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A total energy system is a means for providing all of the varied energy requirements for a total plant from a single fuel source. This report evaluates some of the factors which are related to the development and use of total energy systems. The factors include--(1) initial and ultimate size of plant, (2) type and source of fuel, (3) sophistication of the system in the specific fuel, (4) rate of change for energy requirements in total plant, (5) availability of technical personnel to operate plant, (6) ability of organization to employ and retain such technical personnel, and (7) location of system and safety implication. The discussion mentions the conditions and limitations on installation of total energy systems, and stresses the questions to be resolved before making a commitment to this type of system. A list of questions which were raised after the presentation is included. (MM)

TOTAL ENERGY SYSTEMS

BASIL L. HICK

Probably all of you know what the topic means, but for those who have been unable to keep up with this aspect of facilities planning, I would like to define the topic as follows:

A total energy system is a system which provides all of the varied energy requirements for a total plant from a single fuel source. The various energy requirements with which an educational facility must be concerned include heating, cooling, lighting, and power for motors.

The stated objective, as reported in most of the literature for the total energy system, is to develop mass produced energy systems that will pay for themselves in annual fuel savings by on-site generation. Obviously, the initial cost of such an installation will be higher than the conventional method of taking care of energy requirements—thus, the long-term look. This, incidentally, is the approach we ought to use on all aspects of planning, from surface finishes to flexible partitions. However, this immediately raises a difficult problem in many districts throughout the country where bond issues are subject to public vote and thereby affected by ever-increasing pressure to keep initial costs down. Moreover, people quite often have a difficult time making judgments on new approaches to education. Thus, it might be difficult to introduce a mechanical system which is new and has proponents and opponents among the engineers.

To me, this concept is not an entirely black or white issue in all plant programs. Before a decision can be made, pro or con, about a total energy system, there are certain factors which one must evaluate. Among those factors are:

1. Initial and ultimate size of plant
2. Type and source of fuel
3. Sophistication of the system in the specific fuel
4. Rate of change for energy requirements in total plant
5. Availability of technical personnel to operate plant
6. Ability of organization to employ and retain such technical or professional operators of such a system
7. Location of system and safety implications

Size of Plant

The first factor mentioned, that of initial and ultimate size of plant, could very quickly decide the issue, particularly if we were considering a neighborhood elementary school on a limited, unexpandable site. It might not be as quickly decided, however, in the case where the initial unit of a community college is being constructed. This would be particularly true if such a facility were located in a rapid growth area and were located on an adequate site which would allow for a considerable increase in enrollment. According to present studies, the minimum requirement for a T.E.S. system would be for a 3,000 kilowatt installation.

Type and Source of Fuel

The source and type of fuel is a factor which cannot, in my opinion, be quickly decided. The types which are now used are generally limited to natural gas and oil—No. 2 through bunker C. However, there are other fuels which should be considered. Obviously, a nuclear submarine has a total energy system which uses neither of the fuels now used in educational total energy systems. Some of the public utilities are operating power plants which use nuclear fuel.

While we try to forecast the fuel we might use in the total energy system, we might pause and give some thought to an observation by Dr. Elliott of Pittsburgh, which seems to indicate that, although the trend of fuels historically has been from coal to oil to gas, there now is some trend back to liquid fuel from coal.

It might be said, however, that once you install a total energy system, the chances are you will be tied up for years with your source of energy and, thus, might be quite inflexible for individual changes.

Sophistication of the System in the Specific Fuel

Although the common fuels of gas and the various grades of oil seem to indicate there is much sophistication within these fuels, the other possibilities as an energy source for such a system, namely, nuclear and liquid fuel from coal, are being investigated from many aspects. Nuclear fuel source is involved in much experimentation; as a result, developments have taken place in the use of this fuel which have resulted in the power plants becoming obsolete before the structure which housed the plant was complete. This point has been made numbers of times with the nuclear submarines. This might be all right for a public utility or for a defense installation, but I believe research and experimentation in this area would be a dangerous practice for an educational institution.

The amount of money spent on research by educational institutions is less than one percent of their total budget, on a nationwide basis. In fact, an estimate in 1960 seemed to indicate that only about 1/200 of the amount of money spent on education could logically be assigned to research. Experiment for research in industry frequently runs to 10 percent of their budget. Thus, it would be my feeling that any experimentation done by an educational institution be directed toward the improvement in the quality of education.

In adopting a total energy system, it seems to me that we are tied up for years with heating design, cooling design, lighting design, and power design. Thus, from a flexibility point of view, there are many limitations. Even though fairly sophisticated systems have been developed in some energy fields, the fact that these are still changing at an ever increasing pace should demand that the whole problem be given thorough consideration before a decision is made. We should not find a lot of schools equipped with either incandescent or fluorescent fixtures being lighted with luminous walls and ceilings which might be activated by radar beams.

Rate of Change for Energy Requirements in Total Plant

Today is a time of rapid change, not only in the educational field but in all other fields. I expect that there were changes even when our schools were heated by wood and lighted by candles, but at this time changes in fuels, as well as within fuels, seem to be more rapid. To fix on any one fuel or a system within a fuel might be hazardous. I have already mentioned the developments and the rapidity of these changes which have taken place in the nuclear field, as well as what seems to be a trend possibly back to a liquid fuel derived from coal. Even after one has decided on the source of energy, the type and form for transporting the energy to the appropriate place is rapidly changing. So also are the components developed to use the resulting energy. For example, some of the voltage requirements in a school such as 110, 208, 220, 277 or 480 which are necessary to provide energy for lights or motors have been developed in recent years. Thus, power requirements for lights, motors, ranges for school lunch programs, refrigeration from thermo-electric units, and higher frequency

utilization are but a few items one must consider and must try to predict the future of before settling on a total energy system. It should be noted that utility companies cannot agree among themselves as to voltage utilization, frequency utilization, transformer locations, transmission and distribution systems. The energy requirements for all structures, schools included, are jumping by leaps and bounds. In 1896 it was generally recommended that a .4-foot candle be provided for classroom lighting (incidentally, this is about the level which some people want for note taking for educational movies). Now, of course, you know that school people are saying the minimum desirable is 70-foot candles. I won't go into quality or other measures used for determining lighting. The fact is, however, that more energy is required to provide light for tasks to be done in schools. Moreover, with the expansion of the school lunch program, energy requirements have been increased.

Nowadays we hear more and more about the year around school. In New York State this past summer we had approximately 350,000 students enrolled in public elementary and secondary schools. If we believe that a correct thermal environment is necessary for better production and learning, we obviously should include air-conditioning in the basic structure. This, of course, should not be planned only for schools which are used during the summer. It should be provided, and can be justified, on the basis of degree days in many states for schools following the traditional 10-month program. Again, in New York State, it is estimated that approximately 40% of the days in which schools are in session the outside temperature is high enough to require cooling in order to maintain a reasonable indoor temperature. Our schools usually start just after Labor Day and finish the last week in June. Cooling obviously adds another energy requirement.

The installation of computers, electrical office machines, learning laboratories, sophisticated instruments and/or machinery in the vocational, industrial or technical shops adds considerably to energy requirements.

Since in New York State, we have approximately 20,000 classrooms in schools which are over 50 years old, you can see that in some schools we keep custodians busy fanning the switch boxes to keep them cool or changing blown out fuses because circuit breakers were non-existent when these buildings were constructed. It really isn't this bad, but it emphasizes the energy requirement change during the life of a building.

Availability of Technical Personnel to Operate Plant

At a time when many organizations require a high school education as one qualification of a custodian, it seems to me that the problem of obtaining competent people to run a total energy system is one to which careful thought should be given. Even though some of the literature seems to indicate that these are push-pull systems, one needs to recall the number

of people necessary to keep the vending machines operating at the World's Fair or the number needed to keep automatic elevators running, to realize that competent personnel are necessary. Engines have to be overhauled, systems must be balanced, electronic devices must be maintained. These are but a few of the personnel problems to be faced when considering a total energy system.

Ability to Employ and Retain Technical or Professional Operators

Public institutions, historically, have lagged behind private industry in salaries; thus, the need to acquire and retain competent people in this area is a real one. In the comparatively new field dealing with computers, districts are essentially acting as training agencies. The people they get to run their computer programs are soon offered, and generally accept, positions in private industry just about the time they become competent in the eyes of the educational institution. It seems that this same possibility would undoubtedly exist with people who would be trained and responsible for the operation of a total energy system in a school.

Location of System and Safety Implications

Since throughout the United States the various school districts operate under different building and safety requirements, the location of such an energy converter and the safety implications should be investigated closely. For example, in New York State, such a system would have to be located in a separate building because of the use of a high pressure vessel utilization and because of the use of high pressure gas. Obviously, if other fuel sources were used, this would not be a deterrent to the location of such a converter within a conventional school in New York State. It is generally agreed that there is an acoustical problem involved with these systems and, as a result, the location again would demand careful thought and planning, either in the actual location so that the sound could be isolated, or in the construction so that the noise could be reduced to an acceptable level. One should not assume that noise can be controlled without proper planning.

I have tried to stress caution in this paper. School districts, because of the varying and peculiar problems they face, have requirements that differ considerably from all other types of organizations. Hence, I believe that we should take a long forward look, before committing ourselves to a total energy system.

The discussion that developed after the presentation centered around the following questions:

1. *Should the Council encourage research on total energy systems especially in those systems currently in operation?*
2. *What is the responsibility of industry in the area of research on fuels and total energy systems?*

3. *What is the anticipated life span of equipment now in use and how can this equipment be economically updated or replaced?*

4. *Can the power rate be changed depending on use especially as it may be affected by change-over to other power sources?*

5. *Why consider a total energy system if adequate power sources are available at reasonable cost?*

6. *Can the energy already available as a by-product be redistributed and reused elsewhere in a plant?*

7. *Under what conditions is it economical to install a total energy system?*