TRACCIA 1

L'Ateneo, nell'ambito della convenzione Consip Servizi Integrato Energia, sta affrontando una riqualificazione energetica con un intervento di relamping diffuso nei vari edifici.

Il candidato descriva gli aspetti di base, e i relativi calcoli ingegneristici, che compongono le fasi della redazione tecnico-progettuale di un impianto elettrico di illuminazione (può riferirsi ad esempi e applicazioni all'interno di un campus universitario).

Il candidato descriva quali sono i principali aspetti critici della gestione dell'intervento, in termini di rapporti tra le varie figure, quali ad esempio all'interno degli uffici tecnici che gestiscono il contratto, con i dipartimenti e utenti che popolano gli edifici oggetto di intervento e con la ditta esecutrice dell'intervento.

Accertamento informatico: Inserire una tabella in file Word

UNIVERSITAS o STVDIORVM o MEDIOLANI

1.2 Electricity Transmission and Distribution

When power is to be supplied to multiple loads, these loads may be series- or parallel-connected. In the case of parallel connection, each load is highly independent. This is the reason why the universally-adopted power supply system is parallel- or shunt-connected, i.e. the same voltage is applied to all loads.

With regard to the type of supply, it may be direct current (DC) or alternating current (AC), single- or three-phase.

The invention of AC machines, at the end of the 19th century (static power transformers, three-phase induction motors and, more generally, induction rotating machines) gave a major contribution to the choice of the above type of power supply. In fact, transformers enable high-voltage (HV) and extra-high-voltage (EHV) AC power transmission and distribution, and reduce losses, which are proportional to the square of the current. This advantage, combined with the long life and little maintenance that these machines require, was crucial in preferring AC to DC. Other factors, which facilitated this choice, are as follows:

- AC may be interrupted, by means of circuit-breakers, much more easily than DC, as it passes through zero every half-period;
- induction motors are much more suited to industrial applications than DC ones;
- in steam turbines, particularly suitable for rotating at high speed, synchronous generators (alternators) are preferred to DC generators (dynamos) because DC generators have commutator bars.

By using AC instead of DC, electricity is generated by alternators where the voltage should not exceed a specified maximum level (about *20-25 kV*), for reasons that are related to the insulation of the conducting material. Moreover, as many electricity consumers are designed for not too high voltage levels, the intermediary of transformers may: i) step up the voltage in power plants to the value most appropriate for transmission and distribution (and thus diminish losses); and then ii) step down the voltage at the load points to the value most appropriate for customers.

The above considerations, however, do not rule out the possibility of using DC transmission. In this case, as the generation and absorption of electricity take place in AC, terminal conversion equipment (rectifiers and inverters) is needed. Whatever the cost of this equipment, a cost/benefit comparison may be made between DC and three-phase AC transmission (preferred to single-phase AC transmission, as discussed later), supposing that transmission losses, transmitted power and conductor voltage remain equal. For this comparison, let us call I_c and I_t the values of DC and AC flowing through each conductor (obviously, I_t is a root-mean-square (rms) value), having the cross-sections S_c and S_t , and a resistivity ρ. If the transmission occurs over a length L, the equality of transmission losses implies that

$$2\frac{\rho L}{S_c} I_c^2 = 3\frac{\rho L}{S_t} I_t^2 \tag{0.0-1}$$

Additionally, let P be the transmitted power, V the conductor voltage (rms value of

TRACCIA 2

Il candidato descriva gli aspetti di base, e i relativi calcoli ingegneristici, che compongono le fasi della redazione tecnico-progettuale di un impianto elettrico (esempio: campus universitario).

Il candidato descriva quali sono i principali aspetti critici che si possono intravvedere nella gestione della fase esecutiva dell'intervento, in termini di rapporti tra le varie figure, quali ad esempio all'interno degli uffici tecnici che gestiscono l'opera, con gli utenti che popolano il campus, con le figure tecniche incaricate e con la ditta esecutrice dell'intervento.

Accertamento informatico: Come formattare una tabella in Excel

INTRODUCTION

1.1 Electricity Generation

Power plants that convert natural sources of thermal or hydraulic energy into electricity may include

- hydro power plants, which may be
    - run-of-river (along rivers),
    - pondage with daily and weekly regulation (basins with low water storage capacity),
    - reservoir with seasonal and annual regulation (basins with high water storage capacity),
    - pumped-storage, consisting of turbine-pump-generator units located between two water storage reservoirs;
- steam thermal power plants, fired by conventional fuels (fuel oil, coal);
- geothermal power plants, harnessing the thermal energy of high-temperature steam jets;
- nuclear power plants;
- gas-turbine power plants;
- combined-cycle thermal power plants (steam and gas turbines).

As is obvious, electricity-generating units in the various power plants inject power into the system, whereas electricity consumers (loads) absorb power from the system, depending on the respective requirements. At any instant, the amount of power injected into the system by generators should match the amount of power absorbed by loads (plus system losses). Any mismatch, whatever its causes, should be rapidly redressed by appropriate control actions. Balancing power generation with load, which is key to *electricity supply continuity*, may be difficult, owing to: i) the variability of the load diagram, which changes on a daily, weekly, monthly or yearly basis; ii) unpredictable events (e.g. adverse weather) or incidents, which may even entail the splitting of the power system in two parts - one with a deficit and the other with a surplus of generated power.

Let us suppose a typical total daily load diagram (Figure 1.1-1) of a large power system, consisting of the above-mentioned power plants. In this system: i) run-of-river hydro, geothermal and nuclear plants generate a practically constant power for technical and economic reasons; ii) thermal plants generate a quasi-constant power, corresponding to their maximum efficiency conditions. It follows that the daily peak loads are actually covered by reservoir hydro, pumped-storage and gas-turbine plants.

It should be noted that systems with high generation from conventional thermal plants may need to reduce their generation or shut down, at least in part, their generating units during low-load hours (e.g. at night), and restart them upon load increase (e.g. in the morning). This mode of operation, which may cause the wear of the generating units (boilers and turbines), is uneconomic. It may be avoided by storing the energy from thermal plants into pumped-storage ones during low-load (*off-peak*) hours. Pumped-storage plants will release this energy during peak-load (*on-peak*) hours, thereby minimising the power that reservoir hydro and gas-turbine plants have to produce in order to cover the expected load diagram. Consequently, the latter plants perform a power reserve or contingency duty, i.e. covering unexpected imbalances between generation and load.