4 Engineering

In accordance with California Energy Commission (CEC) requirements, this section presents information related to the design and engineering of the Darden Clean Energy Project (Project).

4.1 Facility Design

4.1.1 Site Conditions

This section summarizes the Project site conditions based on information detailed in Section 5.13, *Water Resources*, Section 5.14, *Soils*, and Section 5.16, *Geological Hazards and Resources*.

No known faults have been mapped through the Project site and the closest active fault to the Project site is within the Nunez Fault Zone, located approximately 20 miles to the northwest (United States Geological Survey 2017). The Project site is located in Seismic Zone 3, as defined by the most recent California Building Code (CBC), which requires specific seismic design standards (Fresno County 2018). The Project site is not mapped within a known liquefaction zone on the California State Geoportal, California Geologic Survey Seismic Hazards Program Liquefaction Zones map (California State Geoportal 2023). However, the Project would be in areas underlain with soils that may be susceptible to liquefaction. In addition, the soils that predominately underlie the Project site have moderate to high shrink-swell classes. Refer to Section 5.14, *Soils*, and Section 5.16, *Geological Hazards and Resources*, for additional information regarding soils and geological hazards, respectively.

A Project-specific preliminary geotechnical engineering report was recently completed and the findings are being evaluated and will be used to inform and finalize the facility design criteria. The geotechnical engineering report includes the results of soil borings, field electrical resistivity testing, laboratory thermal resistivity testing, laboratory corrosion testing, and pile load testing, as well as geotechnical engineering recommendations for the Project. Geologic hazards evaluated within the report included pile drivability, shallow bedrock, frost potential, expansive soils, shallow groundwater, and liquefaction (Terracon 2023). The Project site is located in areas that have experienced or are likely to have experienced land subsidence in the past (California State Water Resources Control Board 2023). As discussed in Section 5.16, *Geological Hazards and Resources*, Project construction would adhere to the specifications, procedures, and site conditions contained in the geotechnical report and final design plans, which would be fully compliant with the seismic recommendations provided by the California-registered professional engineer in accordance with CBC requirements. Potentially unstable soils present at the Project site would be addressed during Project construction in compliance with CBC requirements such that Project components would not operate on unstable soils.

A *2D Hydraulic Study* (Intersect Power 2023) and the *Preliminary Drainage Report* (IP Darden I, LLC 2023) have been prepared for the Project to inform site design and layout. Portions of the northern and northeastern Project site are within FEMA-designated flood hazard areas associated with existing drainage channels and depressions in the ground surface where surface water collects when precipitation and runoff occur. These flood hazard areas are designated “Zone A,” which represents areas that comprise the 100-year floodplain but have not been subject to detailed analyses such as flooding depths or base flood elevations (Intersect Power 2023). Solar facilities and a portion of the gen-tie easement may be placed in these areas. As discussed in Section 5.13, *Water Resources*, the

PV panels would be supported on steel piles spaced approximately 18 feet apart, and the gen-tie line would be constructed on steel monopoles or H-frames that would be spaced apart along the gen-tie corridor. Placement of these structures within a Flood Hazard Area would preserve the direction of flow and, given the small footprint size of individual poles (for the solar facility and the gen-tie), placement of individual structures would not substantially impede or redirect flood flows.

The Project site is located within the middle-western portion of California's Central Valley, where the climate is hot semi-arid, with long, dry summers, and wet winters. The average temperature is 59 degrees Fahrenheit (°F). Section 5.13, *Water Resources*, provides a detailed description of the meteorological and climate conditions of the Project site.

4.1.2 Improvement Measures

Project construction would adhere to the requirements and specifications contained in the geotechnical report and final design plans, which would be fully compliant with the seismic recommendations provided by a California-registered professional engineer in accordance with CBC requirements.

4.1.3 Foundation Design

Solar panels would be installed directly on steel piles and would not have a foundation. However, each solar panel sub-array would include an inverter-transformer station constructed on a concrete pad or steel skid centrally located within the surrounding solar arrays.

For the battery energy storage system (BESS), battery packs would be installed on a level foundation base strong enough to support the weight of the equipment in accordance with the manufacturer's design requirements. Foundation or base examples include, but are not limited to, concrete pads, grade beams, structural steel deck or skip.

For the hydrogen facility, analysis and design of structures would utilize the American Society of Civil Engineers 7 hazard tool and Process Industrial Process structural load combinations and comply with national/local building codes.

Foundations at the substation(s) and switchyard(s) may include both concrete pads and concrete piers. Foundation design considerations include the area-specific geotechnical characteristics, ice and wind loading, short circuit forces, seismic forces, and more as required by industry best practices, Institute of Electrical and Electronics Engineers standards, and regional requirements.

Foundation and structural design would take into consideration all seismic and flood considerations for the Project-specific location.

4.1.4 Facility Description

The following sections provide a description of each of the Project components based on preliminary design. Drawings with dimensions, where available, are provided in Appendix F.

4.1.4.1 Solar Facility

Chapter 2, *Project Description*, Section 2.1.2, *Solar Facility Description*, provides a description of the solar facility. Heat dissipation systems, cooling systems, atmospheric emission control systems, waste disposal systems, noise emission abatement systems, geothermal resource conveyance and re-injection lines are not applicable to the solar facility. Section 4.1.4.4 provides a description of associated switchyards and transformers.

4.1.4.2 Battery Energy Storage System

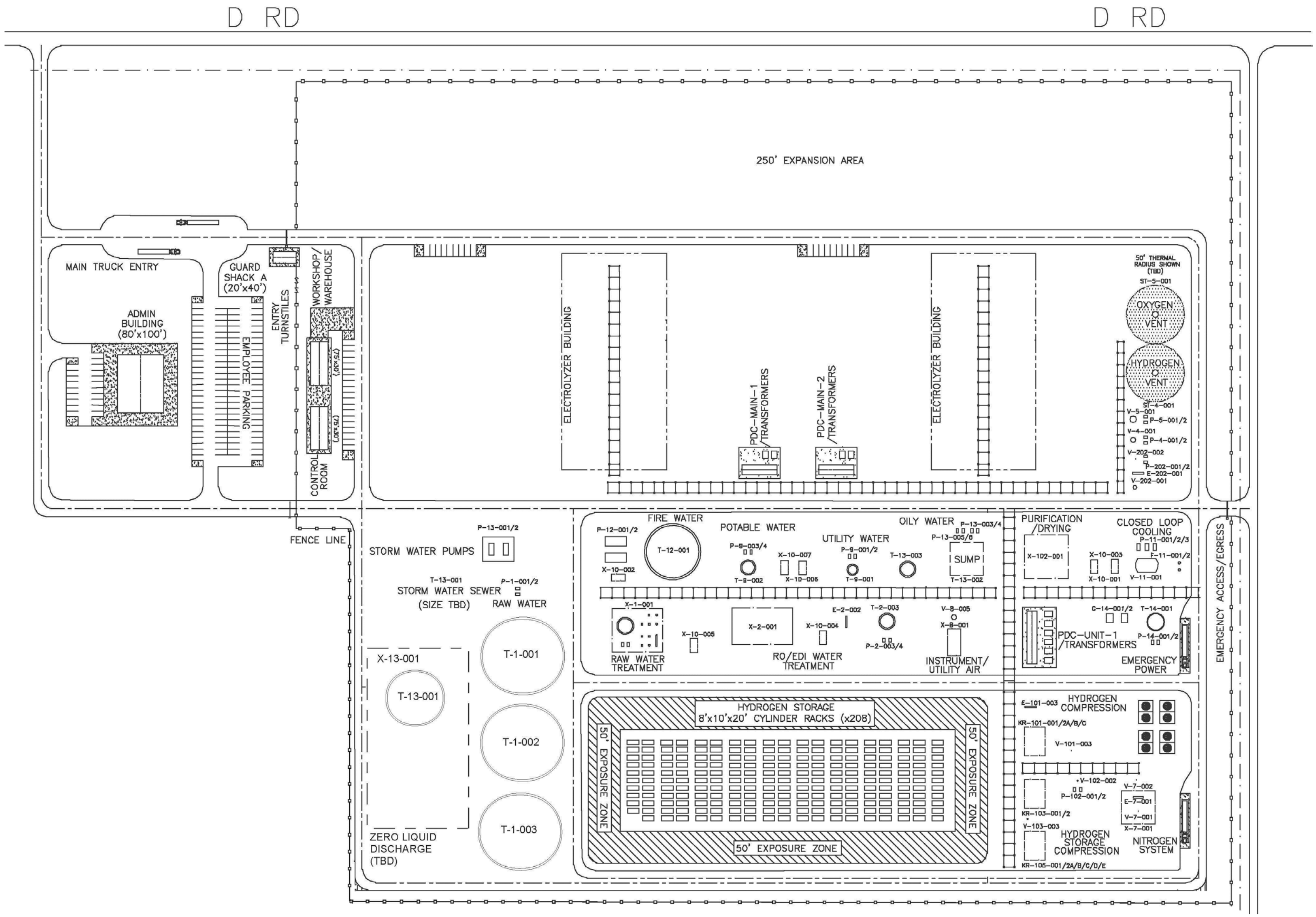
Chapter 2, *Project Description*, Section 2.1.3, *Battery Energy Storage System Description*, provides a description of the BESS. The BESS is not a power generation system. Battery packs would include an integrated thermal management system that provides active cooling and heating to the internal components; therefore, an external heating, ventilation, and air conditioning (HVAC) or thermal system would not be required. The thermal system would include radiators and pumps that circulate coolant through the battery, as well as an in-line heater that can warm the coolant. Atmospheric emission control systems, waste disposal systems, geothermal resource conveyance and re-injection lines are not applicable to the BESS. Noise emissions are discussed in Section 5.3, *Noise*.

4.1.4.3 Hydrogen Facility

Chapter 2, *Project Description*, Section 2.1.4, *Green Hydrogen Facility Description*, provides a description of the Project's green hydrogen facility. Figure 4-1 shows the preliminary layout for the hydrogen facility. Section 2.1.12, *Cooling System*, provides a description of the green hydrogen facility cooling system. The following factors are being considered in the design of a large-scale green hydrogen facility:

- Hydroelectric power was used by historic projects, which was available 24 hours a day, 7 days a week. Currently, modern projects are considering using solar and wind power, which are not constant by nature. Therefore, the facility's design must consider the dynamic nature of renewable energy sources.
- Although the proton exchange membrane electrolysis can be ramped up and down within seconds, the rotating equipment that supports the electrolyzer, such as pumps and compressors, cannot. Therefore, grid connections may be necessary to prevent time-consuming start-ups and unnecessary hydrogen venting in order to ensure stable operation of this rotating machinery at minimum turndown (facility may not generate hydrogen but all systems are ready to ramp-up).
- Hydrogen generation requires approximately 1.2 U.S. gallons of demineralized water for each 1 pound of hydrogen produced. The water use in electrolysis needs to be purified to a very high standard, similar to that used in the semiconductor and pharmaceutical industries. Depending on the source of incoming water (amount of minerals it contains) approximately 20-40 percent of water would be rejected as waste and would need to be reprocessed and/or disposed of.
- Facility operation – electrolyzers at the hydrogen facility would be powered by behind the meter solar power resulting in a capacity factor of approximately 40 percent.

Figure 4-1 Hydrogen Facility Preliminary Site Plan



The hydrogen facility would be designed with minimal venting. Continuous venting of hydrogen is not anticipated, and it is expected that hydrogen would be released only during maintenance, start-up, or shutdown. The venting from electrolyzer stacks would be carried out via localized vents located either at the top of the electrolyzer building or enclosure. Since the hydrogen would be purified, compressed, and potentially stored (Balance of the Plant equipment) on-site, a common vent for the balance of the plant equipment is also considered. The vent would be located in a safe location and the exact dimensions of the vent to be calculated during front end engineering design (FEED). Oxygen (the other gas generated during electrolysis) would be vented into the atmosphere in a safe location during normal operation. The hydrogen facility would control atmospheric emissions by routine inspection and monitoring of hydrogen equipment and piping for leaks.

The hydrogen facility would produce high salinity (brine) water from the water purification process. The plant may employ a Zero Liquid Discharge philosophy. Methods for solids concentration are being evaluated in the subsequent engineering phases of Project design, but the Project currently includes the potential use of a thermal evaporator and/or salt crystallizer. Solids would be maintained on-site and disposed of via an external solids handling company.

The hydrogen facility would follow Occupational Safety and Health Administration guidelines for noise abatement. Noise emissions are discussed in Section 5.3, *Noise*.

Geothermal resource conveyance is not applicable to the hydrogen facility.

The hydrogen facility would be fed from 35 kilovolt (kV) feeders from the main project substation, and could have a separate switchgear to feed the electrolyzer units. The plant would also have pad mount transformers to "step-down" the 35 kV voltage at required low voltage ratings to supply other auxiliary loads.

The hydrogen facility would have a control building, electrolyzer facility, water treatment plant, and hydrogen purification, compression, and storage facilities. If the alternate site is selected for the green hydrogen facility, a switchyard and substation would also be included. Section 4.1.4.4 provides a description for substations, switchyards, and transformers.

4.1.4.4 Substations/Switchyards/Transformer Systems

Chapter 2, *Project Description*, Sections 2.2.2 through 2.2.4 describe the Project substations, switchyards, and transformer systems. They are not power generation systems. Transformers would utilize radiators with passive and active fans for airflow to dissipate heat in the substation transformers.

For substations, each transformer would have concrete oil containment. Oil containment would be designed to catch and hold oil from transformers in the event a leak develops, or the transformer fails. Containment would be designed to prevent transformer oil from entering soil.

Cooling water supply systems, atmospheric emission control systems, noise emission abatement systems, and geothermal resource conveyance and re-injection lines are not applicable to the switchyard and transformer systems.

4.2 Transmission System Design

4.2.1 Need and Junction Points

The Project would interconnect into and bisect the PG&E Los Banos-Midway #2 line. The utility switchyard that would be built to bisect the PG&E line was sited to minimize the gen-tie length. The Project would interconnect at the 500 kV level due to the size of the Project and ability to access the 500 kV backbone of the PG&E transmission network.

The hydrogen facility would be located adjacent to a substation (either the Options 1 and 2 step-up substation or the alternate green hydrogen facility site substation) and it would receive up to sixteen 35 kV feeds from a substation to allow for redundancy.

4.2.2 Transmission Requirements

The 500 kV gen-tie line has been sited to minimize overall distance and avoid unnecessary road and pipeline crossings, where possible. The step-up substation locations (Options 1 and 2 sites) were chosen to optimize the transmission and distribution losses and capital expenditures. The alternate hydrogen substation location is sited immediately adjacent to the alternate hydrogen facility.

4.2.3 Transmission System Safety and Nuisance

The locations and a description of the existing switchyard and overhead transmission lines that would be affected by the Project are included in Chapter 2, *Project Description*.

4.2.3.1 Electrical Effects

The electrical effects of high-voltage transmission lines fall into two broad categories: corona effects and field effects. Corona is the ionization of the air that occurs at the surface of the energized conductor and suspension hardware attributable to high electric field strength at the surface of the metal during certain conditions. Corona may result in radio and television reception interference, audible noise, light, and production of ozone. Corona is a function of the voltage of the line, the diameter of the conductor, and the condition of the conductor and suspension hardware. The electric field gradient is the rate at which the electric field changes and is directly related to the line voltage. Field effects are the voltages and currents that may be induced in nearby conducting objects. A transmission line's inherent electric and magnetic fields cause these effects. Operating power lines, like energized components of electrical motors, home wiring, lighting, and other electrical appliances, produce electric and magnetic fields commonly referred to as an electromagnetic field (EMF). The EMF produced by the alternating current (AC) electrical power system in the U.S. has a frequency of 60 hertz, meaning that the intensity and orientation of the field changes 60 times per second.

Corona from a transmission line may result in the production of audible noise or radio and television interference. Corona is a function of the voltage of the line, the diameter of the conductor, and the condition of the conductor and suspension hardware. The electric field gradient is the rate at which the electric field changes and is directly related to the line voltage.

The electric field gradient is greatest at the surface of the conductor. Large-diameter conductors have lower electric field gradients at the conductor surface and, hence, lower corona than smaller conductors, everything else being equal. Also, irregularities (such as nicks and scrapes on the conductor surface) or sharp edges on suspension hardware concentrate the electric field at these locations and, thus, increase corona at these spots. Similarly, contamination on the conductor surface such as dust or insects can cause irregularities that are a source for corona. Raindrops, snow, fog, and condensation are also sources of irregularities.

4.2.3.2 EMFs, Audible Noise, and Radio and Television Interference Assumptions

EMFs, audible noise, and radio and television interference near power lines vary regarding the line design, line loading, distance from the line, and other factors. Electric fields, corona, audible noise, and radio and television interference depend on line voltage and not on the level of power flow. Because line voltage remains nearly constant for a transmission line during normal operation, the audible noise associated with the 500 kV lines in the area would be of the same magnitude before and after the project. Specifically, assuming use of a 2-bundle 1590 ACSR design conductor, audible noise under fair weather criteria (48.5 decible [dBA] limit for Environmental Protection Agency’s 55 day-night average sound level [Ldn] criteria) for the gen-tie line is estimated to be 38.6 dBA. Audible noise under foul weather criteria for the gen-tie line is estimated to be 63.6 dBA. Audible noise under foul weather criteria at the edge of the gen-tie easement is estimated to be 59.8 dBA. Radio interference is estimated to be 56.9 decibels-microvolt per meter (dBuV/m) under fair weather criteria (56 dBuV/m limit 50 feet from conductor). Television interference is estimated to be 30.8 dBuV/m (24 to 27 dBuV/m limit 100 feet from conductor). Corona losses are estimated to be 5.335 megawatts (MW) or 0.432 percent; resistive losses are estimated to be 3.567 MW or 0.289 percent; and total losses are estimated to be 8.902 MW or 0.721 percent.

The magnetic field is proportional to line loading (amperes), which varies as demand for electrical power varies and as generation from the generating facility is changed by the system operators to meet changes in demand. It is expected that EMF levels from the Project gen-tie line would be less than the existing PG&E Los Banos-Midway #2 500 kV utility transmission line that it would interconnect to as the amount of power flowing through the Project gen-tie line would be less than the ratings of the existing 500 kV transmission lines. EMF at the Project step-up substation and utility switchyard would also be less than the proposed gen-tie outside the step-up substation and utility switchyard fences due to the distance from energized equipment.

Overall, construction and operation of the Project, including the interconnection of the facility with PG&E’s transmission system, are not expected to result in increases in EMF levels, corona, audible noise, or radio and television interference and mitigation would not be required. Specifically, electric field is estimated to be 2.052 kilovolt per meter (kV/m) at the edge of the gen-tie corridor, electric field is estimated to be 11.585 kV/m throughout the corridor, and magnetic field is estimated to be 78.52 milligauss (mG) at the edge of the corridor.

4.3 Reliability

4.3.1 Fuel Availability

The Project would not rely on an external fuel source. The green hydrogen facility would use power generated by the solar facility and stored by the BESS, which would be supplied behind the meter. The green hydrogen facility would also connect to the power grid to support auxiliary site loads during periods of no solar production and depleted energy storage. Emergency diesel generators would provide emergency backup in the event that solar power wasn’t available during a grid outage. The generators would run on locally sourced diesel.

4.3.2 Facility Reliability

This section discusses the anticipated service life and degree of reliability expected to be achieved by the proposed Project.

4.3.2.1 Solar Facility Reliability

The solar facility would be designed to be available to operate at its maximum possible output (based on meteorological conditions) at least 99 percent of the time. For the solar facility, an annual availability factor of 99 percent is anticipated.

Availability is the duration of time that the entire plant 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 is either (1) ready to either charge or discharge (during idle/standby periods); (2) is charging or discharging, all divided by the total number of hours in the period; or (3) actively exporting electrons directly to the point of interconnection (rather than first to the BESS).

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 where 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 megawatt hour (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 solar facility is expected to have an annual and lifetime capacity factor of 20 to 40 percent.

The proposed solar generating equipment has a proven track record of reliability based on multiple gigawatts of power plants using this technology permitted, financed, and installed and operating across North America. Power capacity would be sized to ensure full capacity output up to 50 degrees Celsius and down to -20 degrees Celsius to withstand climactic extremes.

It is anticipated the solar facility would provide around 3,000 gigawatt hour (GWh) of electricity per year. It is also anticipated the solar facility would operate for approximately 4,000 hours per year (daylight hours). Operation and maintenance procedures would be consistent with manufacturer's and industry standard practices to maintain the useful life of the plant components.

4.3.2.2 Battery Energy Storage System Reliability

The BESS would be designed to be available to operate at its full load at least 98 percent of the time. The BESS is anticipated to be designed for a 4-hour system, cycled up to two times a day, to not exceed 365 cycles a year, with an annual capacity factor of 33.33 percent. The BESS is expected to have a design life of approximately 25 years.

The BESS is anticipated to use lithium iron phosphate lithium-ion battery technology, extensively analyzed for feasibility in terms of energy density, cycle life, and cost-effectiveness. This battery technology has undergone rigorous testing and simulations to ensure that it meets the facilities' energy demands while ensuring long-term viability.

To maintain optimal performance, the BESS would include a robust thermal system which has been designed with a liquid cooling mechanism. Power capacity would be sized to ensure full capacity output up to 50 degrees Celsius and down to -30 degrees Celsius to withstand climactic extremes.

Operation and maintenance procedures would be consistent with manufacturer and industry standard practices to maintain the useful life of the components.

4.3.2.3 Hydrogen Facility Reliability

The operating life of the hydrogen facility is anticipated to be 30 years. The overall availability is expected to be between 94 percent and 96 percent over the Project lifetime. The hydrogen facility is expected to have an annual and lifetime capacity factor of approximately 40 percent. This availability would be achieved by:

- Performing regular maintenance of all process equipment at intervals prescribed by the equipment vendors.
- Installing spares for equipment operating on a continuous basis like water circulation pumps, reverse osmosis units, compressors, etc.
- Maintaining equipment levels within the warehouse.
- Ensuring, where practical, to use the same equipment specification in the design to reduce number of unique spares (i.e., installed motors of the same rating).
- 24/7 monitoring of the process by on-site personnel and performing ad-hoc repairs if required.
- 24/7 monitoring of the performance of the electrolyzes by the supplier via Long Term Service Agreement between the Applicant and Electrolyzer vendor.

Water availability and reliability is discussed in the Project's water supply report in Appendix S.

4.3.2.4 Transmission Equipment Reliability

The gen-tie, switchyard(s), and substation(s) are expected to have a lifetime capacity factor of 40 years or more. All components utilized in these areas have been used previously in the utility industry to provide similar stations with equal or greater design life.

The utility switchyard utilizes an equipment configuration that provides high reliability for continued and reliable service, while providing flexibility for system maintenance and damaged equipment. The Project substation(s) would be designed such that generation (or hydrogen load) behind all transformers would be able to be tied to an adjacent transformer in the event of a transformer failure or maintenance. This would be accomplished by connecting the 35 kV busses together with a tie switch or circuit breaker. Should the alternate hydrogen facility location be selected, the alternate hydrogen switchyard would be designed in either a ring or tap configuration, allowing for isolation of the hydrogen facility or solar generation while still allowing access to the utility interconnection.

4.4 Efficiency

4.4.1 Solar Facility Efficiency

It is anticipated the solar facility would provide around 3,000 GWh or 3,000,000 MWh of electricity per year. Heat and mass balance diagrams are not applicable to the solar facility and the solar facility would not consume fuel. The plant would operate approximately 4,000 hours per year.

4.4.2 Battery Energy Storage System Efficiency

The BESS would produce approximately 419.75 GWh or 419,750 MWh per year (considering 1 discharge cycle per day per year). It is anticipated that the BESS would operate in charge mode 1,570 hours each year and in discharge mode 1,460 hours each year (assuming 1 cycle per day per year).

4.4.3 Hydrogen Facility Efficiency

The hydrogen facility is not a power plant, but would use electricity to produce gaseous hydrogen through electrolysis of water. The facility would operate between 14 and 24 hours per day (5,110 to 8,760 hours per year), requiring up to 1,150 MW of energy at any given time. Annually, the hydrogen facility would require 5,876,500 MWh (14-hour operating schedule) to 10,074,000 MWh (24-hour operating schedule). The facility will produce up to approximately 220 metric tons (approximately 243 tons) of gaseous hydrogen per day.

4.5 References

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