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Designing an energy efficient school

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California State College
San Bernardino

DESIGNING AN ENERGY EFFICIENT SCHOOL

A Project Submitted to
The Faculty of the School of Education
In Fulfillment of the Requirements of the Degree of
Master of Arts
in
Education: Administrative Services Option
By
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INTRODUCTION

Energy conservation is of paramount importance to schools. In an era of shrinking revenue and spiralling costs, there are few areas where schools can make significant reductions. Salaries, fringe benefits, supplies, lunch programs, insurance, and transportation are expenses which are subject to minimal cost-cutting because of legal requirements, contractual obligations, and general public expectations of such programs as being necessary concomitants of the educational program.

One expense that can be substantially lowered is money spent on utilities. By means of new architectural design and modification of existing facilities, savings can be realized in energy usage. Energy conservation in general, and in relationship to education specifically, is a recent phenomenon. More and more engineers and architects are speaking and writing to the issue of energy savings in educational buildings, however, and not so much from the desire to effect savings that can be realized in school budgets, but primarily from the knowledge that school energy consumption comprises a large part of the total electricity and gas used nationally.

It has been found that "one-third of all energy used by our nation is consumed in operating institutional buildings.

Educational facilities are the largest group of institutional buildings."[1] Thus, in schools alone, the "potential for saving our finite resources is immense."[2]

"In a typical school it is possible to save as much as 15 percent of utility costs through common-sense actions without any appreciable capital expenditure."[3] Even more energy can be saved with some wise investment in energy-efficient facilities and equipment. According to Federal Energy Administration estimates, a "building owner may expect to save 10 to 20 percent more with an investment which can be paid back in savings in three to ten years."[4] The British Columbia Department of Education concurs that 'most school districts can reduce energy consumption by 20 percent which can be attained at a cost that would pay for itself in one to two years."[5]

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[1] Donald F. Burr, "Creating Energy-Efficient Buildings" (Atlanta: Paper presented at American Association of School Administrators' annual meeting, February 1978), p. 3.

[2] Council of Educational Facility Planners International, Energy Sourcebook for Educational Facilities: An Authoritative and Comprehensive Sourcebook for the Design and Management of Energy Efficient Educational Facilities (Columbus: Council of Educational Facility Planners International, 1977), p. 3.

[3] Department of Energy, Energy Audit Workbook for Schools (Washington: Office of State and Local Programs, 1978), p. 6.

[4] Thomas V. Tiedeman, An Energy Conservation Retrofit Process for Existing Public and Institutional Facilities (Washington: Public Technology, Inc., 1977), p. 2.

[5] British Columbia Department of Education, Energy Conservation for Schools (Victoria: British Columbia Department of Education, 1978,) p. 8.

It is the purpose of this paper to discuss the various methods available to school facilities to conserve energy and the costs and savings involved. To accomplish this, the paper will first delve briefly into the history of architectural ideas regarding energy-saving measures that are still useful today. Next, various energy sources will be discussed, both past and future ones, with emphasis on solar power, and how it and other means can be utilized in school plants. Types of organizational plans for implementing energy programs will be analyzed. Then, specific recommendations for existing facilities will be studied, followed by those for new facilities. Finally, an energy education program will be considered followed by a checklist of energy-saving methods.

CHAPTER I

HISTORY OF ENERGY-SAVING ARCHITECTURAL CONCEPTS

Much of the technology for building modification is not new but rediscovered concepts utilized in the past and applicable to an energy-conscious present. During most of recorded history, man considered climatic conditions when designing buildings. Snow, wind, and heat influenced the pitch of roofs, size of windows, and location of entrances since man was at the mercy of the elements.

Egyptians constructed thick, windowless walls and flat stone roofs to ward off the heat. Door openings and roof slits allowed the sunlight to penetrate. The Greeks built porches as protection against sun and rain, an idea which the Romans used in gardens and courtyards in their semi-tropical climate. They later borrowed other architectural ideas to develop the first central heating system. A few centuries later northern Europeans built larger window and door openings to admit light and used steep roofs for drainage of rain and snow, while in the south windows were smaller and roofs flatter. Shutters were used, doors of English cathedrals were situated towards the southwest and sheltered by porches, and trees served as windbreakers.[6]

Colonial America acquired many of these architectural ideas which were adapted to the climate and materials available here. Schools established in the United States in the

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[6] Ralph J. Askin et al., <u>California School Energy Concepts</u> (Sacramento: Bureau of School Planning, California State Department of Education, 1978), p. 1.

mid-1880's used similar construction methods of other buildings in the area, beginning with the one-room school and later the multiple-story structures that dominated school architecture through the 1930's. Great strides in heating, lighting, restrooms, and fire safety were made. The design remained basically the same, however, until 1935 when the low, sprawling plants were built which introduced the functional, conform-controlled schools of today.[7]

The technological changes brought about by the industrial revolution freed designers from concerns of the past. Climate could be disregarded in favor of mechanical cooling and heating systems. The capability of controlling the indoor climate artificially enabled designers to ignore the demands of nature that formerly were considered. Trees, shutters, walls, and building orientation no longer constituted an important factor in design. As technology allowed man to regulate the environment, the more sensitive he became to variations in lighting and temperature. Lighting requirements became very stringent and air-conditioning, which at one time was a luxury, became commonplace in the schools.[8]

Now, with the energy situation so pressing, architects must again take into account the techniques for climate control developed and used in the past. They must consider

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[7] Ibid., p. 2.

[8] Ibid., p. 3.

climatic conditions so that dependence on scarce and expensive resources can be lowered. Insulation, directional orientation of windows and entrances, landscaping, and utilization of solar power can result in major reductions in our reliance on traditional energy sources.

CHAPTER II

ENERGY SOURCES: PAST AND FUTURE

Just a century ago, the primary energy sources were wood, water-power, and windpower and had been since ancient times. Wood was by far the most important source, supplying three-quarters of the total fuel supply of the United States.[9] By the mid-1880's, however, coal had replaced wood as the primary source of energy, supplying about half of the country's needs. Water was also an important source of power for industry as was windpower important to both agriculture and manufacturing. As fuel demands grew, these sources were no longer sufficient. Rivers and lakes were often not located near industrial centers, and wind-power was inadequate for the growing industrial needs.

Since huge deposits of coal had been discovered and could be transported easily by the new rail system, coal continued to furnish as much as one-half of the supply until after World War II[10] when oil and natural gas took its place. In 1947, oil and natural gas supplied the same amount of energy as coal.[11] The nation was self-sufficient in oil since the exports and imports nearly balanced. Since then, usage of coal has stablized while natural gas and oil consumption has increased greatly, due in part to imported oil. By 1955,

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[9] Sam H. Schurr, Energy in the American Economy: 1850-1975 (Baltimore: John Hopkins Press, 1976), p. 31.

[10] Ibid.

[11] Charles J. DiBona, "U.S. Energy: Yesterday, Today, and Tomorrow" (Williamsburg: Seminar presentation to New Members of 95th Congress, Jan. 8, 1977), p. 4.

liquid and gaseous fuels were accounting for two-third's of the energy supply.[12]

The country began depending more and more on imported oil to meet the demands. "All projections ...show imports of six to twelve million barrels per day in 1990, compared with about seven million" in 1976. "But if price controls aren't removed, if demand projections are understated, if the economy grows faster than projected, imports could be higher---as much as 70 percent."[13] According to figures from the Federal Energy Administration, as of November 1, 1977, there were 2,596 oil days remaining.[14] So, at the current rate of consumption, the known reserves of domestic oil would last until the end of 1986.

The cost of fossil fuel has increased dramatically. The cost of utility coal rose because of increased transportation and refining costs. Utility oil has increased because the shift was made from "high-sulfur residual oil to the more expensive low-sulfur oil."[15]

Since 1964 "there have been sharp increases in virtually every component of electricity costs."[16] Rising construction

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[12] Schurr, p. 35.

[13] Di Bona, p. 15.

[14] Burr, p. 8.

[15] John Fischer, Energy Crisis in Perspective (New York: John Wiley and Sons, 1974), p. 133.

[16] Michael S. Macrakis, ed., Energy: Demand, Conservation and Institutional Problems (Cambridge: MIT Press, 1974), p. 348.

costs, higher interest rates, lower labor productivity, licensing problems, and more stringent environment regulations are all to blame.

The total technology needed to exist without petroleum and natural gas is not available today, according to Burr. It is, therefore, essential that existing supplies of these energy sources be conserved to extend their lifeline. It is also imperative to consider alternate sources of energy. The most practical to date is solar. "In one year the radiation that reaches the surface of the continental United States exceeds the total amount of fossil energy that will ever be extracted."[17] About three percent of the land now used for agriculture would be required to furnish the nation's total yearly energy needs.[18] Fischer states that it is clear that solar energy resources are more than adequate for supplying the world with energy, although they may not be the least expensive.[19]

Most schools are "naturally suited for the installation of solar equipment" because they are usually well-constructed, have flat roofs suitable for solar collectors, and have their peak energy demands during the day which reduces the energy

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[17] Edmund Faltermayer, "Solar Energy is Here, but It's Not Yet Utopia," Fortune (February, 1976), p. 103.

[18] Fischer, p. 27.

[19] Ibid.

storage needs.[20] Many schools in the United States are using solar energy for water and space heating and cooling. Presently, solar energy is being utilized by several California schools because it is nonpolluting, inexhaustible, and available in varying amounts everywhere. The California Energy Commission in 1977 estimated that solar power could supply 8 to 12 percent of California's total energy needs.

Solar energy has its disadvantages which include undependability, low concentration, and an initial expensive cost for installation of collection units. Even though solar energy is present everywhere, it is often obscured by cloudiness and fog. Such conditions require collection panels which store the energy and allow it to be used when the sun's rays are not present. Back-up alternate fuel sources are also required.

Even with its disadvantages, solar energy will play an increasingly important part in the lighting, cooling, and heating needs of schools. Savings on fuel costs will pay for the initial conversion expense from traditional fuels to solar power. With an abundance of sunshine, southern California can benefit from solar energy more than most other areas. Reliance on back-up systems should also be less.

Concerning the applicability of solar energy to heating, both passive and active systems are utilized for this function.

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[20] Gregg W. Downey, "Some Sunshine for Your Fiscal Life: Solar Energy Schools May Not Be as Far Off or as Blue Sky as We've Thought," American School Board Journal 164, 8 (August 1977), p. 57.

> An active solar system uses mechanical devices---pumps, fans, or motors---to move the sun's heat to the interior of a building or to storage areas. A passive system uses natural means---gravity, convection or radiation---to do the same thing.[21]

The main component of an active system is the solar collection panel. The panel is usually made of metal coated on the outside with black paint to increase its absorption and is undercoated with insulation so that it retains heat. Collection panels should be placed on south-facing roofs to receive the maximum amount of sunlight. Water tanks or rock beds then receive and store the heat until it is needed. These tanks are located underground for insulation purposes. When needed, the stored heat is transferred to the heating system.

Active solar energy systems are good for school use because energy demands are at their highest during daylight when sun is available. Schools have large hot water requirements for showers and kitchens, so solar heat could be utilized to satisfy, at least partially, these needs.

Initial costs for active systems are higher than those for traditional energy systems. Operating and maintenance costs, however, are much lower, so investment costs can be recovered after a few years. For example, a feasibility study requested by the school board of Florida, New York, showed a projected fuel savings of 35 percent a year so that by 1986,

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[21] Askin, p. 7.

their $80,000 investment will have paid for itself.[22] Grant money is often available for energy conservation programs.

Burr feels that even though solar collecting devices may not be installed immediately, it is essential to modernize or design buildings so that solar systems could be added in the future. Thus, heating and plumbing systems should include connections now to which solar systems may be added later. Provision for space collectors and storage tanks should also be made.

Passive solar heating relies on the absorption of the sun's winter rays by the building's double-glazed windows. Thick walls and roofs retain the heat and radiate it throughout the room during the evening and night when the temperature drops.

Another passive system that is more complicated is described in <u>California School Energy Concepts</u>. Solar panels carry heated air or water to the storage system to be utilized in the building at a later time. When either active or passive solar systems are used, alternate heating systems must be available. During overcast days or poor weather, solar systems obviously will not function.

Water heating and air conditioning can also be accomplished by the use of solar energy. Solar panels filled with water absorb the sun's warmth, and that water is either sent

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[22] Downey, p. 58.

directly to the water storage tank or is transmitted through a heat exchanger coil in the tank to heat the stored water.

In the case of air conditioning, equipment that is used in natural gas refrigeration units is powered by solar heat rather than a gas flame. Such units work best on hot days when it is really needed. The solar panels are very sophisticated and thus relatively expensive. In hot climates, however, the initial investment will be offset by expected major increases in both electrical and gas rates.

In addition to the use of solar power for heating and cooling, it can also be utilized to produce electricity, although no method is currently in operation. One method now being researched, solar thermal conversion, involves steam produced by solar heat to generate electricity. A second method is photovoltaic conversion, which is the conversion of sunlight directly into electricity as solar cells. The Department of Energy is attempting to reduce the price by the mid-1880's, so it is a possibility for the future.

Wind power is another possible source of energy. By the year 2000, practical wind-driven power plants could generate enough electricity to meet nearly 20 percent of the United States' electrical needs.[23] The California Energy Commission estimates that 9 to 15 percent of the state's electricity needs could be provided by wind power by 1996.[24]

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[23] Energy Conservation: Understanding and Activities for Young People (Washington: Federal Energy Administration, 1975), p. 5.

[24] Askin, p. 10.

Advances in engineering design and improvements in storage methods are needed before that amount can be produced, though.

Nuclear power plants are another potential source, although problems, including high construction costs, do exist. Oil shale is still another source, but an acceptable method of rendering oil from shale will not be available until the late 1980's. Perhaps as much as 100 billion barrels are available in Colorado, Wyoming, and Utah.[25]

The creation of artificial fuels is also being researched and may be the fuels of the future, along with energy from the ocean, breeder reactors, and nuclear fission. Time is needed for more research, however, so in the meantime the options to schools are limited to what is currently available: chiefly, the utilization of solar power, and modification of existing buildings or new, energy-efficient designs.

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[25] Ibid., p. 11.

To implement an energy-saving program in the schools, several sources suggested various organizational plans. The first step in conserving energy in the schools is to form an energy conservation team. Included on the team should be the superintendent, principals, maintenance and transportation supervisors, teacher and student representatives, business manager, and a district-wide energy coordinator responsible for administering the program.[26]

The next step involves planning for the development of district energy usage. This would include determining assignments of duties and responsibilities, energy audit methods to be used, and consultations with energy experts. Then a building-level task force, consisting of school personnel and students and community, is formed to implement the district-level programs. The district-level conservation team then would collect the energy-use information or "energy audit" on each school from monthly reports in order to monitor the district plan.

A more theoretical organizational plan was developed by the Council of Educational Facility Planners which calls for the formation of a "Management Committee" to fulfill policy-making responsibilities for the program. This committee would consist of board of education members, superintendent, district energy manager, district facility planners, public

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[26] British Columbia Department of Education, p. 4.

CHAPTER III

ORGANIZATIONAL PLAN FOR ENERGY SAVINGS

relations personnel, office staff and energy experts. The energy plan is developed and implemented by the "Energy Conservation Team" composed of principals, teachers, parent and student representatives, maintenance and transportation supervisors, and outside energy consultants, and headed by the district energy manager who provides the status and authority necessary to assure the success of the program.

This team "should have operational authority over all aspects of energy management"[27] and is directly responsible to the policy committee. The team should have extensive in-service training in order to collect data and assess energy needs and develop goals and programs. Then building-level task forces are formed to carry out the activities prescribed by the conservation team.

The plan suggests three questions for evaluation purposes: Are the task force activities being implemented and to what extent? Are the activities meeting the stated program objectives, and did the objectives accomplish the program goals?

Another plan suggested by the British of Columbia Department of Education eliminates the committees and uses only an "Energy Conservation Manager" to run the program. This could be any interested person: a teacher, board member, administrator, maintenance man or someone from outside the school system. The energy manager would first calculate the

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[27] Council of Educational Facility Planners, p. 73.

total energy used by each school by using energy consumption sheets: one for electrical consumption, one for gas, and a third that calculates both total energy used and the school's rating on an energy-use index which takes into account the outside temperature.[28] The electricity and gas sheets take the amount of Kilowatt hours used and divide it by the school's area, thus giving the figure for the average amount of KWH used for one square meter of space.[29] Then, an energy survey or audit by experts is undertaken to find ways of using energy more efficiently through good management, adequate maintenance, and energy-efficient equipment.

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[28] Ibid.

[29] Ibid.

CHAPTER IV

RECOMMENDATIONS FOR EXISTING FACILITIES

As far as existing facilities are concerned, little can be done about their location, shape, and direction. Steps can be taken, however, to conserve energy. Some of these suggestions may not be applicable to some schools or may necessitate changes to meet individual schools' needs. Factors such as different geographical locations, weather conditions and types of building design must be considered when developing an energy-saving program. Before implementing any conservation measures, it is necessary to determine if the plant has air cooling, if it is mechanically ventilated, if the design will permit insulation or if it is even necessary, and what academic features may be affected if physical changes are made.

Some ideas may be expensive, but a district that can afford to pay fuel bills for inefficient consumption can afford to make repairs that will more than pay for themselves in energy savings. It is important to seek expert advice before authorizing major remodeling, purchases, or maintenance. It is also necessary to train the maintenance staff so they will be able to operate equipment properly and efficiently. Equally important is establishing a preventative maintenance program so equipment will be clean and operate properly.[30]

"Quick-fixes" can help, but redesign and modification, i.e. retrofitting, will be the long-term answer for existing facilities since it is the most practical approach right now.

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[30] Askin, p. 20.

The building energy retrofit process is divided into four work phases and has been used on many projects. Phase I involves "review of current energy consumption and selection of the most promising facilities for retrofit." Phase II centers on "detailed engineering and architectural study of potential energy conservation modifications." The third phase concerns "implementation of desirable retrofit changes," while the last phase is "monitoring of energy savings achieved and aggressive follow-up maintenance programs."[31]

The second phase is especially important since energy usage for equipment within buildings is highly interrelated. Modifications in any major component can affect the operation of other components. Only after a thorough study of the facility as a whole can the best set of retrofit modifications with the highest payback be chosen.

As far as the cost is concerned, Phase I is fairly inexpensive and also rapid, so without having spent much money, it can be determined whether to continue with conservation efforts. Some low-cost savings methods identified in Phase I can be implemented immediately, which will save money that can then be used to pay for Phase II, the engineering study which is of moderate cost. The implementation phase involves a significant financial commitment. The

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[31] Tiedeman, p. 5.

monitoring phase is of minimal expense to the district but is of importance since it provides program results, assures that the savings are being realized, and provides accountability for energy uses.[32]

When management has continued to emphasize energy conservation, retrofitting has often saved from 10 to 30 percent in energy consumption. When retrofitting is used, management has generally expected a payback period of one to seven years. Savings show much variation depending on variables: acceptable payback period, percent of energy savings, and financial commitment to retrofit.[33] Overall, for low cost retrofit (below .15 per square feet) facilities have obtained savings of from one percent to just under 25 percent in energy costs.[34]

Retrofitting involving higher capital expenditure (between .30 and .90 per square feet) yields savings from eight to 80 percent, with most cases falling between 15 to 40 percent. Examples include: Greenfield Community College with 32 percent electrical savings at a payback of 1.6 years; Bunker Hill Community College with oil consumption savings of $33,330 and electrical savings of $34,909 per year with a payback of 1.3 years.[35]

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[32] Ibid., p. 13.

[33] Ibid., p. 46.

[34] Ibid., p. 48.

[35] Ibid., p. 49.

As shown in case studies, retrofit of public buildings for energy conservation can be successful. It has produced significant energy conservation savings with quick payback and continuing yearly savings. Problems can develop and must be monitored closely, however.

Some steps that all existing schools can take with little expenditure involved include: removal of unnecessary lights, setting thermostats at 68° in winter and 78° in summer,[36] painting roofs and outside walls with a light, reflective color to reduce heat gain; shading exterior walls and windows, replacing glass windows with insulated walls, and installing night set-back of the heating system.

Other inexpensive suggestions are checking automatic controls to see that they are working properly, turning off unused equipment and minimizing use when possible, adjusting warm-up time of building to outside temperature, using lock thermostat controls, using drapes wisely according to the weather, and reducing ventilation to minimum required by code.[37]

Other minor-cost recommendations include turning off unused lights, reducing light level to minimum requirements, eliminating display lighting, cleaning light fixtures frequently, and servicing air-conditioners and heaters regularly.[38]

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[36] Askin, p. 22.

[37] Ibid.

[38] Ibid., p. 23.

Minor expenditures regarding savings in transportation include purchasing fuel by the truckload to obtain discounts, ordering large quantities of parts to obtain the lowest price, using the most suitable and energy-efficient buses available, encouraging efficient driving methods, planning routes to reduce idling-time, eliminating staggered-dismissal times, encouraging bicycling, walking, and car-pooling;[39] scheduling regular maintenance, eliminating overlapping routes, avoiding dead-heading, and contracting with parents in remote areas.[40]

Inexpensive suggestions concerning water include reducing temperature to 90° to 120° except for dishwashing, turning off unused showers, repairing leaky fixtures, and turning off gas pool heaters.

As for suggestions involving major expenditures, their initial cost may be high, but it should be remembered that it is an investment that can be repaid in energy savings in a few years. As part of the federally-funded "Saving Schoolhouse Energy" project, ten United States elementary schools underwent a "comprehensive engineering analysis" to determine areas of potential energy savings. Recommendations were made for each site ranging from $1,000 to $80,000 with an average of $25,000. The amount of energy savings was projected at

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[39] Ibid., p. 24.

[40] Ibid., p. 25.

an average of 50 percent at all ten sites.[41] The most frequent suggestions, and the ones with the quickest recovery rates were to lower outside air intake to minimum requirements and to adjust various controls. Other suggestions included modifying the building envelope such as insulating and weather-stripping and decreasing glass surfaces, and modernizing boilers and ventilation systems. Still other major expenses would be to replace inefficient equipment, install heat recovery systems to reuse waste heat, reduce glass areas, install spark pilor lights, shade windows, install solar systems, and maximize landscaping.

Major lighting expenditures would include replacing incandescents with fluorescents, which are three times as efficient and provide more illumination and better quality of light. In some instances, it is possible to adapt flourescent luminaires to existing fixtures. Usually, the incandescent fixtures need to be completely removed and flourescent lights installed. Although the initial investment is costly, it repays itself in reduced electrical bills within several years.

During the past twenty years, public buildings have often been supplied with excessive lighting. Lighting

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[41] American Association of School Administrators, Public Schools Energy Conservation Measures: Management Summaries (Washington: American Association of School Administrators, 1978), p. 6.

specifications should be designed with optimum illumination necessary for the tasks to be performed by the occupants, but once the optimum limit has been attained, the excess lighting is wasteful. On the other hand, a reduction in lighting below the optimum level can be counterproductive. Less than adequate lighting can result in less productivity by students and employees and reduced accuracy. Savings realized by reduced lighting can also be offset by increased heating costs.

Use of natural light saves power needed for artificial illumination and also lowers cooling loads since it does away with heat build-up caused by lights. Although natural light reduces the usage of artificial light, the latter must still be provided and at times uses less energy than the heating or cooling required because of heat transmission and infiltration via windows and skylights.

Until recently, mercury vapor lighting has been a favorite means of illuminating outdoor areas. Less costly in energy usage and just as illuminating are high intensity discharge lamps, which are high pressure or sodium halide illuminaires, used for gymnasiums and exterior areas. Again, while initial change-over costs are expensive, within three years the energy savings pay for the initial installation.[42]

Photocell units are an efficient means of controlling outdoor illumination. Outdoors, they can be used to turn on

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[42] Alan R. Meyers, "Better Lighting with Less Energy," <u>American School and University</u> 52 (September, 1979): p. 31.

lighting when daylight diminishes to a certain level, and indoors they can be used for fixtures near windows.[43]

The installation of additional switches allows one to control light usage more efficiently. Usually one switch regulates one bank of lights. This is wasteful since one or two lights may suffice for a particular task. Multiple switches permit as much or as little illumination as is required.

Major transportation expenditures would include replacing buses and cars with the smallest and most economical vehicles possible, and installing two-way radios to redirect buses when necessary.

In regards to water, installing water restrictors on shower heads and master control on showers, and solar collectors to heat water or pools all involve major cash outlays.

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[43] Ibid., p. 32.

CHAPTER V

RECOMMENDATIONS FOR NEW FACILITIES

While we have seen that there are many methods to conserve energy in an existing facility, there are far more means available when designing a new school plant. Many states have established energy regulations pertaining to buildings which have to be met when designing new buildings or modernizing existing ones.[44] In California, for example, the new standards contain the legal requirement for energy efficiency of the building skin or "envelope" (i.c., roofs, walls, and floor), heating, ventilating and air conditioning systems; lighting, and water system.[45] Burr believes that "we have the technology for energy conservation design available to us today to further reduce energy use by another 40 to 50 percent" above minimum state standards.[46]

Compliance with the regulations can be shown by architects and engineers with two methods: component performance standard, which means completing compliance forms and satisfying energy efficient criteria for each component, or by energy budget standards which involves calculation of the annual energy usage of the building and demonstrating that it will not exceed the maximum permitted annual energy consumption. Increased cost due to compliance will increase fees by about 0.3 percent of the cost of the facility while construction costs will probably increase by 3 percent.[47]

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[44] Burr, p. 6.
[45] Askin, p. 12.
[46] Burr, p. 6.
[47] Askin, p. 13.

Because of the need to become more efficient, architects are now rediscovering many of the techniques for climate control which have existed since ancient Egypt, such as building design orientation, shading, and site selection.[48] The latter is a major factor since climate affects different sites and buildings with varying severity depending on location, topography, winds, vegetation, and nearby structures.

Energy consumption is also affected by the orientation of a building. For instance, a rectangular building absorbs less solar heat if its longest side is positioned in an east-west direction. A building using a solar system should be situated so that the collector panels face south; a building utilizing breezes should be positioned to obtain the most air flow. Another possible recommendation is building into a slope or using earth berms to reduce heat loss and provide cooling.[49]

As far as design is concerned, no special advantage was found for any plan, whether campus, configuration or finger; and it is doubtful that one design would be suitable for all climates. It is recommended that an engineer work with the architect, that self-shading building shapes be used, and that external shading be considered since it is more effective than interior shades.

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[48] Ibid., p. 3.

[49] Ibid., p. 14.

Architects must also consider the building's shape. Because heat is gained or lost through walls and roof, reducing these surface areas will lessen energy consumption. "A round building has less surface area in relation to interior space than any other building configuration."[50] A square building has less surface than a rectangular one and a three-story classroom wing has 35 percent less surface than a similar one-story building.

Burr states that a building which is nearly square will collect the heat that is produced from bodies and lights and which masses at the building core or middle of the square. The excess can then be collected and distributed to the perimeter for heating needs or else stored.

Ideally, in winter the building mass should be heated by the sun in the daytime and the configuration and insulation system should be designed so some heat will be retained during the night. Heat is released by the building mass to the rooms by convection and radiation during the day. In summer, the building mass should collect the heat generated by students and lights and then release it to the outside air at night by natural or mechanical ventilation systems. In addition, the water may be used to absorb the unwanted heat.

These heat recovery systems involve storage systems for wasted heat from kitchens, lights, boilers, computers,

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[50] Ibid.

and people. For instance, the collective body heat of thirty quiet students in a classroom could release 14,000 BTU's each hour.[51] Most of this heat escapes to the outside but often, enough will remain to require air-conditioning even in winter. Removing this energy and reusing it where it is wanted can save energy and money. If it is recaptured, it can be used immediately to heat or cool rooms or water, or it can be stored for use later. Burr believes that "not a single new building or renovation of an old one should take place without inclusion of such a storage system," even if it is not activated at present.[52]

According to him, there are three types of storage systems: water, rock, and eutectic salt storage. The advantage to water storage is that it can capture heat and store it in water for use later. Also, if the energy source is electric, it can be purchased at night when rates are much cheaper. Efficient heat recovery systems and storage areas could eventually make active solar heating systems unnecessary and traditional furnaces obsolete.[53]

In addition, a water storage system is useful because it can be directly connected to a hydroponic or water-based heating and cooling system. This provides a distribution system to transport the stored heat throughout the building.

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[51] Ibid., p. 16.

[52] Burr, p. 6.

[53] Askin, p. 16.

The piping system will thus be connected to the normal source, plus to the storage area in subterranean areas and also to the roof level for future solar devices. A collection, storage, and distribution system is thus provided via the hydro heating/cooling system.

Reclamation of waste water takes place in areas of heavy water use like showers. Warm water is collected in insulated storage tanks. Chilled water is pumped through the warm water via closed pipes. As it passes, heat will be transferred. A water chiller is used to transfer heat from warm water to incoming cold water. Eighty percent of heat that would have been lost is reclaimed.[54]

Another recommendation for school design is an on-site well with a heat pump system, which uses well water as a heat source in conjunction with a heat sink. Water is circulated through a heat pump in the building and returned to a second well, thus eliminating storage.

Landscaping is another important factor when planning a new facility. Deciduous trees for shade and evergreens for windbreaks are ideal but should not block cool breezes. Dark-colored pavement, which absorbs heat and radiates it to buildings should be avoided when possible.

Likewise, the darker the roof and walls, the more heat absorbed. In addition to heat absorption, heat also deteriorates the roof. Of course, in a cold climate where heating

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[54] Askin, p. 10.

is important, a dark roof may be preferred. The color of interior walls is also important since light-reflective finishes can increase illumination and thus reduce artificial lighting levels by 30 to 40 percent.[55]

Use of insulation which blocks heat loss in winter and heat gain in summer is one other way to prevent wasted energy. As mentioned for existing facilities, reducing the glass surface to the minimum required will reduce waste. Double-glazed windows roughly double the thermal resistance of single-glazed windows but are still not nearly as effective as replacing them with insulated walls. An engineer can calculate the light infiltration and assist the architect in this area. Double sets of outside doors and sheltered entryways can also be used to reduce energy loss in vestibules.

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[55] Ibid.

CHAPTER VI

ENERGY EDUCATION AND PUBLIC RELATIONS

The public schools have a double duty concerning energy conservation: to become energy-efficient themselves and also to educate the students to be energy-conscious themselves. They must help students "develop the skills, knowledge and attitudes they need to use energy wisely."[56] California's Superintendent of Education Wilson Riles said in 1977 that the quality of lives the students will live "is very much dependent upon the quality of the physical environment and the availability of natural resources," so that "we have a responsibility...to help students understand the need for wise use of natural resources."[57]

The energy educational program should not be tacked on to the curriculum but should instead be incorporated, when possible, into many subject areas such as science, social studies, home economics, shop, and mathematics. Included should be such factors as the distribution and utilization of natural resources, pollution of the environment, and technology. The program should also concern itself with social factors such as the effect of the energy crisis on national and international politics, economics, and values.

An energy education will also directly benefit the district since, if both students and staff are educated to the consequences of their energy-wasting habits, they can

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[56] California State Department of Education, "Energy and Water Conservation Suggestions for California's Elementary and Secondary Schools"(Sacramento: California State Department of Education, 1977), p. 1.

[57] Ibid.

then reduce the amount of energy lost through carelessness. As Riles wrote: "It is each school person's immediate and primary concern to take every reasonable step to conserve energy."[58]

A good public information program to explain what is being done and why is also desirable. Records on the energy savings should be kept and displayed to encourage students and staff to continue their conservation programs. Publicizing savings achieved demonstrates to the public that the energy program is designed to save the taxpayers' money as well as save energy.

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[58] Ibid., p. v.

CONCLUSION

Approximately one-third of all energy consumed in the United States is to heat and cool public buildings, the majority of which are schools. Since the country is quickly running out of its fossil fuel supply and energy costs are rising steadily, school districts need to consider implementing energy conservation methods as soon as possible, not only for local savings but also in the broader, national interest.

It is not necessary to wait twenty or thirty years for the technology to be developed to adjust building designs, as many people have concluded. On the contrary, there are many measures that can be taken immediately to reduce energy use. The implementation of these measures will decrease the amount of present-day energy consumed, thus conserving it for use later.

Whether it is for a facility which already exists or for a new one, there are plenty of options available to save energy. There are measures involving minor expenditures which will nevertheless produce savings both monetarily and energy-wise. Retrofitting of existing buildings involves a major initial expense, which repays itself, however, in reduced utility bills within a few years. Designers of new plants must consider such factors as the existing regulations, building shape and direction, landscaping, and insulation.

The addition of solar systems must also be considered for both existing and new facilities, even if they are not put into use immediately.

The combined total of all these suggestions is what produces an energy-efficient building, which is why an individualized organizational plan is necessary for each school district in order to implement the best energy-efficient suggestions for each particular plant. School districts simply cannot postpone any longer the adoption of an energy-conservation plan and the implementation of as many ideas available as is feasible to reduce their energy use as well as alter their energy supply.

APPENDIX

CHECKLIST OF ENERGY-SAVING MEASURES

District Administration
*Form energy conservation team
*Develop public information program
*Include energy as part of curriculum
*Life-cycle costing for major expenditures
*Inservice training for maintenance personnel
*Establish a regular preventative maintenance program
*Energy audit
*Hire private consultants

Equipment
*Turn off when not in use
*Minimize use
*Replace with energy-efficient models
*Size equipment correctly

Heating, Ventilation, Air Conditioning
*Set thermostats at 68° in winter and 78° in summer
*Adjust warm-up time to outside temperature
*Disconnect or lock classroom controls
*Use drapes and blinds wisely
*Lower ventilation to minimum allowed
*Educate concerning opening windows and doors unnecessarily
*Install heat recovery system
*Caulk, weatherstrip, and insulate
*Reflective film or double glaze windows
*Reduce glass area when appropriate
*Add economizer cycles to units
*Add spark pilot lights
*Shade windows inside and outside
*Solar system
*Maximize landscaping; minimize paving

Lighting
*Turn off when not in use
*Reduce to minimum requirements
*Eliminate decorative lights
*Replace with fluorescents
*Install local switches
*Paint walls and ceilings light
*Seven day clock timers

Maintenance
*Top operating condition
*Clean lights frequently
*Service air conditioners and furnaces regularly
*Doors and windows close properly
*Full-time maintenance specialist

Transportation
*Encourage walking, bicycling, car-pooling
*Use smallest vehicle for job
*Audit fuel use monthly
*Regular maintenance and tune-up
*Gas tanks locked and full
*Tires properly inflated
*Computer bus scheduling
*Eliminate route overlapping
*Centralize pickup points
*Eliminate staggered school schedules
*Eliminate dead-heading
*Train for better fuel economy
*Fill driver-training cars to capacity
*Reduce miles driven and speed for driver training
*Use simulators when possible
*Reduce field trips
*Share buses with other districts
*Replace with most economical vehicles possible
*Install 2-way radios to redirect buses

Water
*Reduce temperature to 90°-120°F except for dishwashing
*Turn off showers when not in use
*Repair leaking fixtures
*Turn off gas pool heaters
*Install water restrictors on showers
*Install master control or timers on showers
*Install solar collectors to heat water

Source: Askin, p. 19-25.

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