Generators

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1 Load types

Critical loads cannot lose power, even momentarily.

Essential loads can tolerate a brief power interruption, but will need to be operational for continued running of the data centre.

Non-essential loads are discretionary and can be done without.

The classification of any particular load will depend on the business needs. The same load might be classed as critical, essential or non-essential in different contexts.

2 Standby generators

A UPS normally protects critical loads for a short period of time. For longer power outages, a separate generator is required.

Standby generators are usually supplied as a package unit, containing:

Prime-mover normally a reciprocating diesel engine.

Alternator to convert mechanical energy into electrical energy.

Controls including a governor to control engine speed, determining frequency, and an automatic voltage regulator to control the excitation in the generator's windings, determining output voltage.

Figure 1: generator$_{s}chematic$

generator-schematic

3 Power system including Generator

The generator normally powers the essential and (via the UPS) the critical loads, **??**.

4 Transfer sequence

The transfer is usually managed by an automatic transfer switch. This is a "break-before-make" switch that disconnects the power from the mains and transfers it to the generator. The transfer switch is normally interlocked

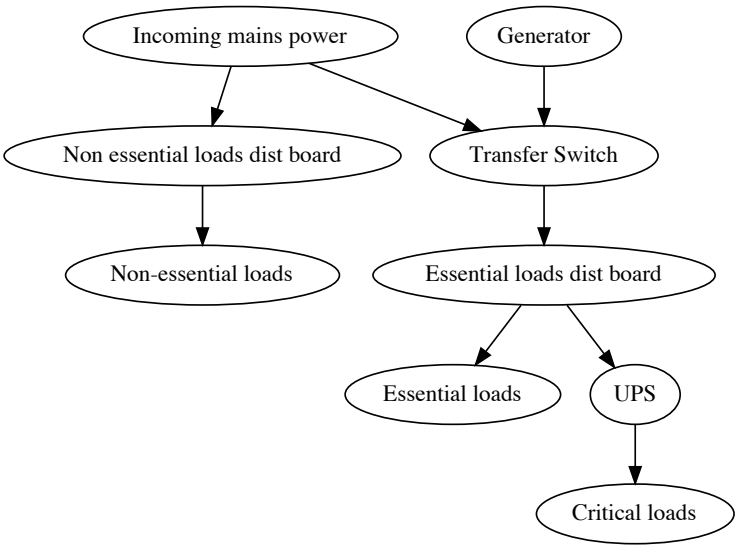

Figure 2: Standby generator arrangement

with the generator's control system so that the generator starts on a loss of power.

4.1 On loss of mains power

1. Power is lost in the mains (i.e. voltage goes out of range). This causes the automatic transfer switch (ATS) to start a short time delay. If power returns, the sequence terminates, otherwise the ATS signals the generator to start.
2. The generator will take some time (1-2 minutes) to:
   (a) Start the prime mover (engine), possibly needing multiple re-trys.
   (b) Engine accelerates to correct speed to produce 50 Hz.
   (c) Excitation and automatic voltage regulation to cause correct voltage to appear 230 V on the output.
3. ATS will break the connection to the mains and make it instead to the generator.
4. Generator maintains frequency at 50 Hz using governor to control engine throttle, and voltage at 230 V using automatic voltage regulator that controls the excitation current.

4.2 On return of mains power

1. ATS senses return of mains power. Initiates a time delay before continuining to ensure mains power is stable.
2. ATS transfers loads back to mains. Generator continues to run for a predetermined cooldown period.
   - If mains power is again lost during this period, can switch back to generator almost immediately.
3. Generator is stopped once cooldown period has elapsed. Ready for cycle to resume again.

5 UPS compatibility

Generators and UPS systems have a complex relationship. Although they synergise well in principle, they can both cause problems for each other in practice.

Standby & line-interactive UPS will require the generator to maintain a very tight tolerence on voltage and frequency. Frequent transfers to battery possible when V and f deviate due to load switching.

Double-conversion (AC-DC-AC) UPS will generally work best, as it is tolerent to incoming frequency/voltage variations. *Double-conversion UPS systems can cause major problems though for undersized generators because their rectifiers can generate harmonics on the power input.*

In general, the less dominant the UPS (and its downstream load) is as a fraction of the total load, the more successful the UPS-generator pairing will be. More generally, a generator will be more successful powering a large number of smaller loads than a smaller number of large loads.

6 Generator Sizing

Generators need to be sized taking into account:

- The critical load attached to the UPS.
- The battery recharging demand of the UPS.
- Inherent inefficiencies in the UPS.
- The essential loads (such as cooling).
- Large starting currents and harmonics when loads (including the UPS rectifier) are connected, particularly when starting up.
- Expansion capacity (since a generator is a large capital investment).

This means that substantial buffer / correction factors are often applied to ensure a generator is adequately sized.

7 Responsibility

Generators are often not managed by IT personnel, but rather facilities management. IT will need to communicate with facilities managament both to maintain a good work relationship and to exchange data, including the setup of automated data feeds.

8 Siting

Many generators are sited outside, but some are sited inside, depending on business needs and space planning. Consideration must be given to:

Ease of interconnection to power system.

Noise generated in use inside and outside building.

Fuel storage and supply using inbuilt and/or external tanks, gravity or pumped supply.

Exhaust system to ensure safety of building fabric and its occupants.

Accessibility for servicing and routine maintenance and testing.

Cooling of the generator itself during operation. If inside, ventilation/cooling will be needed.

Security since sabotage could “take out” a data centre!

9 Routine maintenance

Starting battery needs to be kept charged and checked on schedule.

Engine-block heating (usually electric) should be considered in cold climates.

Generator must be tested regularly, preferably on load.