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FINAL SCIENTIFIC/TECHNICAL REPORT

Polk Power Station NGCC Carbon Capture FEED Study

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1. FEED STUDY PLANNING AND DEFINITION

1.1 BACKGROUND AND PURPOSE

Tampa Electric Company (TEC) engaged Sargent and Lundy (S&L) to perform a Front-End Engineering Design (FEED) Study for the implementation of an amine-based Carbon Capture System (CCS) by ION Clean Energy (ION) at the Polk Power Station, Unit 2 (PK2). PK2 is a Natural Gas Combined Cycle (NGCC) power plant located in the City of Mulberry in West Central Florida. This facility is owned and operated by TEC.

TEC is committed to providing reliable electricity in a manner that supports long-term affordability for customers while adapting operations for increased energy demand and evolving regulations. TEC has identified carbon capture as a technology that could help address these needs. As such, this FEED Study was conducted as part of the Department of Energy (DOE) National Energy Technology Laboratory (NETL) issued award DE-FE0032224 to evaluate the technical feasibility and develop the cost of a carbon capture retrofit project for PK2. In this FEED study, ION is the technology provider of the CCS design, TEC is the prime, and S&L is aiding with process design and balance of plant (BOP) integration.

The ION CO₂ capture system will be designed to treat 100% of flue gas from all four combustion turbines at the facility. CO₂ will be captured, dehydrated, and compressed to meet CO₂ pipeline specifications for transportation via a dedicated pipeline for off-site transport and storage.

The primary objective of the project was to develop an Association for the Advancement of Cost Engineering (AACE) Class 3 Cost Estimate to demonstrate the economic feasibility of constructing a CO₂ capture plant that is fully integrated into the existing PK2 facility. This summary report will outline the FEED activities of the PK2 Carbon Capture FEED Study.

1.2 PROJECT SCOPE AND DESIGN

1.2.1 Polk Power Station Base Plant

PK2 is a natural gas combined cycle (NGCC) facility which consists of four (4) combustion turbines (CT), four (4) heat recovery steam generators (HRSG) and one (1) steam turbine generator (STG). Inputs into the power station include natural gas and water. Unit input and output data were obtained from design documentation and/or as-measured data as available.

1.3 PROJECT DESIGN BASIS

A Project Design Basis was developed for the FEED Study. The basis of design is intended to clearly identify

all key inputs and boundary conditions required to design and install the CCS. All members of the Project Team contributed to identifying and quantifying the key inputs and boundary conditions. The Overall Project Design Basis was developed encompassing site / ambient conditions, flue gas design basis, and a design criteria for the various systems included within the inside boundary limits (ISBL) and balance of plant (BOP) islands. The design criteria are further detailed in Section 1.4.

Additionally, a process-specific carbon capture island (CCI) design basis was developed that discusses the design considerations and approach taken to produce the project-specific CCS process deliverables and also identify the ISBL design with a brief description on the individual inputs and outputs to each stream.

1.3.1 Site / Ambient Conditions

The following site and ambient conditions were used as the basis for the project.

- Site Design Pressure is 14.62 psia
- Site Elevation is 146 feet above AMSL
- The Winter Haven Airport weather station (ASHRAE WMO #747931) was used for this FEED Study.

Table 1-1 — Ambient Conditions

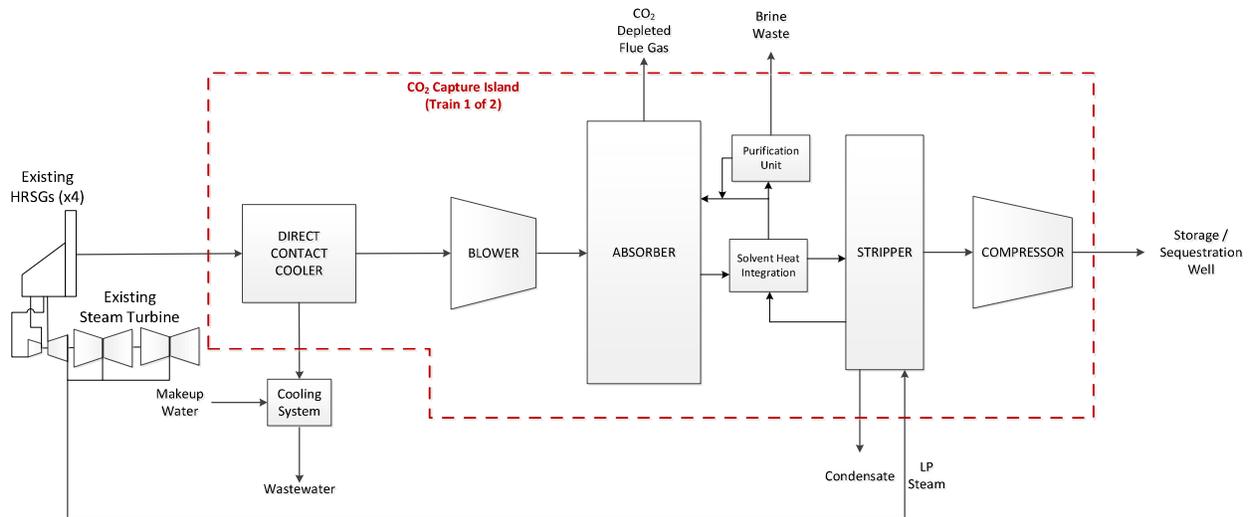
Parameter	Units	Value
50 Year Minimum Ambient Dry Bulb	°F	22.1
Annual Average Ambient Dry Bulb	°F	73.8
50 Year Maximum Ambient Dry Bulb	°F	100.8
Evaporative Cooling Design Wet Bulb (2% Occurrence)	°F	77.9
NFPA Frost Depth for Underground Piping	Ft	2'-6"
HVAC System Heating Dry Bulb (99.6% Occurrence)	°F	38.8
HVAC System Cooling Dry Bulb (0.4% Occurrence)	°F	94.5
HVAC System Cooling Wet Bulb (0.4% Occurrence)	°F	75.5

1.3.2 CCS Technology Description

This system description is categorized into individual subsystems that represent the CCS as designed for the processing of all flue gas produced at PK2. The CO₂ Capture System utilizes ION’s ICE-31™ technology. The basic configuration of the CO₂ capture system for PK2 is comprised of two (2) parallel Carbon Capture Trains, each consisting of one (1) Direct Contact Cooler (DCC), one (1) Flue Gas Booster Fan, one (1) CO₂ Absorber

Contactor, one (1) Stripper Contactor, one (1) CO₂ Compressor and Dehydration System, a solvent filtration system, and various heat exchangers and pumps. Common equipment that serves both CCI trains includes a vessel maintenance system, solvent make-up system, solvent reclamation system and surge tank for wash water.

Figure 1 — Carbon Capture System



First, in the DCC, recirculating process water cools the flue gas and removes residual acid gases. The pH is balanced through caustic addition, and heat is indirectly rejected from the process water loop via a set of plate and frame heat exchangers supplied with cooling water from the BOP open-loop Cooling Water System. The Flue Gas Booster Fan moves flue gas from the DCC to the CO₂ Absorber Contactor where the ION solvent selectively absorbs CO₂ via an exothermic, reversible reaction. Within the CO₂ Absorber Contactor, the flue gas enters the AWW section, above the CO₂ absorption zone, to recover practically all solvent vapors and maintain overall water balance. The ION solvent exiting the CO₂ absorption zone is now rich with CO₂ and is collected in the CO₂ Absorber Contactor sump before being pumped to the Regeneration System.

The solvent is pumped from the CO₂ Absorber Contactor sump through heat exchangers and then to the Stripper Contactor. At the bottom of the Stripper Contactor, low pressure steam is added to the Stripper Reboiler System (or Stripper Steam Heaters) to indirectly heat the solvent and release CO₂. The low-pressure steam is extracted from the PK2 STG and is transported to the CO₂ Island. The condensate from the Stripper Steam Heaters is returned to a Condensate Break Tank in the BOP System and eventually rejoins the Steam Turbine Condensate System. The CO₂-lean solvent is pumped from the Stripper Contactor sump, heat exchangers, then back to the CO₂ Absorber Contactor for further capture.

The released CO₂ exits the top of the Stripper Contactor and enters the Stripper Overhead (OH) Condenser

where virtually all the remaining water is condensed. The CO₂ stream then passes on to the CO₂ Compressor, which is an electric motor-driven, integrally geared centrifugal type compressor (IGC). After the initial stages of compression (referred to as “LP” for “low pressure”), the CO₂ stream exits compression for interstage cooling and dehydration and then reenters the IGC for the final stages of compression to supercritical pressures (referred to as “HP” for “high pressure”). The CO₂ stream is dried by a triethylene glycol (TEG) Dehydration System upstream of the HP IGC stages to mitigate water condensation and hydrate formation. Upon exiting the HP compression stages, the CO₂ is a stream of dense-phase supercritical CO₂ (sCO₂), which is cooled for further pressurization by the sCO₂ Pumps for transport to sequestration.

1.3.3 Flue Gas Design Basis

A flue gas design basis was developed to outline the flue gas characteristics including but not limited to flow, temperature, pressure, composition, and emissions that will be sent to the CCS. Development of the flue gas design basis was an iterative process through evaluation of multiple operating scenarios of PK2 to determine the selected design. Flows relative to maximum and minimum operating cases, frequency of operation, along with steam extraction considerations were factored into the decision process. The final design of the flue gas was selected based on the results of the Steam and Electric Power Sourcing Study, detailed later in the report, which utilized advanced gas path (AGP) upgrades to the combustion turbines. Several operating conditions were considered when selecting the design case, which is the flue gas design basis that established the major CCI process vessel sizing. The ideal design case should allow for CCS operation through the full range of operating conditions, with an optimal balance between capital expenses through equipment sizing and high capture efficiency at the maximum operating conditions. For the FEED study, the CO₂ capture island is sized with a capture rate of 95% of the CO₂ produced. Additional operating cases were provided as part of the flue gas design basis document to set rating cases for the CCS design and account for impacts where the flue gas and constituents deviate from design. Additionally, care was taken to ensure that the CCS equipment is sized to ensure that the CCS can accommodate the full range of operating conditions – from the minimum turndown case to the maximum operating condition. The final Flue Gas Design is shown below for the range of operating conditions considered. Additional cases developed are included in the Flue Gas Design Basis.

Table 1-2 — Flue Gas Design Basis

Parameter	Units	Value
Temperature	°F	175 - 201
Pressure	Psia	14.3
Flue Gas Composition		
N ₂	Vol%	73.2 – 74.8
Ar	Vol%	0.9

Parameter	Units	Value
O ₂	Vol%	11.0 – 12.7
H ₂ O	Vol%	8.1 – 10.5
CO ₂	Vol%	3.7 – 4.5

1.4 DESIGN CRITERIA

The Design Criteria was developed to establish the key parameters needed to effectively execute the FEED study phase of the subject project. The intent was for this document to be maintained and added upon if and when this project moves into subsequent design phases, including Detailed Design.

1.4.1 Balance of Plant Scope / System Descriptions

1.4.1.1 HRSG Exhaust Stack Tie-In Ductwork

The flue gas will be routed from the existing PK2 No. 2, 3, 4, and 5 HRSG stacks into a common duct and south to the CO₂ capture process island. One (1) new flue gas booster fan per CO₂ capture train will provide additional pressure to the flue gas stream to accommodate the system pressure loss associated with the existing HRSG stack tie-ins, flue gas ductwork and dampers, DCC vessels, and CO₂ absorber vessels and associated extension stacks. New ductwork will split to each train's DCC vessel. The new flue gas booster fans are located between the DCC and the Absorber vessels.

The new ductwork and fans will be sized for the flue gas conditions established in the, (i) Flue Gas Design Basis Document, (ii) project process flow diagrams (PFDs), (iii) associated heat & mass balances, (iv) including OEM equipment requirements (i.e., DCC and CO₂ Absorber vessels' internal design), (v) ductwork routing and (vi) ductwork components.

Each CO₂ capture train will be provided with a 1x100% capacity, variable pitch blade controlled Booster Fan (located between the DCC and the Absorber). The booster fans will provide the necessary pressure to draw flue gas from the existing Polk Unit 2 HRSG exhaust stacks through the new ductwork and DCC vessels, and through the Absorber vessels and associated continuous emissions monitoring system (CEMS) stack extension. This includes pressure loss through the various packed beds, demisters, and other vessel internals.

On the occasion where the flue gas needs to bypass the CCS, isolation dampers to the CO₂ capture process island will close, and the flue gas will exhaust through the existing HRSG stacks. When the CCS facility is turned down, the booster fans (variable pitch blade controlled) will turn down accordingly such that only the required flue gas flow is drawn from the Polk facility to the CCS. CCS turndown will be achieved by variable pitch blade control due to the axial fan type selected. As flue gas flow decreases, the CCS flue gas duct

isolation dampers (per HRSG stack breaching and/or per DCC inlet duct) will close based on the required CCS flue gas flow to maximize capture efficiency.

The CCS flue gas duct isolation dampers will either be in an open position or a closed position and will not modulate. A throttling control damper will be located in each HRSG tie-in branch dedicated to maintaining a target pressure in the associated HRSG exhaust stack, so as not to “overdraw” flue gas flow from a single HRSG stack.

The following ductwork segments are integrated into the design of the CCS:

- Four (4) separate tie-in branches, one (1) at each existing HRSG exhaust stack, to a common header to the CCI.
- Common flue gas ductwork header from PK2 to the CCI.
- DCC inlet branches (one (1) per CO₂ capture train) from common ductwork header.
- Booster fan suction from DCC and discharge to CO₂ Absorber vessels (one (1) segment per CO₂ capture train).

1.4.1.2 Induced Draft (ID) CCS Booster Fan

The CCS consists of 2 x 50% capacity trains that collectively treat 100% of the flue gas generated by the station. Each CCS train includes an axial-type booster fan, a direct contact cooler (DCC), and a CO₂ absorber contactor.

1.4.1.3 Circulating Water and Cooling System

A new cooling water system will be installed to provide cooling water to the CO₂ capture facility users to accommodate the CCS heat duty. A Cooling Water Sourcing Study, described further in Section 1.5.2, was performed to review the potential options for cooling water sourcing, whether from evaporative cooling, dry cooling, or hybrid cooling systems.

The cooling water system supplies and distributes cooling water throughout the CO₂ capture facility, from the new mechanical draft cooling tower (MDCT) and associated circulating water pumps to the cooling water equipment and CO₂ Process Equipment Area. The cooling water is heated as it passes through the CCS heat exchangers. The cold side of the system is pumped via multiple, vertical turbine wet pit pumps. The cooling water system is designed to supply 88°F cooling water to the process heat exchangers.

1.4.1.4 Demineralized Water Supply and Tie-In

A new demineralized water distribution system is included to provide demineralized water to the CO₂ Facility's users. The new demineralized water distribution system will tie-into the existing PK2 demineralized water system and utilize the existing storage and forwarding pumps.

1.4.1.5 Makeup Water Supply and Service Water Supply and Tie-In

TEC's existing Reclaim Water Treatment Plant (RWTP) provides makeup water of various qualities for use in the existing facility. Reclaimed water, from the cities of Lakeland and Mulberry, is first treated in the RWTP. The RWTP currently consists of clarification via a Densadeg followed by multi-media filtration, and then reverse osmosis. Water produced from the RWTP is currently primarily used as supplemental makeup water for the cooling systems, cooling tower makeup, and secondary plant water users. Wastewater generated from the RWTP is injected into two Class I Underground Injection Control (UIC) wells.

A mechanical draft cooling tower was selected as the cooling technology from the Cooling Sourcing Study. The above described RWTP expansion will meet all cooling tower makeup requirements, providing makeup water of sufficient quality to the Mechanical Draft Cooling Tower to make up water lost to evaporation and blowdown. 1st pass RO permeate water from the RWTP will be used as direct makeup to the MDCT. This water flow will come from RO Permeate Transfer pumps that take suction off the existing RO permeate tank located in the RWTP.

Water produced within the CO₂ capture process (DCC Blowdown) will discharge into a vertical, field-erected DCC Equalization Tank which will also provide makeup water to the MDCT. This water will be treated to meet discharge limitations on the existing cooling reservoir discharge Outfall D-001.

During off-peak months where the MDCT is operating at a reduced capacity and the CO₂ capture facility is operating at full load, less makeup flow is needed for the MDCT. If the CO₂ capture facility is operating at a reduced capacity, and if the water produced from the CO₂ process (DCC blowdown water) generates more makeup water than the MDCT can accept, the makeup water may be directed to another appropriate location (i.e. the existing PK2 Cooling Tower). Alternately, the DCC Equalization tank may be oversized to accommodate this excess capacity. The RWTP would not provide additional makeup in this scenario.

A new service water distribution system is included to provide service water to the CO₂ Facility for area hose stations. The new service water distribution system will tie into the existing PK2 service water system and utilize the existing infrastructure.

1.4.1.6 Potable Water Supply and Tie-In

The existing base facility potable water system will be expanded in capacity to fill a new potable water storage tank within the CO₂ capture facility. Two (2) 50% capacity potable water transfer pumps will distribute potable water to new emergency safety showers and eyewash (SSEW) stations. Two (2) bladder tanks are provided to account for minor demands from system users. SSEW stations will be provided with anti-scald valves, as needed.

1.4.1.7 Fire-Protection Water Supply and Tie-In

This fire protection design concept describes the fire protection measures to minimize the possibility of fire and promote safe operation and maintenance for the new CO₂ capture facility. These measures are designed to fulfill the following requirements:

- Inhibit the outbreak and spread of fire.
- Protection of operating personnel.
- Early detection, warning, and suppression.
- Minimize damage resulting from a fire and the migration of smoke.

All fire protection, suppression and detection materials, equipment and systems furnished and installed shall be subject to approval of the Authority Having Jurisdiction (AHJ). The material, equipment and system components shall be listed by Underwriters Laboratories, Inc. (UL) and/or approved by Factory Mutual Research Corporation (FMRC) for their intended use. The equipment and system components shall be installed in accordance with the applicable codes and standards, the manufacturer recommendations, and within the limitations of the UL listings or FMRC approvals. Components for which UL listing and/or FMRC approval is "pending" will be unacceptable.

The existing Polk Power Station underground fire water loop will be expanded to include a new CCS facility underground fire water loop(s) around the CCS facility as necessary to avoid dead legs in the system. New hydrant spacing shall be a maximum of 250'.

New electrical equipment areas will be provided with incipient-type smoke detection systems, including manual pull stations, horns and strobes. New process areas will be provided with standpipe and hose station coverage unless dedicated fire suppressions systems are required per NFPA and coordination with the Fire Marshall (FM) and AHJ. The new Fire Protection, Suppression and Detection Systems shall be provided with local fire alarm control panels and a new main fire alarm control panel for the new facility, connected to the existing

plant main fire alarm control panel.

No Fire Suppression deluge systems shall be provided for oil-filled transformers. Adequate separation and/or fire walls will be provided.

Portable fire extinguisher selection, placement, and installation shall be in compliance with the requirements of NFPA 10 and the local statutory authorities.

A CO₂ and O₂ detection and monitoring system will be installed to monitor and alarm high local CO₂ and/or low O₂ ambient concentrations in the Compressor/Dehydration Area(s).

Per the Fire Water Supply & Storage Evaluation, no new fire water storage tank or pumps are required as the existing Polk Power Station fire water system is adequately sized to support the expansion.

1.4.1.8 Wastewater Handling

The Wastewater Treatment System for the CO₂ capture facility recovers high quality treated water from the wastewater produced from the capture process and discharges remaining wastes to appropriate outlets.

Wastewater from the CCS capture facility will include DCC blowdown, MDCT blowdown, dehydration waste, and reclaimer waste. DCC Blowdown will be treated and will then be sent to the MDCT to meet a portion of the MDCT makeup water requirements. MDCT blowdown will be discharged into the site cooling reservoir for discharge through Outfall 001. The dehydration and reclaimer waste streams will be sent to the Class I UIC wells for disposal.

The DCC Blowdown will be treated prior to use in the MDCT. This treatment system is required to meet permit discharge limits at the site Outfall 001 for the MDCT blowdown waste stream. No treatment is expected for the MDCT blowdown, as the cycles of concentration will be set to meet discharge permit limits.

1.4.1.9 CCS Solvent Storage and Handling

A new solvent storage system is included to allow for complete evacuation of useable solvent and provide storage capacity for a single flush cycle of the CO₂ absorber contactor and stripper vessel and associated piping for a single CCS train.

The amine solution will be pumped via the Rich Solvent Pumps to the solvent maintenance storage tank which will have sufficient capacity to store the entire amine solution volume for the CO₂ absorber contactor, stripper vessel and associated piping for a single CCS train. After the absorber column is emptied of the amine solution, the absorber column will be flushed with absorber water wash water to rinse residual amine solution. The washdown water will be pumped via the Rich Solvent Pumps to the solvent washdown storage tank.

Washdown water will be removed from the solvent washdown tank via vacuum truck. After any necessary maintenance is completed, the amine solution will be pumped back to the CO₂ absorber via the tank / vessel maintenance pumps from the solvent maintenance storage tank for normal operation to commence.

At this time, since there is not a commercially available, cost-effective, large-scale amine-in-water treatment system, all solvent amine contaminated processes will be directed to the Tank / Vessel Washdown Tank for offsite treatment. This will be further evaluated with the Project Team during future phases of work.

1.4.1.10 Steam Extraction and Conditioning Systems

Low pressure steam is extracted from the PK2 steam turbine generator (STG) intermediate pressure turbine to low pressure turbine (IP-LP) crossover pipe assembly to support the CCS facility steam demand. As part of this study, a Steam and Electric Power Sourcing Study was conducted with the steam turbine OEM to understand the impacts and cost associated with extracting a large quantity of steam from the IP-LP crossover pipe assembly. See Section 1.5.1 for additional details.

The LP steam line splits with one main header for each CCI train. There is no other steam demand or systems users beyond the stripper steam heaters. There are no consumptive users.

The common LP steam header includes multiple drip legs and drain pots to remove condensate generated in the pipeline during startup and shutdown. A valve station with motor-operated valves is provided on the common LP steam header to provide isolation of the main steam source to the CCS facility.

Each CCI Train LP steam header includes an automated isolation valve and steam conditioning assembly to modulate pressure and attemperate the steam supply to the stripper steam heaters. Steam attemperator spray flow is sourced from the CCS facility condensate return system.

1.4.1.11 Condensate Return System

Steam supplied to the CCI Stripper Steam Heaters condenses within the island and the resulting condensate will be collected and returned to the existing plant condensate system. The pH and conductivity of the condensate return from each stripper steam heater will be monitored for leakages from the CO₂ process equipment (amine solvent).

Condensate from the stripper steam heaters will first be collected in train-specific condensate break tanks. Slipstreams from each stripper steam heater will be directed to pH and conductivity analyzers to monitor for solvent/amine leakages into the condensate process. If pH and conductivity is maintained, the train-specific condensate transfer pumps will direct the condensate through a heat exchanger to a common condensate return tank. The condensate cooler heat exchanger is sized to cool the condensate return stream to match the

existing PK2 condensate system tie-in location operating temperature.

Condensate return pumps then transfer the condensate from the common condensate return tank back to the existing PK2 condensate system.

The common condensate return header includes a final set of pH and conductivity analyzers. If condensate return conductivity is out of range, the condensate return pumps will trip and prevent flow back to PK2 via an automated isolation valve at the existing condensate system tie-in. While there are condensate treatments such as polishing systems that include filtration as well as ion exchange resin for treatment of dissolved solids, the condensate in the CCS is not expected to have any dissolved contaminant issues.

If at any point the pH or conductivity of the condensate return is out of acceptable range, this would indicate amine solvent leakage into the train-specific condensate return stream. To avoid amine solvent contamination of the PK2 steam cycle, automated valves downstream of the transfer pumps will direct flow from the condensate coolers to the condensate dump tank. The dump tank allows time for the operations team to confirm a solvent leak before tripping the corresponding CCS train system. At this time, the collected condensate can be transferred to the Tank / Vessel Washdown tank, to be evacuated and trucked off-site for treatment. In the event the condensate is not contaminated, the condensate can be transferred from the condensate dump tank to the condensate return tank via the condensate dump pumps.

Initial fill and makeup due to potential losses in the system will be supplied from the CCS demineralized water distribution system.

1.5 INITIAL SCOPE DEFINITION STUDIES

Several scope definition studies were conducted to evaluate the optimal design concept for the project. These studies also allowed informed decisions to be made, which increased confidence in the level of accuracy of the cost estimate. The conclusions of these studies were used as a basis of the preliminary design or as a selection criterion for design basis or configuration. This section of the report outlines the purpose, scope, and conclusions of those studies.

1.5.1 Steam and Electric Power Sourcing Study

The purpose of the Steam and Electric Power Sourcing Study was to identify, evaluate, and ultimately select the source of steam and power to meet the requirements of the CCS at PK2. The steam requirement at the CCS is low-grade steam to serve the CCS reboilers.

Four steam sourcing scenarios were evaluated:

- 1) Steam extraction from PK2 steam turbine (ST) intermediate pressure (IP) to low pressure (LP) turbine

crossover assembly; electric motor-driven CO₂ compressor; no PK2 combustion turbine generator (CTG) upgrades.

- 2) Auxiliary Boiler Equipment producing intermediate-pressure (IP) steam (approx. 650°F/600 psia) to provide the energy to a steam turbine-driven CO₂ compressor; the subsequent letdown steam supplies CCS reboilers.
- 3) Combined Heat and Power (CHP) (Combustion Turbine / Heat Recovery Steam Generator) to supply low-pressure (LP) steam and on-site power for CCS; electric-motor driven CO₂ compression.
- 4) Steam Extraction from PK2 ST IP-LP crossover assembly in conjunction with a 7FA.04 Advanced Gas Path (AGP) Upgrade to CTGs, electric motor-driven CO₂ compression.

An evaluation methodology was developed consisting of multiple key performance indicators to compare the scenarios at various PK2 operating cases. Scenario 3: CHP was removed early in the review process due to high capital costs associated with the CTG-HRSG trains required for steam production and the associated 45% increase in flue gas design flow compared to steam extraction cases. The 45% increase in flue gas design flow would also lead to additional capital and O&M cost for a larger CCS facility. The remaining scenarios were evaluated based on review of the utility requirements and the subsequent impact on PK2 power output and heat rate. A comparison of Scenarios 1 and 2 against the selected Scenario 4 is provided in **Error! Reference source not found.**, below.

Table 1-3 — CCS Design Case Plant Performance of Steam Sourcing Scenarios

Parameter	Units	Scenario 1	Scenario 2	Scenario 4
Flue Gas Volumetric Flowrate	ACFM	- 1.4 %	+ 9.9 %	BASE
Net Plant Output Over Base	%	- 12.1 %	- 0.1 %	BASE
Net Plant Heat Rate Over Base	%	+ 3.9 %	+ 13.0 %	BASE

Scenario 2 has the largest heat rate penalty, in that the additional natural gas consumption for the auxiliary boilers adds fuel without adding net generation. In addition, the additional flue gas would result in an increase in incoming flue gas mass flow which would lead to associated increases in capital and O&M costs for ductwork and a larger CCS facility. Scenario 4 yields the lowest heat rate impact across the cases (AGP efficiency gain offsets the extraction penalty), followed by Scenario 1. Scenario 4 also has the highest net output with CCS. The performance evaluation ultimately led to selection of an IP-LP turbine crossover steam extraction at the PK2 STG coupled with CTG AGP upgrades in Scenario 4 as the approach for this FEED study. This was selected due to the high performance scores across all criteria including steam demand, cooling duty, auxiliary power requirements, and heat rate. HMBs were developed for alternative tie-in locations (cold reheat (CRH)

and hot reheat (HRH) steam) at the current PK2 operation and the estimated AGP operation and were evaluated at a high level, however, these options were not selected for use in this FEED.

Regarding the electrical sourcing, the CO₂ Capture Facility's power will be sourced from the adjacent 230kV substation to which the Polk Power Station facility currently connects. Yard expansion (new bays, breakers, disconnects, buswork, structures, lines) and corridor routing will be coordinated with concurrent plant, substation, and transmission projects. Due to TEC's ownership of and familiarity with the substation and its potential expansion capabilities, expansion of and sourcing power from the existing substation was the most viable and economic option.

1.5.2 Cooling Sourcing Study

A study was performed to evaluate cooling water availability and cooling capacity for the new CCS systems. In this study, mechanical draft cooling towers (MDCT), fin fan heat exchangers (FFHX), wet surface air coolers (WSAC), once-through cooling, and hybrid cooling schemes were evaluated as potential cooling options. Dry (FFHX) and hybrid cooling systems were eliminated from consideration due to the amount of excess water currently available at Polk, and the cost and performance detriments associated with each. FFHX is a poor fit for the cooling duty required and the climate, requiring a large installed footprint, high auxiliary power usage, and the subsequent high cooling water supply temperatures would degrade CCS performance. Once-through cooling using the existing 755-acre reservoir was reviewed, however, the reservoir would not have enough existing capacity to meet the entire cooling demand of the CCS without potentially significant modifications. Higher velocities through the once-through cooling system resulting in erosion would be a concern, along with thermal and/or National Pollutant Discharge Elimination System (NPDES) constraints that could be exceeded during the summer months. Even in the steam extraction case, which provides cooling duty savings in the form of reduced condenser duty in the base plant's steam cycle, only about 55% of the CCS duty could be offset, and the aforementioned constraints would still be applicable. Thus, once-through cooling via the existing reservoir was eliminated from further consideration.

Both MDCTs and WSACs were the primary options considered for meeting the cooling water requirements of the CCS. While both options are viable, MDCTs were selected as the best option when considering the site-specific design criteria and currently available water at Polk. MDCTs exhibited the lowest overall cost, footprint, and power requirements, and a similar design from the existing MDCT at PK2 can be utilized. While a WSAC may provide some water savings due to higher operating cycles of concentration, water savings is not considered critical as PK2 has an abundance of sustainably sourced water. WSACs were eliminated from further consideration due to unfavorable economic modeling as compared to MDCTs, requiring additional utilities such as power, and taking up a larger installed footprint than MDCTs. A summary comparison of MDCTs and WSACs is provided in Table 1-4, below.

Table 1-4 — CCS Design Case Plant Performance of Cooling Sourcing Scenarios

Parameter	Units	MDCT	WSAC
Installed Cost Over Base	%	BASE	+ 284 %
Cooling Footprint Over Base	%	BASE	+ 378 %
Cooling Aux Load Over Base	%	BASE	+ 343 %

1.5.3 Water and Wastewater Treatment Study

The Water & Wastewater Treatment Study summarizes the approach of supplying makeup water to CCS and BOP systems, the treatment or disposal of wastewater sources, and the need for wastewater treatment system(s).

Polk’s RWTP is a state-of-the-art reclaimed water treatment facility that is capable of treating reclaim water from the cities of Lakeland and Mulberry to various qualities to meet the makeup water needs of Polk. This is accomplished by first clarification via a Densadeg followed by multi-media filtration and then reverse osmosis. The water products from the RWTP are then used throughout the plant, for uses such as makeup for cooling systems, steam cycle makeup, service water, and other secondary plant water users. Wastewater generated from the RWTP are injected into the existing UIC wells for disposal. Independent of the CO₂ capture project development, there are plans for extensive equipment modifications including a transition to ultrafiltration in lieu of the clarification and media filtration process. Should this project be executed, it is expected that sufficient capacities of each required quality of makeup water will be available.

The CCS will require makeup water to various processes, both within the CCI and for the balance of plant (BOP) systems. Makeup water requirements and qualities for the CCS can be broken down into four primary categories: Service Water, Cooling Tower Makeup, Water Wash Makeup, and demineralized water. CCS service water and potable water demand will be met by tying into the existing systems at PK2 and extending a supply line to the CCI. Cooling tower makeup will be sourced from both RWTP 1st Pass RO permeate and treated DCC Blowdown produced in the CCS. Produced water from the CCS will require treatment prior to usage in the cooling tower in order to meet discharge permit requirements. Any demineralized water requirements for the CCS will be handled via tying into the existing demineralized water system at Polk and extending a supply line to the CCI with no CCS required upgrades.

The CCS and BOP systems will produce wastewater streams that will need to be directed to various discharge locations and potentially treated to meet the permit limits associated with the discharge points. Treatment

systems were selected based on initial wastewater constituents, required limits at the respective discharge points, and commercially available technology suited to accommodate the necessary treatment. Major wastewater streams associated with the CCS and BOP systems include the following: DCC blowdown, MDCT blowdown, reclaimers waste, dehydration waste, and RWTP wastewater. DCC blowdown water will be treated based on a preliminary characterization of the stream prior to use as cooling tower makeup. As such, MDCT blowdown will be sent directly to the Polk cooling reservoir with no additional treatment required. RWTP wastewater including ultrafiltration (UF) backwash and RO reject will be handled in two ways. UF backwash is planned to be sent directly to the cooling reservoir, subject to regulatory approval. RWTP 1st Pass RO reject will be sent to the UIC injection wells, which will require an increase in the permitted capacity of the wells. Both brine wastewater and dehydration waste flows were determined to be acceptable for disposal via the injection wells. No treatment for either waste stream is included for the FEED.

1.5.4 Train Configuration Study

The purpose of this Train Configuration Study is to describe and document the alternative equipment configurations that were considered for the PK2 FEED. Numerous considerations are factored into the configuration selection including, but not limited to, capital cost, operational flexibility of the CCS (taking into consideration the range of PK2 flue gas flows), and equipment sizing restrictions. This evaluation is typical of early FEED studies where multiple options are screened using macro-level drivers. Since a RAM (Reliability, Availability, and Maintainability) analysis is typically not available at this stage of project development, considerations for equipment spares and redundancy are not included for the train configuration study. Additionally, the amount of time spent at flue gas flow rates less than the design rate (such as required performance turndown cases) can have a significant effect on the operating cost for a particular configuration option (expressed as \$/ton of CO₂), considering that the Compressor could be running in significant recycle.

Alternative options were considered and screened for the CCS facility early in the FEED study. The configurations evaluated were:

- Option A: 2x50% train configuration (Design Case)
- Option B: 2x50% train configuration but with 1x100% STR
- Option C: 3x33% train configuration
- Option D: 4x25% train configuration

Each Option was considered, discussed, and evaluated based upon the benefits and drawbacks of the Option. Dehydration was considered a subsystem of the compression package and not a standalone Option for this study. Since the dehydration package is in between the LP and HP stages of compression, crossover piping to allow the dehydration package to serve alternate Compressors was not considered viable.

Ultimately, it was determined that Options A and B were lower in cost than Options C and D. Option A was confirmed as the train configuration for the FEED Study. Option A was ultimately selected as it reduces the risk of an entire CCS outage due to the failure of a single system component.

2. FEED STUDY ENGINEERING AND DESIGN PACKAGE

2.1 INITIAL ENGINEERING DESIGN

The initial engineering design purpose was to develop the preliminary process design package (PDP) for the process which served as input to the design of the ISBL and the BOP scope. The following section details the work performed. The subject award's process design was completed in 2023 and thus utilizes learnings from prior ION work up through pilot demonstration at the National Carbon Capture Center completed in 2021.

2.1.1 Process Modeling

ION performed the process modeling utilizing OGT's ProTreat® process simulation tool to simulate the carbon capture process. ProTreat® requires solvent-specific parameters to accurately predict the operation of a post-combustion carbon capture system using ION's solvent. These parameters were determined and shared with OGT under previous projects.

Once the software was updated with ION's solvent, it was used to predict performance of the carbon capture plant, including the required steam, electrical and cooling duties. The software also assists in sizing the heat exchangers and predicts capture efficiency and specific reboiler duties while allowing for the manipulation of operating conditions for the plant. The evaluation and performance of all major equipment, as well as comprehensive stream tables are generated as the output of the model. The validation of this process model was completed in a previous DOE sponsored program (DE-FE0013303), resulting in high confidence of the process simulations conducted for TEC PK2.

ION utilized a proprietary module of ProTreat® developed by OGT, to design a carbon capture plant optimized to take advantage of the properties of ION's advanced solvent at PK2 based on the Design Basis documentation.

Table 2-1 displays the output summary from the ProTreat® process model for one of the two identical trains for TEC PK2. This shows the amount of flue gas treated, the capture efficiency, captured CO₂, and required L/G for an SRD of 2.62 MJ/kg CO₂ (1,129 BTU/lb CO₂).

Table 2-1 — Model Results

Parameter (Flue Gas Inlet)	Units	Value
Flow Rate	MMSCFM	96.8
CO ₂ Content	Vol %	4.1
Percent Capture	%	95
CO ₂ Captured	lb CO ₂ / hr	430,416
	Tonne CO ₂ / day	4,686

2.1.2 Process Modeling Output

The output of the ProTreat® simulation tool allows for the development of the Process Design Package that was delivered to the project. The following process deliverables were provided to the Project Team as part of ION’s process design responsibilities:

- System Description
- Process Flow Diagram
- Material Selection Guide

2.1.3 Preliminary Design Review Meeting

A Preliminary Design Review (PDR) was held by the project team from May 22 – 24, 2023. The purpose of the PDR was to perform a Project team review of preliminary design deliverables focusing on overall scope of design to ensure cohesiveness between the different project parties. The PDR serves as the first checkpoint to ensure project goals are being met, identify major CCI system changes to be evaluated, and address comments and questions prior to further engineering and design development.

2.2 PROCESS AND OVERALL PROJECT ENGINEERING DESIGN

Critical design documents were developed to form the basis of generating input to the capital cost estimate for the project. These documents include the Site Plan, General Arrangement (GA) Drawings, and Process Flow Diagrams (PFDs), among others. Ultimately, the development of these documents informed the capital and operating cost estimates. The documents developed during the project are outlined in more detail below.

2.2.1 Process Design Package Review Meeting

A Process Design Package (PDP) Review was held by the project team including TEC, ION, S&L, Koch, and Siemens from November 14 – 15, 2023. The purpose of the PDP review was to perform a Project team review of the process design package focusing on CCI process systems and equipment. The PDP Review serves as the second checkpoint to ensure project goals are being met, and comments and questions can be addressed prior to beginning BOP CCS engineering and design and further developing PK2 integration and major tie-ins.

2.2.2 Environmental and Mechanical Engineering

The mechanical engineering effort determined the process and non-process mechanical systems and equipment necessary for the operation of the new CCS at PK2. The mechanical engineering scope for the PK2 project included both the process and the balance of plant scope identified above and interconnections to the CCS. Preliminary process engineering for the CCS process equipment was completed, supplemented by further engineering and design. The following deliverables were developed as part of the environmental and mechanical engineering and design.

- PFDs
- Project Site Plan
- General Arrangement Drawings for the Carbon Capture Island

PFDs were prepared for the BOP system (including booster fans, steam tie-ins, condensate return, cooling tower, and various water and wastewater treatment systems). Separate PFDs were prepared for the CO₂ capture process equipment from flue gas conditioning through compression of CO₂. Both separate PFDs were then incorporated into the unified project PFD deliverable. These deliverables were used to determine all project components and major tie-in locations related to the carbon capture process island. Process material balances were prepared for all major gas and liquid process flows. These balances were used as a basis for sizing pipelines, pumps, heat exchangers, and storage vessels and tanks, and other equipment. Further, the balances served as a check on process flows, waste generation, and commodity consumption rates.

2.2.2.1 Fire Water Supply Evaluation

The purpose of the Fire Water Supply & Storage Evaluation was to evaluate the existing Polk 2 fire protection water supply and distribution system and determine if the existing underground fire protection system has sufficient capacity for a new, extended underground loop which can accommodate the new CCS facility, or if a dedicated new fire protection storage, supply and distribution system is required. The existing plant-wide underground fire water loop serves PK1 (IGCC), PK2, RWTP, and PK plant common areas (e.g., the control and administration building, warehouses, etc.). The water source is the cooling water reservoir via four pumps

installed per NFPA 20: three main pumps and one jockey pump. The approach to the evaluation was as follows to determine the extent and capabilities of the existing fire protection system:

- Determine the fire water demands for the new CCS Facility.
- Assess whether the existing fire protection system can meet the fire water demands of the new CCS Facility at the Polk Power Station.

Three possible tie-in points were identified, two of which should be used to ensure that a single point of failure is avoided or that if a portion of the underground loop needed to be isolated and worked on, the overall system would remain operable. The new CCS underground fire loop consists of 12-inch high-density polyethylene (HDPE) SDR 9 piping, compatible with the site's design pressures and temperatures. Hydraulic estimates utilizing field test data estimated the available firewater supply to the CCS island would have adequate flow and pressure under the governing demand case to extend the existing fire water system at site. Each evaluated tie-in supports the CCS demand with substantial pressure margin, even when estimating head losses along the longest run to the most remote CCS fire water demand. As the demands of the new CCS Facility are expected to be similar to the existing station's current fire water demands, it was concluded there is sufficient capacity and pressure to meet the new demands. Therefore, no additional equipment (i.e., fire water storage tank(s) or fire water supply and distribution pump(s)) will be included in the CCS FEED Study fire water system design. Section 1.4.1.7 contains additional detail on the Fire Water Supply design.

2.2.2.2 Natural Gas Supply Evaluation

Gas transmission pipelines deliver natural gas to Polk via a 12-inch Class 600 pipeline into the site's metering and regulating (M&R) compound, then a 16-inch, 300# underground header feeds Unit 1 (IGCC) and Unit 2 (4x1 NGCC), including CT fuel skids and HRSG duct burners. The M&R has three parallel regulator runs and common pre-regulation equipment (filter, meters, pressure control station, coalescer). Site regulated supply pressure ranges about 550–625 psig.

This study evaluated the effects on the natural gas system at the Polk Power Station due to two different options for providing process steam for the CCS. The two options include 1) adding new natural gas-fired auxiliary boilers and 2) using extraction steam from the existing STG in a post-AGP upgrade operation.

The study then evaluated the existing Polk Power Station metering and regulating (M&R) station and major natural gas supply pipelines to determine if expansion or upgrade of these components is required due to the increase in natural gas flow for the auxiliary boiler option, which is the conservative case due to the higher natural gas flow rate. Using historical operational data, the pressure regulators at the M&R station are expected to have sufficient capacity for the increase in natural gas flow rate.

A hydraulic analysis shows that most of the major natural gas pipelines would fall within industry-accepted velocity limits for natural gas. The hydraulic analysis showed that adjustments to the pressure regulator set points at the M&R station are likely required to deliver the natural gas at the pressures required at the facility interface points.

The conclusion of this study is that the existing M&R regulators and primary distribution have sufficient flow capacity to support either the AGP upgrade or auxiliary boiler options and regulator setpoint adjustments should be adequate to meet interface pressures, without regulator replacement. It is recommended that the next phase of this project engages further on the increase in natural gas supply and pressure, consider inspection and/or testing to establish Polk Station natural gas velocity criteria based on erosion conditions in the existing natural gas piping, confirm compatibility of GE fuel gas equipment, and confirm compatibility of site fuel gas conditioning equipment.

2.2.2.3 Permitting & Regulatory Review (Permitting Matrix)

A permitting matrix was developed to summarize the expected permitting requirements and permitting schedule for construction and operation of the CCS facility at an existing NGCC plant facility. The major permitting areas investigated were air quality regulations and permits, water use permits and limitations, wastewater discharge permits, and solid waste management and disposal.

2.2.3 Electrical Engineering

The electrical engineering effort determined the electrical systems and equipment necessary for the operation of the new systems.

The overall CCS electrical power system design was developed based on CCS and BOP power requirements. The main source of power will be from the existing plant 230kV switchyard located on the north side of the Polk Power Station. The existing switchyard will be expanded to the west and a new transmission line will be routed along the west side of the existing Polk station and into the new 230kV substation located at the CO₂ Capture island. The 230 kV power is stepped down to 13.8 kV and supplied to the main CO₂ Capture island electrical equipment located in and around the common electrical building. All medium-voltage (MV) equipment is powered from the common electrical building switchgear and distributed to the local power distribution centers (PDC) at Train A, Train B, and the CCS Cooling Tower. MCCs and all other equipment (480V and below) are supplied from the nearby local PDC to reduce the length of smaller cables.

The project electrical load list, including CCS and BOP, was used along with the site plan to determine the electrical distribution layout and to size electrical equipment for the auxiliary power transformer, switchgear, and MCC. A single-line diagram was also created to ensure that the operation of electrical equipment on the CCS island remains energized even if one service station transformer (SST) fails.

A detailed auxiliary power study was conducted by modeling in ETAP to determine the power rating (MVA) for transferring power from the 230 kV substation to the auxiliary equipment. The auxiliary power system is analyzed under steady-state operating conditions to assess equipment loading and voltage levels throughout the system. In general, Load Flow, Short Circuit, and Motor Starting studies are performed to determine the minimum running voltages at each bus, the maximum available interrupting and momentary fault current at each bus, and the minimum motor terminal voltages at the largest medium and low voltage motors during starting.

2.2.4 Instrumentation and Controls Engineering

The Instrumentation and Controls (I&C) engineering effort focused on development of facility control and process/system monitoring requirements required for reliable, safe, and efficient operation of the new CCS. Instrument & controls selection was driven by demand to provide the highest possible level of automation to eliminate human intervention as much as possible and to minimize errors leading to process upsets causing disruption of operation. As part of the P&ID development effort, the I&C engineering team collaborated with the mechanical and process engineers, ION (CCS technology supplier), and TEC to ensure adequate instrumentation and controls were in place to safely and effectively operate and control all CCI systems. One of the most critical aspects of the CCS facility is reliable operation, thus significant attention was given to eliminating single points of failure while designing instrumentation and controls. Accurate instrument counts along with a defined CCI scope and operating philosophy supported development of I/O counts which were used to solicit budgetary quotes for the CCS distributed control systems (DCS), which would be integrated with the existing PK DCS.

Additionally, S&L worked with TEC to develop a Network Architecture Diagram and a conceptual control room layout for the integrated CCS control system with the existing PK control systems and control room operations consoles.

2.2.5 Structural and Civil Engineering

The structural and civil engineering effort focused on the development of sitework, and preliminary design of the flue gas ductwork, structural support steel, and foundation designs to support the BOP and CO₂ Capture equipment and systems.

The civil engineering scope included a study of the CCS site grading and was based on existing PK2 site storm water and site grading drawings. Also included is preliminary design for site drainage, storm water management, and a water quality pond.

2.2.5.1 Geotechnical Evaluation

A geotechnical study was developed to summarize the evaluation of available geotechnical information and geotechnical recommendations for PK2 CO₂ Capture FEED Study. Based on a detailed review, the following information was used as the basis for conceptual foundation design:

- Augered Cast-in-Place (ACIP) Pile capacity – 100 tons at a pile design length of 80 ft (allowable with a factor of safety of two, to be confirmed with pile load tests). For a pile axial capacity of 80 tons allowable, the pile design length is 70 ft. This considers an 18" diameter auger cast pile. Pile type may change if future project specific geotechnical investigation encounters karst conditions. These values are applicable to single isolated piles (group effect is not included).
- Lateral capacity – 8 tons (allowable with FS = 2 to be confirmed with pile load tests). Group effect is not included.
- Allowable Bearing Capacity for a minimum foundation width of 5 ft – 2.5 kilo-pound per square foot (not including effects due to settlement).

The project team recommends performing additional project specific geotechnical subsurface investigation during detailed design in order to obtain additional site-specific soil data, confirm the basis of design, and to confirm no karst features are present.

2.2.5.2 Site Grading and Stormwater Drainage Study

As part of the Site Grading and Stormwater Drainage Study, the project team summarized the evaluation of existing site conditions to provide a recommendation for the proposed site grade for the Polk 2 CO₂ Capture Facility. It is assumed that the site grade elevation of 143 feet used for the current plant has been adequate to mitigate potential flood water levels from impacting site operations and equipment. Therefore, it is proposed that the CCS equipment will use similar elevations, with the high point of grade in the CCS equipment area being 143 feet. The vegetated area south of the existing PK2 plant has a high point of 143 feet, so matching existing grades and top of concrete elevations is a feasible criterion.

The CCS facility will occupy a portion of the vegetated area south of the existing plant equipment. The balance of the vegetated area south of the CCS facility will be converted to a construction laydown and fabrication area that will be used during CCS facility construction. The two land use changes will increase runoff volume and runoff peak flow that will ultimately discharge to the existing reservoir south of the new CCS facility. To meet water quality requirements that would be typically stipulated by the Southwest Florida Water Management District, it is proposed to maintain as many vegetative ditches as practical and add a water quality pond at the

far south end of the site that would accommodate a 1-inch runoff from the modified CCS facility and construction use areas.

The new CCS drainage system that is intended to provide water quality treatment for storm water runoff will also need to handle the 100-year storm event. It is anticipated that the existing ditches and the existing culverts currently used to discharge this vegetated area to the south cooling reservoir have a large amount of hydraulic capacity, and these existing systems would be evaluated to handle the 100-year runoff flow from the developed CCS area. It is assumed that the existing reservoir south of the site, can accommodate the increase in 100-year runoff volume considering the CCS plant and laydown area site modifications.

2.2.6 Contactor and Compression & Dehydration Design

Koch Engineered Solutions (KES), primarily with the support of Koch Specialty Plant Services (KSPS) and Koch-Glitsch (KG), had the responsibility of the design, supply, fabrication and installation of the main CCS train vessels, including the Direct Contact Coolers (DCC), CO₂ Absorber Contactors and the Stripper Contactors, and vessel internals and packing.

Siemens Energy's scope on the project involves the design, supply and fabrication of the CO₂ Compression System, including the integrated inter- and after- CO₂ coolers. Additionally, Siemens Energy scope includes the oversight and supply of the Dehydration System, as well as associated interconnecting piping and accessories.

2.2.6.1 Contactor Design

ION's strategic partner, Koch Engineered Solutions (KES), scope involves the design, supply, fabrication and installation of the main train vessels. This includes working with Koch-Glitsch to design, accommodate, and supply the vessel internals. The main train vessels and their internals are developed by KSPS and Koch-Glitsch as per ION's process design, the Project Design Criteria documentation, and Project Team inputs via Design and Constructability Reviews. KES also provided vessel design documents and drawings for the vessel internals and contactor vessels.

KES evaluated different material options and construction strategies that may be employed in the design and construction of the large process vessels. This evaluation is intended to identify an optimum solution for the construction and erection of the major CCS process vessels, on which additional design and estimating efforts can be focused to support the overall FEED study. Some items considered in the evaluation include shop vs. field fabrication, concrete vs. solid alloy vs. clad materials of construction, design code options (e.g., ASME Section VIII Div 1 vs 2), degree of non-destructive examination (NDE), and, in the case of the Absorber and DCC vessels, round vs. square or rectangular construction. The evaluation ultimately concluded round vessel construction utilizing solid alloys and as much shop fabrication as practical to be the best strategy.

2.2.6.2 Compression and Dehydration Design

CO₂ Compression System equipment was developed by Siemens Energy as per ION's process design, the Project Design Criteria documentation, and Project Team inputs via Design and Constructability Reviews. Siemens Energy provided technical deliverables to the Project Team in the form of a Division of Responsibility Matrix and System Design Documents and Drawings.

Siemens Energy's scope involved the design, supply and fabrication of the Compression System. This included the Integrally Geared Compressor (IGC) CO₂ compressor units, Dehydration System Equipment, LP CO₂ Coolers, and HP sCO₂ Coolers, as well as the associated interconnecting piping and accessories.

Siemens Energy provided pricing and drawings as project deliverables with respect to an electric-driven IGC compressor and Dehydration System utilizing an electric heater.

2.2.7 Process Hazard Analysis (PHA) / Hazard and Operability (HAZOP) Review

The project team conducted a multi-session multi-day PHA, using HAZOP methodology, to review the safety and operability of the CCS Process systems and major BOP systems at the proposed CCS facility. Safe operation of these systems is of utmost importance to protect the employees and contractors (personnel), the environment, equipment (asset/property, business interruption). All sessions were based on the design of the subject systems.

The study consisted of a systematic review of the available PFDs for the proposed CCS system to identify hazardous operating scenarios and potential areas of concern, in accordance with American Institute of Chemical Engineers (AIChE) and Center for Chemical Process Safety (CCPS) recommendations for PHA and Hazard Identification and Risk Analysis (HIRA). The HAZOP methodology also meets the OSHA 1910.119 Process Safety Management regulatory requirements for Process Hazard Analysis.

S&L completed the FEED Study PHA in five (5) sessions in March 2024 following industry best practices for "What If" methodology. The overall conclusion from the FEED Study PHA is that the systems are generally well-designed with the necessary safeguards in place to prevent hazards and risks from occurring and/or mitigate them appropriately. S&L assumed that all systems have been designed according to applicable industry codes and standards. This study resulted in 175 total recommendations to improve the design of the project, to be addressed across this FEED, future FEEDs, and Detailed Design, prior to construction of the Carbon Capture facility.

An additional HAZOP, to review the design further and confirm adequate system safety and operability, will be part of the next design phase of this project.

Main topics of discussion and outcomes from this meeting included:

- Overall, The FEED Study CCS sub-systems were determined to be generally acceptable from a safety and operability standpoint with enhancements identified in the Recommendations List for incorporation during this FEED Study, and consideration during the subsequent FEEDs Study or Detailed Design.
- Various enhancements of the control system and instrumentation redundancy (2 out of 3 voting) were identified to be incorporated into this FEED's design.
- Project Team noted further evaluation of the DCC vessel and flue gas ductwork with regards to the CCS Booster Fan is recommended to occur during future FEED Studies.
- Project Team indicated further review of transient conditions within the CCS process systems and major support systems (flue gas supply, steam supply, condensate return) is recommended during future FEED Studies.
- Project Team identified the control system and associated permissives and interlocks will be required for interconnecting systems between PK2 and the CCS facility (flue gas supply, steam supply, condensate return) and should be established during Detailed Design.
- Project Team identified existing Polk Plant operating, safety, and personnel related procedures to be evaluated in detail to determine revisions or new practices to be developed to address the new CCS facility during Detailed Design.

2.2.8 Constructability Review

Constructability reviews were conducted to review the arrangement, identify critical construction activities, identify constructability challenges, and develop a preliminary construction sequence. The constructability reviews included review of the design criteria, system description, conceptual drawings, the 3D model and other related information. Construction design review meetings were held with members of the ION project team, S&L, Kiewit, Koch, and TEC project team members. A construction plan, including construction sequencing and equipment handling, was then developed to ensure that the design and General Arrangement of the facility were reasonable and that key construction activities can be carried out in an efficient order. During the review process, the basis of the construction schedule and costs were developed. Ultimately, the installation contractor will be responsible for developing a detailed plan and sequence that will be used for the work during the execution phase, including the additional elements not addressed herein such as personnel safety, protection of plant equipment, the protection of equipment being installed, and construction quality assurance.

Another major constructability objective was to assign Construction Work Areas (CWA), which are the framework for development of the execution plan and becomes the guideline for Construction Work Packages (CWP).

Main topics of discussion and outcomes from the constructability meetings included:

- Laydown space requirements should be re-evaluated, and lead times updated accordingly as the project progresses. In order to keep the construction areas open for construction activities and reduce as much congestion as possible for construction crews, the land to the south and east of the project will be utilized for laydown, office trailers, parking, prefabrication areas for Vessels & Ductwork, and temporary Construction warehouse.
- Access needs should be considered to ensure that the piling equipment can access areas with existing infrastructure. Additionally, helical piles should be investigated as an option for this project.
- Evaluate whether a permanent dewatering system is required or if local dewatering will be adequate.
- To reduce the period of time for heavy lift crane usage during vessel construction, multiple prefabricated sections can be erected in the laydown yard using a smaller crane during prefabrication. The heavy lift crane can then be used to set ductwork while in between lifts for the vessels.
- For concrete foundations, utilize mudmats for working surfaces; reuse/reconfigurable form systems; evaluate multiple ready-mix suppliers or an on-site plant; standardize shapes and use Helix fiber where practicable.
- For structural steel, maximize shop fabrication (baseplates, platforms, handrail, pipe supports/lugs); erect process pipe racks east→west then south→north by elevation; mitigate trade stacking with just in time deliveries and complete-elevation turnover; consider precast options as able.
- For ductwork and duct support steel utilize shop panelized, pre-insulated where feasible. Set HRSG tie-in duct short spools first and stage road over sections later to maintain access.
- Mechanical piping should be bottom supported where possible. Utilize shop spooling and painting leveraging multiple fab shops. Pre-install supports/hangers to reduce work at height; stage equipment setting to avoid crane conflicts near compressor/tanks.
- Site-fabricated vessels should be shop rolled components preassembled into ring sections in the laydown yard, moved by SPMTs, and set with heavy lift crane. Plan just in time deliveries, multiple QA hold points, and staged packing installation. Coordinate vessel erection with structural steel sequencing and leave out foundations to allow for heavy crane(s) to be located adjacent to vessels.

2.2.9 Project Execution Plan

The purpose of the Project Execution Plan (PEP) is to describe and document the overall project management approach and project organization for the project. The PEP defines objectives, roles and

responsibilities, organization, and controls necessary for successful completion of the full execution project.

While Power / Utility companies have been executing new generation construction projects for over 100 years, the financial and physical scope of a carbon capture project is generally at the upper bounds of projects commonly undertaken by these companies. Owners of power generation fleets have historically utilized one of two major contracting strategies; either a single contract “Engineer-Procure-Construct (EPC)” project model or a multiple contract “Multiple Lump Sum (MLS)” project model. The decision process for selection of a contracting strategy has typically been based on the Owner’s risk tolerance, funding requirements, performance guarantees, and historical experience.

For this FEED the MLS model was selected with the Owner and Owner’s Engineer developing and executing multiple procurement packages and integrating them into a cohesive design to provide construction work packages to a primary General Work Contractor (GWC) and smaller sitework and piling contractors for implementation. Total equipment and work procurement packages preliminarily consist of forty-six (46) mechanical, twenty-two (22) electrical and controls, six (6) structural, and seven (7) labor or site services contracts.

Scope for the entirety of the project was developed via a division of responsibility matrix (DOR). The DOR defines which entity is responsible for engineering/design, supply/procurement, and installation/implementation for all major parts and pieces of the project. This document in combination with the procurement packages was used to group the project capital cost estimate into packages of known scope for future cost control and alignment on scope definition. Utilizing the project schedule, cashflows and escalation were developed.

To manage and monitor all entities supporting the execution project, progress updates will be required to provide monthly reporting on schedule performance, procurement, milestone forecasts, scope changes, delay notifications, and construction quantities.

Other project structural components being implemented to drive quality, safety, value and operations and maintenance include the following:

- Project review meetings to collectively review and challenge high-value design documents such as general arrangements, piping & instrumentation diagrams (P&ID), electrical single lines, 3D modeling, and constructability will be planned into the execution schedule to ensure their implementation is timely.

- Environmental, Health, Safety and Security reviews to expand and revisit previous decisions and recommendations made in process hazard analysis (PHA) and HAZOPs to ensure future design details are vetted for safety.
- Value engineering reviews will be scheduled and implemented to review opportunities to lower capital and/or O&M costs while ensuring the design remains technically acceptable.

2.2.10 Critical Design Review Meeting

A Critical Design Review (CDR) was held by the project team including TEC, ION, S&L, and Siemens from February 27 – 28, 2024. The purpose of the CDR meeting was to review the FEED study design with the project team from plant integration to the CCS process through CCS facility support systems and infrastructure. During the CDR, the focus was on identifying open items and establishing actionable paths forward. The goal at the end of the CDR was to freeze the design in order to kick-off multi-discipline modeling activities and quantity development to support the FEED cost estimate.

2.3 DOE FOA FEED REQUIRED STUDIES

2.3.1 Business Case Analysis

The FEED team performed a Business Case Analysis (BCA) to evaluate the current and projected landscapes of the natural gas and industrial point sources of CO₂ and the potential utilization of tax credits including their projected revenue and duration. This analysis has been developed in accordance with Appendix M of DE-FOA-0002515.

This business case analysis first summarizes the key inputs and results of the pro forma financial model conducted, quantifying the projected financial parameters such as operating costs, operating revenues, financing cash flows, EBITDA, tax credits/liabilities, and ROI over the project lifespan. Key economic/financial assumptions are also outlined.

Next, a description of ION's amine-based CO₂ Capture technology is provided, as well as a description of the potential applicability across the natural gas power generation and industrial point source sector areas – including applicability to TEC's fleet of power generating assets. The market analysis includes discussion of potential financing structures and partnerships for deployment of the technology, as well as potential utilization of tax credits and other incentives.

Finally, future development and deployment projections for the technology for current and future natural gas and industrial point source sectors is outlined at a high-level. Competing technology options and potential barriers to large scale deployment are also identified. Estimates of the potential benefits of large-scale technology deployment are provided in terms of job creation, revenue, emissions reduction, etc.

2.3.2 Life Cycle Analysis

The FEED team conducted a Life Cycle Analysis (LCA) to demonstrate net carbon emissions of the electricity delivered to the consumer from the NGCC plant with carbon capture. This assessment has been developed in accordance with Appendix L of DE-FOA-0002515.

The goal of the LCA is to model the life cycle of greenhouse gas emissions from “cradle-to-gate”, presumably defined as “cradle-to-delivered electricity” (including natural gas extraction and transport, operation of the NGCC, CCS construction and operation, CO₂ transport and sequestration, and electrical transmission and distribution losses), for the proposed CCS to demonstrate significant decrease in carbon emissions of electricity production with carbon capture. This study utilizes the Environmental Protection Agency’s (EPA) Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI) 2.1 method combined with the latest global warming potential (GWP) factors included in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) report where possible.

The CO₂ capture system (CCS) will be capable of capturing a minimum of 95% of the CO₂ emissions from the flue gas and compressing the treated CO₂ to conditions suitable for transportation and sequestration. Additionally, as a part of the proposed project, TEC is retrofitting their combustion turbine generators (CTGs) to an Advanced Gas Path (AGP) technology. This evaluation assumes the facility will operate at a capacity factor of 90% in the future. This results in 3,078,673 tonnes/year of CO₂ captured and 7,298,480 megawatt-hour (MWh) of facility net output per year (including steam derate, auxiliary power and transmission & distribution loss).

A process was created in OpenLCA to represent existing operations at Polk Unit 2. Inputs into the base facility include natural gas and water. Natural gas extraction and distribution were modeled using the “Natural Gas Through Distribution” process from the NETL database. This process represents the complete cradle-to-gate life cycle of natural gas extraction, processing, and distribution for the average United States natural gas system. Outputs include electricity and a breakdown of flue gas emissions. Unit input and output data were obtained from CT data pages, combustion calculations and the facility heat balances developed for this FEED study. Data included fuel flow and composition, gross and net facility electrical generation, and facility stack emissions. The materials and energy inputs associated with the original construction of Polk Unit 2 were not included in the model as this is an existing facility. Polk uses pipeline natural gas for fuel.

Future operations at Polk Unit 2 with CCS were represented by a separate process. Inputs into the process are unchanged from the existing operations process. Outputs include the produced electricity, captured and uncaptured CO₂ and a breakdown of other flue gas emissions from the base facility. The CO₂ emitted from the proposed facility was modeled to be captured at 95% efficiency. Steam and electrical crossties between the host facility and the CCS were determined using the heat balances and electrical loads developed during the

feasibility study. Auxiliary electrical loads feeding the CCS were subtracted from the gross plant output. Steam is extracted from the host facility to feed the CO₂ capture system. Base plant power production was reduced to account for steam extracted from the steam turbine for the CO₂ capture system.

Manufacturing inputs for the CCS were included in the carbon capture process. Materials for the CCS were broken down into aluminum, copper, fiberglass, galvanized steel, cast iron, mineral wool, plastic, HDPE, PVC, concrete, stainless steel, and carbon steel as processes in OpenLCA based on input from ION (inside battery limits) and S&L (outside battery limits). Each material is given its own LCA process for production. Inputs to the CCS due to construction include electrical consumption modeled as “Electricity” processes sourced by the “Current U.S. grid mix” process. Additional construction impacts include diesel combustion modeled using “Combustion of Diesel - US” and gasoline modeled using “Combustion of Gasoline - US”. Utilities used during construction were estimated based on the duration of construction, types of construction activities, temporary equipment needed, and S&L’s construction management experience. The production of chemicals for the CCS was included in the carbon capture process. Chemicals for the CCS were broken down into TEG, amine-based solvent, and NaOH. The transportation impact of delivering all chemicals to site, including the chemicals without OpenLCA processes, is represented within the model. Outputs from the CCS include captured CO₂ which is sent to the Saline Aquifer, nitrogen oxides (NO_x) and carbon monoxide (CO) emissions, water, and disposal of chemical waste.

The transportation and sequestration of the carbon dioxide produced by the CCS was modeled using the pre-established “Saline Aquifer Transport and Storage” process from NETL. Pipeline and sequestration well construction was not included in the scope of the FEED study and therefore not included in this LCA.

Emissions due to the transportation of equipment and construction materials were estimated using the truck transport process in OpenLCA. For each process OpenLCA uses the total weight of all process equipment materials and distance covered of the delivery to determine the amount of diesel combusted during transportation and associated emissions. An assumed 450 miles of transportation was used as the basis for this project.

The contributing processes are shown in Figure 1-1 below for the comparison project with no carbon capture and in Figure 1-2 for the proposed system with carbon capture. The overall generating process for the comparison system emits 497.0 kg CO₂e per delivered 1 MWh of electricity versus 155.4 kg CO₂e per delivered 1 MWh of electricity for the proposed project demonstrating a 68.7% reduction in CO₂e emissions.

Figure 1-1 Global Warming Potential Comparison – Baseline Operations

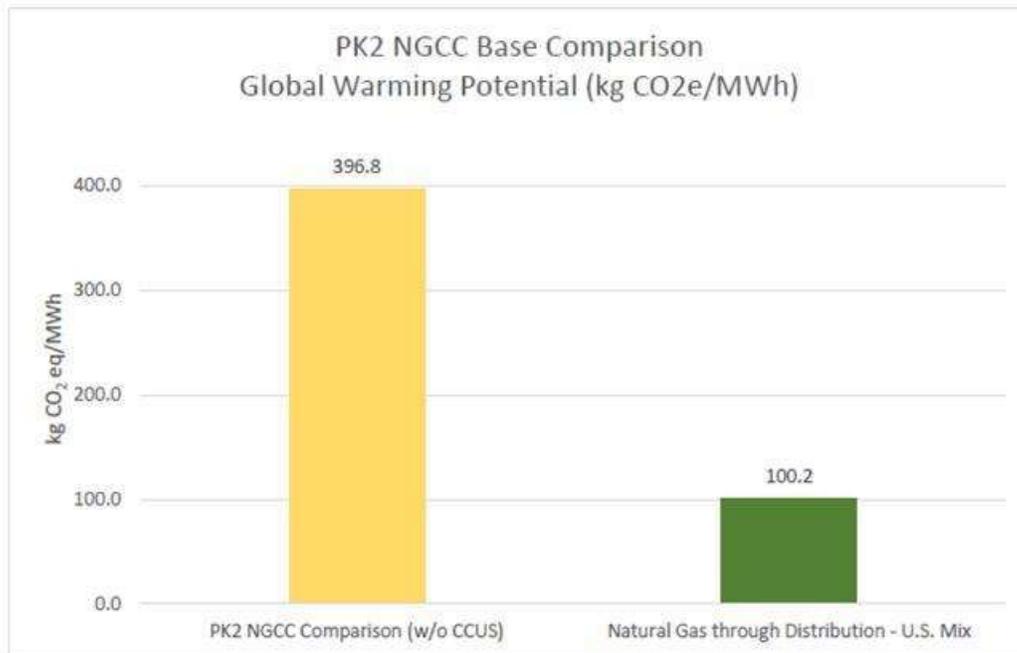
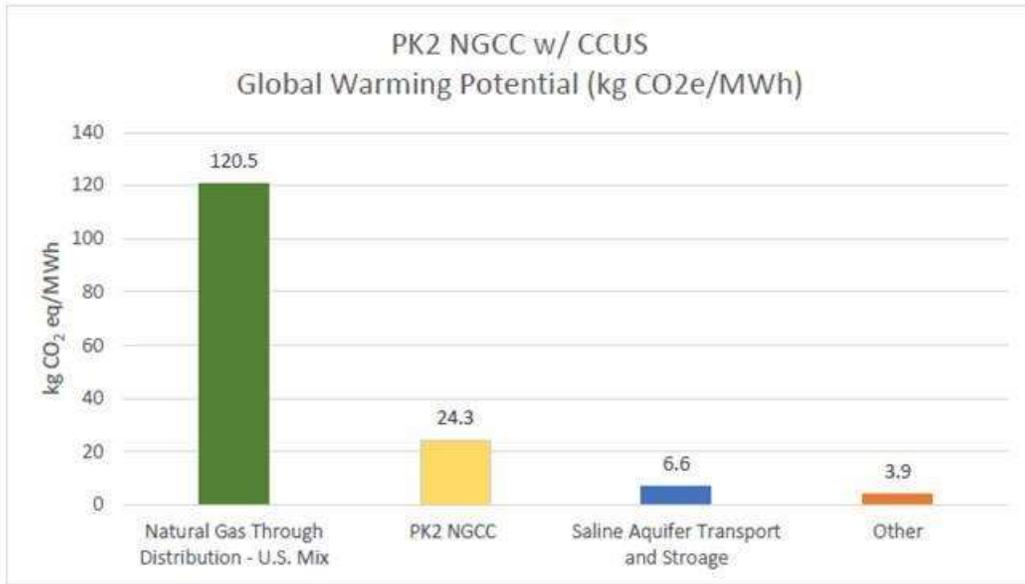


Figure 1-2 Global Warming Potential Comparison – Proposed Operations



Note that “Other” category includes manufacturing and transportation of materials required to build the CCS, construction utility requirements, and transportation of chemicals for CCS operation.

As demonstrated in Figure 1-1, the largest CO₂ emitters for the Comparison Project are due to uncaptured CO₂ emissions from electricity production and the distribution of natural gas to Polk. For the Proposed System in Figure 1-2, CO₂ emissions associated with electricity production with Carbon Capture are significantly reduced to just the 5% of CO₂ stack emissions which are not captured by the CCS and SF₆ emissions. The natural gas through distribution emissions increases relative to 1 MWh of delivered grid electricity as power supplied to the grid decreases due to CCS auxiliary power requirements and steam derate. The emissions from the transport and sequestration process are due to the construction of 100 miles of pipeline to get to a shared, large-capacity CO₂ pipeline, and the impacts at the saline aquifer storage site. Other emissions include material manufacturing impacts for the construction of the CCS, construction utility requirements, and chemical and construction material transportation.

Note that a range of processes are available in OpenLCA and public databases for the same material and have varying global warming potentials. In order to improve accuracy benchmark, processes should be defined by DOE or NETL to perform the LCA for DE-FOA-00002515. Assumed processes used to model the material inputs in OpenLCA will vary the LCA results. Although the global warming potential for any given material is expected to be site-specific depending on the material source, at this level of evaluation not using the same processes across projects is expected to result in inconsistencies by comparison that are difficult to identify as project specific.

The results of the LCA are that with retrofit of the ION carbon capture facility, the process will have a net global warming potential (GWP) of 155.4 kg CO₂e per delivered MWh of electricity. Therefore, additional negative emission technologies are required for this project to reach zero net carbon emissions. TEC is currently evaluating several NETs including renewable natural gas (RNG) and the purchase of direct air capture (DAC) credits.

2.3.3 Environmental Health and Safety Analysis

The FEED team performed an assessment of EH&S risks for the proposed facility / technology. This assessment has been developed in accordance with Appendix I of DE-FOA-0002515.

The EH&S first summarizes the ancillary or incidental air, water, and hazardous waste emissions from the facility. Air emissions from the CO₂ Capture process come from the absorber where CO₂-depleted flue gas from the existing HRSGs are emitted. While almost all of the CO₂ is removed in the CO₂ capture process, a minimal amount (less than five percent of existing CO₂ in the flue gas) will still be emitted to the atmosphere. Water discharges from the CO₂ capture process consist of direct contact cooler wastewater, stripper condensate, and contact stormwater. Direct contact cooler wastewater and stripper condensate will both be routed to existing systems at Polk and thus do not constitute a discharge. Contact stormwater containing spilled solvent will be disposed of in the same manner as solvent waste. Finally, hazardous waste will consist of the waste brine produced by the solvent reclamation process. The waste brine will be stored and then treated via a bionitrification batch reactor, with the resulting wastewater being acceptable for disposal via the RWTP.

The EH&S then describes the toxicological effects of the constituents in the emissions and waste streams, and the applicability of any regulatory requirements for each constituent. Finally, the EH&S discusses any alternatives to the proposed hazardous material, and the necessary precautions for safe handling and storage of the hazardous material being stored on-site.

2.3.4 Environmental Justice Analysis

The FEED team performed an Environmental Justice Analysis (EJA) to assess the impacts of the proposed project and technology. This analysis has been developed in accordance with Appendix N of DE-FOA-0002515.

The EJA focuses on identifying and addressing disproportionately high and adverse human health or environmental effects of the agency's programs, policies, and activities on minority populations and low-income populations to achieve an equitable distribution of benefits and burdens. The estimated population within a three-mile radius of the facility is 45, with a total of 15 residences, and EPA's EJScreen did not identify any schools, hospitals, or places of worship within this radius. Notably, TEC gives special consideration to all

environmental impacts, especially those around the project site. Polk Power Station is located on over 2,800 acres of reclaimed mining land, which is adequate to site the project and to maintain vegetative buffers. The previously described award-winning Polk RWTP will supply water needs to the facility. Polk also has a robust waste management system. Solid waste is collected in dumpsters which are removed for solid waste disposal in a municipal landfill; there will not be a notable increase in this waste that would impact local residents negatively. TEC will dispose of reverse osmosis concentrate produced at the RTWP for water used in the project in existing permitted on-site deep injection wells. TEC will characterize any additional waste streams and direct them to the reservoir, the deep injection wells, or local landfill, as permitted. No notable impact on the surrounding communities is anticipated.

Local stakeholders assisted in the original siting of Polk Power Station, and TEC may develop a public engagement team again to understand local concerns about the project, proactively keep the community apprised on the potential benefits of the project and make any necessary adjustments to address concerns raised by community members.

2.3.5 Economic Revitalization and Job Creation Outcomes Analysis

The FEED team evaluated the economic revitalization and jobs creation outcome of the proposed project and technology. This analysis has been developed in accordance with Appendix O of DE-FOA-0002515.

This project will support economic revitalization by bringing skilled labor into the local communities who will in turn stimulate these local economies throughout the construction period. Further restoration of marine habitat in Tampa Bay due to reduced nutrient loading because of additional wastewater treatment generating feedwater for this project could increase the product of Tampa's commercial shrimping operations. This project will generate a peak of approximately 500 skilled construction jobs with an average workforce of 250 throughout the construction period. The constructed facility will require an additional five operations staff 24/7, the plant operates on a modified Dupont schedule with four operating teams, resulting in 20 permanent, full time, highly skilled jobs. The industrial construction market in Central Florida has an average pay rate greater than the prevailing wage, and all created jobs will be in Polk County, within 5 miles of the communities of Chicora and Bradley. Both communities are economically distressed, and Polk County is below both the Florida and National per capita income averages. TEC has a strong inclusion and diversity program which will be incorporated into the hiring process for all jobs created by the project. The existing labor force already possesses the skills necessary for the construction jobs, and the operations jobs will be sourced from the local industrial market as possible, training on the nascent technology will be required for these new positions.

2.3.6 Technology Maturation Plan

This document further describes ICE-31 solvent throughout its development, from inception to present, including the relevant Technology Readiness Level (TRL) as defined by the DOE. TRL classifications are used

to describe ION's progress at each TRL level completed. This document is meant to be dynamic and will evolve along with major milestones in ION's technological development to correlate with the TRL level completed.

The Technology Maturation Plan declared the Technology Readiness Assessment System for the ICE-31 solvent with respect to development and testing to date of this project. Further, the plan covered the Maturation of the TRL from Proof of Concept through Pilot Plant validation with a summary of results. Finally, the document details the plans for scale-up and commercialization of the ICE-31 solvent.

ION continues to develop technology towards commercialization. Over the course of this project, ION has completed large scale pilot testing at the Technology Centre Mongstad in Norway and has continued to progress the technology through the TRLs.

2.3.7 Workforce Readiness Plan

This document summarizes TEC's approach to training its workforce to operate the CCS facility, including any necessary training programs, certifications, or other educational attainment that may be required for the PK2 CCS facility operators.

The nature of the equipment and systems to be installed are not novel to the industrial sector and are similar to the Acid Gas Recovery system used in the Polk 1 Integrated Gasification Combined Cycle process which TEC has operated for nearly 30 years. Thus in-house training programs are already in place for the existing equipment and can be expanded to accommodate the new equipment – and supplemented by vendor training for specific pieces of major equipment as needed.

Finally, the Workforce Readiness Plan details the ongoing or planned collaboration with education and training partners, any certification or educational requirements for the operators, and economically distressed communities in the project area.

3. COST ESTIMATE DEVELOPMENT

One of the primary objectives of the PK2 CCUS FEED Study was to develop the project engineering and design in sufficient detail to support development of an AACE Class 3 estimate (Per AACE 18R-97). A Class 3 estimate coincides with a project definition level of 10-40% complete with an expected accuracy range of (-)20% to (+)30% for the capital cost estimate. Costs are broken down by material, equipment, labor, and subcontracted costs. Inputs for the estimate were prepared by the project team, and were combined into a single cost estimate report prepared by the project team. Many pieces of critical/major equipment are costed based on budgetary quotes received from vendors, while other prices are based on previous project experience and engineering judgement. The operating and maintenance (O&M) cost estimate was developed using commodity pricing confirmed by TEC, process flows depicted on the project mass balances, and engineering judgement. Annualized capital costs are combined with the yearly O&M costs to calculate the cost of CO₂ capture in \$/tonne.

3.1 CAPITAL COST ESTIMATE DEVELOPMENT

The cost estimate is based on the project team's experience on similar projects and the project defined maturity of the engineering deliverables. In addition, to achieve the desired accuracy level required per the agreement, budgetary quotes were requested from equipment and system suppliers.

FEED engineering has been performed to support the required accuracy level of the project estimate. Use of allowances has been minimized, however, where used, these allowances are considered minor scopes of work, and are not expected to affect the accuracy of the estimate. All allowances are indicated as such in the detailed cost estimate.

Listed below is a summary level scope (not all inclusive) of facilities included in the estimate, see detailed cost estimate for a detailed scope:

- CO₂ Capture and Process Equipment (includes vessels)
- CO₂ Compression and Dehydration
- Balance of Plant (BOP) Systems
- Process Equipment Coolers & Heat Exchangers
- Piping Systems
- Civil Work
- Concrete Work
- Structural Steel
- Buildings (stick built and pre-engineered)
- Flue Gas Ductwork and Fans
- Electrical Equipment and Commodities

- Instrumentation and Control System
- Steam Turbine Generator (STG) Modifications
- Heat Recovery Steam Generator (HRSG) and Exhaust Stack Modifications
- Combustion Turbine Generator (CTG) .04 Advanced Gas Path (AGP) Upgrade
- Reclaimed Water Treatment Plant (RWTP) Upgrade and Expansion

The cost estimate is built up using equipment costs and MTOs developed during the FEED Study. MTOs were developed by S&L for piping, valves, cables, raceway, grounding, lightning protection, lighting, instruments, steel, etc. The 3D model was used to develop the majority of the MTOs. MTOs for quantities and commodities not modeled, such as small-bore piping, steel tonnage, cable, etc., were developed. MTO information is then imported into S&L’s estimating system with associated materials and labor. In addition, other related costs (pipe support, coatings, terminations, etc.) have been estimated based on the developed MTO information. See detailed cost estimate for detailed listing of all commodity costs.

3.2 CAPITAL COST ESTIMATE INPUT

Budgetary quotes were solicited and used as input to the cost estimate. Where vendor budgetary quotes were not obtained, equipment costs were developed based on the project team’s in-house pricing data (equipment / components) which is based on recent similar projects and/or historical data. Additionally, internal reference CCS project estimates are used for comparative cost information and scaling to adjust any referenced costs. However, the scaling approach was minimized in the development of this estimate.

Labor-hour estimates are included for most line items in the cost estimate, with the exception of some all-in costs provided for subcontracted efforts and allowances. The magnitude of labor-hours is indicative of the level of effort for the installation for each item. The labor-hours are converted to labor costs using prevailing wages for Lakeland/Bradley, FL.

3.3 CAPITAL COST ESTIMATE

Direct costs are prepared based on equipment, material, labor, and subcontracted costs. Additional costs are applied to the total direct cost at percentages consistent with projects of similar type and size; these additional costs include additional labor costs, site overheads, other construction indirects, project indirects, contingency, escalation, sales tax and interest during construction (AFUDC).

The following table summarizes the results of the capital cost estimate.

Table 4-1 — Summary of Capital Cost Estimates (in \$2024-Q2)

CO ₂ Capture System	
Total	1,546,721,000

3.4 O&M COST ESTIMATE

The variable O&M costs are based on the rates of raw material consumption and waste generation established by the project mass balances. Many of the commodity prices were confirmed by TEC as either consistent with prices experienced by PK2, or otherwise regionally accurate.

ION's solvent cost, make up rate, and certain other chemical usage is proprietary information that is not explicitly shown in the line items within the estimate. However, the annual cost associated with these items combined is shown. It is assumed that transportation, storage, and monitoring costs to maintain the CO₂ pipeline and sequestration are outside the project scope. These costs will be handled by another entity and are not included in this estimate.

O&M costs associated with the lost power generation are included in the estimate. This includes both sold power as well as de-rate attributed to steam extraction.

Fixed O&M costs are flat rates that will be applied to the annual costs regardless of fluctuations in unit operation. Fixed costs are included for maintenance material and labor. These costs are applied at 1.5% of the direct equipment and material costs for the CO₂ process equipment consistent with these types of projects.

Table 4-2 — Total O&M Costs

O&M Cost (First Year)	Project Cost (\$2024-Q2)
Total	102,817,000

3.5 COST OF CAPTURE

The cost of capture is the dollar amount required to remove, treat, and compress one tonne of CO₂. The economics of carbon capture is quantified in \$/tonne for direct comparison to future tax incentives and CO₂ sale pricing, which are also depicted in \$/tonne.

The capital costs are annualized and combined with the O&M costs to determine the total annual cost of the capture facility. Based on TEC feedback, the facility has been evaluated over a 30-year lifespan (n) based on the expected functional lifespan of the CCS system. The CO₂ system capital investment is therefore amortized over 30 years, based on TEC's preference. The annualized capital cost is combined with the total annual O&M costs to determine the expected annual costs for the project. Based on estimations of the total amount of CO₂ that will be capture based on an assumed capacity factor, the cost of capture (\$/tonne) can be calculated.

Table 4-3 — Total Cost of Capture

Description		Total Project (\$2024-Q2)
Cost of Capture	\$/tonne	68.0

4. OPEN ISSUES & NEXT STEPS

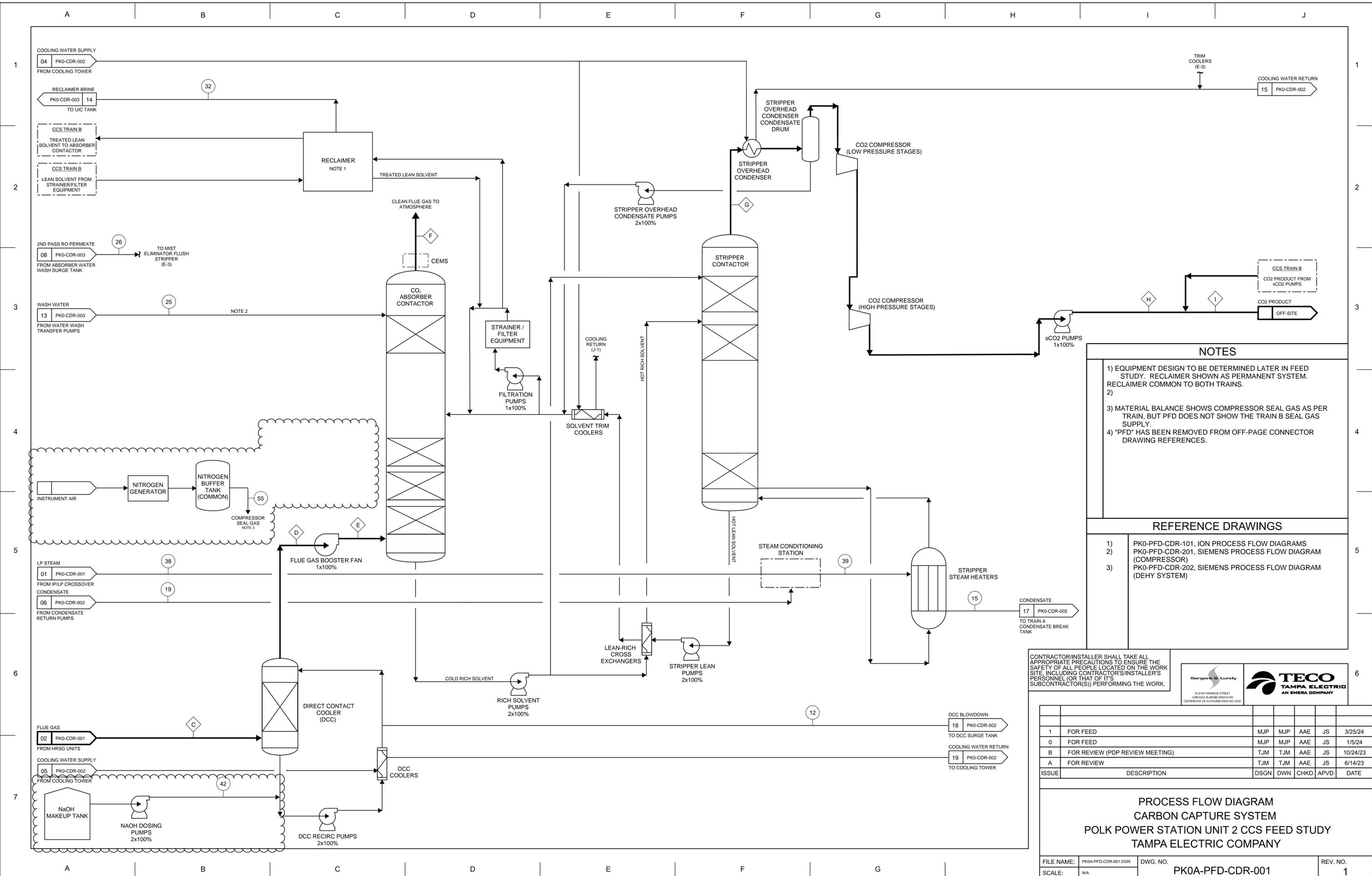
The completion of the PK2 FEED Study has generated a CCUS facility design based on a clear and well-defined concept as reflected on PFDs. The completed work supports entering the detailed engineering phase and ultimately, the construction and commissioning of the facility.

Due to the first-of-a-kind nature of an NGCC CCUS, the contract development will generally require a bridging phase to advance the Front-End Engineering and Design tasks, to firm up the design concepts, construction planning, and allow improvement of the cost estimate.

In support of this effort, TEC was awarded an integrated FEED under DE-FOA-0002738 to expand upon the engineering detail developed during this FEED study and continue to advance the project. A construction partner will be engaged to provide more detailed construction planning and construction estimating. This integrated FEED will also include scope for the associated CO₂ pipeline.

APPENDIX A: ATTACHMENT LIST

1. Process Flow Diagram
2. Level 1 Project Schedule
3. CCS Facility General Arrangement
4. CCS Permit Matrix



NOTES

- 1) EQUIPMENT DESIGN TO BE DETERMINED LATER IN FEED STUDY. RECLAIMER SHOWN AS PERMANENT SYSTEM. RECLAIMER COMMON TO BOTH TRAINS.
- 2)
- 3) MATERIAL BALANCE SHOWS COMPRESSOR SEAL GAS AS PER TRAIN, BUT PFD DOES NOT SHOW THE TRAIN B SEAL GAS SUPPLY.
- 4) "PFD" HAS BEEN REMOVED FROM OFF-PAGE CONNECTOR DRAWING REFERENCES.

REFERENCE DRAWINGS

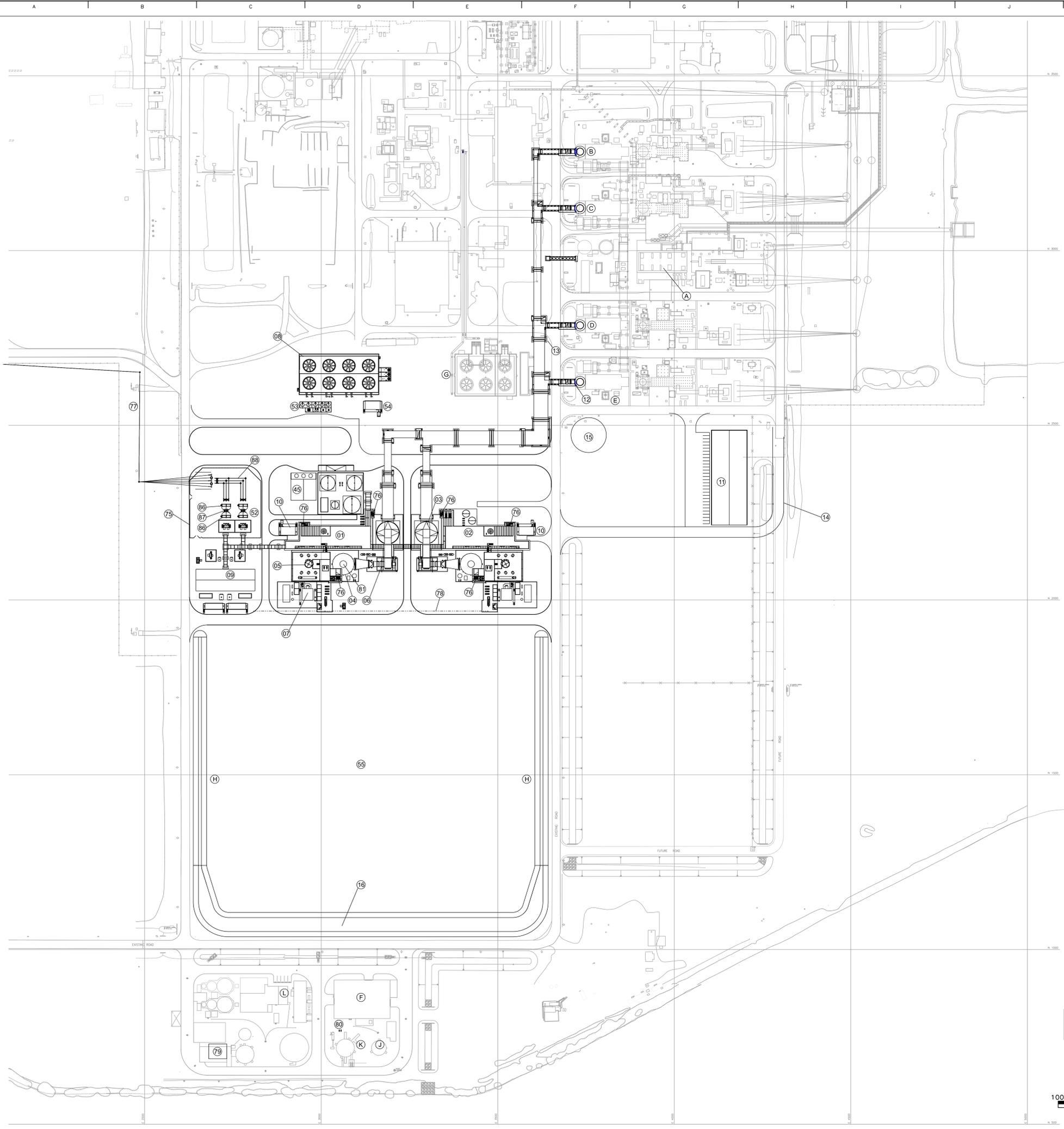
- 1) PK0-PFD-CDR-101, ION PROCESS FLOW DIAGRAMS
- 2) PK0-PFD-CDR-201, SIEMENS PROCESS FLOW DIAGRAM (COMPRESSOR)
- 3) PK0-PFD-CDR-202, SIEMENS PROCESS FLOW DIAGRAM (DEHY SYSTEM)

CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.



ISSUE	DESCRIPTION	DSGN	DWN	CHKD	APVD	DATE
1	FOR FEED	MJP	MJP	AAE	JS	3/25/24
0	FOR FEED	MJP	MJP	AAE	JS	1/5/24
B	FOR REVIEW (PDP REVIEW MEETING)	TJM	TJM	AAE	JS	10/24/23
A	FOR REVIEW	TJM	TJM	AAE	JS	6/14/23

**PROCESS FLOW DIAGRAM
CARBON CAPTURE SYSTEM
POLK POWER STATION UNIT 2 CCS FEED STUDY
TAMPA ELECTRIC COMPANY**



LEGEND	
01	CCS PROCESS AREA TRAIN A
02	CCS PROCESS AREA TRAIN B
03	DIRECT CONTACT COOLER (DCC)
04	CO2 ABSORBER CONTACTOR
05	STRIPPER CONTACTOR
06	CCS BOOSTER FAN
07	CO2 COMPRESSOR
08	COOLING TOWER
09	CCS ELECTRICAL EQUIPMENT BUILDING
10	CCS TRAIN ELECTRICAL POWER DISTRIBUTION CENTER (PDC)
11	POLK (PK) CONSTRUCTION MANAGEMENT BUILDING (CMB)
12	HRSG STACK DUCT BREACHING
13	CCS FLUE GAS DUCTWORK
14	NEW POLK 2 PLANT ROAD
15	FUEL RESILIENCY PROJECT (RESERVED AREA)
16	WATER QUALITY POND
45	CCS WATER TREATMENT BUILDING
52	CCS 230KV-13.8KV AUX POWER TRANSFORMER
53	COOLING TOWER CHEMICAL TREATMENT AREA
54	COOLING TOWER POWER DISTRIBUTION CENTER (PDC)
55	CONSTRUCTION LAYDOWN AND STAGING AREA
75	SWITCHYARD FENCE
76	STAIR ACCESS
77	CCS SWITCHYARD TRANSMISSION LINE
78	sCO2 PRODUCT PIPELINE
79	CCS ULTRAFILTRATION (UF) BUILDING (REPURPOSED EX. BLD)
80	CCS 1ST PASS RO PERMEATE PUMPS
81	CO2 ABSORBER CONTACTOR EXHAUST STACK
86	230KV DISCONNECT SWITCH
87	230KV CIRCUIT BREAKER
88	230KV BUSSWORK

EXISTING LEGEND	
A	PK2 STEAM TURBINE GENERATOR ENCLOSURE
B	PK2 HRSG STACK NO. 2
C	PK2 HRSG STACK NO. 3
D	PK2 HRSG STACK NO. 4
E	PK2 HRSG STACK NO. 5
F	PK RECLAIMED WATER TREATMENT PLANT (RWTP)
G	PK2 COOLING TOWER
H	PK STORMWATER DITCHES
J	EXISTING UIC TANK
K	EXISTING PERMEATE TANK
L	EXISTING 1ST PASS RO FEED PUMP BAY

NOTES

1. NEW 1ST PASS RO CARTRIDGE FILTERS AND 1ST RO SKIDS INSTALLED IN EXISTING RWTP BUILDING "F".

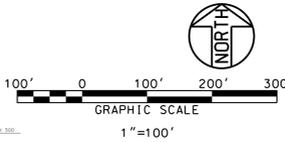
REFERENCE DRAWINGS

PK0-EM-001A	PLANT ARRANGEMENT - GRADE FLOORS
PK0-EM-001B	PLANT ARRANGEMENT - UPPER FLOORS
PK0-CS-0004	SITE UTILIZATION PLAN

CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTORS/INSTALLERS PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.



PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION



ISSUE	DESCRIPTION	DSGN	DWN	CHKD	APVD	DATE
3	FOR INFORMATION (FEED)	RAM	KF	JAS	-	07/11/2024
2	FOR INFORMATION (FEED)	RAM	KF	JAS	-	06/13/2024
1	FOR INFORMATION (FEED)	RAM	KF	JAS	-	06/06/2024
0	FOR INFORMATION (FEED)	RAM	KF	JAS	-	02/24/2024

GENERAL ARRANGEMENT - SITE PLOT PLAN
CCS FACILITY & PLANT INTEGRATION
POLK POWER STATION UNIT 2 CCS FEED STUDY
TAMPA ELECTRIC COMPANY

**Tampa Electric Company
Polk Power Station Unit 2**

Carbon Capture Permitting Matrix



PK0-GN-0006

January 9, 2024

Project No.: A14808.400

LEGAL NOTICE

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ISSUE SUMMARY AND APPROVAL PAGE

This is to certify that this document has been prepared, reviewed, and approved in accordance with Sargent & Lundy's Standard Operating Procedure SOP-0405, which is based on ASQ/ANSI/ISO 9001:2015: Quality Management Systems–Requirements.

Revision	Purpose of Issue	Date	Sections Affected
A	For Review	November 16, 2023	All
0	For FEED	January 9, 2024	All

Contributors

Revision	Date	Prepared By	Reviewed By	Approved By
A	November 16, 2023	L. Rao	C. Kwiatkowski	K. Patel
0	January 9, 2024	L. Rao	C. Kwiatkowski	K. Patel

TEC Carbon Capture Permit Matrix					
Category	Agency	Permit or Approval	When Required	Expected Agency Review Time	Comments
Federal Permits					
NEPA Review	Lead Federal Agency (e.g., Department of Energy (DOE), Office of Fossil Energy)	NEPA Analysis (Environmental Assessment [EA] or Environmental Impact Statement [EIS])	Prior to Construction	EA decisions within 1 year and EIS within 2 years per 40 CFR § 1501.10.)	Required for projects with a federal agency approval that is determined to be a major federal action. Federal financial assistance (i.e., DOE funding) is considered a major federal action under 40 CFR § 1508.18.
		Categorical Exclusion	Prior to Construction	Approximately 90 to 180 days	Category of actions that a federal agency, in its NEPA procedures, has deemed to not have a significant effect on the human environment after review by the Council on Environmental Quality (CEQ) and therefore no EA or EIS is required. A list of DOE's categorical exclusions are listed in 10 CFR part 1021 under Appendix A and B to Subpart D.
Wetlands and other Waters of the United States (WOTUS)	U.S. Army Corps of Engineers (USACE)	Section 10 of the Rivers and Harbors Act Permit	Prior to Construction	45 days for a Nationwide Permit 120 days for an Individual Permit	USACE authorization under Section 10 of the Rivers and Harbors Act is required for any construction of structure in or over any navigable WOTUS. S&L reviewed the Project Area and notes there is no construction proposed in or over any navigable WOTUS. Additionally, a Section 10 permit is required if any structure or work impacts the course, condition, or location of any body of water.
	USACE	Section 404 Permit	Prior to Construction	45 days for a Nationwide Permit (NWP) 120 days for an Individual Permit	A Section 404 permit is required for dredge or fill activities in WOTUS. A pre-construction notification (PCN) to USACE is generally required if the activity includes discharge that will result in the loss of greater than 1/10-acre of WOTUS. Preliminary potential impacts can be assessed based on a review the National Wetlands Inventory maps; however, a jurisdictional wetlands delineation is recommended and is considered best practice to confirm wetland boundaries and whether wetlands/waters within the site vicinity are considered WOTUS. (Note that consultation under the federal Endangered Species Act and National Historic Preservation Act is required for projects affecting WOTUS. Additionally, here is a list of all NWPs https://usace.contentdm.oclc.org/utills/getfile/collection/p16021coll7/id/19757).
Federal Threatened & Endangered Species	United States Fish and Wildlife Service (USFWS)	Informal Coordination	Prior to Construction	30-60 days	Coordination with USFWS is recommended to request comments from USFWS regarding presence of threatened or endangered species and required species-specific surveys.
	USFWS	Endangered Species Act (ESA) Section 7: Endangered Species Consultation	Consultation is required prior to issuance of federal permit or to support NEPA review.	3-6 months (concurrent with federal agency review)	Section 7 consultation is required if a project is subject to NEPA review or other federal permitting.
	USFWS	ESA Section 10: Incidental Take Permit	Prior to Construction	3-6 months	Section 10 regulates non-federal entities carrying out lawful activities that may result in the take of endangered or threatened animal species by issuing an Incidental Take Permit. The application for an Incidental Take Permit should include a "Habitat Conservation Plan" (HCP).
Determination of No Hazard to Air Navigation	Federal Aviation Administration (FAA)	Determination of No Hazard (DNH)/Airspace Obstruction Analysis for permanent or temporary (construction) equipment	Prior to Construction	45 days	Determination of No Hazard to Air Navigation is required if any construction equipment, structures, or alteration will be greater than 200 feet above ground level (AGL) or some height less than 200 feet AGL and/or located within 20,000 feet of an airport. S&L reviewed the location of local airports and notes there are none located within 20,000 feet of the Project Area. Additionally, FAA DNH is required for any activity that requires aeronautical review under 14 CFR § 77.9.

Category	Agency	Permit or Approval	When Required	Expected Agency Review Time	Comments
Risk Management Plan Rule	U.S. Environmental Protection Agency (USEPA)	Risk Management Plan (RMP)	By date that regulated substance becomes present above a threshold quantity, or within 6 months of a change that requires a revised process hazard analysis or review	7 days from date of Electronic Signature Agreement (ESA) approval through RMP*Submit	Required by Section 112(r) of the 1990 Clean Air Act Amendments. A RMP outlining potential effects of a chemical incident, along with preventative measures and emergency response procedures will be required if storing or utilizing over threshold quantities of regulated substances. Sargent & Lundy (S&L) recommends hazardous substances and their quantities are compared to the List of Regulated Substance under the RMP Program (https://www.epa.gov/rmp/list-regulated-substances-under-risk-management-plan-rmp-program) to determine if an RMP will be necessary.
Spill Prevention Control and Countermeasure (SPCC) Plan	USEPA	SPCC Plan	By date that regulated substance becomes present above a threshold quantity	N/A SPCC Plans do not need to be submitted to the USEPA, rather they must be maintained at the facility	Per 40 CFR part 112, an SPCC plan is required if storing greater than 1,320 gallons of oil aboveground or greater than 42,000 gallons below ground during construction or operation of a project. An update to the existing facility's SPCC, if any, would also be required if there are changes to petroleum product storage post-project.
Class VI Injection Well	USEPA	Class VI Well Permit	Prior to construction/sequestration	Variable. The USEPA aims to issue permits within 24 months (including completeness check, drafting, and public comment).	Class VI wells inject carbon dioxide deep into rock formations (geologic sequestration) for carbon capture and storage projects.
Transportation by Pipeline	U.S. Department of Transportation (DOT) - Pipeline and Hazardous Materials Safety Administration (PHMSA)	DOT Special Permit or Approval	90 days prior to transportation is to begin.	90 days	The PHMSA issues DOT special permits or approvals for hazardous materials, hazardous liquid, and natural gas pipelines. 49 CFR Part 195 of "Transportation of Hazardous Liquids by Pipeline" covers the specific applicability, reporting requirements, and safety standards for pipeline facilities used for the transportation of carbon dioxide. Permits are issued for operations that are not currently authorized under the Hazardous Materials Regulations (HMR). Approvals are granted for specific operations already outlined in the HMR.

Category	Agency	Permit or Approval	When Required	Expected Agency Review Time	Comments
State Permits					
Licensing of Large Power Plants	Florida Department of Environmental Protection (DEP) - Siting Coordination Office (SCO)	Power Plant Siting Act (PPSA)	N/A	N/A	Note: Applicable if the Carbon Capture Project will be directly combined with the Hydrogen Project into one "Project." A Site-Certification Modification under the PPSA (Sections 403.501-.518) of Florida Statute. A centralized process for the licensing of large power plants (steam or solar electrical generating facilities that generate 75 megawatts or more).
	Florida Public Service Commission	"Notice of Intent" and "Need Determinations"	Prior to Construction	Variable	Note: Applicable if the Carbon Capture Project will be directly combined with the Hydrogen Project into one "Project." A Notice of Intent can be filed to indicate an application will be submitted. From there, reviewing agencies will work together to decide what is needed in the application (Section 403.5063, F.S.). Then the Commission will review the need for power generated by the proposed facility in relation to the needs of Florida (Section 403.519, F.S.)
Air	Florida DEP	Title V Air Permit (Modification)	225 days before expiration	90 days after complete application is received.	Modification of TEC's Polk Power Station Title V Operating Permit #1050233-051-AV issued 09/23/2022 and expires on 09/21/2027. Project related modifications to the power station and its emissions will require modification of the Title V Operating Permit.
		Air Construction Permit	Prior to construction	90 days after complete application is received.	An Air Construction Permit is required for emission units (any activity at a stationary source that emits or has the potential to emit any air pollutant) or air pollution control equipment (facility or equipment intended to prevent, control, reduce, or eliminate, emissions of specific air contaminants to the atmosphere). TEC's Polk Power Station had a permit #1050233-033-AC issued 09/17/2012 and expired 09/20/2017. Potential modification needed - Florida's PPSA.
Water	Florida DEP	State 404 General/Individual Permit/Authorization	Prior to dredge/fill in WOTUS	<u>Exemption and/or General Permit:</u> 30 days for completeness review or 60-90 days for Request for Additional Information (RAI). Subsequent 30 days for completeness review. <u>Individual Permit:</u> Same as above except for an additional Public Notice (15-30 days) and possibly EPA review (30 days).	USEPA approved the DEP's administration of the State 404 Program on December 22, 2020. This program is responsible for overseeing the permitting of any dredge/fill activities within state assumed waters. There are two types of State 404 Program permits, General Permit and Individual Permit. Note: Environmental Resource Program (ERP) permit may be required. The State website located in Column H provides a matrix outlining when an ERP authorization is required to accompany the State 404 Program authorizations along with the various differences between General and Individual Permits (Column I). Preliminary impacts can be assessed based on a review the National Wetlands Inventory maps; however, a surface waters delineation is recommended and is considered best practice to confirm wetland boundaries and whether wetlands/waters within the project boundary are considered Waters of the United States.
	Florida DEP and Florida Water Management District (WMD)	Environmental Resource Permit (ERP) Program	Prior to dredge/fill in WOTUS and/or generating stormwater runoff	Variable, field verification of WOTUS is required.	Activities located in uplands that generate stormwater from upland construction and/or dredging and filling in wetlands and other surface waters require approval. The ERP Program oversees all activities regarding alterations that affect surface water flows. Note: The "Environmental Considerations Summary" for the Hydrogen Hub Project identified 10.8 acres of wetland and 10.5 acres of other surface water features. The wetlands are considered State jurisdictional by Florida DEP Section 404 Program.

Category	Agency	Permit or Approval	When Required	Expected Agency Review Time	Comments
Land	Florida DEP - Division of State Lands	State Land Easement and Road Right-of-Way Permit	Prior to using/crossing state owned lands	9 - 12 months if less than 50 acres of easement sought, if more than 50 acres estimate 18 months	Application to use state land, crossing of state owned uplands, or sovereign submerged lands.
Cultural Resources	Florida DEP and State Historic Preservation Officer (SHPO)	National Historic Preservation Act Consultation (Section 106) Florida Historical Resources Act (FHRA)	Prior to issuance of federal permit or to support NEPA review	Variable based on survey findings and Project impact.	Consultation required for projects with a federal nexus. Projects that require a federal agency permit or approval (e.g., Section 404 permit, NEPA) require a Section 106 Consultation under the National Historic Preservation Act. Coordination with Florida SHPO is recommended to request comments regarding presence of cultural and historic resources. SHPO will advise and assist the Florida DEP with carrying out its historic preservation responsibilities under the FHRA.
State Threatened & Endangered Species	Florida Fish and Wildlife Conservation Commission (FWC)	Protected Wildlife Permit	Prior to any collection and/or handling.	Variable based on survey findings and Project impact.	The Florida FWC issues permits allowing impacts to Florida's protected land-dwelling wildlife. Coordination with the Florida FWC is recommended to request comments regarding the presence of any endangered and/or threatened species.
	Florida FWC	Gopher Tortoise Relocation Permit	90 days prior	45 days or less	The gopher tortoise and their respective burrows are protected under Florida state law. Any disturbance within/work within 25 feet of a gopher tortoise burrow requires a relocation permit from FWC. There are no longer any Incidental Take permits issued.
	Florida FWC	Kestrel Incidental Take Permit	45 days prior	Within 90 days of receipt	S&L reviewed the USFWS IPaC report and identified the American Kestrel as a "Bird of Conservation Concern" (BCC) / Bird Conservation Regions (BCR). The American Kestrel is a Florida state-Threatened species and requires a permit from the Florida FWC for any incidental take.
Stormwater	Florida DEP	National Pollutant Discharge Elimination System (NPDES) Construction Generic Permit (CGP) Storm Water Discharges from Construction Activities	Submit Notice of Intent (NOI) 2 days before construction/clearing	Permit coverage begins 2 calendar days after the DEP determines the submittal complete.	Construction activities that disturb greater than or equal to one acre; or less than one acre and are part of a larger common plan of development/sale require coverage under the CGP. CGP coverage requires a SWPPP be developed prior to NOI submittal and implemented during construction. The SWPPP must be implemented in compliance with the permit until construction activities conclude and a Notice of Termination (NOT) is submitted to discontinue permit coverage.
	Florida DEP	Construction Stormwater Pollution Prevention Plan (SWPPP)	Retained at job site	N/A	A SWMPPP is required for Projects who obtain a NPDES permit. The SWPPP must be site-specific and outline Best Management Practices (BMPs) with the goal of reducing storm water discharged pollutants from the Project site.

Category	Agency	Permit or Approval	When Required	Expected Agency Review Time	Comments
State Permits (cont.)					
Transportation	Florida Department of Transportation (FDOT)	Oversize and Overweight Permits	Prior to Transportation	Dependent on vehicle dimensions, axle weight, starting and ending points...etc.	FDOT issues permits for any load exceeding legal limits outlined by the state of Florida. A permit is required for any load or vehicle exceeding legal weight and/or size limits and is moving on or across a highway which the state is responsible for. Typically transporters responsibility.
		Right-of-Way Permits	Prior to encroachment of Right-of-Way	Variable	Florida Administrative Code - Rule: 14-46.001 regulates the installation of utility facilities on any FDOT Right-of-Way.
Fire Services	Florida State Fire Marshal - Bureau of Fire Prevention	Regulatory Licensing	Variable	Variable	The Regulatory Licensing Section of the Florida State Fire Marshal enforces laws relating to the regulation and licensing of (1) Engineered Fire Protection Systems, (2) Fire Equipment, (3) Explosives, and (4) Sparklers.
Waste	Florida DEP	Hazardous Waste Management Permit	Pre-Application meeting is suggested per Florida DEP website. Prior to treating, storing, or disposing of hazardous waste or remediation.	Dependent on type and amount of waste.	A hazardous waste permit is required for treating, storing, or disposing of hazardous waste.
Local Permits - Mulberry City/Polk County, Florida					
Building	City of Mulberry	Planning and Zoning Department Approval	Prior to Construction	Variable	The Planning and Zoning Department administers programs, policies, and regulations that oversee development within the City of Mulberry. Site Development Plan Application and Zoning/Rezoning of Property Application, Variance Applications...etc.
	City of Mulberry	Building Department	Prior to Construction	Varies based on size (square foot) of buildings/construction	The Building Department requires a construction permit for proposed structures and setbacks.
	Polk County	Building Permit/Certificate of Occupancy	Prior to Construction	Varies based on size (square foot) of building	Polk County issues building permits through their "Accela Citizens Portal." A permit is required (per Florida Building Code) for any construction, alteration, enlargement, repair, movement, demolishing, or changing the occupancy content of a building. Additionally, a permit is required to install, enlarge, erect, alter, repair, remove, convert, or replace any gas, electrical, mechanical, or plumbing system.
Stormwater	Polk County	Local Stormwater Approval of NPDES Construction CGP Storm Water Discharges from Construction Activities	Submit NOI 2 days before construction/clearing and a SWPPP	Permit coverage begins 2 calendar days after the DEP determines the submittal complete.	A NPDES stormwater permit must be obtained and a SWPPP must be implemented to adequately manage runoff from a construction site. These permits are issued by the Florida DEP (discussed in Rows 28 & 29 above). The Polk County Land Development Division reviews all plans for any proposed development meet county infrastructure construction standards and development ordinances (meet the 100-year storm event criteria and the runoff rate from new developments are less than or equal to the pre-development rate.)
Land Development	Polk County	Site Plan Approval	Prior to land development	Variable	The Land Development Division of Polk County works with county surveyors, engineers, planners, floodplain staff, and attorneys to oversee land development and ensure projects are in accordance with Polk County Land Development Code. S&L recommends coordination with Polk County.

Category	Agency	Permit or Approval	When Required	Expected Agency Review Time	Comments
Floodplain	City of Mulberry - Floodplain Management Ordinance	Development Permit	Prior to Construction	Variable	A development permit is required for any construction or work conducted within a flood hazard area per Municipal Code 5.01.04
Other Coordination					
Existing Infrastructure	Various Agencies/Owners of any existing infrastructure	Coordination As Applicable	Prior to Construction	Varies based on type of existing infrastructure and owner	Existing infrastructure within, under, around, above, and/or impacted by the Project should be considered and addressed with the appropriate owner of the existing infrastructure. (example: pipelines)
Land Owners	Various Property Owners	Coordination As Applicable	Prior to Construction	Variable	Local land and property owners where the Project will overlap should be coordinated with as applicable.
Railroad	Railroad Owner	Encroachment Coordination	Prior to encroachment	Varies based on railroad owner	Example: https://www.up.com/real_estate/utilities/encroach_procedure/index.htm