


# *Reference Project*
# *PSIcontrol at SBB*

PSI

# PSIcontrol Railways Switzerland

## Introduction

Swiss Federal Railways operates the highest density rail network in the world. In no other country are trains operated more frequently than in Switzerland. The local network boasts the highest utilization worldwide and presents the highest challenges on the rail infrastructure.

*SBB Energy generates electric traction energy mainly in its own hydroelectric plants.*

Swiss Federal Railways is divided into four divisions: Passenger, SBB Cargo, Infrastructure and Real Estate. The Infrastructure division is responsible for the operation, maintenance, and development of the rail infrastructure. This also includes SBB Energy, responsible for supply of traction energy which is predominantly created by hydro-electric power plants. SBB Energy operates six hydroelectric plants and is also involved with other power plants. Utilizing five frequency converter stations owned by Swiss Federal Railways, energy exchange between the rail electrification network and the 50 Hz national distribution network is possible.

The rail electrification network, running at 16.7 Hz, consists of a 132 kV high voltage network with 1,800 kilometers of transmission lines and a 15 kV catenary network with 3,000 kilometers of overhead lines.

## Project Goals

The existing control systems of Swiss Federal Railways have reached the end of their lifecycles. These will be replaced with two network control systems:

*Two new control systems -EMS and CCS- with a uniform system architecture.*

- The Energy Management System (EMS) will control, optimize, and monitor energy generation and transmission from power plants up to infeeds to the catenary network.
- The Catenary Control System (CCS) will control and monitor the overhead line system which runs along the rail network.

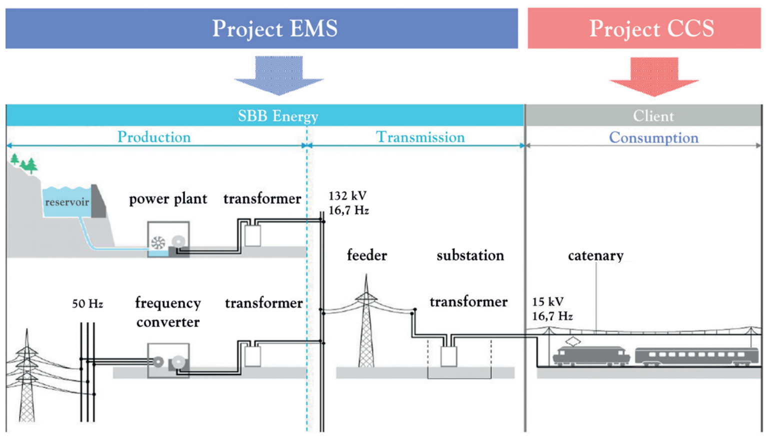


*Figure 1: Task EMS and CCS*

In both cases, multiple legacy systems will be decommissioned and replaced with a modern and uniform system architecture.

## System Engineering

The central systems are located at two locations each with two redundant computers which guarantees the highest level of availability.

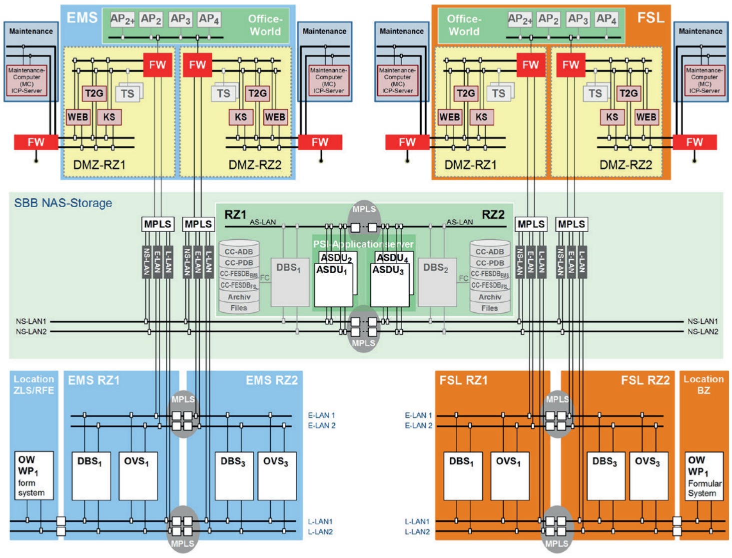


*Figure 2: SBB-System Configuration (schematically)*

*The parameters are setting in a database management systems for both EMS and CCS.*

The Energy Management System and Catenary Control System are separate control systems. Using the TASE.2 protocol, the systems can exchange data while in operation. Parameterization for both systems occurs in a common database, the network control system process database. Using this method, objects which are used in both systems must only be defined once. For example, a substation with all feeders, transformers, and busbars need only be defined once in the database. The data model generator creates a custom tailored database for each respective system.

The Energy Management System consists of a main control center in Zollikofen and a secondary station in Kerzers. The central servers are housed at these locations. The information connection is made using seven data concentrators which connect to serial telecontrol lines and their information is then transferred over network connections to the control system locations. There is also a connection to various external systems at the control system locations.

The central servers for the Catenary Control System are also installed in Zollikofen and Kerzers. From here, there is a connection to twelve data concentrators of the Catenary Control System. Control centers are located at Swiss Federal Railway operation centers in Lausanne (west), Lucerne (central), Kloten (east), and Bellinzona (south).

All control centers and the central Catenary Control System servers are networked together and operated as one single control system. If needed, duties from one location may be given over to any of the other locations.

## Multi-Lingual

*The control system controls the languages German, French and Italian.*

In both systems, each operator workplace can be operated in German, French, or Italian. The user's desired language is set in the user profile and automatically activated whenever the user logs into an operator workstation. Users may also switch between language during active operation.

Language neutral indications are distributed from central servers to all computers and translated into the correct language at the user's workplace.

## Energy Management System Functions

The Energy Management System controls a distribution network including operations and optimization of energy generation. To fulfill these requirements there are a wide array of special functions. Some examples are:

1. **Power Frequency Controller**
   The core function of the power frequency controller is the power balance in the monitored network area taking in to consideration agreed upon transmission power and the nominal frequency. Partly due to the specific Swiss Federal Railway timetable, the rail electrification network exibits extremely erratic characteristics.
   As a result, the power frequency controller has high requirements for dynamics and availability.
   Failure of this function threatens rail electricity supply.
   In particular, the high voltage network of Swiss Federal Railways is weakly meshed in western and southern Switzerland. Here network islands may be created due to de-energization as a result of network faults or maintenance work. In addition, these network islands must be controlled by the network controller. This is done using topology analysis as well as frequency analysis. Integrated into the power frequency controller are energy balance functions for exchange with the distribution network as well as with network partners and the supply of controlling power for the Swissgrid.

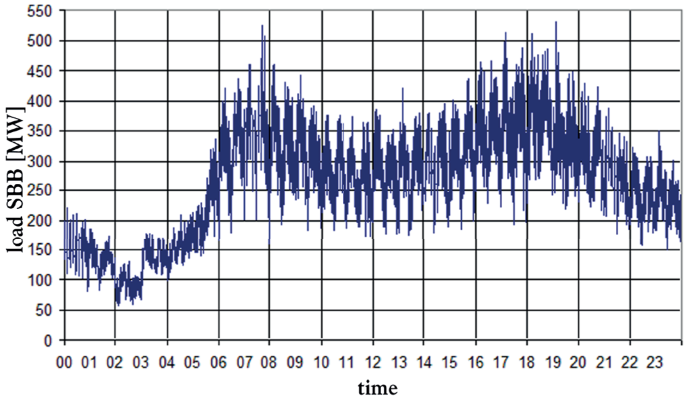


*Figure 3: Load distribution on a random work day*

*Isolated networks are compensated separately.*

2. **Energy Generation Optimization**
   The majority of energy generated by Swiss Federal Railways is hydro-electric. Remaining energy requirements, around 30%, comes from the 50 Hz distribution network utilizing frequency converter stations. While the seven frequency converter stations are distributed over the entire network, hydro-electric power is primarily generated in the alpine region. Optimal energy infeeds are calculated by the Energy Management System taking into account technical and economical conditions. The basic principle of the optimization calculation is optimal power flow. Losses in the whole Swiss Federal Railway high-voltage network are taken into account during the calculation and encompass electrical losses from generators, transformers, and powerlines as well as hydraulic and other losses from hydro-electric power plants and frequency converters. The optimization is seamlessly integrated into the Energy Management System and when needed automatically controls network elements.

*Calculation of the optimal energy supply, taking into account technical and economic constraints.*

3. **Network Calculations with Forecast Calculation**
   The Energy Management System includes extensive network calculations. These include the state estimation (calculation of current network states), short circuit calculation, and load flow calculation. These processes are utilized for monitoring the current network state, monitoring switching operations, calculating contingencies, maximum load calculation, congestion correction, and for forecast calculation. The forecast calculation considers future network states which places particular demands on data supply. Measurements are not used for loads and infeeds, rather infeed schedules and load forecasts are utilized. The topology is based on data from outage planning. The forecast calculation is used for the following three applications:

*Calculation of the current and future network condition.*

- Monitoring future operational states:
  Based on the current state, future network states are calculated first in 1 minute intervals and then in 15 minute intervals. Possible congestion occurences in the network are visualized.

- Calculation for outage planning:
  In the scope of integrated outage planning, planned switching measures are checked with assistance from the forecast calculation. For a planned switching operation, (for example de-energizing a powerline or a generator) the system checks if there are adverse effects on network protection for the time of the switching operation. This is done considering planned and forecasted infeed and load situations and already approved switching operations.

- Trade Limit Calculation
  Trade limits specify the upper and lower limits for energy exchange with the distribution network with due consideration for network protection. These are calculated multiple days into the future using the forecast simulation. In addition, the network transfer capacity calculation is used.

4. **Multistage Outage Planning**
   In the Energy Management System, all switching operations of the high voltage network are planned, administered, and implemented. Outage planning is multistage and comprises annual planning (for the next four years), monthly planning (for one month), and daily planning (for the next day). Each measure is checked for admissibility with assistance from network calculations. Responsible sites are informed about planned measures and must release the switching operations. Outage planning structures the workflow within Swiss Federal Railways and has an individual progress and status diagram.

## Catenary Control System Functions

The Catenary Control System monitors and controls the overhead powerline network. The main focus is efficient and secure operation of numerous switching operations. This is supported with rail-specific switching programs integrated into PSI*control* which allow individual overhead lines, complete routes, and operation points to be switched. Dynamic system technology allows for many switching devices to be switched with just a few mouse clicks.

*The CCS supports the operator in the many circuits.*

Protection is guaranteed by using topological display of future network states and background topological checks.

In addition, the Catenary Control System includes integrated outage planning which utilizes daily planning based on workflows of the organization.

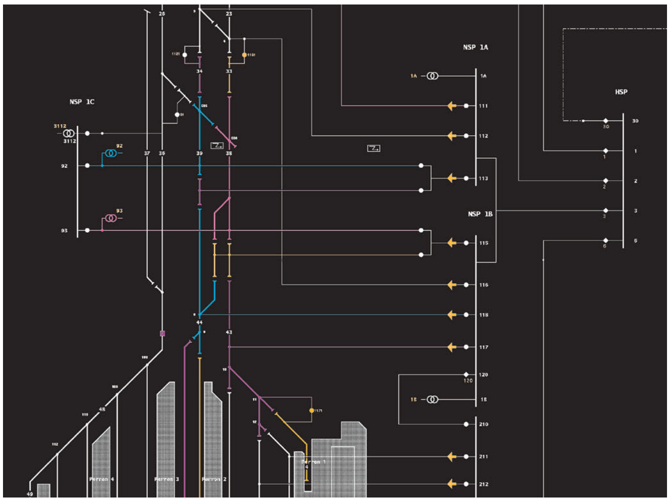


*Figure 4: Representation of a railway station*

## Operator Training System

Both systems make use of a robust operator training system. Utilizing one trainer workplace, multiple trainees may be trained at their workplaces simultaneously. The trainer workplace uses an integrated process simulator which replicates the network behavior. Network state variables for load flow and short circuit events, behavior of network protection, chronological behavior of power plants, and reactions to control operations from trainees are simulated.

The trainer can set primary faults, for example a short circuit on a powerline, which have network reactions calculated by the process simulator, indications and switch settings. These are sent to the trainee computer.

*With the training and education system, operators can be optimally designed.*

With this system, operators can be trained in a realistic environment using the actual network control system. Together with routine conditions and simple faults, mastery of significant faults and difficult situations can be recreated for training purposes which occur only extremely rarely in real network operations.

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