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Electrical System Stability and Reliability: Life After SONGS

San Onofre Nuclear Generation Station

The San Onofre Nuclear Generation Station (SONGS) is located south of San Clemente, within the Camp Pendleton military reserve and is owned by Southern California Edison (SCE – 78.2%), San Diego Gas & Electric (SDG&E – 20%), and City of Riverside Utilities Department (1.8%). SONGS consists of three nuclear powered electric generator units. Unit 1 was commissioned in 1968, but as the reactor aged it became less efficient and eventually was no longer cost-effective leading to its decommissioning in 1992. The reactor was dismantled as part of the decommissioning process and the waste fuel is stored on site. Units 2 and 3 started operation in 1983 and 1984, respectively, and both have been offline since January 2012. Units 2 and 3 together provided approximately 2,200 megawatts (MW) of power capacity.

Steam generators for SONGS Unit 2 were replaced in 2009 and those for Unit 3 in 2010. The generators were manufactured by Mitsubishi Heavy Industries and each contains over 9,000 tubes intended to carry high pressure, high velocity steam. During a scheduled refueling outage in January 2012, inspections revealed excessive wear on the Unit 2 steam tubes. On January 31, tubes in the Unit 3 steam generator failed and vented a small amount of radioactive steam within the containment dome. Subsequent inspections showed that the Unit 3 steam generator also had significant tube wear similar to Unit 2. Units 2 and 3 have both been offline while SCE and the Nuclear Regulatory Commission (NRC) investigated the cause of the excessive wear and developed a plan for restarting the plant. Investigations by SCE determined that the cause of the tube wear was an unanticipated level of vibration between the tubes and the support structures, and between the tubes themselves.

After the initial shut-down and investigations, the plant operators sought to restart Unit 2, while leaving Unit 3, which had more extensive damage, in a shut-down state. SCE proposed a plan to the NRC in October 2012 that included restarting SONGS Unit 2 at 70 percent power for a five month period. After the five-month evaluation period, they would perform an additional inspection to determine if the steam generator tubes deteriorated any further. The NRC determined a license amendment would be required to implement this plan, which SCE applied for in April 2013. Other stakeholders in the NRC proceeding continued to argue for public



judicial hearings to investigate the causes of the incident. This process would have extended the outage beyond summer 2013 and potentially through 2014.

On June 7, 2013 the plant owners announced plans to permanently shut down and decommission the power plant. In a press release, SCE cited uncertainty relating to the plant restart as a reason for the decision and subsequently filed a Certification of Permanent Cessation of Power Operations with the NRC. This notice verifies the operator's intent to permanently close the facility and that it is currently not producing power. Accompanying the plant closure will be a series of employee layoffs, which has already begun with the elimination of 600 non-union jobs. There are 1,500 people employed at SONGS, and this workforce will be reduced to 400 by next year, leaving 1,100 people out of work.

Near-Term Reliability

Reliable and stable power transmission across the electrical grid requires that a number of variables be maintained, including power capacity, voltage level, and voltage frequency. The primary supply-side resource for the electrical grid is electric generation, or power measured in megawatts (MW). SONGS provided approximately 2,200 MW of power capacity, while other power plants typically have capacity in the hundreds of megawatts. In order to move that power reliably, the grid voltage must be maintained, which can be supported by synchronous condensers and capacitors.

Governor Brown directed the state's top energy experts, including the California Energy Commission (CEC), the California Public Utilities Commission (CPUC), the California Independent System Operator (CAISO), the State Water Resources Control Board, the South Coast Air Quality Management District, the California Air Resources Board (CARB), SDG&E, and SCE to develop options for moving ahead without SONGS and to develop a plan by mid-September. The workgroup will rely on the experience of the past year for short-term plans, but is primarily charged with transitioning to a long-term plan for accommodating the retirement of the power plant. The CEC and CPUC will host a joint workshop to discuss challenges of planning and electricity infrastructure in Southern California on July 15. Energy demand forecasts, utility resource mix, state regulations, and environmental quality will need to be considered in planning for the long-term closure of SONGS.

SONGS has been offline for one-and-a-half years, and some modifications to the grid have been made to accommodate its absence. During the summer of 2012, system reliability was supported by restarting gas-fired generators at Huntington Beach that were previously retired. The added generation provided 440 MW of capacity. Since then the Huntington Beach generators have been converted from power generation to synchronous condensers in order to provide voltage support. Additionally, substations in Santiago, Johanna, and Viejo have had capacitors added, also to support voltage. The Barre-Ellis 220 kilovolt (kV) transmission lines have been reconfigured from two circuits to four circuits in order to provide greater flexibility. New gas-fired generation includes plants at El Segundo (564 MW), Sentinel (800 MW), and Walnut Creek (500 MW).

The investor-owned utilities (IOUs) are permitted to contract for a reserve margin of capacity, which acts as a buffer to serve the grid in situations of high demand or reduced supply. The

CAISO continually monitors the reserve margin and issues warnings and flex alerts when the reserve margin is low. Under normal circumstances the CAISO maintains a reserve margin near 20 percent. When extraordinary circumstances arise, such as heat waves or downed power lines, the reserve is tapped as a resource to meet demand. If the remaining reserve margin drops to three percent, the CAISO initiates “load shedding”, also known as rolling blackouts. The CAISO estimates that for summer 2013, reserve margins for Southern California under normal conditions will be 23 percent. Under extreme conditions, which combine reduced capacity and high demand, the CAISO estimates the reserve margin will drop to six percent for Southern California.

Long-Term Reliability

The closure of SONGS leaves a 2,200 MW hole in the generation portfolio of the IOUs. The main challenge moving forward is figuring out how to fill that hole, or if other resources can be mobilized to meet the electricity needs of the region. There are several planning mechanisms used by state entities that forecast for electric supply and demand. Those planning entities will need to determine what mix of resources is best to fill the deficit of generation, including energy efficiency measures, demand response programs, grid support measures, new renewable generation, new conventional generation, and distributed generation.

The CEC is required by statute to develop a biennial Integrated Energy Policy Report (IEPR) that provides information on trends and issues concerning electricity and natural gas, transportation, energy efficiency, renewables, and a ten-year forecast of expected energy demand. To develop this forecast, the CEC has, since 2007, convened a demand analysis working group with stakeholders, including representatives of the CPUC and CAISO.

Modeling and Forecasting by CAISO and CEC includes contingency scenarios that assume certain challenges of the system. These challenges can arise by weather or related events that cause a strain on resources. For example, a heat wave will add demand to the system, or a fire might take out a transmission line. These scenarios are classified by the likelihood of occurrence in a given year, so a “one-in-ten” has about a 10 percent chance of occurring in a given forecast.

The CPUC regulates IOU power procurement and ensures the IOUs meet energy efficiency and renewable portfolio standard (RPS) goals. Power procurement is reviewed and approved by the CPUC through a Long Term Procurement Plan (LTPP) proceeding, which occurs every two years. To determine the amount of demand, the CPUC relies on the ten-year demand forecast from the CEC and considers analysis from CAISO that evaluates the needs to meet system reliability. Demand-side resources include energy efficiency measures, demand response programs, and flex alerts. All of these measures are intended to reduce energy consumption and the load on the grid. By reducing demand, energy efficiency and demand response programs reduce the need to build power plants. The CPUC also considers its loading order in the LTPP process, which prioritizes cost-effective energy efficiency projects before contracting for renewable energy or conventional energy generation.

The challenge to regulators and utilities goes beyond maintaining basic system reliability and also includes balancing the needs of the region with the state-wide goal to reduce greenhouse gas

emissions. Were the IOUs to replace the 2,200 MW of power capacity from SONGS completely with gas-fired generation, they would actually increase the amount of greenhouse gas emissions. On the other hand, intermittent renewables such as wind and solar do not provide the same stability and reliability as a conventional power plant. What portion of new generation can come from renewable resources or distributed generation, and what level of conventional generation is required to provide grid stability and reliability?

Some stakeholders will argue that SONGS can be completely replaced with renewable generation and/or distributed generation. For example, the Rocky Mountain Institute (RMI) argue that the gap could be filled with a combination of behavior change, demand response, energy efficiency, solar photovoltaic, combined heat and power and fuel cells, and energy storage. They recommend creating incentives for distributed power and facilitating faster adoption of solar power by streamlining permitting and interconnection procedures for distributed resources. However, distributed generation presents a set of challenges on its own that may not be resolved until new technologies become available, including a fully operational smart grid and energy storage. SCE has argued against RMI on this point, noting that coastal communities such as San Diego and Orange Counties are not ideal for distributed generation because they have space restrictions and inherently low capacity factors.

Riverside Public Utilities, who has a 1.8 percent ownership of SONGS, has recently reached an agreement with CalEnergy LLC to purchase 86 MW of geothermal power. The 24-year power-purchase agreement runs from 2016 to 2039 and will provide power from 10 geothermal generating facilities in the Salton Sea area of the Imperial Valley. The contract will satisfy about 20 percent of the city's energy needs.

Once Through Cooling

Adding to the challenges of grid reliability are new state regulations on the use of once through cooling (OTC) systems for power plants. The OTC system draws water from the ocean to absorb waste heat from the generators before pumping the water back to the ocean. This method of cooling power plants has been controversial for its significant impacts on the environment. The ocean intake brings marine life as well as the water necessary for cooling the plant. Some of the larger wildlife gets caught on the intake screens (impingement), but small and microscopic organisms get carried through the full cycle (entrainment). After being heated by the power plant, the water is returned to the ocean and alters the local environment.

Nuclear power plants have particularly large impacts, because they consume a large quantity of water. SONGS used 9.8 million gallons per day to remove waste heat from the power plant. In the process it entrained 1590 fish larvae per 1000 m³ of water. The premature shutdown of SONGS has relieved much of the environmental impacts of OTC, but other power plants that provide approximately 7,400 MW of capacity still rely on the technology. While that capacity could help support the electrical grid, plant operators simultaneously face state regulations that require them to convert to alternative cooling technologies, or shut down.

A Note on the Diablo Canyon Power Plant

The Diablo Canyon Power Plant (DCPP) is owned and operated by Pacific Gas & Electric (PG&E). The plant was opened in 1985 and has two nuclear power electric generation units approximately equal in capacity to SONGS. Recently, on June 26, 2013, maintenance workers noticed a small leak while working within the containment dome. The leak was located on the weld between two pipes, and leaked 3 drops of boric acid water per minute. The plant was powered down in order to fix the leak, which took a week to complete. The power plant was restarted and reached full power on the morning of July 4, 2013.

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