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## Energy transportation

A fundamental study of the phenomena of energy transportation is an essential ingredient to any comprehensive development of future energy policies, the optimization of energy-related parameters in end use systems, or sources to serve these systems. Energy transportation has been utilized for centuries, but previous developments have been the result of an immediately available supply to satisfy an immediately available demand. In many cases, the transport phenomena have been confused with the terminal use requirement or the source form. This chapter simply presents an overview of the concept of energy transportation as food for thought.

The first category to be considered is that of transporting the energy from its source through various stages of processing or conversion and then to the consumer or user. Only the current state of the art will be discussed initially. This category includes:

- Bulk or batch transportation of raw materials, such as coal ore and uranium ore; crude petroleum liquids or gases; processed solid fossil fuels; refined nuclear fuel; various grades of liquid petroleum products; gaseous fuels liquefied for transportation effectiveness or efficiency; gaseous fuels in gaseous phase; dry wastes for processing as fuel; and fuel processed from dry wastes.

- Electromagnetic wave transportation of solar energy to the earth's environment.

- Steady-state conduit flow (pipeline) of crude petroleum products to points of refinement or use.

- Pipeline flow of refined petroleum products to either distribution stations for transfer to other transport systems or into distribution piping systems and processed natural gas to distribution system storage and piping systems.

- Distribution piping system transport from storage or primary pipelines to user entities and distribution of various forms of manufactured gas to user entities.

- Transportation of electric energy from generating stations either directly to user entities or to use entities via network transport systems.

- Two-phase transport fluid systems, such as steam systems, that convey high-level thermal energy from a central conversion plant to user entities or refrigerant systems that convey low-level thermal energy from a user entity to a refrigeration plant.

- Single-phase transport fluid systems, such as high-temperature water or other thermal fluid, that convey high-level thermal energy to a user entity or low-temperature chilled water or other thermal fluid that conveys low-level energy from the user entity to a refrigeration plant.

### User entity

The process needs or thermal environmental devices within the user entity (building or plant) can use a variety of energy forms. Also, the transport systems available to the site generally provide a choice of the forms available to satisfy the user needs. Usually, all the various process needs within an entity are not best satisfied by the same form of energy, and the same available form is not necessarily best suited to all the various process needs. Thus, based on the relevant parameters, a system designer or analyst must determine the form best suited to the needs of each individual process, the form(s) of energy available for purchase that could best serve the needs, the proper conversion system(s) to employ, and the method(s) of transport or distribution that is most effective between the point of entrance to conversion and, subsequently, from the

point of conversion to the product. These subsystem parameters, although intimately interrelated, should be considered on the basis of individual merit.

The transport systems available within a building include:

- Single-phase high-level distribution, such as hot water or thermal fluid.
- Two-phase high-level distribution, such as steam.
- Single-phase low-grade high-level transport systems, such as condenser water systems or energy transfer systems for heat pumps.
- Two-phase low-grade high-level transport systems, such as refrigerant condenser circuits—hot gas and liquid.
- Single-phase low-level distribution systems, such as chilled water or thermal fluid.
- Two-phase low-level distribution, such as refrigerant suction vapor.
- Electric energy distribution via electrical conductors.

This chapter does not include a complete discussion on the relative features of each of these alternatives. However, the systems designer should thoroughly investigate the advantages and disadvantages of each of these distribution forms. Basic considerations should include: parameters of investment cost of both the distribution system and the interface at the process or terminal and at the

source, flexibility for changes in source form, distribution system efficiency or energy effectiveness, maintenance requirements (and costs), and adaptability to future system growth or modification.

Although the energy transportation systems to the user entity are not of immediate concern to the systems designer, they are of paramount importance to society and its business institutions in the future. The ramifications of energy transportation must be considered in depth by corporate decision makers in both energy industries and the user facility industries and by policymakers at all levels. Energy is a resource; most forms are both depleting and highly localized in nature. Thus, the transport concept is the key to future viability of both local and national economies.

Perhaps it is the recognition by many that the universal distribution of solar energy directly to the user entity negates the need to address this complex problem and is thus responsible for the appeal of solar energy. Others have recognized the limitations of solar availability due to limited flux density and, consequently, have turned to the conceptual development of such transport systems as laser beams and extremely high-density electromagnetic radiation to address our transportation needs of the future. Until such times as these are developed to the demonstration stage, however, our needs must be satisfied by optimum utilization of current technology in conversion and transport.