16
A definition of energy

The concept of a subscience of energy economics is presented in some detail in Chapter 21. Since engineering is an applied science founded to a major degree upon the basic science of physics, engineers tend to think as applied physicists. A natural consequence is the tendency to seek exact definitions when addressing engineering problems.

This chapter will consider the seemingly parochial problem of defining "energy." Doubtless, there are few engineers who do not know what energy is; just as there are few Americans of any walk of life who must even stop to think of what energy is as they listen to energy-related news reports or read endless references to energy shortages, crises, and related problems in the daily newspapers.

Most engineers will probably think back to the fundamental definition in introductory physics: "energy is work or the capacity to do work."

Energy is capacity to do work

Those with a less technical background will form mental images of energy, which take such diverse forms as gasoline for the family car, warm homes in winter, cool homes in summer, electric bills, gas bills, active children in constant motion, etc.

Whether one relates to the fundamental physics definition or the less structured concept, our society has managed to develop a frightening dependence upon the energy potential stored in the earth's nonreplenishable resources without the benefit of exactly defining the source of our dependence. Partially, as a result of this, we find ourselves in the midst of an energy consciousness that has been called everything from a crisis to a mere situation and which has generated the expending of literally tens of millions of man-hours and billions of dollars in discussions, studies, research projects, etc., resulting to date in numerous documents drafted and published ranging from policies, standards, and guidelines to federal, state, and municipal laws.

Other definitions of energy

After reading a number of these documents, it becomes evident that if the classical definition were applied to the word energy as used therein in the legal context, it would likely be thrown out in the lowest court. Let us then consider a definition of energy as it might relate to the so-called popular movement of energy conservation or the science of energy economics. A brief scattering of some readily available sources reveals the following definitions (or lack thereof) of the word, energy.

- *Webster's Dictionary:* "capacity for performing work."
- High school physics text: "the capacity to do work."
- Engineering thermodynamics text (Stoever): ". . . the something that is transferred to or from a system: a) when work is done on or by the system, and b) when heat is added to or removed from the system."
- Introductory economics text (Samuelson): no definition.
- State of Minnesota Legislation HF No. 2675, an act relating to energy: no definition.

From this brief sampling, it is seen that little has been done to define energy beyond the basic physics definition. Yet, when we start discussing energy in terms of energy economics or energy conservation, most will agree that we are addressing the conservation of tangible things—not simply forces, distances, and relative temperature levels.

Stored energy must be converted

Considering the concerns of energy resources available to mankind, starting at the practical source, all energy on earth emanates (or emanated) from the sun in the forms of nuclear and thermal energy transmitted in mass migration with the formation of the solar system, or on an ongoing basis by radiation waves. Following many centuries since its formation, the earth has stored a given amount of the original mass migration energy in relatively fixed or limited quantities. This stored energy is available for conversion to useful forms, generally through chemical conversion processes, then through the first law processes (building heating and industrial thermal needs), or second law processes (transportation, electrical power generation, refrigeration, shaft power). It is these sources that are the rightful target of so-called energy conservation efforts. Few would deny that efforts in energy conservation do not relate to reducing the energy available from the sun, the tides, or the human energies of mankind.

Conservation reduces use rate

Thus, efforts at energy conservation are actually efforts at reducing the *rate of use* of the limited or finite-energy-producing potential stored within the earth. All attempts at the control or reduction of energy usage or consumption should therefore address a definition of energy relating to this consumption or depletion of the nonreplenishable resources of the earth regardless of the quantity that is stored. Any finite quantity will eventually be depleted.

Consider then the following definition of energy as it would relate to energy conservation efforts, energy economics, or energy policies: *"Energy is the potential for providing useful work or heat stored in the finite resources of the earth."*

Although it may appear that the various available forms can be totalized by reducing to a common denominator, such as the potential heat content (say, Btu), the study of energy economics must take into account the available quantity of each form, and the convertible use for the given forms by the current state of the art technology.

The resources, within the current context of known technology include three general forms (which could be further subdivided): fossil fuels, nuclear, and geothermal. Other chapters address the issue of the value of the various forms in which the resources are found.