17.5: The Fourth Commandment

GIVEN THAT ENERGY IS A KEY TO SUSTAINABILITY, THE DEVELOPMENT OF EFFICIENTLY-USED, ABUNDANT SOURCES OF ENERGY THAT HAVE LITTLE OR NO ENVIRONMENTAL IMPACT IS ESSENTIAL

As discussed in Chapter 15, “Sustainable Energy: The Essential Basis of Green Systems,” abundant, sustainable energy that can be used without harming the environment is arguably the most important facet of sustainability. Several aspects of energy in sustainability are discussed here. Examples of what can be accomplished with sufficient sustainable energy include the following: Toxic organic matter in hazardous waste substances can be totally destroyed and any remaining elements can be reclaimed or put into a form in which they cannot pose any hazards, wastewater from sewage can be purified to a form in which it can be reused as drinking water, pollutants can be removed from stack gas, and essential infrastructure can be constructed.

The accomplishment of sustainability is impossible without the development of efficient, sustainable, nonpolluting sources of energy. Here lies the greatest challenge to sustainability because the major fossil-fuel-based energy sources used today are inefficient, unsustainable, and, because of the threat to world climate from greenhouse gases, threaten Earth with a devastating form of pollution. Other means to provide energy that are friendly to the environment and sustainable must be developed.

Fortunately, as discussed in Chapter 15, alternatives are available to fossil fuels, given the will to develop them. Most renewable energy sources are powered ultimately by the sun. The most direct use of solar energy is solar heating. Solar heating of buildings and of water has been practiced increasingly in recent decades and should be employed wherever possible. The conversion of solar energy to electrical energy with photovoltaic cells is feasible and also practiced on an increasing scale. At present, electricity from this source is more expensive than that from fossil fuel sources, but solar electricity is gradually coming down in price and is already competitive in some remote locations far from power distribution grids.

Wind energy has emerged as a somewhat surprising alternative to fossil fuels and is now competitive in price in many areas. There are numerous geographical locations that are suitable for installation of large aerogenerators, which are to be found increasingly on the European landscape, particularly in Denmark and Germany. In the U.S., areas of California, Kansas, and West Texas are particularly well adapted to the installation of wind generating facilities. Some people regard the tall, graceful aerogenerators as ugly (others see them as graceful and picturesque), but they are certainly not as ugly as the landscape will become if massive climate warming occurs.

There is one big problem common to solar and wind energy—their intermittent nature. Solar energy works poorly when the sun does not shine and wind energy fails when the wind does not blow (although modern aerogenerators function at remarkably low wind speeds). Therefore, it is necessary to have reliable means of energy storage to provide for an even energy flow. Batteries for storage in major electrical systems would be too large and expensive. Possible alternatives include pumped water storage, kinetic energy in rapidly spinning flywheels, and production of hydrogen and oxygen by electrolysis of water with these two gases later recombined in fuel cells to produce electricity.

For some applications, most notably aircraft fuels, there are no realistic substitutes for carbon-based fuels. The challenge is to utilize such fuels with minimal addition of greenhouse gas carbon dioxide to the atmosphere. The best sustainable alternative for producing such fuels is to make them from biomass. It is possible to synthesize and utilize biomass fuels in a manner that is greenhouse-gas-neutral, that is, the carbon in the carbon dioxide released by their combustion came originally from the atmosphere by photosynthesis (as did the carbon in fossil fuels, but over a vastly longer time frame). Biomass is now used for liquid fuels in two major forms. One of these is ethanol made from the fermentation of sugar from grain starch or sugar from sugarcane. The other alternative is diesel fuel made by esterifying plant oils, particularly soybean oil. But these sources require a high-value raw material that is in demand for food and are economic only because of substantial government subsidies. Efforts to extract sugars for fermentation to alcohol from wood and crop byproduct sources including stalks, leaves, and straw have proven difficult and uneconomical.

The best alternative for preparing liquid fuels from biomass sources is thermochemical gasification, which produces a synthesis gas consisting of a mixture of carbon monoxide, CO, and elemental hydrogen, H_2. The proportion of H_2 can be increased by reacting CO with steam (H_2O). The CO and H_2 can be combined in various proportions to produce a wide range of fuels including methane, gasoline, jet fuel, and diesel fuel. The fraction of biomass that is consumed to generate the H_2 required to make synthetic fuels, a process that generates one molecule of greenhouse gas CO_2 for each molecule of H_2 produced, can be greatly reduced by using hydrogen gas made by the electrolysis of water using renewable wind energy.

Other alternatives for energy production, conservation, and utilization are presented in Chapter 15. The most promising of these are summarized below:

- Use of water power without dams by means including turbines anchored in flowing river water and tidal energy sources.
- Generation of geothermal energy, especially from dry hot rock sources.
- Use of fossil fuels with underground carbon dioxide sequestration.
- Increased use of nuclear power with breeder reactors that produce more fissionable matter than they consume and destruction of long-lived fissionable radioactive transuranic elements such as plutonium by their use as reactor fuel.
- Conversion of rail systems from diesel-powered locomotives to electricity generated from renewable sources.
- Increased use of methane (synthetic natural gas) made from biomass sources as fuel for motor vehicles
- Storage of energy from intermittent renewable sources by means such as pumping hydrogen gas made by electrolysis of water into underground storage sites

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