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Colombian Blackout 2007

Blackout Watch



Understanding what happened can help us prevent it in the future.

Some questions arise:

■ Why didn't the interlocking control system of the busbar arrangement prevent the operator from making a wrong maneuver?

■ Also, why did the power lines trip when they became overloaded, thereby accelerating the breakdown of the CEPS?

The Torca substation is one of the main 230 KV substations in the area surrounding the capital city of Colombia, Bogota. There is one main busbar sectionalized in two (B1 Sec. 1 and B1 Sec. 2) and a transference busbar (Barra 3) linked with a breaker, as is shown in Figure 1.

ON APRIL 26TH, 2007, AT 9:58 AM, THE COUNTRY OF COLOMBIA suffered a total blackout that affected 25 million people; with a cost of US \$130 million, it was the worst blackout in the last 22 years in Colombia.

This blackout was due to human error at the 230 KV Torca substation: An operator at the substation didn't follow the correct sequence of maneuvers when transferring circuits from one busbar to another before a scheduled maintenance task in one sectionalizer. The wrong maneuver overloaded the inter-bus breaker, and breaker failure operation de-energized the whole Torca substation, igniting a cascade of events that brought down the entire Colombian Electric Power System (CEPS).

The power was reestablished after four hours and 30 minutes.

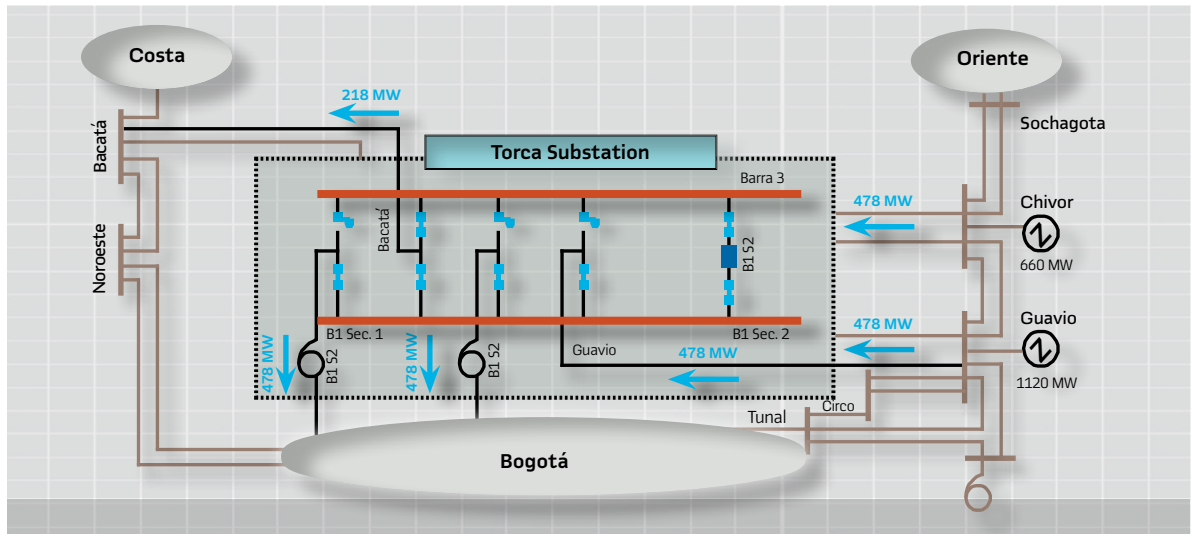
One day before the maintenance maneuver, on April 25th, the National Dispatch Center (NDC) in Colombia analyzed the risk of the maintenance activity and then confirmed that the CEPS was not vulnerable to an unwanted tripping of the power line Torca-Guavio 1, and therefore they authorized the maintenance operation. In fact, previous to the blackout, the CEPS was in a very favorable situation under N-2 conditions.

In 2007 the CEPS relied entirely on an automatic load shedding scheme (ALS) to regain balance in the different subareas of the interconnected system in case of a contingency

The Colombian Blackout

Torca is one of several main 230 kV substations in the area surrounding Bogota - the capital of Colombia.

1 Torca Substation Arrangement



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affecting the frequency. As a consequence of the outage at the Torca substation, six power lines and three 230/115KV transformers were shut down, and a sequence of events took place: Firstly, the lines Guavio-Circo were overloaded and tripped. Secondly, the outage of these lines (Figure 2) caused a reduction in voltage and overload conditions in some regions.

In spite of the weakened condition of the CEPS, the biggest power plants in the region, Chivor and Guavio, and other smaller power plants, remained online, with about 2100 MW, 31% of the country's total demand (6644 MW) at that moment.

The only remaining links (*Guavio-Tunal and Guavio-Reforma-Tunal*) became overloaded, so frequency and bus voltages collapsed beyond the safe limits, thus causing the islanding of this area from the rest of the interconnected system with the opening of the lines Guavio-Tunal and Tunal-Reforma.

With the partition of the CEPS into two areas, A and B (*Boyaca and Santander regions*), there was a deficit of power in area A which collapsed the frequency in this area and a power surplus in area B which created an over-frequency situation in area B. The evolution of the frequency in the areas A and B during the contingency is shown in Figure 3.

The severity of the contingency didn't give the ALS a chance to compensate the power unbalance in area A. The ALS worked as it was designed to work, but it had to work under an unexpected contingency and could not control the drop in frequency.

Figure 3 shows the interval where the ALS worked (see the box highlighted in blue). Colombia was then isolated from Ecuador's electric power system, and all the power plants

shut down in sequence, thus collapsing the entire CEPS and leaving the whole country without electricity.

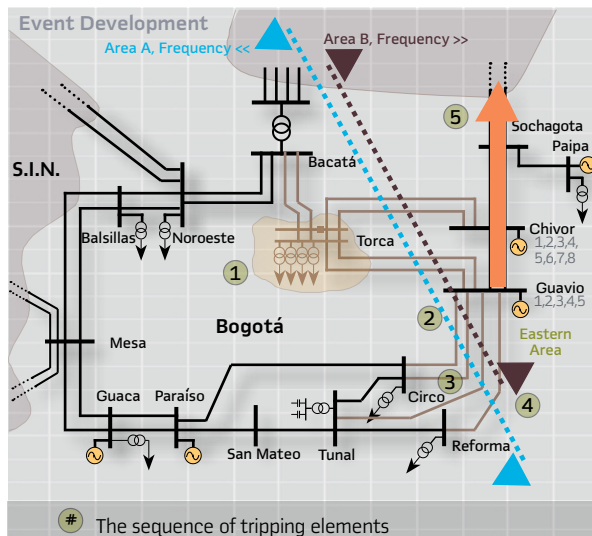
The restoration of the CEPS took between 4-5 hours, as the NDC coordinated activities with 40 transmission control centers, generation companies and regional transmission operators.

Approximately 600 power lines (23,000 km), 193 transformers and 52 power plants had to be reestablished. The restoration started with power plants with black start capacity, and the interconnection lines with Ecuador and Venezuela. Post contingency guides developed previously were used in successful restoration of the Colombian power system.

The adverse experience of the blackout was used as a source of improvement in different areas. Some of the most important results were:

- Definition of guidelines to minimize the risk of blackouts in the future
- Improvements of the standard procedures for the execution of substation maneuvers
- Determination of critical substations which have to have special procedures for maintenance programming
- Definition of a management plan for events of big impact on the system
- Improvement of the training programs for operators
- Definition of supplementary protection schemes and protection settings review
- Improvement of the communication channels among the control centers
- Improvement of the coordination schemes during the operation and restoration of the interconnected national system ■

2 Substations around Bogota



3 Frequency during the contingency

