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2.0 Project Description

The Willow Rock Energy Storage Center (WRESC, or Willow Rock) will be located on approximately 88.6 acres of private land immediately north of Dawn Road and between State Route (SR) 14 and Sierra Highway within unincorporated, southeastern Kern County, California. The WRESC will be a nominal 520-megawatt (MW) gross (500 MW net) and 4,160 megawatt-hour (MWh) gross (4,000 MWh net) facility using Hydrostor, Inc.'s (Hydrostor's) proprietary, advanced compressed air energy storage (A-CAES) technology. Energy stored at the WRESC will be delivered to Southern California Edison's (SCE's) Whirlwind Substation located southwest of the WRESC at the intersection of 170th Street W and Rosamond Boulevard, via a new approximately 19-mile 230-kilovolt (kV) generation-tie (gen-tie) line. The WRESC will be capable of operating on a 24-hour basis, 365 days a year with an approximately 50-year lifespan.

The proposed project includes the following key features:

- A-CAES Energy Storage Process, Cooling Systems and Electric Transmission
  - Eight electric-motor-driven air compressors configured in four trains, totaling nominally 500 MW net
  - Four nominally 130 MW air-powered turbine generators with 100-foot-tall air vent stacks
  - Heat extraction and recovery main process heat exchangers
  - Thermal storage system using water, including up to six, 87.5-foot-diameter by 100-foot-tall (maximum) hot-water spherical storage tanks and two 150-foot-diameter, 60-foot-tall cold-water storage tanks
  - Cooling system: three air-cooled heat exchangers with evaporative mist system using excess internally produced process water
  - One approximately 21.5-acre, ~~577~~600-acre-foot capacity hydrostatically compensating surface reservoir with liner and interlocking shape floating cover
  - One lined evaporation pond for process water
  - Aboveground piping pipe racks and filter houses
  - Underground compressed air storage cavern (approximately 900,000 cubic yards capacity)
  - Interconnecting conduits for movement of compressed air to and from the cavern
  - Potential permanent aboveground architectural berm for onsite re-use of excavated cavern rock[1]
  - Onsite 230 kV substation with oil-filled transformers with 230/13.8 kV rating
  - One approximately 19-mile-long 230 kV single-circuit double-bundle conductor generation-tie (gen-tie) line interconnecting to the SCE Whirlwind Substation with a preferred gen-tie route and route options
  - Approximately ~~125~~ 186 transmission poles (approximately 0.~~1~~ 2 acres permanent disturbance)
- Operation and Maintenance Facilities, Ancillary Support Systems, and Other Features
  - Site stormwater drainage system and stormwater percolation/evaporation ponds
  - Water supply connection to an existing Antelope Valley East Kern Water Agency's supply pipeline adjacent to Sierra Highway east of the WRESC Site
  - Fire detection and fire monitoring systems
  - Firewater tank and fire suppression system
  - Acoustic enclosures for Turbomachinery
  - Weather Enclosures for Motor Control Center
  - One diesel-fired 345-kilowatt (kW) (460 horsepower) emergency fire pump
  - Three diesel-fired up to 2.5 MW, 4.16 kV emergency backup power supply engines to maintain critical loads in the event of a loss of power
  - One combined office, control room, and maintenance building
  - Employee and visitor parking area with electric vehicle charging ports and landscaping
  - Primary and secondary entrances with security access gates and site perimeter fencing

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[1] Approximately 1.3 million cubic yards of crushed rock (accounting for swell and void space) would be extracted during construction of the cavern. The WRESC will include options for managing the extracted rock that may be implemented alone or in any combination, including (a) permanent on-site storage in the form of an architectural berm around portions of the WRESC; (b) off-taker transport for commercial use; and (c) off-taker transport for permanent off-site storage. The size of the potential architectural berm will depend on the quantity of rock. The height is expected to not exceed approximately 10 feet. If all the rock were re-used onsite, the total facility size would increase by up to an additional approximately 74.6 acres for a total of approximately 163.~~2~~ 5 acres.

- — Permanent plant access roads within the WRESC Site
- — Extension/upgrades to Dawn Road between the SR 14 interchange and Sierra Highway
- — ~~An estimated up to 1.75 miles of unpaved service access road along the gen-tie line corridor as needed (approximately 4 acres permanent disturbance)~~

■ Temporary Construction Facilities

- — Up to approximately ~~136.3~~122.2-acre total laydown areas including cavern construction laydown area, construction phase earthwork areas, cavern rock temporary re-use areas, cavern rock temporary backup re-use areas, and parking areas located on adjacent and nearby parcels
- — Rock crushing facility and concrete batch plant to support cavern construction and excavated rock management (acreage included in ~~136.3-acre~~ total temporary disturbance)
- — Two temporary entrances for construction; the Dawn Road construction entrance may be converted to permanent
- — An estimated up to 1.5 miles of unpaved temporary access road along the gen-tie line corridor as needed (approximately 3.7 acres)
- — ~~Up to five~~Approximately 35 conductor pull and tensioning sites (approximately 21.5 ~~3.4~~ acres total)
- — Approximately 75- by 75-foot temporary disturbance for placement of each transmission pole (~~16.1~~approximately 23.6 acres total)

Willow Rock will not require the combustion of fossil fuel and will not produce combustion-related air emissions during normal operation.[2]

The WRESC Site is located immediately north of Dawn Road and immediately west of Sierra Highway, Rosamond, California, on the 88.6-acre portion of Assessor's Parcel Number 431-022-13, located west of Sierra Highway. The final site boundary and potential construction laydown areas depend on whether the facility will include onsite re-use of excavated cavern rock in an architectural berm on the west and north sides of the facility. **Figure 2-1** and **Figure 2-2** show the WRESC Site and potential construction laydown areas with and without the architectural berm option, respectively. **Table 2-1** summarizes all parcels that will be associated with immediate site development if excavated cavern rock is hauled offsite. **Table 2-2** summarizes all parcels that will be associated with immediate site development if excavated cavern rock is re-used onsite in an architectural berm.

Table 2-1: Main Facility and Associated Parcels with Excavated Cavern Rock Hauled Offsite (No Architectural Berm)

Assessor's Parcel Number	Owner	Parcel Size (acres)	Use
431-022-13	*Zevsar Concepts LLC*	*88.6*	*Main facility - permanent*
431-122-18	*Private Owner*	*20.3*	*Temporary construction laydown and parking, if needed*
431-022-12	*Private Owner*	*17.2*	*Temporary construction laydown and parking*
431-022-11	*Private Owner*	*17*	*Temporary construction laydown and parking*
431-022-08	*GEM A-CAES LLC*	*79.4*	*Only approximately 13.4 acres of the parcel are expected to be used for ~~T~~temporary construction laydown and parking and/or Permanent environmental mitigation site*

[2] The project will include three emergency diesel-fired engines to maintain critical loads in the event of a loss of power and one diesel-fired fire pump engine. These engines are expected to operate less than 50 hours per year for reliability testing and maintenance and will not operate concurrently during testing. The diesel-fired engines will operate in an emergency for other critical facility loads when electric power is not available. A separate diesel-engine-driven fire pump will provide water in the event of an emergency. This emergency backup equipment does not need to operate for the WRESC to function during normal operation.

Table 2-2: Main Facility and Associated Parcels with Onsite Cavern Rock Re-use (with Architectural Berm)

Assessor's Parcel Number	Owner	Parcel Size (acres)	Use
431-022-13	*Zevsar Concepts LLC*	*88.6*	*Main facility - permanent*
431-122-18	*Private Owner*	*20.3*	*Architectural berm – permanent, if needed*
431-022-12	*Private Owner*	*17.2*	*Architectural berm - permanent*
431-022-11	*Private Owner*	*17*	*Architectural berm - permanent*
431-122-01	*Private Owner*	*0.9*	*Temporary construction and gen-tie line corridor*
431-122-02	*Private Owner*	*2.4*	*Temporary construction and gen-tie line corridor*
431-122-03	*Private Owner*	*4.9*	*Architectural berm - permanent*
431-122-04	*Private Owner*	*2.5*	*Temporary construction and gen-tie line corridor*
431-122-07	*Private Owner*	*5.1*	*Architectural berm - permanent*
431-122-08	*Private Owner*	*5.1*	*Architectural berm - permanent*
431-122-14	*Private Owner*	*1.3*	*Architectural berm – permanent, if needed*
431-122-15	*Private Owner*	*1.3*	*Architectural berm - permanent*
431-122-16	*Private Owner*	*1.3*	*Architectural berm - permanent*
431-122-17	*Private Owner*	*1.2*	*Architectural berm - permanent*
431-111-30	*Private Owner*	*20.6*	*Temporary construction laydown*
431-112-24	*GEM A-CAES LLC*	*5.1*	*Temporary construction laydown*
431-112-25	*GEM A-CAES LLC*	*5.1*	*Temporary construction laydown*
431-112-26	*GEM A-CAES LLC*	*5.1*	*Temporary construction laydown*
431-112-27	*GEM A-CAES LLC*	*5.1*	*Temporary construction laydown*
471-061-05	*Private Owner*	*2.5*	*Temporary construction laydown and parking*
471-061-06	*Private Owner*	*2.4*	*Temporary construction laydown and parking*
471-061-07	*Private Owner*	*2.5*	*Temporary construction laydown and parking*
471-061-08	*Private Owner*	*2.6*	*Temporary construction laydown and parking*
431-022-08	*GEM A-CAES LLC*	*79.4*	*Only approximately 13.4 acres of the parcel are expected to be used for ~~T~~temporary construction laydown and parking and/or Permanent environmental mitigation site, if needed*

A summary of total permanent and temporary disturbances with and without the architectural berm is provided in **Table 2-3.**

Table 2-3: Summary of Estimated Permanent and Temporary Disturbance With and Without Onsite Rock Re-use

Project Element	Disturbed Acreage Without Berm (Rock Hauled Offsite)	Disturbed Acreage With Berm (Onsite Rock Re-use)	Permanent or Temporary~~[2]~~[1]
Main Facility	*88.6*	*88.6*	*Permanent*
Architectural Berm	*0*	*74.6*	*Permanent*
Site Construction Laydown and Parking[3]	*~~133.9~~72.6*	*~~136.3~~69.8*[6]	*Temporary*
Transmission Pole~~s~~ Foundation	*~~0.1~~0.2*	*~~0.1~~0.2*	*Permanent*
Transmission Pole Construction Sites[4]	*~~16.1~~23.6*	*~~16.1~~23.3*[6]	*Temporary*
Pull and Tensioning Sites[2]	*~~3.4~~21.5*	*~~3.4~~21.5*	*Temporary*
Transmission Line Undergrounding	*0.7*	*0.7*	*Temporary*
New Access Roads	*~~4~~3.7*	*~~4~~2.1*	*~~Permanent~~Temporary*
Total Permanent	**~~92.6~~88.8**	**~~167.3~~163.5**	*Permanent*
Total Temporary[5]	**~~153.5~~122.2**	**~~155.9~~117.3**	*Temporary*

[1] Temporary impacts that occur within a permanent impact area were classified as permanent impacts.
[2] Some Pull and Tensioning Sites overlap with Site Construction Laydown and Parking. The overlapping areas have been measured as Pull and Tensioning Sites.
[3] Temporary impacts within pole construction sites, pull and tensioning sites, and access roads that occur within site construction laydown and parking area were subtracted from the site construction laydown and parking area total to avoid double counting of temporary disturbance.
[4] Some Transmission Pole Construction Sites overlap with Site Construction Laydown and Parking. The overlapping areas have been measured as Site Construction Laydown and Parking.
[5] Temporary impacts within pole construction sites, pull and tensioning sites, and access roads that occur within site construction laydown and parking area were subtracted from the site construction laydown and parking area total to avoid double counting of temporary disturbance.
[6] "With berm" acreage reduced marginally from "Without berm" acreage because a portion of this project element lies within the architectural berm boundary

Project elements are described in the following subsections. The project location, ownership, and benefits are described in detail in Chapter 1, Introduction.

Figure 2-1: WRESC Site and Construction Laydown/Parking – With Architectural Berm Option

Figure 2-2: WRESC Site and Construction Laydown/Parking – No Architectural Berm Option

2.1 Generating Facility Description, Design, and Operation

The WRESC will be a nominal 4,160 MWh energy storage facility capable of charging and discharging daily. The overall facility will consist of four nominal 130 MW (gross) trains, outputting a total of 500 MW net at the point of interconnection. Each train will contain an electric motor-driven air compressor drivetrain, heat exchangers, an air turbine generator, air exhaust stacks and ancillary equipment. Each train will share a common set of thermal storage tanks (hot and cold water), as well as the air storage cavern.

The WRESC will be designed and constructed following the design criteria provided in Appendix 2A, Engineering Design Criteria following applicable laws, ordinances, regulations, and standards (LORS).

2.1.1 General Site Arrangement and Layout

Figure 2-3 and **Figure 2-4** show the plot plan or general arrangement for the WRESC Site during the construction phase and operations phase, respectively. **Figure 2-5** and **Figure 2-6** present elevation drawings showing the project profile with and without the berm option, respectively. The main access to the Willow Rock site will be from Dawn Road. There will be two entry/exit points from Dawn Road for heavy load traffic. Access at the west side will lead to the laydown area, while access at the east side will lead to the east end of the Power Block. Temporary access during construction will be obtained from crushed rock driveways from both Dawn Road and Sierra Highway; the Dawn Road temporary construction access may be converted to permanent. The Sierra Highway access point will enter the WRESC Site at the construction laydown areas to the north. The permanent entrances and main plant roads within WRESC Site will be surfaced to provide internal access to all project facilities and onsite buildings. Personnel parking spaces, electric vehicle charging stations, and parking lot landscaping will be provided and will conform to Kern County requirements. The areas around equipment will have crushed rock surfacing, not paved or concreted. **Table 2-4** summarizes the preliminary square footage for the single onsite building, a combined office, control room, warehouse and maintenance building.

Table 2-4: Approximate Building Square Footage

Building Structure	Area (square feet)
Office and control room	*5,000*
Warehouse and maintenance area	*1,600*
Combined building area	*6,600*

Figure 2-3: WRESC Plot Plan – Construction Phase

Figure 2-4: WRESC Plot Plan – Operations Phase

Figure 2-5: WRESC Site Elevation Profile – With Architectural Berm Option

Figure 2-6: WRESC Site Elevation Profile – No Architectural Berm Option

2.1.2 Process Description

Hydrostor's proprietary A-CAES technology is a low-cost, bulk-scale energy storage solution. It provides long-duration, emission-free storage that can be sited where the electricity grid requires long-duration storage, providing multi-hundred MW of generation capacity and a suite of ancillary services with an estimated 30-year service life for major equipment and an estimated 50-year service life for the cavern. This is enabled by combining industry-proven technologies with two key innovations: the use of hydrostatically compensated air storage caverns and a proprietary water-based thermal management system.

The system stores compressed air in a purpose-built underground storage cavern, analogous to those used worldwide for hydrocarbon storage. The storage cavern is filled with water through a hydraulic conduit from a water storage compensation reservoir at the ground surface level. The weight of the water in this compensation reservoir maintains a near-constant air pressure in the cavern throughout both the charging and discharging cycles, supporting efficient operation, and significantly reducing the cavern volume requirements.

The water-based thermal management system captures the heat developed during air compression, stores it, and re-uses it when generating electricity, making the process nearly adiabatic. This increases the system's efficiency and eliminates the need for burning fossil fuels.

When the Hydrostor A-CAES system is charging (known as the "charge cycle"), off-peak energy or surplus electricity (such as excess solar that might otherwise be curtailed when production exceeds demand) from the grid is used to drive air compressors, converting the electrical energy into potential energy in the compressed air and heat energy stored by the thermal energy management system. At multiple points in the compression process, the heat generated during air compression is transferred to boiler-grade water as the only thermal water by a set of heat exchangers and is stored separately for later use during the discharge cycle.

The air stream exits the compression process at the same pressure as that maintained in the air storage cavern which is governed by the vertical distance between the cavern and the connected hydrostatic compensation reservoir located at the surface. As air is charged into the storage cavern, water is displaced up the hydraulic conduit and into the surface reservoir. This maintains near-constant air pressure within the cavern and stores substantial potential energy in the elevated water. Once in the cavern, the air can be stored until electricity is required.

To generate electricity (known as the "discharge cycle"), compressed air is discharged from the cavern, which allows the compensation water to flow back into the cavern. Similar to the charge cycle, the compensation water from the reservoir maintains near-constant air pressure in the cavern during discharging. The cool high-pressure air exiting the cavern is reheated using the heat stored by the thermal management system and the same set of heat exchangers that were initially used to extract it. The reheated compressed air is then used to drive air-expansion turbine generators, which efficiently convert the stored potential energy back into electricity for the grid.

This energy storage system uses non-toxic materials and does not use fossil fuels as part of the energy storage process. The process combines proven, off-the-shelf technologies (air compressors, water-based thermal storage and turbine generators) and the underground storage cavern design, all with a track record of successful performance in other industries/applications.[3] **Table 2-5** summarizes the main process.

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[3] A video summarizing Hydrostor's technology can be found at the following link: https://www.youtube.com/watch?v=cN39gCh9PWg.

Table 2-5: Energy Storage Process Steps

STEP 1 Air Compression Using Electricity	STEP 2 Heat Capture in a Thermal Management System	STEP 3 Compressed Air Storage	STEP 4 Compressed Air Conversion to Electricity
Off-peak or surplus electricity from the grid is used to operate air compressors that produce high-pressure heated compressed air.	*Heat is extracted from the compressed air and stored in a proprietary thermal management system. This nearly adiabatic process increases overall cycle efficiency and eliminates the subsequent need for burning fossil fuels.*	*Air is stored in a purpose-built storage cavern, where hydrostatic compensation is used to maintain the system at near-constant air pressure during operation.*	*Hydrostatic pressure forces air back to the surface, where it is recombined with the stored heat and expanded through turbine generators to generate electricity on demand.*

The WRESC heat and mass balance block flow diagrams are shown in Appendix 2C, Heat and Mass Balance Diagrams (confidential). These balances are based on the mean weather conditions at the nearest ASHRAE weather station (Fox Field, Lancaster) using the 95th percentile dry bulb temperature and associated relative humidity for the charging cycle.

The actual net electrical output of the system will vary in response to ambient air temperature conditions, electrical grid operating requirements such as voltage or volt ampere reactive (VAR) support and other operating factors. Operational modes will be driven by good operating practices, market conditions, and grid dispatch requirements.

As a long-duration energy storage asset, the WRESC will be able to provide power during periods of increased need on the grid such as times of high electrical load, periods when intermittent renewable source generation fluctuates, when baseload plants are not operating or are being brought online, or during grid emergency conditions and/or local reliability needs. To maximize efficiency, the facility is expected to charge during times of low demand on the grid such as times of low electrical load and during periods when renewable source generation is higher than the instantaneous system demand, thus affording the ability to store excess renewable generation that might otherwise be lost.

2.1.3 Facility Operational Modes

Hydrostor's facility is an electrical energy storage technology with unique operating characteristics that must be considered across its operating states (charge, discharge, standby).

Based on 95% availability, the facility will be designed to operate:

- Up to 13.5 hours per day and 4960 hours per year in charging mode at a total capacity of 500 MW (plus 213 hours at 75% or less).
- Up to 8 hours per day and 2976 hours per year in discharging mode at a total capacity of 500 MW (plus 128 hours at 75% or less).
- A minimum of 372 hours in standby mode.

2.1.4 Energy Storage Facility Charge Mode Cycle

The facility is designed for 520 MW gross rated capacity on both charge and discharge with an 8-hour discharge duration at full rated capacity. The facility will be designed to achieve an average round trip efficiency of 55 to 60 percent. This means that the facility will return 55 to 60 percent of the electric energy used to complete the storage cycle as useful power output during the discharge cycle and that a complete charge of the cavern will require about 13.5 hours at full rated capacity (8 hours divided by 60 percent RTE).

The frequency of charging the system is dependent on the electrical grid operator's requirement to discharge the system. The system could be charged, or partially charged, daily. It could feasibly remain charged for long durations before discharging, but the hot water stored in the spherical tanks must be maintained by electrical heaters for very long standby periods (exceeding a few days).

When electricity from the electrical grid is available, the system will enter charge mode. While charging, electricity is drawn from the electrical grid to operate multi-stage, electrically driven air compressors. Air at atmospheric pressure and ambient temperature is compressed to cavern storage pressure. The cavern storage pressure is expected to be 870 to 1,100 pounds per square inch gauge (psig) across three sequential pressure sections of compression, low pressure, intermediate pressure, and high pressure (LP, IP, and HP, respectively), to allow storage in an underground hydrostatically compensated rock cavern with a floor depth of approximately 2,000 to 2,500 feet below ground surface (bgs).

As the compressed air enters the storage cavern, the air pressure will overcome the hydrostatic head of the compensation water system, forcing an equivalent volume of water out of the cavern and up the compensation shaft (water conduit), increasing the water level of the surface reservoir.

The hot air exiting each section of compression is cooled using boiler-grade water in the LP, IP, and HP heat exchangers. The water exits each heat exchanger and combines into a common stream. The heated water (water) flows to the hot-water spherical tanks, where it is stored at its vapor pressure to avoid vaporization. This is achieved through a system of self-pressurization whereby water vapor generated inside the tank acts as the head gas to maintain positive pressure.

2.1.5 Energy Storage Facility Generation/Discharge Mode

When the plant is sufficiently charged and is called to operate as a power generation facility, a discharge cycle will commence. A grid signal will initiate the operation of the appropriate electrical breakers and transformers, heat exchangers, and balance-of-plant equipment and begin operation of the turbine generators. With the air flowing from the storage cavern, the turbine generators will start receiving reheated high-pressure air, which will allow the turbine generators to ramp up to "sync-idle" speed, whereupon they can be electrically synchronized to the grid. Thereafter the turbine generators will begin loading (increasing electrical output) until they reach the required plant electrical output.

While discharging, the high-pressure air from the cavern will pass through three turbine sections (HP, IP, and LP) to expand the gas from cavern pressure down to atmospheric pressure. The power produced by the turbine will drive a synchronous electrical generator. The turbine stages are pressure-grouped into the same number of pressure sections as the compressors, and, just as in the case with the compressor, air will flow though the turbine sections sequentially. As the air exits the cavern, the surface water reservoir level will decrease and the compensation water level will increase in the cavern, maintaining a near-constant cavern pressure throughout discharge.

For the discharge cycle, the same heat exchangers (LP, IP, and HP) that were used to remove heat-of-compression for storage will be used, but in reverse, using the stored hot water to increase the temperature of the air before each expansion through each turbine section. This is necessary to avoid low temperatures and liquid condensation from the air as it is expanded and naturally cooled through the turbine's blade path. As the water passes through the heat exchangers, it will be cooled by the air, but will not reach a low enough temperature for the next charge cycle. Accordingly, a secondary cooling system is used to reduce the water temperature as required.

2.1.6 Energy Storage Facility Standby/Idle Mode

When the plant is not actively charging or discharging, it will be maintained in standby/idle mode. Standby/idle mode may occur either at the end of a charge cycle (e.g., the plant is ready and waiting to be called to operate as a power generator) or can occur at the end of a discharge cycle (e.g., the need for power generation has ceased and there is no immediate need to (re)charge the facility with potential energy (high-pressure air and hot water). The electrical power draw of the facility during standby/idle primarily consists of relatively small pumps, heaters, and coolers in various sections of the plant.

If the standby/idle mode follows a complete charge cycle, the stored air contained in the cavern will be at the maximum level and maintained at a high pressure by the hydrostatic compensation system, and the stored thermal energy (heat) will be maintained in the insulated hot-water spherical tanks, which are full. Both the motor-driven air compressors and the air-expansion turbine generators will be idle, with the lubricating oil systems heated and lubricating oil circulating through them to keep them warm and ready to start, slow-speed turning gears operating if required, and with the generators or motors internally heated to keep them at an optimum temperature.

If the standby/idle mode follows a full discharge cycle the stored air contained in the cavern will be at the minimum level and the cavern will be mostly filled with compensation water, leaving the water level in the surface-level compensation reservoir at its minimum level, while the remaining air in the cavern stays at constant hydrostatic pressure. Very little water will remain in the hot-water spherical tanks, and the cooled water will be held in the cold thermal storage tank. Both the motor-driven air compression equipment and the air-expansion turbine generators will be idle, with heated lubricating oil circulating, and motor and generator heaters maintaining them at optimum temperatures, all to keep them ready to start. With the hot-water storage tanks are holding a low level of liquid, the temperature will reduce quickly due to the small amount of water in the tank.

Therefore, supplementary heating via tank immersion heaters will be initiated to counteract any temperature and pressure drops.

In very exceptional circumstances (e.g., a complete plant shutdown for major maintenance), the complete plant could be in a wholly de-pressurized, and potentially a wholly cooled state, with potentially all piping and tanks in a de-watered state (except for the cavern and the compensation reservoir), and all turbomachines allowed to cool as major work is conducted.

2.1.7 Energy Storage Air Compression Equipment Drivetrain

There WRESC will include four air compression drivetrains in the system, one LP compressor, and one IP/HP compressor for each nominal 130 MW gross train, totaling a nominal 520 MW gross load during charge mode.

The compression/charge portion of the basic facility design will consist of a two-part compression drivetrain, each part using a dedicated electrical motor. The basic framework for the charge/compression equipment consists of:

- **LP compressor:** A dedicated LP compressor drawing filtered ambient air, driven by a synchronous electrical motor, with capacity flow and surge control managed by inlet flow mechanisms combined with discharge piping blow-off valves. Filtration and moisture knockout provisions are fitted as required. A non-return valve will be fitted in the LP compressor discharge to prevent air backflow.

The “low-pressure” air discharge from the LP compressor, after being cooled by the downstream heat exchanger, will then be piped to the inlet of the IP/HP compressor, as described below.

- **IP/HP compressor:** A separate compressor with a combined IP compressor and HP compressor, all driven by a single, separate, synchronous electrical motor. Cooled and filtered inlet air for both pressure groups in this combined compressor will be delivered from the upstream air-to-water heat exchanger.

The high-pressure discharge from the HP compressor section will be directed to a final air-to-water heat exchanger and the resulting cooled air will thereafter be directed to the air storage cavern at near-constant pressure. All compressors will utilize heavy process-industry quality synchronous motors with brushless excitation. Each compressor will be fitted with a dedicated lubricating/control oil system, dedicated synchronous motor controllers, and protective relaying. The compressor surge controller will be integrated to monitor and manage the compressors.

2.1.8 Energy Storage Air-Expansion Turbine Generators

The WRESC system will include four air-expansion turbine generators. There will be one turbine and one generator for each 130 MW (gross) train for a plant-wide total of 520 MW (gross).

All turbine generators will be single-casing axial-bladed machines with multiple air inlets and outlets, driving a synchronous generator, and will be complete with power-generation-industry-quality speed/load controls, generator-protective relaying, voltage regulators, and synchronizing equipment. Each unit will have a dedicated lubricating/control oil system, a dedicated turbine and generator control, and protection systems.

Each air-expansion turbine will consist of three sections or pressure groups. The high-pressure air (produced from the charge cycle) that has been stored in the underground cavern will be utilized to power the turbine. The discharge air will first be piped to the first HP set of heat exchangers where it will be heated, using the hot water from the hot-water (spherical) tanks. The heated air will be used to power the HP heated turbine sections.

After the HP turbine section, the exiting air will have cooled due to the expansion process and will be routed to the IP heat exchangers, where it will be reheated using the hot water. After the IP turbine section, the cooled air will be routed to the LP heat exchangers. This reheated air will be admitted to the low-pressure expansion section of the turbine machine, after which it will exit to the atmosphere via an exhaust stack.

2.1.9 Thermal Management System

The thermal management system will consist of water, main process heat exchangers, fin fan coolers, and both hot and cold thermal storage tanks. During charging, the system will use water to extract heat from the air in the compression process. This heated water will be stored separately in a dense and insulated environment. During discharging, the heat from the heated water will be re-injected back into the air during the expansion process on discharge. The thermal management system is key to an adiabatic and fuel/emission-free process.

The water management system is a closed system whereby the water will be passed between the hot- and cold-water storage tanks during the charge and discharge cycles (as described above). The stored volume within each of the tanks will fluctuate as part of normal operations. Make-up water for the thermal management system will be taken from the reservoir or the Antelope Valley East Kern (AVEK) water supply line and treated before it is sent to the cold-water tank.

Cold water will be stored outdoors in two cylindrical tanks (approximately 150 feet in diameter by 60 feet high). The cold-water tanks will be fitted with a nitrogen blanketing system, operated at low pressure, to prevent air ingress and oxygenation of the treated water.

Hot water will be stored outdoors in up to six spherical storage tanks, each with a diameter of approximately 87.5 feet and a maximum estimated height of up to 100 feet, including appurtenances. The head gas in the hot-water tanks is steam in liquid-vapor equilibrium with the stored water.

The hot-water tanks will be outfitted with immersion fluid electrical heaters that will counteract any thermal losses. Each tank will be insulated for heat conservation.

The LP, IP, and HP heat exchangers will be designed to both heat the air on discharge and cool the air on charge. They are standard industrial shell and tube heat exchangers and will be insulated to retain heat on standby periods. **Table 2-6** summarizes the number of shells of the heat exchangers per 130 MW gross train.

Table 2-6: Heat Exchangers[a]

Stage	Low Pressure	Intermediate Pressure	High Pressure
Type	*Shell and Tube*	*Shell and Tube*	*Shell and Tube*
Number of Shells	*3 per train (12 total)*	*2 per train (8 total)*	*2 per train (8 total)*

[a] Refer to Appendix 2B, Construction Schedule for the heat balances

2.1.10 Hydrostatically Compensating Surface Reservoir

An approximately ~~575~~600-acre-foot surface reservoir will be excavated and constructed predominantly in cut (below finished grade) using earthen berms approximately 6 feet high. The reservoir will cover a surface area of approximately 21.5 acres and have an average depth of approximately 45 feet. The berms will be constructed from a combination of excavated soil and excavated rock from underground storage cavern construction. Each berm will have an approximate height of up to 6 feet from the exterior toe to the berm's top. The water level in the reservoir will fluctuate as to maintain constant underground air storage pressure and be designed to operate with a minimum freeboard of approximately 4 feet at full state of charge. The surface reservoir will be equipped with an engineered liner on the bottom (to prevent percolation and possible comingling with groundwater) and a floating cover consisting of interlocking shapes to minimize evaporative water loss.

The Applicant designed the reservoir to not be DSOD jurisdictional. However, the Applicant was informed during consultation with DSOD that the design will likely be jurisdictional due to technical definitions. The Applicant is currently working to obtain a formal jurisdictional determination from DSOD and is working with CEC Staff to integrate the processes. The reservoir will be constructed in compliance with all applicable laws, ordinances, regulations and standards (LORS). The Applicant expects DSOD will review the final engineering design of the reservoir system which is anticipated to occur post certification by the CEC..Because of the height of the berms and the quantity of water stored between the maximum water elevation and the outside toe of the berm, the reservoir is not expected to be subject to California Division of Safety of Dams jurisdiction.

2.1.11 Underground Storage Infrastructure (Cavern and Shafts)

The A-CAES facility will utilize underground storage infrastructure consisting of one underground manmade cavern for the storage of compressed air and compressed air as well as manmade shafts for conveyance of air and water between the cavern and topside facility.

The storage cavern will be constructed in the bedrock below the WRESC Site targeting a depth of approximately 2,000 to 2,500 feet bgs. Initial access to the cavern depth ("cavern access") for mobilization of the construction equipment and crews will be accomplished by one of two methods:

1. Construction of a large-diameter conventionally sunk shaft, or
2. Construction of several rotary drilled (blind bore) shafts.

The preferred cavern access approach is still being finalized, so both options have been shown on the plot plan to date. Regardless of the cavern access technique employed, cavern excavation will be accomplished using the same mining approach and techniques. The cavern construction requirements associated with each of these approaches are described below.

Cavern Access

To access the cavern during construction, a combination of conventionally sunk shafts and/or rotary drilled shafts will be constructed on a 24-hour-per-day, 7-day-per-week basis.

Conventionally Sunk Shaft

If a conventionally sunk shaft is used for cavern construction access, a concrete-lined shaft with 24 feet inside diameter will be constructed and equipped with a double-drum hoist, service hoist, dual ventilation ducts, and utilities to support cavern construction. For construction of this shaft, controlled detonations will occur from the top of bedrock surface (approximately 50 to 100 feet bgs) until the cavern construction horizon (2,000 to 2,500 feet bgs) is reached. The controlled detonation associated with shaft construction will increase in depth and decrease in frequency as the shaft is advanced from the surface down to the cavern construction depth. The amount and frequency of controlled detonations will depend on rock properties, but an average of one or two controlled detonations per day are anticipated. Each detonation would last less than a few seconds.

It is expected that the rate of conventional shaft sinking will be around of 5 to 8 feet/day, with an overall shaft construction duration of about 12 to 14 months, including pre-grouting of the overburden. Deeper grouting of the broken bedrock zones will be performed from within the shaft as a step in the sinking cycle if and when necessary.

Once completed, this 24-foot shaft will be sufficient for supporting the hauling, ventilation, and equipment/ personnel all in one shaft.

Rotary Drilled Shafts

If rotary drilled shafts are used for construction access, it is expected that 5- by 8-foot-diameter shafts will be constructed to support the proposed operations. No controlled detonation will be done at the surface or during the drilling phase of the cavern construction if this approach is utilized. Of the five shafts that are constructed, one will be used for equipment and personnel access, two will be used for material movement (rock hauling), and two will be used for ventilation. To construct these shafts, a lined drill cuttings pond will be required that will hold up to approximately three times the shaft volume in water to support the boring operations. Once complete, the pond will be emptied and backfilled. The drilling water will be used for reservoir fill or disposed offsite by a licensed hauler.Liner material from the drill pond will be removed or perforated, and surplus muck will be spread on top of the settled drill cuttings to completely backfill the pond excavation.

A-CAES Process Shafts

Two types of flow conduits connected to the cavern will be necessary to operate the A-CAES facility: one for the conveyance of air and another for water. It is expected that up to two shafts will be constructed for water conduits, and up to four shafts will be constructed as air conduits. It is possible that fewer shafts will be constructed, but a conservative case is being assumed for this AFC.

If rotary drilled shafts are used for cavern access, two of the cavern access shafts are expected to be repurposed for use as the water shafts for A-CAES operation upon completion of construction. In this case, only the four air wells would need to be constructed. If a conventionally sunk shaft is utilized for cavern construction access, then all six shafts will need to be drilled.

Similar to the rotary drilled cavern access shafts, a drill cuttings pond will be required for the delivery of the A-CAES process shafts. This pond will be sized so that it holds up to approximately three times the shaft volume in water to support the boring operations. Once complete, surplus water will be pumped into the water reservoir, liner material from the drill pond will be removed or perforated, and surplus rock will be spread on top of the settled drill cuttings to completely backfill the pond excavation.

Water Shaft

One large-diameter blind bore or conventionally sunk shaft, approximately 8 feet (blind bore) to 24 feet (conventional) in diameter, will be constructed for use as water conduit during A-CAES operations. Depending on the cavern access used, the shaft either will be a converted construction shaft (for blind bore access) or will be purposely constructed (for conventionally sunk access). The water shaft will be used to convey compensation water between the cavern and topside compensation reservoir during A-CAES operations. The water shaft will be lined and cemented in place to provide formation isolation. The lower end of the water shaft will extend into a sump below the cavern floor to ensure that a water seal will be maintained at all times during operation.

Air Shaft

Up to two blind-bored air shafts, approximately 4 feet in diameter, will be constructed during the cavern construction for use as air shafts during A-CAES operations. The air shaft will be lined and cemented in place for formation isolation. These air shafts will be used to convey compressed air between the cavern and topside process trains during A-CAES operations. The lower end of the air shaft will be located at a high point in the roof of the cavern, such that it is never submerged during operation.

Cavern Excavation

The cavern will be constructed by conventional mining methods including drilling and controlled detonation. The cavern layout will be designed to have a room and pillar or parallel gallery layout. The size and shape of excavated openings will depend on the strength of the host rock and will be finalized during detailed engineering. The size and shape selection of the excavated openings does not materially influence the overall volume of the cavern or rock excavated.

After completion of the cavern access shaft(s), cavern excavation will begin using a combination of conventional controlled detonation methods and physical/mechanical excavation. Cavern excavation will continue on a 24-

hour-per-day, 7-day-per-week basis until excavation is complete. The following are the typical steps included in the normal full-scale mining cycle:

1. A jumbo face-drill drills holes into the working face on a predetermined pattern and to a predetermined depth.
2. The drilled holes are loaded with explosives and the charges are set off to break the rock into muck (broken rock).
3. Load-haul-dump vehicles load the muck and haul it from the working face to the production shaft, where it is dumped into the loading pocket and hoisted to the surface.
4. The roof and sidewalls are scaled to remove any loose hanging rock.
5. Rock bolting machines install appropriate ground support (typically rock bolts and wire mesh) for the newly exposed roof and sidewalls.
6. The centerline and drill pattern are marked on the new working face by surveyors and the cycle is repeated.

During underground construction, twice-daily controlled detonation episodes of a few seconds duration each will occur at the beginning of each shift. Controlled detonation is NOT continuous throughout the day and will occur on a regular scheduled approximately 10- to 12-hour intervals. During full-scale cavern excavation, explosives will be placed in closely spaced locations and detonated remotely. Early in the cavern excavation process, personnel will clear the underground area and remain aboveground during the detonation sequence. Once the cavern is large enough, personnel will remain underground during the detonation sequence.

For gallery construction, a top heading will be initially driven, and roof support will be installed as the excavation advances. One or more successive benches will then be excavated to develop the cavern opening to full height. Waste muck will be crushed underground and brought to the surface via a shaft skip. The cavern floors will be graded to drain toward water sump and shaft. Where geology and ground conditions permit, roofs will be sloped up to naturally vent into the air shaft and avoid the possibility of trapped air pockets. Most caverns are completed with unlined, bare rock surfaces, though some are lined with a thin layer of shotcrete for worker safety and geotechnical integrity. Grouting may also be used, if required, to seal large fractures that could permit water inflow. Upon completion of cavern excavation, the cavern will be commissioned into operations which will require the filling and sealing of the construction shafts that are not converted for use in A-CAES operations.

During operations, the cavern will be filled with water through a hydraulic conduit from the surface reservoir. The weight of the water in this surface reservoir will maintain a near-constant air pressure in the cavern throughout both the charging and discharging cycles. This approach supports efficient operations and significantly reduces the cavern volume requirements. The dimensions and design of the cavern are presented in **Table 2-7**.

Table 2-7: Cavern Design

Design Element	Value
Depth	*Approximately 2,000 to 2,500 feet bgs*
Pressure	*870 to 1,100 psig*
Volume	*Approximately 900,000 cubic yards*

bgs = below ground surface; psig = pounds per square inch gauge

2.1.12 Black Start Capability

The facility will not be designed to be black start capable (i.e. capable of starting up without an external utility power feed).

2.1.13 Major Electrical Equipment and Systems

The net electric power generated at the WRESC will be transmitted to the electrical grid at the point of interconnection. Transmission and auxiliary uses are discussed in the following subsections. The electric power required for charging the system will be drawn from the electrical grid with additional power for the auxiliaries. Refer to the preliminary single-line diagram provided in Chapter 3.0, Electric Transmission (Figure 3-3) depicting the onsite Willow Rock main substation, including applicable ratings of key equipment.

For metering of the import and export of power, a power quality meter suitable for revenue metering of MWh and megavolt ampere reactive-hours will be located at the SCE Whirlwind Substation. The power revenue metering will be constructed according to SCE standards.

A power management system will interface with SCE to coordinate power export/import quality and voltage regulation.

2.1.13.1 Generators and Motors

Turbine Generators

Generators will generate at medium voltage (13.8 kV). This power will be transformed via unit transformers to 230 kV for the electrical grid connection.

Generators are preliminarily rated 150 megavolt amperes (MVA) at 0.9 to 0.95 power factor to supply 130 MW gross and 125 MW net to the electrical grid at the point of interconnection. This allows maximum turndown (reduction in total overall output) of plant, whereby a single generator can operate while other generators are offline for maintenance.

Synchronous Motors for Compression Train

Full charging capacity requires eight synchronous motors running to supply the four air compressor trains. The power to the synchronous motors will be supplied via unit transformers.

The synchronous motors will normally run at unity or a slightly leading power factor in order to mitigate the VAR import requirements of induction motors within the auxiliary power system.

The synchronous motors will be started using a variable frequency drive (VFD) soft start system. One soft start unit will be utilized for each of the four sets of motors (one two-motor set per compressor power train) if required.

2.1.13.2 Alternating Current Power—Transmission

Power will be generated by the four generators at 13.8 kV and transformed to 230 kV for the grid interconnection. 230/13.8 kV main transformers in each train support connection to the local 230 kV network at the SCE Whirlwind Substation. For motor operation, four additional 230/13.8 kV unit transformers provide back-feed power to the compressor motors. Surge arrestors at the point of interconnection would protect the system from disturbances in the 230 kV system caused by lightning strikes or other system disruptions.

The transformers will be set on concrete foundations, and the design will include a secondary oil containment reservoir to contain the transformer oil in the event of a leak or spill. There will be differential protection on transformers rated 5 MVA and greater. The 230/13.8 kV transformer will be connected to a single-circuit three-phase 230 kV line, which will be connected to the Whirlwind Substation via an approximately 19-mile predominantly overhead gen-tie line. A detailed discussion of the electric transmission system is provided in Chapter 3, Electric Transmission.

2.1.13.3 Alternating Current Power—Distribution to Auxiliaries

The distribution voltages for plant auxiliary systems and lighting will include: 4.16 kV, 480 V, and 208/120 V.

Auxiliary power supplies for instruments will be 24 volts direct current (VDC); however, in the even that increased power consumption is required, 120 volts alternating current (VAC) will be used.

2.1.13.4 Direct Current Power Supply System

Turbine/generator and compressor/motor auxiliaries will be supplied by 125 VDC.

Process control systems (PCS) will be supplied from 24 VDC power supply modules within system cabinets. Control power for the switchgear will be 12 VDC supplied from a dedicated direct current (DC) battery system.

The 125 VDC battery system will be independent of the 120 VAC uninterruptible power supply (UPS) battery system. All DC systems will have 8-hour battery duration.

The system will be designed to provide continuous rated power in the event of main power failure. The DC systems will be located on the emergency generator bus. The DC systems' health will be monitored by the distributed control systems (DCS).

2.1.13.5 Uninterruptible Power Supply System

An independent UPS system will be dedicated to supply power to the following loads:

- Critical instruments, emergency lighting, and valves
- Control panel fans and other ancillaries
- DCS control racks, including programmable logic controllers (PLCs), flow computers, vibration monitoring system, etc.
- Telecommunications system
- Building cameras and security access system
- Smoke and building heat detector UPS systems include:
  - 20 kVA or less:
    - Input voltage: 208 volts (V)
    - Output voltage: 208 V
  - Greater than 30 kVA:
    - Input voltage: 480 V
    - Output voltage: 480 V

The system will be designed to provide continuous rated power in the event of main power failure. The UPS will be located on the emergency generator bus. The UPS and emergency generators health will be monitored by the DCS.

2.1.13.6 Emergency Power

Three diesel-fired self-contained 4.16 kV generators, up to approximately 2.5 MW each, will supply emergency power for all critical loads via double sided 5 kV emergency switchgear. These units will meet U.S. Environmental Protection Agency (USEPA) Tier 4 emissions standards and will normally operate only to facilitate maintenance and reliability testing for up to 50 hours per year. Only one unit will operate at a time to perform maintenance and reliability testing.

When needed for emergency power due to a loss of utility interconnection, the generators would activate and operate during the emergency period.

2.1.14 Water Supply and Use

The AVEK water agency currently owns and operates a 36-inch-diameter water supply line that is located adjacent to the WRESC Site approximately 300 feet east of the WRESC Site's boundary. AVEK will supply Willow Rock with the required water rates and quantities from a new dedicated tap into its water supply line at a location adjacent to the WRESC Site. A permanent 6-inch-diameter buried water pipeline will be installed onsite to deliver water from the AVEK main supply pipeline to the surface reservoir.

These sources will also provide water for filling the storage tank used for fire protection and service water. Appendix 2D, Water Balance Diagrams and Construction Water Use, provides water balance diagrams showing annual average and high temperature ambient operating conditions.

During plant operation, the expected water consumption from AVEK will be less than 2,000 gallons per day, as shown in the water balance. As the cooling and thermal storage systems operate in a closed loop, losses are minimal, and make-up water demand will be small. The reservoir volume is balanced by controlling evaporation with the floating cover, the inflow of annual precipitation, and condensed water from compressed air.

When the plant is operating in charging mode and the compressors are filling the cavern with compressed air, water is produced at the exit of each compression stage. This is caused by compressed air becoming saturated during compression and moisture in the air condensing in each post-cooling stage. The condensate must be removed from the system to avoid damage to the compressors and sent to the water reservoir and evaporative cooling system.

The water provided by AVEK during operations will mostly be used as a tap water source for offices, maintenance facilities, service water, fire system re-filling, and make-up water for cooling and thermal system water.

During construction and during the initial filling of the surface reservoir the WRESC will require approximately 1,400 acre-feet of water. Construction water requirements are discussed further in Section 5.15, Water Resources. Once the facility commences operation, it is expected to have an annualized surplus of approximately 3.6 acre-feet per year (on average) of non-potable recharge quality water to provide surface reservoir water make-up. Evaporative loss will be reduced by the use of a cover on the reservoir. Since there will be a seasonal variation associated with the production of water as well as evaporation losses, the reservoir will be designed with adequate freeboard to allow for seasonal fluctuations in water inventory.

2.1.14.1 Construction Water

An estimated 1,400 acre-feet of water (incorporating approximate 20 percent contingency) will be needed throughout the construction and startup period. Most of the water will be used for filling the hydrostatically compensating reservoir. Other uses include supporting construction of the cavern works (shaft drilling and cavern excavation), surface works (hydrotesting and general purpose washdown), and fire system testing. These are discussed briefly below. Refer to Appendix 2D, Water Balance Diagrams and Construction Water Use for the estimated water consumption required during construction by month.

Cavern Works

Construction of the cavern is estimated to require an estimated 252 acre-feet of water over the construction period. Uses include site preparation, air and shaft drilling, and excavation of the cavern. Refer to Appendix 2D, Water Balance Diagrams and Construction Water Use for the estimated water consumption required during construction by month. Water remaining in the drilling pond(s) after shaft sinking will be filtered, water quality tested and then either sent to the reservoir, or, if necessary based on test results, hauled offsite by an approved waste hauler.

Surface Works

The surface construction is expected to require approximately 47 acre-feet of water for several purposes over the 24-month period, including the following:

- General purpose (de-dusting roads, daily washdown, etc.)
- Tank and sphere hydrotest
- Piping and vessel hydrotest
- Fire system testing

Water used for hydrotesting will be reused for hydrotesting other systems, including the spheres, pipe circuits, and initial fill. A temporary pumping sub-system with screening and filtering capabilities will be utilized to re-use this water. After all testing, the volume of hydrotest water (losses at flange breaks, nozzle spray tests, etc.) will be screened and filtered to a suitable cleanliness level to supplement the initial fill volume of the cold thermal storage tanks and/or reservoir.

Surface workers are assumed to use 20 gallons of potable water per person per day during all stages of construction, including drinking and wash water.

Refer to Appendix 2D, Water Balance Diagrams and Construction Water Use for the estimated water consumption required for surface construction, by month.

Hydrostatically Compensating Surface Reservoir Fill

The roughly 600-acre-foot surface reservoir will require approximately 868 acre-feet of water for initial fill (accounting for evaporation losses during the filling period). The reservoir fill will require approximately 14 months, with monthly fill requirements as shown in Appendix 2D, Water Balance Diagrams and Construction Water Use. The required fill amount accounts for both precipitation and evaporation. After initial filling, the surface reservoir will be equipped with an interlocking shape floating cover estimated to be 90 percent effective in reducing evaporation. The estimated fill amount conservatively assumes no benefit from the cover.

2.1.14.2 Water and Wastewater Requirements

Demineralized water will be produced onsite and used as make-up water for the water-based thermal storage and closed-cooling medium loops. Appendix 2D includes water balance diagrams for annual average and high temperature conditions, respectively, as well as an estimated month-by-month water balance. Water requirements are further discussed in Section 5.15, Water Resources, subsection 5.15.1.5.

The evaporative cooling water is used intermittently during hot temperatures when the closed-cooling loops cannot meet the cooling objectives of the turbomachinery. The water for the evaporative cooling is expected to be sourced from the produced water at the air compressors such that the evaporative cooling does not require sourcing of additional water.

2.1.14.3 Water Quality

Section 5.15, Water Resources, includes a projection of the water quality based on available testing data.

2.1.14.4 Water Treatment

The AVEK supply water will be used for make-up to the plant water system, fire protection, and general needs such as equipment and surface washdown.

The thermal energy storage system and cooling system will be filled with demineralized water during commissioning. A temporary, portable demineralization system will be used to generate water for the first filling and commissioning. Make-up demineralized water will be produced during operations to cover minor losses in the system. The expected quality of demineralized water used for the first filling will have the following characteristics:

- Appearance: clear and colorless
- Odor: odorless
- Total dissolved solids maximum: < 1 part per million (ppm)
- Hardness: < 0.01 Deutsche Harte
- Oil and grease: none
- Conductivity at 25 degrees Celsius: < 0.5 micro Siemens per centimeter
- Chlorides: <0.5 ppm
- Iron: <0.005 ppm
- Copper: <0.01 ppm

2.1.14.5 Water Availability

AVEK will provide the required quantity and quality of water required by the project. GEM A-CAES LLC (GEM, the Applicant) has filed an application for water service with AVEK and is in the process of securing a water service agreement.

2.1.15 Waste Management

Waste management is the process whereby all wastes produced at Willow Rock will be properly collected, treated if necessary, and disposed of. Wastes include process wastewater, as well as nonhazardous waste (primarily excavated waste rock) and hazardous waste, both liquid and solid. Waste management is discussed below and in more detail in Section 5.14, Waste Management.

2.1.15.1 Wastewater and Stormwater Collection, Treatment, and Disposal

Wastewater and Septic Waste

Project wastewater will be diverted to the zero-discharge evaporation pond. The oil-free evaporation pond will be maintained, and the remaining “sludge” will be hauled offsite by an approved waste disposal company to an approved disposal facility. The water balance diagrams in Appendix 2D show the expected wastewater stream and flow rate under operating conditions.

The septic waste from the administration/control building will be handled by one of the two methods described below:

- Sanitary waste from the administration/control building will be directed to a nearby underground septic storage tank, pumped out periodically by truck, and trucked offsite to an approved disposal facility.
- Alternatively, the sanitary sewer system will consist of a lateral septic system containing a lateral line from the structure to a septic tank. From there, the waste will flow to the lateral system of pipes that allows the waste from the septic system to discharge via perforations in the lateral pipes.

Willow Rock will not have a practice of washing down any equipment with oily residues. Equipment that has oily residues will be cleaned with rags and sorbents, and appropriate cleaning solutions will be applied to the rags and sorbents.

After cleaning, the oily rags and sorbents will be properly stored, manifested, and disposed of by licensed disposal companies in the regulatory-required time frames.

Stormwater

Onsite stormwater flows generated within the WRESC Site boundary will be routed to an unlined stormwater pond and will not be discharged outside the WRESC Site. Plant area drains will be directed to oil-water separators. There will be at least one oil-water separator for the common plant areas, and one oil-water separator for each power block. Water from the oil-water separator sumps will be discharged to the waste drains sump and then to the lined evaporation pond. The separated oil will be periodically pumped out of the oil-water separators by truck and disposed of offsite by a licensed hauler.

A summary of the approach for offsite perimeter stormwater drainage is described below for the “without berm” and “with berm” options.

Option 1 – Without Berm

Offsite flows will be diverted via proposed ditches along the north and west side of the WRESC Site to route them to where they are currently flowing. The flows conveyed by the west ditch will discharge stormwater south and then to the ditch along Dawn Road. The flows conveyed by the north ditch will discharge stormwater to the east to the ditch along the Sierra Highway. These ditches will be sized to carry, at a minimum, the 100-year discharge calculated using TR55 SCS Unit Hydrograph methodology.

Onsite flows generated by the WRESC Site will not be discharged outside the WRESC Site Boundary. All the WRESC Site stormwater will be conveyed via sheet flow and system flow (catch basins, swales, and stormwater conveyance piping) to a proposed, unlined stormwater pond on the southeast corner of the WRESC Site.

Option 2 - With Berm

Offsite flows will be diverted via proposed ditches along the north and west side of the architectural berm and route them to where they are currently flowing. The flows conveyed by the west ditch will discharge stormwater south and then to the ditch along Dawn Road. The flows conveyed by the north ditch will discharge stormwater to the east to the ditch along the Sierra Highway. These ditches will be sized to carry at a minimum the 100-year discharge calculated using TR55 SCS Unit Hydrograph methodology.

Rainwater that falls on the north and west sides of the architectural berm will flow to the proposed ditches along the north and west side of the architectural berm described above. Rainwater that falls on the south and east side of the architectural berm will be directed south and east via ditches on the north and west boundaries of the WRESC Site and flow towards the Dawn Road and Sierra Highway ditches, respectively.

Onsite flows generated by the WRESC Site will not be discharged outside the WRESC Site. All the WRESC Site stormwater will be conveyed via sheet flow and system flow (catch basins, swales, and stormwater conveyance piping) to a proposed, unlined stormwater pond on the southeast corner of the site.

Excavation Waste

The WRESC will produce excavated material associated with typical mining techniques to create the underground compressed air storage cavern. Excavation waste generally includes soil and rock. The cavern has an equivalent volume of excavated material of approximately 1.3 million cubic yards based on an expected swell by a factor of 1.4. The swell factor accommodates the volumetric expansion from solid rock at depth to crushed rock at the surface. Waste management is discussed further in Section 5.14, Waste Management.

Based on preliminary engineering and environmental planning, the Applicant is considering options for adaptive re-use of the cavern rock onsite within the project boundaries or hauled offsite to up to four independent third parties. To plan conservatively, the project analyses assume that cavern rock will be fully reused in four options: up to 100 percent reused onsite as an architectural berm, up to 100 percent hauled offsite to the Robertson's Ready Mix in Los Angeles County, up to 100 percent hauled offsite to the Holliday Rock facility in Kern County, , and/or up to 100 percent hauled offsite to the Vulcan Materials Inc. processing facility in Los Angeles County. At the time of filing, commercial agreements are underway with the private off-takers, and design of an onsite architectural rock berm is being advanced through engineering.

All of the offsite third-party off-takers have expressed interest in potentially reusing the rock material for commercial purposes. Each potential off-taker ~~has~~will have the appropriate permits in place to import material from third parties.

In lieu of hauling the excavated rock offsite, another option is to re-use the material within the project boundaries as an architectural berm. The specific design of the feature is to be determined through final engineering.

2.1.15.2 Solid Nonhazardous Waste

The WRESC will produce nonhazardous waste related to construction, operation, and maintenance that is typical of power generation and energy storage operations. Surface construction wastes will generally include soil, scrap wood, excess concrete, empty containers, scrap metal, insulation, and sanitary waste. Cavern construction wastes will include some of the same materials, as well as explosives packaging.

Facility waste during operation will includes oily rags, scrap metal and plastic, insulation material, defective or broken electrical materials, empty containers, and other solid wastes, including the typical refuse generated by workers. Solid waste will be trucked offsite for recycling or disposal. Waste management is discussed further in Section 5.14, Waste Management.

2.1.15.3 Hazardous Wastes

Several methods will be used to properly manage and dispose of hazardous wastes generated by the project. Waste lubricating oil will be recovered and recycled by a waste oil recycling contractor. Spent lubrication oil filters will either be recycled or disposed of in a Class I landfill. Workers will be trained to handle hazardous wastes generated at the WRESC Site. Chemical cleaning wastes will be temporarily stored onsite in portable tanks or sumps and disposed of offsite by an appropriate contractor in accordance with applicable regulatory requirements.

Hazardous materials management is further discussed in Section 5.5, Hazardous Materials Handling.

2.1.16 Management of Hazardous Materials

A variety of chemicals will be stored, handled, and used during the construction and operation of Willow Rock, following applicable LORS. Chemicals will be stored in appropriate chemical storage facilities. Bulk chemicals will be stored in storage tanks, and most other chemicals will be stored in returnable delivery containers. Chemical storage and chemical feed areas will be designed to contain leaks and spills. Containment pits and drain piping design will allow a full-tank capacity spill without overflowing the containment area. For multiple tanks located within the same containment area, the capacity of the largest single tank will determine the volume of the containment area and drain piping with an allowance for rainwater. Drain piping for reactive chemicals will be trapped and isolated from other drains to eliminate noxious or toxic vapors.

Safety showers and eyewashes will be provided adjacent to, or in the vicinity of, chemical use and storage areas. Plant personnel will use approved personal protective equipment during chemical spill containment and cleanup activities. Personnel will be properly trained in the handling of these chemicals and will be instructed in the procedures to follow in the event of a chemical spill or accidental release. Adequate supplies of emergency response equipment, including absorbent material, will be stored onsite for spill cleanup.

A list of the chemicals anticipated to be used at Willow Rock, and their storage locations, is provided in Section 5.5, Hazardous Materials Handling.

2.1.17 Fire Protection

The fire protection system will be designed to protect personnel and limit property loss and facility downtime in the event of a fire. The system will include an electric fire pump, a small jockey pump to keep the system under pressure, and a fire protection water network system consisting of hydrants or standpipes and portable fire extinguishers. Where required, automatic or fire sprinkler systems will be provided. A diesel-fired approximately 345 kW (460 horsepower) fire pump will be provided for emergency backup. The fire protection and piping network system will be designed to protect the facility, which will be designed under the following regulations:

- Federal, state, and local fire codes, and occupational health and safety regulations, in concert with the Authority Having Jurisdiction
- California Building Code, where applicable
- Applicable, mandatory National Fire Protection Association standards

The diesel-fired pump engine will meet USEPA Tier 3 emission standards and normally only operate for maintenance and reliability testing for up to 50 hours per year.

Firefighting water will be stored in the service/fire water storage tank. The tank will have an internal service water pump suction standpipe so that the required water volume for a fire event is always available to the fire water pumps. The system can supply maximum water demand for any fire suppression requirements, as well as water for fire hydrants. The total capacity of the tank is estimated at 350,000 gallons, with 300,000 gallons reserved for fire water.

Separation criteria will be evaluated in a fire protection study during further engineering.

Portable and wheeled fire extinguishers will be provided at strategic locations around the facility. Their locations will be determined based on the guidelines of National Fire Protection Association 10 or relevant local requirements.

The following types of portable fire extinguishers can be used as appropriate for the type of risk:

- For areas where there are ordinary combustibles such as wood, cloth, paper, plastic, etc., extinguishers will be suitable for Class A fires. These can be in the form of water, foam, or dry powder.
- For areas where there are flammable liquids, oils, grease, paint etc., extinguishers will be suitable for Class B fires. These can be carbon dioxide (CO_2) dry powder, or foam or any other suitable film forming foams.
- For areas where there is energized electrical equipment, extinguishers will be suitable for Class C fires. These will be CO_2 or other suitable dry chemicals.

Portable fire extinguishers, where applicable, will be installed at a suitable distance above the floor for ease of deployment and to minimize the potential for corrosion. Fire extinguishers will be fixed to walls, columns, or structural supports as appropriate. Weatherproof storage cabinets will be provided for extinguishers located in open areas. Wheeled extinguishers located in external areas will be equipped with a weatherproof cover.

Section 5.5, Hazardous Materials Handling, includes additional information about fire and explosion risk, and Section 5.10, Socioeconomics, provides information about local fire protection capability.

2.1.18 Plant Auxiliaries

The following systems will support, protect, and control the Willow Rock facility.

2.1.18.1 Process Systems

A 5 kV substation will be required in the process area to supply power to the area loads. The 230/5 kV transformers will be distributed at the WRESC Site. Large motors in the process area (above 300 horsepower) will be fed from the 5 kV system with many of the motors on emergency power for operation during a power outage.

Smaller motors will be fed from the 480 V system, and some will be on emergency backup power.

2.1.18.2 Heating, Ventilation, and Air Conditioning Systems

All buildings will be equipped with suitable heating, ventilation, and air conditioning systems and critical systems will operate on emergency power as required.

2.1.18.3 Lighting

Indoor building lighting will be designed consistent with building code requirements to provide adequate indoor illumination with consideration for human factors. Exterior lighting will be hooded and downward facing to provide adequate space lighting while minimizing offsite glare.

The emergency lighting will be sufficient to illuminate the exit path from process areas and inside the buildings and will be supplied from a 120 V UPS located indoors. Exit signs will be self-illuminating. In outdoor areas, emergency light fixtures will be equipped with rechargeable battery packs with minimum 1-hour battery backup. These emergency lighting fixtures will not normally be switched on and will be identical to the fixtures used throughout the facility.

Process plant lighting and convenience outlets will be supplied from a 208 V/120 V, three-phase, four-wire, 60 hertz system.

Section 5.13, Visual Resources provides additional information regarding the potential for offsite lighting impacts. A detailed lighting plan is included in Appendix 5.13B.

2.1.18.4 Grounding

All systems will be grounded and bonded as per the National Electric Code and local municipal codes and standards.

All equipment containing flammable liquids or gases and liable to static discharge ignition will be grounded by having one or more anchor bolts connected to the reinforcing bar of the equipment foundation.

The grounding system design will be as per Institute for Electrical and Electronics Engineers (IEEE)-80 and IEEE-142 guidelines. A detailed step/touch potential, including ground potential rise calculation, will be performed. The substation grounding systems will be designed to limit the overall resistance to earth to safe step and touch voltage conditions.

Prior to detailed design execution, sufficient site soil data will be obtained for performing grounding studies and calculations

All equipment will be connected to the ground through a minimum of two paths, except for small equipment that can be safely connected to a single source.

A dedicated, clean, instrument-grounding system will be provided to connect all PCSs, in addition to a standard equipment grounding system.

The instrumentation grounding system will be bonded to the electrical system ground below grade.

2.1.18.5 Control System

Process Control System

The PCS will provide all monitoring and control of the facility. The PCS configuration will be justified with the plant engineering contractor based on the facility complexity.

The facility will function automatically with minimum operator intervention. Emphasis will be given to automating routine actions so that the operator will have more time to analyze and identify short- and medium-term plant performance, efficiency, and imminent failures.

Adequate instrumentation will be installed to enable operations personnel to monitor facility performance from the central control room with minimum field intervention. Field operators will only assist in visual surveillance and will intervene only when critical equipment and systems warrant immediate attention. All field functions will require a permissive signal from the control system.

For standalone control packages within the facility where operator action will be entirely local, a package common alarm will be connected to the PCS to direct an operator to examine local indicators or panels to determine equipment status.

Operator Interface System

Under normal conditions, the facility will be operated from the central control room with operator displays with mouse and operator keyboards, radio, and telephone panels, monitors for internet protocol camera access.

The PCS operator workstations will provide the following functions at minimum:

- Presentation of process information to the operator
- Facilities to enable the operator to adjust and control the process
- Monitoring and control of packaged equipment
- Monitoring and control of utility systems
- Short-term logging of process conditions and operator actions
- Diagnostic of the PCS and its component parts
- Site security

Monitoring and Controls

The PCS will use solid-state equipment and a PLC or DCS to increase reliability and flexibility.

Electromechanical control relays will not be used, except when required for safety interlocks. The plant DCS will meet cyber-security standards as required by the California Independent System Operator.

If the control system involves electromechanical timing sequences or interlocks, auxiliary dry contacts will be provided for indication of steps or conditions. These contacts will be used to interface with the PCS to monitor the operational status.

All failure and alarm switches will be “fail safe”—i.e., an abnormal condition will cause a loss in output signal. Upon loss of power, control circuits and alarms will go to the “fail safe” condition. Solenoid valves and actuating relays will be normally energized and will de-energize upon protective action or alarm. All alarm contacts shall open to alarm. When contacts are controlled by a pneumatically loaded device, the device will be normally loaded and will vent to create the alarm or shutdown condition.

In general, interlock system circuits will be activated from separate primary instruments. Each interlock signal initiating a shutdown will also activate a separate pre-alarm point to indicate that an abnormal condition exists, and failure to take corrective action will result in a shutdown of the affected equipment. Pre-alarms may be actuated by a "normal" instrumentation system signal.

Communications between the PLC and human-machine interface, and PLC to PCS will be Ethernet transmission control protocol/internet protocol or ProfiNet.

Communications to motor control centers and VFDs will be Ethernet- or fiber-based. Communications to discrete field contacts will be automated with limit switch indications.

Wireless communication devices will be used for communication between control room and operators in the facility.

2.1.18.6 Cathodic Protection

The cathodic protection system will be designed to control corrosion of metallic piping when buried in the soil. Depending on the corrosion potential, type of soils on the WRESC Site, ease of isolation of buried pipe from the aboveground facilities, and proximity to ground grid and foundations, either a passive or impressed current cathodic protection will be provided where required.

2.1.18.7 Freeze Protection System

Freeze protection for above- and below-grade piping and instrumentation lines will be evaluated and installed as necessary, based on the expected minimum ambient temperature at the facility. Given that the record minimum temperature near Willow Rock is 24 degrees Fahrenheit, freeze protection is not expected to be required for large piping but may be required for small piping and air tubing. Below-grade piping will be installed below freezing depth according to site's climate and soil data. Where necessary, the above-grade piping will be protected with an electrical heat tracing system and/or continuous circulation in rare instances of freezing temperatures. The foundation of aboveground pipe support will be rooted below the freezing depth.

2.1.18.8 Service Air

The service air system will supply compressed air to hose connections for general use at the WRESC. Service air headers will be routed to hose connections located at various points throughout the facility.

2.1.18.9 Instrument Air

The instrument air system will provide dry, filtered air to pneumatic operators and devices. Air from the service air system will be dried, filtered, and pressure-regulated before delivery to the instrument air piping network. An instrument air header will be routed to locations within the facility equipment areas.

2.1.19 Interconnect to Electrical Grid

The facility will connect to the SCE electrical grid via a 230 kV overhead (predominantly) single-circuit gen-tie line that will run approximately 19 miles from the SCE Whirlwind Substation to the WRESC Site (see Chapter 3, Electric Transmission). The 230 kV line will terminate at a dead-end tower before the main power transformers, which will step down the voltage to 13.8 V and 5 kV, suitable for distribution within the WRESC. The grid connection will be capable of power import and export, rated to suit all operating scenarios. There are expected to be a small number of short underground gen-tie line segments to allow for crossing of a Los Angeles Department of Water and Power high-voltage transmission corridor and in other locations where the transmission corridor is congested with preexisting facilities (see Figure 1-4 in Chapter 1.0, Introduction). Open trenching or horizontal directional drilling will be used to complete these short underground segments.

A preliminary single-line diagram depicting the onsite Willow Rock main substation, including applicable ratings of key equipment, are included in Chapter 3, Electrical Transmission.

2.1.20 Project Construction

2.1.20.1 Construction Schedule

The construction of the WRESC from site preparation and grading to full-scale operation and construction closure is expected to take roughly 60 months. Major milestones are listed in **Table 2-8**. A more in-depth construction manpower and equipment schedule is provided in Appendix 2B, Construction Manpower and Equipment Schedule. The Applicant will assess the prospect of initiating full-scale operations for a portion of the facility's energy capacity in advance of the target date shown below.

Table 2-8: Major Project Milestones

Target Project Milestones	Begin		Complete	
	Month Number	Calendar Date	Month Number	Calendar Date
Site Preparation & Mobilization	*1*	*Dec-25~~Mar 2025~~*	*3*	*Feb-26~~May 2025~~*
Grading	*2*	*Jan-26~~Apr 2025~~*	*13*	*Dec-26~~Mar 2026~~*
Reservoir Excavation	*3*	*Feb-26~~May 2025~~*	*13*	*Dec-26~~Mar 2026~~*
Shaft Drilling (Ventilation and Process Connections)	*10*	*Sep-26~~Dec 2025~~*	*35*	*Oct-28~~Jan 2028~~*
Access Shaft Excavation	*11*	*Oct-26~~Jan 2026~~*	*23*	*Oct-27~~Jan 2027~~*
Topside Equipment Installation	*15*	*Feb-27~~May 2026~~*	*45*	*Aug-29~~Nov 2028~~*
Transmission Line Construction	*24*	*Nov-27~~Feb 2027~~*	*39*	*Feb-29~~May 2028~~*
Cavern Construction (and Cavern Rock Crushing and Hauling)	*24*	*Nov-27~~Feb 2027~~*	*47*	*Oct-29~~Jan 2029~~*
Topside Equipment Commissioning	*40*	*Mar-29~~Jun 2028~~*	*52*	*Mar-30~~Jun 2029~~*
Subsurface Commissioning	*47*	*Oct-29~~Jan 2029~~*	*52*	*Mar-30~~Jun 2029~~*
Full Plant Commissioning	*52*	*Mar-30~~Jun 2029~~*	*55*	*Jun-30~~Sep 2029~~*
Startup	*55*	*Jun-30~~Sep 2029~~*	*60*	*Oct-30~~Feb 2030~~*
Construction Demobilization	*59*	*Sep-30~~Jan 2030~~*	*60*	*Oct-30~~Feb 2030~~*
Commercial Operation	*60*	*Oct-30~~Feb 2030~~*	*61*	*Nov-30~~Mar 2030~~*

Source: Hydrostor ~~2024~~2025

2.1.20.2 Construction Workforce

During construction, there will be an average and peak workforce of approximately 273 and 749 workers, respectively, including construction craft workers and supervisory, support, and construction management personnel onsite if 100 percent of the waste rock is hauled offsite. The construction average and peak workforce would decrease slightly to 269 and 731, respectively, if all the excavated rock is re-used onsite in the form of an architectural berm (see Section 5.10, Socioeconomics, Table 5.10-8 for a more detailed breakdown of expected labor requirements).

Surface work will normally occur in 8-hour shifts, 5 days a week. Cavern work is planned as follows:

- Mobilization and site preparation (months 1 through 3): 5 days a week, 10-hour shifts
- Grading, excavation, and shaft drilling (months 2 through 26): 12 hours/day, 10 days on, 4 days off
- Cavern construction (months 26 until completion): 24 hours/day, 7 days/week, 12-hour shifts

During cavern construction, trucks will either haul excavated waste rock up to 24 hours per day from the WRESC Site or re-use the material onsite. Excavated rock during construction may be temporarily stored for re-use if necessary. The temporary storage areas will be located as shown in **Figure 2-1** and **Figure 2-2**.

Cavern construction will occur 24 hours per day, 7 days per week. Additional hours may also be necessary for surface construction work to make up schedule deficiencies or to complete critical activities (e.g., pouring concrete at night during hot weather, and working around time-critical shutdowns and constraints).

2.1.20.3 Construction Laydown and Traffic

Construction laydown and parking will be located on property to the west and north of the WRESC Site, as depicted on the WRESC Site plot plans in **Figure 2-1** and **Figure 2-2.** The peak construction site workforce level is expected to last from month 25 through month 46 of the construction period, with the peak being months 26 and 27.

Table 2-9 provides an estimate of the average and peak construction traffic during the 60-month construction/ commissioning period for Willow Rock based on the worst-case workforce (100 percent excavated rock hauled offsite).

Table 2-9: Estimated Worst-Case Average and Peak Construction Traffic

Vehicle Type	Average Daily Trips	Peak Daily Trips
Construction Workers (one way, no carpooling assumed)	*273*	*749*
Deliveries	*45*	*60*
Total	*318*	*809*

2.1.20.4 Temporary Construction Rock Crushing Facility

A temporary portable rock crushing facility will be located onsite for up to 10 hours per day, 7 days per week for 22 months beginning approximately in month 25. The rock crushing facility will be capable of processing up to 350 tons per hour and is expected to consist of a primary jaw crusher, a secondary cone crusher, screens, three conveyors, and two stackers. The facility will use a combination of water sprays and a baghouse to control fugitive dust and fine particulate matter emissions. The facility will be capable of operating from a locally provided power feed or using two 779-horsepower diesel-fired engine generators meeting USEPA Tier 4 emission standards. The entire facility is expected to be certified under the California Air Resources Board Portable Equipment Registration Program.

The overall quantity of rock to be crushed will depend on whether an architectural berm will be constructed onsite or whether excavated rock will be hauled offsite. If an architectural berm is constructed, only 25 percent of the excavated rock is expected to be crushed to facilitate berm stability. If the excavated rock is hauled offsite, then up to 100 percent of the excavated rock is expected to be crushed to meet off-taker specifications. These options are depicted diagrammatically in **Figure 2-7**.

Figure 2-7: Rock Crushing Operation Process Diagram With and Without Berm Options

2.1.20.5 Temporary Concrete Batch Plant

A temporary portable concrete batch plan is also expected to be located onsite to support construction of the shafts and, if necessary, initial cavern construction. The concrete batch plant is expected to operate onsite for approximately 12 to 15 months. Construction is expected to require up to 80 cubic yards per day of finished cement. The facility will be capable of operating from a locally provided power feed or using one 500-horsepower diesel-fired engine generator meeting USEPA Tier 4 emission standards. The entire facility is expected to be certified under the California Air Resources Board Portable Equipment Registration Program.

2.1.21 Willow Rock Facility Operation

The WRESC will be operated and monitored continuously 24 hours per day, 7 days per week by qualified and licensed onsite operations staff and will not be remotely operated (other than potential grid regulation-required operations such as generator transfer trips or special protection schemes).

There will be a total of approximately 40 full-time staff to operate the facility. The operations staff will include control room operators (24 hours per day, 7 days per week) and roving operators in the field conducting general rounds at least twice per 12-hour shift.

Additional field checks will be done as needed for maintenance activity, upsets, or other general operations requirements.

2.2 Engineering

In accordance with California Energy Commission (CEC) regulations, this section together with the engineering appendix (Appendix 2A, Design Criteria) and Chapters 3, Electric Transmission present information concerning the design and engineering of Willow Rock. The LORS applicable to Willow Rock's engineering are provided in Appendix 2A along with a list of agencies that have jurisdiction, the contacts within those agencies, and a list of the permits that will be required.

2.2.1 Facility Design

Summary descriptions of the design criteria for all the major engineering disciplines are included in Appendix 2A, Design Criteria.

Design and engineering information and data for the following systems may be found in the related subsections of this Application for Certification:

- Power Generation: see Section 2.1.8, Energy Storage Air-Expansion Turbine Generators. Also see Appendix 2A and Section 2.1.17 which describe the various plant auxiliaries.
- Power Consumption: see Sections 2.1.7, Energy Storage Air Compression Equipment Drivetrain and 2.1.6, Energy Storage Facility Standby/Idle Mode.
- Water Supply System: see Section 2.1.14, Water Supply and Use. Also see Appendix 2D.
- Waste Disposal System: see Section 2.1.15, Waste Management and Section 5.14, Waste Management.
- Noise Abatement System: see Section 5.7, Noise.
- Switchyards/Transformer Systems: see Section 2.1.13, Major Electrical Equipment and Systems; Section 2.1.18.4, Grounding; Section 2.1.13.2, Alternating Current Power—Transmission; Section 2.1.19, Interconnect to Electrical Grid; and Chapter 3, Electric Transmission. Also see Appendix 2A.

2.2.1.1 Facility Safety Design

Willow Rock will be designed to maximize safe operation. Potential hazards that could affect the facility include earthquake, flood, and fire. Facility operators will be trained in safe operation, maintenance, and emergency response procedures to minimize the risk of personal injury and damage to the facility.

2.2.2 Facility Reliability

This section discusses the expected facility availability, equipment redundancy, fuel availability, water availability, and project quality control (QC) measures.

2.2.2.1 Facility Availability

The WRESC will be designed to be available to operate at its full load at least 95 percent of the time.

Availability is the duration of time that the entire facility will be able to perform its intended task. It is calculated as a ratio expressed in percentage, where the numerator is the number of hours when the system as a whole either (1) is ready to either charge or discharge (during idle/standby periods), or (2) is charging or discharging, all divided by the total number of hours in the period.

Typically, both planned and unplanned outages are subtracted from the availability calculation numerator to calculate actual availability for a period. The availability calculation denominator can be the total amount of time in the day, week, month, or, most commonly, year during which availability is being calculated.

For further clarity, availability is not the same as a typical generating plant's capacity factor, which accounts for annual criteria such as the plant's actual energy MWh output (numerator) versus the plant's nameplate capability to produce MWh over a full year (denominator), and which is usually based on the general assumption that the relevant plant will always operate at baseload.

The WRESC is intended to be operated for approximately 50 years. Reliability and availability projections are based on this operating life. Operation and maintenance procedures will be consistent with industry standard practices to maintain the useful life of plant components.

2.2.3 Redundancy of Critical Components

The following subsections identify equipment redundancy as it applies to project availability. Sparing of equipment must take into consideration the requirement to provide the targeted overall system availability of 95 percent. A Reliability, Availability, and Maintainability (RAM) study will be performed during final engineering design to further refine this preliminary redundancy information.

2.2.3.1 Turbomachinery

As is typical in the industry, there is no redundancy in turbomachinery (spares), given the overall reliability of the component parts and the need to control capital expenditures. Routine minor inspection and maintenance will be performed between charge and discharge cycles during pre-planned outages. Major inspections and overhauls will require shutdowns for removal of the turbomachinery casings, rotors, and other major components.

2.2.3.2 Pumps

All types of pumps are considered susceptible to mechanical breakdown and generally have one installed spare. The decision not to install a spare will depend on the criticality of the service. In general, pumps will be spared in an N +1 arrangement as an early front-end engineering design assumption until either more accurate input is available or the RAM analysis has completed.

2.2.3.3 Heat Exchangers

Shell and tube (S&T) heat exchangers are less susceptible to mechanical breakdown, though appropriate protection will be provided to safeguard equipment against tube failures and cross contamination of fluids. S&T heat exchangers will not be spared; however, the parallel nature of the heat exchanger system will allow the plant to remain available when individual exchanger units are under service. Appropriate filtration will be included to prevent corrosion and increase reliability. Tube inspection and maintenance allowances will be made in the layout design and procurement.

2.2.3.4 Storage Tanks

Multiple spherical tanks are required due to size constraints on the technology at the required operating condition, effectively resulting in sparing. They are not spared beyond the minimum number of spherical tanks required to store the hot water. That is, the WRESC will still be able to operate with a spherical tank rendered unusable, but at a reduced charge/discharge duration.

The low-pressure (atmospheric) tank is not susceptible to mechanical breakdown and, as such, does not require frequent shutdowns for maintenance purposes.

Both types of tanks will be inspected and maintained during pre-planned outages, with major inspections coordinated with major work on the turbomachinery.

Critical sensors and transducers will have triple redundancy.

2.2.4 Fuel Availability

The WRESC will not use fuel for the process. California ultra-low sulfur diesel (15 ppm sulfur by weight) will be used for the emergency backup generators and fire pump and is readily available in the marketplace.

2.2.5 Water Availability

Potable and process water will be provided by interconnection with the AVEK water distribution system. The availability of water to meet the requirements of the facility need is discussed in more detail in Section 5.15, Water Resources.

2.2.6 Project Quality Control

The project will implement a QC program that will ensure the highest level of oversight while meeting the desired project outcomes, as well as the appropriate license and social license for ongoing operations.

2.2.7 Quality Control Records

The following QC records will be maintained for review and reference:

- Project instructions manual
- Design calculations
- Project design manual
- Quality assurance audit reports
- Conformance to construction records drawings
- Procurement specifications (contract issue and change orders)
- Purchase orders and change orders
- Project correspondence
- Any other records as required by LORS

During construction, field QC activities will be performed during the last four stages of the project: receipt inspection, construction/installation, system/component testing, and plant operations. The construction contractor will be contractually responsible for performing the work in accordance with the quality requirements specified by contract.

The subcontractors' quality compliance will be surveyed through inspections, audits, and administration of independent testing contracts.

A plant operation and maintenance program, typical of a project this size, will be implemented at the Willow Rock site to control operation and maintenance quality. A specific program for this project will be defined and implemented prior to initial plant startup.

2.2.8 Facility Closure

Closure of the facility can be temporary or permanent. Temporary closure is defined as a shutdown for a period exceeding the time required for normal maintenance, with an intent to restart in the future. Permanent closure is defined as a cessation in operations with no intent to restart operations. Section 2.3.1 discusses temporary facility closure, and Section 2.3.2 discusses permanent facility closure in relation to the WRESC.

2.2.9 Temporary Closure

For a temporary closure where there is no release of hazardous materials, the Applicant will maintain security of the WRESC facilities and will notify the CEC and other responsible agencies as required by law. If the temporary closure includes damage to the Willow Rock facilities, and if there is a release or threatened release of regulated substances or other hazardous materials into the environment, procedures will be followed as set forth in an Emergency Management Plan in accordance with a Hazardous Materials Plan. Procedures will include methods to control releases, notification of applicable authorities and the public, emergency response, and training for facility personnel in responding to and controlling releases of hazardous materials. Once the immediate problem is solved and the regulated substance/hazardous material release is contained and cleaned up, temporary closure will proceed as described above for a closure where there is no release of hazardous materials.

2.2.10 Permanent Closure

When the facility is permanently closed, the closure procedure will follow a decommissioning plan that will be developed as described below.

The conditions that would affect the decommissioning decision will be presented to the CEC when more information is available and the timing for decommissioning is more imminent.

To ensure that public health and safety and the environment are protected during decommissioning, a decommissioning plan will be submitted to the CEC for approval prior to decommissioning. The plan will discuss the following:

- Proposed decommissioning activities for Willow Rock and all appurtenant facilities constructed as part of Willow Rock
- Conformance of the proposed decommissioning activities to all applicable LORS and local/regional plans
- Associated costs of the proposed decommissioning and the source of funds to pay for the decommissioning

In general, the decommissioning plan for Willow Rock will attempt to maximize the recycling or re-use of all facility components. It is anticipated that the potential cavern rock architectural berm will remain in place to minimize environmental impacts associated with its removal. It will be decommissioned such that no ongoing maintenance is needed for flood control. All nonhazardous wastes will be collected and disposed of in appropriate landfills or waste collection facilities. All hazardous wastes will be disposed of according to all applicable LORS.

APPENDIX 2A

Engineering Design Criteria

APPENDIX 2B

Construction Manpower and Equipment Schedule

APPENDIX 2C

Heat and Mass Balance Diagrams

(This Appendix Is Filed Under a Request for Confidential Designation)

APPENDIX 2D

Water Balance Diagrams and Construction Water Use

APPENDIX 2E

Construction Traffic Volume Estimate