DISCLAIMER

Project Diamond Vault Carbon Capture FEED Study

DE-FE0032165

FEED Study Summary Public Report

Revision A

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1. INTRODUCTION

Cleco Power (Cleco) performed a three-phase front-end engineering and design (FEED) study evaluating installation of a carbon dioxide (CO_2) Capture System at Madison Unit 3 (MU3), Project Diamond Vault (DV) The work was performed under a Department of Energy (DOE) grant DE-FE0032165. The FEED study included three phases: (1) a feasibility phase which sought to define the scope of the project, (2) a pre-FEED phase which sought to develop a detailed cost estimate, and (3) a final FEED phase which sought to develop the project to be ready to move into execution. The FEED study was completed by Cleco, Mitsubishi Heavy Industries America (MHIA), and Sargent & Lundy, LLC (S&L) with oversight provided by the Louisiana Economic Development (LED).

The feasibility phase was completed in February 2023, which was followed by the pre-FEED phase which concluded in January 2024. The project subsequently entered the final FEED phase, during this phase Cleco made the decision to stop work on the FEED study due to market conditions which resulted in a project that was not economically viable at the time.

This report documents the results of the project, including the latest complete deliverables that had been produced at the time the project was halted.

MU3 is located at the Brame Energy Center facility and is a petroleum coke (petcoke) and coal-fired power plant located on Lake Rodemacher in the City of Boyce in central Louisiana. MU3 has two (2) circulating fluidized bed (CFB) boilers that share a dual flue chimney and produce steam for one (1) common steam turbine generator (STG).

The CO_2 Capture System is based on MHIA's technology and consists of flue gas handling, solvent regeneration and CO_2 compression systems which will process the combined flue gas flows discharged from the two (2) MU3 boilers. The CO_2 Capture System was sized to capture CO_2 from the full flue gas flow from MU3 and the turndown condition of a single boiler operating at full load. MHIA and S&L were responsible for the design of the CO_2 Capture System inside battery limit (ISBL) and outside battery limit (OSBL)/balance of plant (BOP) scopes, respectively.

The CO_2 Capture System was designed to treat a full-load flue gas flowrate of approximately 6,696,720 lb/hr (or approximately 1,864,000 acfm) MU3. This equates to approximately 15,429 tonnes per day of CO_2, which at a capture rate of 95% results in approximately 14,657 tonnes per day of captured CO_2. This study has been performed considering an 80% plant capacity factor, which results in approximately 4,280,000 tonnes per annum. The CO_2 was intended to be compressed and transported to on-site sequestration for permanent storage. The CO_2 transport pipeline and sequestration wells were not part of the scope of this FEED study.

Louisiana does not currently require the reduction of CO_2 from emission sources. The primary driver for the project at the time of this study was the Section 45Q tax code which would provide a credit for each metric tonne of CO_2 captured and successfully sequestered at a value of $85/tonne. At the time of this report, in order to qualify for the 45Q tax credit, construction for the new capture facility would have to begin prior to January 1, 2033.

2. FACILITY DESIGN DEVELOPMENT

The combined S&L and MHIA team were tasked with performing preliminary engineering and design to support implementation of a CO_2 capture facility on MU3. Facility design and engineering was supplemented by information provided by Cleco regarding the operating conditions of the host unit, existing electrical layouts, existing foundations, surrounding landscape and facilities, and Cleco standard practice.

2.1. TECHNOLOGY/PROCESS DESCRIPTION

The CO_2 Capture System design is based on the application of MHIA's KM CDR Process™ CO_2 Capture Technology, an amine-based technology using MHIA's proprietary KS-21™ solvent. The process is well-established for post-combustion capture that has been developed over many years, and thousands of hours of laboratory research & development, pilot campaigns, demonstration projects and full large-scale deployment for the post-combustion treatment of flue gas.

The CO_2 capture unit consists of the following major steps:

- Flue Gas Conditioning
- Flue Gas Pre-Treatment
- CO_2 Absorption
- Solvent Regeneration
- CO_2 Compression and Conditioning

Figure 2-1 High-Level MHIA Process Flow Diagram

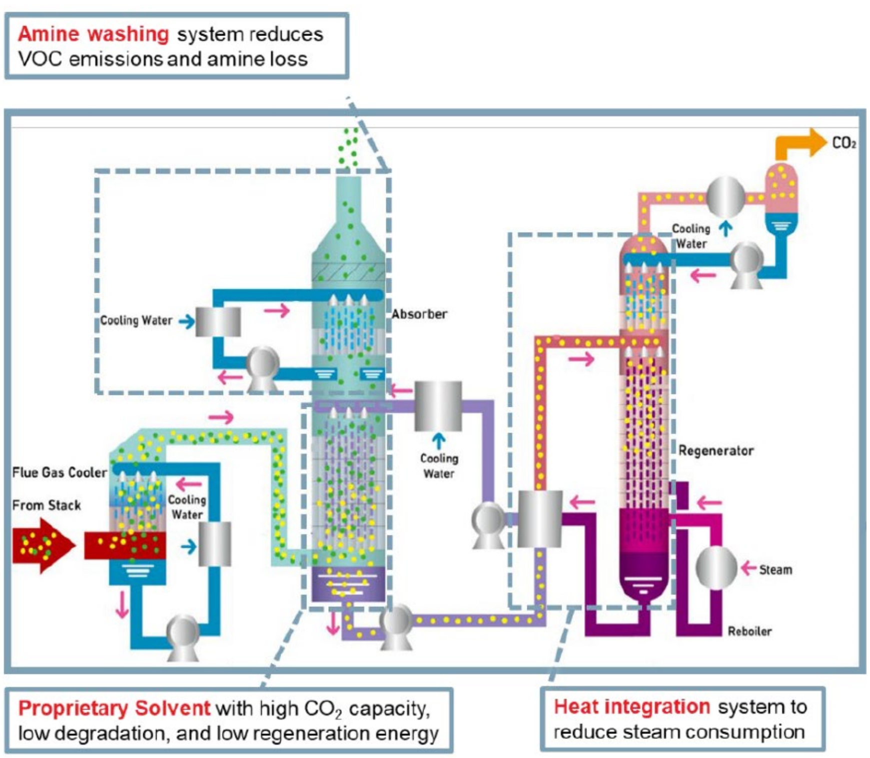

Figure 2-1 shows a high-level process flow scheme of the MHIA CO_2 Capture System.

The flue gas from the host unit is directed to the CO_2 Capture System's quencher, flue gas pre-treatment, and absorber vessel. Due to the additional pressure drop across flue gas handling equipment, the incoming gas must be pressurized via a new fan/blower.

Flue gas entering the CO_2 Capture System must be cooled before entering the CO_2 absorber to increase absorption of the CO_2 by the circulating solvent. To achieve this temperature reduction, the flue gas is cooled via gas-water contact in the quencher. The quencher contains mass-transfer internals to facilitate mixing and enhance gas-liquid heat transfer between the flue gas and the quencher circulating water. A blowdown stream from the quencher circulating water is used to avoid build-up of contaminants and is removed from the system as a wastewater stream.

CO_2-lean amine is supplied to the top of the CO_2 absorber to facilitate CO_2 removal. As the lean amine flows down the absorber column packing, it absorbs CO_2 from the flue gas and is collected in the bottom sump as CO_2-rich amine. The rich amine is pumped out to the regenerator while CO_2-depleted flue gas exits the top of the absorber column. Water washes at the top of the absorber are used to reduce solvent carried over in the exiting flue gas, helping mitigate emission increases associated with the solvent and reduce the rate of solvent makeup.

CO_2-rich solvent from the absorber is warmed in a lean-rich solvent heat exchanger before entering the top of the regenerator. The CO_2-rich solvent then flows down through the regenerator through a series of trays and structured packing to promote heat distribution. A steam reboiler provides regeneration heat needed to separate CO_2 from the solvent. The lean solvent is then recirculated back to the absorber while CO_2 and moisture exit the top of the regenerator to the reflux drum. A portion of the moisture contained in the CO_2 product stream is removed in the reflux drum and recycled back to the regenerator or circulating solvent while the CO_2 stream is sent for conditioning and compression.

The CO_2 compression and conditioning system consists of a multi-stage compression system with dehydration to condition the product CO_2 to meet sequestration product specifications. The CO_2 compressors are integrally-geared, motor-driven machines with variable inlet guide vanes and anti-surge control. The CO_2 product is compressed to dense phase condition at the battery limit suitable for sequestration. The CO_2 product is dehydrated to meet pipeline quality requirements.

Process Flow Diagrams are included as Appendix D.

2.2. PRELIMINARY ENGINEERING

2.2.1. Design Inputs

The design of the CO_2 capture unit is based on the high-end normal operating conditions at full load (i.e. two boilers operating at 100% load). The CO_2 capture unit turndown design considers a single boiler operating at 100% load. The CO_2 Capture System is sized for a capture rate of 95% of the CO_2 produced by MU3.

A design criteria document was also prepared which outlines the technical requirements of the different disciplines. As part of the design criteria, a flue gas design basis document was prepared that outlines the design conditions, boiler operating parameters, and process assumptions that affect flue gas conditions. The Project Design Criteria is located in Appendix A.

2.2.2. Capture Train Configuration / Facility Layout

Basic design input documented at the start of the study, including flue gas conditions and turndown requirements, were utilized to establish the train configuration and overall facility layout.

The study team coordinated in the development of the layout and arrangement of the CO_2 Capture System.

The CO_2 Capture System was located north of the boilers which is currently the site of an existing laydown and greenfield area, as shown in the general arrangement.

The following deliverables were developed to support the overall and balance of plant facility layout:

- Conceptual Model
- General Arrangement Site Plan
- General Arrangement Drawings for Cooling Water Intake Structure and BOP Electrical/Mechanical Building

The general arrangement drawings and site plan are provided in Appendix B.

2.2.3.Process and Mechanical Engineering

A process engineering and design package for the CO_2 Capture System ISBL scope was completed. BOP scope and associated deliverables include the following:

- Utility Flow Diagram (UFD) and Utility Flow Summary
- Water Balance
- Heat Balance
- BOP Piping & Instrumentation Diagrams (P&IDs)
- BOP Mechanical Equipment List
- Tie-in List

The UFD is provided in Appendix C.

Utility flow diagrams for the BOP system and plant integration were prepared to visualize all project components and major tie-in locations related to the CO_2 Capture System. An overall utility flow summary was developed for all major gas and liquid process flows to and from the CO_2 Capture System. The flow summary aided in sizing BOP pipelines and equipment and served as a check on process flows and waste generation and commodity consumption rates. CO_2 Capture System ISBL Process Flow Diagrams (PFDs) are provided separately by MHIA and provided in Appendix D.

An overall project water balance was prepared to identify the makeup water and wastewater streams of the process. Stream constituent data was developed based on recent facility water testing or process information based on the technology design. The water balance was used determine makeup water or wastewater rates, composition and potential treatment requirements which are discussed further in Section 3.4.

An overall heat balance was prepared to understand the impact of steam extraction on the overall steam cycle. Steam was sourced from the IP/LP crossover piping which provides an extraction location with steam conditions available close to the required carbon capture pressures and temperatures. The heat balances depicts all heat content, enthalpy, mass flow rates, and power allocations associated with the major boiler and turbine sections, extractions streams, and heat rejection sources.

The team developed P&IDs for the CO_2 capture system and BOP systems, as well as an equipment list which was input to the overall system design. Piping, valve, and specialty quantities were also generated and provided the technical details necessary for the project estimate.

For major BOP mechanical equipment (cooling water pumps, traveling screens, automatic backwash strainers, compressed air systems, steam conditioning valves, and flue gas dampers) budgetary proposal request packages were developed to solicit vendor technical information and pricing. The vendor proposals were reviewed for technical acceptability, and once accepted, formed the basis for the major equipment pricing input to the project estimate.

2.2.4. Electrical Engineering

The electrical system design included the following deliverables as part of the preliminary electrical engineering and design package.

- Existing 230 kV Switchyard Modification Single Line Diagram and Equipment Layout Drawing
- Proposed 230 kV Transmission Line Layout Drawing
- 230 kV Substation Transformer Layout Drawing
- BOP Single Line Diagrams
- BOP Electrical Load Lists

The overall CO_2 Capture System ISBL electrical power system design is represented on the ISBL Key Line Diagram. The main ISBL electrical equipment is located inside the PDC building. The BOP electrical equipment is located inside the BOP Electrical/Mechanical Building. Both of these buildings are in the main CO_2 facility. The list of ISBL electrical equipment, along with their respective sizes, was provided as interface to the OSBL design and to ensure that the ISBL area electrical requirements were incorporated into the overall facility design.

The OSBL electrical load list and ISBL electrical load list were used in conjunction with the site plan to establish the electrical distribution layout, perform preliminary electrical equipment sizing, and develop the single line diagrams.

For the OSBL electric equipment, preliminary high-level technical specifications were prepared for the purposes of obtaining budgetary quotes for the electrical equipment as input to the overall cost estimate.

2.2.5. Instrumentation and Controls Engineering

The Instrumentation and Controls (I&C) engineering effort focused on development of CO_2 Capture System control integration required for reliable operation of the new system. The following information was developed as part of the preliminary I&C engineering and design.

- Instrument List/Quantities
- I/O Quantities

The study was based on provision of a new standalone DCS, with interface with the existing MU3 DCS. A separate standalone DCS for the CO_2 Capture System ISBL.

An overall control strategy identifying the system layout assumptions as well as BOP system tie-in assumptions was developed to set the basis of instrumentation location, control system equipment and control logic. The I&C scope was integrated into the BOP P&IDs and OSBL instrument and I/O quantities.

2.2.6. Structural and Civil Engineering

As part of the structural and civil engineering scope the above and below ground systems required to physically support the ISBL and OSBL equipment and systems was developed. The following information was developed as part of the preliminary structural and civil engineering and design for ISBL and OSBL.

- Foundation Types and Sizes
- Ductwork and Expansion Joint Arrangement
- Ductwork Layout and Typical Detail Sketches
- Ductwork and Utility Rack Layout
- Mass Grading Plan and Elevation Sketches

The structural engineering scope for the study included the preliminary design and estimates for the anticipated ISBL structural steel, ductwork and utility support steel, OSBL flue gas ductwork including reinforcement for existing tie-in ductwork, buildings, intake and outfall structures, and all associated foundations (and piles) for the ISBL and OSBL equipment and systems.

Foundation design considered preliminary equipment loading and data supplied by vendor quotations or historical reference data. Steel design utilized duct load estimations including dead, live, snow, wind, seismic, thermal, and friction loads as appropriate. These loads were determined in accordance with IBC and ASCE standards.

The majority of ISBL foundations are anticipated to be supported on deep foundations. These ISBL foundations are anticipated to be supported on auger cast piles (18" or 24" in diameter, with depths ranging from 60'-0" to 100'-0" based on loading conditions) due to the magnitude of the supported equipment/structure/vessel loading. The majority of OSBL foundations are anticipated to be supported on soil-supported shallow foundations.

The civil engineering scope for the study included the preliminary design and estimates for, erosion and sediment control; earthwork including clearing, grubbing, stripping, dredging and mass grading; stormwater, oily water and sanitary systems; roadwork and surfacing; temporary sheet piling and shoring; and fencing.

Civil site development work supporting the ISBL and OSBL areas of the site will primarily include mass earthwork, stormwater drainage, roadway development, and surface stabilization for both temporary construction-use areas and permanent plant equipment and operational areas. The initial scope of site development activities will be to grade and prepare the ISBL area to facilitate substructure work that includes foundation construction and buried utility installation, and to develop construction laydown and temporary use areas.

The cooling water intake and outfall structures are located on the shoreline of Lake Rodemacher. The intake structure will pump lake water to the CO_2 Capture System for use, and the discharge structure will include a seal well to maintain system pressure and return the water to the lake in a manner that minimized erosion of the adjacent lakebed. Temporary cofferdams will be used to construct these structures in a dry condition. Soil fill will be placed and compacted adjacent to these structures on the no-lake sides for vehicle and utility access, and permanent sheet piles may be used to limit the extent of soil fill that is needed to otherwise protect the structure area from long term damage due to marine conditions.

There are a number of satellite construction laydown areas at strategic locations near the CO_2 equipment area to be used for craft parking, warehousing, and material storage. These areas will be cleared and graded to accommodate the planned temporary use and stabilized with gravel surfacing. It is planned that when the construction use areas are no longer needed, they will be covered with a prepared topsoil layer and seeded to restore these areas to a vegetated condition.

Roads that are developed during the construction phase to serve construction use areas and CO_2 equipment areas will be comprised of an aggregate road base underlain by a geotextile soil separator. Temporary roads will be removed and the area restored to preconstruction conditions, while permanent plant roads will primarily be asphalt or concrete paved as applicable. As final design grades for permanent plant facilities are obtained, the completed areas will be stabilized with pavement, crushed stone ground cover surfacing, or grass seeded topsoil as appropriate.

2.3. BALANCE OF PLANT SCOPE

2.3.1. Flue Gas System

Flue gas from each MU3 boiler is currently routed through a circulating dry scrubber and baghouse via ID fans which discharge into a chimney/stack with independent flues for each boiler. New ductwork to supply the CO_2

Capture System will tie into the existing ductwork downstream of each boilers' ID fan and upstream of the existing stack. The ductwork to the existing stack will remain in place to bypass the CO_2 Capture System for venting during CO_2 Capture System upsets or maintenance cycles.

New actuated dampers will be located at the entrance of each stack flue to isolate the existing flue gas path from the stack during CO_2 Capture System operation. For the new ductwork, modulating and isolation dampers will be provided at each tie-in to the existing ductwork for balancing pressure from each boiler to the common ductwork and to allow for independent isolation of each boiler's flue gas path. The new ductwork from each boiler then combines into a common duct which is routed on an elevated utility rack to the CO_2 Capture System quencher inlet. Guide vanes are installed in duct turns to assist in even flue gas distribution and to minimize pressure losses through turns and transitions.

2.3.2. Steam System

The CO_2 capture process relies on thermal energy provided by steam to facilitate the release of CO_2 from the amine solvent. S&L prepared a steam and electric sourcing study to determine the best steam extraction and condensate return locations from the MU3 steam cycle. This study is discussed in detail in Section 3.2. Heat energy is provided by steam from the MU3 steam cycle and routed to the CO_2 Capture System. Steam is attemperated with condensate returning from the CO_2 capture system to meet the conditions required by the CO_2 capture regeneration process.

2.3.3. Cooling Water System

Cooling is required throughout the CO_2 capture process for flue gas cooling/conditioning, solvent performance, and CO_2 compression. S&L prepared a Cooling Water Options study, discussed in detail in Section 3.3. Based on the study, a once-through cooling system with water supply from Lake Rodemacher that is located adjacent to the station will be used. Two (2) x 50% pumps supply cooling water from the cooling water intake structure located at Lake Rodemacher through backwash filters to remove suspended solids. Traveling water screens located at the intake structure remove large debris prior to the water reaching the pump intake bays. A large cooling water header will be routed underground from the cooling water pumps to the CO_2 Capture System, where it will split to the various CO_2 Capture System users and come above ground. The cooling water return header is routed underground to a new outfall structure which is located a distance away from the intake to allow for temperature distribution.

2.3.4. Demineralized Water System

Demineralized water is required by the CO_2 Capture System for various uses including pump seal water and makeup water for initial startup of various equipment. The demineralized water will be supplied from the existing MU3 facility Demin Water Storage Tank. New pumps are provided to transfer water from the storage tank to the CO_2 Capture System users.

2.3.5.Wastewater System

Several new sources of wastewater will be produced and managed from to the new CO_2 Capture System, including quencher blowdown, filter backwash, oily waste drains, steam drains, and other miscellaneous drains. The main source of wastewater from the CO_2 Capture System is the blowdown stream from the quencher circulating water (flue gas condensate). The wastewater streams were evaluated to determine the necessary water treatment that would be required based on the expected composition and associated regulations. Oily waste drains and quenched steam drains will be sent to a new oily water separator for treatment prior to disposal.

2.3.6. Utility Systems

Miscellaneous BOP process support utility systems were included in the project design, these are described below.

Service water is utilized in both the BOP and CO_2 Capture System for utility hose stations. Service water is also used for traveling screen wash and quenching of the steam drains tank. A new low pressure service water pump is located at the new intake structure to provide the service water supply for Diamond Vault.

For the project, a new fire water supply and distribution system independent from MU3 was selected as the design basis. New motor driven and diesel engine driven fire pumps are located at the new cooling water intake structure to supply water to the fire main routed throughout the new BOP and ISBL areas. New fire protection systems are included in the design for the administration and control areas, warehouse, and general site protection (yard hydrants).

The project will tie into the existing city water header to supply potable water to emergency eyewash and shower stations and for plumbing to the administration and control building.

A source of instrument air is needed in the CO_2 Capture System ISBL and OSBL areas to supply instruments and pneumatic actuators, CO_2 compressors (including back-up supply to dry gas seals), and the dehydration units, among other users. Compressed air utility stations are located throughout the process and BOP areas. New air compressors, dryers, and receiver tanks are included in the BOP design to meet the compressed air demand. A common instrument and station air header is routed from the compressed air system in the BOP Electrical/Mechanical Building to the various users.

New HVAC systems are included in the design and cost estimating for the new BOP buildings, including the Administration and Control Building, BOP Electrical/Mechanical Building, and Warehouse.

2.3.7. Electrical System

Primary power for the new CO_2 Capture System will be sourced from the existing Brame Energy Center 230 kV switchyard. A substation transformer will be located near the CO_2 Capture System and source directly from the existing switchyard at 230 kV via overhead lines. Switchyard modifications consist of a new 230 kV breaker with disconnect switch, a new 230 kV gas circuit breaker with manually operated disconnect switches. A new dead-end structure will be installed with coupling capacitor voltage transformers (CCVT's), relaying and metering, and the switchyard will be expanded to the north. A new motor operated disconnect switch will be installed in between the CCVT's and the new dead-end structure at the existing switchyard. A manually operated disconnect switch will be installed in between the dead-end structure and the high side of the new 230/13.8/13.8 kV substation transformer. Sourcing from the substation transformer secondary winding will be underground cables via duct bank. Separate secondary windings will be used for the ISBL and OSBL loads and associated transformers.

2.3.8. Control System

The study is based on provision of a new standalone distributed control system (DCS) for the CO_2 Capture System, with interface with the existing MU3 DCS. A separate standalone DCS for the CO_2 Capture System ISBL will be provided. The main operator workstations and control consoles for the CO_2 Capture System will be located in a control room in the new Administration Building. A separate DCS room in the building will house the networking, controllers, engineering workstations and input/output (I/O) cabinets for services at or near the Administration Building.

3. ENGINEERING STUDIES & EVALUATIONS

Several scoping investigations were performed throughout the FEED to evaluate the optimal design concept for the project. 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. The studies conducted were:

- Geotechnical Investigation
- Topographic and Bathymetric Survey
- Steam & Electricity Sourcing Study
- Cooling Water Options Study
- Water & Wastewater Treatment Study
- Train Configuration and Turndown Evaluation Summary
- Preliminary Process Hazard Analysis (PHA)
- Preliminary Constructability Review

3.1. GEOTECHNICAL INVESTIGATION

A geotechnical report was utilized to determine subsurface soil conditions at the proposed site. The report includes results of a subsurface investigation, which included buried utility location/avoidance, vacuum excavation (soft-dig), surveying, soil borings, rock coring, field classification, field sampling and testing, preparing boring logs, sample preparation, laboratory testing, soil resistivity surveys, thermal conductivity of the soil, and seismic surveys. The findings of this report were used to inform civil and structural design aspects of the project.

3.2. STEAM & ELECTRICITY SOURCING STUDY

Amine-based CO_2 Capture Systems require a significant amount of steam and electrical power. A majority of the steam is used in the reboiler for the regenerator which provides the heat needed to strip CO_2 from the solvent. Power is required for CO_2 compression, a new induced draft (ID) fan, and process pumps. Process steam and auxiliary power requirements for the CO_2 capture facility were considered.

A steam and electric sourcing study was performed to identify available steam and power sourcing options for the CO_2 Capture System and evaluate each option's technical feasibility and cost impacts. The following options were evaluated for steam and power sourcing:

- Steam Sourcing
  - Steam Extraction from Madison Unit 3
  - Steam Extraction from Nesbitt Unit 1 (located at Brame Energy Center)
  - Steam Extraction from Rodemacher Unit 2 (located at Brame Energy Center)
  - New Auxiliary Boilers
  - New Natural Gas Combined Cycle
- Power Sourcing
  - Switchyard Expansion and Direct Sourcing
  - Switchyard Expansion with UAT and RAT Sourcing

Steam extraction from the host unit was selected as the basis of design for the project. The steam turbine original equipment manufacturer (OEM) was contracted to evaluate the turbine impacts due to steam extraction. None of the technical risks to the steam turbine that were identified were considered fatal flaws to the project.

Power sourcing directly from the switchyard was selected the base case for the completion of the study.

Sourcing power directly from the switchyard has the advantage of eliminating the iso-phase bus tap to the generator bus and the UAT transformer and is the most cost-effective option. A 1x100% substation transformer would be located near the CO_2 capture facility and would source directly from the switchyard at 230 kV via overhead lines.

3.3. COOLING WATER OPTIONS STUDY

Amine-based CO_2 Capture Systems require a significant amount of heat rejection for flue gas conditioning processes, absorber water wash and various heat exchangers throughout the solvent circulation loop and the CO_2 compressor.

MU3 currently uses a once-through cooling system with water supply from Lake Rodemacher that is located adjacent to the station. However, because the CO_2 Capture System will require a significant increase in cooling load, the existing MU3 cooling system will not have sufficient capacity for the additional CO_2 Capture System cooling demands and a new cooling system will be needed. A cooling water options study was performed to evaluate potential cooling system options that could be used to provide the additional heat rejection capacity.

The evaluated options are summarized below:

1. Once-Through Cooling
2. Evaporative Cooling
3. Fin-Fan Dry Cooling
4. Hybrid Cooling (Multiple Configurations)

The study determined that once-through cooling was the most favorable option to provide the additional heat rejection capacity required by the CO_2 Capture System. Therefore, a new once-through cooling water system was used for heat rejection loads in the study.

3.4. WATER & WASTEWATER TREATMENT STUDY

A Water & Wastewater Treatment Study was prepared to evaluate and provide recommendations on handling the CO_2 Capture System water and wastewater streams. Amine-based CO_2 Capture Systems involve a number of water and wastewater systems related to heat rejection, flue gas cooling, process makeup and facility drains.

3.4.1. Cooling Water

A large amount of heat rejection will be needed for the CO_2 Capture System, as discussed in Section 3.3. The once-through cooling system design parameters are based on historical operation of the existing MU3 once-through cooling system and lake temperatures. A summary of the design parameters is provided in Table 3-1.

Table 3-1 CO_2 Capture Cooling System Design Parameters

Parameter	Value
Design Cooling Water Supply (°F)	95
Maximum Cooling Water Supply (°F)	100
Minimum Cooling Water Supply (°F)	39

Lake Rodemacher will be the source of once-through cooling water for the CO_2 Capture System. Water samples were tested monthly for one year to determine the quality of the water and subsequently any treatment requirements. Intake water screens and filters have been designed based on the water quality testing in order to minimize the risk of potential damage to downstream heat exchangers.

3.4.2. Flue Gas Condensate Water

The quencher is designed to reduce flue gas temperatures to optimize CO_2 capture kinetics and efficiency in the absorber. As the flue gas is cooled below saturation temperature, a large volume of water will be collected in the quencher as it is condensed from the moisture laden flue gas. Due to the build-up of water in the quencher from flue gas moisture, the quencher will generate a blowdown stream to maintain water and particulate levels.

The quencher blowdown will not be reused within the plant and will therefore be discharged via a new outfall in Lake Rodemacher. Based on quencher blowdown composition information estimated for the project, this stream was evaluated to determine the required treatment prior to discharge in order to meet current permit requirements.

3.4.3. Demineralized Water System

Small amounts of reverse osmosis (RO) or demineralized water are required throughout the CO_2 capture facility. RO and demineralized water sources are available from the existing plant. The demineralized water system at MU3 has sufficient capacity and quality to support the CO_2 capture facility.

3.4.4. Miscellaneous Drains

The CO_2 capture facility will include several drain systems, including sanitary drainage water, clean storm water, oil contaminated storm water, and chemical contaminated storm water. Sanitary drainage water will tie directly into the existing city sanitary sewer system to be disposed of. Water within sumps and containments that have the potential for contamination will remain isolated to allow for monitoring of any water build-up. Water within these areas can then be tested and properly disposed of, depending on the level of contamination.

3.5. TRAIN CONFIGURATION AND TURNDOWN SUMMARY

A Train Configuration / Turndown Summary was prepared in order to describe and document the equipment configurations for the project. Train configurations for major equipment within the CO_2 Capture System are defined as it relates to equipment limitations and minimum future operating load (i.e. turndown) of MU3.

The proposed equipment arrangement allows the CO_2 Capture System to operate across all boiler operating loads equivalent to and above the turn down design point (i.e. a single MU3 boiler operating at 100%). The proposed system can operate below 50%, however, impacts to the performance of the system would need to be evaluated (i.e. reduced capture efficiencies, increased utility consumption rates per ton of CO_2 captured). Operation outside of the design conditions may result in the system not meeting the predicted system performance. Extreme excursions within MU3 may result in the need to avoid the CO_2 Capture System by diverting the flue gas through the existing boiler flue gas stack.

3.6. PRELIMINARY PROCESS HAZARD ANALYSIS (PHA)

A process hazard analysis (PHA) study was performed to identify potential operating hazards and risks in systems and processes. Because not all design parameters and equipment have been finalized, this PHA was conducted with less precision and at a higher level than what would be typical for a detailed design Hazard and Operability Analysis (HAZOP), in alignment with the preliminary status of the design. Herein, this study will be referred to as the Preliminary PHA.

The project scope includes construction and operations of an amine-based carbon capture plant at MU3. PHAs were separated into BOP and ISBL scope.

The Preliminary PHA study consisted of a systematic review of the available P&IDs and PFDs to identify hazardous operating scenarios and potential areas of concern, in accordance with American Institute of Chemical Engineers (AIChE) Center for Chemical Process Safety (CCPS) guidance.

3.7. CONSTRUCTABILITY REVIEW

Construction Management subject matter experts performed a preliminary constructability review of the CO_2 Capture System. This review evaluates the constructability of the overall project and identifies the preliminary construction site layout, crane placements, and construction sequence.

The constructability review was completed by reviewing the design criteria and systems description, conceptual drawings, and other related project information. The equipment handling plan and construction sequence developed as part of this constructability review are a suggested plan and sequence intended to ensure that the design is reasonable and to form a basis for the project cost estimate and preliminary schedule. The installation contractor will be responsible for developing a detailed plan and sequence that will be used for their work, 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.

The scope of this evaluation includes the following areas:

- Infrastructure Areas – Temporary areas required for construction of new facility.
  - Access to site and parking
  - Laydown and staging areas
  - Construction trailers/offices/infrastructure
  - Temporary power
  - Security and fencing
- ISBL - CO_2 Capture System
  - ISBL sitework & grading
  - Underground cooling water piping
  - Piles
  - Duct banks
  - Deep foundations
  - Underground piping and stormwater
- OSBL – All permanent components outside the ISBL Area
  - OSBL piles
  - OSBL foundations
- Facility Construction and Equipment Erection
  - Modular transportation and equipment erection
  - Vessel installation
  - Internals and packing
  - Process modules
  - CO_2 compressors
  - Piping and mechanical installation
  - BOP utility rack
  - Electrical equipment
  - Raceway and cable installation
  - Instrumentation
  - Final site grading
- Start-up and Commissioning
  - Electrical Systems
  - Mechanical Systems

A preliminary conceptual construction sequence was developed for the scope of the project as part of the constructability review. Changes to the sequence will likely occur as contractors optimize their work crews and maximize the use of construction equipment during detailed design.

3.8. CONTRACTING STRATEGY

The preferred contracting strategy for Diamond Vault was determined to be either a full or partial EPC. The EPC contract is expected to be between Cleco and a Joint Venture or Consortium partnership between the technology provider and the construction contractor.

3.9. STAFFING STRATEGY

A staffing strategy was developed for the CO_2 Capture System. The intent was to determine the quantity of staff required to successfully operate the CO_2 Capture System, how to source and train the appropriate workforce, and where the staffing will be located within the facility. Cleco has assumed that the plant manager, environmental manager, operations manager, and maintenance manager positions will be staffed by existing Cleco personnel. Due to the specialized nature of the CO_2 capture process and number of new systems / components, the CO_2 Capture System will require dedicated operations and maintenance staff to fulfill the remaining positions. The new facility operations and maintenance personnel are expected to be drawn from a variety of backgrounds, including oil and gas industry, power industry, and chemical industry.

3.10. LIFE CYCLE ANALYSIS

The Life Cycle Analysis (LCA) was developed to demonstrate zero net carbon emissions of the electricity delivered to the consumer from the power plant with carbon capture and proposed negative emissions technologies (NETs). The scope of the LCA was cradle-to-delivered electricity, inclusive of transmission of the electricity to the final customer and transport and storage of the captured CO_2 in a saline aquifer. This analysis was developed in accordance with NETL Guidance. The goal of the LCA is to model the life cycle of greenhouse gas (GHG) emissions from cradle-to-delivered electricity, associated with the CO_2 Capture System. The LCA model developed in OpenLCA utilized the pre-established NETL process from OpenLCA or LCA Commons wherever possible, supplemented by publicly available information as needed. Information developed as part of the study was used to develop process inputs and supplemented with engineering judgement as needed.

The base case of the process considers all of the CO_2 Capture System's electricity to be sourced from MU3 and no NETs. In order to reach net-zero capture for the combined power plant and CO_2 Capture System, NETs must be introduced. For this LCA, net-zero capture is modeled by using direct air capture (DAC) to offset the remaining CO_2 emitted.

The LCA is provided in Appendix E.

3.11. BUSINESS CASE ANALYSIS

The Business Case Analysis (BCA) was developed to demonstrate an understanding of the current and projected landscapes of the DAC or DACUS markets and the potential utilization of tax credits, including their projected revenue and duration. This analysis was developed in accordance with NETL Guidance.

The first section of the business case analysis develops a pro forma statement for the projected financial parameters associated with the financing and operation of the CO_2 Capture System. This includes projected financial parameters like operating costs, operating revenues, earnings before interest, taxes, depreciation and amortization (EBITDA), tax credits, net present value (NPV) and internal rate of return (IRR) over the project lifespan.

The second part of the business case analysis discusses the applicability of the associated CO_2 capture technology to coal-fired power plants.

The third part discusses a high-level analysis of the potential deployment of the Advanced KM CDR Process™

across future coal-based power plants. This includes identifying competing technology options and barriers to large scale deployment. In addition, the potential benefits of large-scale deployment are also summarized.

The BCA is provided in Appendix F.

3.12. ENVIRONMENTAL HEALTH AND SAFETY ANALYSIS

The Environmental Health and Safety (EH&S) Assessment was developed to assess the environmental friendliness and safety of any future process based on the materials and process being proposed. This assessment was developed in accordance with NETL Guidance.

The purpose of the EH&S Assessment is to evaluate the environmental friendliness and safety of the proposed CO_2 capture project based on a review of the materials and processes being proposed for the project. EH&S issues associated with the CO_2 capture project include potential exposure to hazardous chemicals and materials used in the process, ancillary or incidental air and water emissions, and solid waste generated by the process. The EH&S Assessment includes: (1) a description of potential ancillary or incidental air and water emissions and solid wastes produced from the proposed technology; (2) a description of the toxicological effects of the substances identified above; (3) properties of the substances related to volatility, flammability, explosivity, other chemical reactivity, and corrosivity; (4) compliance and regulatory implications of the proposed technology with reference to applicable U.S. EH&S laws and associated standards; (5) an engineering review of potentially hazardous material to look for ways their use can be eliminated or minimized; and (6) precautions for safe handling and conditions for safe storage of potentially hazardous material.

The EH&S Assessment is provided in Appendix G.

3.13. ENVIRONMENTAL JUSTICE QUESTIONNAIRE

The Environmental Justice (EJ) Questionnaire was developed to provide a preliminary summary of environmental justice considerations of the proposed technology, process, or system, in accordance with Executive Order 13985 officially titled Advancing Racial Equity and Support for Underserved Communities Through the Federal Government. All work related to the Environmental Justice Questionnaire was completed by December 22, 2024. This analysis was developed in accordance with NETL Guidance and was completed as part of the Pre-FEED phase.

The EJ Questionnaire is provided in Appendix H.

3.14. ECONOMIC REVITALIZATION AND JOB CREATION OUTCOMES ANALYSIS

The Economic Revitalization and Job Creation (ER&JCOA) Outcomes Analysis was developed to provide a preliminary summary of the economic and workforce impacts associated with the proposed technology, process, or system, in accordance with Executive Order 13985 officially titled Advancing Racial Equity and Support for Underserved Communities Through the Federal Government. This analysis was developed in accordance with NETL Guidance and was completed as part of the Pre-FEED phase.

The ER&JCOA was prepared in accordance with Executive Order 13985 officially titled Advancing Racial Equity and Support for Underserved Communities Through the Federal Government. This analysis includes a summary of the economic and workforce impacts associated with installing the Advanced KM CDR Process™ at Cleco's MU3 power plant, in Boyce, Louisiana.

The new CO_2 Capture System will require significant labor for fabrication, construction, and operation of the new facility. At the direction of the Department of Energy, a Jobs and Economic Development Impact (JEDI) model from the National Renewable Energy Laboratory (NREL) was prepared to estimate the number of jobs created as a result of this project.

The JEDI model utilizes project economic parameters and location information to estimate the number and types of jobs created for the local community. Noted is that a CO_2 capture system-specific JEDI model does not currently exist; therefore, it was assumed that of the models available, the coal power plant template was the best starting point for this evaluation.

Project-specific parameters were entered into the coal power plant JEDI model, as applicable to a CO_2 capture system, such that the complete project was characterized within the bounds of the JEDI model. This evaluation fundamentally assumes that with CO_2 capture project values entered into the coal power plant JEDI model, the resulting job data was accurately predicted within the ability of the model.

Without basis for updating percent of work performed locally, it is assumed that the model's default values were reasonable for this evaluation. This approach is expected to be reasonable as line items that would be anticipated to be performed by local contractors (i.e., General Facilities) has a high local percentage, while the line item that includes the specialty process equipment (i.e., Plant Equipment) has a low local percentage.

All work related to the Economic Revitalization & Jobs Creation Outcomes Analysis was completed by December 22, 2024.

The ER&JCOA Analysis is provided in Appendix I.

4. COST ESTIMATE DEVELOPMENT

The purpose of the study was to develop the necessary project engineering and design in order to support development of a detailed cost estimate, the result of the pre-FEED phase was an AACE Class 3 estimate. 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, combined into a single cost estimate which reflects the design developed during the pre-FEED phase. Many pieces of critical/major equipment are costed based on budgetary quotes received by 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 for the facility, process flows depicted on the project mass balances, and engineering judgement. Annualized capital costs are combined with the annual O&M costs to calculate the cost of CO_2 capture in $/tonne.

4.1. CAPITAL COST ESTIMATE INPUT

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

Listed below is a summary level scope (not all inclusive) of costs included in the estimate:

- CO_2 Capture and Purification Equipment (ISBL)
- CO_2 Compression (including Electric Motor Drives) (ISBL)
- Cooling Water System (BOP)
- Piping Systems:
  - CO_2 Capture Facility Integration (ISBL)
  - BOP Systems Integration (BOP)
- Fire Protection Systems (ISBL+BOP)
- Civil Work
- Concrete Work (ISBL+BOP)
- Structural Steel (ISBL+BOP)
- Buildings (ISBL+BOP)
- Electrical Equipment and Commodities (ISBL+BOP)
- Existing switchyard modifications and new transmission line to new CO_2 Capture System substation
- Instrumentation and Controls (ISBL+BOP)

4.1.1. Pricing and Quantities

The cost estimate has been built up using equipment costs and MTOs developed during the study by each discipline.

MTOs were provided for ISBL piping, valves, cables, instruments, steel, etc. MTO information has been imported into S&L's estimating system, and associated materials and labor (pipe support, coatings, terminations, etc.) have been estimated based on the provided MTO information.

MTOs were provided for BOP piping, valves, cables, instruments, steel, etc. MTO information has been imported into S&L's estimating system, and associated materials and labor (pipe support, coatings, terminations, etc.) have been estimated based on the provided MTO information.

MTOs for the entire project (ISBL and BOP areas) were also developed.

ISBL pricing included the following CO_2 Capture System equipment, systems, and components:

- Quencher
- Absorber
- Flue Gas Pre-Treatment
- CO_2 Regenerator
- Process Vessels
- Process Vessel "Internals"
- CO_2 Compressors (including motor drives and auxiliary systems)
- Flue Gas Blower (including motor drives and auxiliary systems)
- Dehydration Packages
- Reclaiming System
- Process Heat Exchangers
- Process Filters
- Rotating Equipment (e.g. Process Pumps)
- Tanks
- Electrical Equipment

Vendor quotes were received for the following BOP/OSBL equipment, systems, and components:

- Cooling Water Pumps
- Oil Filled 230 kV Substation Transformer
- Dry Type 13.8 kV-480V Transformers
- 13.8 kV and 480V Switchgear
- CO_2 BOP 480V Motor Control Centers
- Steam Conditioning Valve
- Automatic Backwash Strainers
- Flue Gas Dampers
- Cooling Water Intake Screens
- Compressed Air Equipment

For certain low value cost accounts, internal reference CO_2 Capture System project estimates have been used for comparative cost information. Scaling was used to adjust any referenced costs. This approach has been minimized in the development of this estimate.

Pricing used in the estimate is based on current 2023 material, equipment, and labor markets. Labor wage rates are based on the prevailing wages for Alexandria, LA and are based on 2023 rates are as published in RS Means Labor Rates for the Construction Industry.

4.2. 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, and EPC project indirects including G&A and profit.

Table 4-1 summarizes the results of the capital cost estimate.

Table 4-1 Summary of Capital Cost Estimates ($2023)[1]

Description	Cost
Total Direct Cost	**667,187,853**
Total Indirect Cost	**509,268,000**
Total Project Cost, Less Contingency	1,176,455,853
Contingency[2]	120,659,000
Total Project Costs[3]	**1,297,114,853**

Note 1: Costs are presented as overnight costs and do not include escalation beyond 2023 or allowance of funds used during construction. Costs are representative of CO_2 capture and do not include costs associated with the transportation, storage or monitoring of CO_2.
Note 2: Contingency is included at 15% on BOP/OSBL costs. No additional contingency is included on the ISBL costs beyond what is included by the OEM.
Note 3: Total Project Costs are based on the scope defined within the basis of estimate.

4.3. OPERATING & MAINTENANCE COST ESTIMATE

The variable O&M costs are based on the rates of raw material consumption and waste generation established by the project design basis and mass balances. The commodity prices were confirmed to be consistent with prices experienced by MU3.

Solvent and other chemical/material makeup costs were provided based on the conditions required by the MU3 CO_2 Capture System and process experience. Transportation, storage, and monitoring costs to maintain the CO_2 pipeline and sequestration facility are outside the project scope. These costs are not included in this estimate.

O&M costs associated with the lost power generation due to additional auxiliary power usage of the CO_2 Capture System and steam turbine derate are included in the estimate.

Fixed O&M costs are flat rates that are be applied to the capital costs regardless of fluctuations in unit operation. Fixed costs are included for operating labor, maintenance material and maintenance labor. These costs are applied at 1.5 % and 2% of the direct equipment and material costs of OSBL scope and ISBL scope, respectively.

A summary of operating costs is provided in Table 4-2.

Table 4-2 Annual Operating Costs ($2023)

Parameter	Cost ($/yr)
Total Variable O&M	**107,915,000**
Total Fixed O&M	**12,952,000**
Total Annual O&M	**120,867,000**

4.4. COST OF CAPTURE

The cost of capture is the dollar amount required to capture, condition, and compress one tonne of CO_2. The economics of carbon capture is quantified in $/tonne for direct comparison to future tax incentives which is 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 Cleco feedback, the facility has been evaluated over a 12-year lifespan (n) to align with the current duration limits of the 45Q tax credit. While it is expected that the functional lifespan of the CO_2

Capture System would exceed 12 years, the loss of credits at the 12-year mark introduces a desire to recover all cost expenditures within the first 12 years of the facility operations. Annualization of the CO_2 Capture System capital is therefore amortized over 12 years. 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 CO_2 that will be capture based on an assumed capacity factor (e.g. 80%), the cost of capture ($/tonne) can be calculated. A summary of the cost of capture is provided in Table 4-3. Note that the complete Business Case Analysis (BCA), which includes the project's financial analysis for capture, transportation, storage and monitoring of CO_2, is attached in Appendix F.

Table 4-3 Cost of Capture ($2023)

Description	Unit	Cost
Annualized Capital Cost[1]	$/yr	163,309,000
Total O&M Cost	$/yr	120,867,000
Total Annual Cost	$/yr	284,176,000
CO_2 Captured	tonne/yr	4,279,947
Cost of Capture[2, 3]	**$/tonne**	**66.4**

Note 1: Annualization Factor: 0.126, Interest Rate: 7% discount rate, Payback Period: 12 Years
Note 2: Cost of Capture reported without 45Q credits.
Note 3: Costs are representative of CO_2 capture only and do not include costs associated with the transportation, storage or monitoring of CO_2.

APPENDIX A. PROJECT DESIGN CRITERIA

CLECO Power

Brame Energy Center – Madison Unit 3

PROJECT DIAMOND VAULT

PROJECT DESIGN CRITERIA
CO_2 Capture Project

Date: 12/15/2023
Revision: 1

Table of Contents

1.0 INTRODUCTION

1.1 Project Overview

Cleco Power (Cleco) has identified Madison Unit 3 (MU3) as a candidate for implementing a carbon dioxide (CO_2) capture and storage (CCS) project. Project Diamond Vault (DV) will retrofit Cleco's MU3 to reduce up to 95% of its CO_2 emissions through post combustion CO_2 capture technology.

MU3 is located at the Brame Energy Center facility and is a petroleum coke (petcoke) and coal-fired power plant located in central Louisiana with a gross generator output of 635 MW. MU3 has two (2) circulating fluidized bed (CFB) boilers that share a dual flue chimney and produce steam for one (1) common steam turbine generator (STG).

The CO_2 capture equipment and systems inside the battery limit (ISBL) include quenching, flue gas pretreatment, absorption, regeneration, CO_2 compression, various heat exchangers and pumps, and solvent handling systems.

Outside the battery limit (OSBL) systems include the necessary utilities, including power, flue gas, steam, and cooling water to the CO_2 capture island. The OSBL scope also includes handling of waste streams produced in the ISBL scope.

1.2 Purpose

The purpose of this Design Criteria document is to define and provide the design criteria and design basis for the project for the OSBL systems. MHIA has provided the design basis for the ISBL systems.

<u>These design criteria apply to the OSBL Balance of Plant (BOP) systems only.</u>

2.0 SITE CONDITIONS

2.1 Location

MU3 is located in Rapides Parish near the City of Boyce in central Louisiana.

2.2 Coordinate Reference Systems

2.2.1 Elevation

All Plant Elevations shall be indicated in feet (ft) and shall be referenced to National Geodetic Vertical Datum of 1929 (NGVD29).

2.2.2 Coordinates

The Project shall use a plant grid system of coordinates which shall be correlated to North America Datum of 1983 (NAD83), Louisiana North Zone.

2.3 Ambient Weather Conditions

Ambient weather conditions are taken from the nearest ASHRAE weather station.

Parameter	Data
Nearest ASHRAE (2021 Fundamentals) weather data location	Alexandria Intl, LA, USA
World Meteorological Organization Number	747540
Latitude / Longitude (at site)	N 31.397° / W 92.719°
Elevation (at site)	112 ft
Standard pressure (at site)	14.7 psia
Heating dry bulb temperature, 99.6% occurrence	26.9°F
Evaporation wet bulb temperature, 0.4% occurrence	80.3°F
Mean coincident dry bulb temperature, 0.4% occurrence	89.4°F
Evaporation design relative humidity	67%
50-year occurrence dry bulb temperatures:	
High	109°F
Low	11.3°F
Hottest month (August) mean daily dry bulb range	19.9°F
Cooling dry bulb temperature, 0.4% occurrence	97.2°F
Cooling wet bulb temperature, 0.4% occurrence	76.8°F
Cooling design relative humidity	39%
Design dry bulb temperatures:	

Parameter	Data
High	110°F
Low	10°F

2.4 Water Quality

Makeup water is required in various conditions for the CO_2 capture system and Balance of Plant (BOP) processes. Cooling water for the CO_2 capture system will be provided from Lake Rodemacher. Make-up demineralized water for the CO_2 capture system will be provided from the existing plant.

3.0 GENERAL DESIGN BASIS

3.1 Flue Gas Design Basis

3.1.1 Flue Gas Data

a. A summary of the full load flue gas design conditions is provided below.

Parameter	Units	Full Load Design
Temperature	°F	205
Pressure at CO_2 Capture Battery Limit	psia	14.56
Mass Flowrate	lb/hr	6,696,720
Volumetric Flowrate	scfm	1,465,903
N_2	vol%	70.4
O_2	vol%	4.3
H_2O	vol%	11.2
CO_2	vol%	14.1

b. Information used in the Flue Gas Design Basis development includes historical PI and Continuous Emissions Monitoring System (CEMS) data and stack testing reports.

3.2 CO_2 Product Specification

The CO_2 capture compression and dehydration system will be designed to provide CO_2 quality based on the following requirements.

CO_2 Product Parameter	Specifications
Pressure at Pipeline Interface (psig)	2,000 (TBV)
Temperature (°F)	≤ 120
CO_2 Purity, mol%	> 95.5%
N_2 Content, mol%	< 4% (all non-condensable gasses)
Argon Content, mol%	< 4% (all non-condensable gasses)
Methane Content, mol%	< 4% (all non-condensable gasses)
Hydrogen Content, mol%	< 4% (all non-condensable gasses)
Moisture Content, ppmv / lb/MMscf	< 50 / 2.4
O_2 Content, ppmv	< 50
CO Content, ppmv	2,000

H_2S Content, ppmv	< 20
NOx Content, ppmv	< 100
SOx Content, ppmv	< 100
Sulfur Content, ppmv	< 10 ppm to 35 ppm by weight
Particulate Content, ppmv	Below detection limit

3.3 Emissions

The CO_2 capture system will be designed to remove 95+% of the CO_2 from the flue gas stream entering the unit. Preliminary emission rates from the absorber were estimated based on the expected performance.

3.4 Turndown

The CO_2 capture equipment and systems will be designed to operate when turned down to approximately 50% of the total flue gas design flow.

3.5 Equipment Sparing and Redundancy

3.5.1 ISBL Systems

. Sparing of equipment for the ISBL systems will be determined based on the results of a Reliability, Availability, and Maintainability (RAM) Analysis.

3.5.2 OSBL Systems

a. Equipment redundancy for the OSBL systems will be based upon the ISBL RAM analysis results such that a failure of the OSBL equipment or systems will not impact the desired reliability, availability, and maintainability of the ISBL equipment or system.

b. The following OSBL equipment is expected to be considered critical and provided with redundancy as indicated:

- Air Compressors and Dryers – 2 x 100% or 3 x 50%
- Fire Water or Fire Water Booster Pumps (if required) – 2 x 100%
- Isolation Damper Seal Air Blowers – 2 x 100%
- Demineralized Water Pumps – 2 x 100%
- Cooling Water Pumps are selected to be 2 x 50% and redundancy is not provided consistent with the ISBL approach.

3.6 Freeze Protection / Winterization

3.6.1 General

a. Outdoor equipment and components shall be designed for the plant minimum design temperature of 10°F.

b. Pipelines located outdoors carrying fluids with a freezing point greater than the wind chill corrected minimum design temperature shall be designed with one of the following freeze protection methods. Operational measures will be examined to avoid excessive use of heat tracing with regards to the ambient conditions.

- Fluid within the pipe shall be continuous and normally flowing. The line shall be able to be drained when the system is out of service.
- Pipe 4” diameter and less, including instrument tubing and sensing lines, shall be electrically heat traced and insulated.
- Pipe greater than 4” will be evaluated for heat tracing on a case-by-case basis.
- The above freeze protection criteria will also apply for indoor pipelines carrying fluids with a freezing point greater than the building low design temperature.

3.7 Noise

Noise levels will consider the requirements of OSHA Standard 29 CFR 1910 Subpart G Standard Number 1910.95, Occupational noise exposure, as well as State and Local guidelines and requirements.

Near Field: The maximum A-weighted sound level will not exceed 85 dB(A) under any normal operating condition when measured at any point three feet away from any piece of equipment in accordance with ANSI Standard S1.13. The noise limits apply at a height of 5 feet above the floor and on all platforms included with the equipment. Equipment not meeting the sound requirements will be placed in an enclosure and acoustically insulated as necessary.

In the case that any new equipment cannot meet the sound requirements (even through use of an enclosure and/or acoustic insulation), plant personnel, when near this equipment, shall wear additional ear protection to reduce sound level. Areas requiring use of personal protective equipment shall be restricted to those in close proximity to major noise sources.

Far Field: There are no known far field stipulations for this site.

4.0 CO_2 CAPTURE SYSTEM

4.1 System Description

The CO_2 capture system for MU3 reduces CO_2 emissions from the flue gas via amine-based solvent which absorbs the CO_2. The CO_2 capture system will capture, treat and compress 95% of the CO_2 emissions sent to the system. This application will use a proprietary amine-based system developed by MHIA. MHIA's proposed CO_2 capture system for MU3 is comprised of quenching, flue gas pre-treatment, absorption, regeneration, CO_2 compression, various heat exchangers and pumps, and solvent handling systems. Treated flue gas will be emitted at a new emission point at the stack of the CO_2 capture system absorber.

4.2 Utility Requirements

The following utilities are required to support operation of the CO_2 capture system.

4.2.1 Cooling Water System

A new dedicated cooling system is required for the CO_2 capture system. The CO_2 capture system will utilize once-through cooling with Lake Rodemacher as the cooling water source. See Section 5.4.4 for additional information regarding cooling water design parameters and system description.

4.2.2 Auxiliary Power Supply

The CO_2 capture equipment requires significant electrical power to operate the mechanical equipment needed to capture and compress the CO_2, with a majority of the power being used for compression. See Section 7.1 for additional information regarding electrical design parameters.

4.2.3 Steam Supply

Steam for the CO_2 capture system is required for the regenerator reboiler. Steam for the CO_2 capture equipment will be extracted from the existing MU3 steam turbine. Steam extraction from the steam turbine reduces the overall gross output of the turbine by removing the steam from the low-pressure/intermediate-pressure (IP-LP) crossover section of the turbine. See Section 5.4.2 for additional information regarding steam design parameters.

4.2.4 Miscellaneous

Additional utility requirements for the CO_2 capture system include makeup water (typically demineralized or RO quality), instrument and plant air, nitrogen, potable water, and service water, including fire water and utility water for hose stations.

4.3 Waste Treatment and Removal

The CO_2 capture system will generate wastewater streams from the quencher blowdown and other areas within the process. These streams will be combined and can be utilized as makeup elsewhere in the base plant, with appropriate treatment, or treated and discharged back to Lake Rodemacher. See Section 5.5 for additional details regarding the wastewater and treatment system.

The solvent reclaim system will have a waste stream that will be hauled off-site for disposal. Final disposal of the solvent-related waste will be dependent on the waste composition and resulting disposal requirements (i.e. landfilled, incinerated, etc.). Additional smaller waste streams will also be generated from the CO_2 capture system.

5.0 MECHANICAL DESIGN CRITERIA

5.1 Piping

5.1.1 General

a. All piping for the OSBL systems will be designed to ASME B31.1, unless noted otherwise in the piping design table.

b. Fire Protection systems will be designed per NFPA, the insurance carrier, and Authority Having Jurisdiction (AHJ) requirements. Plumbing and sanitary piping will be designed per local code requirements.

5.1.2 Design Pressure and Temperature

a. The design pressure for piping systems designed by S&L will be the maximum sustained pressure during normal or transient conditions, plus an additional 10% minimum. The design pressure will be rounded up to the next 5 psi and will be no less than 50 psig.

b. In general, the design temperature of piping systems will be the maximum sustained temperature during normal operating or transient conditions plus an additional 10% or 10°F, whichever is greater. The design temperature for piping with operating temperature greater than 250°F will be the maximum sustained temperature during normal operating or transient conditions plus 25°F. The design temperature will be rounded up to the next 5°F.

c. Pipe joints will be welded construction. Compression couplings, Victaulic Vic-Press™ or similar, may be used for compressed instrument or plant air service with Cleco approval.

5.1.3 Buried Piping

a. Buried piping will be installed below the frost depth indicated in Section 6.2.5. Fire protection piping will be buried with a minimum depth of cover of 2.5 ft per NFPA 24.

b. Underground process piping will be high-density polyethylene (HDPE) except where service conditions, fluid characteristics or other considerations dictate use of metallic or alternative non-metallic pipe materials. Non-metallic buried piping systems will have a tracer tape system installed. HDPE piping entering into or emerging from a structure will extend through the building substructure or foundation and will transition to metallic pipe materials inside the structure above the floor elevation. The transition for fire protection piping will be provided with suitable protection. Fire protection HDPE piping will be FM approved.

c. Large diameter circulating water piping will be prestressed concrete embedded cylinder pipe or mortar lined steel pipe.

5.1.4 Insulation and Heat Tracing

a. Hot insulation will be mineral wool with aluminum lagging.

b. The maximum surface temperature design for heat conservation and personnel protection is 140°F.

c. For piping and equipment operating below 50°F, anti-sweat insulation will be provided in occupied areas and over walkways and will be elastomeric type (closed cell or foam glass). A fire-retardant vapor barrier will be provided to prevent condensate formation from corroding the piping.

d. Insulation for valves, flanges, instruments, etc., will be removeable to provide access for operations and maintenance.

e. Heat tracing will be applied for freeze protection as noted in Section 3.6.

5.2 Valves

5.2.1 Isolation Valves

a. Ball valves should be used to the fullest extent practical on lines 3” and under for manual isolation.

b. For piping larger than 3”, high performance butterfly valves should be used for isolation wherever possible.

c. Gate valves or plug valves are an acceptable alternative for isolation in either the fully open or fully closed position. Globe valves shall not be used as the primary isolation valve.

d. Globe valves shall primarily be used in throttling services. Butterfly valves may also be used for throttling service where approved.

e. Large diameter cooling water valves shall be butterfly valves meeting the requirements of AWWA C504 and C516 standards.

f. Instrument sensing lines, pressure taps, vents, drains and similar branch connections on high pressure systems (greater than ASME class 600) will be provided with two manually operated isolation valves (i.e. double block).

g. Double block and bleed will be considered for high energy systems (greater than ASME class 600 and/or greater than 800°F) or hazardous equipment and components that must be isolated and maintained while the system is still energized or online. This will be reviewed on a case-by-case basis.

5.2.2 Check Valves

a. Check valves shall be used to automatically prevent flow reversal.

b. Check valves located on pump discharges shall be placed between the pump and they system block valve so the check valve may be serviced.

c. Non slam type check valves should be selected for pump discharge service to minimize water hammer upon a pump start/shutdown condition if there is any concern about water hammer.

5.2.3 Control Valves

a. Control valves shall be used to regulate the flow, pressure, or temperature of a fluid in a piping system and will be pneumatically operated with a diaphragm or cylinder operator.

b. All control valves will be provided with manual isolation capabilities. Bypasses for the control valves will be provided on a case-by-case basis as approved by Cleco.

5.2.4 Valve Operators

a. Handwheels or lever actuators may be used for smaller valves that do not require excessive force to open.

b. Gear operators shall be furnished for manually actuated valves to obtain mechanical advantage when opening forces with handwheels or levers are excessive and for manually actuated valves 8-in. size and larger. Handwheel rim pull for manually operated valves shall generally not exceed 50 lb at the maximum operating torque requirement. This limit can be exceeded where the valve supplier recommends a higher force limit for valves in which the seating / unseating torque exceeds the running torque. In such cases, the handwheel rim pull shall not exceed 100 lbs.

c. Electric motors may be used for automatic operation of valves. Multi-turn motor actuators shall be Limitorque L120, unless otherwise approved. Electric motors should not be used in applications where failure in last position is not acceptable.

d. Pneumatic actuators may be also be applied for automatic operation of valves and where fast closing times or modulating service is required (e.g., control valves). Pneumatic valves may be specified to fail in place, fail opened, or fail closed, as required by the system. Fisher pneumatic actuators with digital valve controller (DVC 6200) are preferred.

e. Remote indication of valve position shall be provided for all electric motor and pneumatic actuated valves. Remote indication of valve position for manual valves will be provided only where required. Limit switches will used for valves that are normally fully opened, fully closed, or opened to a predetermined intermediate position. Valves requiring full range position indication shall be provided with position transmitters.

5.2.5 Relief Valves

a. Pressure relief valves protect systems from excessive overpressure by automatically opening upon a rise in system pressure, typically due to an excursion from the design conditions, and close promptly when pressure returns to normal levels. Capacity may be based on specific code requirements of ASME Section VIII, B31.1, and API 520/521. All relief valve discharges will be routed away from personnel access areas.

b. For steam system safety relief valves, the vent stacks will be sized to pass the required relieving capacities and prevent blowback at the vent stack slip joint.

5.2.6 Vents and Drains

a. All systems will have high point vents and low point drains as required by the process and for hydrostatic testing as applicable.

b. Steam system low points will consist of a drain pot sized per S&L standards. Steam systems will be drained automatically with the use of pneumatically operated valves actuated via drain pot level or temperature sensors. Low pressure steam systems may be drained using steam traps.

5.3 Mechanical Equipment

5.3.1 Pumps

a. The design flow for pumps should be a minimum of 10% greater than the total maximum expected flow, divided by the number of pumps in operation. The design total developed head will be selected to include an additional 10% margin on piping and component friction loss. For the large cooling water supply pumps, these margins may be reduced or eliminated.

b. Net Positive Suction Head (NPSH) available to pumps should be at least 25% greater than the manufacturers NPSH requirements, based on 3% head loss.

c. Pumps will be provided with minimum flow recirculation to prevent operation below the minimum continuous stable flow, where required. Minimum flow recirculation may be in the form of an automatic recirculation valve, control valve, or orifice and will generally return to the pump suction source.

d. Horizontal, centrifugal, direct motor drive pumps shall be used for most general pump services. Pumps located in the intake structure, including cooling water pumps, fire pumps, and low pressure service water pumps will be vertical, centrifugal, wet pit circulating water pumps with motor drives.

e. Positive displacement metering pumps will be used for chemical injection when precise flow control is needed and will be either piston, rotary, or diaphragm type pumps. Pumps shall be specified with a minimum 10:1 turndown.

f. Vertical line shaft sump cover-mounted or submersible type pumps will be used for sump pump applications. Submersible sump pumps will be supplied with a guide rail removal system.

5.3.2 Atmospheric Tanks

a. Atmospheric steel tanks storing water will generally be designed per API 650.

b. Chemical storage tanks shall be located outdoors within containment. Containment will be sized to hold the volume of the single largest tank, plus a minimum volume of a 25-year, 24-hour rainfall (110% minimum total volume). Containments will be valved closed to prevent contaminated discharge to the stormwater system. Chemicals will be reviewed for compatibility and separate containments for chemical segregation provided as required.

c. Atmospheric storage tanks will be sized for the appropriate storage time. Storage volume will consider working volume between the established high and low tank levels.

5.3.3 Pressurized Vessels

a. Pressurized tanks and equipment will be designed and constructed in accordance with the requirements of ASME Section VIII.

b. The design pressure will be the maximum sustained pressure during normal or transient conditions, plus an additional 10% minimum.

5.3.4 Heat Exchangers

a. Balance of plant heat exchangers may utilize shell and tube or plate and frame construction. The heat exchangers shall be designed and manufactured in accordance with the ASME Section VIII, Div. 1

b. Shell and tube heat exchangers will be specified to conform to TEMA and API 660 requirements and shall be purchased with a minimum of 6% excess tubes.

c. Plate and frame heat exchanges will be specified to conform to API 662 and shall be purchased to incorporate an additional 20% heat exchanger area in the future.

d. Shell and tube heat exchangers utilizing water from Lake Rodemacher shall be designed with a fouling factor of 0.003 $ft^2h^\circ F/Btu$.

5.4 Mechanical Systems

5.4.1 Flue Gas Ductwork System

a. Flue gas ductwork will be routed from the tie-in at the ID fan outlet / stack inlet ductwork from each MU3 boiler.

b. To overcome pressure losses of the CO_2 capture system and the new ductwork, a flue gas blower provided by MHIA in the ISBL scope will be installed downstream of the quenchers. Detailed design of the blowers will be in MHIA's scope.

a1. It is anticipated that the existing MU3 ID fans will maintain their current operation to achieve 0 in w.c. at the stack outlet, therefore the ductwork system will operate under negative pressure. The existing MU3 fan performance was also reviewed to determine the available pressure at the ductwork tie-in to the CO_2 capture system and will be further studied during the FEED phase.

c. Ductwork will be designed to operate at a flue gas velocity of approximately 3600-4500 fpm. Computational Fluid Dynamics (CFD) modeling will be used during the FEED or detailed design stage of the project to determine the optimal duct arrangements and turning vane configurations as needed to minimize pressure drop and provide good flow mixing and distribution.

d. Design operating temperatures and pressures of the new ductwork will be considered to occur simultaneously. Excursion temperatures and pressures will be combined as dictated by the associated transient event. Excursion pressure will not be combined with any other environmental transient event (e.g. wind or seismic).

e. The flue gas blower addition may alter existing flue gas system operating pressures, as well as the magnitude of pressure excursions in the existing furnace and balance of plant ductwork system due to master fuel trips, control malfunctions, or other transients. The effects of these changes to the boiler draft system will be evaluated.

e1. If the new design operating pressure for the existing ductwork exceeds the original design pressure, then the ductwork will be reinforced as required.

e2. The evaluation of the existing flue gas systems will be in accordance to NFPA 85. A detailed evaluation of the flue gas and ductwork system, including transient analysis, will be performed during detailed design.

f. Flue gas from the outlet of the CFB boiler and dry scrubber system will be generally low in moisture and not operate near the dew point of the flue gas. Carbon steel materials of construction are anticipated to be suitable for the conditions and will be verified during the design.

g. Ductwork will be insulated for personnel protection where accessible. Insulation for heat retention is not required. The current design includes a thin layer of insulation to limit condensate formation and mitigate any noise concerns. A thermal heat loss calculation should be performed during detailed design to determine the worst-case heat loss through the ductwork. Insulation thickness may be increased if it is required to maintain temperature above the dew point of the flue gas and limit condensate formation.

h. Dampers will be used to control and isolate flue gas flow in the ductwork. Isolation dampers will be provided at the tie-in to the existing ductwork and between the new tie-in to the existing ductwork and upstream of the existing stack.

i. Dampers will be motor or pneumatically actuated (depending on torque, actuation time, and fail position) and equipped with position feedback signals for remote monitoring of damper position.

j. Seal air will be provided for isolation dampers to maintain zero leakage per vendor requirements.

k. Dampers will be accessible from gallery and serviceable from outside the normal flue gas stream. Lock out devices will be placed for easy access without the use of a ladder.

l. Expansion joints will be provided to allow for thermal expansion and movement without transmitting forces or moments to the inline equipment or adjacent ductwork segments.

m. Expansion joints will be non-metallic belt type with a man-safe inside gap cover to prevent ash accumulation.

5.4.2 Steam System

a. Steam will be supplied to the CO_2 capture system for use in the regenerator reboilers from a new tie-in connection off the existing MU3 turbine IP-LP cross over piping.

b. The new tie-in to the MU3 turbine IP-LP crossover will be designed in compliance with ASME TDP-1 for turbine water induction protection.

c. If required, a steam conditioning valve will be provided to knock down the pressure and temperature of the steam down to the low-pressure steam conditions needed for the reboiler. Attemperation water will be supplied from the CO_2 capture condensate return system.

d. Steam piping will generally be sloped downward in the direction of flow to low point drains under cold and hot position. Low point drains will consist of a steam trap, upstream or integral strainer, isolation valves, and check valve if required. Alternately, an automated drain valve may be utilized. The automated drain valve will normally be energized and closed but will automatically open upon high-water level in the drain pot as sensed by level switches or high temperature in the drain pot as sensed by thermocouples for superheated steam, or on signal failure.

e. Drains in the vicinity of MU3 will be routed to existing flash or blowdown tanks, condenser, or sumps where possible. Steam drains located along the piping utility header and near the CO_2 capture island will be routed to a new flash tank. The flash tank(s) will discharge to atmosphere and the condensate will be quenched (if required), collected, and discharged or returned to the MU3 condensate system or to the oily waste drain system.

f. Warming lines will be provided as required at any dead legs to prevent condensate buildup and potential water hammer upon header valve operation.

5.4.3 Steam Condensate System

a. The steam supply to the CO_2 capture system will be condensed in the regenerator reboiler. The condensed steam will be collected into a tank and pumped back to MU3 by MHIA. Piping systems outside of the CO_2 capture island are within the OSBL scope.

b. Condensate will be returned to the steam cycle at the most efficient return location based on condensate return temperature. It is anticipated that condensate will be returned to the MU3 deaerator. Heat balances will be performed to determine the preferred condensate return location.

5.4.4 Cooling Water System

a. A new dedicated cooling system will be installed to supply the large amount of cooling required for the CO_2 capture system.

b. The CO_2 capture system will utilize once-through cooling with Lake Rodemacher as the cooling water source. A new once-through cooling pump intake structure will be located on the east side of the plant along Lake Rodemacher.

c. Cooling water will be returned to outfall at Lake Rodemacher at a distance away from the cooling water supply intake structures to allow the warmer cooling water return to mix with the lake water.

d. The cooling water supply and return headers will be hydraulically evaluated for hydraulic gradient and water hammer. These detailed evaluations will be performed during detailed design.

e. Large cooling water lines will be routed underground from the intake structure to/from the CO_2 capture island, where they will split to various users and come above ground.

f. Individual cooling lines may require throttling to achieve proper flow through the various heat exchangers. These valves will be provided by MHI.

g. Filtering of the cooling water supply will be required based on the water quality and plant experience.

5.4.5 Fire Protection System

a. The fire protection system shall include measures designed to fulfill the following objectives:

- 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

b. The fire protection and detection systems will be in accordance with NFPA and the Authority Having Jurisdiction (AHJ), as applicable. Material and components shall be UL listed or FM Approved for their intended use.

c. New areas will be protected by a fire protection underground yard piping system to include a main fire loop around the CO_2 capture island. New hydrants will be located based on approximately 300 ft diameter coverage zones.

d. A new set of fire pumps will be provided in the cooling water intake structure with water supply from Lake Rodemacher. The new pumps will be selected to achieve the required flow and pressure to the CO_2 capture system or to meet code requirements or requirements of the AHJ or insurer. During the FEED project stage it is recommended that the existing MU3 fire pumps could be evaluated to determine if they are able to provide the required flow and pressure to the Diamond Vault fire water system. If the existing pumps are adequate, extending the existing MU3 fire protection underground system may be reviewed as an alternative approach to new fire pumps.

d1. New pumps will meet the requirements of NFPA, including NFPA 850 and NFPA 20.

e. Fire protection systems are anticipated to be provided for the new areas as detailed below. This list will be evaluated as system design progresses.

e1. Control and electrical rooms will be provided with smoke detection systems and a double interlocked pre-action fire suppression system. Battery rooms will be provided with detection and protection per code requirements.

e2. Office areas will be provided with smoke detection systems. A wet-pipe sprinkler system shall be provided where required by the NFPA or local fire codes.

e3. General process equipment buildings will not include fire detection or suppression. Standpipes and hose stations will be provided as required based on the building height.

e4. Fire protection systems for process equipment such as compressor lube oil systems will be evaluated upon receipt of equipment design information. Deluge systems may be provided depending on oil quantity.

e5. Power Distribution Centers (PDC's) will be provided with smoke detection.

e6. Oil-filled transformers will be adequately separated as required by code. Deluge systems will only be provided if adequate separation is not available.

e7. Manual pull stations, fire alarm horns/strobes and fire alarm bells will be provided as required for all new buildings

e8. Each respective building or area fire protection system shall be integrated into a local fire alarm panel. The local fire alarm control panels shall be connected to a main fire alarm control panel located in the new CO_2 capture facility control room. The new fire alarm control panel shall be tied to the existing main fire alarm control panel located in the MU3 control room.

5.4.6 Compressed Air System

a. Plant (service) air and instrument air will be provided to the OSBL and ISBL areas from a new compressed air system consisting of air compressors, dryers, and receivers dedicated to the CO_2 capture system.

b. Air compressors and dryers will be 2x100% or 3x50%. Air will be provided at normal pressure of 120-135 psig and at a dew point of -40°F.

c. Instrument air demand will be sized at 125% of the facility's design requirements.

d. Instrument air receivers will be located in remote areas, if required, to ensure adequate pressure is available.

e. A common instrument and plant air piping distribution system to the ISBL system boundary will be used. Back-pressure regulators will be provided on the service air taps to automatically cut off the service air users when system pressure falls below an acceptable pressure for instrument air.

5.4.7 Make-up Demineralized Water System

a. Make-up water is required to the CO_2 capture system for services including wash water make-up, make-up to the solvent reclaimer system, initial fills, and other users as defined by MHIA.

b. The make-up water source will be provided from MU3 demineralized water system.

c. New demineralized water pumps (2x100%) will be provided to supply water from the MU3 Demin Water Storage Tank to the CO_2 capture system users.

5.4.8 Service Water System

a. A new service water pump (1x100%) located at the intake structure will be provided to supply the CO_2 capture area.

b. The service water system will supply water to the wash down utility stations located throughout the OSBL and ISBL buildings and areas as well as supply water to the intake water traveling screen wash system (pending vendor input), quench water to the steam drain tanks, supply water to the fire water maintenance pump, and motor bearing cooling water (pending vendor requirements).

5.4.9 Potable Water System

a. Potable water will be supplied from a new tap off an existing city water line.

b. All plumbing in new restroom facilities required for the project will be designed and installed in accordance with state and local code requirements.

c. Safety shower & eye wash (SSEW) stations per ANSI Z358.1 will be provided as required for chemical and other hazardous material areas.

d. Tepid water temperatures per ANSI Z358.1 will be provided. This can be accomplished using local heaters at each station or a common heater and recirculating loop, as well as installation of anti-scald valves at each SSEW. MHIA will be responsible for providing tepid water with the CO_2 capture island ISBL.

5.4.10 Plant Drains

a. Piping systems will be provided with low point drains. Equipment and low point drains will be drained back to sumps, trenches, floor drains or other approved destinations.

b. Plant and oily water drains will be collected and contained. Drains will be sent to a new oily water separator.

c. Equipment drains within the ISBL will be collected with funnel drains tied into an underground piping system. The underground piping will be connected to the MHIA provided sump tanks to allow for the drains to be reused in the process. There is no interface from amine drains with the OSBL scope.

5.5 Wastewater System

a. Waste streams from the ISBL equipment will be pumped to the CO_2 capture system battery limit where it will be combined with a wastewater stream from the strainer backwash.

b. This stream can be utilized as makeup elsewhere in the base plant, with appropriate treatment, or treated if required and discharged back to Lake Rodemacher.

5.6 Sanitary System

a. Facilities to support occupied spaces (i.e. control room, offices, kitchen/break room, toilets, showers, etc.) shall be provided per local requirements and guidelines.

b. Sanitary drains system shall be discharged as per Section 6.2.8.

5.7 Heating, Ventilation, and Air Conditioning (HVAC)

a. HVAC systems will maintain the indoor environmental conditions in terms of space temperature and humidity, air filtration, air quality, and enclosure pressurization in order to provide efficient equipment operation and comfortable working conditions for personnel.

b. General equipment enclosures, maintenance shops and warehouses will be heated, air conditioned and ventilated, as necessary. Heating will be by electric unit heaters. Ventilation will be by dual combination louver-dampers and induction fans.

c. New buildings including electrical / DCS equipment rooms, control rooms, offices, kitchen, lunchrooms, and locker rooms will be air conditioned and heated to maintain suitable operating temperatures.

d. The heating and cooling required for each space will be calculated in accordance with the methodology described in the ASHRAE Fundamentals Handbook chapter for Nonresidential Heating and Cooling Load Calculation Procedures and ASHRAE Standard 183. The design shall be based on the heating dry bulb temperature, 99.6% occurrence and cooling dry bulb temperature, 0.4% occurrence.

e. Indoor design conditions shall be as per the table below:

Building / Area	Min Temp	Max Temp	Min RH	Max RH
Office space, kitchen, lunchroom, locker rooms (Note 1)	68°F	78°F	20%	60%
Control room	68°F	78°F	20%	60%
Electrical equipment / IT rooms, VFD enclosures	65°F	85°F	20%	60%
Battery rooms (Note 2)	77°F ± 3°F		20%	60%
Miscellaneous Unoccupied Process Equipment Areas	40°F	104°F	---	---

Notes:

1. Dedicated ventilation fans will be provided as required for bathroom and kitchen areas
2. Two (2) by 100% ventilation fans dedicated to the battery room will be installed if required based on battery technology and will be powered from the emergency power system.

f. Critical electrical equipment areas and control rooms will be provided with N+1 redundant equipment, while unoccupied spaces will be provided with multiplicity redundancy, meaning multiple pieces of equipment will be provided to account for the required capacity. Occupied office areas, etc. will be provided with 1x100% capacity equipment.

6.0 CIVIL STRUCTURAL

6.1 Risk Category

The CO_2 capture plant and associated structures shall be designed per ASCE 7 for Risk category II. Existing structures, containment structures, or pipe supports containing potentially toxic materials shall have their toxicity and potential risk evaluated per IBC Table 307.1 and may be classified as higher risk categories per IBC Table 1604.5.

6.2 Civil Site Design Parameters

6.2.1 Rainfall

Rainfall depths shall be based on National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 6, Version 2 for Site Coordinates: Latitude: 31.3976N, Longitude: 92.7203W. The 10-year, 24-hour rainfall event is 9.72 inches; the 25-year, 24-hour rainfall event is 10.10 inches.

6.2.2 Stormwater Drainage System and Detention Basin Requirements

a. The stormwater drainage system for the new CO_2 capture system plant facilities will comply with Chapter 24 of the Rapides Parish Police Jury Code of Ordinances. Chapter 24 requires a grading permit application comprised of a detailed site plan and drainage calculations as applicable. A pre-application meeting is recommended to identify Rapides Parish design criteria and confirm the permit application process.

b. Temporary stormwater control measures during construction will follow the Louisiana Department of Environmental Quality’s construction general permit LAR100000. As part of a construction general permit, a storm water pollution prevention plan for construction activities will be developed to document required stormwater management practices and controls to be implemented, monitored, and maintained during the course of construction activities.

6.2.3 Storm Sewer Piping

a. The storm water drainage system will be designed to minimize the use of catch basins and underground piping to capture and divert storm water. Unless the Rapides Parish permitting requirements are more stringent, the stormwater system will be designed to manage stormwater runoff from a 10-year design storm event without ponding at inlets and manage the 50-year event without overtopping roads.

b. The storm water sewer system will collect uncontaminated storm water runoff from plant areas. Examples of such areas include building roofs, plant equipment areas without containment, roads, parking lots, and stone and grass surfaced areas. Catch basins and manholes will be provided to collect site runoff and discharge into an underground stormwater drainage system. The storm water sewer system will discharge to a detention pond, if required, or directly to Lake Rodemacher. Building roof drains will discharge directly onto paved surfaces or splash blocks.

c. Storm sewer pipe materials will generally be constructed of corrugated high-density polyethylene pipe, having a corrugated outer wall and a smooth inner wall and rated for gravity service. In areas where anticipated surcharge loads are high, reinforced concrete pipe will be used. Storm sewer manholes and catch basins will be precast reinforced concrete structures, designed for HS-20 traffic load. Manholes and catch basins will have a cast iron frame and removable solid or grated cover.

d. All areas not drained via storm sewers shall be drained via an open ditch system consisting of trapezoidal ditches with culverts at road crossings. Ditch side slopes shall not exceed 3H:1V. Ditches shall be sized to produce velocities not more than 4 feet per second for vegetative ditches or 10 feet per second for lined ditches.

e. Truck unloading and storage areas for chemical will be concrete paved and will be designed to contain a spill from a full truck or tank. Each such area will have a sump with a valved outlet draining to the storm drainage system. Truck unloading and storage areas for hydrocarbons will have a sump and valved outlet drainage to an oil water separator.

6.2.4 Groundwater

a. Groundwater depth is currently based on the geotechnical investigation performed by Aquaterra Engineering, LLC for Madison Unit 3, which estimated the groundwater level around ten feet below grade. As noted in Aquaterra's report, the groundwater level is temporal and will vary depending upon seasonal moisture conditions. Groundwater levels in the areas affected by the CO_2 capture facility installation will be assessed via an additional geotechnical investigation.

6.2.5 Foundation Frost Depth

a. The extreme depth of frost penetration shall be taken as 5 inches per AWWA D100-21. Foundations shall, at a minimum, extend below grade per the requirements of the IBC, Section 1809.4.

6.2.6 Access Roads and Parking

a. It is assumed that the existing plant roads are adequate for access to the CO_2 capture facility. New roads will be added for access within new OSBL and ISBL plant areas.

b. All new two-lane roads will have a minimum asphalt paved width of 20 feet (two 10-foot lanes) plus 3 foot wide shoulders for a total width of 26 feet. Single lane roads will be a minimum asphalt paved width of 12-feet wide with two 2-foot shoulders. The minimum radius of horizontal curves will be 50' minimum (centerline) unless restricted. A larger radius will be provided where required for stopping sight distance.

c. The maximum slope for plant roads shall be 6.0%. Vertical curves shall be provided for grade breaks of 0.5% or more on asphalt paved roads and 1.0% or more on rock surfaced roads. The minimum length of vertical curve for roads will be based on AASHTO requirements.

d. All roads will be designed for AASHTO HS 20-44 truck and auto loads. Plant roads subject to equipment removal and maintenance activities will also be designed for loading due to a 50-ton wheel mounted maintenance crane. Minimum pavement thickness will be based on design traffic volume and vehicle type. Minimum thickness will be increased as required because of poor subgrade soils or other local conditions as recommended in the geotechnical report. Design life of the pavement structure will be 15 years.

e. Parking shall conform to the tables below. If required by the Parish Building Official, handicap parking spaces shall be provided in lots in accordance with the requirements of the Americans with Disability Act (ADA) and local and state regulations.

Lot Location	Number of Cars	Surfacing Type	Painted Striping
To be determined based on GA	TBD	Asphalt	Yes
To be determined based on GA	TBD	Asphalt	Yes
Total Number of New Stalls	TBD	-	-

			Parking Stall and Lot Dimensions (feet)			
Surfacing Type	**Asphalt Thickness**	**Agg Base Thickness**	**Angle**	**Width**	**Length**	**Aisle Width**
Asphalt	4 inches (min)	6 inches (min)	90°	10	20	24

6.2.7 Oily Water Drain System

a. An oily water sewer system(s) shall be provided to collect discharges from plant areas with a potential for oil contamination, which may include building floor drains, equipment drains, oil cooled transformer containments, and oil storage secondary spill containment drains.

b. Underground gravity lines will be metallic (ductile iron or cast iron) if drainage systems may have elevated fluid temperatures. Cold drains as part of the gravity system may be PVC. Pressure pipe from the oil separator tank discharging treated effluent will be HDPE pressure rated pipe. Pipe for oil-contaminated discharges will not require double containment piping.

c. Oily water system manholes and catch basins, if applicable, will be precast reinforced concrete structures, designed for HS-20 traffic load. Manholes and catch basins will have a cast iron frame and removable solid or grated cover.

d. The underground oily water sewer system will be discharged to an oil water separator that will be designed to handle the anticipated peak discharge flow. The oil water separator will have the following features:

- Dual wall steel tank with interstitial leak detection
- Packaged coalescing plate elements providing 15 mg/l effluent quality.
- Effluent lift station (if necessary) to discharge the treated effluent to the plant wastewater sump.

e. Waste oil from the separator tank will be pumped to a truck for offsite disposal.

6.2.8 Sanitary Drainage and Disposal System

a. A gravity sanitary sewer system will be provided to collect sanitary waste from domestic waste sources and discharge the collected waste to the existing city sewer system. A lift station will be utilized if necessary for proper tie-in to the existing sewer system.

b. Gravity pipe will be sized to handle the maximum daily peak flow based on either the building fixture unit water demand, or an appropriate peaking factor based on daily personnel and daily usage. The daily per person usage is assumed to be 25 gallons per day.

c. Gravity pipe will be PVC, with a minimum pipe size of 4 inches in diameter and shall be no more than half full during peak flow. Force main piping from the lift station will be HDPE. Manholes and basins will have a cast iron frame and removable solid cover.

d. Piping will be sized and sloped to maintain a minimum self-cleansing velocity of 2.0 feet per second during peak flow conditions.

e. The sanitary lift station will be equipped with two 100% pumps rated for the daily peak flow while meeting the required total dynamic head of the system, and the wet well shall be sized to provide a minimum pump run time of 5 minutes.

6.2.9 Process Containment

a. Vessels containing amine solution, including the absorber and regenerator, will include concrete containment walls for spill prevention. The containment will be sized for the maximum liquid volume in the associated vessel. Containments may be provided with a closed isolation valve for the purpose of draining clean rainwater (after testing) to the stormwater system

6.2.10 Finish Plant Surfacing

Final area paving and surfacing will be provided in the following table.

Type	Thickness	Location
Reinforced Concrete	8 inches	Chemical truck loading and unloading spill containment areas 10 feet x door width in front of all roll-up maintenance doors Areas which require access to equipment by mobile cranes, forklifts, and other maintenance vehicles
Unreinforced Concrete	4 inches	5 feet wide sidewalks to building doors. 4 feet wide parking area sidewalks
1-1/2" dia. Crushed Rock Area Surfacing	12 inches	Equipment and building areas not otherwise paved All other areas subject to light traffic
Seeding on topsoil	4 inches	Storm water ditches Pond dikes Slopes, dikes, and other areas not otherwise surfaced Spoil disposal areas

6.2.11 Chain Like Security Fencing

a. Site perimeter fencing will not be provided for the CO_2 capture facility. Perimeter fencing around the substation transformer will be 6-feet tall chain link fence and gates. Vehicle gates, if required, will be manually operated, dual leaf swing gates. The fence ground shall be tied into the ground grid or locally installed ground rods. NEC and NESC require “Metallic fences enclosing, and other metal structures in or surrounding, a substation with exposed electrical conductors and equipment shall be grounded and bonded to limit step, touch, and transfer voltages.”

6.3 Structure Design Loads

6.3.1 Wind Loads

Wind load criteria is per ASCE 7-16.

Design Wind Speed, V (mph) -Risk Category II -Risk Category III	 109 mph 115 mph
Exposure Category	C
Topographic Factor, K_{zt}	1.0
Directionality Factor, K_d -Buildings & Equipment -Tanks, Round Structures	 0.85 1.0
Ground Elevation Factor, K_e	1.0

6.3.2 Snow Loads

Snow load criteria is per ASCE 7-16 Chapter 7.

Snow Importance Factor, I_s -Risk Category II -Risk Category III	 1.0 1.10
Ground snow load, p_g	5 lb/ft^2

6.3.3 Ice Loads

Ice load criteria is per ASCE 7-16 Chapter 10. Atmospheric ice loads caused by freezing rain, snow and in-cloud icing shall be considered in the design of ice-sensitive structures. The ice load shall be determined using the weight of glaze ice formed on all exposed surfaces of structural members, components, appurtenances, etc. Ice accreted on these items increases the projected area of the structure exposed to wind. The projected area shall be increased by adding the design ice thickness, t_d, as determined per ASCE 7 Section 10.4.6, to all free edges of the projected area. Ice loads shall be combined with other loads per the load combinations in ASCE 7 Section 2.3.3.

Ice Importance Factor, I_i -Risk Category II -Risk Category III	 1.0 1.15
Nominal ice thickness on a cylinder at 33 ft, t	1 in

6.3.4 Seismic Load

Seismic criteria is per ASCE 7-16. Until a geotechnical investigation of the CO_2 capture facility area is performed, and a geotechnical report is received, the site class will be taken as the default site class of D per ASCE 7-16 Section 20.1. The site class and subsequent seismic design values will be updated as required once a site-specific geotechnical report is obtained.

Seismic Importance Factor, I_e -Risk Category II -Risk Category III	 1.0 1.25
Site Class Definition	D (default)
Spectral Response Acceleration, S_S	0.095g
Spectral Response Acceleration, S_1	0.062g
Short-Period Response Seismic Design Acceleration, S_{DS}	0.101g
One-Second Period Response Seismic Design Acceleration, S_{D1}	0.100g
Site Coefficient for Peak Ground Acceleration (PGA)	0.046g
F_a	1.6
F_v	2.4
F_{PGA}	1.6
Seismic Design Category	B

6.4 Foundations & Geotechnical Data

6.4.1 Soil Data

Soil data is from the Terracon Geotechnical Investigation draft report dated as December 1, 2023.

Modulus of Subgrade Reaction (K) on Soil	TBD
Soil Unit Weight (in situ and compacted fill), saturated	120 pcf
Active Soil Pressure, K_a	0.33
Passive Soil Pressure, K_p	3.0
At Rest Soil Pressure, K_o	0.5
Coefficient of Sliding Friction (Mass Concrete on Clayey Sand)	0.35
Overturning Factor or Safety	1.5
Sliding Factor of Safety	1.5

6.5 Structural Steel

6.5.1 Material

New Rolled W and WT Shapes	ASTM A992 Gr 50
New Channels and S Shapes	ASTM A36
New Angles	ASTM A529 Gr 50
New Plates	ASTM A572 Gr 50
New Pipes	ASTM A53 Gr B
New HSS	ASTM A500 Gr C
Existing Steel - As Indicated on Record Drawings	-
Coating	Galvanized

6.5.2 Connections

Bolted Connections	ASTM F3125 Gr A325
Welding Electrode	E70XX
Weld procedures	AWS D1.1
Cast-in-Place Anchor Rods to Concrete	ASTM F1554
Post-Installed Adhesive Anchors	ASTM F1554
Anchor Rod Nuts	ASTM A563 Gr A Heavy Hex
Anchor Rod Washers	ASTM F436
Coating for Anchor Rods	Galvanized
Adhesive for Post-Installed Anchors	Hilti HIT-HY 200 or HIT-RE 500 V3
Mechanical Post-installed Anchors	Hilti Kwik Bolt 3 or TZ2
Shims	Stainless Steel or Galvanized Carbon Steel

6.5.3 Grating

Grating shall be manufactured in accordance with Metal Bar Grating Manual MBG 531-17.

Welded Steel Bar Grating	19-W-4, 3/16” bearing bars
Finish	Galvanized
Surface	Serrated
Nominal Depth	1-1/4”
Maximum Deflection (Dead + Live)	¼”

6.5.4 Platforming / Stairs

Platforms will be provided at all equipment requiring routine maintenance, including roof or floor mount HVAC equipment, control valve stations, etc.

Walkway Width (minimum)	2'-6"
Stair Landing Depth (minimum)	2'-6"
Stair Width (minimum)	3'-0"
Headroom Clearance (minimum)	7'-0”
Handrail, Toe Plate, Ladder, Fall-Arrest System, Gate, etc.	Per OSHA 29 CFR 1910.23

6.6 Buildings

6.6.1 Scope

a. New permanent buildings will be installed to house OSBL mechanical and electrical equipment and for storage of spare parts as required. New buildings include the Administration Building/Control Room, BOP Electrical/Mechanical Building, and Warehouse.

b. Temporary structures including construction offices, warehouses, or shops are not covered by these design criteria.

7.0 ELECTRICAL

7.1 General

a. The existing 230 kV substation switchyard will be modified to provide the expected 112 MW for the CO_2 capture system facility.

b. The existing Brame Energy Center switchyard will provide feeds from the existing East and West bus. Switchyard modifications will consist of one (1) new 230kV gas circuit breaker with two (2) manually operated disconnect switches located between disconnect 9056 and breaker 9292. A new dead-end structure will be installed with coupling capacitor voltage transformers (CCVT's), relaying and metering, and the switchyard will be expanded to the north. A new motor operated disconnect switch will be installed in between the CCVT's and the new dead-end structure at the existing switchyard.

c. Site expansion of the switchyard and transmission line routing for the project and includes the following equipment:

- 230 kV gas circuit breaker with manually operated disconnect switches
- 230 kV motor operated disconnect switch
- Dead-end structures and switchyard modifications
- 230 kV overhead line
- Direct embed steel tangent poles
- Steel dead end poles
- One (1) new 230kV/13.8/13.8 kV substation transformer (at CO_2 capture island)

d. The new 230kV gas circuit breaker will source the new CO_2 facility via an overhead line exiting the east side of the switchyard, then turning to the north following the tree line, then turning to the west to the new CO_2 capture island switchyard dead-end structure.

e. A manually operated disconnect switch will be installed in between the dead-end structure and the high side of the substation transformer. One (1) new 230/13.8/13.8 kV transformer would be configured as 1x100%. The proposed rating of the transformer is 112.5/150MVA.

f. Sourcing from the 230/13.8/13.8 kV transformer secondary winding to the CO_2 capture island auxiliary power distribution system will be underground cables via duct banks. Separate secondary windings will be used to the ISBL (MHIA) and OSBL (BOP) loads and associated transformers. The medium voltage and low voltage auxiliary power systems for ISBL and OSBL are single train (non-redundant).

g. A BOP electrical equipment building will be located at the CO_2 facility, which would include 13.8kV switchgear, 13.8kV-480V transformer, 480V switchgear, 480V

MCC's, DCS cabinets, variable frequency drives, UPS system, 125VDC battery system and other electrical equipment to support the CO_2 equipment.

h. This project will also include a new Warehouse Building and Administration Building. The Warehouse building and Administration Building will have 480V distribution panelboards which will be fed from the BOP electrical building 480V switchgear via duct bank. The Administration Building will also include the new CO_2 capture system control room.

i. A separate PDC is provided by MHIA for the CO_2 capture island loads and control. Of the expected 112 total MW for the project, 98 MW are expected for the CO_2 capture island provided by MHIA, and 14 MW are expected for BOP loads.

j. Redundancy from the existing switchyard is provided from each of the East and West 230 kV buses. There is no diesel generator backup. Vital instruments shall be on UPS.

k. Arc flash energy: All new construction shall be at or under an 8 cal/cm^2 level as much as reasonably possible, but never exceeding 40 cal/cm^2 for any switchgear.

l. These design criteria apply to the BOP electrical equipment and systems.

7.2 Electrical Equipment

7.2.1 Main Auxiliary Power Transformer

a. The transformer will be used for step-down service to connect the switchyard 230 kV buses to the CO_2 capture system medium voltage auxiliary power system.

b. The transformer will be three -phase, three winding, 60 Hz, outdoor, step down, oil-immersed type (ONAN/ONAF).

c. The transformer will have the following ratings:
230/13.8/13.8kV
H: 112.5/150MVA
X: 72/96MVA (For ISBL MHIA)
Y: 40.5/54MVA (For ISBL MHIA and BOP)

d. The high side of the transformer will use high voltage overhead conductors to connect to the 230kV transmission lines at the dead-end structure.

e. Underground cables via duct banks will be used on the secondary side of the transformer to connect the transformer to the MHIA and BOP 13.8kV loads.

f. Allowances will be included for modification and additions for relay and metering.

7.2.2 Medium Voltage Switchgear (13.8 kV)

a. The medium voltage switchgear will supply auxiliary power to loads greater than 250HP.

b. Switchgear will be designed as defined in ANSI C37.20.2, and derating factors for unusual service conditions (i.e., altitude) will apply in accordance with this standard.

c. Indoor, Type 2B, arc-resistant, NEMA 1 gasketed, metal-clad switchgear and assemblies will conform to the requirements of IEEE C37.20.2, IEEE C37.20.7, NEMA ICS 3, NEMA SG4 and SG5. Circuit breakers will have ratings per ANSI C37.06 and conform to ANSI C37.04 rating structure. Protective relays will conform to ANSI C37.90 and indicating instruments to ANSI 39.1.

d. Medium voltage switchgear will comprise of one or more arc-resistant vertical sections mounted side by side and connected mechanically and electrically together to form a rigid, self-supporting structure. Each vertical section will consist of separate compartments where all live parts are completely enclosed within grounded metal barriers. In addition, opening of the door of the control compartment will not defeat the arc resistant feature of the switchgear. The arc event will not enter the switchgear control compartment. The arc event will be exhausted through a plenum to a designated protected outdoor area.

e. The switchgear will consist of electrically operated, draw out vacuum type circuit breakers installed two high, with necessary buses, and associated equipment as specified, installed and connected in the factory, in a self-supporting arc-resistant steel enclosure.

7.2.3 Low Voltage Switchgear (480V)

a. The low voltage switchgear will supply auxiliary power to loads greater than 200HP and up to and including 250HP. Considering the low number of loads expected in the 251-4999 HP range, the project may power motors in this range from the 480V switchgear to eliminate the need for a 4.16 kV switchgear and a 4.16 kV-480V transformer.

b. Switchgear assemblies will be supplied in accordance with the requirements of ANSI/IEEE Standard C37.20.1 and C37.20.7 for arc-resistant type.

c. Each low voltage switchgear will consist of one or more vertical sections bolted together to form a rigid, free standing, ventilated, indoor, Type 2B, arc-resistant, NEMA 1 gasketed enclosure assembly. Enclosure will meet all the requirements of ANSI C37.20.1. The arc event will be exhausted through a plenum to a designated protected outdoor area.

d. The circuit breaker interrupting device will be of the air magnetic type. Circuit breakers will be draw-out, three-pole, 60 Hz, 600 V class and will be rated on a symmetrical basis in accordance with ANSI/IEEE Standard C37.13. They will be electrically operated. The switchgear lineup will be configured in a “single-ended” configuration where redundancy is not required.

7.2.4 Motor Control Centers (480V MCC)

a. The low voltage MCC will supply auxiliary power to loads greater than 1/2HP and up to and including 200HP.

b. Motor Control Centers suitable for indoor service in power generating and distribution facilities will be provided. Each low voltage motor control center will consist of one or more vertical sections, nominally 20” wide, 15” deep, and 90” high bolted together to form a rigid, free standing assembly. Enclosure type will be NEMA 12 suitable for installation indoors. MCC will be front access only.

c. Circuit breakers will be 600 V, 60Hz, and three-pole. Circuit breakers will be molded case, draw-out, thermal magnetic type. Exceptions are circuit breakers to Resistance Welding and heater circuits; they will be 600 V, 60Hz, three-pole with instantaneous magnetic-only trip units.

d. Motor starters for 480 V service will include 480 V circuit breakers, 480 V, 3-phase, 60Hz contactors with manual reset electronic overload relays, 120 V ac or 460 V ac operating coils and control power transformers. Motor starters will not be smaller than NEMA Size 1.

e. Circuit breakers will be 600V, 60Hz, three-pole with instantaneous magnetic only trip units.

f. Control transformers will be rated at a minimum of 100VA.

g. MCC feeders will be manually operated thermal magnetic circuit breakers.

h. Power for motor starters, contactors, feeders, etc. will be supplied from two separate MCCs inside the BOP Electrical/Mechanical Building, arranged so that all equipment will be distributed evenly. Three additional MCCs will be fed from the existing plant PDC/Switchgear buildings.

i. Contactors for heaters, etc. will not be smaller than NEMA Size 1.

j. Minimum bucket size will be minimum 12 inches.

k. All feeder circuit and motor starter buckets will be capable of being Locked Out/Tagged Out.

7.2.5 Motors

a. Motors ½ HP and less will be rated 120V, 1-phase, 60Hz. Motors more than ½ HP and up to and including 250 HP will be rated 460V, 3-phase, 60Hz.

b. Motors greater than 250 HP and up to and including 4999 HP will be rated 4000V, 3-phase, 60 Hz. Given the quantity of BOP loads in this size range deviations to this may be allowed and motors up to 400 HP rated to 460V, 3-phase, 60Hz.

c. Motors 5000 HP and above will be rated 13200V, 3-phase, 60 Hz.

d. 4000V and 13200V motors will have a 1.0 service factor.

e. 120V and 460V motors will have a 1.15 service factor.

f. Motors 25 HP and larger will be provided with 240V rated space heaters operated from a 120V power source.

g. 4000V and 13200V motors will be provided with single element 100Ω platinum resistance temperature detectors (RTDs), one (1) per bearing and six (6) winding RTDs.

h. Motor terminal enclosures and auxiliary enclosures will be rated NEMA 4X unless located in hazardous areas in which case the hazardous rating will govern.

i. Motor protection shall be provided using SEL hardware.

7.2.6 Low Voltage Variable Frequency Drives (VFD)

a. The VFD continuous output rating will meet the motor and driver load combination requirements.

b. The VFD base rating will be capable of operating the motor at its service factor.

c. The VFD will be capable of producing a variable AC voltage/frequency output to provide continuous operation over the normal system 0-100% speed range. The VFD will be capable of sustaining operation at 0% speed to facilitate checkout and maintenance of the driven equipment. When V/Hz control is utilized, the V/Hz ratio will be constant over the operating speed range.

d. The overload rating of the drive will be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating will meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.

e. The VFD output will allow the motor to produce full rated torque at any speed in the operating range.

f. VFD's will comply with the latest edition of IEEE 519 for total harmonic voltage and current distortion calculation and measurement.

g. VFD will be capable of maintaining a 0.98 minimum true power factor, adjustable between 0.90 lagging to 0.90 leading, from 10% to 100% speed.

h. Allen Bradley VFD's are preferred. Yaskawa drives may be considered based on lead time and cost.

7.3 Cable Bus, Cables, and Cable Tray

7.3.1 Cable Bus

a. The cable bus will be used to connect the primary side of the 13.8 kV-480V transformer to the 13.8 kV switchgear.

b. The cable bus will be suitable for indoor and outdoor installation.

c. Conductors will be rated 105ºC, fully insulated and shielded power cables. Conductor ampacities will be based on full-load application, with consideration given to site conditions and the effects of solar radiation. The temperature rise of the conductor carrying continuous current will not exceed 50C rise over 40ºC ambient. Conductors will be suitable for indoor or outdoor use.

d. Individual conductors will be supported on cable support blocks. The blocks will be molded glass reinforced polyester (fiberglass) or approved equal. Block sections will be bolted together with stainless steel, non-magnetic bolts and held firmly in place to prevent movement during short circuit. Properties of the support blocks will be flame-retardant, track-resistant, and non-hygroscopic.

e. The bus enclosure will be made of extruded aluminum with top removable covers.

7.3.2 Medium Voltage Power Cables

a. 5 kV medium voltage rated power cables for the 4.16kV system (if required), will be copper and shielded with copper tape for all applications

b. 15 kV medium voltage rated power cables for the 13.8kV system, will be copper and shielded with copper tape for all applications

c. All three (3) conductor medium voltage power cables will include an integral ground conductor(s).

d. Single conductor medium voltage power cable circuits will include an insulated ground conductor. Single conductor cable can be triplexed or placed in triad configuration.

e. Insulation will be EPR, 133% rated for 105ºC conductor temperature. Jackets will be thermoset CPE.

f. Minimum conductor size will be #4/0 AW for all medium voltage cables.

g. Maximum conductor size will be 750KCMIL for all medium voltage cables.

7.3.3 Low Voltage Power Cables

a. 600V low voltage power cable will have thermosetting cross-linked polyethylene (XLPE) insulation rated for 90°C and the conductors will be copper.

b. Low smoke zero halogen (LSZH) jackets will be provided for single conductor and multi conductor cables.

c. All three (3) conductor low voltage power cables will include an integral ground conductor.

d. In low voltage variable frequency drive (VFD) applications, VFD rated cable will be used. The voltage rating will be 2000 volts and the cable will be provided with 3 symmetrical ground conductors and an overall shield.

e. The minimum conductor size will be #12 AWG.

7.3.4 Control Cable

a. 600V control cable will have thermosetting XLPE insulation rated for 90°C and the conductors will be copper.

b. Jackets will be LSZH.

c. The minimum size of control cables will be #14 AWG. Control cable will utilize E-2 (formerly K-2) color coding.

7.3.5 Instrumentation and Thermocouple Cable

a. 600V instrumentation cable and 300V thermocouple cable jackets will be LSZH.

b. The insulation will be thermosetting XLPE with copper conductors for instrumentation cable, chromel-constantan (Type E) or chromel-alumel (Type K) for thermocouple cables, with individual pair/triads shielded, and a tinned #18 AWG copper drain wire, with a minimum twist frequency of 1-1/2 to 2 inches.

c. The minimum conductor size will be #16 AWG.

7.3.6 Fiber Optic Cable

a. Multiple-fiber cable will be used in telecommunication systems, SCADA systems, and Distributed Control Systems. 48-fiber cables will be used for home runs.

7.3.7 Cable Tray and Conduit

a. Medium voltage power cables, low voltage power cables, control cables, and low-level signal instrument cables will be installed in separate raceways.

b. Cables of like levels may be run together in conduits or trays and unlike levels will be run in separate conduits or trays. Power cable will be limited to one (1) cable per conduit.

c. Intermixing of circuit levels is not allowed in the same raceway, except in cable tray with appropriate barriers installed to provide separation.

d. Redundant circuits that are critical, such as DCS fiber communications, will be routed in separate raceways.

e. All cable trays will be heavy duty type with a minimum load rating of NEMA 20C. Minimum cable tray width will be 12”.

f. Cable trays will generally be provided where ten or more circuits of the same separation class are routed in the same direction above ground.

g. Power, control, and instrumentation cable trays will be aluminum, ladder type, 6 inches deep unless otherwise noted with topmost tray provided with covers.

h. Tray supports will have a maximum spacing of 10 feet depending upon the layout.

i. Conduits will be used for areas where a tray system is not feasible or economically justifiable.

j. Conduits will also be used for routing cables from the tray system or embedded conduit to the terminal equipment.

k. Conduits will be rigid galvanized steel, and will generally be limited to 3/4, 1, 1-1/2, 2, 3 and 4-inch diameters. There will be at least 20% spare conduits in underground ducts.

l. Intermediate conduit (IMC) and electrical metallic tubing will not be used.

7.4 Electrical Systems

7.4.1 DC System and Inverter (UPS)

a. The DC and UPS system will provide uninterruptible power to critical components under emergency loss of AC power conditions.

b. The battery rating will be sized such that power will be maintained for a minimum of 8 hours, in the event of loss of AC power.

c. The battery chargers will be sized to provide the normal operating power for the 125VDC loads as well as recharge the battery system in 12 hours.

d. The UPS panel will normally be fed from the bypass transformer. During loss of AC power, the inverter will feed the UPS panel.

e. A manual bypass switch will be provided to bypass the inverter for maintenance.

f. The DC power system is expected to supply the following loads:

- Distributed Control System (DCS)
- Emergency lighting in control room
- Fire detection / protection system
- MV and LV switchgear control power
- Protective relay panel
- UPS

7.4.2 Lighting

a. Lighting will be provided for all new equipment, roadways, buildings, and areas associated with the CO_2 capture facility.

b. For normal operation, the lighting systems provide illumination in all interior and exterior areas

c. During emergency or abnormal conditions, minimum lighting will be provided for personnel safety and emergency egress.

d. The 277V lighting system will be served by 480/277V lighting transformers fed from the 480V auxiliary system.

e. All outdoor lighting will be corrosion-resistant. Outdoor and indoor high-bay lighting will utilize 277V fixtures.

f. The emergency lighting will be from self-contained wall mounted lighting fixtures with battery backup units.

g. The normal AC lighting will be powered from dedicated lighting transformers and panels generally located in the vicinity of the lighting loads.

h. 480-120/208 VAC panels will supply power to the 120V convenience receptacle circuits.

i. Convenience receptacles rated 20A, 125 VAC will be limited to five per circuit. Duplex receptacles will be located such that 75 foot extension cords will reach.

j. All distribution panel breakers will be capable of being Locked Out/Tagged Out.

k. All new lighting fixtures will be of LED type.

7.4.3 Grounding

a. The existing power plant grounding system will be extended to include an inter-connection of buried bare copper conductors and ground rods to from a new ground grid for the CO_2 capture system.

b. All new structures and equipment will be connected to the ground grid.

c. The grounding ring around equipment foundations will be approximately 3 feet from the foundation edge.

d. The new areas of grounding will be connected to the existing grounding system at multiple points.

e. The conductors for the power block grounding loops and interconnections will be a minimum of #4/0 AWG bare stranded copper cables.

f. Ground rods will be copper weld ¾” x 10 feet long.

g. The horizontal ground conductors will be laid 30 inches below grade level.

h. Foundation rebar will be connected to the underground conductors (Ufer ground) to improve the overall grounding system.

i. Above ground connections will be mechanical (compression) type connections.

j. Below ground connections will be exothermic welds.

7.4.4 Lightning Protection

a. Lightning protection will be provided for structures that are not adequately shielded from direct lightning strikes by other structures.

b. Lightning protection generally will not be required for metallic structures that are not likely to be damaged by a lightning stroke, provided the structure is electrically continuous and capable of conducting lightning currents without damage.

c. Lightning protection systems will be designed per NFPA-780.

d. Lightning protection systems will be UL 96A certified.

8.0 INSTRUMENTATION & CONTROLS

8.1 General

a. The BOP systems will be controlled through a DCS system.

b. A new Control Room will be designed and integrated with the new BOP Administration and Control Building. This new Control Room will house the operator workstations and consoles for all the new CO_2 capture systems. A separate DCS room in the Building will house the networking, controllers, engineering workstations, and IO cabinets for services at/near the BOP Administration and Control Building.

c. CO_2 Capture Island control system will be provided by MHIA.

d. Additional remote IO locations will be designed and implemented to save costs on cabling. Remote IO locations will be optimized at the CO_2 Capture Island, BOP locations, and at the existing plant tie-in locations.

e. I&C equipment and instrumentation will be designed for redundancy for safety systems to actuate without single failure.

f. Programmable Logic Controllers (PLCs) will only be used for packaged equipment (such as an air compressor) with the prior approval from the Owner. Allen-Bradley PLCs shall be used where possible.

8.2 Control Systems and Equipment

8.2.1 Distributed Control System (DCS)

a. The DCS control system will perform the functions of modulating and discrete control, equipment protection and process interlocking, component diagnostic, unit/process upset analysis and maintenance guidance, and data archiving of the entire system to meet all operational conditions, assuring a safe, environmentally compliant and economic operation of the unit. The DCS extended and remote I/O cabinets will be supplied with redundant power supplies, redundant communication, and redundant fiber optic communication to the existing redundant processors.

b. The fundamental functions such as control, alarm, monitoring, interlock, and protection will be fully integrated within the DCS. DCS graphic development will be in accordance with the existing plant’s requirements.

c. The control system will be designed so that no single fault will cause the complete failure of any system or cause the process to result in mis-action or anti-action. Process variable point redundancy will be provided for all parameters that require safety functions to activate. Redundancy in the control system will be provided so that no single fault within a control system can cause failure of the controlled equipment or cause the standby equipment to be unavailable. In case of a failure of in-service equipment, the standby equipment will start automatically without any system interference.

d. The DCS hardware and software (logic and graphics) design will be consistent with the existing generating station DCS. ABB and Emerson are preferred DCS vendors. CLECO shall be advised prior to selection of control system used.

e. Revisions to the plant DCS and the addition of the CO_2 Capture System DCS will be designed and implemented following all applicable station NERC CIP compliance requirements (applicability for CO_2 capture system to be verified).

f. Signals from redundant components will be partitioned to separate DCS Input/Output modules to improve reliability.

g. The DCS will allow data links to packaged control system PLCs (i.e. air compressors) for indication and monitoring. Open Platform Communications (OPC) is the preferred datalink protocol.

h. The CO_2 Capture DCS will be linked with the existing plant DCS for integrated control with the tie-ins (flue gas, steam, power). Integration shall also be provided between the current GE Mark VIe turbine controls and the CO_2 Capture DCS as required.

i. A minimum 20% spare hardware shall be provided.

8.2.2 Control Room Equipment

a. Console layouts will be reviewed with the operating group(s).

b. Operator workstations will be provided with dual screens (4 estimated).

c. A separate large alarm screen will be provided.

d. The DCS historian may have a separate workstation.

e. Printers.

f. CO_2 capture facility fire alarm panel will be wall-mounted in eye sight of the operators and linked to the overall plant system.

g. Central IO, engineering workstation(s), and networking cabinets will be located in a separate DCS room near the control room.

8.2.3 Vibration Monitoring

a. Vibration for rotating equipment at or above 1000 HP shall be integrated with new Bently Nevada Vibration Monitoring System (VMS). Tie to existing plant shall be modified to include new rotating equipment.

8.3 Instruments

8.3.1 General

a. The use of process transmitters is preferred over switches.

b. The general control alarm wiring philosophy will be such that field alarm devices utilize normally open contacts during normal operating condition (close to alarm and trip). Normally Closed (N/C) contacts for fail safe operation may be used in some cases so that a broken wire, etc. will indicate a non-normal condition.

c. Power feeds to control devices will be monitored. Loss of power will result in an alarm condition. Bad quality alarms shall be provided in addition to loss of power alarms.

d. The manufacturers and models of the instruments and instrument accessories to be used will be subject to approval by the Owner. Rosemount 3051 transmitters shall be used for pressure and DP.

e. All instrument and control devices will be suitable for service in outdoors area (NEMA 4 or 4X minimum). Indoor equipment may be rated NEMA 12 (similar to MCCs).

f. Local indications will be provided on all remotely operated valves/dampers, analog transmitters, and auxiliary system local control panels.

g. Local audible alarms will be provided for remote independent systems when warranted for system and personnel safety or system troubleshooting (i.e., gas detection systems).

h. Instrument enclosures will be provided where required for instruments mounted outdoors, instrument pedestals will be provided for instruments mounted indoors. O'Brien enclosures are preferred.

i. All pressure instrumentation will be capable of withstanding the greater of their body rating conditions or 1.5 times the process design pressure without permanent damage or loss of calibration.

j. In general, air or flue gas duct pressure connections will be 2-inch pipe. Any connection to duct work will be capable of serving as a test tap location and be provided with the ability for rod out without removal of any instrument lines. Purge air connections with rotameters shall be included.

k. Differential pressure transmitters will be used to measure level in atmospheric tanks. Guided wave radar level transmitters will be used in low pressure and vacuum applications. Magnetrol is the preferred guided wave radar vendor.

l. Seals with capillaries will be used for instrument with fluid that is hazardous or high energy. Seals and capillaries may also be used on large vessels.

m. Orifice plates will be used, in general, for flow measurements. Conditioning orifice plates may be used when straight runs of piping are limited.

n. Averaging pitot-type flow elements may be used for measurement of flow in 10" pipes and larger.

o. Temperature measurements for control and monitoring inputs will be made with RTDs or Type E or K thermocouples. RTDs should be 3-wire 100 ohm platinum. Temperature transmitters providing a 4-20 mA signal will generally not be used. When used, they are mounted in the head to avoid external cabling.

p. Process switches will be avoided in favor of transmitters wherever possible with control logic to replace functionality of the process switch.

q. If used, pressure and temperature switches will be of the snap action type and will have a minimum of two SPDT contacts or one DPDT contact. SOR, Inc. is the preferred switch supplier.

r. All switches, unless otherwise specified, will be rated 10 amperes @ 120 VAC or 0.5 amperes conductive @ 125 VDC, continuously.

s. Primary process and pneumatic tubing will be in accordance with ANSI B31.1. Tubing will be ½" O.D., minimum, 316 stainless steel with 0.049" wall thickness. Compression fittings will be stainless steel. High pressure applications will use ½" O.D., minimum, 316 stainless steel with 0.065" wall thickness.

t. Sensing lines shall be heat traced for critical instrumentation.

u. Solenoids will have a 120 VAC, 125 VDC, or 24 VDC encapsulated coil with Class H insulation and rated for continuous duty. ASCO is the preferred solenoid supplier.

9.0 CODES AND STANDARDS

Codes listed below are the primary codes used on the project but not intended to be all inclusive. Latest editions as of project initiation will be used.

AASHTO – American Association of State Highway and Transportation Officials

ACI – American Concrete Institute

- ACI 543R – 12 – Guide to Design, Manufacture and Installation of Concrete Piles
- ACI 318-19 – Building Code Requirements for Structural Concrete and Commentary

AGMA - American Gear Manufacturer Association

AISC – American Institute of Steel Construction

- AISC – Manual of Steel Construction
- AISC 341-16 – Seismic Provisions for Structural Steel Buildings
- AISC 360-16 – Specification for Structural Steel Buildings

AMCA - Air Movement and Controls Association

ANSI – American National Standards Institute

- A 14.3 American National Standard for Ladders – Fixed – Safety Requirements
- MBG 531-17 - Metal Bar Grating Manual
- Z358.1 Standard for Emergency Eyewash and Shower Equipment

API – American Petroleum Institute

- API STD 520 - Sizing, Selection, and Installation of Pressure-relieving Devices
- API STD 541 - Form-wound Squirrel Cage Induction Motors—375 kW (500 Horsepower) and Larger
- API STD 546 - Brushless Synchronous Machines - 500 kVA and Larger
- API STD 610 - Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
- API STD 650 – Welded Steel Tanks for Oil Storage
- API STD 660 – Shell and Tube Heat Exchangers
- API STD 662 Part 1 – Plate and Frame Heat Exchangers

ASCE – American Society of Civil Engineers

- ASCE 7-16 – Minimum Design Loads for Buildings and Other Structures
- ASCE 20-96 – Standard Guidelines for the Design and Installation of Pile Foundations

ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.

ASME – American Society of Mechanical Engineers

- ASME B31.1 – Power Piping Code
- ASME Section VIII – Boiler and Pressure Vessel Code
- ASME PTC (applicable standards)

ASTM – ASTM International

AWWA – American Water Works Association

AWS – American Welding Society

- AWS A2.4 – Standard Symbols for Welding, Brazing and Nondestructive Examination
- AWS A3.0 – Welding Terms and Definitions
- AWS A5.1 to A5.31 – Specification for Welding Electrodes
- AWS A6.1 – Recommended Safe Practice for Gas-Shielded Arc-Welding
- AWS D1.1 – Structural Welding Code – Steel
- AWS D1.3 – Structural Welding Code – Sheet Steel
- AWS D1.6 – Structural Welding Code – Stainless Steel

CFR – Code of Federal Regulations

CGA – Compressed Gas Association

CRSI – Concrete Reinforcing Steel Institute, Manual of Standard Practice

CTI – Cooling Technology Institute

EJMA – Expansion Joint Manufacturers Association

FM Global – Factory Mutual

- Loss Prevention Data Sheets

HEI – Heat Exchanger Institute

HI – Hydraulic Institute

HMI – Hoist Manufacturers Institute

IBC 2021 – International Building Code

ICEA – Insulated Cable Engineers Association

IEC – International Electrotechnical Commission

IEEE – Institute of Electrical and Electronics Engineers

IES – Illuminating Engineering Society

IMC – International Mechanical Code - 2021[1]

IPC – International Plumbing Code - 2021[1]

ISA – International Society of Automation

ISO – International Standards Organization

LaDOTD – Louisiana Department of Transportation and Development

LSBC – Louisiana State Building Code - 2021

MBMA – Metal Building Manufacturer's Association, Metal Building Systems Manual

MSS – Manufacturers Standardization Society

NACE – North America Corrosion Engineers International

NEC – National Electrical Code (NFPA 70)

NEMA – National Electrical Manufacturers Association

NERC – North American Electric Reliability Corporation

- CIP – Critical Infrastructure Protection Standards

NESC – National Electrical Safety Code

NFPA – National Fire Protection Association

- NFPA 1 – Fire Code - 2015[1]
- NFPA 70 – National Electrical Code[1]
- NFPA 70E – Standard for Electrical Safety in the Workplace
- NFPA 72 – National Fire Alarm and Signaling Code
- NFPA 85 – Boiler and Combustion Systems Hazards Code
- NFPA 101 – Life Safety Code - 2015[1]
- NFPA 850 – Recommended Practice of Fire Protection for Electric Generating Plants

OSHA – Occupational Safety & Health Administration 29 CFR Part 1910

PFI – Pipe Fabrication Institute

RCSC 2009 – Research Council on Structural Connections – Specification for Structural Joints Using High-Strength Bolts, Endorsed by the American Institute of Steel Construction, Inc.

TEMA – Tubular Exchanger Manufacturer Association

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[1] With amendments, as adopted by the State of Louisiana

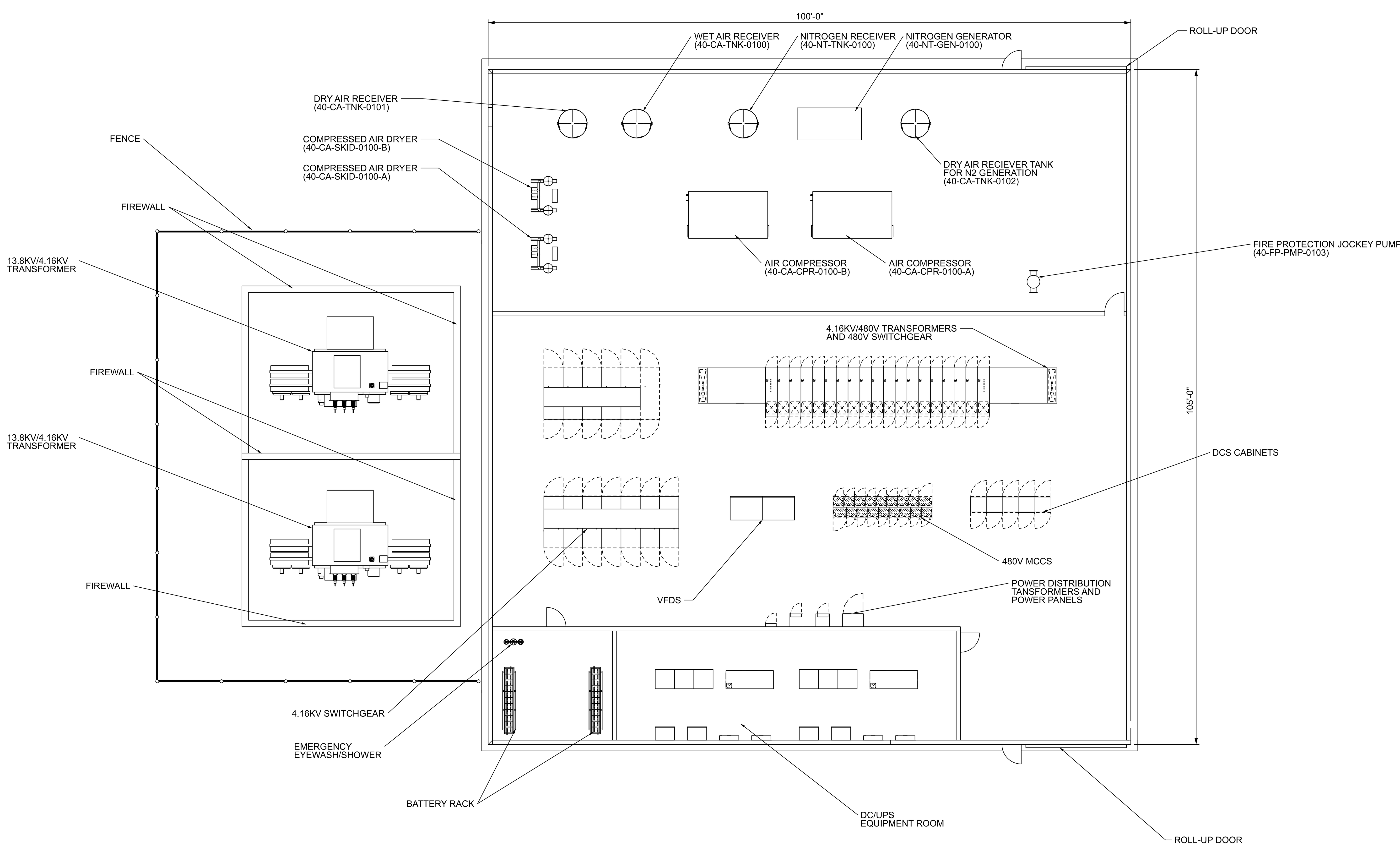
SSPC – Steel Structures Painting Council

UL – Underwriter's Laboratories, Inc.

APPENDIX B. GENERAL ARRANGEMENT DRAWINGS

DRAWING NUMBER

14254-40000-M-GA-001



CONFIDENTIAL

NORTH

8' 0 8' 16' 24'

GRAPHIC SCALE

DRAWING SCALE 1/8" = 1'-0"

HOLD INFORMATION	
NO.	DESCRIPTION

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RELEASE INFORMATION		
REV.	DATE	DESCRIPTION
0	11-13-2023	FOR PRE-FEED STUDY

ISSUE PURPOSE: FOR PRE-FEED STUDY

SPECIFICATION: -

PROJECT NO.: 14254.004

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PROJECT

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CLECO POWER LLC
BRAME ENERGY CENTER
LENA, LA

Sargent & Lundy

SARGENT & LUNDY
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CHICAGO, ILLINOIS 60603-5780

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DRAWING TITLE

GENERAL ARRANGEMENT
ELECTRICAL/MECHANICAL BUILDING

DRAWING NUMBER	REVISION
14254-40000-M-GA-001	0

SHEET 1 OF 1

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Form GDG-0401-01-08, ARCH (Imperial) MicroStation Border - Size E - 36 x 48
Revision 10, Revision Date: 10-16-2009

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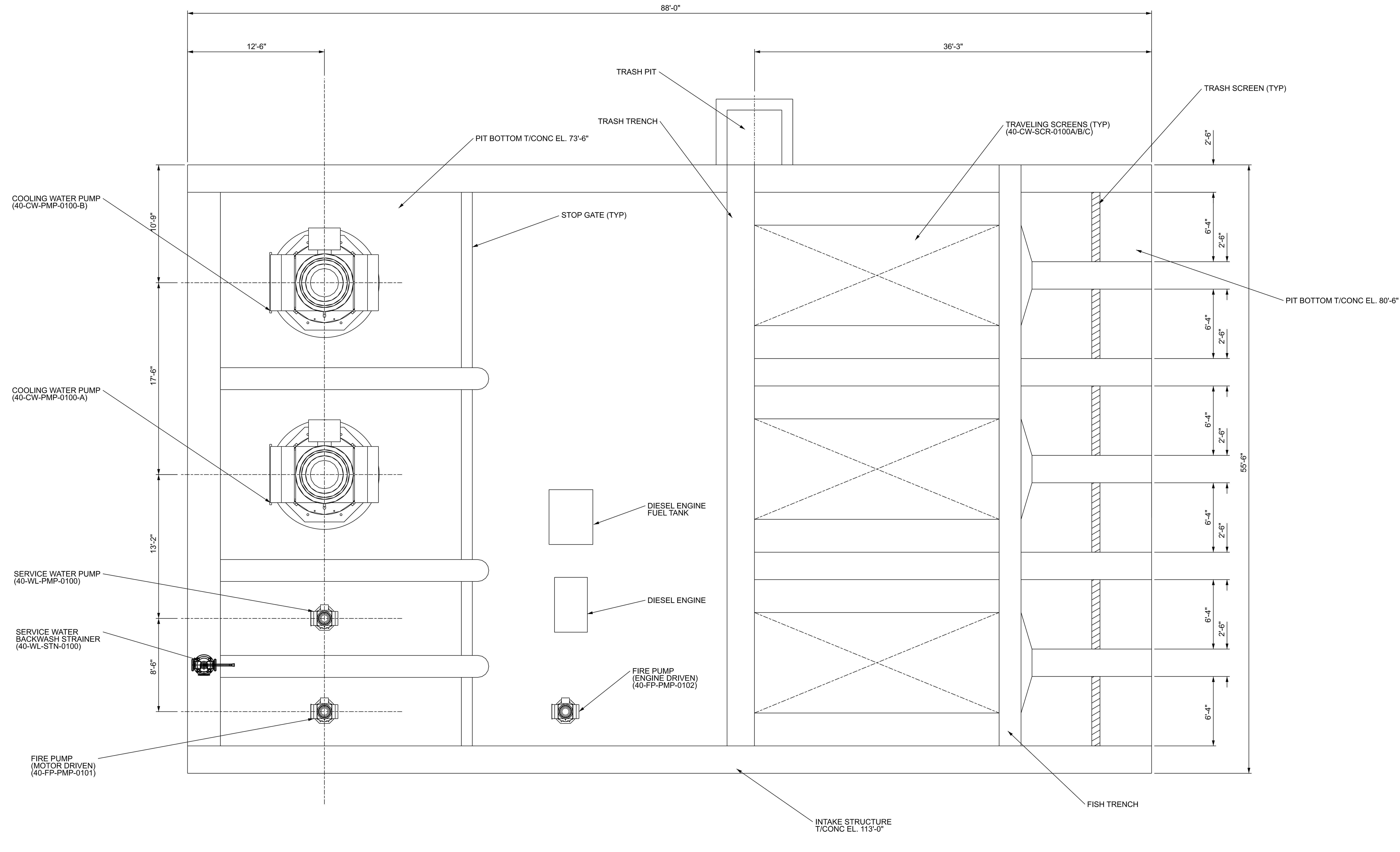
DRAWING NUMBER

14254-40000-M-GA-002



CONFIDENTIAL

NOTE:
1. INTAKE STRUCTURE MODELED AFTER MADISON UNIT 3 EXISTING CIRCULATING WATER INTAKE STRUCTURE. HYDRAULIC STUDY OF INTAKE STRUCTURE TO BE PERFORMED DURING DETAILED DESIGN.

NORTH

4' 0 4' 8' 12'
GRAPHIC SCALE
DRAWING SCALE
1/4" = 1'-0"

HOLD INFORMATION

NO.	DESCRIPTION

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RELEASE INFORMATION

REV.	DATE	DESCRIPTION
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ISSUE PURPOSE: FOR PRE-FEED STUDY
SPECIFICATION: -
PROJECT NO.: 14254.004

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LENA, LA

Sargent & Lundy

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CHICAGO, ILLINOIS 60603-5780

DRAWING TITLE

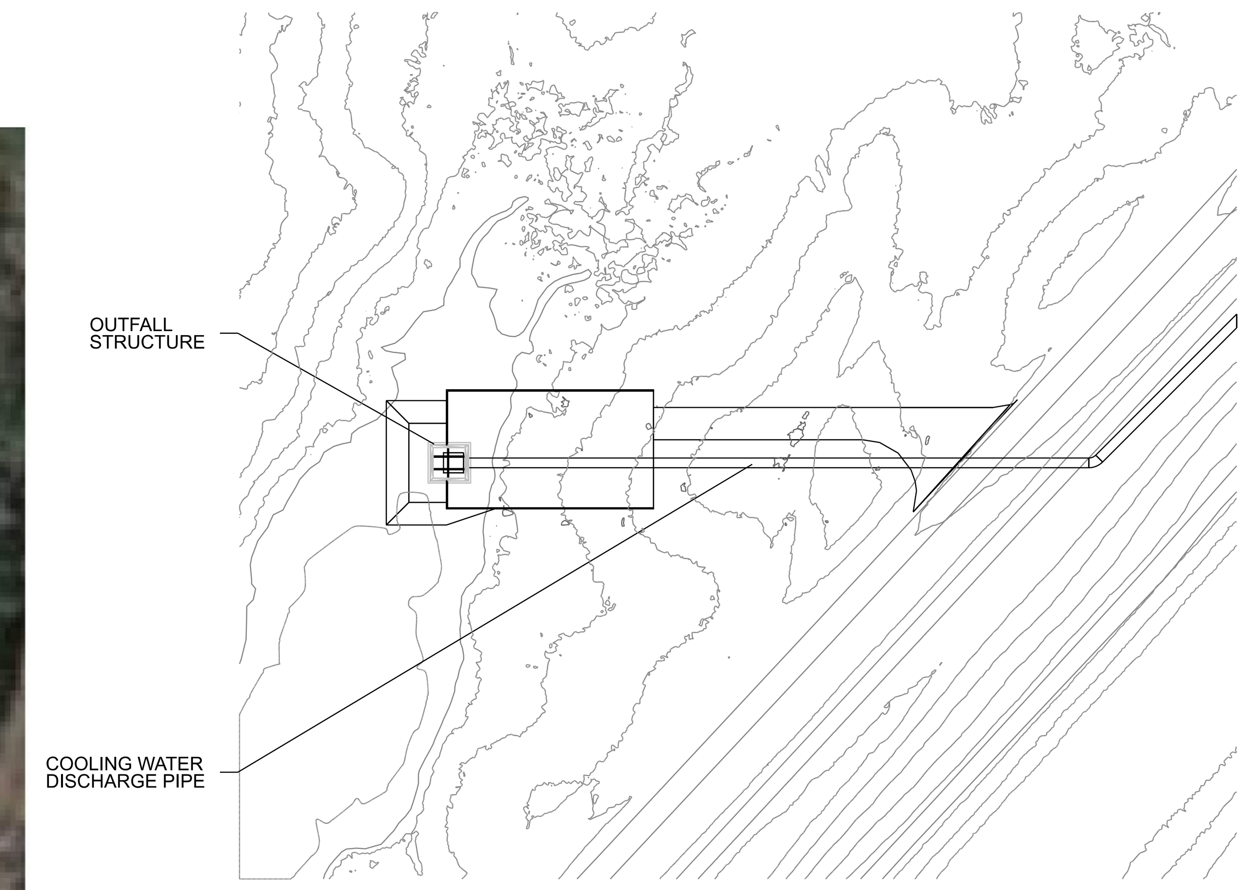
GENERAL ARRANGEMENT
COOLING WATER INTAKE STRUCTURE

DRAWING NUMBER	REVISION
14254-40000-M-GA-002	0

SHEET 1 OF 1

DRAWING NUMBER

14254-40000-M-PP-001



OUTFALL STRUCTURE

NOTES:

1. FOR CARBON CAPTURE AREA PLOT PLAN SEE DRAWING 8397-P610-G00-0010.
2. WETLAND AND POND AREA TO BE FILLED TO THE EXTENTS SHOWN.
3. GRADE ELEVATION OF GENERAL CARBON CAPTURE AREA AND NEWLY DEVELOPED ADJACENT CONSTRUCTION AREAS TO BE 117'.
4. REFER TO PRE-FEED CONSTRUCTABILITY PLAN FOR COMPLETE CONSTRUCTION LAYDOWN PLAN.

CONFIDENTIAL

NORTH

100' 0 100' 200' 300'

GRAPHIC SCALE

DRAWING SCALE
1" = 100'-0"

HOLD INFORMATION

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ISSUE PURPOSE: FOR PRE-FEED STUDY

SPECIFICATION: -

PROJECT NO.: 14254.004

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APPROVED BY: -

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CLECO POWER LLC
BRAME ENERGY CENTER
LENA, LA

Sargent & Lundy

SARGENT & LUNDY
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CHICAGO, ILLINOIS 60603-5780

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DRAWING TITLE

GENERAL ARRANGEMENT
SITE PLAN

DRAWING NUMBER	REVISION
14254-40000-M-PP-001	0

SHEET 1 OF 1

ZL11796(0L0227)D:\Cleco\14254-40000-M-PP-001.dgn
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Revision 10, Revision Date: 10-15-2009

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DRAWING NUMBER

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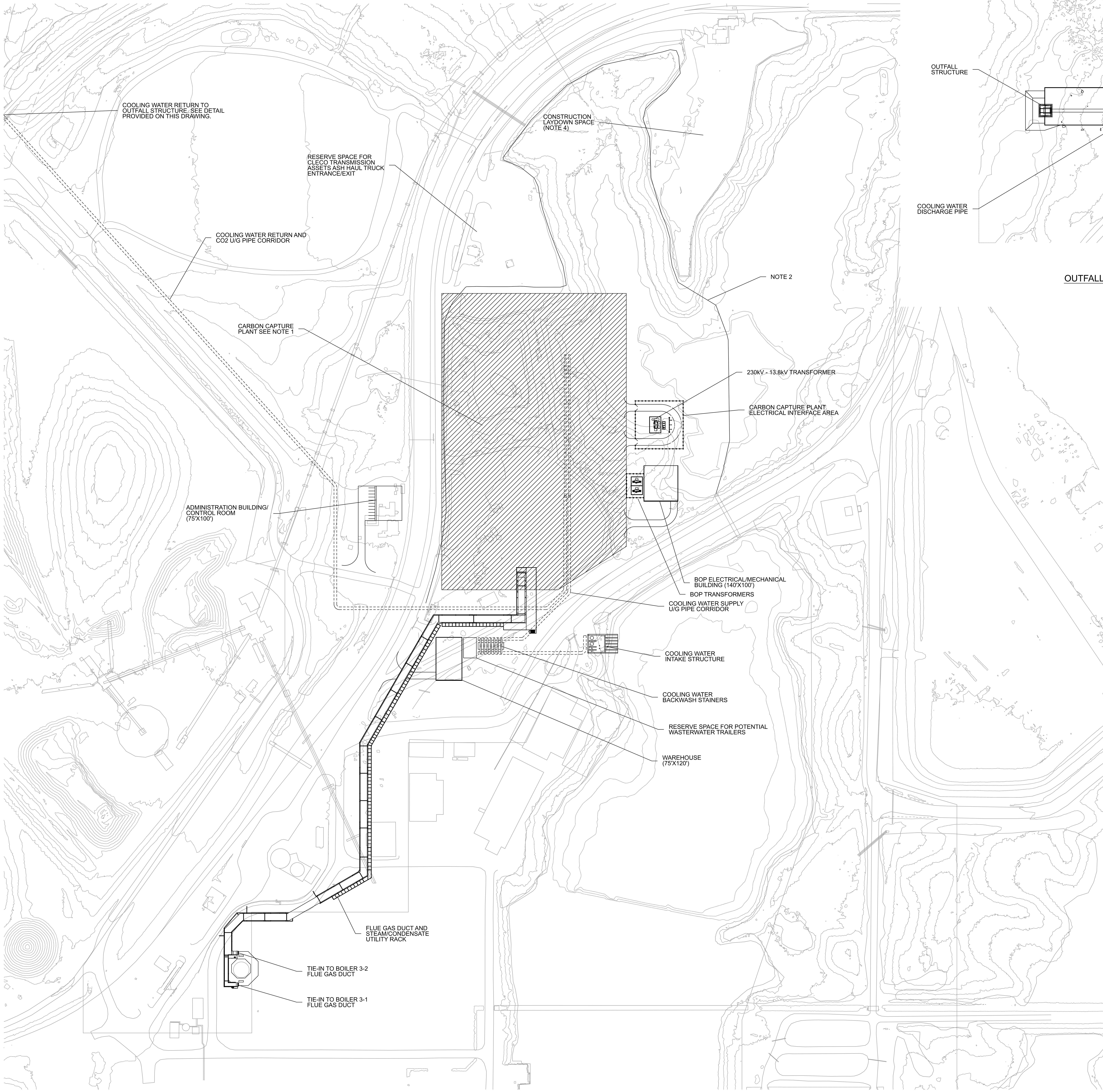

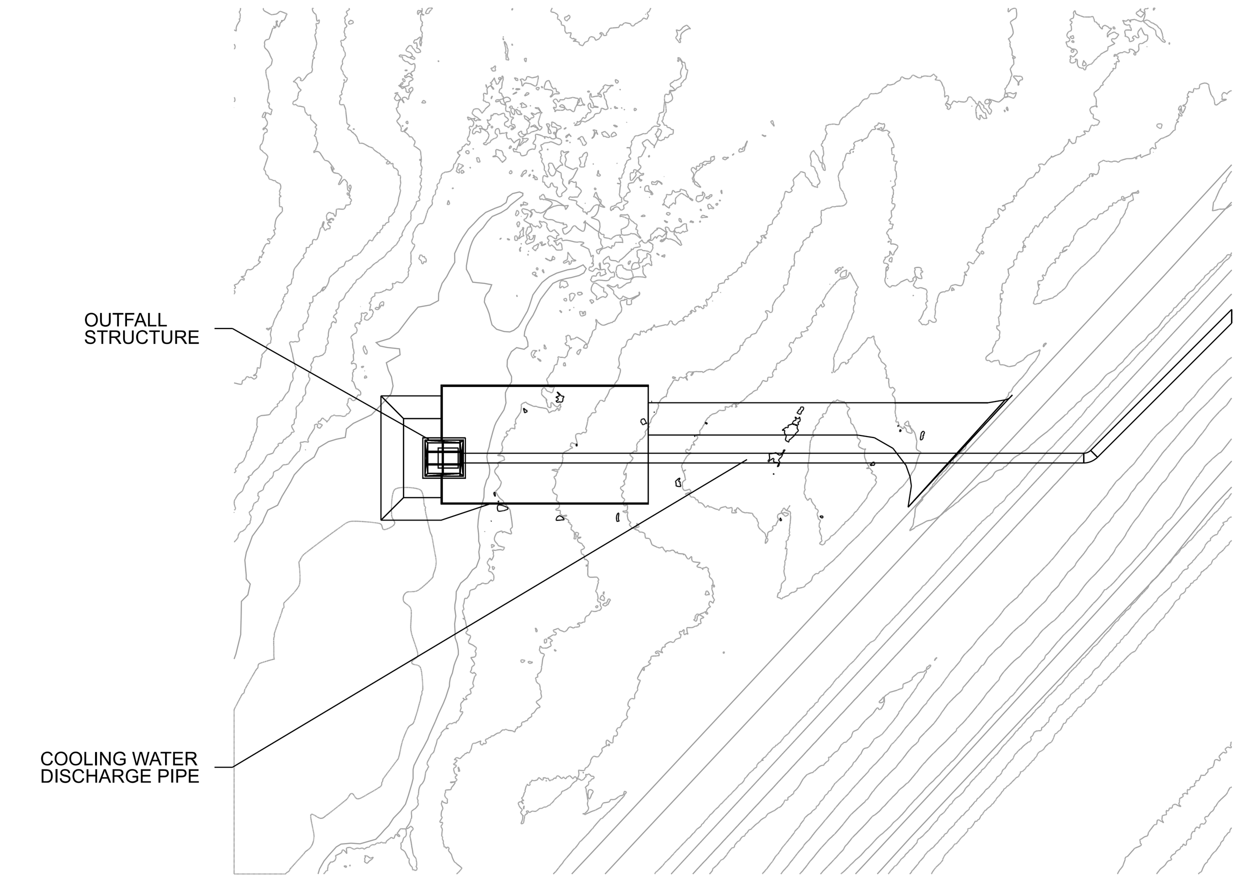

OUTFALL STRUCTURE

NOTES:

1. FOR CARBON CAPTURE AREA PLOT PLAN SEE DRAWING 8397-P610-G00-0010.
2. WETLAND AND POND AREA TO BE FILLED TO THE EXTENTS SHOWN.
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4. REFER TO PRE-FEED CONSTRUCTABILITY PLAN FOR COMPLETE CONSTRUCTION LAYDOWN PLAN.

CONFIDENTIAL

NORTH

100' 0 100' 200' 300'

GRAPHIC SCALE

DRAWING SCALE
1" = 100'-0"

HOLD INFORMATION

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CLECO POWER LLC
BRAME ENERGY CENTER
LENA, LA

Sargent & Lundy

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GENERAL ARRANGEMENT
SITE PLAN

DRAWING NUMBER: 14254-40000-M-PP-002

REVISION: 0

SHEET 1 OF 1

ZL11796(0.0227)D:\Cleco\14254-40000-M-PP-002.dgn
Form GDG-0401-01-08, ARCH (Imperial) MicroStation Border - Size E - 36 x 48
Revision 10, Revision Date: 10-16-2009

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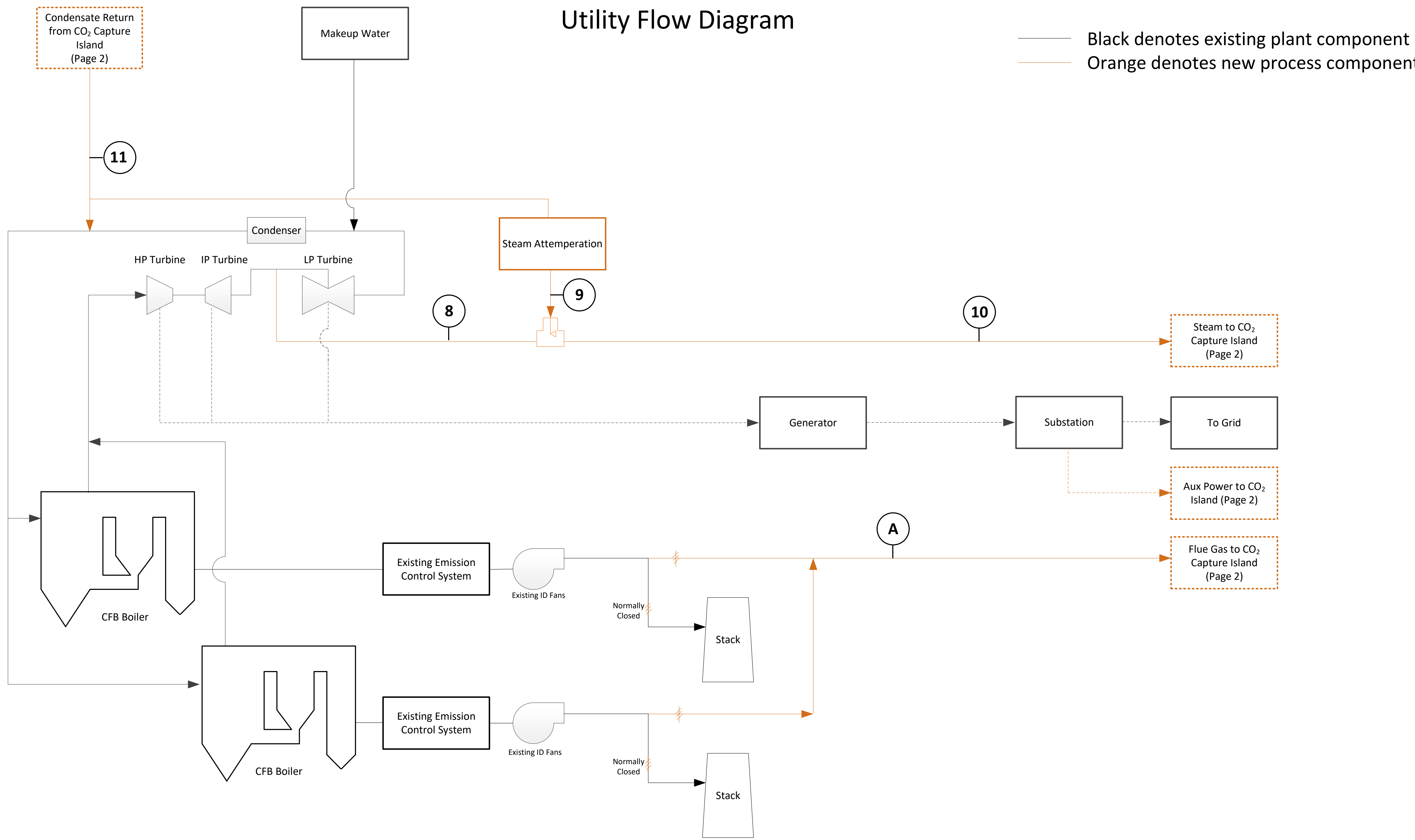
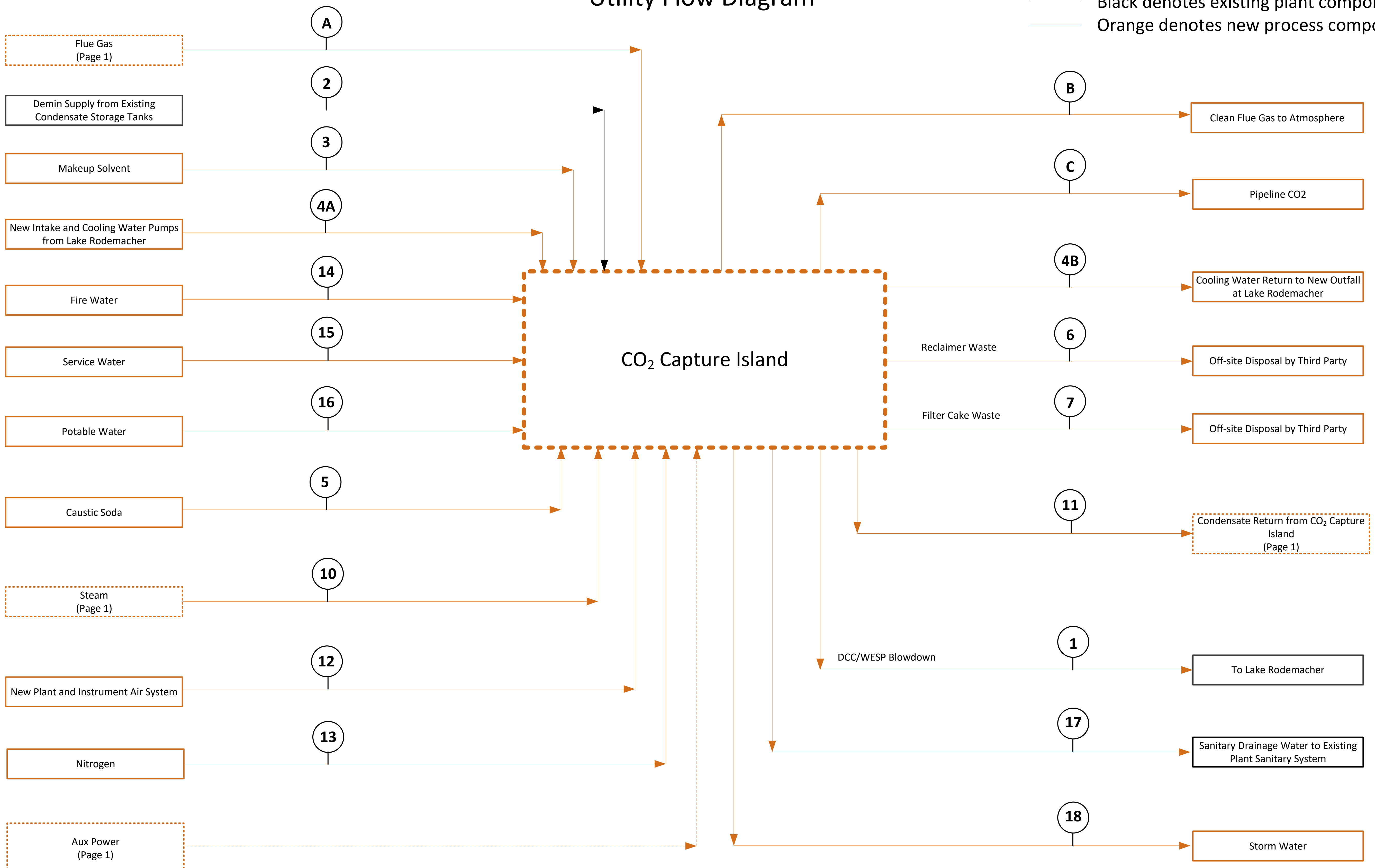
APPENDIX C. UTILITY FLOW DIAGRAM

Utility Flow Diagram



Utility Flow Diagram

Black denotes existing plant component
Orange denotes new process component



APPENDIX D. ISBL PROCESS FLOW DIAGRAMS

KS-TNK-0007 — FRESH SOLVENT TANK

FG-TWR-0001 — QUENCHER

CPW-HX-0001 — QUENCHER COOLER

CPK-HX-0002 — WASH WATER COOLER

KS-FLT-0001 — FILTRATION UNIT

KS-TNK-0001 — SOLVENT TANK

CS-TNK-0003 — CAUSTIC SODA TANK

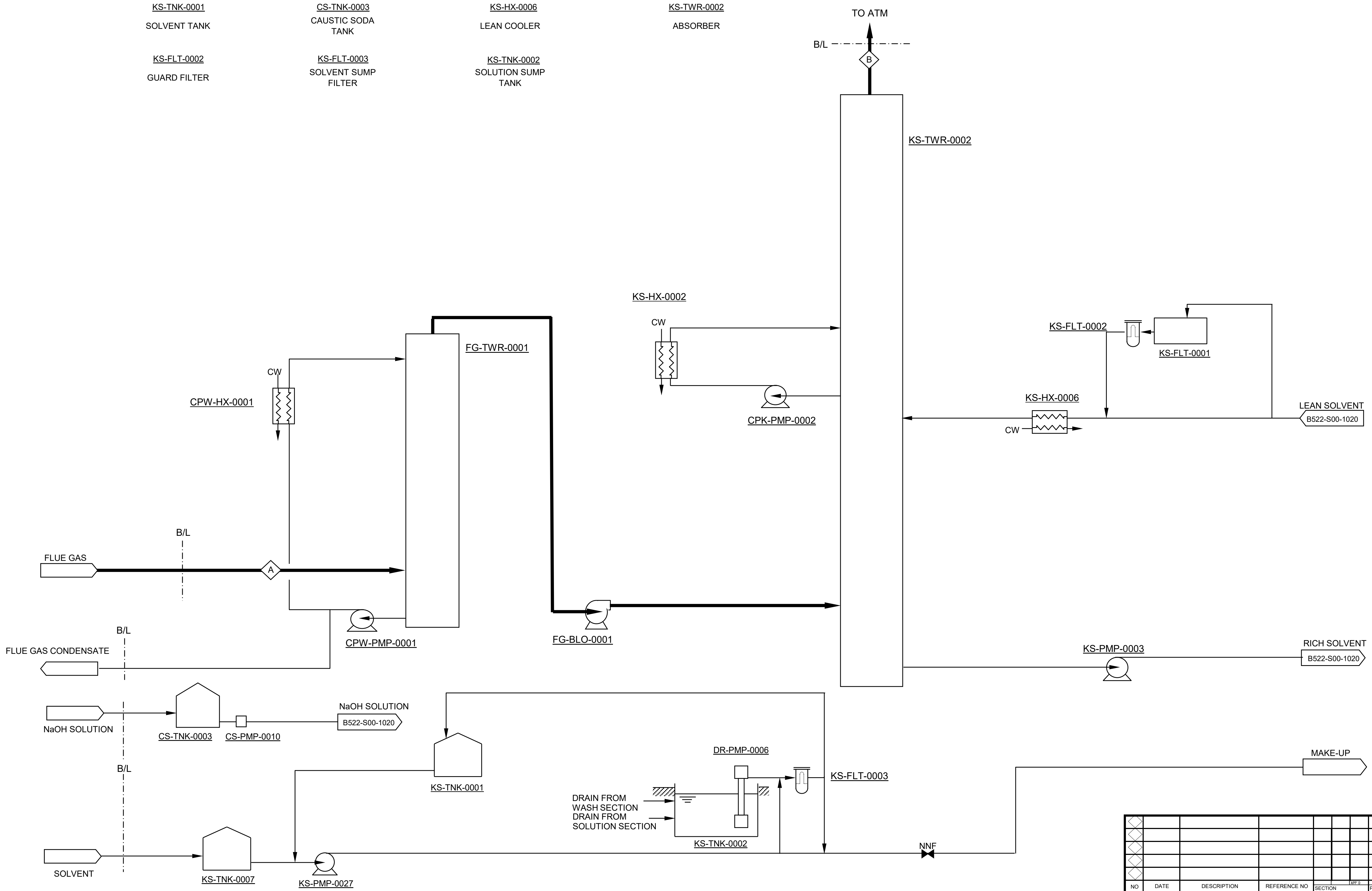
KS-HX-0006 — LEAN COOLER

KS-TWR-0002 — ABSORBER

KS-FLT-0002 — GUARD FILTER

KS-FLT-0003 — SOLVENT SUMP FILTER

KS-TNK-0002 — SOLUTION SUMP TANK



LEGEND

NNF : NORMALLY NO FLOW

FG-BLO-0001 — FLUE GAS BLOWER

CPK-PMP-0002 — WATER CIRCULATION PUMP

DR-PMP-0006 — SOLVENT SUMP PUMP

CS-PMP-0010 — RECLAIMER CAUSTIC SODA PUMP

CPW-PMP-0001 — QUENCHER CIRCULATION PUMP

KS-PMP-0003 — RICH PUMP

KS-PMP-0027 — SOLVENT TRANSFER PUMP

NO	DATE	DESCRIPTION	REFERENCE NO	SECTION	PROJECT TEAM

ORDER: 584603

CUSTOMER: CLECO

PROJECT: Cleco Diamond Vault

DEPARTMENT: Process. Gr. - North America

PROCESS FLOW DIAGRAM FOR QUENCHER & ABSORBER SECTION

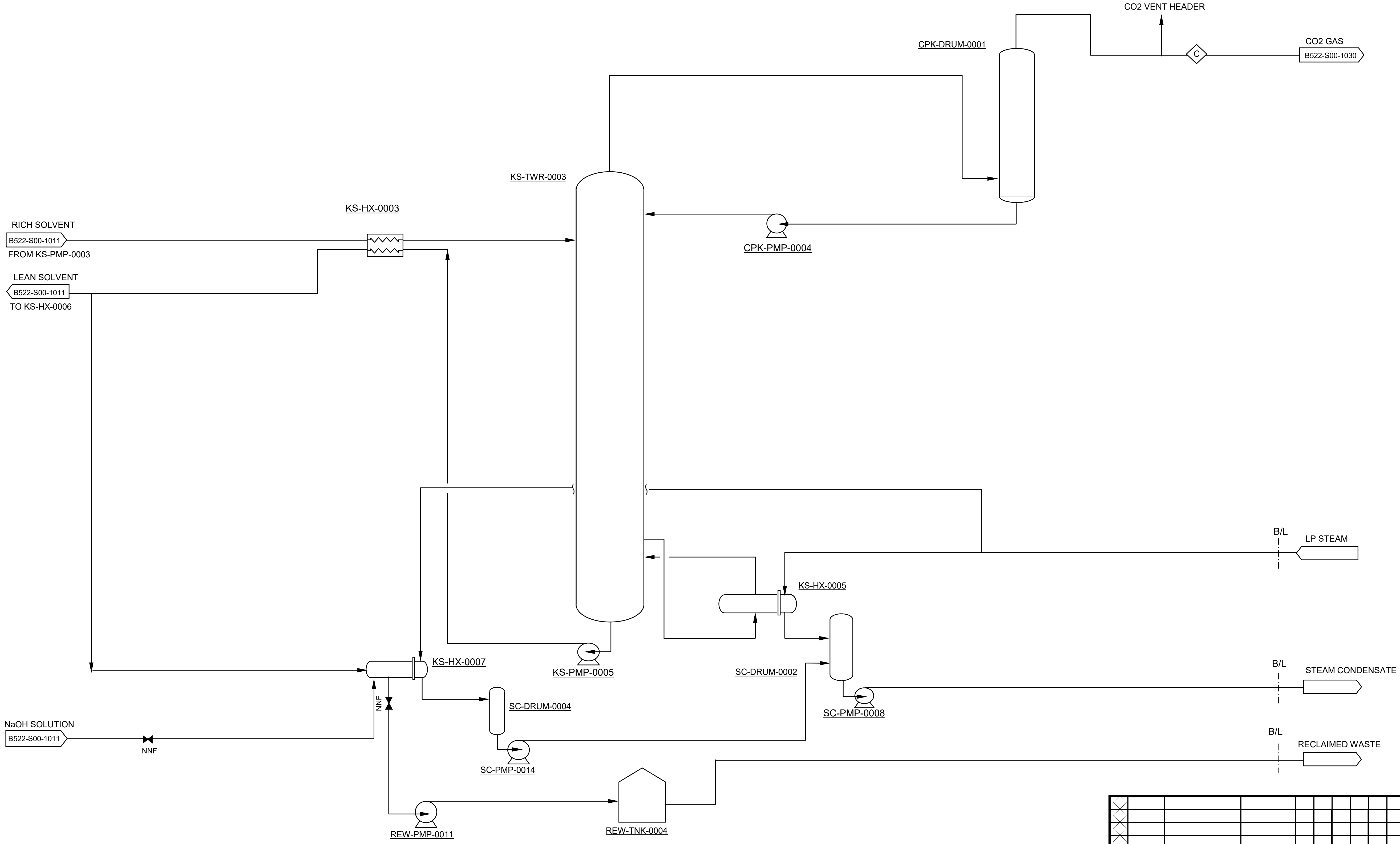
DWN. DATE: 03/14/2025

DWG. NO: 8397-B522-S00-1111

REV: 0

DISTRIBUTION	
DOE	E
CLECO	
S&L	
-	
MHIA	
PM	
EM	
PE	
QA/QC	
PROCURE.	
SUBCONT.	
LOGISTICS	
COST	
SCHEDULE	
BUSINESS	
PROCESS	
MACHINE	
EQUIP.	
UNIT	
PIPING	
I&C	
ELECT.	
CIVIL	
CONST.	
VENDOR	
SITE	
TOTAL	

KS-HX-0003	KS-TWR-0003	SC-DRUM-0002	CPK-DRUM-0001	KS-HX-0005
LEAN RICH EXCHANGER	REGENERATOR	STEAM CONDENSATE DRUM	REFLUX DRUM	REGENERATOR REBOILER
KS-HX-0007	REW-TNK-0004	KS-HX-0005	SC-DRUM-0004	
RECLAIMER	RECLAIMED WASTE TANK	REGENERATOR REBOILER	RECLAIMER STEAM CONDENSATE DRUM	



LEGEND

NNF : NORMALLY NO FLOW

CPK-PMP-0004	SC-PMP-0008	SC-PMP-0014
REFLUX DISTRIBUTION PUMP	STEAM CONDENSATE PUMP	RECLAIMER STEAM CONDENSATE PUMP
KS-PMP-0005	REW-PMP-0011	
LEAN PUMP	RECLAIMED WASTE PUMP	

NO	DATE	DESCRIPTION	REFERENCE NO	SECTION		APP'D	PROJECT TEAM		APP'D

ORDER	584603
PROJECT TEAM	
APRROVED	
DEPARTMENT	Process. Gr. - North America
APRROVED	
DWN. DATE	03/14/2025

CUSTOMER: CLECO, Sargent & Lundy

PROJECT: Cleco Diamond Vault

PROCESS FLOW DIAGRAM FOR REGENERATOR SECTION (REGENERATOR)

DWG. NO 8397-B522-S00-1120 REV 0

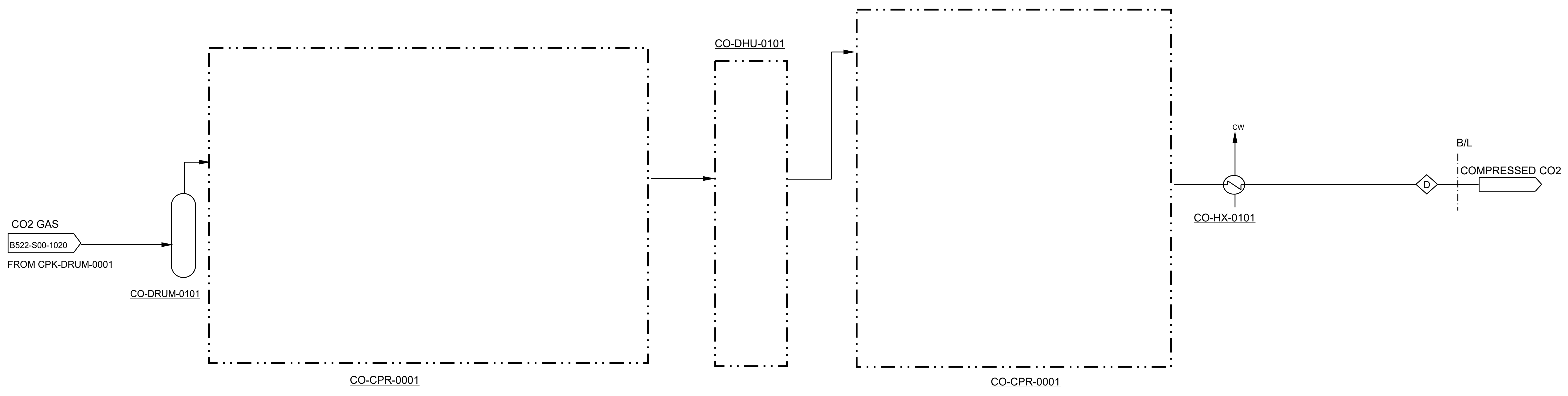
DISTRIBUTION	
DOE	E
CLECO	
S&L	
-	
MHIA	
PM	
EM	
PE	
QA/QC	
PROCURE.	
SUBCONT.	
LOGISTICS	
COST	
SCHEDULE	
BUSINESS	
PROCESS	
MACHINE	
EQUIP.	
UNIT	
PIPING	
I&C	
ELECT.	
CIVIL	
CONST.	
VENDOR	
SITE	
TOTAL	

MITSUBISHI HEAVY INDUSTRIES

CO-DRUM-0101
COMPRESSOR LP SUCTION SCRUBBER

CO-HX-0101
HP DISCHARGE COOLER

CO-DHU-0101
DEHYDRATION UNIT



CO-CPR-0001
CO2 COMPRESSOR

DISTRIBUTION	
DOE	E
CLECO	
S&L	
-	
MHIA	
PM	
EM	
PE	
QA/QC	
PROCURE.	
SUBCONT.	
LOGISTICS	
COST	
SCHEDULE	
BUSINESS	
PROCESS	
MACHINE	
EQUIP.	
UNIT	
PIPING	
I&C	
ELECT.	
CIVIL	
CONST.	
VENDOR	
SITE	
TOTAL	

NO	DATE	DESCRIPTION	REFERENCE NO	SECTION (APP'D)	PROJECT TEAM (APP'D)

ORDER	584603
PROJECT TEAM	
APRROVED	
DEPARTMENT	Process. Gr. - North America
APRROVED	
DWN. DATE	03/14/2025

CUSTOMER: CLECO / Sargent & Lundy

PROJECT: Cleco Diamond Vault

PROCESS FLOW DIAGRAM FOR CO2 COMPRESSION & DEHYDRATION SECTION (COMPRESSOR)

DWG. NO 8397-B522-S00-1130 REV 0

MITSUBISHI HEAVY INDUSTRIES

STREAM TABLE

STREAM NO.		A	B	C	D
FLUID NAME		FLUE GAS	TREATED GAS	CO2 GAS	COMPRESSED CO2
TEMPERATURE	°F	205	112	106	120
	°C	96	44	41	49
PRESSURE	psiG	-0.1	0.0	14	2,000
	kg/cm2g	-0.01	0.0	0.98	140.61
VOLUME FLOW	scfm(68)	1,465,903	1,216,837	102,118	-
DENSITY	kg/m3	0.959	1.054	3.285	-
MOLECULAR WEIGHT	-	29	27	43	-
MASS FLOW	ston/hr	-	-	-	673.2
COMPOSITION					
H_2O	mol%-wet	11.2	9.1	3.8	< 50 ppmv / 2.4 lb/MMscf
N_2+Ar	mol%-wet	70.4	84.9	N2 < 4 vol% Ar < 4 vol%	N2 < 4 vol% Ar < 4 vol%
O_2	mol%-wet	4.3	5.2	< 50 ppmv	< 50 ppmv
CO_2	mol%-wet	14.1	0.8	96.2	> 95.5 vol%
NOx	ppmv-dry	46.2	< 55	-	< 100 ppmv
SO_2	ppmv-dry	59.4	< 1	-	< 100 ppmv

MITSUBISHI HEAVY INDUSTRIES

APPENDIX E. LIFE CYCLE ANALYSIS

Department of Energy (DOE)
Office of Fossil Energy (FE)

CLECO PROJECT DIAMOND VAULT CARBON CAPTURE FEED STUDY

DE-FE0032165

Life Cycle Analysis

TABLE OF CONTENTS

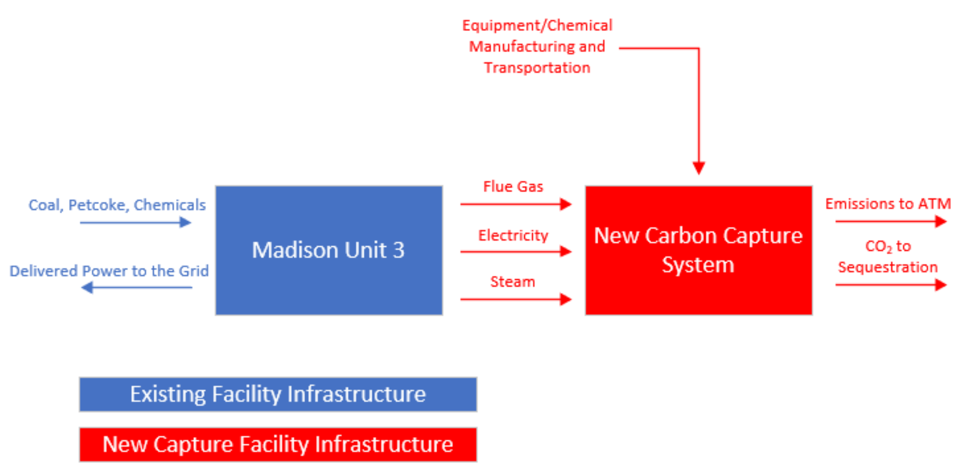
EXECUTIVE SUMMARY

This life cycle analysis (LCA) is being commissioned for the United States (U.S.) Department of Energy (DOE) National Energy Technology Laboratory (NETL) to satisfy the award requirements for Front End Engineering and Design (FEED) DE-FE0032165 Diamond Vault Carbon Capture FEED Study. The Principal Investigators (PI) for this project are Louisiana Economic Development (LED), with Cleco LLC (Cleco) as a Co-PI. Cleco contracted Sargent and Lundy LLC (S&L) to prepare the LCA model and summary report. This LCA report has been prepared in accordance with ISO 14040/14044 requirements for public release of comparative assessments for third parties. This report is an update from the previously submitted Preliminary LCA completed for DE-FE0032165.

The goal of the LCA is to model the life cycle of greenhouse gas (GHG) emissions from cradle-to-delivered electricity, for Cleco's proposed CO_2 capture system. The proposed project is a full-scale integrated CO_2 capture system at Madison Unit 3 (MU3) at Brame Energy Center. Madison is a coal and petroleum coke (petcoke) power facility, located in Lena, Louisiana, owned and operated by Cleco. The facility consists of two (2) circulating fluidized bed (CFB) boilers and one (1) steam turbine (ST), with a gross output of 635 MW. The facility currently operates with a net baseload outlet of 563.58 MW after considering auxiliary power and 7% transmission & distribution (T&D) losses (as defined by Appendix C of the DE-FE0032165 Scope of Project Objectives [Appendix C]). The proposed project would retrofit Mitsubishi Heavy Industries' (MHI) proprietary CO_2 capture technology on the existing facility. MHI's CO_2 capture technology currently holds a technology readiness level (TRL) of 8. The MHI capture system will recover CO_2 from the flue gas and compress the treated CO_2 to conditions suitable for transportation and sequestration. The CO_2 capture system was modeled based on 95% capture efficiency.

A simplified flow chart of the MU3 LCA model is included in Figure ES-1-1 below.

Figure ES-1-1: Simplified Flow Diagram of Proposed Project



With retrofit of the MHI carbon capture facility, the process will have a net global warming potential (GWP) of 206.5 kg CO_2e per delivered MWh of electricity. Therefore, additional negative emission technologies are required for this project to reach zero net carbon emissions. Direct air capture

(DAC) credits are used in the LCA as a negative emissions technology (NET) to reach zero net carbon emissions.

1. GOAL AND SCOPE

1.1 STUDY GOAL

The specific goals of this life cycle analysis (LCA) are described below:

1. Intended application – The intended application of this LCA is to compare the life cycle greenhouse gas (GHG) impact of the proposed project, a full-scale integrated CO_2 capture system on Madison Unit 3 (MU3).
2. Reasons for carrying out the study – To understand how the environmental impact (measured as life cycle GHG impact) of Project Diamond Vault (PDV).
3. Intended audience – The intended audience for the LCA described herein is the United States (U.S.) Department of Energy (DOE) Carbon Utilization Program.
4. Public disclosure – The LCAs conducted as part of the U.S. DOE Funding Opportunity Announcement (FOA) requirement will become part of the public record for the award within the final scientific/technical report.

1.2 STUDY SCOPE

1.2.1 Functional Unit of the Study

As defined by DE-FE0032165 Appendix C, life cycle modeling reporting is to be from “cradle-to-gate”, presumably defined as “cradle-to-delivered electricity” including the transmission of the electricity to the final customer. Therefore, the functional unit of the study is based on the reporting metric kg of CO_2e/MWh of electricity delivered.

1.2.2 System Boundary

The LCA was performed using the OpenLCA software recommended in DE-FE0032165 using database information from the National Energy Technology Laboratory (NETL) to the greatest extent possible. The OpenLCA model developed was a cradle-to-delivered electricity analysis and included fuel and chemical supply to MU3, transmission of electricity to the final customer, production and transportation of equipment, materials and chemicals for the CO_2 capture system as well as transport and storage of the captured CO_2 in a saline aquifer. It should be noted that emissions associated with the production of petcoke are assumed to be zero as it is a waste byproduct of oil refinement. A model was developed for both the existing MU3 facility and the proposed facility with carbon capture and sequestration equipment installed. A simplified flow chart representing the existing and the proposed retrofit facility model is included in

Figure 1-1 and Figure 1-2 respectively below.

Figure 1-1: Existing Product System

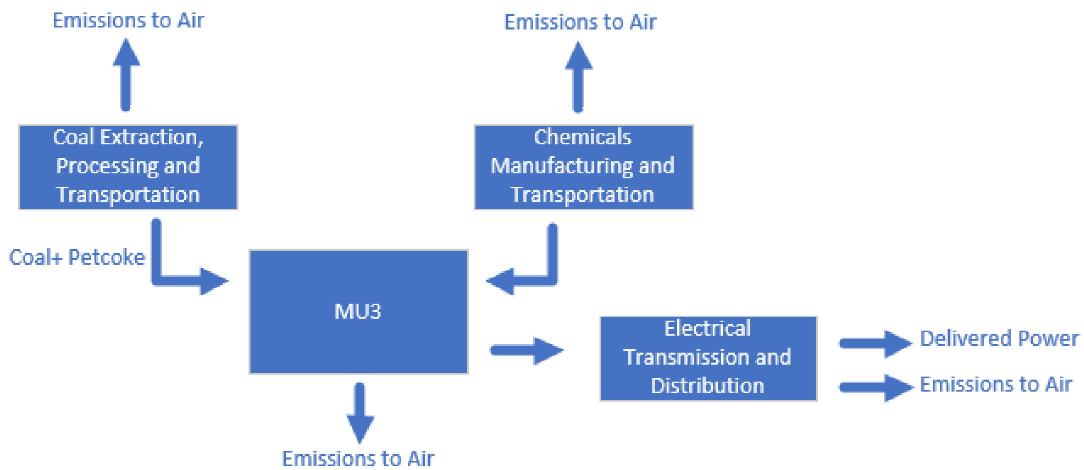
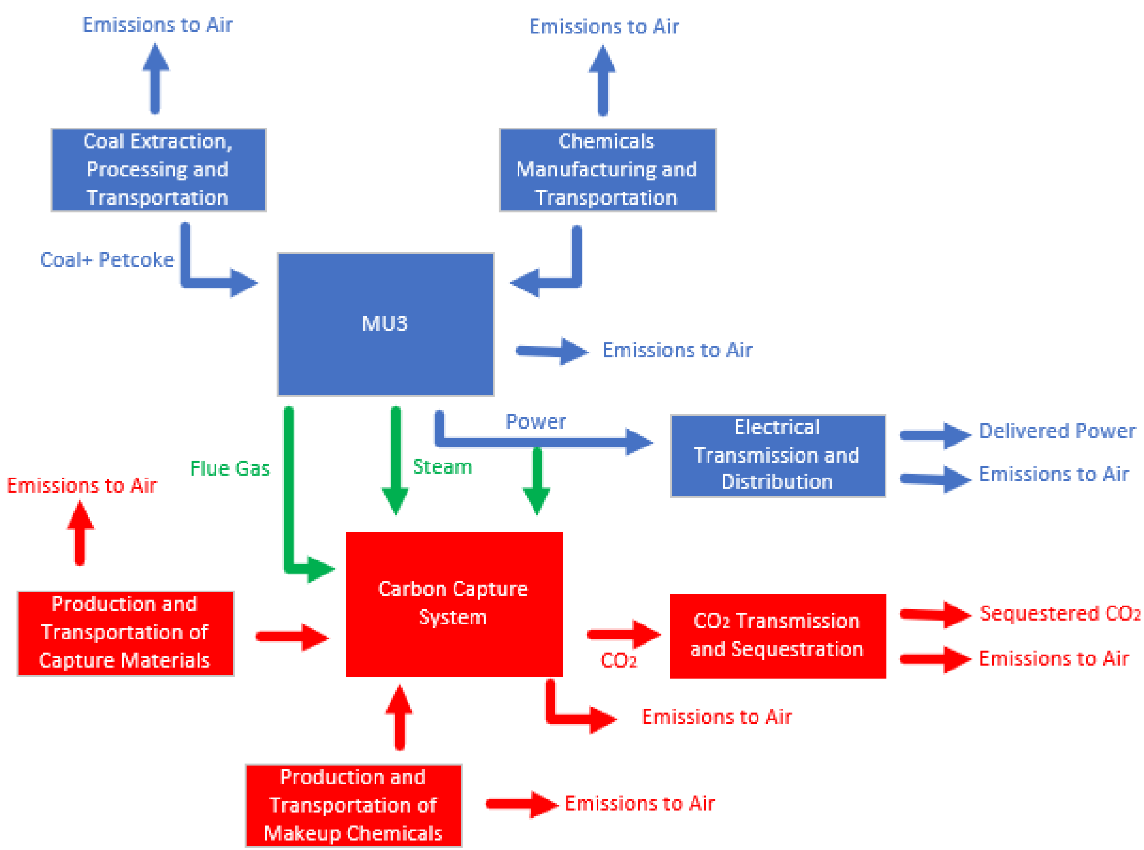


Figure 1-2: Proposed Product System



In the figure above, the blue represents the existing processes at MU3, the red represents the new processes including the CO_2 capture system, and the green represents streams from the station that will be integrated into the CO_2 capture system. The LCA model developed in OpenLCA utilized the pre-established NETL processes wherever possible.

1.2.3 Carbon Dioxide Source

The CO_2 delivered to the sequestration site comes from carbon dioxide removed from MU3 flue gas and will have a purity of > 99.9%.

1.2.4 Geographical Representativeness

MU3 is a coal/petcoke fired facility, located in Lena, Louisiana. The site is located approximately 1 mile southwest of Interstate 49 and on the northeast side of Lake Rodemacher. The intention is to send captured CO_2 to a nearby CO_2 pipeline to be brought to an onsite sequestration location.

1.2.5 Temporal Representativeness

The purpose of the project is to install a new CO_2 capture system in order to permanently sequester CO_2.

1.2.6 Life Cycle Impact Assessment Methods for Results Interpretation

This study utilizes the 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. Only GWP (kg CO_2e), based on IPCC AR5, 100-year time horizon; accounting for carbon climate feedback (abbreviation: GWP-100) has been modeled as an impact category as part of this report.

1.2.7 Completeness Requirements

Uncaptured CO_2 emissions from MU3, coal extraction and processing, CO_2 sequestration, and barge transportation of fuel all contribute to the majority of GWP. The following processes contribute at least 0.001 kg CO_2/MWh:

- Truck Transportation Makeup Chemicals for the Base Facility
- Ammonia Production for the Base Facility
- Limestone Production for the Base Facility
- Quicklime Production for the Base Facility
- Stainless Steel Manufacturing
- Sodium Hydroxide Manufacturing
- Diesel and Gasoline Combustion for Construction

- Concrete Manufacturing
- Galvanized Steel Manufacturing
- Copper Manufacturing
- Carbon Steel Manufacturing
- Truck Transportation of Process Equipment and Materials
- Truck Transportation of Makeup Chemicals
- Amine Manufacturing
- Mineral Wool Manufacturing
- Aluminum Manufacturing
- PVC Manufacturing
- Truck Transportation for Construction
- Asphalt Manufacturing

1.2.8 Sensitivity and Uncertainty Analysis

A sensitivity and uncertainty analysis was not completed for this project as key model inputs with known technical variability such as construction materials have not been identified/determined.

1.2.9 Reporting Units and Method of Comparison

The international System of Units (SI) are the reporting units for this model as is the standard by NETL. Results are demonstrated in the form of a bar chart as produced by OpenLCA.

2 LIFE CYCLE INVENTORY ANALYSIS

2.1 MODELING PLATFORM

The LCA was performed using the OpenLCA software recommended by the DE-FE0032165 documentation and database information from the National Energy Technology Laboratory (NETL) to the greatest extent possible. The OpenLCA model developed was a cradle-to-delivered electricity analysis and included fuel and chemical supply, transmission of electricity to the final customer, production and transportation of equipment, materials and chemicals for the CO_2 capture system as well as transport and storage of the captured CO_2 in a saline aquifer.

This report was completed with the guidance of the NETL CO2U LCA Report Template.

2.2 DATA SOURCES AND QUALITY ASSESSMENT

As noted previously, the LCA was performed using the OpenLCA software recommended by Appendix C of DE-FE0032165 and database information from the National Energy Technology Laboratory (NETL) to the greatest extent possible.

Table 2-2 below lists the processes used as the basis for the base facility and its source. Table 2-2 lists the processes used as the basis for the CO_2 capture system and its source. Note, plastic, mineral wool, amine solvent, PDMS and copper processes were unable to be sourced from the LCA commons database thus an outside source was required to create a new material process in OpenLCA.

Project-specific material sourcing has not been finalized at the time of this LCA. A range of processes are available in OpenLCA and public databases for the same material and have varying global warming potentials. Since no benchmark processes were defined by DOE or NETL to perform the LCA for DE-FE0032165 and specific material sourcing for the project has not yet been determined, material processes were selected to the best of the projects knowledge, tending towards industry averages where available. The 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.

Table 2-1: Processes for Base Facility

Material	Process Source
Ammonia	Ammonia Products with Carbon Capture
Coal	Coal extraction and processing - Illinois Basin, BIT, Underground
Limestone	Limestone, at mine
Quicklime	Quicklime, at plant

Table 2-2: Processes for CO_2 Capture System

Material	Process Source
Ammonia	Lost foam casting, aluminum
Asphalt	Asphalt mix 1 - virgin mix with SBS
Copper	Copper Development Association Inc.: Life Cycle Assessment Copper Tube and Sheet
Onroad Diesel	Combustion of Diesel - US
Offroad Diesel	Diesel, combusted in industrial boiler
Electricity for Construction	Current U.S. grid mix - US
Galvanized Steel	Galvanized steel sheet, at plant
Gasoline	Combustion of Gasoline - US
Iron	Iron, sand casted
MEA	University of Houston
Mineral Wool	International Journal of Life Cycle Assessment: Life Cycle Assessment of Three Insulation Materials: Stone Wool Paper Wool, and Flax Cellulose
PDMS (Antifoam)	Universiteit Leiden: Life Cycle Assessment of microfluidic devices for point-of-care testing
Plastic	Life cycle inventory of the carbon fibre production process[1]
Plywood	Plywood - US
Rubber	Polybutadiene, butadiene rubber, BR, at plant
HDPE	Polyethylene, high density, HDPE, virgin resin, at plant
PVC	Polyvinyl chloride, PVC, virgin resin; at plant
Concrete	Portland Cement Concrete; NRMCA Industry Average
Sodium Hydroxide	Sodium hydroxide; chlor-alkali average, membrane cell; at plant; 50% solution state
Stainless Steel	Stainless steel; Manufacture; Production mix, at plant; 316 2B, 80% recycled
Carbon Steel	Steel plate; Blast furnace route; Production mix; 85% recovery rate

Note 1: From the Paper: Life Cycle Assessment of a Thermal Recycling Process as an Alternative to Existing CFRP and GFRP Composite Wastes Management Options. Assumptions include ammonia bicarbonate as ammonium carbonate, epoxy resin being equal parts ECH and BPA, polyacrylonitrile fibres as acrylate ion, polydimethylsolixane being equal parts bromodichloromethane and silicon dioxide, and potassium permanganate being equal parts potassium hydroxide and manganese.

It should be noted that the plastic and amine solvent processes in the table above have some input flows which are categorized as negative emissions in the OpenLCA model. NETL did not have alternate resource streams for these materials.

This data meets the technical, geographical, and temporal representativeness requirements defined in the Study Scope based on the current level of project definition.

2.3 RESULTS OF LIFE CYCLE INVENTORY MODEL SENSITIVITY CHECK

Additional sensitivities and uncertainty analysis were not completed as once key model inputs with known technical variability such as supplier of construction materials have been identified/determined.

3 LIFE CYCLE IMPACT ASSESSMENT

3.1 LIFE CYCLE IMPACT ASSESSMENT METHODS

The 100-year GWP factors for CO_2, CH_4, and N_2O utilized in this analysis are depicted in Table 3-1. Table 3-1 and associated detail in this section come directly from the NETL CO2U LCA Report Template.

Table 3-1: IPCC AR5 GWPs

GHG	20-year	100-year	Units
CO_2	1	1	kg CO_2e
CH_4	87	36	kg CO_2e
N_2O	268	298	kg CO_2e
SF_6	17,500	23,500	kg CO_2e

This analysis utilizes the latest factors available in TRACI 2.1, with modified *characterization factors* for GWP to reflect the current state of science from the IPCC. The following describes the non-GWP midpoint impact assessment categories included in this analysis:

- **Acidification Potential (AP):** The increased concentration of hydrogen ions in a local environment. This can be from the direct addition of acids, or by indirect chemical reactions from the addition of substances such as ammonia. [14] Reporting units are kg SO_2-equivalent.
- **Eutrophication Potential (EP):** The "enrichment of an aquatic ecosystem with nutrients (nitrogen, phosphorus) that accelerate biological productivity (growth of algae and weeds) and an undesirable accumulation of algal biomass." [16] Reporting units are kg nitrogen (N)-equivalent.
- **Photochemical Smog Formation Potential (PSFP):** Ground-level ozone, formed by the reaction of NO_x and volatile organic compounds (VOCs) in the presence of sunlight. [14] Reporting units are kg trichlorofluoromethane (CFC-11)-equivalent.
- **Ozone Depletion Potential (ODP):** The deterioration of ozone within the stratosphere by chemicals such as CFCs. Stratospheric ozone provides protection for people, crops, and other plant life from radiation. [14] Reporting units are kg ozone (O_3)-equivalent.
- **Particulate Matter Formation Potential (PMFP):** Particulate matter (PM) includes "a mixture of solid particles and liquid droplets found in the air" that are smaller than 10 microns in diameter. [17] Smaller diameter particulate matter (2.5 microns or smaller) can be formed by chemical reactions in the atmosphere (e.g., SO_2 and NO_x). Almost all PM impacts are caused by PM 2.5 microns or smaller ($PM_{2.5}$). Reporting units are kg $PM_{2.5}$-equivalent.
- **Water Consumption (WC):** Water consumption is measured as the volume difference between water withdrawal and discharge and is measured in units of liters (l).

3.2 DATA QUALITY ASSESSMENT

Data quality was limited as project-specific material sourcing would be determined as part of detailed design and has not been finalized at the time of this LCA. As noted above a range of processes are available in OpenLCA and public databases for the same material and have varying global warming potentials. Since no benchmark processes were defined by DOE or NETL to perform the LCA for DE-FE0032165 and specific material sourcing for the project has not yet been determined, material processes were selected to the best of the projects knowledge, tending towards industry averages where available. The 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.

3.3 LIFE CYCLE IMPACT ASSESSMENT RESULTS

The impact analysis tool in OpenLCA was used to determine the major contributors to the project's GWP. The four largest processes contributors are uncaptured emissions from MU3, coal extraction and processing, CO_2 Saline Aquifer Transportation and Storage, and Fuel Transportation.

4 LIFE CYCLE INTERPRETATION

Contributions to global warming for the existing plant with proposed carbon capture retrofit were evaluated using EPA's TRACI 2.1 environmental impact tool. Because the scope of this LCA is greenhouse gas contributions, only the 100-year global warming potential impact factor was evaluated.

4.1 CURRENT OPERATION LCA RESULTS

The overall process for the current operation of the MU3 facility and the coal extraction and processing results in emissions of 877.7 kg CO_2e per delivered MWh.

4.2 PROPOSED OPERATION LCA RESULTS

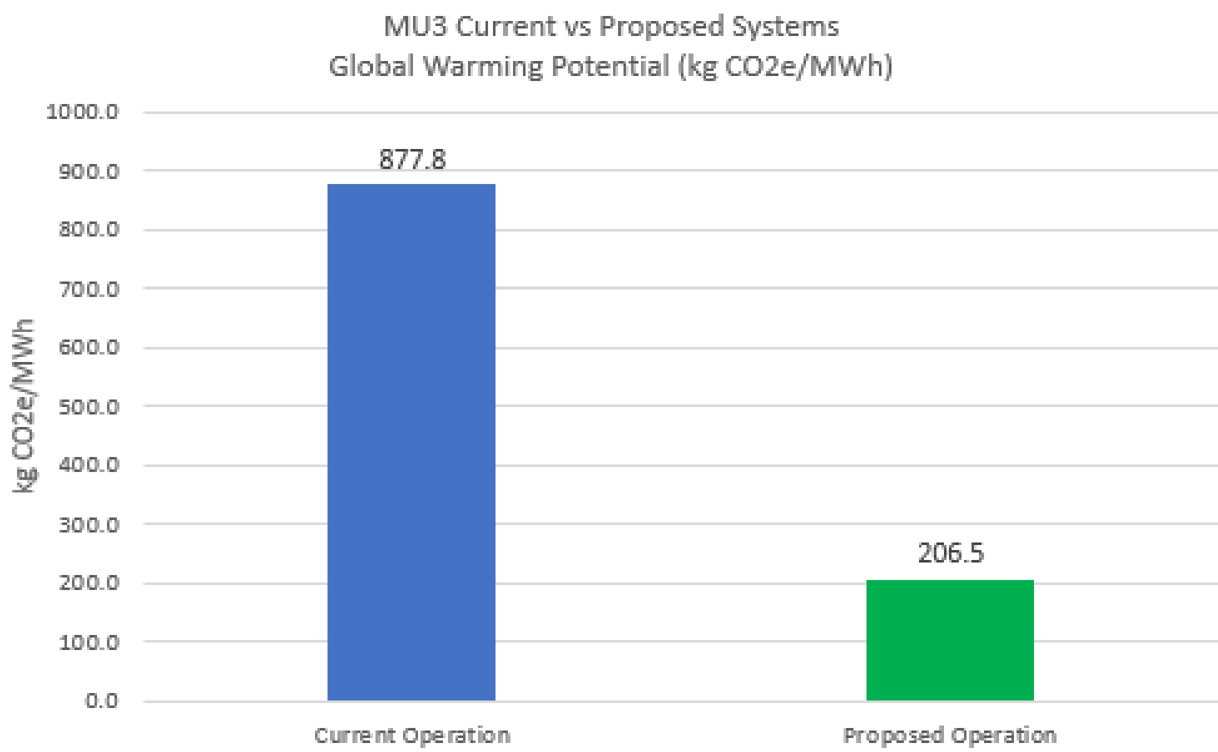
The overall process of the proposed retrofit facility results in emissions of 206.5 kg CO_2e per delivered MWh.

4.3 COMPARISON OF PROPOSED PRODUCT SYSTEM AND COMPARISON PRODUCT SYSTEM

Table 4-1: Processes for Material Production

	Proposed Product System	Comparison Product System
Total GWP	206.5 kg CO_2e/MWh	877.7 kg CO_2e/MWh
Percent Change	-76.5%	

Figure 4-1: Comparison of the Existing and Proposed Facilities



4.4 NEGATIVE EMISSIONS TECHNOLOGY

In order to achieve the required zero net carbon emissions in Appendix C of DE-FE0032165 a negative emission technology must be implemented. DAC credits are used in the LCA to meet net zero emissions. As DAC credits are purchased from an outside entity by Cleco no emissions associated with the construction and operation of a DAC facility are considered. DAC credits are represented in OpenLCA as -1 kg CO_2 per credit. As the proposed system produces 206.5 kg CO_2e/MWh, 206.5 kg CO_2 of DAC credits must be purchased.

5 CRITICAL REVIEW

The U.S. DOE Carbon Utilization Program will serve as the critical reviewer for this study.

APPENDIX F. BUSINESS CASE ANALYSIS

Department of Energy (DOE)
Office of Fossil Energy (FE)

CLECO PROJECT DIAMOND VAULT CARBON CAPTURE FEED STUDY
DE-FE0032165

BUSINESS CASE ANALYSIS

ACKNOWLEDGEMENT

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DISCLAIMER

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1. BUSINESS CASE ANALYSIS

1.1 INTRODUCTION

Cleco Power (Cleco) developed a business case analysis (BCA) as part of Diamond Vault, the ongoing front-end engineering and design (FEED) study (DE-FE0032165) evaluating CO_2 capture on Madison Unit 3 (MU3).

The Diamond Vault BCA economic model covers construction and operation of the CO_2 capture system, transport pipeline, and sequestration wells. The economic model uses cost and technical information from MU3 and the preliminary FEED (pre-FEED) studies. AACE Class 3 cost estimates for the CO_2 capture system were developed as part of the pre-FEED study while AACE Class 4 cost estimates for the transportation pipeline and sequestration wells as part of a separate study. Sequestration field and interconnecting pipeline technical data and indicative cost estimate inputs were prepared under independent preliminary FEED studies, outside the scope of DE-FE0032165.

The economic model takes the various economic components of each of these independent studies and develops an overall economic model including capital costs, operating & maintenance (O&M) costs, and all associated revenue streams to demonstrate an economic justification for Diamond Vault.

1.2 MODEL DEVELOPMENT OVERVIEW

The business case model was developed in order for Cleco to validate the economic viability of the proposed CO_2 capture and sequestration project. This was achieved by creating pro-forma financial statements which incorporate project construction costs, revenues, expenses, additional capital expenditures (i.e., project development costs), and tax benefits provided by Section 45Q tax credits.

The model is shown on a quarterly basis to reflect precision around the timing of cash flows. The resulting cash flows determined that after the commercial operation date (COD), the project would not maintain sufficient net positive cash flows to offset the construction costs of the project and provide a satisfactory rate of return.

The model was constructed to be able to dynamically sensitize the economic inputs to determine the key drivers that are most impactful to the economic viability of the project. This has enabled Cleco to direct additional efforts into monitoring and mitigating risks for these items.

Construction cost estimates and O&M costs for the CO_2 capture system were derived under a joint effort between Sargent and Lundy (S&L) and Mitsubishi Heavy Industries America (MHIA) as part of the pre-FEED and represent an AACE Class 3 cost estimate (-20%/+30%). MHIA provided capital estimates and operating costs for the CO_2 capture system island that are specific to MU3. Capital costs associated with installation of the CO_2 capture system island and the complete balance of plant scope were developed by S&L based off the scope of work and their experience on other CO_2 capture projects and FEED studies.

Costs associated with power and steam needed to operate the CO_2 capture system were developed internally by Cleco based off the utility rates from the pre-FEED study. Because this is a fully integrated system and the power and steam will be produced by the host unit, the cost of these utilities were estimated based off the fuel consumption cost of MU3. MU3 is a 635 MW power plant fueled by a mix of petroleum coke and Illinois coal. It is owned 100% by Cleco.

Construction and O&M cost estimates for the sequestration wells was developed by Battelle Memorial Institute (Battelle) based on a preliminary FEED study specific to the proposed sequestration field identified for permanent storage of CO_2 captured from MU3. These costs correspond to an AACE Class 3 cost estimate.

Construction estimates for the transportation pipeline were developed by S&L based on the quantity of CO_2 being produced, the number of sequestration wells and the preliminary pipe route. These costs correspond to an AACE Class 4 cost estimate.

Property taxes were also developed internally based off Cleco's experience of location-based parish millage rates for this type of project.

The construction schedule was developed based off project team experience on other CO_2 capture projects and FEED studies where detailed cost estimates, execution plans, and constructability studies were completed and used to develop detailed project execution schedules.

The major driver of revenue associated with the project stems from the Internal Revenue Code Section 45Q. Section 45Q incentivizes investment in CO_2 capture and sequestration by providing a tax credit on a per metric ton of qualified carbon dioxide captured basis. Eligibility to claim this credit is tied to the party that owns the equipment and physically or contractually ensures the disposal, utilization, or use as a tertiary injectant of the CO_2. Cleco expects to qualify at the $85/tonne 45Q credit rate.

The CO_2 capture system is designed to capture 4.3M tonnes of CO_2 annually at an 80% capacity factor. At this rate, the project would generate more than $4 billion in credits over the 12-year life of the credits.

1.3 BUSINESS CASE SUMMARY

The model currently shows an IRR of 5.5%. This is largely a function of significant increases in capital costs since Cleco submitted its grant application, as well as an extended construction period.

In order to fund the project, Cleco met with several potential financial partners to review the project's business case analysis. However, according to the investors, an IRR less than 10% was not acceptable and declined involvement. Cleco has not been able to find any other investors that are interested in financing the project. Without financial investment outside of Cleco, Diamond Vault will not be viable.

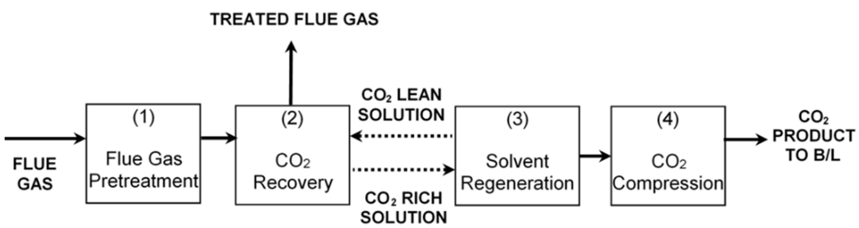
2. TECHNICAL OVERVIEW

The project will utilize Mitsubishi Heavy Industries' (MHI) Advanced Kansai Mitsubishi Carbon Dioxide Recovery Process (Advanced KM CDR Process™) to capture the CO_2 from the flue gas produced by Cleco's Madison Unit 3 at the Brame Energy Center. The Advanced KM CDR Process™ is an amine-based CO_2 capture process which uses a newly developed solvent known as KS-21™. The CO_2 capture system will recover 95% of the total CO_2 from the boiler flue gas compress and treat the CO_2 to adequate pipeline conditions. This system will produce a total of 14,657 tonnes/day of CO_2.

The flue gas is extracted from the outlet of the existing flue gas stack, which is fed by two circulating fluidized bed boilers. The boilers provide heat for a single steam turbine producing approximately 635MW. Flue gas is brought to the CO_2 capture facility by a new flue gas blower. CO_2 is recovered from the flue gas and the treated flue gas is emitted from the top of the CO_2 absorber. In the event of a CO_2 capture facility shutdown, the flue gas is emitted from the existing stack at the power plant.

The CO_2 capture system will consist of four main sections: 1) flue gas pretreatment, 2) CO_2 absorption, 3) solvent regeneration, and 4) CO_2 compression and dehydration. The following block flow diagram shows the system's configuration.

Figure 2-1. Block Flow Diagram of the CO_2 System



Mixed flue gas from the power plant first enters the Flue Gas Quencher. The Flue Gas Quencher is a rectangular tower with structured packing that has two important functions: (1) flue gas cooling and (2) SO_2 removal.

The efficiency of CO_2 absorption increases with lower temperatures, so the flue gas is cooled in a quencher tower before it enters the CO_2 absorber. The flue gas is cooled by direct contact with water on the surface of structured packing in the quencher. The circulating water is fed to the top of the packing and recirculated through the system by the flue gas cooling water pump, and the water is cooled by the flue gas cooling water coolers. Cooling of the flue gas generates large amounts of condensate that accumulates in the bottom of the quencher. Excess process condensate is discharged to the battery limit to maintain a stable liquid level in the quencher.

The flue gas blower is required to draw the flue gas from the existing plant to overcome the pressure drop across the flue gas quencher and CO_2 absorber.

The CO_2 absorber is a rectangular tower with packing. The CO_2 absorber has two main sections: (1) the CO_2 absorption section in the lower part and (2) the flue gas washing section in the upper part.

The cooled flue gas from the quencher is introduced into the bottom of the CO_2 absorber. The flue gas moves upward through the packing while the CO_2 lean solvent is supplied at the top of the absorption section packing. The flue gas contacts with the solvent on the surface of the packing where 95% of the CO_2 in the flue gas is absorbed by the solvent.

The cool CO_2-rich solvent from the bottom of the CO_2 absorber is sent through the solution heat exchanger to be pre-heated prior to the regenerator for CO_2 removal. As the treated flue gas exits the absorption section, it continues upward into the washing section of the CO_2 Absorber.

The regenerator is a cylindrical column with packing. The purpose of the regenerator is to recover the KS-21™ by removing the CO_2 using steam-stripping. The CO_2-rich solvent from the bottom of the CO_2 absorber is heated by the lean solvent from the bottom of the regenerator in the solution heat exchangers. The preheated rich solvent is introduced at the top of the packing in the regenerator. As the rich solvent flows down through the packing, it contacts with steam, which desorbs CO_2 from the solvent. The steam in the regenerator is produced by water content in the circulating solvent that is boiled using low pressure (LP) steam in the regenerator reboiler. The lean solvent from the bottom of the regenerator is sent back to the CO_2 absorber by the lean solution pump. The lean solvent exchanges heat with the cold, CO_2-rich solvent in the solution heat exchangers before being cooled to the optimum temperature by the lean solution cooler just before entering the regenerator.

The overhead vapor from the regenerator is sent to the regenerator reflux system and then to compression. The CO_2 compressor has multiple stages of compression split into a low pressure (LP) side and a high pressure (HP) side. After compression, the CO_2 is cooled by the final stage discharge cooler before it is transported to the pipeline.

2.1 TECHNOLOGY APPLICABILITY

The Advanced KM CDR Process has been applied or assessed on post-combustion point source flue gas across the power and industrial sectors. The technology is not directly applicable to nuclear or geothermal sector areas.

3. MARKET ANALYSIS

3.1 SURVEY OF RELEVANT CARBON EMISSIONS POINT SOURCES

When evaluating the scope of carbon emission point sources for the implementation of carbon capture technology, it is important to consider sources that significantly contribute to the carbon emissions footprint. These sectors include large-scale coal power plants, natural gas power plants, diverse industrial processes, and others such as oil and gas extraction operations.

Coal power plants, particularly those with a capacity exceeding 100 MW, are significant carbon emitters.

Natural gas power plants, while producing less CO_2 per unit of energy output compared to coal plants, are still substantial carbon emitters. Especially, facilities with capacities over 250 MW are suitable for carbon capture technology, which can further enhance their environmental efficiency and impact. However, carbon capture on natural gas facilities poses other challenges not seen in coal such as higher oxygen content, which causes solvent degradation. Furthermore, coal-fired flue gas contains more CO_2 and is thought to be a more economic choice per ton of CO_2 recovered.

Other industrial processes, including cement production, steelmaking, and chemical production, also release significant CO_2 amounts. Given their carbon output, these industries could benefit substantially from carbon capture technology implementation.

The oil and gas extraction industry is another noteworthy CO_2 emitter that could benefit from carbon capture technology. In these cases, the captured CO_2 may be utilized for enhanced oil recovery (EOR) operations, offering a dual benefit of reducing atmospheric emissions and improving extraction efficiency.

Overall, fossil fuel combustion, although CO_2 emissions-intensive, still accounts for about 66% of the existing energy generation capacity. Coal combustion contributes to approximately 18% of this generation capacity, while natural gas combustion provides around 45%. With post-combustion carbon capture technology, we have a commercially viable and available option to decarbonize these critical assets while maintaining grid stability.

The application of carbon capture technology is influenced by several factors, such as the presence of various air quality control equipment at the facility and access to suitable geological storage or a CO_2 off-taker. For instance, Cleco's Madison Unit 3, equipped with an SO_2 scrubbing system, NOx reducing technology, and particulate controls, has the essential infrastructure to accommodate the amine solvent-based post-combustion carbon capture process.

Also, proximity to potential CO_2 storage sites or industries that can utilize captured CO_2 enhances a project's feasibility. The Cleco facility is planning for the permanent geological storage of CO_2 captured from MU4 and seeks to acquire 45Q tax credits. In the region surrounding the facility, there is anticipated to be ample pore space for the recovered CO_2.

3.2 TECHNOLOGY APPLICABILITY TO SOURCES

Over the last few decades, the Department of Energy (DOE) has been developing post-combustion carbon capture technologies for a variety of emission sources, including coal-fired power plants. One of the challenges with coal-based sources is the presence of contaminants that are not typically found in applications like natural gas combined cycle (NGCC) power plants. The applicability of carbon capture technology to different emission point sources depends on the presence of such contaminants. For coal-based power facilities, it is essential that the facility has a full air quality control system (AQCS) in place. While this is also important for NGCC facilities, the primary concern in those cases is NOx.

Amine-based post-combustion capture technologies have emerged as the most robust solutions, according to DOE's research and market trends. The proposed project aims to demonstrate that amine-based capture can achieve 95% reductions in CO2 emissions on a significantly larger scale using the advanced MHIA solvent, KS-21™.

By demonstrating the effectiveness of the solvent and design in reducing CO_2 emissions more cost-effectively from existing fossil-based assets, a pathway towards decarbonization can be paved while maintaining baseload electric supply. Full-scale deployment of this technology on coal-fired boilers and other applications will contribute to the United States' greenhouse gas reduction goals, which include achieving a net-zero economy by 2050, a carbon pollution-free power sector by 2035, and a fifty percent reduction from 2005 levels in economy-wide net greenhouse gas emissions by 2030.

The KM CDR Process™ has already been demonstrated to be applicable to coal-fired power plants, as evidenced by the successful Petra Nova project in Texas. This technology can be retrofitted to existing coal plants or incorporated into new plants during construction. Additionally, the technology can be adapted for use in natural gas power plants and other industrial processes that produce large quantities of CO_2. Given the proven success at Petra Nova and the versatility of the amine-based CO_2 capture technology, it is expected to be universally applicable across various point sources of carbon emissions, with a priority for those that already have environmental controls in place.

3.3 FINANCIAL ANALYSIS OF TECHNOLOGY APPLICABILITY TO SOURCES

For a financial analysis of CO_2 capture technology, several critical components need to be considered. First, the cost of installation and implementation of the technology must be accounted for. CO_2 capture technologies have high upfront costs. However, the advantage of amine-based capture lies in its maturity, as it has already been proven at large scale. The well-established technology does not require as much margin in equipment design, thus reducing the overall financial risk relative to new, unproven technologies.

In terms of operational costs, it is essential to consider both the energy requirement and the maintenance cost of the CO_2 capture system. Amine-based systems are relatively energy-intensive compared to some developing technologies, which can increase the relative operational costs. However, these costs are partially justified due to the amine's ability to achieve high removal ratios. For instance, amine-based capture, specifically MHIA's KS-21™ solvent, has been demonstrated to remove up to 99.8% of the CO_2 entering the capture plant. This was a result of MHIA's testing at the Technology Centre Mongstad in 2021. However, the economic optimum is calculated to be approximately 95%, which is where MHI will design. Additionally, because amine systems are so common, do not require high pressures, and contain no unproven rotating equipment, the maintenance cost for amine-based systems may be lower than that of less mature technologies.

For Cleco's Madison Unit 3, the application of MHIA's Advanced KM CDR Process™ is anticipated to be cost-effective in the long run. The existing infrastructure at the facility, including an SO_2 scrubbing system, NOx reducing technology, and particulate controls, reduces the need for significant pretreatment requirements. This pre-existing infrastructure complements the carbon capture process, thus reducing the overall cost of implementation. Additionally, the proximity of the plant to potential CO_2 storage sites and industries that can utilize captured CO_2 benefits the viability of the project.

3.4 POTENTIAL FINANCING STRUCTURES AND PARTNERSHIPS

Financing CO_2 capture projects can be complex due to the diversity of involved parties and the unique characteristics of the technology. The financing structure generally depends on who is leading the project, whether it be developers, emitters, consortiums, or others, and it may change throughout the project's lifetime. In some cases, the technology provider may play a role in ownership or development of the project.

For projects led by developers, they may choose to form a special purpose vehicle (SPV), where the developer and investors create a new entity solely for the purpose of the carbon capture project. This structure shields the parent companies from the financial risks associated with the project. The SPV can issue both debt and equity to finance the project. Debt financing can be in the form of loans, bonds, or other debt instruments, with the SPV's assets used as collateral. Equity financing allows investors to own a stake in the SPV, giving them a share in the project's profits. This type of structure is particularly useful when there are multiple parties involved, such as in consortium-led projects.

Emitters may choose to self-finance or partner with external financiers to fund their carbon capture projects. This approach allows the emitter to retain control over the project while sharing the financial risk. It can be attractive to emitters that have a strong balance sheet and an ability to absorb some of the project risk. They may also choose to enter into a partnership with other emitters, forming a consortium to share the costs and benefits of the project.

One possible structure in a consortium-led project involves forming a joint venture (JV), where multiple parties contribute equity and share the project's profits and losses. This structure can be beneficial when the project requires a broad set of skills or resources that no single party possesses. Alternatively, a consortium could form an SPV, similar to a developer-led project, to isolate the financial risks.

For project finance, it is typical to see a higher portion of debt in the capital structure, sometimes up to 70-80%, due to the large capital requirements and the long-term nature of carbon capture projects. Lenders usually provide non-recourse or limited recourse loans, where the debt is serviced solely by the project’s cash flow and secured by the project’s assets.

In terms of equity financing, the investment can come from a variety of sources, including private equity funds, infrastructure funds, sovereign wealth funds, or even corporations that are interested in the carbon capture sector. The equity investors will bear the brunt of the risk, but they also stand to gain the most if the project is successful.

For U.S. projects, tax equity financing is an attractive option due to the availability of the 45Q tax credit. However, the structure of these tax equity deals can be complex, especially considering the direct pay provision for the first five years, and then the necessity of tax equity involvement for the next seven years. In these cases, the tax equity investor contributes capital in exchange for a significant portion of the project’s tax benefits.

For entities like electric cooperatives that can access 45Q direct pay for the entire 12-year period, the structure can be more straightforward. They can leverage this extended direct pay provision to attract more equity investment or secure better debt financing terms.

It is crucial to mention the role of power purchase agreements (PPAs) or carbon offtake agreements in these financing structures. These long-term agreements between the project and an offtaker can provide a guaranteed revenue stream, making the project more attractive to both debt and equity investors. These agreements can be particularly valuable for emitter-led projects, where the emitter is also the offtaker of the captured carbon.

The optimal financing structure for a carbon capture project will depend on a variety of factors, including the type of entity leading the project, the specific characteristics of the project, the availability of tax credits and other incentives, and the market conditions. It is often a combination of debt and equity financing, with the possibility of tax equity financing for projects in the U.S.

3.5 TAX CREDITS AND OTHER INCENTIVES

3.5.1 45Q Carbon Capture

The Section 45Q tax credit was extensively changed in a variety of ways by the Inflation Reduction Act (IRA), primarily on changes to the definition of eligible facilities and the credit rate. Based on the changes, Diamond Vault will be an eligible project to receive Section 45Q tax credits at the $85/tonne unescalated for 12 years. A summary of the eligibility requirements and the characteristics of Diamond Vault are provided in Table.

Section 45Q Eligibility Requirement	Diamond Vault Design / Characteristics
Design capacity of not less than 75% of the carbon oxide production of that unit.	The capture system is designed to capture 95% of the CO_2 in the flue gas from MU3.
Capture at least 18,750 metric tons of qualified carbon oxide during the taxable year.	The facility is expected to capture 4.3M tonnes/year after COD.
Wage and Apprenticeship Requirements for 5x Bonus	Cleco intends to meet the wage and apprenticeship requirements in order to qualify for this bonus, this is included as part of the project execution strategy.
Construction Qualification Dates, After the date the IRA is enacted and before December 31, 2032.	The project is currently expected to begin construction in Q1 2026, which is within the specified date range.

3.5.2 Other Incentives

In addition to tax credits, Cleco believed there may be an opportunity to register our carbon reduction with American Carbon Registry, Verra, or another similar entity to verify and serialize this carbon reduction. This would then allow us to sell these Emission Reduction Tonnes (ERTs) on an established market. However, after discussions with consultants and brokers: 1) we found it extremely difficult to estimate a sales price, 2) many buyers are not interested in ERTs coming from coal-fired plants, 3) the ERTs from this project might flood the market, and 4) in the end these markets are still emerging, and thus, without more certainty, the current business case does not account for any income or financial incentives associated with the voluntary credit market at this time. Finally, Section 111(d) of the Clean Air Act will require plants to reduce their CO_2 emissions, no longer making the ERTs a viable revenue stream.

4. FUTURE DEPLOYMENT PROJECTION

4.1 POTENTIAL DEPLOYMENT SCALE OF TECHNOLOGY

The potential deployment scale of carbon capture technology, specifically amine-based post-combustion capture systems like the Advanced KM CDR Process™, applied to coal-based power plants is substantial. There are numerous coal-fired power plants in operation worldwide, and many of these plants are major contributors to greenhouse gas emissions. Implementing carbon capture technology on a large scale in these plants could significantly reduce CO_2 emissions and help countries achieve their climate goals.

Retrofitting existing coal-fired power plants with carbon capture systems can provide an immediate impact on emissions reduction, while new coal plants can integrate the technology during the design and construction phase. The Advanced KM CDR Process™ has already demonstrated its applicability to coal-fired power plants, as evidenced by the successful Petra Nova project in Texas.

The global market for coal-based power plants remains significant, particularly in developing countries where coal is still a dominant source of energy. As countries work towards meeting their greenhouse gas reduction targets, the demand for carbon capture technologies in these regions is likely to increase. In addition to coal-fired power plants, the KM CDR Process™ can be adapted for use in natural gas power plants and other industrial processes that produce large quantities of CO_2. This versatility further expands the potential deployment scale of the technology across various sectors and industries.

4.2 COMPETING TECHNOLOGY OPTIONS

Carbon capture technologies can be broadly categorized into several competing approaches, each with its advantages and drawbacks. These are described below.

Amine solvents: Amine-based carbon capture is a widely studied and commercially proven technology, as demonstrated by the Petra Nova project in Texas. It involves the use of amine solutions to selectively absorb CO_2 from flue gas. The primary advantage of amine-based systems is their high CO_2 capture efficiency. However, they can also produce amine degradation compounds, which may include volatile organic compounds (VOCs), and tend to have higher energy requirements for solvent regeneration. MHI's technology leads this category because they have the most extensive experience in the industry, accounting for approximately 70% of the total post-combustion capture market share.

Non-aqueous solvents: These carbon capture systems use solvents that are not water-based, such as ionic liquids or organic solvents. Non-aqueous solvents typically have lower vapor pressures, which can reduce energy consumption during the solvent regeneration process. They may also exhibit higher CO_2 absorption capacities and greater resistance to degradation compared to aqueous amine solvents. Furthermore, by removing water, regeneration energies can be significantly reduced. However, non-aqueous solvents are generally less studied, and their long-term stability and environmental impact are not yet fully understood.

Sorbents: Solid sorbents, such as metal-organic frameworks (MOFs) and zeolites, can also be used to capture CO_2 from flue gas. The main advantages of sorbent-based systems include their lower energy requirements for regeneration and the potential for higher CO_2 capture capacities compared to amine-based systems. However, challenges in developing suitable sorbent materials with the desired combination of properties, such as high selectivity, stability, and cost-effectiveness, still need to be overcome. Additionally, the scalability of sorbent-based systems has yet to be demonstrated at a large scale, and further research is needed to optimize these technologies for various industrial applications.

Membranes: Membrane-based carbon capture systems involve the use of selectively permeable materials that allow CO_2 to pass through while retaining other gases. These systems have the potential to be more energy-efficient than amine-based systems, as they do not require thermal regeneration. However, current membrane materials may not have the desired combination of high selectivity, permeability, and mechanical stability. Developing more advanced membrane materials and improving their long-term durability remains a key area of research.

Cryogenic carbon capture: This technology involves cooling the flue gas to extremely low temperatures, causing the CO_2 to condense and separate from the other gases. The primary advantage of cryogenic carbon capture is its potential for very high capture efficiencies, with some systems claiming to capture over 99% of the CO_2. However, the high energy requirements for cooling the flue gas and the complexity of managing the cryogenic process can present significant challenges. Additionally, the scalability and cost-effectiveness of cryogenic carbon capture systems have yet to be demonstrated at a large scale.

MHI is the leading company in post-combustion carbon capture and will participate in this project to help achieve wide-scale greenhouse gas emission reduction by introducing its globally adopted high-performance CO_2 capture technology. MHI's KM-CDR Process™ has been adopted for fifteen (15) commercial plants all over the world (as of April 2023). This process has several outstanding features; (1) Can be applied to various types of flue gas sources, (2) Advanced energy saving process - significant operation cost savings, (3) Highly efficient proprietary solvents, which have the lowest energy consumption and the least degradation in industrial use. The specific characteristics of MHI's KS-21™ solvent enable it to absorb CO_2 more effectively than other solvents in use in commercial applications. It also degrades at a higher temperature as compared to most solvents and has a lower vapor pressure which leads to reduced solvent losses.

4.3 POTENTIAL BARRIERS TO LARGE-SCALE DEPLOYMENT

One of the barriers to large-scale deployment of amine-based carbon capture technologies is the potential emission of amine degradation compounds, which may include volatile organic compounds (VOCs). As the scale of the facility increases, so does the concern for these emissions. Ensuring that these degradation products are adequately managed and mitigated will be crucial for the environmental safety and public acceptance of large-scale carbon capture projects. Research into alternative solvents and improvements in capture processes may help address this issue.

Another challenge is the continued reduction in the cost of renewable energy sources. As renewable energy and energy storage technologies become more affordable, they may increasingly be seen as more viable options for baseload power compared to fossil fuels with carbon capture. This shift could reduce the demand for carbon capture technologies in the power generation sector, making it more difficult to justify the cost of large-scale projects.

Public perception of large-scale carbon capture projects can also present a barrier to their widespread deployment. The process of injecting captured CO_2 underground can raise concerns about potential environmental risks, such as groundwater contamination, induced seismic activity, or leakage. Addressing these concerns requires extensive communication with local communities, rigorous environmental monitoring, and the implementation of appropriate safety measures to ensure public trust in the technology.

Securing project financing for large-scale carbon capture initiatives can also be challenging due to the high capital costs and perceived risks associated with such projects. Potential investors may be hesitant to commit billions of dollars to carbon capture projects, especially if they are uncertain about future regulatory environments or the long-term viability of fossil fuel-based power generation. To overcome this barrier, public-private partnerships and government incentives could play a crucial role in helping to de-risk and finance these projects.

Lastly, supply chain constraints can limit the development of large-scale carbon capture facilities. The procurement of equipment, solvent, labor, and materials can be a complex and time-consuming process, especially for projects of this magnitude. Delays or difficulties in obtaining essential components can lead to increased costs and prolonged project timelines. To address these challenges, it is essential to establish strong relationships with suppliers, develop contingency plans for potential disruptions, and ensure that a skilled workforce is available to support the construction and operation of the facility.

In addition to these barriers, regulatory and permitting issues may also impact the large-scale deployment of amine-based carbon capture technologies. Navigating complex regulatory frameworks and obtaining the necessary permits for CO_2 storage and transportation can be a lengthy and costly process. Streamlining regulations and providing clearer guidelines for carbon capture projects could help alleviate these challenges and encourage more widespread adoption of the technology.

In summary, barriers to large-scale deployment of amine-based carbon capture technologies include concerns about emissions and degradation compounds, competition from renewable energy sources, public perception issues, challenges in securing project financing, and supply chain constraints. Addressing these barriers will require a combination of technological innovation, effective communication and engagement with stakeholders, supportive regulatory environments, and creative financing strategies. By overcoming these challenges, carbon capture technologies can play a critical role in mitigating climate change and supporting the transition to a low-carbon economy.

5. QUANTIFIED POTENTIAL BENEFITS OF TECHNOLOGY

Carbon capture technology offers a range of potential benefits that can significantly contribute to global efforts to combat climate change and improve energy security. One of the primary benefits of carbon capture is its ability to facilitate low-carbon baseload power generation. As noted previously, fossil-fuel-based power plants account for 66% of the current power generating capacity, CO_2 capture on this sector would have a significant impact on the path to net zero carbon goals. By capturing and storing CO_2 emissions from power plants, carbon capture technology allows for the continued use of reliable, baseload power sources like natural gas and coal-fired power plants, while significantly reducing their greenhouse gas emissions. This helps to maintain grid stability and reduces the risk of power blackouts, which can save lives and prevent substantial economic losses. In regions with extreme weather conditions, reliable baseload power is crucial to ensure the continuous operation of critical infrastructure like hospitals, emergency services, and transportation networks.

Another significant benefit of carbon capture technology is job creation. The development, construction, operation, and maintenance of carbon capture facilities can generate tens or hundreds of thousands of high-wage jobs over time. These jobs span a wide range of disciplines, including engineering, construction, operations, maintenance, and research and development. The growth of the carbon capture industry can contribute to regional economic development, particularly in areas with a strong fossil fuel industry presence, by providing new employment opportunities and helping to transition workers from traditional energy sectors to low-carbon technologies.

Moreover, carbon capture technology can play a vital role in decarbonizing hard-to-abate industrial sectors, such as cement, steel, and chemical production. These industries emit significant amounts of CO_2 as part of their production processes, and alternative low-carbon solutions may not be readily available or economically viable. By deploying carbon capture technology in these sectors, it becomes possible to reduce their greenhouse gas emissions without compromising production output or competitiveness. This enables a more sustainable and climate-friendly growth trajectory for these critical industries, while also helping to achieve national and international emissions reduction targets.

APPENDIX G. ENVIRONMENTAL HEALTH AND SAFETY ANALYSIS

Department of Energy (DOE)
Office of Fossil Energy (FE)

CLECO PROJECT DIAMOND VAULT CARBON CAPTURE FEED STUDY

DE-FE0032165

INITIAL ENVIRONMENTAL, HEALTH, AND SAFETY ASSESSMENT

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DISCLAIMER

1. INTRODUCTION

The purpose of the Environmental, Health & Safety (EH&S) Assessment is to evaluate the environmental friendliness and safety of the proposed carbon dioxide (CO_2) capture project based on a review of the materials and processes being proposed under DE-FE0032165. EH&S issues associated with the CO_2 capture project include potential exposure to hazardous chemicals and materials used in the process, ancillary or incidental air and water emissions, and solid wastes generated by the process. The EH&S Assessment includes: (1) a description of potential ancillary or incidental air and water emissions and solid wastes produced from the proposed technology; (2) a description of the toxicological effects of the substances identified above; (3) properties of the substances related to volatility, flammability, explosivity, other chemical reactivity, and corrosivity; (4) compliance and regulatory implications of the proposed technology with reference to applicable U.S. EH&S laws and associated standards; (5) an engineering review of potentially hazardous materials to look for ways their use can be eliminated or minimized; and (6) precautions for safe handling and conditions for safe storage of potentially hazardous material.

2. ANCILLARY OR INCIDENTAL AIR AND WATER EMISSIONS AND SOLID WASTES

This section identifies potential ancillary or incidental air and water emissions associated with the carbon capture process, and a description of the solid wastes anticipated to result from Project Diamond Vault (PDV).

2.1 AIR EMISSION AND WATER EMISSIONS

2.1.1 Carbon Capture Facility

The Mitsubishi Heavy Industries Americas, Inc. (MHIA's) CO_2 capture system uses their proprietary amine solvent, KS-21. Based on preliminary evaluations, the CO_2 capture system would remove 95% of the CO_2 in the treated flue gas, reducing emissions by 4,300,000 tonnes/year from Cleco's Madison Unit 3. Because the flue gas will be scrubbed with an amine solvent a small quantity of residual amine and/or degradation of the amine solvent will carry over in the exhausted effluent and be released in the atmosphere. It is anticipated that this carryover will be characterized as volatile organic compounds (VOCs).

An amine handling and storage system will be included in the project to supply make-up solvent to the system. Fugitive VOC emissions from the handling and storage would potentially be released into the atmosphere.

A caustic solution will be used to pre-treat the flue gas as part of the CO_2 capture system. No emissions would be expected for normal storage and handling. Fugitive emissions from the handling and storage would potentially be released into the atmosphere.

2.2 WATER UTILIZATION

2.2.1 Carbon Capture Facility

A new once-through cooling system will be used to supply heat rejection to the CO_2 capture system. Water will be supplied and returned to Lake Rodemacher, increasing the overall heat rejected to the lake. Lake Rodemacher is a cooling impoundment designed and constructed specifically for use by the facility for heat dissipation. The heat rejection to Lake Rodemacher after installation of the CO_2 capture system is estimated to increase the current MU3 heat rejection loads by approximately 40%. S&L has recommended that thermal modeling be performed to verify that the additional load will not impact intake temperatures or the outfall to Bayou Jean de Jean. Heat exchangers are expected to be designed such that any total suspended solids from the materials of construction are limited.

Flue gas entering the CO_2 capture system will be cooled in a direct contact cooler (DCC) at which point moisture in the flue gas will condense. A blowdown stream will be generated to avoid build-up of particulates. This stream is relatively clean and is not expected to require treatment to meet current Louisiana Pollutant Discharge Elimination System (LPDES) limits and discharged to Lake Rodemacher.

2.3 WASTE STREAMS

2.3.1 Carbon Capture Facility

The CO_2 capture system will produce a small quantity of spent solvent. The spent solvent is expected to be either a solid or liquid waste stream. The quantity and composition of the waste solvent produced from the CO_2 capture facility has not yet been characterized as it requires flue gas testing. This waste stream will be appropriately disposed of offsite based on the classification.

3. TOXICOLOGICAL EFFECTS OF SUBSTANCES IDENTIFIED

The following subsections provide a concise description of the various toxicological effects of the primary substances identified in Section 2. Toxicological information provided below was determined based on a literature search conducted to examine potential human health effects and ecotoxicity, and a review of Safety Data Sheets (SDS) available for each substance.

3.1 KS-21 SOLVENT

The KS-21 solvent is a proprietary amine solution developed by MHIA. Due to the proprietary nature of the product, the SDS data is available to the end user only after execution of the requisite NDAs and confidentiality agreements.

3.2 CAUSTIC SOLUTION

Table 3-1 lists the toxicological information of the caustic solution on the SDS. Table 3-2 lists the ecological information of the caustic solution on the SDS.

Table 3-1: Caustic Toxicological Information

Hazard Class	Associated Hazard Category
Irritation	No information available
Sensitization	No information available
Carcinogenicity	Not listed for IARC, NTP, ACGIH, OSHA or Mexico
Mutagenicity	No information available
Reproductive toxicity	No information available

Hazard Class	Associated Hazard Category
Teratogenicity	No information available
Specific target organ exposure	Single exposure: respiratory system repeated exposure: non known
Aspiration hazard	No information available
Endocrine disruptor information	No information available
Physical symptoms / effects (acute & delayed)	Product is a corrosive material. Use of gastric lavage or emesis is contraindicated. Possible perforation of stomach or esophagus should be investigated: Ingestion causes severe swelling, severe damage to the delicate tissue and danger of perforation
Other adverse effects	The toxicological properties have not been fully investigated.

Table 3-2: Caustic Ecological Information

Hazard Class	Associated Hazard Category
Toxicity to aquatic species	Not listed (algae, microtox, or water flea) LC50 (Oncorhynchus mykiss (fish)): 45.4 mg/L, 96h static
Persistence and degradability	Not established
Bio accumulative potential	Not established
Mobility in Soil	Will likely be mobile in the environment due to its water solubility
Additional ecological information	Do not empty into drains. Large amounts will affect pH and harm aquatic organisms. Contains a substance which is: Harmful to aquatic organisms. The product contains following substances which are hazardous for the environment.

3.3 COMPRESSED CARBON DIOXIDE (CO_2)

Table 3-3 lists the toxicological information of compressed CO_2 listed on the SDS. Table 3-4 lists the ecological information of CO_2 found on the SDS. While not listed as a hazard class, in general CO_2 is an asphyxiant and should not be inhaled.

Table 3-3: Carbon Dioxide Toxicological Information

Hazard Class	Associated Hazard Category
Irritation	No information available
Sensitization	No information available
Carcinogenicity	No information available
Mutagenicity	No information available
Reproductive toxicity	No information available
Teratogenicity	No information available
Specific target organ exposure	Single exposure: No information available repeated exposure: No information available
Aspiration hazard	No information available
Endocrine disruptor information	No information available
Other adverse effects	Avoid breathing gas

Table 3-4: Carbon Dioxide Ecological Information

Hazard Class	Associated Hazard Category
Toxicity to aquatic species	No information available

Hazard Class	Associated Hazard Category
Persistence and degradability	No information available
Bio accumulative potential	$LogP_{ow}$: 0.83 Potential: Low
Mobility in Soil	No information available
Additional ecological information	No known significant effects or critical hazards

3.4 RECLAIMED WASTE

Waste from the reclaimer unit is comprised of KS-21 solvent, water, salts, and organic compounds. A detailed SDS has not been developed for this waste stream as it will not be fully characterized until the CO_2 capture system is in operation. A preliminary waste characterization datasheet for the waste stream is not available. The waste is expected to be a liquid solution comprised of mostly water. The hazards, toxicity, and ecological impacts associated with this mixture is assumed to be no more severe than that of the component described in Section 3.1.

3.5 OTHER CHEMICALS

In addition to the chemicals previously discussed in detail, based on preliminary design considerations, it is anticipated the following chemicals will be used at the facility:

- Anti-foam chemical
- Dehydration catalyst chemical

Specific anti-foam and dehydration catalyst chemicals have not been selected at this time but are not anticipated to pose severe health or environmental risks with proper handling and use.

4. COLLECTION OF DATA ON VOLATILITY, FLAMMABILITY, EXPLOSIVITY, CHEMICAL REACTIVITY, AND CORROSIVITY

Information related to volatility, flammability, explosivity, other chemical reactivity, and corrosivity associated with each of the substances identified in Section 3 is provided in the following subsections.

4.1 KS-21 SOLVENT

The KS-21 solvent is a proprietary amine solution developed by MHIA. Due to the proprietary nature of the product, the SDS data is available to the end user only after execution of the requisite NDAs and confidentiality agreements.

4.2 CAUSTIC SOLUTION

Table 4-1 lists the chemical properties data provided by a SDS for a typical caustic solution.

Table 4-1: Chemical Properties of Caustic Solution

Parameter	Description
Flammability	Not applicable
Explosivity	No data available

Parameter	Description
Reactivity	No dangerous reactions known under normal conditions of use
Chemical Stability	Stable under normal conditions
Possibility of hazardous reactions	No dangerous reactions known under normal conditions of use
Conditions to avoid	Excess heat and incompatible materials
Incompatible materials	Acids, organic materials, and metals
Hazardous decomposition products	Sodium oxides
Corrosivity	Corrosive to metals

4.3 COMPRESSED CARBON DIOXIDE (CO_2)

Table 4-2 lists the chemical properties data provided on the SDS for compressed carbon dioxide.

Table 4-2: Chemical Properties of Compressed CO_2

Parameter	Description
Flammability	No data available
Explosivity	No data available
Reactivity	No specific test data related to reactivity available for this product or its ingredients
Chemical Stability	Stable under normal conditions
Possibility of hazardous reactions	No dangerous reactions known under normal conditions of use
Conditions to avoid	No specific data
Incompatible materials	No specific data
Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.
Corrosivity	No data available

4.4 RECLAIMED WASTE

Waste from the reclaimer unit is comprised of KS-21 solvent, water, salts, and organic compounds. A detailed SDS has not been developed for this waste stream as it will not be characterized until the CO_2 capture system is in operation. A preliminary waste characterization datasheet for the waste stream is not available. The chemical properties associated with this mixture is assumed to be no more severe than that of the component described in Section 4.1.

4.5 OTHER CHEMICALS

Specific anti-foam and dehydration catalyst chemicals have not been selected at this time but are not anticipated to pose severe health or environmental risks with proper handling and use.

5. EH&S COMPLIANCE AND REGULATORY IMPLICATIONS

The potential federal environmental laws and regulations for which compliance will be necessary for the CO_2 capture system include, but are not limited to, the following:

- Comprehensive Environmental Response and Liability Act of 1980 (CERCLA)
- Toxic Substances Control Act (TSCA)

- Clean Water Act (CWA)
- Clean Air Act (CAA)
- Safe Drinking Water Act – UIC Class VI
- Resource Conservation and Recovery Act (RCRA)
- National Environmental Policy Act (NEPA)
- Superfund Amendments and Reauthorization Act (SARA) Title III
- and the Occupational Safety and Health Act (OSHA)

Design standards that apply to the process equipment include, but are not limited to:

- Compressed Gas Association (CGA) standards
- National Fire Protection Association (NFPA) standards

Installation and operation of the carbon capture equipment will be subject to a number of EH&S laws and regulations. Environmental and social impacts resulting from the proposed project will be subject to review and evaluation under the National Environmental Policy Act (NEPA). Environmental permits or approvals will be required for new project-related air emissions, wastewater discharges, and solid waste management and disposal. The use and storage of hazardous chemicals will be subject to applicable OSHA health and safety standards. A brief description of the compliance and regulatory implications of the proposed technology is provided in the following subsections.

5.1 NATIONAL ENVIRONMENTAL POLICY ACT

NEPA requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions. The range of federal actions covered by NEPA is broad and includes the federal rulemaking and regulatory process, decisions on permit applications and issuing federal permits, and similar actions undertaken by federal agencies. Title II of NEPA established the Council on Environmental Quality (CEQ) to oversee NEPA implementation. The duties of CEQ include issuing regulations and other guidance to federal agencies regarding NEPA compliance and ensuring that federal agencies meet their NEPA obligations. Many federal agencies, including the Department of Energy, have developed their own NEPA implementation procedures that implement and supplement CEQ regulations at 40 CFR Parts 1500 – 1508.

Project proponents will work closely with the DOE to assess potential environmental and social impacts associated with the proposed project, and to identify, to the extent possible, alternatives available to mitigate or eliminate potential impacts.

5.2 AIR EMISSIONS

As described in Section 2.1.1, treated flue gas will be emitted to atmosphere from the absorber column. Emissions from the absorber column include de-carbonized flue gas with the presence of VOCs. Under both federal and state air quality regulations a construction permit will be required prior to construction of the new emissions source. The type of construction permit required for the project will depend upon the type and quantity of project-related emissions.

Air emissions from the CO_2 capture system will be monitored to ensure compliance with all applicable federal and state emissions standards.

5.3 WASTEWATER DISCHARGE

The National Pollutant Discharge Elimination System (NPDES) permit program, created in 1972 by the Clean Water Act (CWA), addresses water pollution by regulating point sources that discharge to waters of the United States. Under the CWA, EPA authorizes the NPDES permit program to state, tribal, and territorial governments.

As described in Section 2.3, operation of the carbon capture process will increase wastewater discharge from the facility. Changes to the facility's wastewater flow and characteristics will likely require a major modification to the facility's existing LPDES wastewater discharge permit. However, due to the marginal change in water quality being sent to Lake Rodemacher, it is expected that the facility's existing operations and wastewater discharges will not be impacted. If LPDES permit modifications are required, normal facility operations will be able to continue while the permit is being modified.

5.4 SOLID WASTES

As described in Section 2.3, operation of the carbon capture system will result in the generation of solid wastes. Solid wastes generated by the carbon capture system will be characterized in accordance with the requirements of 40 CFR Section 261 and associated Louisiana regulations. Byproducts generated by the process will be classified as either non-waste byproducts for use in commerce or solid wastes designated for disposal. Solid wastes will be classified as non-hazardous solid wastes subject to the RCRA Subpart D standards (and associated state solid waste standards), while solid wastes exhibiting one or more hazardous waste characteristic or listed as a hazardous waste will be subject to the RCRA Subpart C standards (and associated state hazardous waste standards).

All solid wastes generated at by the carbon capture process will be properly characterized, managed, stored, and treated, recycled, or disposed of off-site at properly permitted facilities in accordance with applicable Federal, state, and local regulations.

5.5 OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Operation of the carbon capture process is not expected to trigger hazardous chemical storage and handling regulatory requirements mandated by the EPA and OSHA.

6. ENGINEERING ANALYSIS OF HAZARDOUS MATERIALS

An engineering analysis will be conducted during the detailed design phase of the project to assess potential alternatives to hazardous materials used or produced by the carbon capture process, and to look for ways their use can be eliminated or minimized. Results of a preliminary engineering analysis are summarized below.

6.1 KS-21 SOLVENT

The basis of the process is the specific, proprietary amine solvent, KS-21. No alternatives are deemed appropriate for evaluation.

6.2 CAUSTIC SOLUTION

No alternatives are deemed appropriate for evaluation.

6.3 COMPRESSED CARBON DIOXIDE (CO_2)

Carbon dioxide is the product of the project and therefore cannot be avoided.

6.4 RECLAIMED WASTE

Reclaimed waste is a by-product of the project and therefore cannot be avoided.

7. HANDLING AND STORAGE SAFETY PRECAUTIONS

Personal protection equipment for KS-21 solvent, caustic solution, and CO_2 are listed in Table 7-1.

Table 7-1: Personal Protection Equipment

Parameter	Description
Eye protection	Wear eye/face protection
Skin and body protection	Wear suitable protective clothing
Respiratory protection	Air Purifying Half Mask Respirators with multi-gas / vapor cartridge type (Respirator Filter Cartridges 6006 in 6000 Series, produced by 3M, VWR or G08E Multi-Gas (ABEK) Cartridge Filter by GERSON)
Hand protection	Wear suitable gloves resistant to chemical penetration

7.1 KS-21 SOLVENT

The KS-21 solvent is a proprietary amine solution developed by MHIA. Due to the proprietary nature of the product, the SDS data is available to the end user only after execution of the requisite NDAs and confidentiality agreements.

7.1.1 Handling

When handling the KS-21 solvent, obtain special instructions before use. Do not handle until all safety precautions have been read and understood. The following precautions should be taken for safe handling:

- Do not breathe dust, fume, gas, mist, vapors, or spray
- Do not eat, drink, or smoke when using this product
- Do not swallow
- Do not get in eyes, on skin, or on clothing
- Handle and open container with care
- Use only in well ventilated areas

7.1.2 Storage

The following precautions should be taken for safe storage:

- Keep out of the reach of children
- Store locked up
- Store in original container
- Keep container tightly closed, dry and in a well-ventilated place
- Store in a cool and shaded area. Keep in an area equipped with alkali and solvent resistant flooring
- Keep away from food, drink, and animal feeding stuffs

7.1.3 Accidental Release Measures

In the event of an accidental release, the following measures should be taken:

- Use personal protection recommended
- Isolate the hazard area and deny entry to unnecessary and unprotected personnel
  - Non-emergency personnel should not touch or walk on the spilled product
  - Emergency responders should evacuate all non-essential personnel
- Ventilate area
- Prevent entry to sewers and public waters

For containment, emergency personnel should stop leak if safe to do so. The spill should be absorbed and/or contain spill with inert material such as sand, vermiculite, or other appropriate material, then placed in suitable container. The solvent should not be flushed into surface water or sewer system. The spill should be swept or shoveled into appropriate container for disposal and then the contaminated surfaces should be cleaned thoroughly.

7.2 CAUSTIC SOLUTION

This section describes the safe handling and storage for the caustic solution.

7.2.1 Handling

While handling the caustic, handle only under a chemical fume hood and follow the listed precautions:

- Wear personal protective equipment and face protection
- Do not get in eyes, on skin, or on clothing
- Do not breathe mist/vapors/spray
- Do not ingest. If swallowed, then seek immediate medical assistance

7.2.2 Storage

While storing the caustic, keep containers tightly closed in a dry, cool, and well-ventilated place. Identify storage area as “Corrosives Area”. Do not store near incompatible materials including acids, organic materials, or metals.

7.2.3 Accidental Release Measures

In the event of an accidental release, the following measures should be taken:

- Isolate the hazard area and deny entry to unnecessary and unprotected personnel
    - Non-emergency personnel should not touch or walk on the spilled product
    - Emergency responders should evacuate all non-essential personnel
- Wear self-contained breathing apparatus and protective suit
- Ensure adequate ventilation
- Do not get in eyes, on skin, or on clothing
- Avoid release to the environment
- Prevent entry to sewers and public waters
- Report the release to the appropriate State and Federal Agencies if the amount of material released exceeds the reportable quantity threshold and/or creates an emergency condition

For containment, emergency personnel should stop leak if safe to do so. The spill should be absorbed and/or contain spill with inert material and then placed in suitable container. The solvent should not be flushed into surface water or sewer system. The spill should be swept or shoveled into appropriate container for disposal and then the contaminated surfaces should be cleaned thoroughly.

7.3 COMPRESSED CARBON DIOXIDE (CO_2)

This section describes the safe handling and storage for compressed CO_2.

7.3.1 Handling

The compressed CO_2 will be immediately transported via pipeline.

7.3.2 Storage

The compressed CO_2 will not be stored prior to being transported for sequestration; it will be immediately transported via pipeline to the injection well.

7.3.3 Accidental Release Measures

In the event of an accidental release, the following measures should be taken:

- Isolate the hazard area and deny entry to unnecessary and unprotected personnel
    - Emergency responders should evacuate all non-essential personnel
- Avoid breathing and ventilate area
- Stop leak if safe to do so
- Prevent entry to sewers and public waters
- Report the release to the appropriate State and Federal Agencies if the amount of material released exceeds the reportable quantity threshold and/or creates an emergency condition

7.4 RECLAIMED WASTE

Waste from the reclaimer unit is comprised of KS-21 solvent, water, salts, and organic compounds. A detailed SDS has not been developed for this waste stream as it will not be characterized until the CO_2 capture system is in operation. A preliminary waste characterization datasheet for the waste stream is not available for PDV, however, this information may be available from MHIA based on past projects. The chemical properties associated with this mixture is assumed to be no more severe than that of the component described in Section 6.1.

APPENDIX H. ENVIRONMENTAL JUSTICE QUESTIONNAIRE

Department of Energy (DOE)
Office of Fossil Energy (FE)

CLECO PROJECT DIAMOND VAULT CARBON CAPTURE FEED STUDY

DE-FE0032165

Environmental Justice Analysis

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ACKNOWLEDGEMENT

This material is based upon work supported by the Department of Energy under Award Number DE-FE0032165.

DISCLAIMER

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1. INTRODUCTION

The purpose of the Environmental Justice Analysis (EJ) is to evaluate the benefits and burdens of the carbon dioxide (CO_2) capture project on the impacted communities. Specifically, in accordance with Executive Order 13985 officially titled Advancing Racial Equity and Support for Underserved Communities Through the Federal Government, a summary of environmental justice considerations of the proposed technology, process, or system is provided.

2. ENVIRONMENTAL JUSTICE QUESTIONNAIRE

1) *How does the technology rely on limited resources such as coal, biomass, freshwater, land, and/or low-carbon energy? What is the relationship between the amount of resources used versus the amount of product formed?*

   Madison Unit 3 (MU3) is located at the Brame Energy Center (BEC) and is a petroleum coke (petcoke) and coal-fired power plant. MU3 fires, on average, 70% petcoke and 30% Illinois 6 coal, to produce electricity. Both coal and petcoke are considered to be limited resources. As a non-renewable resource, the life cycle efficiency of a coal/petcoke facility is negative, in that more energy is consumed by the system than is produced in the form of electricity. The current net efficiency of production for MU3 is approximately 40%.

   Installation of a CO_2 capture system at MU3 would not use additional coal or petcoke beyond the current design heat input of the facility. The power generated after installation of the CO_2 capture system will be 95% decarbonized.

2) *If coal is used as a feedstock, where will it be mined and what are associated near-term and legacy environmental impacts of the coal mining, including methane leakage?*

   Over the past several years, coal for MU3 has been sourced from the Gateway Mine in Coulterville, Illinois (owned by Peabody). In previous years, Cleco has sourced coal from Knight Hawk Coal (KHC) Southern Illinois Mines. KHC Southern Illinois Mines supplied coal from several mines, including Hawkeye Mine, Blackhawk Mine, Prairie Eagle Mine, Red Hawk Mine, and Golden Eagle Mine. Cleco has also used Foresight Coal in the past to source coal. Foresight Coal supplied coal from several mines, including Williamson Energy's Mach #1 Mine, Sugar Camp Energy's MC #1 Mine, and Macoupin Energy's Shay #1 Mine.

   As a coal consumer, Cleco is not privy to the environmental impacts specific to the coal mining process at the Gateway Mine.

3) *How does the technology remediate legacy environmental impacts of the energy industry, including environmental impacts associated with the use of coal?*

NOTICE: All work related to the Environmental Justice Questionnaire was completed by December 22, 2024.

Installing a CO_2 capture system at an existing coal power plant would reduce the existing site CO_2 emission rates by 95%. Implementing this technology would decrease the amount of CO_2 released to the atmosphere. Although there is no remediation available for CO_2 previously released as a direct result of this project, installing a CO_2 capture system at MU3 would reduce the impact that Cleco could have on the atmosphere going forward and generate decarbonated power for the central Louisiana area.

4) *If coal wastes are being remediated, what is the relationship between the amount of coal waste used versus the amount of product formed?*

Coal waste remediation is not applicable to the Diamond Vault Carbon Capture FEED Study.

5) *What is the project's waste management strategy and what are the anticipated impacts of residual waste on local residents?*

There are no anticipated changes to the existing host facility waste rates or managements plans.

The CO_2 capture system generates several new waste streams, most notably the spent solvent that is removed from the system due to solvent degradation over time. The composition of this waste cannot be determined until start-up of the facility or a small test-pilot system is installed on a flue gas slip stream. The hazard level is expected to be dependent on the flue gas composition. The spent solvent will be removed from site and safely disposed of by a waste management company. Means and methods for disposal will be established by the selected waste management company. The disposal contractor has not been determined as of the beginning of the FEED study.

The CO_2 capture system also generates spent catalysts and materials which will either be regenerated, recycled, or landfilled. The final materials will be selected as part of detailed design and a waste management plan will be developed to properly handle these materials.

Finally, the CO_2 capture system will also produce a wastewater stream comprised of flue gas condensate blowdown. This stream is relatively clean and is not expected to require treatment to meet current Louisiana Pollutant Discharge Elimination System (LPDES) and discharged to Lake Rodemacher.

6) *To what extent does the technology provide ancillary environmental benefits, such as reductions in NO_x and SO_x emissions, particulate matter, or hazardous pollutants?*

Installation of a CO_2 capture system at MU3 would have the additional added benefit of reduction of NOx, SO_x, particulate matter (PM) and aerosol emission concentrations. SO_2 will be removed via caustic injection in the direct contact cooler that cools the flue gas entering the CO_2 capture system as it is detrimental to the circulating solvent. Additional pre-treatment is included upstream of the absorber to remove flue gas constituents such as aerosols and fine particulates as these pollutants can also negatively impact the CO_2 capture system operation and new stack gas emissions. NOx, SOx, PM an aerosols will all be beneficially removed in the direct contact cooler. Finally, NOx and SOx will be reduced in the absorber by reacting with the circulating solvent which has an affinity for nitrogen dioxide (NO_2) and sulfur dioxide (SO_2).

An additional environmental justice benefit is that installation of the CO_2 capture system will result in an increase in employment, both during construction and operation of the facility as well as the indirect impacts to the surrounding area and supply chain.

During the construction phase of the project, there would be approximately 2,335 jobs created between project development and onsite labor impacts. This would have a value added of $282.2 million. Additional ancillary jobs could potentially generate 569 jobs with a value added of approximately $51.7 million.

Approximately 29 additional jobs would be created to operate the CO_2 capture system which would have a value of approximately $4.1 million per year. Ancillary jobs would create approximately 55 jobs with a value added of $5.0 million per year.

7) *If the project involves carbon capture retrofit technology, what are the potential co-benefits of the carbon capture technology (e.g., reduction of other hazardous air pollutants or reduction of other negative environmental impacts commonly associated with existing natural gas power plants or industrial processes)?*

See response to question 6.

Based on a life cycle analysis performed for installation of a CO_2 capture system at MU3, greenhouse gas emissions from the facility are expected to be reduced by approximately 671.2 kg $CO_{2\text{-eq}}$/MWh, or a 76.5% reduction over the lifetime of the facility.

8) *How is the project incorporating a plan to ensure community and stakeholder input and engagement from underserved communities which include persons of color: members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality?*

Cleco's workforce is comprised of individuals with different abilities, backgrounds, and experiences. The company strives to provide a work environment where everyone is treated fairly, is encouraged to share information, works as a team, and feels a sense of pride in working at Cleco. Cleco has pledged an equal employment opportunity program that provides employment and promotional opportunities for minorities, women,

NOTICE: All work related to the Environmental Justice Questionnaire was completed by December 22, 2024.

veterans, and individuals with disabilities. The key goal of project-specific Diversity, Equity, and Inclusion (DEI) activities will be to expand the pipeline of applicants with diverse backgrounds to join Cleco's workforce (including contractors and suppliers) and ultimately into leadership positions within the company and in the community.

A stakeholder analysis was conducted using a mix of publicly available information and information collected and maintained by Cleco for their operational and planning needs. Publicly available information used to identify potential stakeholder groups includes census data, DOE Disadvantaged Communities dataset, Climate & Economic Justice Screening Tool (CEJST), local government officials, and web searches of news, social media, business organizations, and community-based organizations (CBO). Data that were used to identify potential stakeholder groups includes: regional maps of the project area and potential impacts, landowners that intersect project right-of-way areas, Cleco customers within specific areas, and Cleco employees. From the stakeholder analysis, it was determined that there are stakeholders within Cleco ("internal stakeholders") and external stakeholders.

Cleco internal stakeholders include the Diamond Vault Team, Cleco employees in departments affected by the retrofit such as BEC (specifically MU3), and various departments. External stakeholders include the host community, which includes underserved and disadvantaged communities (DACs), local businesses and private sector industry operating in proximity to BEC, community educators, environmental groups, and recreators. As part of a stakeholder analysis matrix, external stakeholders were grouped into five categories based on geographic relationship to the project, common interests, and influence to facilitate outreach to groups with common interests and goals. The five external stakeholder categories are: community members, community leaders/government officials, resident business owners, local timber interests, and local agricultural interests.

Of identified stakeholders, traditionally excluded stakeholder groups include low-income populations and people of color. Demographic data shows that 16.5% of people in the project area are low income and 33.5% are Black, Indigenous, and People of Color (BIPOC). Linguistic isolation does not appear to be a barrier to inclusion for the affected stakeholders. Historically, barriers to inclusion are due to a lack of purposeful outreach. Additional one-on-one discussions with local officials and community connectors will be planned to understand any additional barriers to participation. Identified mitigation measures will be incorporated into the Engagement Strategy.

APPENDIX I. ECONOMIC REVITALIZATION AND JOB CREATION OUTCOMES ANALYSIS

Department of Energy (DOE)
Office of Fossil Energy (FE)

CLECO PROJECT DIAMOND VAULT CARBON CAPTURE FEED STUDY

DE-FE0032165

Economic Revitalization and Job Creation Outcomes Analysis

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ACKNOWLEDGEMENT

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DISCLAIMER

1. INTRODUCTION

The economic revitalization and job creation outcomes analysis is prepared in accordance with Executive Order 13985 officially titled Advancing Racial Equity and Support for Underserved Communities Through the Federal Government. This analysis includes a summary of the economic and workforce impacts associated with installing Mitsubishi Heavy Industries America's (MHIA) carbon dioxide (CO_2) capture process at Cleco's Madison Unit 3 (MU3), a petroleum coke (petcoke) and coal-fired power plant in central Louisiana.

2. JOB CREATION

The new MHIA CO_2 Capture System (CCS) will require significant labor for fabrication, construction, and operation of the new facility. At the direction of the Department of Energy, a Jobs and Economic Development Impact (JEDI) model from the National Renewable Energy Laboratory (NREL) was prepared to estimate the number of jobs created as a result of this project.

2.1 JEDI MODEL INPUTS

The JEDI model utilizes project economic parameters and location information to estimate the number and types of jobs created for the local community. Noted is that a CO_2 capture system-specific JEDI model does not currently exist; therefore, it was assumed that of the models available, the coal power plant template was the best starting point for this evaluation.

Project-specific parameters were entered into the coal power plant JEDI model, as applicable to a CO_2 capture system, such that the complete project was characterized within the bounds of the JEDI model. This evaluation fundamentally assumes that with CO_2 capture project values entered into the coal power plant JEDI model, the resulting job data was accurately predicted within the ability of the model.

Without basis for updating percent of work performed locally, it is assumed that the model's default values were reasonable for this evaluation. This approach is expected to be reasonable as line items that would be anticipated to be performed by local contractors (i.e. General Facilities) have a high local percentage, while the line item that includes the specialty process equipment (i.e. Plant Equipment) has a low local percentage.

2.2 JEDI MODEL OUTPUTS

The JEDI model predicts the number of jobs, broken into major area, that are expected to be required as a direct or indirect result of the evaluated project. The model shows that CCS will generate jobs both directly and indirectly as a result of the fabrication, construction and operation of the facility.

Table 2-1 Summary of Local Economic Impacts (JEDI Model)

	Jobs	Earnings $M, $2023	Output $M, $2023	Value Added $M, $2023
During construction period				
Project Development and Onsite Labor Impacts	1,707	167.6	319.9	223.2
Construction and Interconnection Labor	1,058	134.6		
Construction Related Services	649	33.1		
Power Generation and Supply Chain Impacts	628	33.3	108.0	59.0
Induced Impacts	569	29.5	90.9	51.7
Total Impacts	**2,903**	**230.4**	**518.8**	**333.9**
During operating years (annual)				
Combined Onsite Labor Impacts, Local Revenue and Supply Chain Impacts	212	16.3	52.7	26.4
Induced Impacts	55	2.9	8.8	5.0
Total Impacts	**267**	**19.2**	**61.5**	**31.5**

Note: Earnings and Output values are reported in millions of dollars in year 2023 dollars, based on the project cost estimate that was completed in 2023 dollars. Construction period related jobs are full-time equivalent for the 36 months (an annual average of approximately 970 full-time equivalent jobs). Plant workers includes operators, maintenance, administration, and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with spending of plant "profits" and assumes no tax abatement unless noted. *Totals may not add up due to independent rounding.*

3. JOB PROFILE

The project will yield economic benefits in the local community by generating construction, maintenance, and operations jobs in a new clean energy industrial economy. It is Cleco's intent to hire highly skilled trades people from the local labor force, ensuring a just transition for local communities that have been negatively affected by previous power and industrial projects.

3.1 CONSTRUCTION JOBS

A majority of the jobs will come from construction of the CO_2 capture system and associated activities (i.e. equipment/material manufacturing, induced impacts, etc.). Specifically, construction of the CO_2 capture system will require labor such as pipe fitters, welders, iron workers and electricians and plumbers. Other support jobs will be needed, including project and construction management, administration, and foreman.

Indirect construction jobs will include those producing and transporting construction materials and equipment to MU3. Local jobs will also be needed to support the influx of construction labor into the area (i.e. general store, grocery store and restaurant workers).

3.2 OPERATING JOBS

The capture system will require new staff to operate process equipment and perform typical maintenance activities. The skills required are similar to those of existing chemical processing plants.

3.3 INDIRECT JOBS

Jobs will be created to support the staff needed for construction and operation of the capture facility. This includes grocery store workers, restaurant staff, and other necessary services needed to support the influx of workers.

3.4 LOCATION IMPACTS

MU3 is located in central Louisiana. Construction jobs will directly support trades people utilizing their existing skills for new clean energy jobs. The project team intends to recruit labor from the local communities surrounding MU3. Cleco is actively engaging with the local community as outlined in the Community Benefits Plan. These construction workers interact with the local community creating indirect economic benefit associated with CCS.

Once constructed, MU3 will require an additional full time operations staff who will be paid at or above prevailing wage, creating permanent industrial jobs in the clean energy economy. Training specific to the post-combustion capture (PCC) technology will be provided by MHIA to ensure a just transition to O&M personnel historically employed in carbon intensive energy industries. Training material developed for CCS can be leveraged if Cleco develops PCC at other facilities. Due to the mechanical and physical nature of these jobs, a large majority of workers will be required to be located in this community. Local businesses that provide maintenance services are well-suited to assist in the maintenance of the CO_2 capture system.

By enabling power plants to remain competitive while delivering low-carbon electricity, these facilities will be able to continue supporting the local communities and schools through their local outreach, charitable giving and taxes.

4. RELATIVE JOB IMPACTS

The job impacts based on the CCF hourly capture rate of approximately 611 tonne/hr are provided in Table 4-1.

Table 4-1: CCF Job Impacts vs CO_2 Captured

Area	Job Created/tonne CO_2 Captured (Hourly Basis)
During Construction Period	
Project Development and Onsite Labor Impacts	2.65
Construction and Interconnection Labor	1.65
Construction Related Services	1.01

Area	Job Created/tonne CO_2 Captured (Hourly Basis)
Power Generation and Supply Chain Impacts	0.98
Induced Impacts	0.89
Total Impacts	**4.52**
During Operating Years (annual)	
Combined Onsite Labor Impacts, Local Revenue and Supply Chain Impacts	0.33
Induced Impacts	0.09
Total Impacts	**0.41**