PROPOSAL FOR
A NEW ELECTRICAL SUPPLY
OF THE COMPUTER CENTRE FOR LHC

A. Funken

Abstract

To handle the future LHC experiment needs, the Computer Centre will go through a complete change of data processing methods. A total of five Computing farms will be built covering an area of 2,000 m2. The electrical power required for the new Computing farms will increase by five fold to 2 MW. This will have major impact on the technical infrastructures. Focusing on electrical issues, this paper initially explains the principle of the present electrical supply and the major drawbacks. Taking advantage of the opportunity offered by these big changes and conclusions drawn from the recent ST/EL reports, the strategy of electrical supply of building 513 is reviewed, in particular the Diesel backup supply. On this basis and benchmarking with similar Computer Centres, a proposal for a new electrical supply is presented, the objectives being to meet the increase in demand, reliability and safe operation of the Computer Centre.

1 INTRODUCTION

High Energy Physics computing has the property of event independence so any number of events can be processed in parallel. For this reason, mass computing in a distributed architecture rather than supercomputing has been chosen to process the data from the future LHC experiments. The Computer Centre will go through a complete change to host the new equipment : a total of five Computing farms will be built covering an area of 2,000 m^2.

The electrical power required for the new Computing farms will increase by five fold to 2 MW. This does not include the electrical power required by the new air conditioning systems.

Focusing on electrical issues, this paper initially explains the principle of the present electrical supply and the major drawbacks. On this basis and benchmarking with similar Computer Centres, a proposal for a new electrical supply is presented, the objective being to cope with the new needs and to increase the reliability and safe operation of the Computer Centre. Different alternatives are also presented.

2 PRINCIPLE OF THE ACTUAL ELECTRICAL SUPPLY

2.1 Building 513 allocation

The Computer Centre includes the following areas spread across the basement, ground level, 1st floor and 2nd floor :

- Areas for electronic equipment directly involved in data processing : processors, tape drives, disk drives. These areas are called *"Computer room"* and *"Tape vault"*.
- Areas for office equipment directly supporting the electronic equipment and the operating personnel.
- Areas for staff offices, conference rooms, welfare facilities, equipment storage, PC shop.
- Plant area for environment control (e.g. air-conditioning) and electrical power substation.

2.2 Description of the load

The nature of the load is given in the table 2.1.

Nature of load	Load, kW
Information Technology equipment Machine room Tape Vault Operator room France Telecom node Storage equipment B613 Computer star point B31	≅ 450
HVAC Chillers & steam boiler Air-conditioning for the ground floor : Machine room, some other rooms Air-conditioning for the basement : Tape Vault, UPS room, some other rooms	≅ 400 in the winter ≅ 1200 in the summer
General Services Lighting and sockets : offices, conferences rooms, storage rooms Lighting and sockets for operating areas :	≅ 250

computer rooms, electrical substation, cooling plant PC shop Elevator , lift	
Safety/Emergency Smoke extraction system HVAC control system : air compressor, control panel Fire detection & evacuation alarms Emergency lighting	≅ 100
TOTAL (kW)	≅ 1200 to 2000

Table 2.1

2.3 Electrical system architecture

The description is given in figure 2.1, with help of block diagrams.

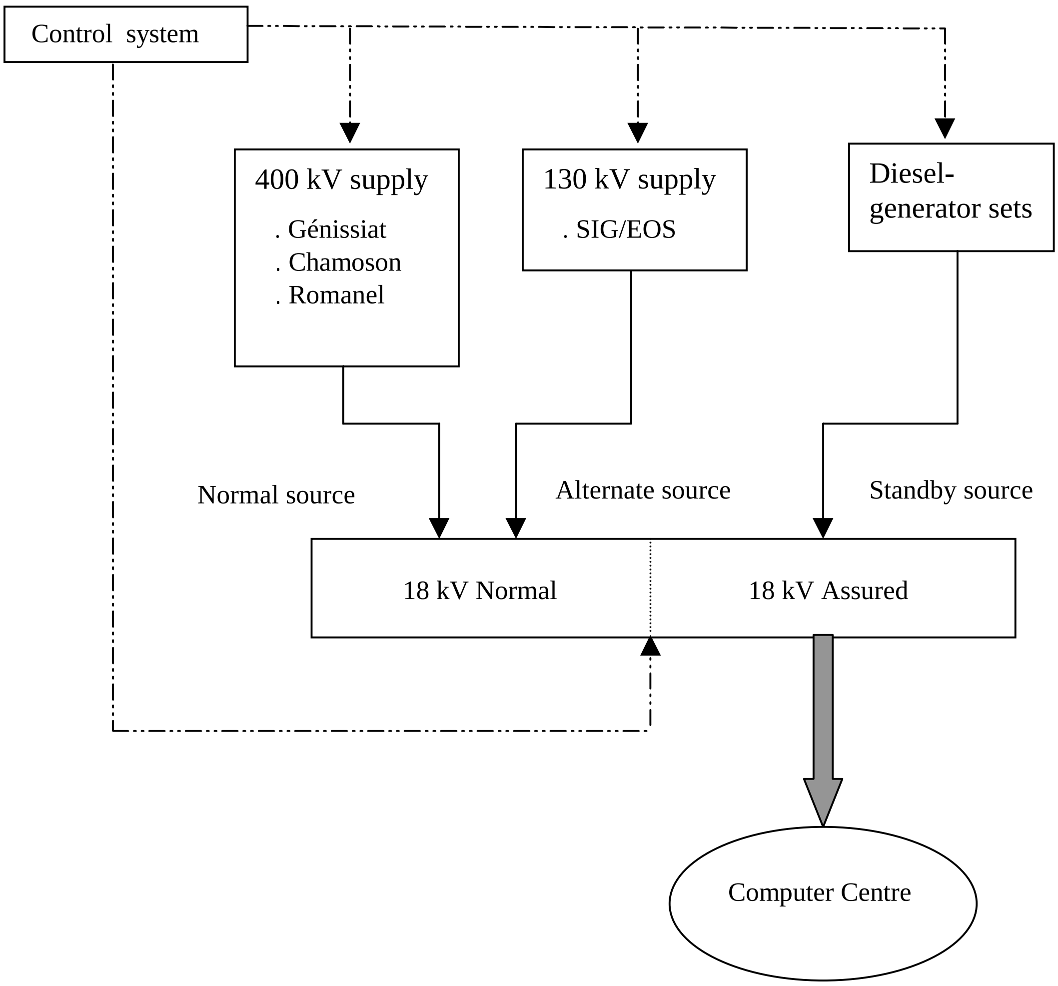

Figure 2.1

2.3.1 18 kV distribution network

The normal 18 kV system consists of a loop configuration, with four substations, supplied by a double busbar. Maximum power available on the loop is 15 MVA. Each of the two busbars can be fed by two different sources. The priority source of supply is the 400 kV. In case of voltage loss, the CERN stable network is switched to the alternate source, the 130 kV SIG/EOS. This system is called *"auto transfer system"*. However due to the new energy contracts, the auto transfer is not available in the winter period. This temporary situation will last until June 2003.

This architecture ensures a high level of reliability regarding continuity of service due to the redundancy of the constitutive elements.

The Computer Centre is fed in single supply from one of the nearest substation of the loop, the substation ME23.

2.3.2 18 kV assured network

In case of simultaneous breakdown of both sources or mal-function of the auto transfer system, a part of the CERN electrical network named "assured network" is automatically separated from the normal network and supplied from three 2.7 MW Diesel-generator sets. These sets are located in building 200 & 201. Their main task consists in covering the needs for emergency supply over the Meyrin and Prevessin sites. But in the meanwhile they are used to back up the entire Computer Centre. The maximum standby power available for B513 is restricted to 1.2 MVA to avoid overloading the generating sets.

Changeover from the mains to standby supply causes a short supply interruption. Critical safe loads are restored when one set is connected to the assured network but the remaining load, e.g. UPS and air-conditioning system, is restored only if two sets are in operation. The mean time is around 90 seconds. In addition to the main control system of the sets, an automatic commutation system governs the switch from the normal network to the assured network at the ME23 substation level, this system is located inside a microprocessor-based protection relay.

2.3.3 Building 513

The safe low-voltage switchboard, called ESD3*43, which feeds critical systems for life safety, is supplied by a 800 kVA transformer located in the substation ME23. This transformer supplies also emergency loads of the PS complex. The maximum available power is about 450 kVA. Furthermore, the condition of this switchboard is poor, mainly due to wear and tear old age.

The loads described in § 2.2 are supplied from two low-voltage switchboards, named EAD1*43 and EAD2*43, which are in turn supplied by a 2-MVA 18/0.4 kV dry transformer. These switchboards are interconnected. Replacement of the old PCB transformers by the dry ones dates back to October '90. All this equipment is located in B513 substation, known as ME43.

HVAC installation, as well as general services for offices, are supplied by the switchboard EAD2*43. The maximum available power is 2 MVA.

Critical equipment which can be interrupted due to voltage fluctuation or interference are protected by uninterruptible power supplies. Examples of critical equipment is as follows : IT equipment, HVAC control system, minimum lighting allowing operation team to intervene immediately after a power cut, PC's of some offices.

The UPS installation consists of :

- an air-conditioned UPS room containing three 400-kVA static on-line UPS modules with one bypass module. Two of them can support the actual load, the third one is a hot-standby. The installation was renovated in 1992.
    - maximum UPS supply available : 1200 kVA ;
    - could be extended to 1600 kVA if the fourth one was equipped with batteries.
- a UPS battery room containing three sets of sealed-lead batteries. During the renovation of 1992, five-minute capacity batteries have replaced the thirty-minute ones for economical reasons. It was due to the back up supply of the Meyrin Diesel-generator sets.
    - based on the actual consumption, the autonomy is around 25 min,

- batteries should be replaced every 8 years. New five-minute capacity batteries will be installed in January 2001.

- a room containing UPS input and output LV switchboards, named EAD1*43 and EOD1*43 respectively. The maximum available power is 2 MVA.

UPS power is distributed from the main switchboard, EOD1, to power distribution units (PDU) located in the computer equipment rooms. Flexible conduit feeder assemblies running in the raised floor (Normabars type) deliver power to the IT equipment.

In the Computer room, services are organised lengthwise and electrical supply is distributed widthwise. For this reason, local distribution switchboards are installed on part of computer racks to allow a manual controlled restart by services after a voltage loss. There are six PDU and the installed power is about 1MW. In the Tape vault, there is one PDU associated with several Normabars. The installed power is about 140 kW.

In both cases, the power distribution path between the UPS output bus and the critical loads is unique, even for the dual-input loads, like networking equipment.

2.3.4 Emergency stops and 48 V distribution

In case of activation of the EMS button in ME23 or B513, all the power will be cut, except the safety power. The general emergency stop are managed from the Emergency Stop rack (EMS rack) of the substation ME23 located upstream. To provide dc power to control circuit of the substation equipment and signaling, 48 V is supplied from substation ME23. Loss of this 48 V supply will lead to the loss of the electrical services to the building, except safety power.

3 IDENTIFICATION OF SINGLE POINTS OF FAILURE

Is defined as a single point of failure a component whose failure is critical regarding the continuity of supply. Identification has been done separately for the B513 distribution and the 18 kV upstream. Results are given in §3.1 and §3.2[1].

3.1 Single points of failure : 18 kV system

Component failure	**Occurrences** (based on historical data since 1992)	**Consequences**
N/S commutation system in ME23 18 kV protection	Several Not since 1997	In case both sources down, no Diesel backup : loss of computers at the end of battery autonomy or due to increase in temperature.
EMS rack / 48V dc failure in ME23	1 in 1999	Similar to a power cut. No backup possible. Loss of computers (no batteries available).
ME23 18 kV normal and assured switchboards supplying B513	-	Similar to a power cut. No back up possible. Loss of computers at the end of battery autonomy or due to increase in temperature.
18 kV safety switchboard supplied by Diesel sets	1 in 1993 1 in 1995	Second level of back up non available. Loss of computers at the end of battery autonomy or due to increase in temperature.

[1] Based on Technical Report “Electrical Power Supply to Computer Centre”, G. Kowalik, May 2000

Control system of Diesel sets	2 in 1998 1 in 1999	Second level of backup non available. Loss of computers at the end of battery autonomy or due to increase in temperature.

As explained in §2.3.1, the configuration of the 18 kV Normal system offers a high level of reliability. 48V dc supply and assured part of the network, which constitutes the second level of backup for IT equipment and the first one for HVAC installation, need to be improved. These issues will be discussed in § 6.

3.2 Single points of failure : B513

Component failure	**Occurrences** (based on historical data since 1992)	**Consequences**
Transformer 2 MVA, in summer time	-	Similar to a power cut. No Diesel backup possible. Loss of computers at the end of battery autonomy or due to increase in temperature.
LV switchboard EAD1 Computers	-	Loss of computers at the end of battery autonomy. No Diesel backup possible.
LV switchboard EAD2 Ai-conditioning		Loss of computers if increase in temperature becomes too high.
UPS distribution switchboard EOD1	-	Similar to a power cut. No backup possible.
Power Distribution Units	-	Loss of the computers fed by the related PDU.

It should be noted that, although procedures are well established, a potentially critical situation exists when the maintenance of the UPS bypass module, and the annual tests of general emergency stops and Normal/Safety control systems are carried out. For this reason, these maintenance works and tests are combined and take place at the beginning of each year.

Due to the fact that all the components listed are unique, they constitute a single point of failure and could lead to the loss of all or part of the Computer Centre.

4 BENCHMARKING WITH DIFFERENT COMPUTER CENTRES

No standards define or assign electrical systems to specific applications such as computer centres. To established some guidelines before making proposals for improvement a benchmarking with other computer or data centres has been carried out.

4.1 Sites visited

The following data centres have been visited :

- Swisscom, Berne (CH) : telecommunication ;
- Crédit Suisse, Zürich (CH) : banking ;
- Reuters, Geneva (CH) : media ;
- Telehouse, Geneva (CH), colocation. These centres house network servers for a wide variety of organisations like telecommunications carriers and internet service providers, enabling them to benefit from speed to market and economies of scale by offering robust and secured facilities ;
- Digiplex, Geneva (CH), colocation.

These large data centres are exceeding 2000 m2 of raised floor and requiring more than 2 MW of protected electrical power. The total area is spread across several separated rooms.

4.2 Classification of loads

Common terminology used to classify facility loads is as follows :

- critical loads : full continuity of the supply is required.

  Examples of critical equipment is as follows : IT equipment, minimum lighting, minimum air-conditioning to avoid quick increase in temperature ;

- essential loads : electrical power is required within a few seconds or minutes after the failure of normal utility supply.

  Examples of critical equipment is as follows : air-handling system, lights, office equipment directly supporting IT equipment and the operating staff ;

- nonessential loads : these loads do not require backup supply during the failure of normal utility electric power.

  Examples of critical equipment is as follows : office facilities, lighting, general air-conditioning and other equipment to provide long-term facilities for personnel.

In most of the computer centres visited, the nonessential loads are categorised as essential loads.

4.3 Results of the benchmarking

Results are presented in table 4.1. To summarize :

- each centre has only one electrical power supplier ;
- solutions chosen to protect critical loads include :
  - static on-line UPS modules with 10 to 15 minutes battery capacity arranged in different UPS system configurations : distributed redundant dual UPS bus system for Swisscom, “N+1” or parallel redundancy for Crédit Suisse and Telehouse. The UPS system is backed up by redundant Diesel-generator sets to extend the running time in case of extended utility outage,
  - rotary UPS : dual output for Reuters and conventional for Digiplex. In dual output rotary UPS, the properties of UPS (no interruptions) and generator set (short interruptions) are combined in one system.
- solutions chosen to protect essential loads include :
  - Diesel-generator sets for all the centres, except Reuters,
  - dual output rotary UPS for Reuters.
- Telehouse is the only centre which makes the difference between essential and non essential loads. This colocation centre is located in a building which was existing and which hosts other independent activities. The technical infrastructures have then been reused and the available secured power is limited. For this reason and due to the existence of a spare chilled water tank, only minimum air-conditioning equipment (pumps, fans) are considered as essential loads. The chillers belong to the nonessential load category and are not backed up by the Diesel sets.

The choice between fully or partially redundant distribution system (busbar, switchboards, distribution paths) depends upon the level of reliability which should be reached. This is strongly linked to economical reasons and space availability.

Data Centres	HV, LV supply	Secured supply		Electrical distribution inside the rooms
		Critical loads	Essential loads	
Swisscom	1 utility source, redundant HV/LV transformers, 2 LV busbars which can be in interconnected	- static UPS modules : 2 sets of 3 x 250 kVA 15-minute batteries - back up by the 2 sets of 2 x 1.25 MVA Diesel- generator sets - IT equipment & minimum air-conditioning, lighting	- Diesel-generator sets 2 sets of 2 x 1.25 MVA, autonomy ~ 2 weeks	- 2 redundant PDU - 2 distribution circuits for each equipment - plug-in busbar trunking in the raised floor (Normabars type)
Crédit Suisse	1 utility source, double HV busbar, redundant HV/LV transformers, double LV busbar, double UPS busbar	- static UPS modules : 1 set of 4 x 300 kVA for each room, 15-minute batteries - back up by the 2 sets of 1 x 2.15 MVA Diesel- generator sets - IT equipment & minimum air-conditioning, lighting	- Diesel-generator sets 2 sets of 1 x 2.15 MVA autonomy ~ 2 weeks	- 1 PDU with 2 supplies : normal & UPS - 2 distribution circuits for each equipment - plug-in busbar trunking in the raised floor (Normabars type)
Reuters	1 utility source, 2 HV busbar which can be interconnected, redundant HV/LV transformers	- "dual output" rotary UPS : 2 sets of 2 x 1.2 MVA, day tank : 30 min of autonomy, tanks : 2 weeks of autonomy at rated load		- 1 PDU per room - 1 distribution circuit per type of equipment, one of the three has dual supply - Normabars distribution
Telehouse	1 utility source,double 18 kV busbar, redundant redundant HV/LV transformers, single LV busbar	- static UPS modules : 1set of 3 x 320 kVA 15-minute batteries - back up by the 2 sets of 1 x 1023 kVA Diesel- generator sets	- Diesel-generator sets 2 x 1023 kVA autonomy ~ 21 days - minimum HVAC system (pumps, fans), existence of a chilled water tank	- 1 PDU outside each room - cable network in the raised floor with plug-in socket terminal
Digiplex	1 utility source,double 18 kV busbar, redundant redundant HV/LV transformers, double LV busbar	- rotary UPS : 2 x 1600 kVA	- Diesel-generator sets 2 x 2 MVA	- 2 redundant PDU per room - 2 distribution circuits for each equipment - plug-in busbar trunking in the raised floor (Normabars type)

Table 4.1

5 COMPUTING FOR LHC : ELECTRICAL REQUIREMENTS

Following the estimation of IT division, the amount of electrical power needed by 2005 is 2 MW. About 10 % of these 2 MW will support the basic infrastructure which will remain, like networking equipment, database, home directory and administrative servers.

Each of the future LHC experiments requires a large computing and data storage fabric. As an example, a computing farm for an experiment like CMS requires 400 kW and consists of :

- a farm network with about 5600 processors requiring a total of 245 kW and,
- a storage network with 100 drives consuming 14 kW and 5400 disks consuming 140 kW.

No automatic shutdown of the equipment is planned in the event of a voltage loss. An operating time as close as possible to 8760 hours per year is then required. A high availability of the electrical power supply is needed.

Additional requirements :

To dissipate the heat generated by the IT equipment, HVAC installations require an electrical power estimated to 1.8 MW or alternative technical solution. The needs for general services and emergency loads remain the same : about 250 kW and 100 kW respectively.

The total amount of electrical power is then around 4.15 MW.

6 PROPOSAL FOR A NEW POWER SUPPLY

Statistics show that the supply is present 99.9 % of the time and most disturbances on the utility sources last less than 10 seconds. A total breakdown due to an internal network event happens about once a year and every three years on the utility source. So does it pay to have the highest level of protection meaning redundancy at all levels and full back up with engine-generator sets ?

Taking into account the auto transfer system, improvements to carry out at the 18 kV level (see § 6.1) and in B513 electrical distribution (see § 6.2), the opinion of ST/EL is that continuous operation of the centre should be ensured during 10 to 30 minutes in case of extended power outage. The way it can be done is presented in § 6.3.

Nevertheless, other solutions based on dedicated Diesel-generator sets or rotary UPS for long term backup requirements are presented in § 6.4, 6.5 and 6.6.

6.1 Improvement of the 18 kV network

Whatever the increase of electrical power, some improvements at the 18 kV network should be undertaken. Analysis of the actual electrical system (see §3) has shown several weak points, mainly due to the fact that B513 building is fed in single supply from ME23 substation.

Improvement consists in supplying B513 from the loop directly. Upgrade of the substation ME43 is estimated to **1.9 MCHF**. This includes :

- two new 18 kV switchboards, Normal and Assured, with a single or double busbar configuration ;
- N/S control system at the 18 kV level ;
- a dedicated 48 V dc source ;
- the construction of a new substation located outside the building to host the high- and low voltage equipment ;
- eventually a direct 18 kV link from the main 130 kV SIG/EOS substation ME10 to B513 substation ME43 in order to allow auto transfer at the Computer Centre level.

The suppression of the general emergency stop system in all electrical substations will also increase the global reliability of the 18 kV network.

6.2 Improvement of the distribution inside the centre

The actual principle of electrical distribution will remain the same : UPS power distributed from the electrical substation to power distribution units (PDU) located in the Computer room or rooms, plug-in busbar trunking (Normabars type or equivalent) running in the raised floor to the computer equipment, multi-sockets in the racks. Changes lie in the increase of the Computer area and the total electrical power needs.

Improvement will consist in using a distributed redundant UPS configuration. Large exposure to single points of failure in a typical data processing room’s power system is from the UPS bus out to the load. This means that what is important is not only maintaining power at the output of the UPS system, but also maintaining power at the input terminals of the load equipment.

The recommended configuration involves creating two redundant UPS system busses and power distribution systems, and eliminating as many single points of failure as possible up to the load equipment’s input terminals. This configuration also guarantees continuity of operation of the Centre during maintenance works.

For dual-input equipment load, like networking equipment, this can be achieved by using two redundant switchboards and distribution paths up to and inside the load equipment. For single input load, transfer between the two sources should be implemented at the PDU level, the objective being to provide redundancy as close to the load as possible.

The type of IT equipment racking is not yet defined. The choice is between mini-tower PC's on shelving, and 1U or 2U systems in 19'' racks. Whatever the solution will be, electrical distribution should be arranged in a flexible way to allow forthcoming extension or moving of equipment. IT equipment should also be supplied by services to avoid the installation of local distribution switchboards on the computer racks themselves.

6.3 Proposal

To ensure a continuous operation of the computer centre during 10 to 30 minutes after a power cut, electrical supply and cooling should be maintained during the same time. To reach this objective, the following are required :

- an appropriate chilled water tank, the actual one having a capacity of 30 m^3, or other solutions like "ice banks" ;
- a backup supply from the existing Diesel-generator sets to feed pumps and fans, minimum lighting. The maximum power available is 1000 kW ;
- parallel redundant static on-line UPS modules with a static bypass switch and 10 to 30 minutes of battery autonomy. N +1 redundancy is obtained by providing one more UPS module than is required to support the load.

6.3.1 Load allocation

To determine how each load shall be supplied, it is necessary to allocate the load into critical, essential and non essential components as shown in table 6.1.

	Load by categories, kW			
Nature of load	Normal (N=C+E+NE)	Critical (C)	Essential (E)	Nonessential (NE)
IT equipment	2000	2000	-	-
HVAC	1800	-	500	1300
General Services	250	10	10	230
Safety/Emergency	100	-	100	-
TOTAL	4150	2010	610	1530

Table 6.1

6.3.2 Electrical installation

Each component of the load shall be supplied as follows :

a) <u>Normal load</u> : total load in normal condition supplied from the normal network by 3 transformers 2.5 MVA feeding 3 LV switchboards for redundancy.

b) <u>Critical load</u> : supplied from static UPS modules with one static bypass and 10-minute to 30-minute capacity batteries. The bypass module transfers the critical load to the normal source either automatically if the UPS fails or manually to isolate the UPS for maintenance. The input lines to the UPS will be supplied from one of the three LV switchboards. Taking into account the actual UPS contract, seven plus one 320 kW UPS are necessary for 2 MW of load. The cost and space needed are given in table 6.2 for 10 minutes and 30 minutes of autonomy.

	Autonomy	
	10 minutes	30 minutes
Purchasing cost	71’378 x 8	96’321 x 8
Maintenance cost / 10 years	33’190 x 8	51’186 x 8
New lead-acid batteries	31’408 x 2	78’144 x 2
Miscellaneous ~10 %	90’000	135’000
TOTAL cost	989’360 CHF	1’471’344 CHF
UPS space	5 m^2 x 8	5 m^2 x 8
Battery space	4 m^2 x 2 x 8	4 m^2 x 6 x 8
TOTAL space	104 m2	232 m2

Table 6.2

Attention should be paid that the principle of reliability dictates that the fewer parallel modules required for redundancy the better.

c) Essential load : supplied from the assured 18 kV switchboard by 1 or 2 transformers 800 kVA for redundancy (maximum power available 1.2 MVA) feeding 2 assured LV switchboards. In case of voltage loss, the essential load will be backed up by the Meyrin Diesel-generator sets when two of the three sets are in operation (90 seconds, max 1.2 MVA available).

d) Nonessential load : allocated to the two other LV switchboards. This load will be restored when power is restored.

The estimated cost of the electrical installation ranges from 1.4 to 2 MCHF.

6.4 Alternative N°1

If a larger autonomy is required with a load of 2 MW, batteries of the static UPS would need to be extremely big. Therefore the rotary dual output version becomes more appropriate. Energy is stored in kinetic form, a flywheel, so no batteries are needed.

These systems combine two functions : no-break and standby. Critical loads do not see any break in the power supply. The Diesel set starts and accelerates to a speed of 1500 rpm in less than two seconds. The systems are “dual output”, allowing them to support also essential loads. Some 10 seconds after the Diesel starts the essential loads are connected.

With 1700 kVA system, 950 kVA are available for critical load and 750 kVA for essential load. A total of 3 plus 1 for redundancy will be needed : the maximum available power for critical load will be 2280 kW and 1800 kW for essential load.

The day tank allow about one hour of autonomy. To extend it, additional tanks are required.

The unique design uses very few components which ends in a high reliability solution. Fewer modules mean also lower space requirements and less cabling.

The drawbacks are related to Diesel-generator sets : handling and storage of fuel, periodic fuel replenishment, periodic maintenance of moving parts, gas emitted from internal-combustion engine, removal of exhaust fumes, removal of heat, noise.

Estimation of the total cost over 10 years is given in table 6.3. Additional costs to host a Diesel set, like tanks and special foundation to carry its weight, are not included.

Purchasing cost 4 x 1700 kVA system	4 x 1.9 = 7.6
Maintenance cost / 10 years	10 x 4 x 0.04 = 1.6
1 person / 10 years	10 x 0.15 = 1.5
TOTAL cost in MCHF	10.7

Table 6.3

The full installation would require one single room of about 180 m^2.

These types of installation are used worldwide in various field of activities : telecommunication, banking & data centres, aviation, healthcare and chemical fields.

6.5 Alternative N°2

To extend the running time of the UPS beyond the battery time when the normal source fails, an engine-generator set is frequently combined with a static UPS system. Three 2.5 MVA Diesel-generator sets would be required to support the full load.

The day tank allow about 1 hour of autonomy. To extend it, additional tanks are required. The drawbacks related to Diesel-generator sets remain the same as mentioned in § 6.4.

Estimation of the total cost over 10 years is given in table 6.4. Additional costs to host a Diesel set, like tanks and special foundation to carry its weight, are not included.

Purchasing cost 3 x 2.5 MVA sets	3 x 1.3 = 3.9
Maintenance cost / 10 years	10 x 3 x 0.03 = 0.9
1 person / 10 years	10 x 0.15 = 1.5
TOTAL cost in MCHF	6.3

Table 6.4

The total cost, including static UPS with 10-minute capacity batteries and Diesel sets, is estimated to 7.2 MCHF. The space needed is about 250 m^2.

6.6 Alternative N°3

Another solution would be to use standard rotary UPS to support the critical load and to back up the essential load from the existing Meyrin Diesel-generator sets, maximum power available being 1.2 MVA. Three 1250 kVA rotary UPS would be required.

Estimation of the total cost over 10 years is given in table 6.5. Additional costs to host a Diesel set, like tanks and special foundation to carry its weight, are not included.

Purchasing cost 3 x 1250 kVA system	3 x 1.25 = 3.75
Maintenance cost / 10 years	10 x 3 x 0.025 = 0.75
1 person / 10 years	10 x 0.15 = 1.5
TOTAL cost in MCHF	6

Table 6.5

The space needed is about 180 m^2.

7 CONCLUSION

To increase the reliability and safe operation of the Computer Centre and cope with the requirements for the future LHC Computing farms, a new strategy of electrical supply has been studied. The proposal is based on the analysis of the drawbacks of the present power supply and benchmarking with five other computer centres.

At first it is recommended to increase the reliability and availability of the 18 kV normal network. To reach this objective, in addition to appropriate maintenance works and correct operation of the selectivity of the network protections :

- building 513 should be included in a loop instead of being supplied in single supply from ME23 substation,
- building 513 should be as independent as possible from ME23 substation (N/S system, 48V dc supply),
- auto transfer between the SIG/EOS and EDF sources should be implemented at the B513 level.

The suppression of the general emergency stop system in the electrical substations will also increase the global reliability of the 18 kV network.

The cost is estimated to **1.9 MCHF**. It is strongly recommended to invest this amount of money whatever will be the decision concerning the power supply of the Computer Centre.

The minimum solution proposed to ensure continuous operation of the Centre during 10 to 30 minutes in case of an extended power outage is estimated to **1.4 to 2 MCHF**. These costs do not include the costs related to improvements of the electrical distribution inside B513. The minimum solution consists in :

- maintaining an adequate temperature in the computer rooms, with help of a spare chilled water tank or other methods, like “ice banks”, and the backup of the minimum HVAC equipment by the Meyrin Diesel sets. Power is limited to 1 MW and available after 90 seconds.
- supplying the critical loads with parallel redundant UPS modules with 10 to 30 minutes of battery autonomy. The UPS system should have a high level of reliability. For this reason, the fewer parallel modules are used for redundancy the better it is.

Moreover it is recommended to install an automatic shutdown process in order to sequentially switch off lower priority equipment and maintain only sensitive applications if, in case of an extended outage, the battery autonomy falls to a low level.

Three other solutions have also been presented. The estimated costs range from 6 to 10.7 MCHF. These alternatives are based on dedicated Diesel-generator sets or rotary UPS allowing long term backup. Due to the presence of Diesel sets, these solutions require considerable supplementary equipment and a well organized program to maintain them.

From the point of view of the electrical services, the minimum solution offers enough guarantee regarding the continuity of operation of the Computer Centre. The alternatives are likely to increase the complexity and the strong investment does not warrant the increase in reliability.

It will be up to the owner to balance the consequences of the interruption in the data processing function with the cost of the equipment needed to reduce the probability it could happen, keeping in mind that “Zero risk” does not exist.

REFERENCES

[1] A. Kusko, “Emergency/Standby Power Systems”, McGraw-Hill, 1989

[2] G. Kowalik, “Technical Report : Electrical Power Supply to the Computer Centre”, réf. ST-EL/GK (2000-067), May 2000