Remedial Action Scheme Based on Synchrophasor Measurements & System Angle Difference for Peru’s 500 kV Grid

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Topics

• Overview
• Responsibilities
• Project Scope
• Technical Solution
• Open Discussion
Peru Facts

• Area: 1’285,216 sq km
• Population: 30,814,175
• Local Currency: Nuevo Sol (PEN)
• Stable government for the last 10 years
• Next presidential election in 2016
Organization of Project

CERRO VERDE (End User)

SEL (Solution Provider)

COES (Project Specs)
COES (Comité de Operación Económica del Sistema)

- COES is a non-profit & private entity. Makes decisions to coordinate secure operation of the energy resources and plan growth of transmission system. All power companies are mandated to follow COES’s decisions in Perú.

- Information Sistems of COES (SICOES) has 5 sub-systems:
  - Sistema de Gestión Operativa del COES (SGOCOES)
  - SCADA / EMS
  - Sistema de Gestión Documentaria del COES (SGDOC)
  - WEB-COES / Extranet / Intranet
  - Transcoes (cálculo de las valorizaciones de transferencias de energía mensuales)

The Ministry of Energy and Mines of Peru and Abengoa Transmisión Sur (ATS), signed a 30-year contract in July of 2010 for the design, financing, construction, operation and maintenance of the 500 KV transmission line that connects Chilca, Marcona, Ocoña, and Montalvo substations (872 kilometers)
Cerro Verde Facts

- Cerro Verde is an open-pit copper and molybdenum mining complex.
- 20 miles southwest of Arequipa, Peru
- Projected for expansion of the concentrator facilities to 360,000 metric tons-per-day (mtd) and provide incremental annual production of approximately 600M pounds of copper and 15M pounds of molybdenum beginning in 2016.
- **Ownership:** 53.56% FCX *(Freeport-McMoRan Inc)*; 21% SMM Cerro Verde Netherlands B.V. (a subsidiary of Sumitomo Metal Mining Company Ltd.); 19.58% Compañía de Minas Buenaventura S.A.A.
Background

• The 220 kV transmission line between Mantaro – Cotaruse – Socabaya connects generation from the north to the loads in the south.

• The 500 kV line between Chilca – Poroma – Ocoña – Montalvo prevent the system to collapse after the disconnection of the 220kV link to the southern part of the country.

• There are many major mining projects in southern Peru such as: Cerro Verde expansion, Constancia Mine, Las Bambas Mine, & Antapaccay Mine.

• High-Speed Load Shedding is required in the southern Mines before disconnecting the 220kV or 500 kV lines in order to prevent a collapse caused by power oscillations between North-Central areas and the South of Peru.
 Defined Solution

• Implement a Remedial Action Scheme (RAS) that, based on the measurement of angles at different points of the 500 kV line, acts on feeders assigned to the ERACMF (Esquema de Rechazo Automático de Carga por Mínima Frecuencia or Under Frequency Automatic Load Shedding Scheme) before power oscillations occur.

• Implement a control scheme to trip the reactors in 500 kV line, giving priority to disconnect bus bar reactors.

• Future implementation of the RAS scheme in new mining projects entering the SEIN (National Interconnected System) of Peru.

• Logics applied to the RAS are defined as DACA
Project Scope
Synchrophasor RAS System

• System Design
• Panel Manufacturing
• Factory Testing
• Panel Onsite Installation
• System Commissioning
• Training
• Local Support (Local)
Applied Solution
LOGIC 1
Fault in L-5032

Result:
25% Load Shedding
Cerro Verde
LOGIC 2
Fault in L-5034

Result:
60% Load Shedding
Cerro Verde
Result: 60% Load Shedding
Cerro Verde
Result: 49% Load Shedding
Las Bambas

LOGIC 4
Fault in L-2051/2052
Staging & RTDS (Real Time Digital Power System Simulation) of Cerro Verde’s RAS
Project Results

• Testing included switching under maximum power flow conditions and disconnection of lines for maintenance.

• The time of operation of the scheme itself (PMUs, PDC, etc) was between 40ms to 80ms, this time includes the 50 milliseconds additional delay for coordination of logics 1, 2 and 3; and 150 ms for logic 4.

• The results were satisfactory and the system was commissioned December 2015.
Synchrophasors: Another Tool in Tool Belt