# FCC Underground Power Distribution Network

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# Introduction

Aiming to design a machine of high luminosity production level, the reliability of its electrical network is one of the most significant parameters to succeed. The limitations of the system - such as the high radiation levels and restricted space in the tunnel - as well as the power demand of a 100-kilometer long machine, arise new challenges for the design of the power distribution system. The aim of this poster is to present the concepts for the medium (MV) and low (LV) voltage electrical network.

# **Underground areas**

FCC tunnel is located under the ground and consists of arcs and straight sections. Power is distributed through the MV network from the surface to the underground substations which are located either in service caverns near the bottom of the shaft either in alcoves located every 1.5 km. In the substations the voltage level is lowered through power transformers and distributed to end users.



Surface

Underground

Network

redundancy

Equipment

redundancy

a.

# **Network types**

The power distribution system consists of four network types with different functionalities. Each type feeds loads with different requirements of acceptable power cut as summarised in table 1 and presented in figure 2.

Network type	Loads	<b>Power cut duration</b>
Machine	Heavy machine loads such as RF, PC, CV motors etc.	Until main supply recovery
General services	Generic power sockets	Until main or secondary supply recovery
Secured	Users power sockets, permanent lighting and elevators	10-30 seconds
Uninterrupted	Machine safety: Cryogenics, cryogenic instrumentation, machine and beam protection systems, power converter control, communications etc.	Uninterruptible power supply
	and fire detection, evacuation sirens, 48V battery chargers	
Table 1: Network types and characteristics		

# Medium voltage network

The power sources are located in the surface and the power is distributed by MV networks to the underground substations housed in dedicated service caverns or in alcoves along the tunnel. Each network has a different layout based on its special requirements of redundancy, operability and maintainability (fig.3a, b,c).



### **Machine network**

- Is fed from the main source on the surface to the underground substations housed in the bottom of the shafts, where all the machine loads are located.
- It is not distributed in the arcs. Machine loads are located in the service and experimental caverns near the bottom of the shaft.
- In case of unavailability of the main source, this network is not powered.

## **General services & Secured network**

- The two networks share a common MV network in a close loop configuration for optimal operability, redundancy and maintainability.
- A coupling switchgear allow the connection of the adjacent loop networks for alternative powering during maintenance.
- In case of loss of the main source, the network is commuted to an alternative power source.
- In case that neither source is available, load-shedding of general services network is implemented by automatic process. Only secured loads are powered from a third power

#### source (diesel generators) located on the surface.

### **Uninterrupted network**

- Guarantees the continuous powering of critical loads.
- Consists of redundant uninterruptible power supply systems with storage units which are located on the surface for easy access and high maintainability.
- Dedicated double redundant network in open loop configuration distributes the power in the underground areas, covering the distance between two FCC points.
- In case of a fault, the network will keep energized the critical loads without interruption within the limits of its energy autonomy, until the recovery of the main source or the connection to another source (secondary or third source). The transition is transparent for the loads.

# **Power distribution in the arc**

The end users in the arc are supplied through LV network which is powered from the substations located in the alcoves. The electrical distribution equipment - such as transformers and switchgears - are redundant for high availability and maintainability.

For the general services and secured network, each alcove feeds the equipment located in the alcove itself and the adjacent 750 m sections on each side of the tunnel (fig.4), length selected based on the voltage drop limits.

Figure 5 shows the reconfiguration of the network in case of unavailability of the main and secondary source.



# **Uninterrupted network**

The most critical network configuration is the uninterrupted, due to its strict requirements. For operability and maintainability reasons, the power source of this network has to be easily accessible thus it is proposed to be located on the surface substation. The main characteristics of this network are the following:

- I. The network is composed of double redundant MV uninterruptible power supply sources.
- II. Local storage systems of minimum <u>autonomy</u> of 10 minutes are located also on the surface.
- III. The power is transmitted to the underground substations through redundant MV power lines.
- IV. The underground substations are housing only passive elements (transformers, switchgears etc.). Redundancy of this equipment is also critical parameter.
- V. In LV level, network consists of two independent and overlapped networks, which are feeding two types of loads:
- B. Dual power input equipment (e.g. Quench Protection System). Users' equipment should have dual source

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