alternative energy

DeMYSTiFieD

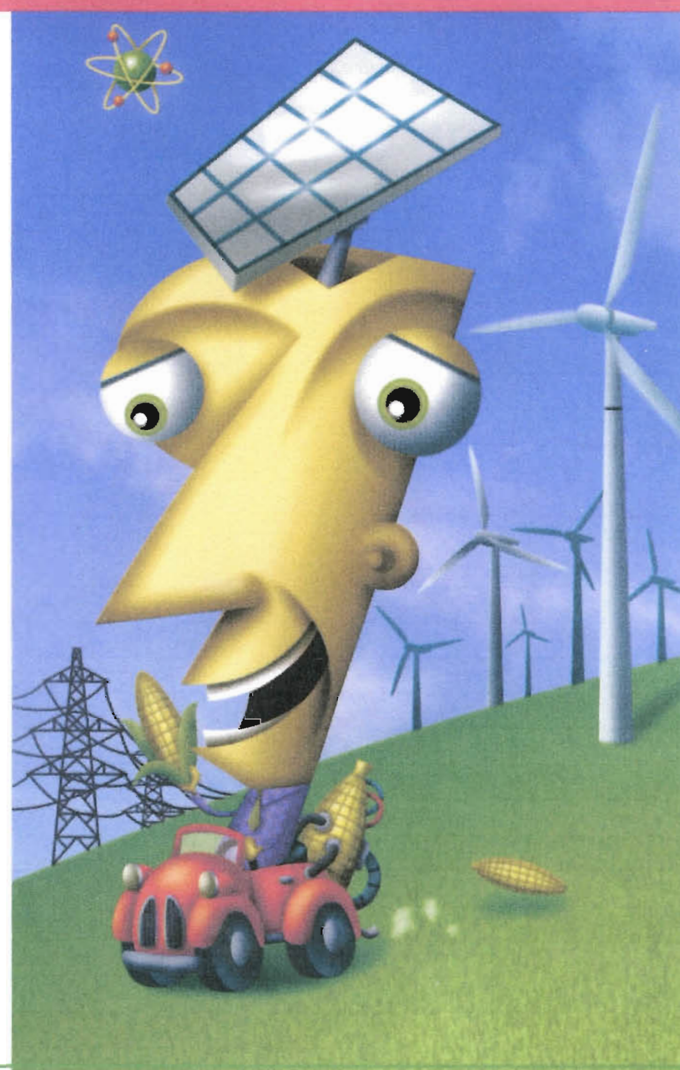
A SELF-TEACHING GUIDE

Gain a strong KNOWLEDGE of energy ALTERNATIVES from conventional to EMERGING SOURCES

Discover relevant information for DEVELOPED and DEVELOPING countries

Learn about energy in terms of the ENVIRONMENT, TRANSPORTATION, and ELECTRIFICATION

Find OBJECTIVE discussions of APPLICATIONS of ALL FORMS of energy



Stan Gibilisco

Mc Graw Hill

There's no better time—or easier way—to LEARN about ALTERNATIVE ENERGY

Thinking about heating your home with solar power but don't know how it really works? Wondering what makes hybrid cars run? *Alternative Energy Demystified* shines the light on the various energy sources and technologies available today.

The book begins by covering a wide range of heat sources, including wood, corn, coal, oil, gas, electricity, and solar heat. Propulsion methods are discussed next, including gasoline, methane, ethanol, biodiesel, hydrogen, fuel cells, and more. Electricity from fossil fuels, water, wind, atoms, and other sources is also covered. Featuring end-of-chapter quizzes and a final exam, this illuminating guide explains the technical basics of many different forms of energy—some that may surprise you!

This self-paced guide gives you:

- A thorough overview of the various sources of energy
- To-the-point explanations and detailed illustrations
- A quiz at the end of each chapter to reinforce learning and pinpoint weaknesses
- A final exam at the end of the book
- A time-saving approach to performing better on an exam or at work!

Simple enough for a beginner, but challenging enough for an advanced student, *Alternative Energy Demystified* is your shortcut to a working knowledge of this timely topic.

Learn more. Do more.

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Science

- The delivery and storage of fuel for hydrogen fuel cells presents a major technological obstacle to the widespread deployment of small-scale power plants of this type. (This is not a problem with liquid alternative fuels.)
- The energy density of hydrogen is relatively low compared with other fuels. (This is not a problem with liquid alternative fuels.)
- Hydrogen is extremely flammable and potentially explosive. (This is not usually a problem with liquid alternative fuels.)
- Hydrogen fuel cells are relatively expensive to operate, largely because of the cost of the processes involved in separating hydrogen from naturally occurring compounds. (This is not usually a problem with liquid alternative fuels.)
- Some fuels, such as petrodiesel and biodiesel, tend to solidify in cold weather. This could render a fuel cell inoperative.
- Some fuels, notably methanol and gasoline, can be toxic to personnel directly exposed to them.

PROBLEM 13-3

Can a system such as the one shown in Figure 13-5 be expanded to take advantage of other sources of energy, such as a solar array or a wind turbine, or both? How might this be done? Could that allow a home to operate entirely off the electric utility grid?

SOLUTION 13-3

This is possible but expensive. For example, a solar panel or array can charge the battery bank during sunny weather. A wind turbine can supplement this, taking over on windy nights or windy, overcast days. The fuel cell can operate when neither wind nor solar energy is sufficient to meet the electrical needs of the home or business. A computer-governed power-control switch can ensure that the available energy is used in the most efficient manner at all times. Such a hybrid system can offer complete independence from the electric utility. The key is diversity and redundancy of energy sources.

Aeroelectric Power

Let's end this book by letting our imaginations run a little bit wild. Some scientists think that atmospheric electricity can be tapped to get usable energy. We can go all the way back to Benjamin Franklin (and some less lucky colleagues) who lofted electrical conductors into the air and demonstrated that clouds are electrified.

Suppose some imaginative group of engineers repeats this experiment on a grander scale?

THE GLOBAL ELECTRIC CIRCUIT

The earth is a fairly good *electrical conductor*. So is the upper part of the atmosphere known as the *ionosphere*. The lower atmosphere does not normally conduct electricity, so it composes an *electrical insulator*. When an insulator is sandwiched between two conductors, that insulator is known as a *dielectric*, and the result is a *capacitor* capable of storing energy as an *electric field*. On a gigantic scale it can be called a *supercapacitor*. The *earth-ionosphere supercapacitor* is constantly charging up in some regions and discharging in others, forming a system that has been termed the *global electric circuit*. If it ever becomes practical to tap the global electric circuit to get usable electricity, we will have an *aeroelectric power plant*.

HOW MUCH POWER?

The maximum *electrostatic charge quantity* (number of charged particles such as electrons) that a capacitor can hold depends entirely on three factors: the combined areas of the conducting surfaces, the average distance separating them, and the type of dielectric material between them. The earth-ionosphere supercapacitor consists of one vast conducting sphere inside another with air as the dielectric, as shown in Figure 13-6. These spheres are both about 6500 km (4000 mi) in radius. This forms a capacitor with two "plates" whose spacing is small (about 50 km or 30 mi) compared with their surface areas (about 530,000,000 km^2 or 200,000,000 mi^2).

A high voltage between the earth's surface and the ionosphere gives rise to a massive electric field in the troposphere and stratosphere. The charge in this supercapacitor is maintained by radiation from the sun, from cosmic rays, and from radioactivity in the earth's crust. All of this radiation interacts with the earth's magnetic field and with atoms in the upper atmosphere to keep the supercapacitor charged up.

Storm clouds, volcanoes, and dust storms tend to improve the local conductivity of the troposphere and stratosphere, creating attractive environments for electrical discharge of the earth-ionosphere supercapacitor. A typical thundershower discharges about 2 A of current, averaged over time. At any given moment, there are about 750 thundershowers in progress on our planet, producing between 35 and 100 lightning discharges per second altogether. A current of 2 A per thunderstorm may seem small, but this current does not flow continuously. It occurs in brief, intense surges. A single lightning discharge lasts only a few thousandths of a second. Therefore, the *peak* current in a lightning stroke is extremely large—in some cases many thousands of amperes. This is why lightning can be destructive.

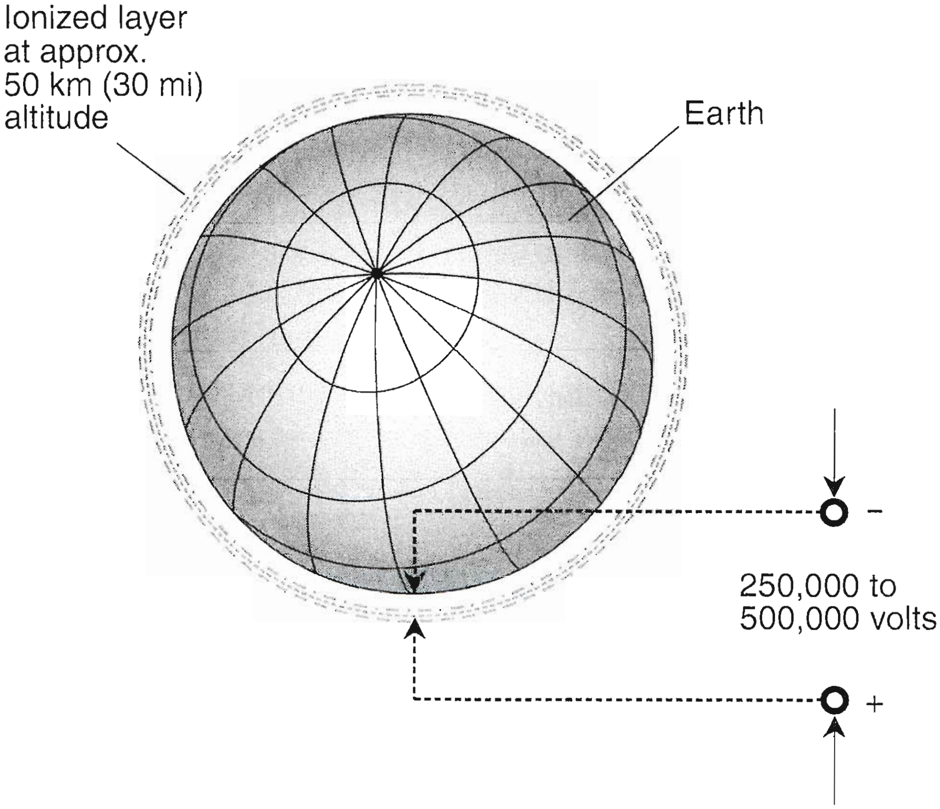

Figure 13-6 The earth and the upper atmosphere act as a supercapacitor that is constantly recharged by various sources of radiation.

The atmospheric supercapacitor maintains a constant charge of 250,000 to 500,000 V, comparable to the voltage in high-tension utility lines. But the earth-ionosphere electrical potential difference is a DC voltage, not an AC voltage. The average current that flows across the atmospheric capacitor as a result of thundershowers alone is roughly 1500 A (2 A per storm times 750 storms). Electrical power in watts is the product of the voltage in volts and the current in amperes. The above figures mean that our atmosphere is constantly dissipating several hundred million watts of power on the average, enough to provide all the electricity needed by a medium-sized city at peak demand.

AN AEROELECTRIC POWER PLANT

How might an aeroelectric power plant work? One approach would involve lofting a set of captive high-altitude balloons tethered by conducting wires. The wires would be grounded through tanks, each containing a solution of water and dissolved electrolyte (see Figure 13-7). If such a balloon is high enough above the surface to reach into the lowest ionized layer of the atmosphere, a constant electric current

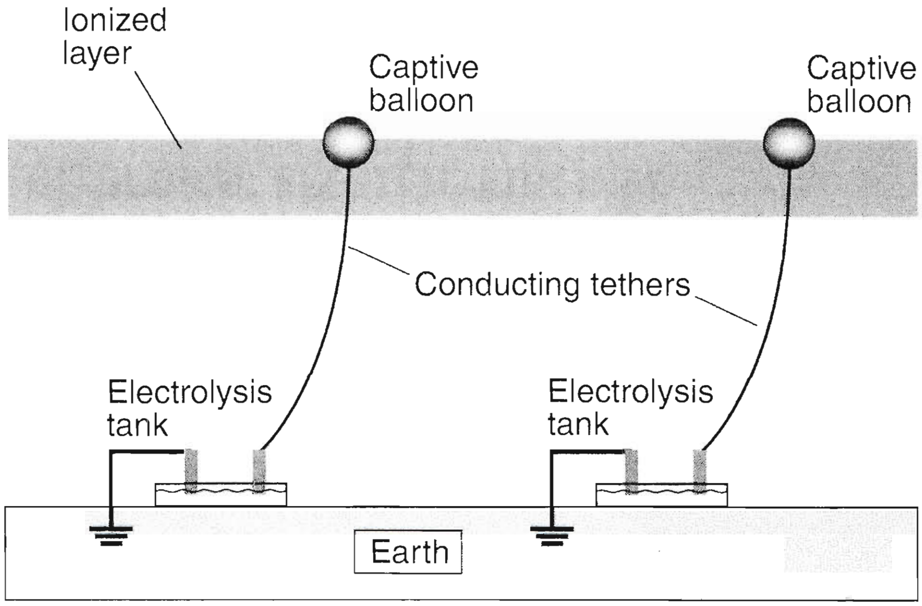

Figure 13-7 A possible scheme for using atmospheric electricity to derive hydrogen fuel from water by electrolysis.

will flow in the wire, and therefore through the electrolyte solution. This will separate the water into hydrogen and oxygen gas, which will bubble from the electrodes. The gases could be collected in the same manner as with any other electrolysis device. The hydrogen could be used in fuel cells or hydrogen-powered cars and trucks. The oxygen could be used for industrial and medical purposes.

ADVANTAGES OF AEROELECTRIC POWER PLANTS

- The earth-ionosphere supercapacitor is constantly recharged by renewable energy sources, notably the sun and various radiation-producing elements in the earth.
- An aeroelectric power plant would produce no pollutants of any kind.
- The facilities for an aeroelectric power plant would be unobtrusive. The balloons would be too far aloft to be seen from the ground without binoculars or telescopes.
- The energy supply could be continuous if captive balloons were kept aloft at all times.

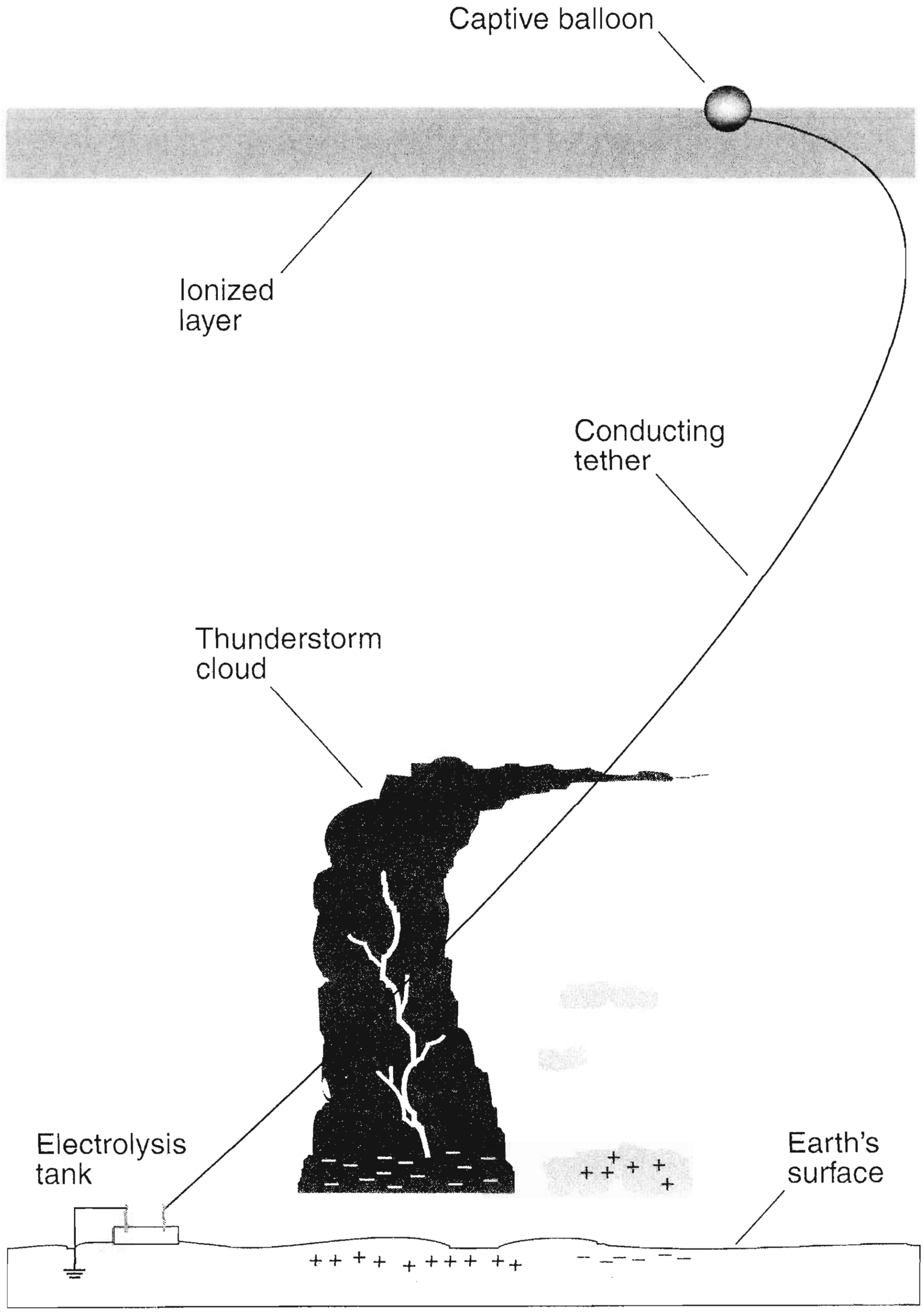

Figure 13-8 What would happen if a captive aeroelectric balloon were to encounter a heavy thunderstorm?