Blackout 2011 - Volume I

An Online Continuing Education Course for Engineers

Course Number: E-3032

Credit: 3 Hours / 3 PDH / 3 CPD

Blackout 2011

Volume I

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Events Leading Up to the Outage

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Preface

On the afternoon of September 8, 2011, an 11-minute system disturbance occurred in the Pacific Southwest, leading to cascading outages and leaving approximately 2.7 million customers without power. The outages affected parts of Arizona, Southern California, and Baja California, Mexico. All of the San Diego area lost power, with nearly one-and-a-half million customers losing power, some for up to 12 hours. The disturbance occurred near rush hour, on a business day, snarling traffic for hours. Schools and businesses closed, some flights and public transportation were disrupted, water and sewage pumping stations lost power, and beaches were closed due to sewage spills. Millions went without air conditioning on a hot day.

Immediately following the blackout, FERC and NERC assembled a team of technical experts to investigate exactly what happened, why it happened, and what could be done to minimize the chance of future outages. The scope of NERC's investigation was to determine the causes of the blackout, how to reduce the likelihood of future cascading blackouts, and how to minimize the impacts of any that do occur. NERC focused its analysis on factual and technical issues including power system operations, planning, design, protection and control, and maintenance.

This is Volume I of a two part series about the September 8th outage. This course looks at the conditions on the bulk electric system that existed prior to and during the blackout, and explains how the blackout occurred. It covers the events leading up to the blackout and gives an overview of the conditions prior to the start of the system failure. Volume II reviews the causes, findings of the investigating committee, and gives recommendations to minimize a future event of this type.

Introduction

The loss of a single 500 kilovolt (kV) transmission line initiated the September 8, 2011 event, but was not the sole cause of the widespread outages. The system is designed, and should be operated, to withstand the loss of a single line, even one as large as 500 kV. The affected line—Arizona Public Service's (APS) Hassayampa-N. Gila 500 kV line (H-NG)—is a segment of the Southwest Power Link (SWPL), a major transmission corridor that transports power in an east-west direction, from generators in Arizona, through the service territory of Imperial Irrigation District (IID), into the San Diego area. It had tripped on multiple occasions, as recently as July 7, 2011, without causing cascading outages.

With the SWPL's major east-west corridor broken by the loss of H-NG, power flows instantaneously redistributed throughout the system, increasing flows through lower voltage systems to the north of the SWPL, as power continued to flow into San Diego on a hot day during hours of peak demand. Combined with lower than peak generation levels in San Diego and Mexico, this instantaneous redistribution of power flows created sizeable voltage deviations and equipment overloads to the north of the SWPL. Significant overloading occurred on three of IID's 230/92 kV transformers located at the Coachella Valley (CV) and Ramon substations, as well as on Western Electricity Coordinating Council (WECC) Path 44, located south of the San Onofre Nuclear Generating Station (SONGS) in Southern California.

Path 44, also referred to as "South of SONGS," is an aggregation of five 230 kV lines that delivers power in a north-south direction from the Southern California Edison (SCE) footprint in the Los Angeles area into the SDG&E footprint.

The flow redistributions, voltage deviations, and resulting overloads had a ripple effect, as transformers, transmission lines, and generating units tripped offline, initiating automatic load shedding throughout the region in a relatively short time span. Just seconds before the blackout, Path 44 carried all flows into the San Diego area as well as parts of Arizona and Mexico. Eventually, the excessive loading on Path 44 initiated an intertie separation scheme at SONGS, designed to separate SDG&E from Southern California Edison (SCE). The SONGS separation scheme separated SDG&E from Path 44, led to the loss of the SONGS nuclear units, and eventually resulted in the complete blackout of San Diego and Comisión Federal de Electricidad's (CFE) Baja California Control Area. During the 11 minutes of the event, the WECC Reliability Coordinator (WECC RC) issued no directives and only limited mitigating actions were taken by the Transmission Operators of the affected areas.

CFE is Mexico's state-owned utility. Only its Baja California Control Area was affected on September 8, 2011.

As a result of the cascading outages stemming from this event, customers in the SDG&E, IID, Arizona Public Service (APS), Western Area Power Administration-Lower Colorado (WALC), and CFE territories lost power, some for multiple hours extending into the next day. Specifically,

- SDG&E lost 4,293 Megawatts (MW) of firm load, affecting approximately 1.4 million customers.
- CFE lost 2,150 MW of net firm load, affecting appr… …on customers.
- IID lost 920 … …ers.
- … …rs.
- … …ners. The

After t… …ion processes. All of t… …ms and, therefo… …in the restorati… …the process was gen… …took 10 hours to … restored … approxim… …ergize …tion to get …ondition …lk to restore … during the … MW for II …

Meanwhile … …2,229 MW of trip… …in 87 hours. IID … …9 hours; APS restore… …hours; WALC restored its 161 kV s… …kV system in 13 hours and its 115 kV system in 10 …

The following map (see Figure 1), showing the areas affected by the September 8th event and the key facilities involved during the event, can be used as a reference throughout the report: