# THE AUTO TRANSFER CONTROL SYSTEM

Automatic Reconfiguration of CERN 18kV Electrical Network

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CERN Electrical Network

210MW supplied from the French grid at 400kV, a partial back up from the Swiss grid at 130kV and 16 diesel generators supplying safety-relevant loads, compose the main power sources at CERN. The high voltage is lowered down to 66kV for transport across distant sites and to 18kV for local distribution. The end users are then supplied at 18kV, 3.3kV and 400/230V.
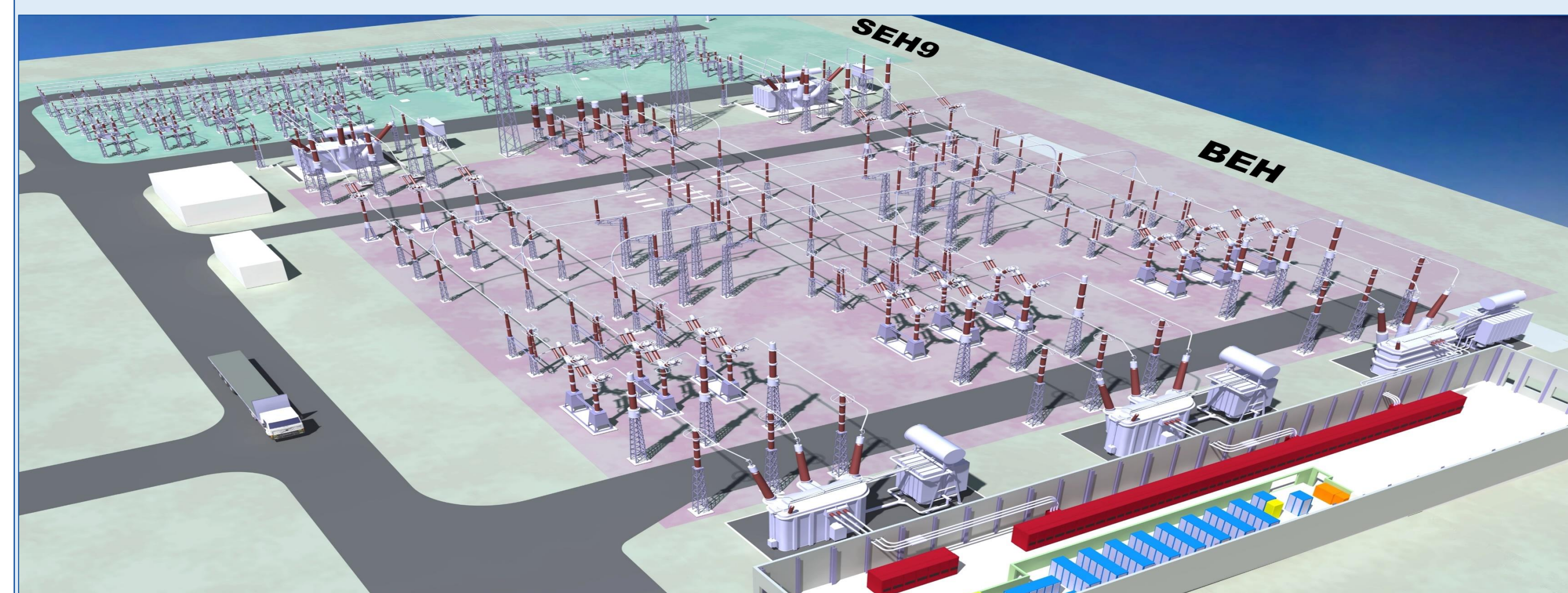
CERN 400kV and 66kV substations (BEH and SEH9)

Principle of 18kV Automatic Transfer System

The 18kV Auto Transfer system is an automatic network switch-over system which ensures that, in the event of a supply failure in one of the three main 18kV substations, ME9, SEM12 and BE9, the general services network is switched over automatically to an alternative supply. The general services network at CERN identifies the network that serves the infrastructure of LHC, Meyrin, SPS, North Area and Prevessin sites.

Other types of network are the machine network, that serves the accelerators and experiments in Meyrin and LHC, the pulsed network that provides power to the pulsed loads of SPS and North Area and the safety network, providing power to safety-relevant loads.

The Auto Transfer system, in addition to the general services of LHC Meryin, SPS, North Area and Prevessin, covers also the machine network in LHC1.8, LHC1, the ATLAS Experiment and the safety network.

ME9, located at the Meyrin site (CH), can be supplied directly from the 130kV Swiss grid (SIG) or ME59 substation or indirectly from SEM12 or BE9 via the inter-substation liaison cables.

SEM12, located at LHC1 site (CH) can be supplied directly from the 66kV network or indirectly from ME9 or BE9 via the inter-substation liaison cables.

BE9, located at the Prevessin site (FR), can be supplied from the 66kV network or indirectly from ME9 or SEM12 via the inter-substation liaison cables.

The automatic source transfer causes a supply interruption below 15 seconds.
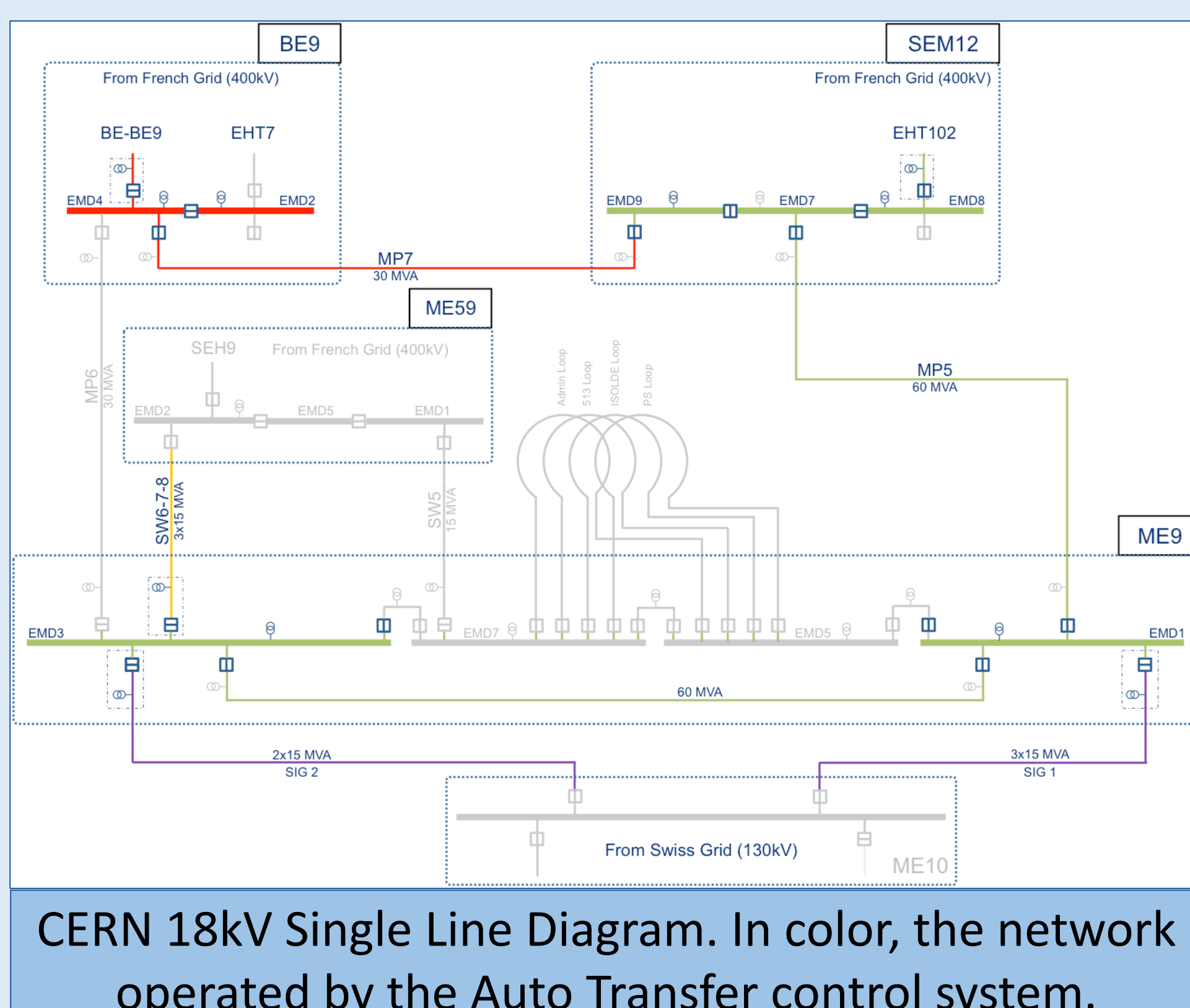
CERN 18kV Single Line Diagram. In color, the network operated by the Auto Transfer control system.

The Auto Transfer Control System

The Auto Transfer is a PLC based control system whose main function consists in automatically reconfigure the three 18kV substations in case of a power outage due to failures in the French grid (400kV), Swiss grid (130kV) or internal failures related to transformers, bus bars or inter-substation liaison cables.

The control system is composed of two redundant CPU's, installed on different substations. An optical fiber link interconnects the two CPUs to manage the synchronization. Each substation hosts a remote IO station to collect the hardwired information from the
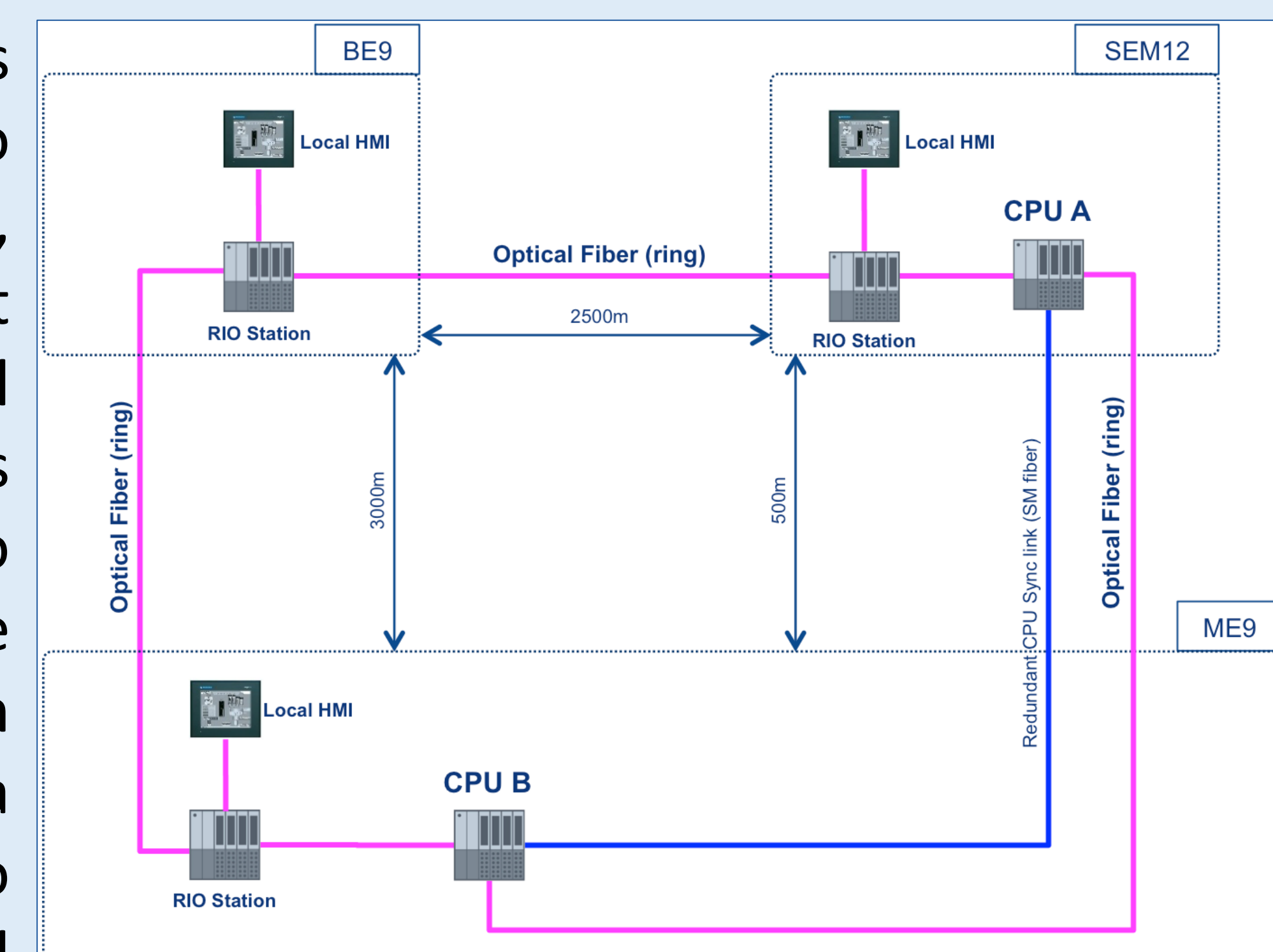
Auto Transfer control system PLC architecture

protection relays and a local HMI allowing the configuration and monitoring of the system. An optical fiber ring across the three substations collects the data from RIO stations using EtherNet/IP as industrial fieldbus. The entire system will be monitored by the Electrical Network Supervision SCADA, using IEC 60870-5-104.

Automatic Reconfiguration Algorithm - *Solver*

The *Auto Transfer Solver* consists of analyzing the entire network as a single entity and calculating dynamically the possibilities of supplying it entirely. These possibilities are calculated based on the status of the electrical path needed to connect one source to a given bus bar. The optimal solution to resupply the entire network is based on a set of rules and restrictions defined by the operations team. For each bus bar in the system, a nominal power source and a set of backup sources are defined with a given priority.
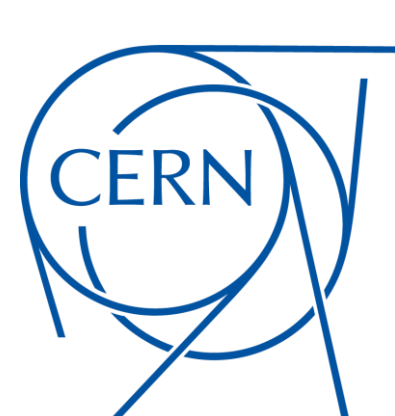
Bus Bar	Source Name						
	BE/BE9	EHT7/E9	EHT102/1E	SW	SIG1	SIG2	SIG1+2
EMD4/E9	Backup 1	Nominal	Backup 2	Backup 3	Backup 5	Backup 6	Backup 4
EMD9/1E	Backup 1	Nominal	Backup 2	Backup 3	Backup 5	Backup 6	Backup 4
EMD7/1E	Backup 2	Backup 1	Nominal	Backup 3	Backup 5	Backup 6	Backup 4
EMD8/1E	Backup 2	Backup 1	Nominal	Backup 3	Backup 5	Backup 6	Backup 4
EMD1*9	Backup 6	Backup 5	Nominal	Backup 1	Backup 3	Backup 4	Backup 2
EDM3*9	Backup 6	Backup 5	Nominal	Backup 1	Backup 4	Backup 3	Backup 2

Auto Transfer *Solver* Configuration set by user

A *score* is assigned to each selected source, having the nominal one the highest score and the last backup source, the lowest score. Based on this configuration and the online status of the network, the *Solver* looks for possible re-supply paths and aims for two objectives:
- Maximize the number of supplied bus bars
- Maximize the total score from all possible solutions

As specified, if a given bus bar is supplied by a backup source N, after being supplied by a backup source N-1 and the backup source N-1 becomes available again, the system does not rollback. If a given bus bar is supplied by a backup source, the system is designed to rollback only when the nominal becomes available