micrometers); $PM_{2.5}$ = PM with aerodynamic diameters equal to or less than (0.000098 in (2.5 micrometer).

Table 2.5 compares the maximum emissions from TCEP to the emissions from conventional power plants in Texas ranging in size from 765 MW to 2,565 MW.

Table 2.5. Comparison of Power Plant Emissions Per Megawatt Hour

Power Plants	Air Emissions (lbs [kg]/MW-hours)				
	SO_2	NO_x	PM_{10}	Hg	CO_2
1970s pulverized coal plant	11.97 (5.43)	4.49 (2.04)	1.00 (0.45)	0.000214 (0.000097)	2,203 (999)
Recently permitted pulverized coal plant	2.01 (0.91)	0.84 (0.38)	0.42 (0.19)	0.000096 (0.000044)	2,203 (999)
Recently permitted coal plant using circulating fluidized bed technology	0.86 (0.39)	0.70 (0.32)	0.26 (0.12)	0.000008 (0.000004)	2,041 (926)
Recently permitted pulverized coal plant with carbon capture	0.65 (0.29)	0.55 (0.25)	0.29 (0.13)	0.000019 (0.000009)	331 (150)
TCEP	0.14 (0.064)	0.13 (0.596)	0.22 (0.10)	0.000007 (0.000003)	228 (103)

Source: Summit (2011).

2.4.6.2 WASTE WATER EFFLUENTS

Process Water Effluents

As described in Section 2.4.3.4, the TCEP would use a ZLD system to eliminate industrial brine water discharges. Cooling tower blowdown (water removed from the cooling system) and brine water generated from gasification and slag processing operations would be routed to the ZLD system. The ZLD process would remove suspended solids in a clarifier, concentrate the dissolved solids using a reverse osmosis system, and remove water from the dissolved solids through heating and vaporization. The system would recover distilled water for reuse in the TCEP, reducing fresh water consumption and concentrating contaminants into a solid waste stream. An optional ZLD system that would use solar evaporation ponds is also be considered.

The ZLD process would result in a solid filter cake material, which would be transported off-site to appropriate facilities for disposal. Based on preliminary design information, Summit estimates that up to 23,360 tn (21,191 t) of clarifier sludge and solids (filter cake) would be generated by the ZLD system annually. The filter cake is expected to be nonhazardous, but would be tested to confirm its characteristics.

Storm Water Management

Noncontact storm water runoff would be directed to an on-site retention pond designed to hold all runoff from the polygen site. Storm water would not be discharged from the retention pond. Any storm water runoff that had the potential to come in contact with oil (such as water runoff from parking lots) would be directed to a separate storm water pond that would direct collected storm water to an oil/water separator before entering the ZLD system pond.

Sanitary Waste Water

Approximately 150 portable toilets would be required during construction, which would be collected and removed by a licensed sanitary waste disposal. Sanitary wastes would be collected and discharged directly to an on-site underground septic disposal field. The septic field would be sized based on the number of workers, site-specific soil conditions and the specific areal requirements of the equipment to be used. It is estimated that sanitary waste would be approximately 55 gal (208 L) per person per day.

2.4.6.3 SOLID WASTES

In addition to the ZLD solid waste stream, other solid wastes such as spent catalyst materials, spent activated carbon beds associated with Hg removal processes, and spent activated carbon beds and char sludge associated with the sour water treatment system would also be generated, along with municipal-type wastes. Summit would manage operational wastes in accordance with applicable regulations, good industry practice, and internal company procedures. Hazardous and nonhazardous wastes would be properly collected, segregated, and recycled or disposed of at approved wastes management facilities. Volumes of these waste streams and their disposal methods are shown in Table 2.6.

Table 2.6. Solid Wastes from the Polygen Plant

Waste	Annual Quantity	Disposal Method
Black water system filter cake	86,870 tn (78,973 t) if filter cake recycle is not feasible 9,259 tn (8,400 t) if filter cake recycle is feasible	Industrial landfill
Clarifier sludge and solids (filter cake)	23,360 tn (21,191 t)	Industrial landfill
Sanitary waste	3,011,250 gal (11,398,820 L)	On-site leach field
Slag from gasifier	178,485 tn (162,060 t)	To be sold (landfill)
Solid waste (office and break room waste)*	252 tn (229 t)	Municipal/industrial landfill

*Quantity estimated for 200 workers using an industrial waste generation rate of 9.2 lbs (4.2 kg) per day per worker (California Integrated Waste Management Board 2006).

Removal of sulfur and downstream production of H_2SO_4 for commercial sale would eliminate sulfur as a significant solid waste. Slag production would be approximately 489 tn (444 t) per day. Slag is considered a potential revenue-producing stream that would be actively marketed by Summit; however, if no market is available slag would be disposed of in an off-site landfill.

2.4.6.4 Pollution Prevention, Recycling, and Reuse

The TCEP would be designed to minimize process-related discharges into the environment. A plan for pollution prevention and recycling would be developed during the detailed design and permitting steps, and the plan would be put into practice after the plant became operational. Table 2.7 lists some measures that may be employed as part of that plan.

Table 2.7. Possible Pollution Prevention, Recycling, and Reuse Features of the TCEP

Feature	Description
Spill prevention, control, and countermeasure (SPCC) plan	The SPCC plan would develop measures to take in the event of a spill, thereby insulating environmental media from the effects of accidental releases. The surfaces under and around aboveground chemical storage tanks would be lined or paved and curbed/diked, and would have sufficient volume to hold the contents of the tank. A site drainage plan would also be developed to prevent routine, process-related operations from affecting the surrounding environment.
Feedstock material handling	The coal storage area would be paved or lined so that runoff could be collected, tested, and treated as necessary. The coal storage area would be managed to control fugitive dust emissions. The coal conveyors would be covered.
Coal drying and grinding	The coal grinding equipment would be enclosed; a portion of the spent drying gas would be purged through a dust collector and vented into the atmosphere.
Gasification	The char produced in gasification would be removed in the black water treatment system as a dewatered filter cake and recycled for blending with the pulverized coal for feed to the gasifiers. This would improve the carbon conversion in the gasifier and reduce the amount of carbon contained in the gasifier slag.

Table 2.7. Possible Pollution Prevention, Recycling, and Reuse Features of the TCEP

Feature	Description
Slag handling	The slag dewatering system would generate some flash gas that contains H_2S. This flash gas would be sent to the H_2SO_4 plant. Water that is entrained with the slag would be collected and sent to the black water treatment system.
Sour water system	Sour water would be collected from the low-temperature syngas cooling system, and the NH_3 and H_2S would be stripped out and sent to the H_2SO_4 plant. The stripped condensate would be recycled to low-temperature syngas cooling.
ZLD unit	The ZLD unit would concentrate and evaporate the process condensate. The ZLD unit would produce high-purity water for reuse and a solid filter cake for disposal off-site. The ZLD would concentrate and dispose of heavy metals and other constituents in the process condensate. The ZLD would also be a recycle unit because the recovered water would be reused, reducing the total plant water consumption.
Hg removal features	The Hg removal unit would use specially formulated activated carbon to capture trace quantities of Hg in the syngas.
Acid gas removal	The acid gas removal system would remove H_2S and CO_2 from the raw syngas and produce a H_2-rich fuel gas for use in the combined-cycle power block and for urea production. The acid gas removal would produce concentrated H_2S feed for the H_2SO_4 plant and concentrated CO_2 for drying, compression, and transport for EOR.
H_2SO_4 plant	The H_2SO_4 plant would convert the H_2S to concentrated H_2SO_4, a commercial product.
Training and leadership	All corporate and plant personnel would be trained on continuous improvement in environmental performance, especially as such training and programs apply to setting, measuring, evaluating, and achieving waste reduction goals.

2.4.7 Marketable Products

2.4.7.1 ELECTRICITY

Approximately 400 MW (gross) of electric power would be generated by the TCEP, with approximately 213 MW (net) going to the power grid under maximum power output conditions. The balance of the gross power generated would be used to operate the plant and produce urea fertilizer.

2.4.7.2 CARBON DIOXIDE

The TCEP is expected to capture approximately 3 million tn (2.7 million t) of CO_2 per year. After compression, drying, and purification, part of the CO_2 would be sent to the urea synthesis plant, and the remainder would be put into the CO_2 pipeline for sale and transport to EOR. For the maximum urea production case, approximately 1,080 tn (980 t) per day of CO_2 would be sent to the urea synthesis plant, with approximately 9,050 tn (8,210 t) per day of CO_2 being compressed and sent to the CO_2 pipeline for use in EOR. In the maximum power case, 600 tn (544 t) per day of CO_2 would be sent to the urea synthesis plant, with approximately 9,100 tn (8,255 t) per day of CO_2 being compressed and sent to the CO_2 pipeline for use in EOR. There would be no storage of CO_2 on site.

2.4.7.3 UREA

Summit would expect to produce 1,485 tn (1,347 t) per day of granulated urea (542,025 tn [491,716 t]) annually at maximum capacity. This product would be transported off-site by rail, using an average of approximately 15 railcars per day. The plant would include storage facilities for seven days of urea production.

2.4.7.4 ARGON

Argon, an inert gas, would be produced as a by-product of the coal gasification process. Up to seven days of argon production may be stored on site; it would be transported off-site for sale in rail tank cars. Summit's market analysis confirms that there would be a viable market for the sale of the argon produced.

2.4.7.5 SULFURIC ACID

H_2SO_4, a hazardous material, would also be produced as a by-product of the coal gasification process. The TCEP would produce up to 56 tn (51 t) per day of H_2SO_4, which would be transported off-site by rail (up to four railcars per week) or truck. Prior to transport, H_2SO_4 would be stored in a small storage tank with a 36,400-gal (137,789-L) capacity and then pumped to the railcars on site. Summit's market analysis confirms that there would be a viable market for the sale of the H_2SO_4 produced.

2.4.7.6 SLAG

Slag production would be approximately 489 tn (444 t) per day. Slag is a potential revenue-producing stream that would be actively marketed by Summit. The slag would be temporarily stored on site prior to being loaded into railcars for sale and transportation off-site. If no market was available, it would be trucked to an off-site permitted solid waste landfill. Using 25-tn (23-t) trucks, off-site transportation of slag would require approximately 20 trucks per day.

2.4.8 Construction Plans

2.4.8.1 CONSTRUCTION STAGING AND SCHEDULE

The TCEP would be constructed over the course of up to 38 months, including the installation of linear facilities (process waterlines, CO_2 pipeline, high voltage transmission line, and road and rail access). Before construction, environmentally sensitive areas at the plant site and along the linear facility corridors would be identified so that impacts could be avoided or minimized. A storm water pollution prevention plan (SWPPP) would be developed for erosion prevention and sediment control during construction. The plan would include a description of construction activities, and address the following:

- The potential for discharge of sediment or pollutants from the site.
- The location and type of temporary and permanent erosion prevention and sediment control methods, along with procedures to be used to establish additional temporary controls as necessary for the site conditions during construction.
- The site map with existing and final grades, including dividing lines and direction of flow for all pre-construction and post-construction storm water runoff drainage areas located

within the project limits. The site map would also include impervious surfaces and soil types.

- The location of areas not to be disturbed.
- The location of areas where construction would be phased to minimize duration of exposed soil.
- The identification of surface waters and wetlands, either on site or within 0.5 mi (0.8 km) of the site boundaries, which could be affected by storm water runoff from the construction site during or after construction.
- Methods to be used for final stabilization of all exposed soil areas.

Initial site preparation activities would include building access roads, clearing brush and trees, leveling and grading the site, removing unnecessary existing pipelines and other oil field infrastructure and connecting to utilities. Construction would involve the use of large earthmoving machines to clear and prepare the site. Trucks would bring fill material for roadways and the plant site, remove plant-site material and debris, and temporarily stockpile materials. Construction crews would spread gravel and road base for the temporary roads, material storage areas, and parking areas.

Worker vehicles, heavy construction vehicles, diesel generators, and other machinery and tools would generate emissions. Fugitive dust would result from excavation, soil storage, and earthwork. Construction-related emissions and noise could be minimized by running electricity to the site from the local utility provider to reduce reliance on diesel generators, and by wetting soil to reduce dust during earthwork.

Summit's TCEP schedule provides the following key dates for the plant construction:

- December 2011–February 2012: Site mobilization and preparation
- February–July 2012: Construction of main foundations
- March–August 2012: Construction of steel
- November 2012–March 2013: Construction of transmission interconnection
- March 2013–April 2014: Construction of power island
- April 2013–September 2014: Construction of gasification island

Summit expects the TCEP to be operational in July 2015.

2.4.8.2 CONSTRUCTION MATERIALS

Construction materials would be delivered to the site by truck and rail. An access road to the plant site would be developed for construction traffic, and completion of the rail spur at the start of construction activities would allow some plant equipment to be delivered by rail. Approximately 20 trucks per day and approximately two trains per week would deliver material to the site.

During construction, temporary utilities would be extended to construction offices, worker trailers, laydown areas, and construction areas. The local electricity utility service would provide temporary construction power. Temporary generators could also be used until the temporary power system was completed. Construction crews would position temporary lighting for safety and security. Local telecommunication lines would be installed for telephone and electronic communications.

Water would be required during construction for various purposes, including personal consumption and sanitation, concrete formulation, preparation of other mixtures needed to construct the facilities, equipment washdown, general cleaning, dust suppression, and fire protection.

2.4.8.3 CONSTRUCTION WASTES

Construction of the TCEP would generate wastes that would be typical of the construction of any large industrial facility. Potential wastes would include soil and land clearing debris, metal scraps, electrical wiring and cable scraps, packaging materials, and office wastes.

Prior to conducting any land clearing or demolition, surveys for regulated substances (e.g., oil drums, asbestos-containing materials, and other regulated wastes) would be conducted. Any such materials found would be managed in accordance with applicable regulations.

Any potentially reusable materials would be retained for future use, and the recyclable materials would periodically be collected and transferred to local recycling facilities. If feasible, removed site vegetation would be salvaged or recycled for mulch. Other recyclable materials would include packaging material (e.g., wooden pallets and crates), support cradles used for shipping of large vessels and heavy components (gasifiers, combustion and steam turbine parts), and cardboard and plastic packaging. Metal scraps unsuitable for reuse would be sold to scrap dealers. Materials that could not be reused or recycled would be collected in dumpsters and periodically trucked off-site by a waste management contractor for disposal in a licensed landfill.

Construction water use would be greatest during the natural gas and CO_2 pipeline testing phase. Hydrotest water would be reused for subsequent pressure tests if practical. Spent hydrotest water would be tested to determine the presence of hazardous characteristics (e.g., traces of pipe oil or grease). If hazardous, the hydrotest water would be sent off-site for treatment; if nonhazardous, it would be routed to the ZLD system, disposed of through a licensed contractor, or discharged (with consideration for erosion protection). Scrap and surplus materials and used lubricant oils would be recycled or reused to the maximum extent practical.

Summit would ultimately be responsible for the proper handling and disposal of construction wastes. However, construction management, contractors, and their workers would be responsible for minimizing the wastes produced by construction activities. They would also be expected to adhere to all project procedures and regulatory requirements for waste minimization and proper handling, storage, and disposal of hazardous and nonhazardous wastes. Each construction contractor would be required to include wastes management in their overall project health, safety, and environmental site plans. Typical construction waste management activities may include the following:

- Creation of dedicated areas and a system for waste management and segregation of incompatible wastes. Wastes segregation would occur at time of generation.
- A waste control plan detailing wastes collection and removal from the site. The plan would identify where wastes of different categories would be collected in separate stockpiles, bins, etc., and clear, appropriate signage would be required to identify the category of each collection stockpile, bin, etc.

- Storage of hazardous wastes, as defined by the applicable regulations, separately from nonhazardous wastes (and other, noncompatible hazardous wastes) in accordance with applicable regulations, project-specific requirements, and good waste management practices.
- Periodic inspections to verify that wastes are properly stored and covered to prevent accidental spills and to prevent wastes from being blown away.
- Use of appropriately labeled wastes disposal containers.
- Implementation of good housekeeping procedures. Work areas would be left in a clean and orderly condition at the end of each workday, with surplus materials and wastes transferred to the wastes management area.

2.4.8.4 CONSTRUCTION LABOR

Based on other coal-fueled power plant construction projects, Summit estimates that an average of approximately 650 construction workers would be employed throughout the project. However, during peak construction, the projected number of on-site workers could be as many as 1,500. Summit expects that most labor would be supplied through the local building trades. It is estimated that construction workers would work a 50-hour workweek, and that construction activity would normally occur during daylight hours, but would not always be restricted to these hours.

2.4.8.5 CONSTRUCTION SAFETY POLICIES AND PROGRAMS

Construction of the entire TCEP would involve the operation of heavy equipment and other job site hazards typical of heavy construction projects. The TCEP would be subject to U.S. Occupational Safety and Health Administration (OSHA) standards during construction (e.g., OSHA General Industry Standards [29 C.F.R. Part 1910] and the OSHA Construction Industry Standards [29 C.F.R. Part 1926]). During construction, risks would be minimized by the TCEP's adherence to procedures and policies required by OSHA. These standards establish practices, chemical and physical exposure limits, and equipment specifications to preserve worker health and safety. Construction permits and safety inspections would be employed to minimize the frequency of accidents and further ensure worker safety. Construction equipment would be required to meet all applicable safety design and inspection requirements, and personal protective equipment would be used when needed to meet regulatory and consensus standards.

These laws and regulations would form the basis of TCEP construction safety policies and programs. In addition, Summit would develop overall site- and project-specific environmental health and safety policies and programs for the TCEP. These would be included in all construction contracts, and construction contractors would be required to adhere to them.

TCEP construction management would develop a manual to include detailed procedures for use in its Occupational Safety and Health Program; to assure compliance with OSHA and EPA regulations; and to serve as a guide for providing a safe and healthy environment for workers, contractors, visitors, and the community. These procedures would include job procedures describing proper and safe manners of working in the TCEP (e.g., handling and storage of NH_3 would comply with 29 C.F.R. § 1910.111), appropriate personal protective equipment (in compliance with 29 C.F.R. § 1910.132), and appropriate hearing-protection devices.

The manual would be used as a reference and training source and would include accident reporting and investigation procedures, emergency-response procedures, toxic gas rescue-plan procedures, hazard communication program provisions, material safety data sheet accessibility, medical program requirements, and initial and refresher training requirements. In addition, supplemental provisions would be added to the TCEP's emergency action, risk management, and process safety management plans.

Emergency services during construction would be coordinated with the local fire departments, police departments, paramedics, and hospitals. A first-aid office would be located on site for minor first-aid incidents. Trained and certified health, safety, and environmental personnel would be on site to coordinate emergency response. All temporary facilities would have fire extinguishers, and fire protection would be provided in work areas where welding would be performed.

The natural gas and CO_2 pipeline facilities would be designed, constructed, tested, and operated in accordance with applicable requirements included in the Department of Transportation regulations in 49 C.F.R. Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, and other applicable federal and state regulations, including OSHA requirements. These regulations provide for adequate protection of the public and workers and prevention of natural gas and other gas pipeline accidents and failures. Among other design standards, 49 C.F.R. Part 192 specifies minimum pipeline materials and qualifications, minimum design requirements, and requirements for protection from internal, external, and atmospheric corrosion.

2.4.9 Operation Plans

2.4.9.1 PLANT OPERATIONS

Following construction, Summit would begin initial startup, followed by demonstration testing and then operational testing. TCEP demonstration testing would include the following:

- Verification of coal feedstock amounts (per heat and material balances for specific cases)
- Verification of overall polygen plant 90 percent carbon capture
- Verification of CO_2 compression and meeting pipeline CO_2-quality specifications
- Plant performance and emissions testing (for compliance with permit limits and conditions)

Operational testing would occur in parallel with portions of the demonstration testing. Operational testing would focus on achieving reliable plant operation along with high thermal efficiency, low emissions, equipment performance improvement, and optimization of power generation and urea production. Operational testing would include the following:

- Plant reliability testing (to meet reliability goals and guarantees for individual gasification, urea production, and power generation systems as well as for the overall TCEP)
- Startup/shutdown testing (number and duration)
- Shakedown period (the shakedown period is expected to continue for three years, through late 2017)

The TCEP would operate for at least 30 years and possibly up to 50 years.

2.4.9.2 OPERATIONAL LABOR

The TCEP operational workforce would include a mix of plant operators, craft workers, managers, supervisors, engineers, and clerical workers. The TCEP would require skilled operations and maintenance personnel, with temporary construction or maintenance workers on site for periodic outages and additional work.

Workforce size would vary between the demonstration period and the period of commercial operation. Operations workforce would be assembled during the last 18 months of construction for training and to assist with startup of the facilities. The TCEP workforce would consist of approximately 150 full-time workers.

2.4.9.3 HEALTH AND SAFETY POLICIES AND PROGRAMS

TCEP design features and management programs would be established to address hazardous materials storage locations, emergency response procedures, worker training requirements, hazard recognition, fire control procedures, hazard communications training, personal protective equipment training, and reporting requirements. For accidental releases, significance criteria would be determined based on federal, state, and local guidelines, and on performance standards and thresholds adopted by responsible agencies.

Basic approaches to prevent spills to the environment would include comprehensive containment and worker safety programs. The comprehensive containment program would ensure the use of appropriate tanks and containers, as well as proper secondary containment using walls, dikes, berms, curbs, etc. Worker safety programs would ensure that workers are aware of, and trained in, spill containment procedures and related health, safety, and environmental protection policies.

2.4.9.4 CLOSURE AND DECOMMISSIONING

As noted above, the planned life of the TCEP would be 30 years. However, if the TCEP is still economically viable, it could be operated up to 50 years. A closure plan would be developed at the time that the plant was to be permanently closed. A closure plan would also be developed should unforeseen circumstances require the polygen plant to be closed earlier than the planned 30-year period. The removal of the TCEP from service, or decommissioning, may range from “mothballing” to the removal of all equipment and facilities, depending on conditions at the time. The closure plan would be provided to state and local authorities as required.

2.5 Avoidance and Mitigation Measures

For all environmental resources, the mitigation of potential adverse impacts from project activities would be achieved through the implementation of controls generally required by permitting processes and other federal, state, or municipal regulations and ordinances. Table 2.8 outlines specific mitigation measures, including those required under federal, state, or local regulations, and permitting requirements that Summit would implement to reduce adverse environmental impacts in specific resource areas.

Table 2.8. TCEP Incorporated Mitigation Measures

Resource	Mitigation Measure
Air Quality and GHG Emissions	Construction During construction, Summit would implement the following practices: • Using dust-abatement techniques such as wetting soils • Surfacing unpaved access roads with stone whenever reasonable • Covering construction materials and stockpiled soils to reduce fugitive dust • Minimizing disturbed areas • Watering land prior to disturbance (excavation, grading, backfilling, or compacting) • Revegetating disturbed areas as soon as possible after disturbance • Moistening soil before loading into dump trucks • Covering material in dump trucks before traveling on public roads • Minimizing the use of diesel or gasoline generators for operating construction equipment • Using modern, well-maintained diesel powered construction equipment Operation The following process enhancements and improved work practices would be implemented to mitigate emissions: • To reduce NO_x: Using diluent injection in the combustion turbine in addition to selective catalytic reduction; incorporating good flare design in accordance with 40 C.F.R. § 60.18; limiting the hours of operation of the fire pump and emergency generators • To reduce CO and volatile organic compounds: Implementing good combustion practices in the combustion turbine; incorporating good flare design; limiting the hours of operation of the fire pump and emergency generators • To reduce SO_2: Using clean syngas in the combustion turbine; incorporating good flare design; limiting the hours of operation of the fire pump and emergency generators; using low-sulfur diesel in the fire pump and emergency generators • To reduce H_2SO_4 mist: Using clean syngas in the combustion turbine • To reduce PM: Implementing good combustion practices in the combustion turbine; incorporating high-efficiency drift eliminators in the wet cooling tower; incorporating good flare design; limiting the hours of operation of the fire pump and emergency generators; using low-sulfur diesel in the fire pump and emergency generators • To reduce CO_2: Capturing as CO_2 90 percent of the carbon entering the plant with compression and pipeline transportation of the CO_2 for use in EOR; limiting use of the CO_2 bypass vent to 5 percent of the year • To reduce Hg: Using clean syngas in the combustion turbine

Table 2.8. TCEP Incorporated Mitigation Measures

Resource	Mitigation Measure
Geology and Soils	<u>Construction</u> Summit would develop and implement an approved SWPPP to reduce erosion, control sediment runoff, reduce storm water runoff, and promote ground water recharge. The SWPPP would be submitted to the TCEQ for approval prior to the initiation of any construction activities. Summit would stockpile and cover excavated topsoil until reuse, install wind and silt fences, and reseed disturbed areas. <u>Operation</u> Summit would continue to implement relevant parts of its approved SWPPP. Summit would develop and implement a SPCC plan covering TCEP operations, as required by TCEQ under the Clean Water Act (Public Law 92-500).
Ground and Surface Water Resources	<u>Construction</u> Summit would develop and implement an approved SWPPP for construction activities. The SWPPP would address the polygen plant site, laydown areas, and construction along linear facilities. Summit would implement dust suppression and sedimentation control measures. For construction of linear facilities, Summit would apply for appropriate permits for all stream and water crossings and would implement required mitigation measures. <u>Operation</u> Summit would continue to implement relevant parts of its approved SWPPP. Summit would develop and implement effective measures, in accordance with a SPCC plan, to mitigate potential impacts caused by the release of petroleum products. As needed, Summit would develop a water management plan to minimize potential impacts on water resources as a result of the TCEP's withdrawals of water for the plant.
Floodplains	<u>Construction</u> Summit would develop and implement an approved SWPPP to minimize sedimentation and the filling of any downstream floodplains. <u>Operation</u> Summit would develop and implement an approved SWPPP to minimize sedimentation and the filling of any downstream floodplains.

Table 2.8. TCEP Incorporated Mitigation Measures

Resource	Mitigation Measure
Wetlands	<u>Construction</u> Summit would develop and implement an approved SWPPP to minimize potential impacts on wetlands. Mitigation of wetland impacts would take place in the form of direct replacement or through the purchase of credits via an approved wetland bank under U.S. Army Corps of Engineers and TCEQ requirements and guidance. A Combined Wetland Permit Application, as applicable, would be submitted to applicable federal, state, and local regulatory entities and would include design details on any wetland replacement sites, wetland banks, and sources of wetland credits for the project. Mitigation requirements would be determined during the wetland-permitting phase of the project following the NEPA process and before construction activities begin. <u>Operation</u> Summit would continue to implement relevant parts of its approved SWPPP to minimize potential impacts on wetlands. Summit would develop and implement effective measures, in accordance with a SPCC plan, to reduce the risk of contamination of wetlands. Summit would use a ZLD system or wells for underground disposal of waste water, which would eliminate any discharges of process water and cooling tower blowdown into any water bodies and would, therefore, eliminate water quality impacts to wetlands.
Biological Resources	<u>Construction</u> Summit would develop and implement an approved SWPPP that would minimize potential impacts on wildlife using downstream water resources, wetlands, and floodplains. Summit would use dust suppression and sedimentation control measures. Summit would comply with the provisions of the federal Migratory Bird Treaty Act, which could include limiting land-clearing activities to periods outside of the nesting season. Summit would coordinate with the TPWD with regard to state-listed species and sensitive habitats listed in the TPWD Natural Diversity Database. Mitigation of impacts to state-listed species could incorporate a variety of options ranging from passive measures (e.g., construction timing outside critical breeding periods and permanent protection of known habitats elsewhere that contain the resource to be affected) or more aggressive measures (e.g., complete avoidance of impact). <u>Operation</u> Summit would continue to implement relevant parts of its approved SWPPP to help minimize impacts to certain biological resources. Summit would develop and implement effective measures, in accordance with an SPCC plan, to mitigate potential impacts caused by the release of petroleum products.
Aesthetics	<u>Construction</u> Summit would develop and implement a SWPPP to reduce erosion and minimize landscape scarring. Summit would employ dust-suppression techniques. <u>Operation</u> Summit would plan and install an outdoor lighting system that would minimize TCEP's nighttime, off-site illumination and glare.

Table 2.8. TCEP Incorporated Mitigation Measures

Resource	Mitigation Measure
Cultural Resources	<u>Construction</u> In accordance with Section 106 of the National Historic Preservation Act (Public Law 89-665), Summit has provided surveys and cultural resource assessments for the proposed polygen plant site and preliminary assessment recommendations for linear facilities to the Texas Historical Commission and other appropriate agencies for review and comment. With regard to the roads, rail lines, high-voltage transmission lines, and other linear facilities, archaeological surveys would only be conducted for corridors identified by state agencies as needing such surveys. Surveys would be completed if DOE issues a favorable Record of Decision.
Traffic and Transportation	<u>Construction</u> To prevent unnecessary traffic congestion and road hazards, Summit would coordinate with local authorities and employ safety measures, especially during the movement of oversized loads, construction equipment, and materials. Where traffic disruptions would be necessary, Summit would coordinate with local authorities and implement detour plans, warning signs, and traffic-diversion equipment to improve traffic flow and road safety. <u>Operation</u> Summit would make road improvements, where necessary, to minimize traffic congestion and road hazards. Improvements may include adding lanes for turning and acceleration.
Safety and Health	<u>Construction and Operation</u> Summit would comply with OSHA requirements as they apply to the project during construction and operation activities.
Noise	<u>Construction</u> Summit would equip steam piping with silencers to reduce noise levels during steam blows by up to 20–30 A-weighted decibels (dBa) at each receptor location. <u>Operation</u> Summit would equip silencers on the relief valves. Summit would perform a noise survey to ensure that operations are in compliance with applicable noise standards. Summit would locate and orient plant equipment to minimize sound emissions; provide buffer zones; enclose noise sources within buildings; install inlet air silencers for the combustion turbine; and include silencers on plant vents and relief valves.

2.6 DOE's No Action Alternative

Under the No Action Alternative, DOE would not share in the cost of the TCEP beyond the project definition phase; in other words, DOE would not share in the costs of detailed design, construction, or the three-year demonstration-phase testing and operations. In this case, some amount of the money withheld from partial funding for the TCEP may be applied to other current or future eligible projects that would meet the objectives of the CCPI program. In the absence of partial funding from DOE, Summit could still elect to construct and operate the TCEP if it could obtain private financing as well as the required permits from state and federal agencies; therefore, the DOE No Action Alternative could result in one of three potential scenarios:

- The TCEP would not be built.
- The TCEP would be built by Summit without benefit of partial DOE financial assistance.
- The TCEP would not be built by Summit and the 600-ac (243-ha) site could be sold for industrial, commercial, or residential development, the impacts of which would be dependent on the type of development pursued.

DOE assumes that if Summit were to proceed with development in the absence of partial funding, the project would include all the features, attributes, and impacts as described for the Proposed Action; however, without DOE participation, it is likely that the proposed project would be canceled. For the purposes of analysis in this EIS, the DOE No Action Alternative is assumed to be equivalent to a "no build" alternative, meaning that environmental conditions would remain in the status quo (no new construction, resource utilization, emissions, discharges, or wastes generated).

If the project were canceled, the proposed technologies of the TCEP (demonstration of commercial-scale IGCC integrated with carbon capture and geologic storage of CO_2 using EOR, and manufacture of urea from gasified coal) may not be implemented in the near term. Consequently, commercialization of the integrated technologies may be delayed or not occur because utilities and industries tend to use known and demonstrated technologies rather than new technologies. This "no build" scenario would not contribute to the CCPI program goals of accelerating the commercial readiness of advanced multi-pollutant emissions control; combustion, gasification, and efficiency-improvement technologies; and demonstrating advanced coal-based technologies that capture and sequester, or put to beneficial use, CO_2 emissions.

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