BURNS McDONNELL

COOPER UNIT 1 SYNCON CONVERSION PROJECT FEASIBILITY REPORT

EKPC

OCTOBER 2023

CONTENTS

FIGURES

TABLES

LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
AC	Alternating Current
AACE	Association for the Advancement of Cost Engineering
AVR	Automatic Voltage Regulator
BMcD	Burns & McDonnell Engineering, Inc.
COD	Commercial Operation Date
DC	Direct Current
DCS	Distributed Control System
DOR	Division of Responsibility
EKPC	East Kentucky Power Cooperative
EME	ElectroMechanical Engineering Associates, Inc.
GCB	Generator Circuit Breaker
GE	General Electric
GSU	Generator Step-Up (Transformer)
HMI	Human Machine Interface
HP / IP	High Pressure / Intermediate Pressure (Steam)
HVAC	Heating, Ventilation, and Air Conditioning
I/O	Input/Output
kVA (MVA)	Kilo Volt Ampere (Mega Volt Ampere)
kW (MW)	Kilo Watt (Mega Watt)
LP	Low Pressure (Steam or Water)
MCC	Motor Control Center

Abbreviation	Term/Phrase/Name
MVA	Mega Volt Ampere
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
O&M	Operating and Maintenance
OE	Owner's Engineer
OEM	Original Equipment Manufacturer
P&ID	Process and Instrumentation Diagram
PJM	PJM Interconnection, Inc. (RTO)
PPT	Power Potential Transformer
PSIG	Pounds per Square Inch Gauge
PSR	Project Scoping Report
RPM	Revolutions per Minute
SynCon	Synchronous Condenser
UPS	Uninterruptible Power Supply
V (kV)	Volt (Kilo Volt)
VAR	Volt-Ampere Reactive
VFD	Variable Frequency Drive

1.0 Executive Summary

East Kentucky Power Cooperative (EKPC or Owner) is investigating the feasibility and requirements to convert the existing Unit 1 at the John Sherman Cooper (Cooper) Power Station to seasonal operation as synchronous condenser (SynCon) unit. If selected by EKPC, this conversion would permit extension of the life of the unit, provide for continued operation as a thermal power generating unit, and provide critical support and stability in the transmission system.

1.1 Purpose

The purpose of this report is to:

- Define the necessary and recommended project scope as described:
  - Convert Unit 1 to seasonal synchronous condenser operation with recommended upgrades and right-sized auxiliary systems to minimize operations and maintenance of existing systems.
- Estimate the capital costs (AACE Class 4) to complete the conversion scoped within the body of the report and accompanying appendices.
- Provide estimated performance characteristics for the machine, including estimated Q-V curves for generator capability post conversion.

1.2 Contracting Approach

EKPC has indicated that the execution strategy will be multi-contract. At the onset of the study, it was determined to develop all cost estimates as part of this study using the multi-contract. This strategy will allow EPKC to maintain a higher degree of control over various scopes of work compared to alternatives. Refer to Appendix F – Scope Matrix for more detail.

1.3 Schedule

EKPC is targeting a synchronous condenser conversion to be commercially operable no later than end of 2028. A level 1 project schedule is included in Appendix B with major activities that will need to be completed to meet this commercial operation date.

A proposed level 1 schedule is included in Appendix B which was utilized to develop the project escalation costs on equipment, material, and labor. Depending on EKPC's generation plans, the project has flexibility to adjust when it is completed and ready for commercial operation. The project will require an outage to complete the generator modifications which is anticipated to take up to 16-weeks.

1.4 Cost Estimate

The capital cost estimate summaries developed for the SynCon conversions and additional options are included in Section 4.0 of this report. The capital cost estimates were developed based on a top-down approach utilizing costs from similar projects and conceptual design

performed as part of this evaluation. Owner costs are excluded. Appendix A summarizes the AACE Class 4 capital cost estimate for the Seasonal SynCon conversion.

Information developed during this evaluation is "feasibility stage" in nature and, as such, is not adequate for establishing actual project budgets. The capital costs developed for the recommended SynCon conversion are estimated to be in the accuracy range of low by -15% to -30%, and high by +20% to +50% (per AACE accuracy definition for Class 4). Additional investigations will be required to further evaluate and estimate more detailed site-specific costs in order to establish information suitable for budgeting and approvals.

1.5 Project Contingency

Project contingency is intended to address inherent uncertainty in the cost estimate due to the level of definition of the project design. This contingency would typically include money to cover potential project risk events which would result in a change to the base scope and execution of the project, as well as cost estimate accuracy based on the estimating methodology. Both values can be methodically estimated using statistical methods such as Monte Carlo analysis. For an AACE Class 4 estimate, this rigorous approach is not utilized. Instead, a single contingency rate was selected by BMcD to represent an estimate of this total.

1.6 Conclusions and Recommendations

The results of this study conclude that the conversion for Unit 1 is feasible based on the available information and the evaluations completed herein. It is recommended that EKPC complete detailed power system modeling, in concert with PJM as necessary, and incorporate necessary economic comparisons for alternative transmission-based solutions to determine if any SynCon conversions are desired. The following additional conclusions and recommendations should also be considered:

- It is recommended that a condition assessment be performed on the candidate generators for SynCon conversion at the earliest available outage by the original equipment manufacturer (OEM) or a tier-one third party to yield new recommended corrective actions for these generators. Such actions are likely not anticipated because of the existing "near retirement" perspective. It is recommended for the assessment scope to be comprehensive in nature. The condition assessment can serve as a final go/no-go gate for the project, and if the results are favorable, it should result in work scope to be included in the final project.
- EKPC should work internally to determine the economic strategy to justify a seasonal SynCon conversion.
- Complete a detailed project scoping report (PSR) as soon as possible after economic and transmission modeling efforts for each of the selected units to establish project budget and schedule.
- If the project moves forward, it is recommended to include a rotordynamic analysis by the party performing the centerline shaft modifications, with the intent to identify critical speeds and the margin of separation.

2.0 Introduction

2.1 Background

EKPC has retained BMcD to provide a feasibility stage assessment of converting the coal fired steam turbine generator for Cooper Unit 1 to seasonal synchronous condenser operation. EKPC will use the information provided in this report to evaluate the SynCon project's performance and cost against other new generation project alternatives. SynCon conversions can be either seasonal or permanent. Seasonal conversions are designed such that the turbine and generator can be decoupled to operate as synchronous condenser and then later recoupled to generate real power. Based on EKPC's plans for the unit in question, the SynCon conversion in this study is considered seasonal. This means that after the conversion, the unit will have the capability to "flip-flop" between operating modes after an outage (several days duration) to make the necessary physical and controls changes.

This study includes technical evaluation, conceptual engineering information, and cost estimates for the SynCon conversion. The evaluation considers leveraging existing infrastructure with recommended and required upgrades. This report is intended to support the Owner's continued development of the project, including its evaluation of the feasibility of the conversion.

It is BMcD's understanding that information provided in this assessment will be used to screen the options for technical and economic feasibility. Information developed during this evaluation is "feasibility stage" in nature and, as such, is not adequate for establishing actual project budgets. Additional investigations will be required to further evaluate and estimate more detailed site-specific costs in order to establish information suitable for budgeting and approvals. The capital cost developed for the recommended SynCon conversion is estimated to be in the accuracy range of low by -15% to -30%, and high by +20% to +50% (per AACE accuracy definition for Class 4).

2.2 Scope of Study

The scope of this study included development of the following major items relating to SynCon conversion:

1. Scope Assumptions
2. Capital Costs
3. High Level Implementation Plan

2.3 Objectives

The objectives of this study were to evaluate the technical feasibility of converting Unit 1 to seasonal SynCon, to establish scope basis of major components for the conversions, to provide capital cost estimates, and to provide evaluation summary information to support internal project development.

2.4 Limitations and Qualifications

The costs presented within this report are subject to:

- Selection of major equipment suppliers and construction contractors.
- Thorough investigation for existing drawings and design details of existing units and facilities.
- Thorough site investigation and laser scan of existing structures.
- Completion of detailed scope definitions for each unit selected for conversion.
- Final determination of the project schedule.
- Negotiation of mutually acceptable Terms and Conditions with the major equipment suppliers and construction contractors.
- Pricing and labor availability from construction contractors.

Estimates and projections prepared by BMcD relating to schedules, performance, construction costs, and operating and maintenance (O&M) costs are based on our experience, qualifications and judgment as a professional consultant. Since BMcD has no control over weather, cost and availability of labor, material and equipment, labor productivity, construction contractor's procedures and methods, unavoidable delays, construction contractor's method of determining prices, economic conditions, government regulations and laws (including interpretation thereof), competitive bidding and market conditions or other factors affecting such estimates or projections, BMcD does not guarantee that actual rates, costs, performance, schedules, etc., will not vary from the estimates and projections prepared by BMcD.

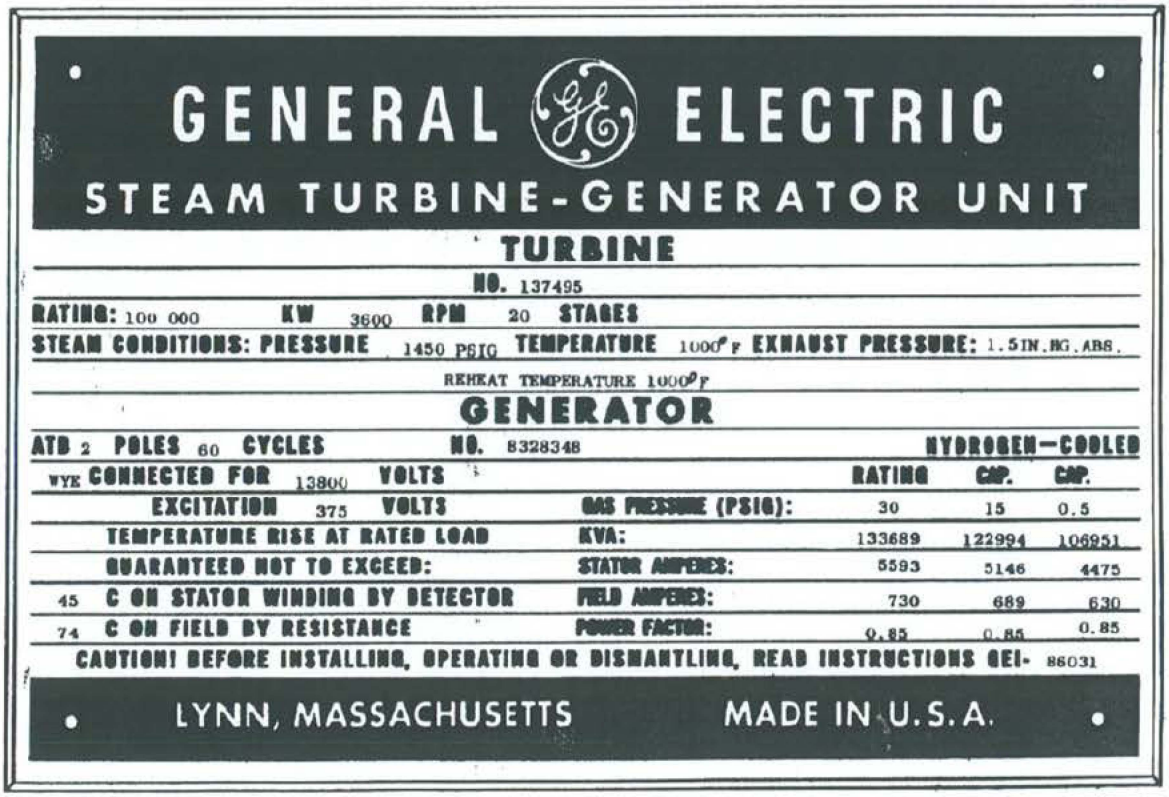
3.0 Project Scope

Burns & McDonnell's understanding is that EKPC's plans for the Cooper Power Station are unknown as of yet. The unit may continue operation for many years into the future, the unit may retire in the near-term, or EKPC may employ a split strategy between these two extremes. The study assumes that Unit 1 at Cooper will be converted to "seasonal" synchronous condenser service, providing for continued operation in both modes of thermal power generation, and synchronous condenser. Future capital projects to "right size" the mechanical and electrical systems may be carried out, but the "seasonal" conversion basis necessitates minimal system changes to support the operation mode changeover over a short timeframe.

3.1 Unit Rating Basis

The Unit 1 generator at John Sherman Cooper Power Station was manufactured by General Electric (GE) and was nameplated for 133.7 MVA output. The unit uses conventional hydrogen cooling for both the rotor and stator (nominal 30 PSIG). The unit entered commercial operation in 1965, while generator engineering documents are dated circa December 1963.

Figure 3-1: Steam Turbine Generator Nameplate for Unit 1


GENERAL ELECTRIC

STEAM TURBINE-GENERATOR UNIT

TURBINE

NO. 137495

RATING: 100 000 KW 3600 RPM 20 STAGES

STEAM CONDITIONS: PRESSURE 1450 PSIG TEMPERATURE 1000° F EXHAUST PRESSURE: 1.5IN.HG.ABS.

REHEAT TEMPERATURE 1000° F

GENERATOR

ATB 2 POLES 60 CYCLES NO. 8328348 HYDROGEN-COOLED

WYE CONNECTED FOR 13800 VOLTS

EXCITATION 375 VOLTS

		RATING	CAP.	CAP.
	GAS PRESSURE (PSIG):	30	15	0.5
TEMPERATURE RISE AT RATED LOAD	KVA:	133689	122994	106951
GUARANTEED NOT TO EXCEED:	STATOR AMPERES:	5593	5146	4475
45 C ON STATOR WINDING BY DETECTOR	FIELD AMPERES:	730	689	630
74 C ON FIELD BY RESISTANCE	POWER FACTOR:	0.85	0.85	0.85

CAUTION! BEFORE INSTALLING, OPERATING OR DISMANTLING, READ INSTRUCTIONS GEI- 86031

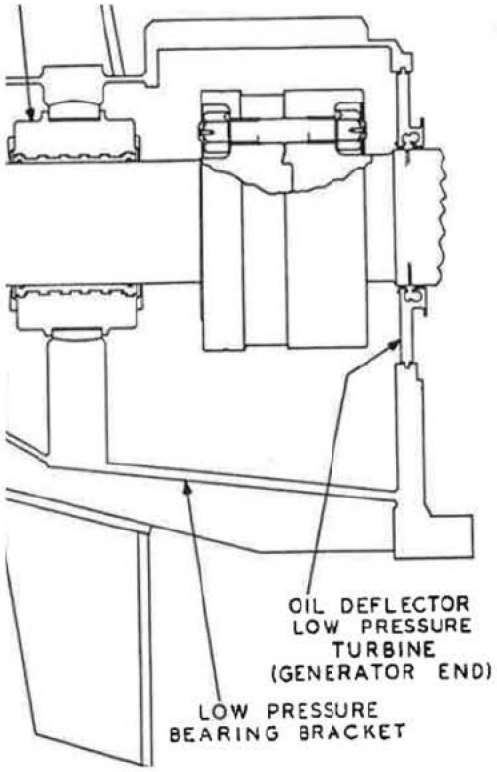
LYNN, MASSACHUSETTS MADE IN U.S.A.

3.2 Mechanical Systems

3.2.1 Turbine to Generator Coupling

Provided data indicates that the turbine to generator coupling for Unit 1 is spacer-type, doing double-duty as the bull gear used in the turning gear.

Figure 3-2: Unit 1 Turbine/Generator Coupling Type (from Turbine Assembly 2128988)

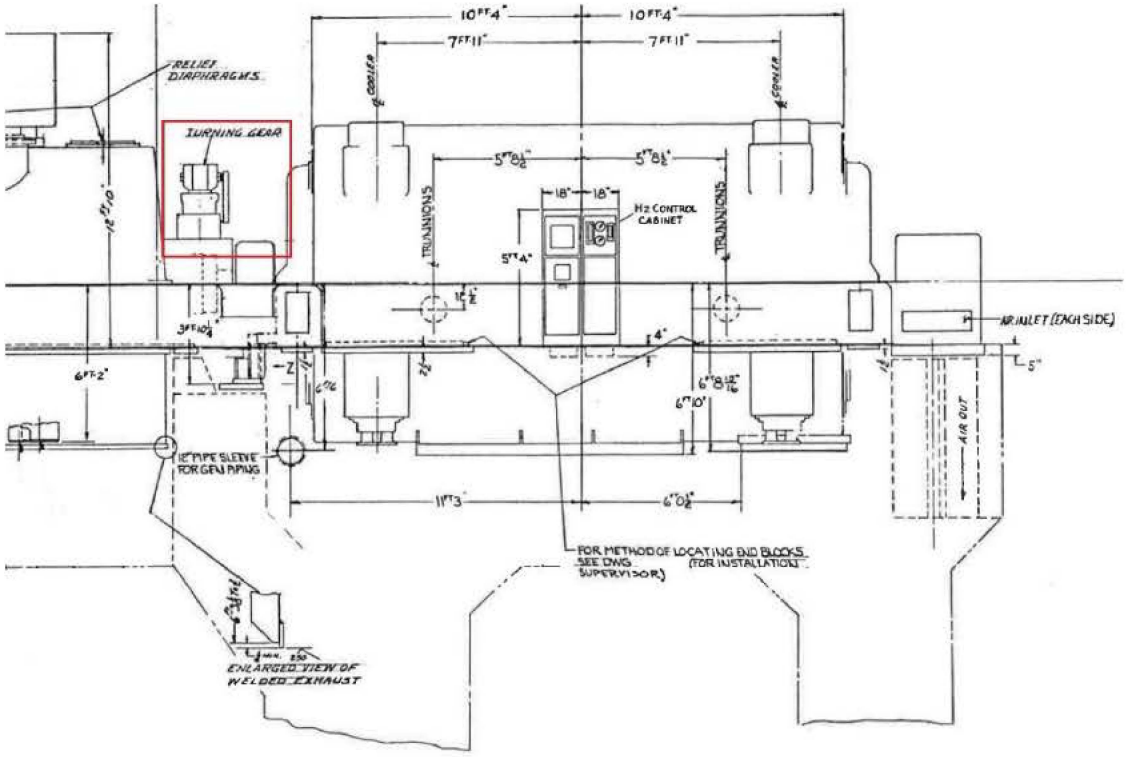


Removal of the spacer coupling/bull gear will provide adequate running clearance between the turbine shaft and generator shaft to allow for SynCon operation. This spacer coupling/bull gear would then later be reinserted as part of restoration to thermal power generating mode.

3.2.2 Turning Gear

The existing turning gear on the turbine is located at the turbine / generator coupling, which is a spacer type with bull gear teeth around the perimeter. This was confirmed by inspection of GE drawings; please see the red outline box in the following Figure 3-3.

Figure 3-3 : Location of Turning Gear (from GE drawing 2128751)



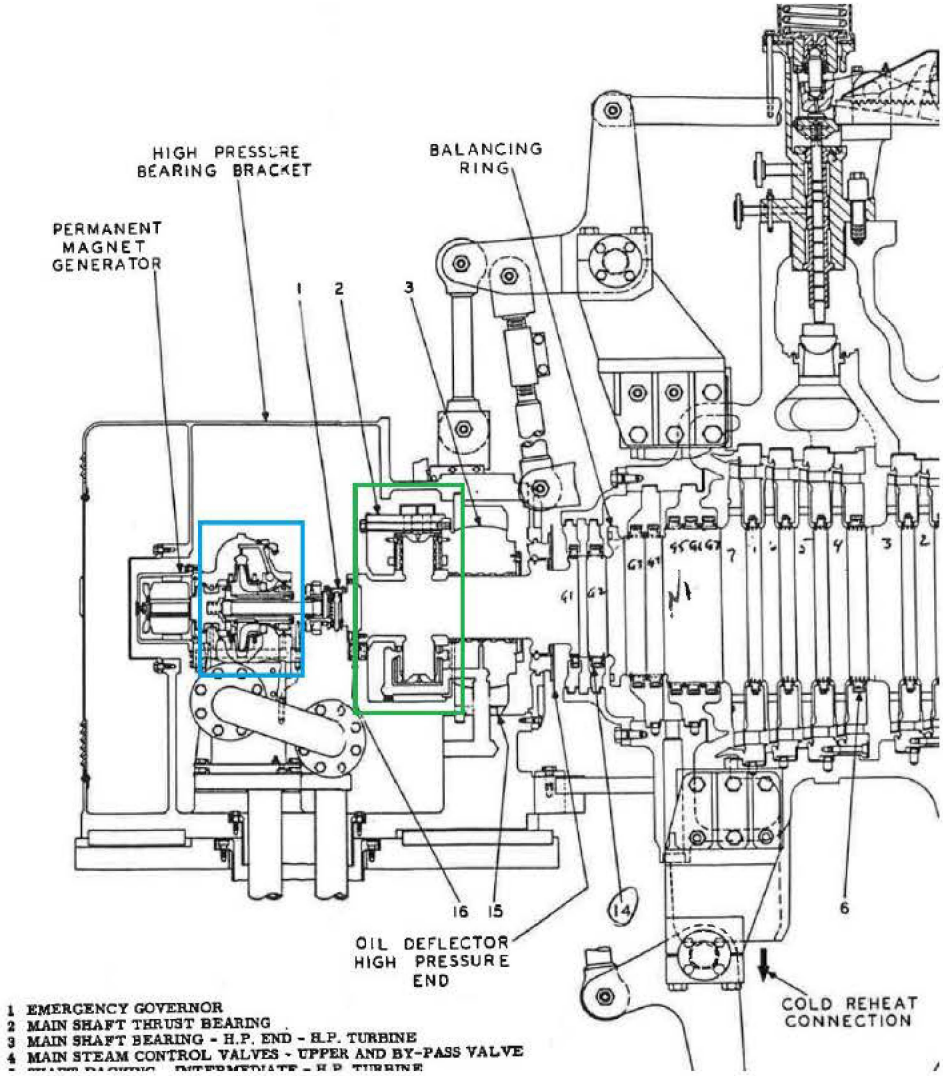
The coupling will be removed to provide free running clearance between the two shafts, and therefore the existing turning gear would not be available during SynCon operation.

The study basis is to provide a new and separate turning gear for the generator. The new turning gear is included with the synchronous condenser equipment and is mounted as part of the starting package assembly (in-line with the motor, combined journal/thrust bearing, and overrunning clutch). The SynCon unit is not anticipated to spend much time at rest, because it can only provide the desired ancillary services while at speed, synchronized with the grid. The unit is anticipated to be offline only for short maintenance intervals. The turning gear provides for the unit to slowly rotate during offline periods, to avoid developing a generator rotor bow. Also, having the unit on turning gear permits engaging the starting system with the rotor in motion (sliding friction) with an oil-film well developed. This results in more reliable starts than if the generator rotor and starting motor were started from rest (static friction). The starting motor is sized for accelerating the rotor to 3600 RPM but is not intended to overcome breakaway torque.

3.2.3 Generator Thrust Bearing

The existing turbine/generator thrust bearing for Unit 1 is located within the front standard. This was confirmed by inspection of GE drawings; please see the green outline box in the following Figure 3-4.

Figure 3-4 : Location of Thrust Bearing and Main Oil Pump (from Turbine Assembly 2128988)



Once uncoupled from the turbine, a new thrust bearing will be required for the generator shaft in order to properly locate the generator rotor in the axial direction during acceleration to synchronous speed for SynCon operation. To accomplish this, a shaft extension, added on to the exciter end of the generator shaft would be included. The new shaft extension would include the thrust bearing and a steady bearing. The new bearings would be supported by the steel housing of the turning gear/clutch assembly installed on the operating deck elevation.

3.2.4 Bearing Lubrication and Generator Seal Oil

Maintaining a reliable source of clean, cooled lubricating oil will continue to be essential for Unit operation. The Unit has an existing lube oil system sized for operation as a power generating unit. The flow rate and heat duty of oil for SynCon operation is reduced from this basis, so some changes will be required. The initial scoping discussions with EKPC regarding the lube oil systems suggested that the existing equipment is in excellent condition (suitable as-is for project design life). Furthermore, the project basis of "seasonal" conversion necessitates the ability to flip-flop back to thermal power generation mode with minimal time delay. Therefore, the study assumes that the existing oil system will be modified with a

minimum of changes to permit operation in both modes. Project-specific Lube Oil P&IDs of the turbine/generator scope were not made available for BMcD to detail the modifications, but the planned system changes generally consist of:

- Isolating the main oil pump. The unit's main oil pump is a shaft-driven centrifugal type located within the front standard, on the turbine-end (please see the blue box within the previous Figure 3-4). This main oil pump will be disconnected from the shaft-drive in SynCon mode, and therefore, the project scope includes addition of manual valves or blind flanges to block the supply / return to this pump.
- Adding a new AC-motor driven vertical oil pump to the existing lube oil module. This pump's sizing basis is to provide oil only for the SynCon mode of operation.
- Pressure control valve. There is some uncertainty in the exact required pump output pressure to achieve the desired oil pressure at the bearings. To provide for flexibility and field tuning, project scope includes a modulating oil pressure control valve to return surplus oil back to the reservoir. The valve is "fail closed" such that valve failure results in continued oil flowing to the bearings, rather than causing a unit trip.
- Piping tie-ins are required to provide supply/return oil to the new bearings associated with the starting package motor, turning gear, and thrust bearing.

The lube oil system provides cooled oil to the generator seal oil system. Because the seal oil equipment duty is not expected to change dramatically from generation mode to SynCon mode, the project basis is for the existing seal oil skids to be pressed into future duty.

3.2.5 Generator Heat Sink / LP Lake Water System

An important goal for the SynCon conversion project is for the future machine's electrical rating to be unaffected by the conversion. Cooper Unit 1 presently uses once-through Low Pressure Lake Water as the heat sink for unit cooling water users (including the generator hydrogen coolers), with water both withdrawn from and discharged back to the Cumberland River. The generator design data from the O&M Manual calls for maximum 90°F cooling water fed into the generator hydrogen gas coolers.

Figure 3-5 : Excerpt from GEI-86031, Generator Design Data

GAS COOLER DATA

Inlet Water Temperature	90°F
Water Flow at Rated Load	530 GPM
Head Loss Through Cooler	7 feet
Gas Flow Through Generator	76,000 CFM
Gas Space in Generator Casing	1775 Cu. ft.

The converted SynCon unit will require water cooling for both the generator auxiliaries and other plant auxiliaries still served by the LP Lake Water System. BMcD's design basis for the SynCon conversion project is to continue use of the existing LP Lake Water System (no changes to the system). Please note that BMcD was informed of an unrelated capital improvement project at Cooper, where a new LP Lake Water Pump (with new minimum flow

recirculation) is to be added. This project has already been planned and budgeted for separately. Cost for this pump upgrade is not included in the cost estimate.

The following LP Lake Water users are recommended to be isolated via existing manual valves during synchronous condenser operation:

1. Governing fluid coolers
2. Boiler feed pumps
3. Water chemistry analysis panel coolers for: steam analyzer, feedwater sample, condensate sample, dissolved oxygen sample, and continuous blowdown sample
4. Pulverizer fans and soot blower air compressors
5. Blowdown tank quench
6. Ash hopper

3.2.6 Compressed Air Equipment

Compressed instrument air is planned for use in actuating valves in the SynCon mechanical systems, therefore a reliable source of instrument air will be necessary. Cooper Unit 1 already includes several trains of compressed air equipment in a parallel/redundant configuration, and these must continue to function for the existing users after the seasonal SynCon conversion. The project scope includes no new additional equipment, only one air user will be added which will be for the pressure control valve associated with the auxiliary bearing oil pump recirculation line.

3.2.7 Synchronous Condenser Capability

From the generator O&M manual contents, the Unit 1 generator is rated 133.7 MVA at 30 PSIG hydrogen pressure based on maximum 90°F cooling water. The generator capability curve (see Figure 3-7) and "Vee" curve (see Figure 3-6) for Unit 1 were provided by EKPC; the reader is directed to the following pages.

Figure 3-6: Unit 1 Generator "Vee" Curve

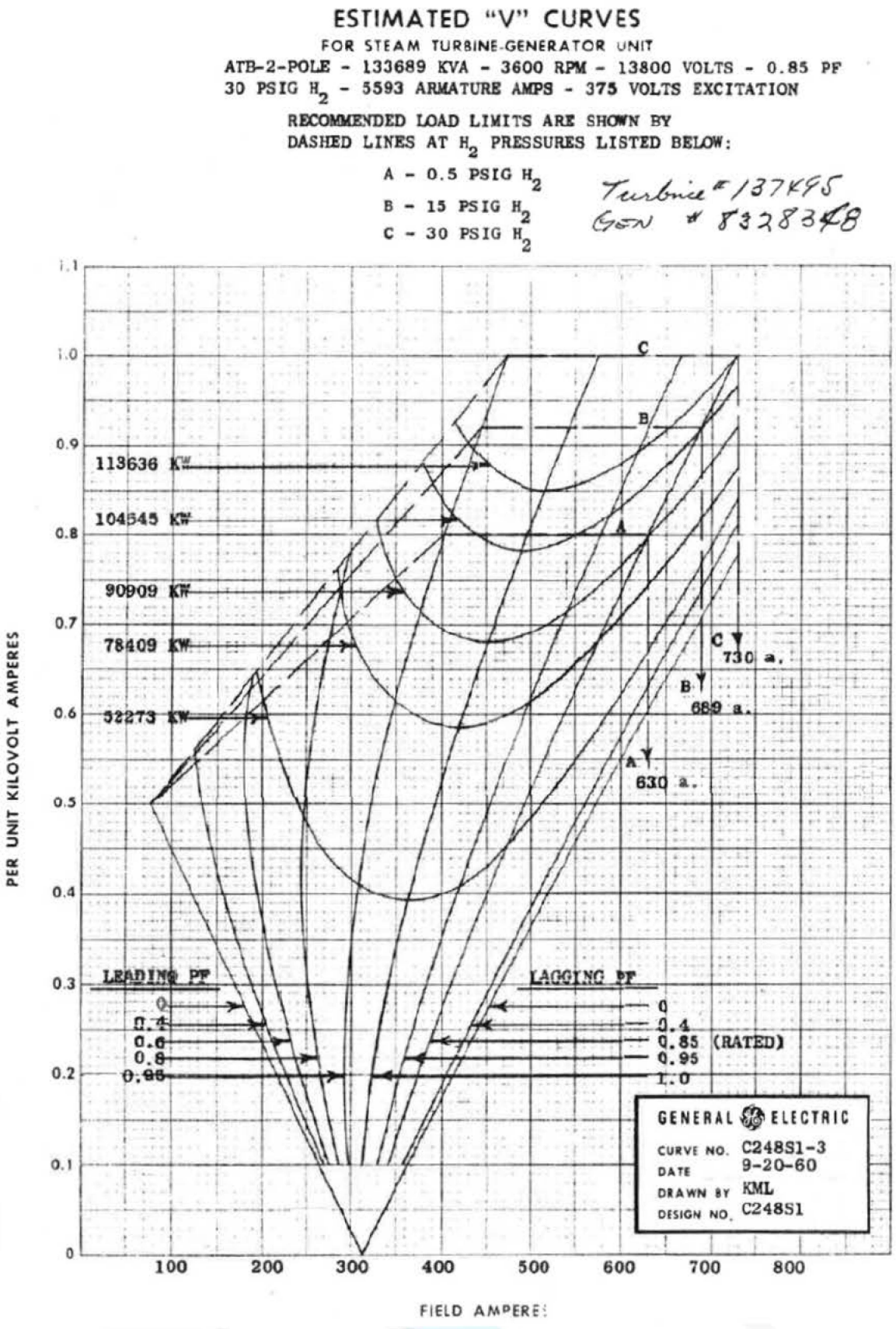
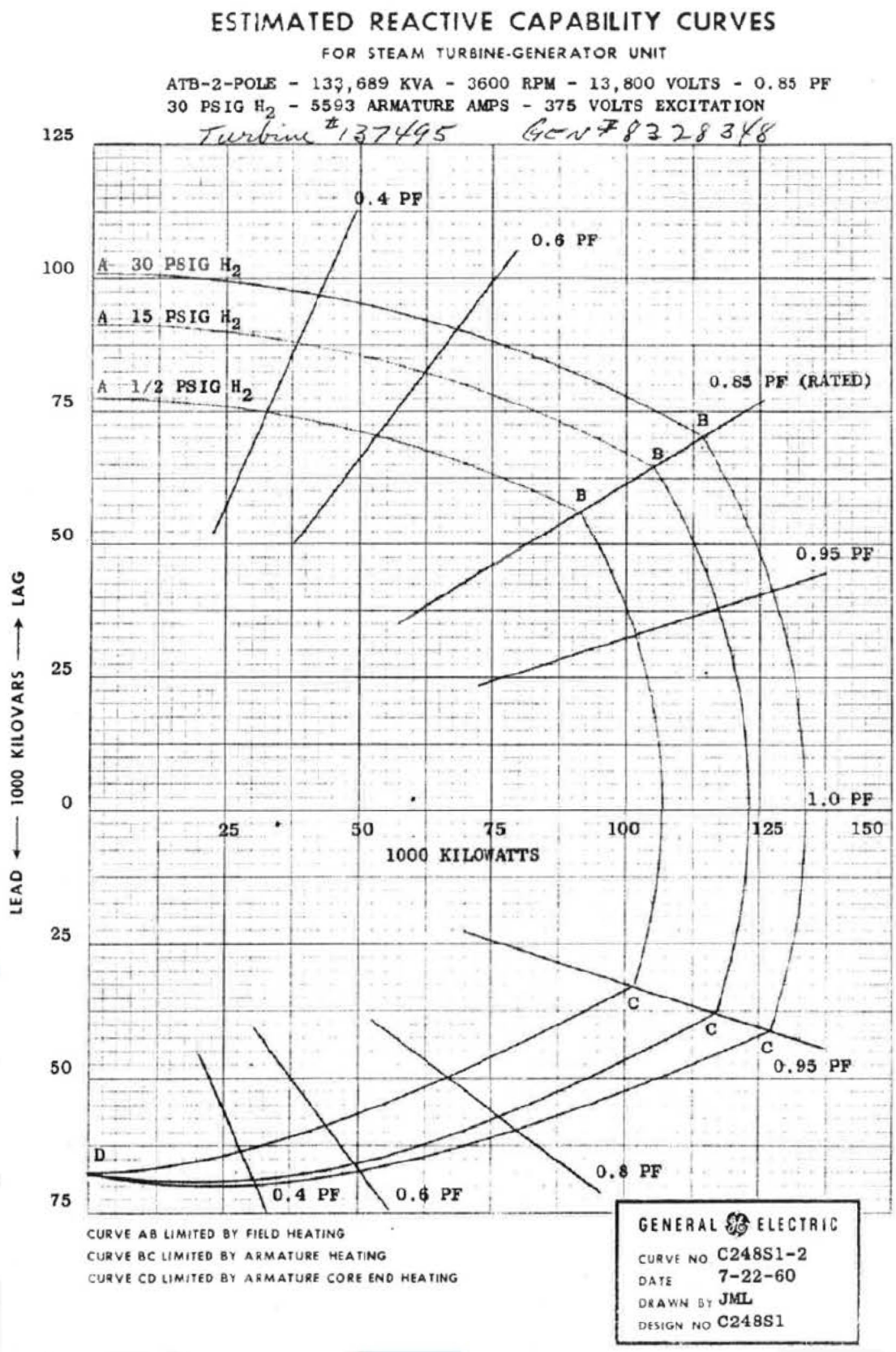
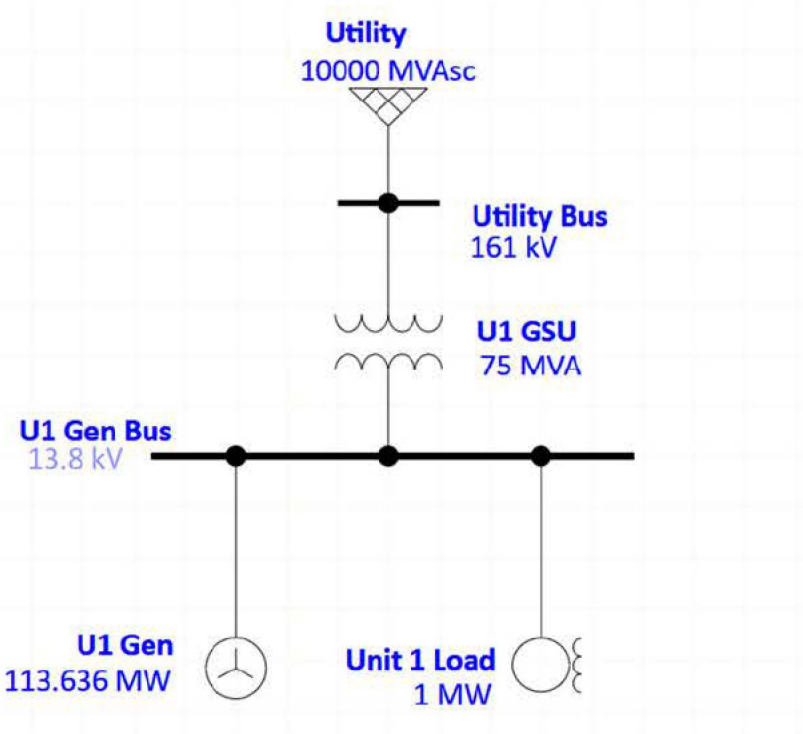


Figure 3-7: Unit 1 Generator Capability Curve



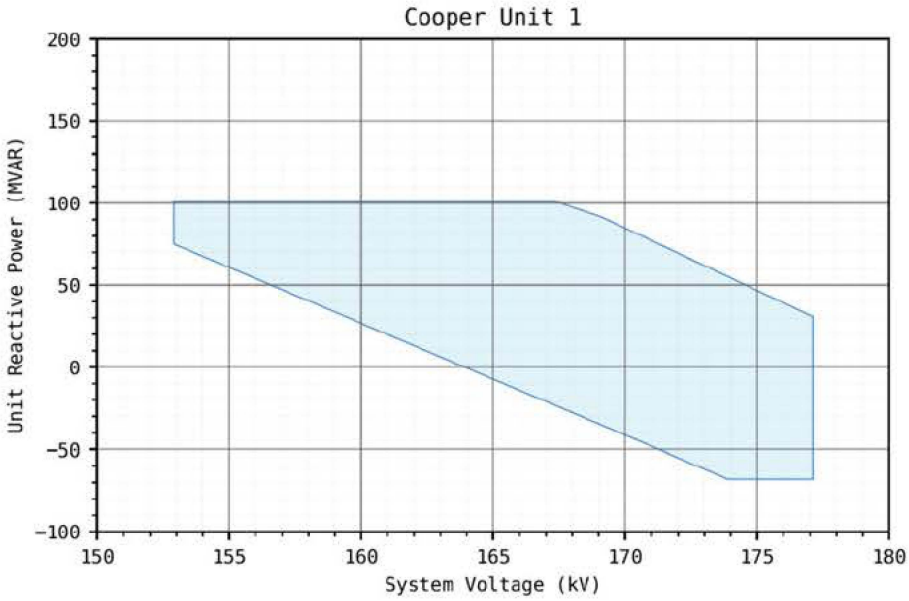
Analysis was conducted using a simple system model in ETAP v21.0.2 software (see Figure 3-8 below) to further define probable machine performance across a range of system voltages. To allow the model to show negative MW (real power consumption by the synchronous condenser), and to allow for finer control over the operating setpoint of the machine, the synchronous condenser was modeled as a parallel synchronous motor and generator. The conservative assumption was utilized that the operation of the synchronous condenser must be limited to the range of 0.95pu to 1.05pu generator bus voltage. Under these conditions, the plant auxiliary equipment is expected to be able to function normally. Considerations for the Under Excitation Limit (UEL) for all units were not included as current parameter information was not available. It should be noted that depending on how tight the UEL limiter follows the generator capability curve, the values from the QV curve could slightly change, especially on the under-excited side.

Figure 3-8: ETAP System Oneline for Modeling Reactive Power Export/Import Capability



The auxiliary system was not modeled, and a load flow analysis of the plant auxiliaries was not conducted as this would be completed during detailed design. Additionally, a load flow study to examine the possibility of starting each unit as a synchronous condenser under depressed voltage conditions would be a detailed design activity and is outside the scope of this study. By necessity, this analysis assumes the synchronous condensers are already online and available to support the system. Results are presented in Figure 3-9 below. In the figure, the reactive power values are given using the generator convention (positive values represent reactive power export, and negative values represent reactive power import). However, the values are net of GSU losses at the 161kV substation bus and are for a single unit. Auxiliary system reactive power consumption is neglected.

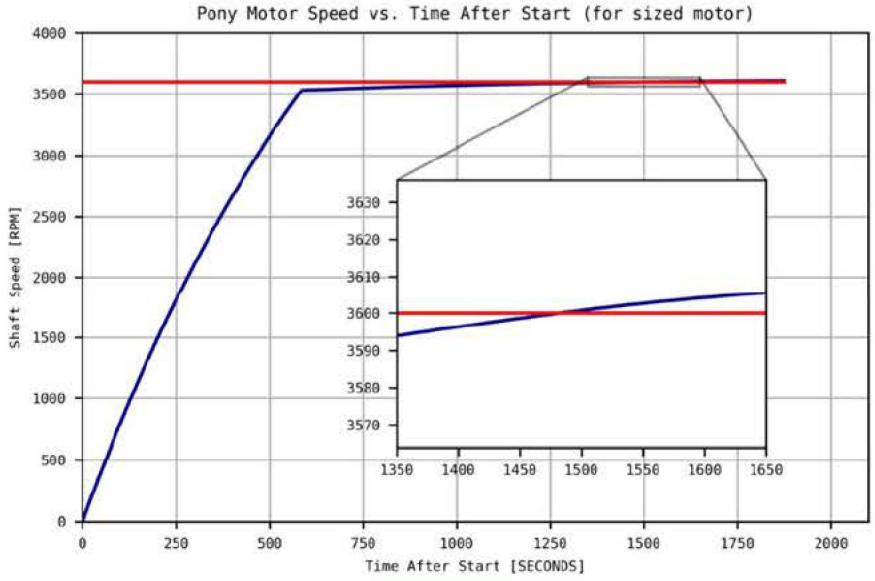
Figure 3-9: Probable Unit 1 SynCon Capability as a Function of System Voltage



3.2.8 Generator Starting System / Acceleration System

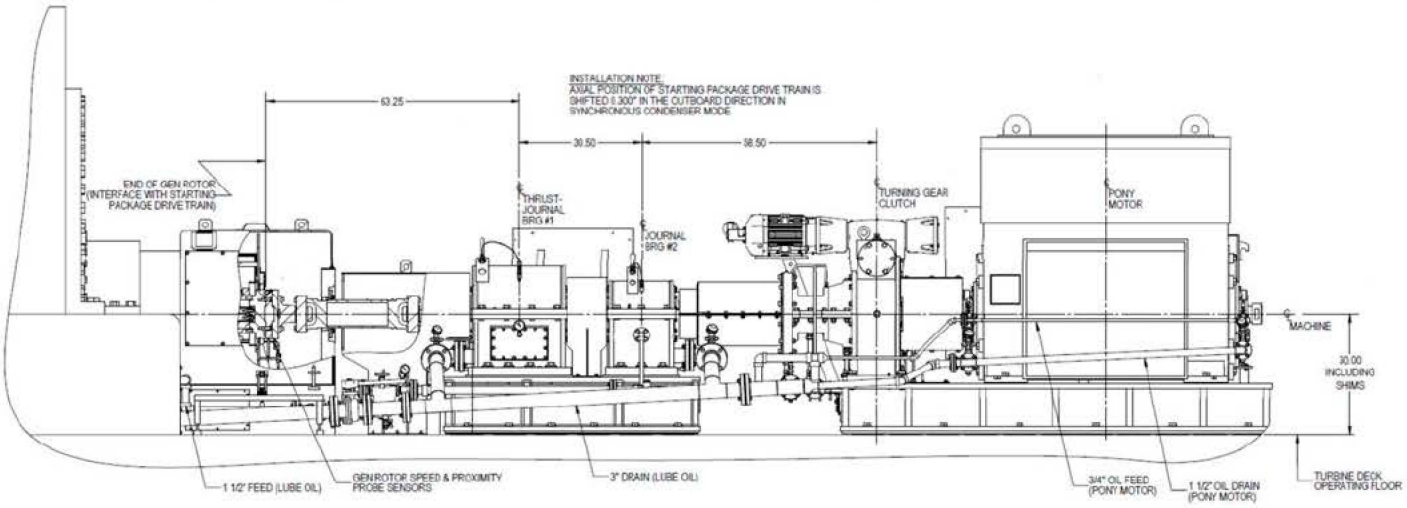
Mechanical starting using VFD plus AC motor has been evaluated to be the most economical solution for bringing the generator rotors from rest to synchronous speed. Using a VFD in the starting system provides for excellent operational flexibility. The VFD parameters can be custom-tailored to the unit needs during start-up/commissioning/tuning. It's not uncommon to have hold speeds/periods or skip speeds based on machine-specific vibration. BMcD performed a preliminary starting motor sizing analysis based on unit-specific data provided by EKPC. The results of the sizing calculation are provided in Appendix E. Bringing the rotor from turning gear speed to 3600 rpm in 25 minutes will require a 1,400 HP motor for Unit 1. An excerpted figure from the sizing calculation is presented below.

Figure 3-10: Shaft Speed vs. Time for Unit 1 Pony Motor Start



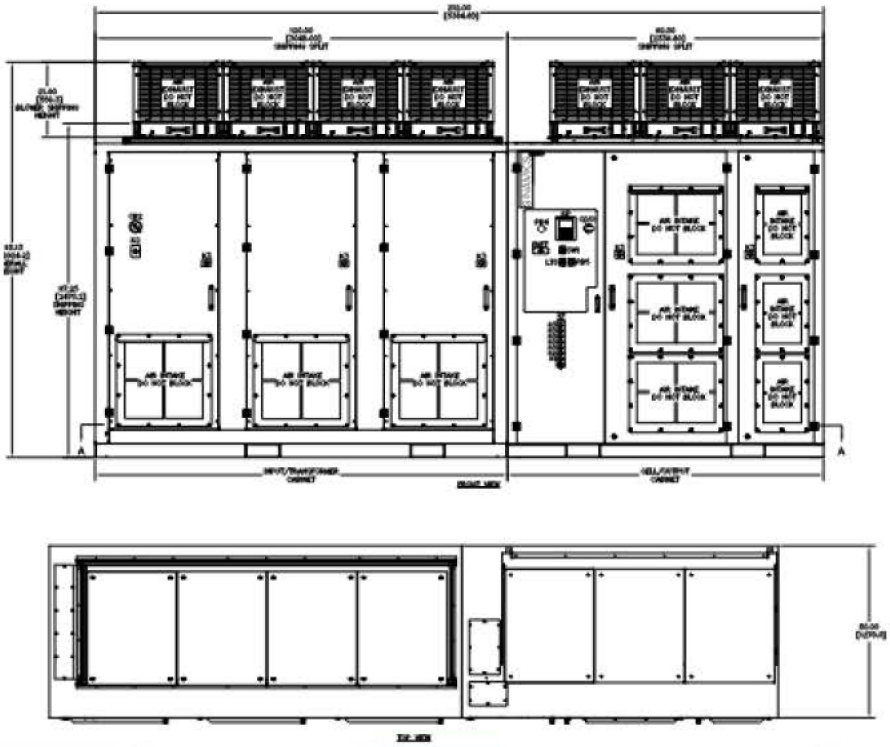
The motor would be mounted on the operating deck (or turbine pedestal) at the exciter-end of the generator. The motor would be connected to the generator shaft extension to engage with the needed thrust bearing. The thrust bearing assembly is tightly coupled with the overrunning clutch and turning gear (see Figure 3-11). The SynCon project scope includes a detailed rotordynamic analysis for the modified rotor train. Flexible couplings will be selected to suit the needed stiffness / damping criteria.

Figure 3-11: Typical side-view for generator collector end, turning gear, clutch, and starting motor



A variable frequency drive system and isolation transformer would be procured for application on the 4160V system. The 4160V air cooled VFD will be installed on the mezzanine level, near the 4160V switchgear.

Figure 3-12: Typical Generator Starting Motor VFD



3.3 Electrical Systems

3.3.1 Electrical Distribution

To feed the new starting motor VFD, a spare breaker from the existing Unit 1 General Service 4160V Switchgear would be utilized. When operating in SynCon mode, a majority of other large loads on the 4160V system would not be operating, likely resulting in a lower overall auxiliary load for the unit and minimizing potential impact of voltage drop. Cost has been included for breaker refurbishment, current transformer replacement, and a protective relay upgrade.

To feed new 480V loads, a new 600A, 480V motor control center would be added near existing motor control centers on the mezzanine floor. A reconditioned circuit breaker will be installed in 480V Unit Sub 1B. to feed the new motor control center.

Some additional DC and essential AC power will be required for new equipment. The existing battery and UPS system was not analyzed as part of this study but is believed to be adequate for the incremental additional load necessitated by the conversion.

Grounding points are available throughout the site and the estimate does not include any modification to the existing grounding system at the plant.

3.3.2 Generator Excitation System

The existing static excitation system was upgraded to the GE EX2100e in 2016. EKPC indicated that the existing PPT and excitation system are adequate, so a replacement or upgrade is not recommended at this time. New AVR settings will be required that utilize multiple settings groups toggled in SynCon mode. Cost has been included for the exciter OEM to make the necessary modifications.

3.3.3 Generator Step-Up Transformers

EKPC informed Burns & McDonnell that all plant Generator Step-up transformers are original. Since GSUs typical life span is around 30-40 years, and the existing GSU has been in service for ~60 years, the Unit 1 GSU is likely nearing end-of-life. However, per EKPC request the replacement cost has been excluded from project scope.

3.3.4 Generator Stator & Rotor

EKPC did not note any current issues with the state of the Generator Stator and Rotor. A generator inspection and testing service contract is recommended and includes:

- Analysis of Generator Testing Reports
- Disassembly and Reassembly of the Generator
- Mechanical inspections (Bearing & H_2 Seals)
- Electrical field and stator testing
- Wedging and Blocking inspections

Costs for a generator inspection and reliability study (life assessment) completed by the OEM is not included in the cost estimate. BMcD recommends that EKPC include Owner's Costs to provide for these services early into the next project phase.

3.3.5 Generator Protection Scheme

Generator protection relays were upgraded in late 2015/early 2016 and includes an SEL-300G relay and a Beckwith M-3425A relay. New protection settings will be required that utilize multiple settings groups toggled in SynCon mode. The relays themselves are adequate and do not need to be replaced.

Auto-synchronization is currently performed in the MarkVIe control system. BMcD recommends the replacement of the existing auto-synchronizer with an SEL-700G. This relay will provide accurate and repeatable synchronization, as well as sophisticated troubleshooting and reporting capabilities to aid in commissioning the SynCon. Cost for this replacement has been included in the estimate.

3.4 Instrumentation and Controls

3.4.1 DCS Control Logic, Hardware

Cooper Unit 1 is currently controlled through an ABB DCS. EKPC has directed BMcD that the SynCon conversion project scope should include modifications to the existing DCS. The equipment for the SynCon systems (starting system, lube oil, electrical feeds, etc.) would be controlled through the DCS. To accommodate the newly added I/O, a new process control unit (PCU) will be added to the existing loop. The amount of I/O needed is estimated in the below breakout table.

Table 3-1: I/O Type Breakout

Signal Type	Quantity	with 30% spare added	I/O Card Quantity
AI	31	41	6
AO	8	11	3
DI	69	83	6
RO	35	46	4
TC	17	23	3
RTD	11	15	2

3.4.2 Supervisory Instruments and Vibration Monitoring

Cooper Unit 1 vibration monitor is currently accomplished through a Bentley Nevada 3500 vibration monitoring system. The synchronous condenser conversion will require, at a minimum, the addition of two radial and two axial transducers for the thrust bearing, and two radial transducers for each of the motor bearings per unit. Because the generator will be decoupled from the turbine during synchronous condenser mode there will likely be no generator speed reference other than that from the starting system. It is recommended that a keyphasor probe be added to the generator to determine the speed of the generator (the cost for this scope is included in Engineered Equipment). A new rack with the appropriate modules will be added to the existing 3500 system. New probes will be furnished and installed.

3.5 Structural Modifications

The new starting motor and turning gear will be mounted on a skid and located on the operating floor at the exciter end of the generator. Since this area is an elevated concrete floor slab, a review of the structure will be performed in the area directly supporting the starting motor skid to determine if additional supports or reinforcing of the slab and structural steel is required.

Miscellaneous pipe and cable tray supports will be fabricated and installed as required. The supports inside the Turbine Building will be attached to existing structural steel or attached to the existing building foundation and floor slabs.

3.6 Winterization Efforts

The project scope plans to exclude any winterization efforts. The only significant piping alterations will be the Lube Oil System, which does not require winterization by virtue of the fluid service and the location of the system indoors. The Lube Oil System scope also already includes a heater for maintaining "standby condition" during cold winter ambients. The LP lake water system will also not require any additional winterization as all that will be changing about its function during synchronous condenser operation will be what users are isolated. Users that are isolated for SynCon mode will need to have the coolers drained out for winter prep by the EKPC team to prevent any freezing concerns. Lastly the compressed instrument air supply will not require any winterization as it is dry air. The cost estimate basis is that, because the SynCon is seasonal then all existing plant winterization equipment (heaters, heat tracing, etc.) will remain serviceable.

3.7 Considerations for Conversions

The "seasonal" nature of the SynCon implies that the Unit will be capable of switching modes to/from power generation mode and synchronous condenser mode. The exact time required to make the change is unknown, but generally believed to be in the range of three to five working days. Activities to complete during the mode switch include: inserting or removing the coupling between the LP turbine and the generator, performing generator shaft balance adjustments ("balance shot"), changing the position of manual valves in the lube oil and LP lake water systems, boiler fuel systems emptying or filling, boiler water side draining (layup) or filling, and changing mode settings in the DCS and generator protection relays.

4.0 Cost Estimate

This section summarizes the development of the capital cost included in the evaluation.

4.1 Cost Estimate Target Accuracy

The basis and scope of the capital cost estimate were developed by Burns & McDonnell and EKPC through scoping meetings and based on plant information, assumptions detailed in this report, and relevant project experience. The intent of the estimate is to provide screening-level costs which cover reasonable risk items for the SynCon conversions. The capital cost developed for the recommended SynCon conversion for each unit are estimated to be in the accuracy range of low by -15% to -30%, and high by +20% to +50% (per AACE accuracy definition for Class 4). This range applies to any additional options described in Section 5.1.3. The following sections summarize the approach and buildup of the cost estimates for the SynCon conversions.

4.2 Direct Cost Estimate Basis

The capital cost estimate are based on the scope, assumptions, and schedule developed for this study and conceptual engineering effort. The cost estimate is generally based on a top-down approach utilizing costs from similar projects (scaling of equipment costs, installation, quantities, etc.) and quantities based on conceptual design (i.e., conceptual takeoffs and equipment size, concrete quantities, etc.). The exception to this rule is the modifications to the shaft centerline equipment. For these costs, BMcD contacted Electro Mechanical Engineering Associates (EME) with special expertise in rotating machine modifications.

BMcD used internal pricing for materials, subcontracts, labor and productivity rates. No contractors have been contacted to provide pricing for this study.

4.2.1 Engineered Equipment

The engineered equipment includes the procurement and installation of equipment associated with the project, including the generator shaft modifications and new combo thrust/steady bearing equipment, starting motor and VFD ("mechanical start" method), turning gear/clutch assembly, pumps and automatic backwashing strainers.

Procurement costs for the generator shaft and bearing modifications are based on budgetary quotes from the generator shaft modification special expertise supplier solicited to support this estimate. Other equipment procurement costs are based on in-house data from recent similarly sized projects.

4.2.2 Concrete

Concrete maintenance pads for the indoor equipment (mechanical and electrical) is included. Rebar associated with concrete is included in the concrete cost. The concrete cost includes all formwork, as well as anchor bolts. Concrete foundation modifications for the starting motors have been included.

4.2.3 Structural Steel

The structural steel scope of work includes supplementary steel to provide additional foundation stiffness under the new starting motors. These quantities were included to approximate the cost but are not final as the structural analysis of the floor has not been completed. No allowance for new support columns was included. An allowance for supplemental steel was included for pipe supports, cable tray supports and other miscellaneous needs.

4.2.4 Piping and Mechanical

The piping scope of work includes above ground piping installation. Piping quantities are based on the conceptual equipment arrangement and previous project experience. Pipes were sized using preliminary flow rates and acceptable velocity limits for each system/fluid service. Appendix C includes conceptual design P&ID's that show the various piping runs (and concept valve/instrument quantities) included in this estimate.

4.2.5 Electrical

The electrical scope includes modifications to the existing MV switchgear lineup to feed synchronous condenser loads, a VFD for the synchronous condenser starting motor, and new 480V 600A MCC. No lightning protection or cathodic protection is anticipated as a part of this project. No heat trace has been deemed necessary in the preliminary Line List.

Cable Tray, conduit and cable taken off from a preliminary cable schedule are also included in the electrical costs. Temporary power material and installation was included though consumption costs were excluded.

Cables were sized using preliminary load data, and accounting for voltage drop. Preliminary routes assumed approximately direct routes through the existing facility, with some margin accounted for to avoid potential interferences. A load flow analysis and short circuit analysis was not performed as part of this preliminary design effort. Estimates for installation assume that no equipment, conduit, lighting, or any other components will need to be classified for installation in a hazardous area.

4.2.6 Instruments & Controls

The instrumentation scope of work is based on the I/O count included for the control of the new equipment, and for the addition of minimal new instrumentation for the lube oil design.

Controls will utilize existing DCS hardware and software with modifications. Costs for these modifications were not based on a budgetary quote but were developed utilizing in-house data from similar projects.

4.2.7 Miscellaneous Directs

Miscellaneous direct costs include scaffolding, flushing, MOD-025/026 testing, craft start-up support and start-up technicians.

4.2.8 Escalation

Escalation has been included on all material and labor at a rate of 4% per year.

4.2.9 Taxes

Taxes are carried below the line as an estimated Owner's Cost.

4.2.10 Labor Wage Rates

Burns & McDonnell used wage rates from RSMeans to get average union labor rates for Lexington, KY. This provided Burns & McDonnell with an estimate of the labor cost in the area. Productivity was based on past experience working in the region as well as consideration for working in a brownfield environment tying into existing infrastructure. A full labor survey for the area would need to be conducted in order to reduce labor risk and contingency.

4.2.11 Project Contingency

Necessary contingency at the project level was evaluated by the engineering team and estimator based on the perceived status of the engineering deliverables (basis of design) and the perceived accuracy of the source pricing information. As described at the beginning of the report, the Project Contingency is intended to cover the accuracy of pricing, commodity estimates, and omissions from the defined project scope (does not account for potential changes in scope). The Project Contingency was assigned a flat rate as a percentage of the project based on BMcD's experience without rigorous supporting analysis.

4.3 Indirect Cost Estimate Basis

Indirect costs include costs for Construction Management, Engineering, Startup and Commercial, as described within the following sections.

4.3.1 Construction Management

The construction management and construction indirect estimate is based on BMcD experience in the construction industry which details costs the Owner will incur during construction to include construction management staff, and indirect service such as site facilities, miscellaneous site services, and staffing supplies. This build up was completed utilizing similar sized projects for reference and the schedule and contract requirements of the project.

4.3.2 Engineering

The engineering costs included in these estimates are based on discipline estimates of the effort necessary to complete the project based on BMcD experience and similar projects. The cost includes engineering to develop the technical requirements for the generator modifications RFP, technical specifications for other major and minor equipment, and to produce the installation specifications and necessary construction documentation for completion of the work. An allowance for construction support engineering hours is also included in the engineering cost in this estimate.

4.3.3 Start-Up and Commissioning

Start-up cost was estimated for the scope of work. This estimate is based on BMCD experience from similar projects. Startup costs include startup management, startup engineering, home office support and startup indirects.

4.3.4 Commercial

Costs for Parent Guarantee, and warranty management have been excluded. Letter of credit and P&P Bonds have also been excluded from the cost estimate.

4.3.5 Owner's Costs

It is anticipated that there will be additional owner costs associated with the project including taxes, builder's risk Insurance, & an independent vibrational analysis consolation. These Are described in Appendix A.

4.4 Cost Estimate Summary

Appendix A summarizes the cost estimate for the SynCon conversion.

5.0 Conclusions and Recommendations

5.1 Conclusions

The results of the investigation indicate that conversion of Cooper Unit 1 is feasible based on the available information and the evaluations completed herein. Whether the conversion is economical or provides the performance characteristics necessary to support the grid is outside the scope of this report. Further investigation and analysis is necessary to establish the complete project scope and determine the relative strength of the proposed conversion compared with other capital projects.

5.2 Schedule

A proposed level 1 schedule is included in Appendix B which was utilized to develop the project escalation costs on equipment, material, and labor. Depending on EKPC's generation plans, the project has flexibility to adjust when it is completed and ready for commercial operation. The project will require an outage to complete the generator modifications which is anticipated to take up to 16-weeks.

5.3 Next Steps and Recommendations

It is recommended that EKPC complete detailed power system modeling, in concert with PJM as necessary, and incorporate necessary economic comparisons for alternative transmission-based solutions to determine if EKPC wants to pursue synchronous condenser conversions. Following this, a detailed PSR should be developed to establish project budget and schedule. Included in this activity would be a complete evaluation of the project execution strategy, contracting strategy, risk mitigation efforts, and development of preliminary design deliverables. This would permit establishment of a project budget and finalization of the project contingency. The final value of this contingency will depend on EKPC's preferred risk profile, the selected contract execution strategy, and on the outcome of risk mitigation efforts.

It is recommended that PSR efforts begin immediately following completion of economic and transmission modeling efforts in order to reduce the potential impact of project schedule on escalation costs. Project scoping efforts can include development of major equipment specifications to potentially further reduce project schedule and should be focused on selecting a final approach to each system design. Additionally, it is recommended to perform condition assessments on the candidate generator for SynCon conversion at the earliest available outage by the OEM or tier-one third party. Condition assessments with the goal of preserving 20+ years of future asset life may yield new recommended corrective actions for these generators not currently anticipated because of the existing "near retirement" perspective. It is recommended for the scope to be comprehensive in nature, including but not limited to: winding testing, insulation testing, vibration assessment, generator cooler condition & pressure test, wedge tightness, etc. The condition assessment can serve as a final go/no-go gate for the project, and if the results are favorable, it should result in work scope to be included in the final project.

If the project is selected for further development, it is recommended to include a rotordynamic analysis by the party performing the centerline shaft modifications, with the intent to identify critical speeds and the margin of separation. Similar to the generator condition assessment, the rotordynamic analysis results can serve as another go/no-go gate early into future project development efforts.

APPENDIX A COST ESTIMATE

AACE Class IV CAPITAL COST ESTIMATE
EKPC
Cooper Station
Unit 1 - 133.7 MVA SynCon Conversion
Somerset, KY
BMcD #157786

	Total Cost
Total Direct Cost	**$8,024,000**
Engineering, CM/CI and Startup	$4,227,000
Total Indirect Cost	**$4,227,000**
Contingency and Escalation	$2,759,000
Total Project Cost	**$15,010,000**
Owner Costs - Estimated Taxes	$649,000
Owner Costs - Builder's Risk Insurance	$363,000
Owner Costs - Independent Vibration Analysis Consultant	$50,000
Total Project Cost Incl. Owner Cost	**$16,072,000**

Rev.	Rev. Date
1	09/26/23

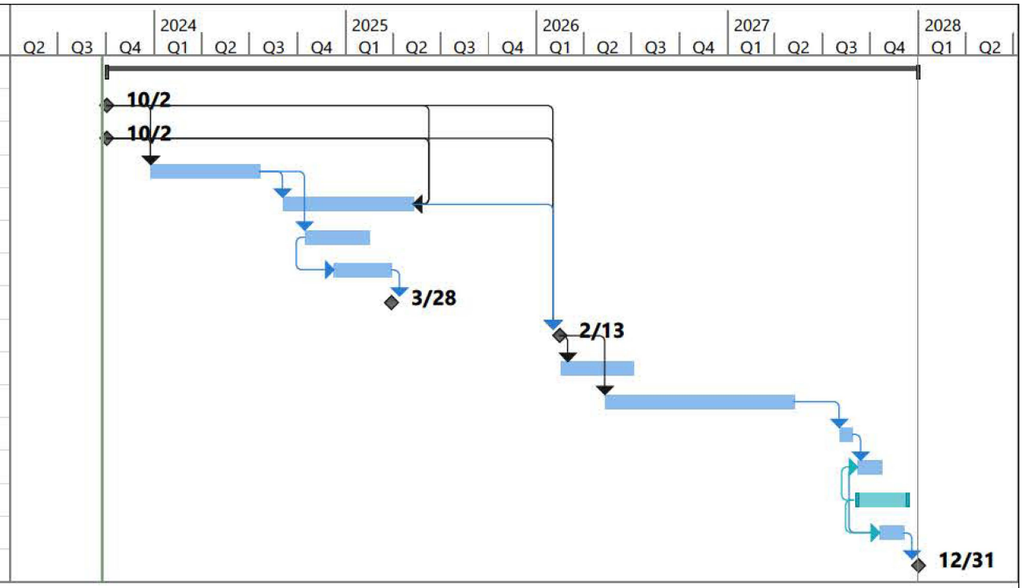
BURNS McDONNELL

V 3.9

Option	Description	Total Cost

APPENDIX B LEVEL 1 SCHEDULE

ID	Task Mode	Task Name	Duration	Start	Finish
1		**Cooper - Unit 1 Synchronous Condenser**	**1110 days**	**Mon 10/2/23**	**Fri 12/31/27**
2		Permitting Application Development and Review Peiod	0 days	Mon 10/2/23	Mon 10/2/23
3		PJM Interconnect Application Development and Review Period	0 days	Mon 10/2/23	Mon 10/2/23
4		PDR/CPCN Development	150 days	Mon 12/25/23	Fri 7/19/24
5		PSC CPCN Review	180 days	Mon 9/2/24	Fri 5/9/25
6		Engineering LNTP Period	90 days	Mon 10/14/24	Fri 2/14/25
7		Generator Modifications OEM Bid/Evaluate	80 days	Mon 12/9/24	Fri 3/28/25
8		Generator Modifications OEM LNTP Award	0 days	Fri 3/28/25	Fri 3/28/25
9		Engineering & OEM FNTP	0 days	Fri 2/13/26	Fri 2/13/26
10		Equipment Fabrication (Mechanical)	100 days	Mon 2/16/26	Fri 7/3/26
11		Equipment Fabrication (Electrical)	260 days	Mon 5/11/26	Fri 5/7/27
12		Construction (pre-Outage)	20 days	Mon 8/2/27	Fri 8/27/27
13		Construction (Outage)	35 days	Mon 9/6/27	Fri 10/22/27
14		Outage Duration	70 days	Mon 9/6/27	Fri 12/10/27
15		Commissioning & Startup	35 days	Mon 10/18/27	Fri 12/3/27
16		Commercial Operation Date	0 days	Fri 12/31/27	Fri 12/31/27



Project: 157786.SynCon Level 1
Date: Sun 9/24/23

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

APPENDIX C MECHANICAL REFERENCE DOCUMENTS

MECHANICAL EQUIPMENT LIST

East Kentucky Power Cooperative
John Sherman Cooper Station Unit 1 Seasonal SynCon Project
BMcD Project #: 157786

Unit Code	Sys. Code	Device Code	Seq. Number	Suffix	Tag Number	Insulation or HT	Equipment Name/Description	P&ID	Nominal Capacity / Rating	Electrical Load	Supply By	Construct By
1	LO	PMP	001		1-LO-PMP-001	-	Aux. Bearing Oil Pump	MBLOT-01	400 gpm @ 120 feet TDH	30 HP	5.2955	5.8320
1	LO	HTR	002		1-LO-HTR-002	-	Recirc Heater Skid	MBLOT-01	20 kW	20 kW	5.2955	5.8320
1	LO	TGR	003		1-LO-TGR-003	-	Turning Gear / Clutch Skid	MBLOT-01	-	10 hp	5.1110	5.8320

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APPENDIX D ELECTRICAL REFERENCE DOCUMENTS

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Client-Site: EKPC Cooper

Project: Unit 1 **Synchronous Condenser Conversion**

ELECTRICAL EQUIPMENT LIST

BMcD Project Number: **157786**

Rev	Equipment Tag Number	Shop Skid Tag Number	Equipment Description	Fluid Type	Operation (Qty X %)	Rating	Voltage (VAC)	Full Load Current (Amps)	Indoor / Outdoor	Insulation (Y/N)	Insulation Thickness	Supply Contract	Install Contract	Reference P&ID	Other Notes
Electrical Equipment															
0	TBD	TBD	Synchronous Condenser Starting Motor	N/A	1 x 100%	1500 hp	4160	TBD	Indoor	N	N/A	5.1110	5.1110	N/A	Electrical ratings are preliminary and subject to change after bid review.
0	TBD	TBD	Synchronous Condenser Starting Motor VFD	N/A	1 x 100%	1500 hp	4160	TBD	Indoor	N	N/A	5.1110	5.8320	N/A	Electrical ratings are preliminary and subject to change after bid review.
0	TBD	TBD	Synchronous Condenser Turning Gear Motor	N/A	1 x 100%	TBD	480	TBD	Indoor	N	N/A	5.1110	5.1110	N/A	Electrical ratings are preliminary and subject to change after bid review.
0	TBD	TBD	480V Synchronous Condenser MCC	N/A	1 x 100%	600 A	480	600	Indoor	N	N/A	5.5310	5.8320	N/A	Electrical ratings are preliminary and subject to change after bid review.

NOTES:

1)

APPENDIX E STARTING MOTOR SIZING RESULTS

SYNCHRONOUS CONDENSER PONY MOTOR SIZING PROGRAM by Burns & McDonnell Engr.

----------Calculation Input Summary---------	
Date and time this sizing calculation was run:	2023-07-06 11:12:55
Version Number for pony motor sizing script:	1.4
Burns & McDonnell Project Number:	157786
Client or Owner of the facility :	EKPC
Project Name :	Unit 1 SynCon Study
Generating Station or Plant name :	COOPER
Generating Unit Number or Code :	1
The Original Equipment Manufacturer :	General Electric
Machine cooling type :	Conventional hydrogen cooled
Machine nominal rated speed aka synch speed (RPM) :	3600
Machine nameplate output (MVA) :	133.689
Machine exciter power source :	Powered w/ rotor torque via pony motor
Generator Circuit Breaker (GCB) location :	High Side
Drag torque applied on rotor from energizing GSU coils (ft-lbf) :	127.1
Drag torque applied on rotor from energizing GSU coils (N-m) :	172.3
Drag torque applied on rotor from energizing exciter (ft-lbf) :	823.3
Drag torque applied on rotor from energizing exciter (N-m) :	1116.2
Shaft speed where exciter losses / rotor energizing losses are engaged (RPM) :	3528.0
Moment of Inertia (Iz) used in calculation including margin (lbs-ft2) :	71877.0
Moment of Inertia (Iz) used in calculation including margin (kg-m2) :	3028.9
Mechanical torque losses used in calculation at full speed, including margin (ft-lbf) :	994.8
Mechanical torque losses used in calculation at full speed, including margin (N-m) :	1348.8
Starting Time duration target from t/g speed to synch speed (minutes) :	25
Percentage split for loss type Mechanical / Electrical / GSU (%/%/%) :	49.9% / 43.4% / 6.7%
----------Sizing Output Results----------	
Sum total of all torque losses at synch speed (ft-lbf) :	1945.2
Sum total of all torque losses at synch speed (N-m) :	2637.3
Equivalent motor power equaling all torque losses at synch speed (HP) :	1333.3
SOLUTION --> Estimated motor power to reach synch speed at target time (HP) :	1340.2
SOLUTION --> Pony motor's nominal rated speed (RPM) :	3600

----------End Text Output ----------

FIGURE 1

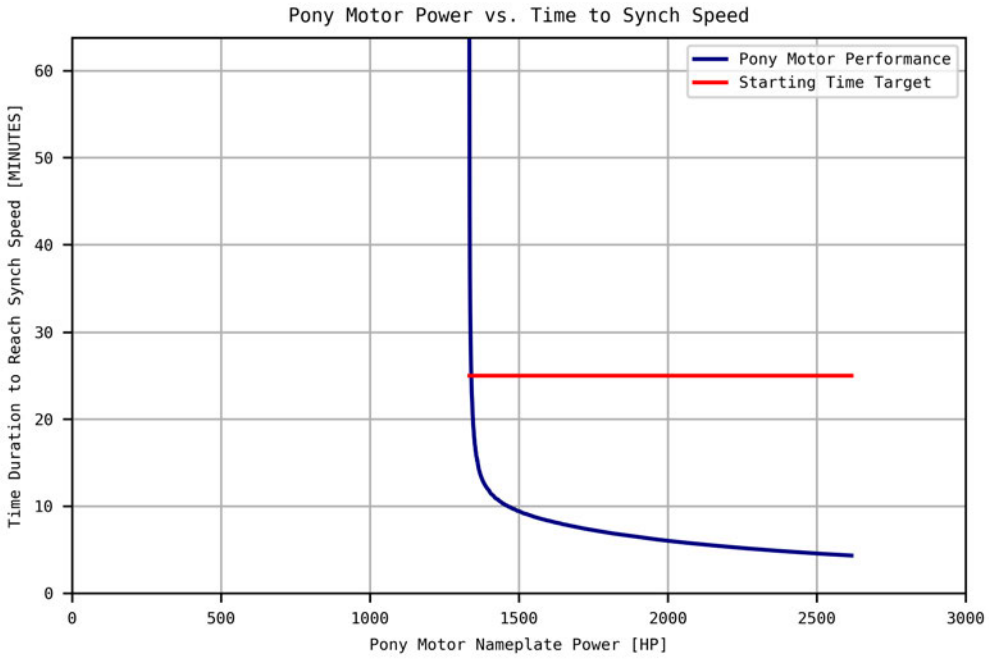


FIGURE 2

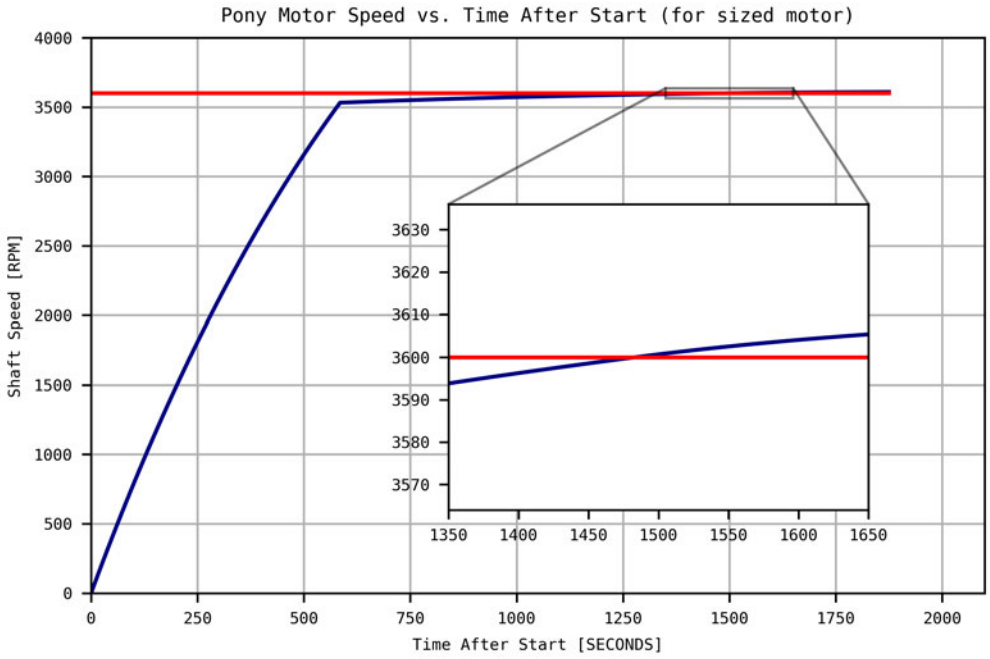
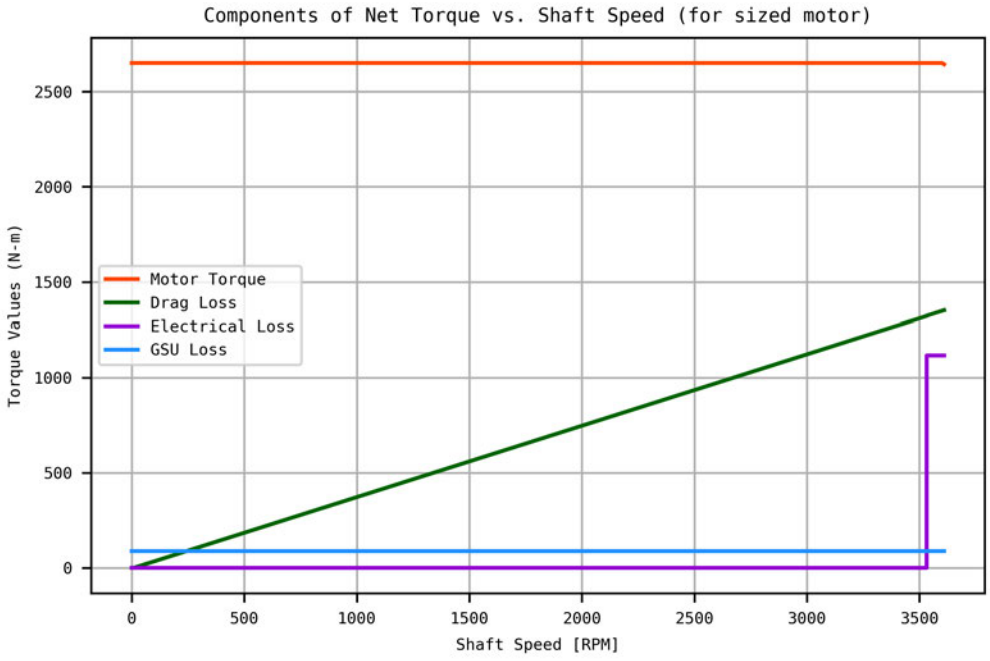


FIGURE 3



APPENDIX F SCOPE MATRIX

EKPC - Cooper Station
Unit 1 SynCon Conversion Project
Scope Basis Matrix

Item	Motor Starting Method	COMMENTS
Project Description	***East Kentucky Power Cooperative - Synchronous Condenser Conversion Study: Cooper Unit 1***	
Number of Condensers	One (1): Unit 1 nominal 133.7 MVA with +100 MVAR / -67 MVAR capability	+ indicates VAR export capability, - indicates VAR import
Manufacturer, Type	General Electric, Conventional Hydrogen Cooled (30 psig H_2), 2-pole	
Project Location	Somerset, KY	Existing brownfield site.
Site Description	Two-unit coal fired generating station. Operators - this will be a manned facility (Operators remain present onsite for continued Unit 2 operation)	Long-term design life of 20+ years. This facility is intended to be a reliable grid support asset.
Overall Scope of Supply	Seasonal SynCon Conversion (Unit can flip-flop b/w SynCon mode and Power Gen mode) Turbine-generator shaft modifications, supplemental bearings, cooling and lube oil system modifications, and generator starting package.	It's possible that Future modifications to make permanent SynCon possible.
	Technical Assumptions	
Decommissioning		
Electrical Systems	Some demolition will be required based on site constraints. This will vary among units and among equipment.	
I&C	Minimal decommissioning of I&C. Existing ABB DCS to be modified.	
Mechanical Systems	Cooling Water (LP Lake Water): no physical modifications required. Lube Oil: Modify existing lube oil system as necessary to make tie-ins.	
Structures	No major demolition or decommissioning planned as part of this project. However, the project has a design goal of not adding to the difficulty of future decommissioning efforts at site. Utilities and tie-ins should be located to make future demolition possible without disturbing the SynCon scope.	
Starting Method		
Starting Method	**Motor Start with VFD ("pony motor")**	
Starting Motor	One (1) required per unit, total one (1) motors, each 3600 rpm at nameplate power rating 1,400 HP.	Target time 25 minutes from turning gear speed to 3600 rpm.
Starting Variable Frequency Drive (VFD)	EKPC's project basis is to add one (1) VFD dedicated to the Unit 1 SynCon.	
Overrunning Clutch	Required / Included	Part of starting package.
Thrust and Steady Bearing with Shaft Extension	Required / Included	Part of starting package.
Low Side Generator Circuit Breaker	None existing - none planned to be added.	The Unit uses high-side GCB to synch with grid.
Cooling Water System/Lube Oil System Modifications	Required / Included	See P&IDs for project mechanical / piping scope.
Static Exciter	Existing system is EX2000 exciter; replaced in 2000. Then to 2016 for the EX2100. Front-end controls upgrade recently completed. Project work scope: need different control settings for SynCon mode (GE services contract). Power fed from PPT tapped on IPB.	
Utilities		
Water Supply:		
Raw Water	Existing LP Lake Water System will remain in-service for the design life of the project. Also note EKPC has project in-progress to replace a wet well pump w/ smaller unit for reduced cooling water withdrawal rate during offline operation (output in the 500 gpm to 1200 gpm range, which matches up to Unit 1 cooling needs nicely). This pump feeds the LP Lake Water header. That project is a 'go' and will be implemented during 2024. **No new LP Lake water pump changes included in project scope.**	Note that the Fire Protection Pumps (and systems) will remain in-service.
Generator Cooling Makeup	Not Applicable to this Unit.	
Wet Surface Air Cooler Make-up	Not Applicable to this Unit.	
Potable Water	No modifications planned (other than tie-in). System to remain in service for emergency showers.	
Wastewater Disposal:		
Process Wastewater Discharge	LP Lake Water Return (used as cooling water) can be discharged back to Cumberland River. No chemicals (biocide) added, no neutralization required.	Assumption is that the intake does not require any modifications to prevent icing. The station intake is ~40' below water level.
Sanitary Wastewater	No modifications planned.	
Internet	Existing dedicated connection. No changes planned.	
Building Conditioning	No modifications planned as part of project scope. HVAC modifications and modified architectural spaces / walls are excluded from the project scope. Project basis is that no heat tracing / insulation to be required indoors. Unit 2 will remain available even with Unit 1 offline. Plant is confident in freeze-protection capability for short-term events. No scope included.	
Civil		
Existing Facilities	No major demolition.	
Disposal of Spoils	Will dispose of spoils on site.	
Soil Conditions / Stability	A preliminary review of existing Geotechnical reports indicates karst subsurface conditions that will require mitigation efforts. However, mitigation efforts will not affect the existing structures impacted by this project.	
Subsurface Rock	No subsurface rock - no rock expected down to bedrock at ~ 40 foot depth.	
Cut & Fill	N/A	
Dewatering	N/A	
Site Access	By existing roads into plant.	
Roads	No modifications planned.	
Site Security:	Excluded from project scope.	
Storm Water	No planned modifications.	
Structural		
Soil Bearing Capacity	Suitable for conventional spread footings or mats supported on native soil.	
Foundations:		
Cooling Water Pump (LP Lake Water)	LP Lake Water pump changes excluded from project scope. Existing system is adequate.	

EKPC - Cooper Station
Unit 1 SynCon Conversion Project
Scope Basis Matrix

Item	Motor Starting Method	COMMENTS
Project Description	***East Kentucky Power Cooperative - Synchronous Condenser Conversion Study: Cooper Unit 1***	
Number of Condensers	One (1): Unit 1 nominal 133.7 MVA with +100 MVAR / -67 MVAR capability	+ indicates VAR export capability, - indicates VAR import
Manufacturer, Type	General Electric, Conventional Hydrogen Cooled (30 psig H_2), 2-pole	
Project Location	Somerset, KY	Existing brownfield site.
Site Description	Two-unit coal fired generating station. Operators - this will be a manned facility (Operators remain present onsite for continued Unit 2 operation)	Long-term design life of 20+ years. This facility is intended to be a reliable grid support asset.
Overall Scope of Supply	Seasonal SynCon Conversion (Unit can flip-flop b/w SynCon mode and Power Gen mode) Turbine-generator shaft modifications, supplemental bearings, cooling and lube oil system modifications, and generator starting package.	It's possible that Future modifications to make permanent SynCon possible.
	Technical Assumptions	
Starting Motor	Modify turbine pedestal, after demolition of existing exciter, with slab foundation and anchor bolts. Possible reinforcement for enhancement of structure needed.	
Steady rest/thrust bearing assembly	Modification of turbine pedestal foundation as necessary to support new assembly.	
Structural Steel supports	As required for new cable tray/pipe supports.	
DCS Cabinets	Added remote I/O cabinets (if necessary) require housekeeping pads.	
Motor Control Centers	Housekeeping pads as applicable.	
Transformers	Housekeeping pads as applicable.	
Buildings/Enclosures	None planned.	
Synch Condensers	Indoors, within existing turbine hall(s).	
Administration	Existing Admin Buildings to remain.	
Control Room	Existing Control Rooms to remain.	
Electrical	Existing Electrical Rooms to remain.	
Warehouse/Maintenance	Existing Warehouse / Maintenance areas to remain.	
Platforms:		
General	Synch condenser hall access platforms and auxiliary module platforms.	
Structural Steel (by Contractor)	Hot Dipped Galvanized	
Maintenance cranes	No new permanent cranes included.	
Overhead Hoists Monorails	Existing bridge crane over turbine hall(s), with removable floor panels for Lube Oil equipment access.	
Mechanical		
Synchronous Condenser:		
Vendor & Model	Existing GE generator / ATB 2-pole	
Generator Cooling Type	Conventional hydrogen cooled (rotor + stator). Nameplate 30 psig hydrogen pressure.	
AGC / Dispatch	SynCon exciter shall receive control signals based on remote bus voltage.	
Turning Gear	Existing turning gear will be disconnected from shaft during SynCon operation. Additional motor-driven turning gear to be added as part of starting package.	
Coupling	Motor drive shaft and flexible couplings as required.	
Clutch Assembly	Overrunning clutch included.	
Vibration Monitoring	Scope assumption: provide new BN Rack with added channels. Logic required to switch between operating mode.	
Lube oil Cooling	Modify existing lube oil system. Major turbine outage in Fall 2021 included overhaul for lube oil pumps, motors, heat exchangers, etc. Project scope will include one (1) additional pump and valves to provide for swapping b/w syncon mode and power gen mode. Lube Oil scope also includes electric heater (20 kW) to maintain standby temperature during cold ambients.	
Turbine Supervisory Instruments	New instruments added as required.	
Pumps:		
Seal Oil Pumps:	Existing seal oil system OK as-is. Major turbine outage in Fall 2021 included overhaul for lube oil pumps, motors, heat exchangers, etc.	
Type	Changes not required.	
Size	Changes not required.	
Drives	Changes not required.	
Stator Cooling Water Pumps:	Not Applicable to this Unit.	
Type	Not Applicable to this Unit.	
Size	Not Applicable to this Unit.	
Drives	Not Applicable to this Unit.	
Chemical Feed Pumps:	Not Applicable to this Unit.	
Type	Not Applicable to this Unit.	
Size	Not Applicable to this Unit.	
Drives	Not Applicable to this Unit.	
Lube Oil Pumps:	New AC-motor driven pump added to existing LO skid (replace function MOP).	
Type	Vertical shaft impeller submersed / cantilever type (mounted on top of reservoir).	
Size	Nominal rating 400 gpm flow at 120 feet total developed head.	
Drives	Fixed speed electric motor ~30 HP.	
Service Water Pumps:	No modifications planned, Seasonal conversion implies minimum changes.	
Type	Not Applicable to this Unit.	
Size	Not Applicable to this Unit.	
Drives	Not Applicable to this Unit.	
Closed Cooling Water Pumps:	Comes from LP Lake Water. See new pump description above - new pumps not added.	

EKPC - Cooper Station
Unit 1 SynCon Conversion Project
Scope Basis Matrix

Item	Motor Starting Method	COMMENTS
Project Description	***East Kentucky Power Cooperative - Synchronous Condenser Conversion Study: Cooper Unit 1***	
Number of Condensers	One (1): Unit 1 nominal 133.7 MVA with +100 MVAR / -67 MVAR capability	+ indicates VAR export capability, - indicates VAR import
Manufacturer, Type	General Electric, Conventional Hydrogen Cooled (30 psig H_2), 2-pole	
Project Location	Somerset, KY	Existing brownfield site.
Site Description	Two-unit coal fired generating station. Operators - this will be a manned facility (Operators remain present onsite for continued Unit 2 operation)	Long-term design life of 20+ years. This facility is intended to be a reliable grid support asset.
Overall Scope of Supply	Seasonal SynCon Conversion (Unit can flip-flop b/w SynCon mode and Power Gen mode) Turbine-generator shaft modifications, supplemental bearings, cooling and lube oil system modifications, and generator starting package.	It's possible that Future modifications to make permanent SynCon possible.
	Technical Assumptions	
Type	Not Applicable to this Unit.	
Size	Not Applicable to this Unit.	
Drives	Not Applicable to this Unit.	
Sparing Philosophy	2x100% or 3x50% for any equipment (e.g. pump, fan) whose loss will affect VAR production. Non-critical are not backed-up.	
Wastewater	Retain existing.	
Instrument Air Supply:		
Compressors	Tie-in to existing station compressed air system. No new compressed air equipment planned.	
Size	Existing.	
Drying	Instrument air filtered and dried to -40°F pressure dew point.	
Fire Protection:	Excluded from project scope. EKPC to modify in the future as required. Fire Protection spray water assumed to stay in service.	This need could be explored / developed in a future phase of design / study.
Firewater Pumps	Retain existing.	
Hydrogen Supply/Storage	Utilize existing storage, and piping. Existing generator gasses system includes Lectrodryer Fast Degas and Automatic Degas (which would be retained for SynCon operation).	
CO2 Supply/Storage	Utilize existing storage, and piping.	
Cooling Water Heat Exchangers	Not required. Heat sink is Cumberland River (intake remains in service). No new heat sink required.	
HVAC	HVAC modifications will be required - however these are to be separate from the SynCon Conversion project. EKPC will use continued operation of Unit 2 Boiler for building heating.	
Pipe Conditioning	Piping containing water to be heat traced for freeze protection at ourdoor locations.	
Electrical		
Generator Step-up Transformer	Existing GSU 125,000 kVA (161/13.2 kV). Note the SF6-type GCB is on the high-side, in the switchyard.	Project scope includes new synchronizing relays (Beckwith)
Start-up Power Supply	To be fed from existing 4160-Volt General Service Bus (2000 ampere)	
Auxiliary Power Supply	To be fed from existing 480-Volt bus (Unit Substation No. 1B); scope includes new breaker.	
Generator Circuit Breakers	Existing high-side GCB.	
Bus and Cable:		
Synch Condenser Bus	Re-use existing Isophase Bus Duct from SynCon' GSU transformer	PPT's existing
Aux Transformers Bus	Re-use existing bus.	
Cable Tray	New cable tray and conduit for all new cables.	
Switchgear:		
MV Switchgear	Existing MV Switchgear to be used (good condition).	Planned relay upgrade as part of project scope.
LV Switchgear	Use existing spares, if available.	
MCCs	Use existing spares, if available.	
DC System and Uninterruptible Power Supply (UPS)	Modifications to the DC / UPS and Batteries are out of project scope because they must remain in good condition for power generation mode. As seasonal SynCon, existing systems remain in place.	
MV Motor	New motor sized and specified and supplied by SynCon OEM, one for each unit. No spare will be provided.	
Starting Variable Frequency Drive (VFD)	Project scope includes one (1) VFD for starting the Unit 1 SynCon drive motor, with two (2) power sources from switchgear busses. The VFD is sized to start Unit 1 only.	Air-cooled VFD.
Generator Excitation System	Project scope requires services contract from GE to provide an additional configuration file for "syncon" mode.	
On-line Battery Monitoring System	Existing left in place. No project scope.	
Generator Protection	Upgrade generator protection relays to microprocessor based system for all units	
Synchronizing	Add autosynchronizers to the units.	
Lighting	Excluded from project scope. Most equipment to be located within existing indoor areas, and existing lighting to remain in service.	
Controls		
Plant Control System	Project basis is to **modify the existing ABB control system** (seasonal conversion, still need power gen mode), pull in newly added points.	
Plant Simulator	Excluded for project.	
Vibration Monitoring	Existing system is Bently Nevada (new probes will be added for motor and new bearing vibration monitoring using spare channels in the Owner's existing system). New key phasor and rotor position probes will be added to the generator end / connection to starting motor.	
NERC CIP Requirements	Low Impact - no review or modification planned as part of this project.	
Plant Communications:		
External	Existing.	
Internal	Existing.	
Dispatch	[Manned Site] dispatched by phone to put unit online / offline (synch with grid), after which the VAR output is modulated automatically by the exciter.	
Switchyard	Existing.	
Performance Testing Provisions	0.3% accuracy PTs and CTs on the MV Switchgear bus. Reuse existing PTs and CTs.	
Transmission / Interconnection		

EKPC - Cooper Station
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Project Location	Somerset, KY	Existing brownfield site.
Site Description	Two-unit coal fired generating station. Operators - this will be a manned facility (Operators remain present onsite for continued Unit 2 operation)	Long-term design life of 20+ years. This facility is intended to be a reliable grid support asset.
Overall Scope of Supply	Seasonal SynCon Conversion (Unit can flip-flop b/w SynCon mode and Power Gen mode) Turbine-generator shaft modifications, supplemental bearings, cooling and lube oil system modifications, and generator starting package.	It's possible that Future modifications to make permanent SynCon possible.
	Technical Assumptions	
Transmission	Existing Infrastructure.	
Switchyard	No changes required in this project scope.	Modifications, if any, under another budget.
Transformer Relaying and Metering	No changes required in this project scope.	
Interconnection to Existing Transmission	No changes required in this project scope.	
Revenue metering (Plant Net)	BMcD recommends EKPC consider adding dedicated generator meter for syncon mode in future phase.	
CONSTRUCTION		
Utilities:		
Power	Construction power paid by EKPC, installed and maintained by installation contractor.	
Communication	Existing.	
Construction Water	Provide by construction contractor.	
Potable Water	Sourced from existing water supply.	
Sanitary	Temporary tank and disposing offsite.	
Parking:		
Construction Parking	Existing	
Permanent Parking	Existing	
Gate Entry:		
Main	Existing guard shack and gate.	
Personnel/Craft	Existing guard shack and gate.	
Delivery	Existing guard shack and gate.	
Construction Field Office / Trailers:		
Owner	Field Office - two personnel, use existing admin building	
Engineer	Field Office - two personnel, use existing admin building. Additional	
Vendors	No field office	
Contractors	Trailers for construction contractors only. Equipment TAs visit only.	
Construction Storage:		
Construction Laydown	Project basis assumes existing site laydown area is adequate.	
Warehouse	Project basis assumes existing warehouse can be used to store materials during / after Construction, with space previously allocated to Unit 1.	
	Execution Assumptions	
Contracting Method	Multi-Contract	
Labor Type	Open Shop (Union or Non-Union) labor, single shift	Either Union or Non-Union contractors may bid work.
Project L/Ds	Performance and Schedule at Market Conditions	
Project COD date	2028	
Construction Indirects:		
General Liability Insurance	Included	
Permits and Fees	By Owner	
Performance Testing	Allowance to be included	
Commissioning / Start-up	Allowance to be included	
Operator Training	Excluded	
Heavy Equipment Receipt	Allowance to be included	
Builder's Risk Insurance	Included in Owner Costs	
Commissioning Consumables	By Owner	
Commissioning First Fills	For Generator, by Owner.	
Commissioning Spares	Included	
Plant Mobile Equipment	By Owner	
Taxes (sales, use, gross receipts, etc..)	Excluded from project cost build-up, but shown as Owner's cost "below the line".	
Escalation	Included	
Warranty	1 year	
Owner's Costs:		
Owner's Operations Personnel	Sunk cost not included in project.	
Owner's Project Management	Not currently included. Can be developed during the project scoping report phase.	
Owner's Legal Counsel	Not currently included. Can be developed during the project scoping report phase.	

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	Technical Assumptions	
Political Concessions / Area Development Fees	Not anticipated to be needed	
Permitting & License Fees	Not anticipated to be needed	
Land	Not anticipated to be needed	
Water Infrastructure and Supply to Site	Not anticipated to be needed	
Permanent Plant Operating Spare Parts	Excluded	
Maintenance Tools & Equipment	Existing.	
Permanent Plant Equipment & Furnishings	Not anticipated to be needed	
Sales Tax	Included as Owner's Cost	
Escalation	Included	
Owner's Contingency	Excluded	
Financing Fees	Excluded	
Interest During Construction	Excluded	
Temporary Utilities	Excluded	
Site Security	Sunk cost not included in project.	
Access	Clear and unobstructed access to work areas	


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