Recently a new type of gas-fired power station, known as the combined-cycle gas turbine (CCGT) station, has been very popular with electricity companies. It uses two stages of energy extraction from the fuel, allowing overall efficiencies to approach 55 per cent. The gas is first burnt in a gas turbine to generate electricity. The exhaust gases from the turbine are then used as in a conventional power station to raise steam for further electricity generation.

A turbine driven by steam or gas is coupled to the rotor of an electrical generator, which consists of a solid steel cylinder with a winding that carries direct current and spins at 3,000 revolutions per minute. Because of the current flowing through it, the rotor becomes a strong electromagnet. The stationary part of the electrical generator, the stator, carries three windings. The rotating magnetic flux induces alternating voltages in these “three-phase” windings. These alternating voltages have a frequency of 50 Hz (hertz, cycles per second). The electrical power produced in an external circuit is proportional to the product of voltage and current. Thus the mechanical power input from the turbine is converted into electrical power output at the generator. The conversion efficiency here is nearly 100 per cent.

IV PROBLEMS OF ELECTRICAL GENERATION

Electrical energy is the lifeblood of all industrialized societies, central to the maintenance of their standards of living, and it is essential to developing countries if they are to escape from poverty. The problem is that in the long term all fossil and nuclear fuels have a limited availability. Predictions range from 40 to 60 years for gas and oil to 200 years for coal at the current rate of consumption (*see* Energy Supply, World). A more pressing problem at present is that the burning of coal, oil, and gas is producing a number of by-products that are harmful to the environment. The accumulation of carbon dioxide, the most important greenhouse gas, over the last few decades is believed to be responsible for increasing the Earth's surface temperature. The majority of scientists

specializing in this area believe that if we continue on our present path severe climatic changes may occur in a few decades.

V SOURCES OF ELECTRICAL ENERGY

If the use of fossil fuels is to be curbed, the only alternatives available are nuclear energy and renewable energy. After the Chernobyl accident, some scientists believe that the risks involved in nuclear power may not be acceptable. The creation of radioactive waste that will have to be contained for many centuries is also felt to be an unfair legacy to our descendants. Other scientists believe that to prevent climatic changes we will have to put up with these risks. In contrast, renewable energy is environmentally very clean, though not problem-free.

The total amount of energy received by the Earth in light from the Sun is immense—more in fifteen minutes than humanity consumes in one whole year. Only a fraction of this is usable, but this fraction could provide a hundred times our energy needs. At present the most promising renewable sources are those from wind, Sun, water, and biofuels. The principal disadvantage of many renewables is aesthetic. This is simply because those renewable energies are so “dilute” that very large or numerous installations are needed to collect the energy. This is particularly true of solar and wind energy.

A wind farm is a group of wind turbines that converts part of the kinetic energy of the wind into electricity. The wind slows down as it passes through the rotating blades of the turbines, and the energy it loses (about 40 per cent) is converted by the turbine into mechanical and then electrical energy, which is fed into the electricity grid.

In photovoltaic devices, sunlight falls on special semiconductor material, which converts about 15 per cent of the sunlight energy directly into DC electricity (direct, or one-way, current). This has to be converted into AC (alternating current) before it is fed into the mains.

In water-driven systems the kinetic energy of falling water is first converted into the mechanical energy of turbines and then into electrical energy (*see* Hydro-Power). The process is reversed in pumped-storage schemes, in which water is pumped into reservoirs electrically at times when demand for electrical power is at a minimum. The water is allowed to flow out of the reservoir at peak times, driving generators and supplementing the electrical supply. This enables the power station to keep running at a more uniform level, which is especially important in the case of nuclear energy plants.