A. ELECTRICAL SYSTEMS

ENABLING OBJECTIVES:

5.1 State the purpose of each of the following:

a) Main Output Transformer;
b) Switchyard;
c) Unit Service Transformer;
d) System Service Transformer.

5.2 Name the four classes of power used in a CANDU station, and explain the purpose of these classifications.

5.3 Name the power source which supplies power when one or both Class IV power sources fail.

5.4 State the function of the Emergency Power Supply (EPS).

Like any factory, a CANDU station requires electrical power to operate. During normal operation the station can provide its own electrical needs. However, when the station is not producing, it must draw power from the grid like any other factory.

MAJOR COMPONENTS

Figure 5.1 shows a simplified diagram of a CANDU station's electrical interconnection with the power grid.

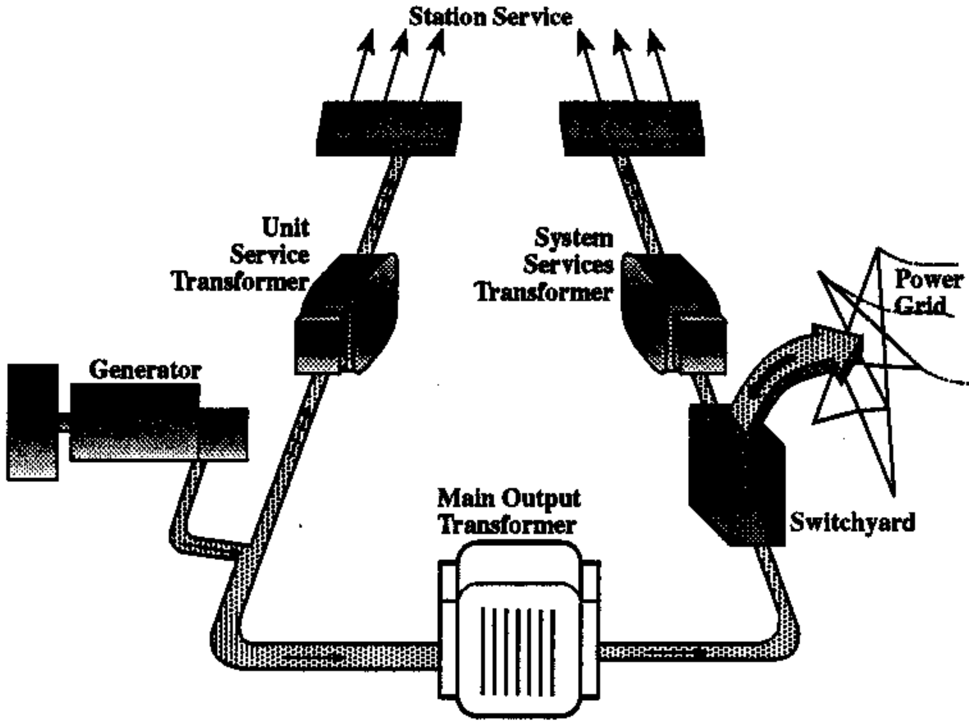

Figure 5.1
Main Power Output and Unit Distribution System

The **main output transformer** steps up the voltage from the unit generator to the level required by the Ontario Hydro grid.[1] This electrical power is delivered to the switchyard. The **switchyard** increases overall reliability by providing the means to switch generator output to available output lines, to isolate a faulty generator or line, and, if necessary, to draw a unit's energy requirements from the grid.

The unit draws power to meet its internal needs from two sources. The **unit service transformer** (UST) is connected directly to the unit generator. The UST is a step down transformer that reduces generator voltage to the level appropriate for the unit. The unit can also draw the power to run its systems directly from the grid by means of a **system service transformer** (SST). This is a step down transformer that reduces grid voltage to the appropriate level for the unit. Although either transformer is able to provide the full power requirements of the unit, they are both normally in service, each providing roughly half of the unit's requirements.

1 A higher voltage means a reduced current and therefore reduced line losses over the long distances that power is transmitted.

CLASSES OF POWER

All power consumers (loads) in the station are not created equal. It is essential to ensure that some loads (eg. protective relaying) never lose their power source, while others (eg. office air conditioning) can go without power almost indefinitely. To handle the various needs, a hierarchy of **four classes of power** has been developed based on the urgency or importance of maintaining power to individual loads. Each class has both a normal power source and an emergency power source. The emergency power source takes over when the normal source is not available. Each class supplies power to **odd** and **even** buses. Equipment is divided up between odd and even buses to ensure independence; failure of one bus does not deprive all similar equipment of power. In the case of redundant equipment, for instance two 100% pumps, one piece would be supplied from an even bus and the other from an odd bus. Figure 5.2 graphically illustrates the four classes of power, the alternate sources for each and the odd/even arrangement.

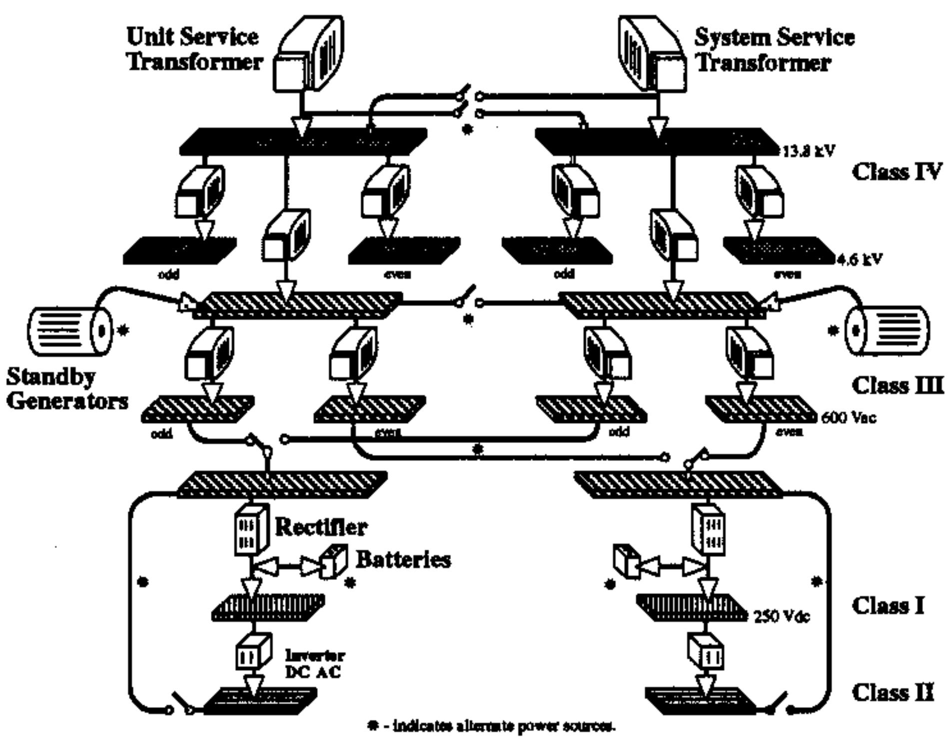

Figure 5.2
Classes of Power and Distribution

CLASS IV POWER

Class IV power supplies ac loads that can be **interrupted indefinitely** without affecting personnel or plant safety. Typical loads on a class IV system are normal lighting and the primary heat transport pump motors. During normal operation, the UST and SST share the unit loads. Should the need arise, the loads can be supplied fully by the SST. Thus, the Ontario Hydro grid serves as an emergency power supply for the class IV system.

CLASS III POWER

Class III power supplies ac loads that can tolerate the **short interruption** (one to three minutes) required to start the standby generators without affecting personnel or plant safety, but are required for safe plant shutdown. Typical loads on a class III system are the moderator main circulation pump motors and the pressurizing feed pump motors. Normally, class III power is supplied from a Class IV source. Should the UST and the SST **both** fail, then one or more of the standby generators (gas turbine driven) will automatically start and begin picking up the loads. This whole process takes less than three minutes.

CLASS II POWER

Class II power is considered **uninterruptable**. Class II supplies **ac** loads that cannot tolerate the short interruptions which can occur in Class III. Typical loads on a Class II system are digital control computers and reactor safety systems. Class II power is normally fed from Class I via an inverter which changes dc to ac. Should the normal Class I supply fail, Class II power is supplied from the battery banks until the standby generators in Class III are operating.

CLASS I POWER

Class I power is considered **uninterruptable**. Class I supplies **dc** loads that cannot tolerate the short interruptions which can occur in Class III. Typical loads on a Class I system are protective relaying, circuit breaker control, turbine lube oil emergency pump, emergency seal oil pump, and emergency stator conductor water cooling system pump. Class I is normally obtained from class III, via a rectifier (battery charger). Should the rectifier or the Class III supply fail, then Class I is supplied from a battery bank, which is always maintained fully charged by the rectifier.

EMERGENCY POWER SYSTEM (EPS)

The purpose of the **emergency power system** (EPS) is to provide electrical power, in the unlikely event of a worst case accident, to certain nuclear safety-related systems that support the capability to **control**, **cool**, and **contain**. The EPS is started from the EPS control room within 30 minutes of a serious incident. It is seismically[2] and environmentally[3] qualified and has sufficient fuel stores to operate for a seven day period, more than sufficient time to restore power from the grid. The EPS must be available whenever there is a significant amount of fission products in a reactor core.

Some worst case accidents, which could lead to a need for an emergency power supply, are:

- turbine disintegration,
- widespread fires,
- external explosions,
- earthquake,
- earthquake combined with a Loss of Coolant Accident (LOCA).

The EPS at each nuclear station is different but each is designed to cope with the worst case accidents. The EPS is quite similar to other standby generators but is located elsewhere (to ensure independence) in a fortress-like building to reduce chances of it being disabled. Cables and control equipment involved in switching the Emergency Power Supply into service are routed through areas that are considered to be at lowest risk of damage.

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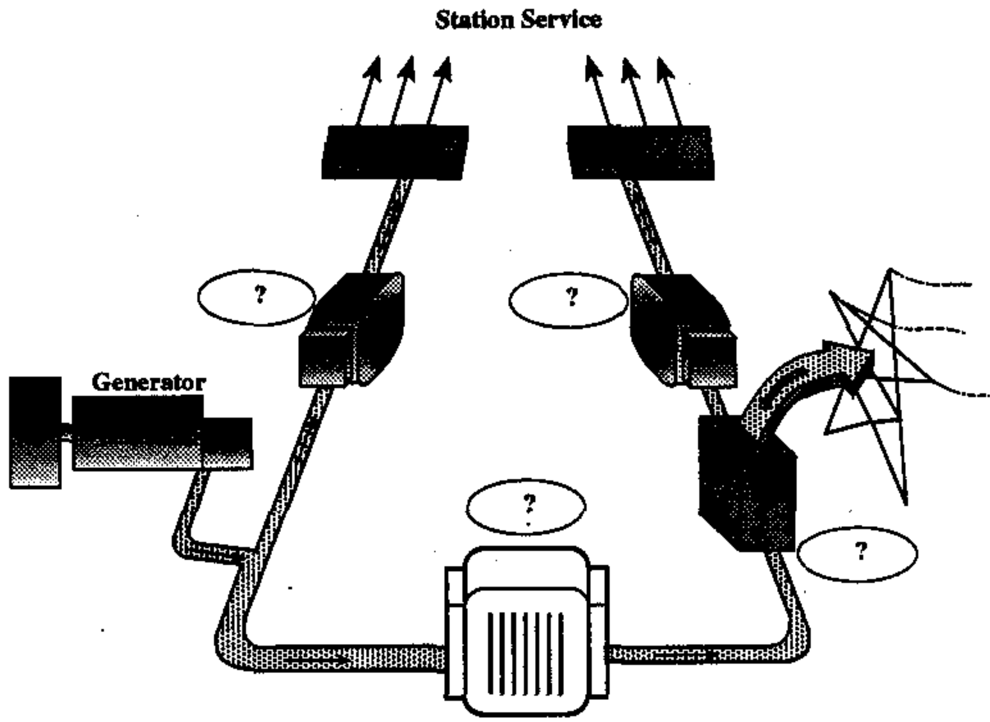
[2] Seismic Qualification requires that equipment and systems retain their specified performance capability following an earthquake.

[3] Enviromental Qualification (EQ) requires that equipment must be protected against steam leaks, water flooding, high intensity fires or other mishaps which could disable it.

ASSIGNMENT

1. In the basic CANDU power system diagram shown below, label and briefly explain the purpose of each component identified by a question mark (?).



2. Fill in the following table.

Class of Power	Length of Possible Interruption	Normal Power Source	Alternate Power Source
Class IV			
Class III			
Class II			
Class I			

3. What is the purpose of the EPS?