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ABSTRACT

An energy task group of the American Institute of Architects discusses design features and options that educational facility designers can use to create an energy efficient school building. Design elements cover the building envelope, energy storage system, hydronic heating/cooling systems, solar energy collection, building orientation and shape, on-site well with heat pump system, and waste water heat reclamation system. Additional considerations examine design temperature adjustments and natural ventilation such as use of wide band thermostats, lighting reduction, unoccupied space shutoff, and skylights. Final comments address central monitoring equipment, use of double doors on main entrances, the benefits of underground buildings, use of wind generation to facility power needs, low temperature room placement on the building's cold side to conserve heating needs, flow restrictors on water sources, greenhouse use, and the use of extract-air windows. (GR)

1 ENERGY CONSCIOUS DESIGN

JULY 1983

ONE OF A SERIES OF BRIEFS PREPARED BY THE AMERICAN INSTITUTE OF ARCHITECTS NATIONAL COMMITTEE ON ARCHITECTURE FOR EDUCATION

ADDRESSING WAYS AND MEANS OF REDUCING COSTS IN THE DESIGN AND DELIVERY OF EDUCATIONAL FACILITIES

ENERGY CONSCIOUS DESIGN

EDUCATIONAL FACILITIES

COMMITTEE ON ARCHITECTURE FOR EDUCATION
THE AMERICAN INSITITUTE OF ARCHITECTS

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PREFACE

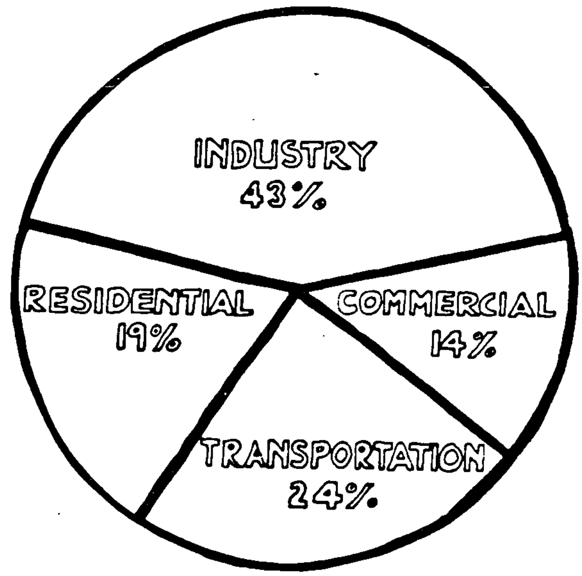
The need for architecture to respond to the energy crisis has started a period of great change in building design. New approaches in the conceptual design of buildings will have the greatest impact on our profession since the beginning of the Industrial Revolution. It is a privilege, as well as a great challenge, to be an architect at this milestone in the history of architecture.

In looking back at the educational facilities we have designed, particularly in the past 25 or 30 years, the conditions and criteria of the time has changed. "Cheap Energy" was a major influence in the design of school buildings. The mechanical systems of the time were technically and economically appropriate responses to the existing criteria. School buildings made little effort to conserve energy, in fact at today's standards are considered "energy gluttons".

In early history, enclosures were simple, using natural forces for space conditioning. As building technology progressed through the years, it moved away from the simple solutions of ancient history and continuously reflected more technological sophistication to fulfill rising expectations of comfort and performance. Advances in mechanical and electrical technology made controlled comfort conditions possible. More highly sophisticated work tasks initiated the demand. One's livelihood was generally achieved outdoors in the daylight behind the plow and oxen.

Advances in various mechanical environmental controls and artificial lighting essentially severed our simple dependence on natural forces. The use of this technology and these conveniences lead to a tremendous rise in modern Americans' expectation of their environments.

The creation of these expected environments and maintenance of the desired comfort conditions within them has been and still is, in most cases, being accomplished with the expenditure of vast quantities of energy. The great and urgent need to conserve our finite energy resources makes it mandatory for us to reduce energy use and re-examine how buildings should be designed.

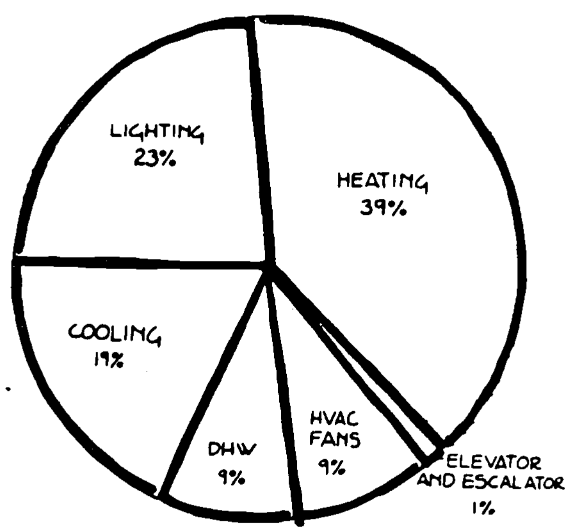


TOTAL ENERGY USE BY U.S.

An important aspect of the architects' design process is his awareness of the importance of the overall building budget, not simply isolated costs. The total price of an automobile can be a simple analogy. There are thousands of parts in an automobile; some are expensive, others are not, yet all are necessary to produce a well-designed, efficient machine. A building is similar. It is important that it be constructed within a predetermined realistic budget. Committed to this idea the owner and architect must face squarely the issue of energy usage giving it a higher priority in the heirarchy of design issues.

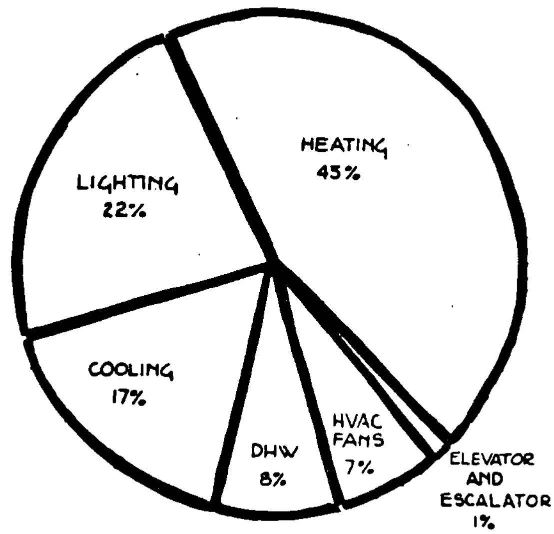
Society today has appropriate technology needed to design energy-efficient facilities. Many of these design techniques have been available for a long time, and simply have not been used. The owner and design profession have been so totally oriented towards the concept of an endless supply of cheap energy that they simply did not bother with energy conservation in the design of educational facilities. The emphasis has been in achieving high levels of comfort with pleasing aesthetic design.

There is much that can be done. Reports from A.I.A., N.S.F, D.O.E. and others indicate it is possible to reduce energy consumption of almost every existing building in America 25% - 30% if energy conservation design adjustments are made. In the case of new buildings, they are being designed to use only a small fraction of the amount of energy that buildings have been permitted to use in the past within the same budge parameters.



ELEMENTARY SCHOOLS

A new building properly designed ought to certainly use less than 50,000 Btu's of energy per square foot per year. It is not possible to generalize completely because the use of energy in a building is related to the building's function and its regional location. The use of a building has an impact on the amount of energy consumed. New office buildings should not use more than 25,000 - 30,000 Btu/SF/YR of energy. Existing buildings should not use more than 50,000 - 60,000 Btu/SF/YR of energy.



SECONDARY SCHOOLS

We have the technology: the use of energy conscious design techniques along with new forms of energy will greatly decrease the amount of energy consumed. Energy performance of buildings is an integral part of architectural design. Virtually every basic design decision affects energy conservation and cost. The interaction of non-mechanical (envelope, internal materials, etc.) with mechanical (heating, cooling and lighting systems) will be largely determined during the preliminary design process. One should not think of energy as the prime shaper of architectural form. Program, structure, physical and cultural context all inter-relate with energy considerations in creating building form.

Energy-efficient architetcure is developing a strong regional character in its architectural form. National and internationally the architectural character of buildings is changing. New structures are appearing that uniquely acknowledge the climatic and mocro-climatic conditions of the building site.

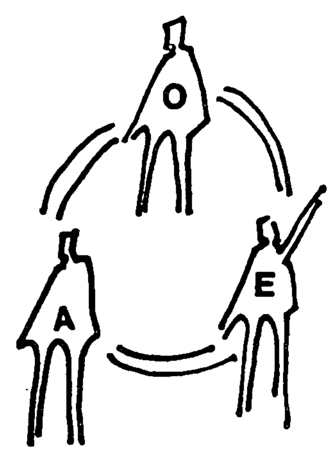
ENERGY CONSICOUS DESIGN PROCESS FOR SCHOOL FACILITIES

Energy-conscious design means that energy needs to become a part of the design process...that energy needs are carefully considered along with all other elements of design...that energy needs are considered equally and neither forgotten nor overemphasized. This is a most important point because while we are correcting one situation, it is important we do not let energy concerns dominate to a point where they take over and control. They must be part of the entire design proces.

Our design philosophy must include continuous and thoughtful concerns for the purchased-energy efficiency of our buildings. These concerns must be applied in our design process based upon adequate knowledge of how to achieve energy efficient architecture.

A point missed by many is that while reducing the purchased energy that buildings use does not necessarily change, to any great extent, the overall energy needs of a structure. In many cases the actual reduction is achieved by the maxiumum use of natural and cascading energies to provide the energy needs of the buildings. Natural energies; such as the sun, wind and daylight, used in cooperation with cascading energies such as internal excess waste heat and use of excess industrial waste heat (compatible neighbors) are joined together in providing 50% to 75% or more of all the energy needed by educational structures. This results in a dramatic reduction in the amount of purchased energy used.

It is natural that adjustments to the design process are necessary in achieving cost-effective energy-conscious design. An important adjustment is the architect/ engineer relationship. The challenge of achieving the best energy-conscious design requires close cooperation between the architect and the engineer from the beginning of the project. It would be a rare situation when an energy efficient building could be achieved by an architect or engineer alone. The intuitive thoughts of architects largely surround building form and shape, while engineer's thoughts largely involve machines and designs. It is the combining of these skills that will achieve the best cost-effective, energy-efficient buildings.

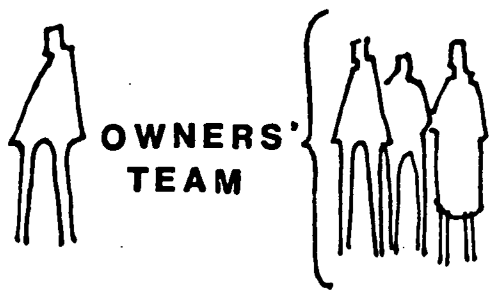


In the past, architects would often design a building with only minor mechanical or electrical engineering input. Communications with the engineers would almost be accomplished by a phone call. This old type of relationship is gone, and the new one requires the closest of cooperation between the architect and all the engineers from the very minute thoughts are beginning to take place concerning a new structure. The manner in which the architect manages the energy-conscious design process is the "key" to the success of an energy-efficient structure.

The role of the owner is of equal importance. The team that must start from the beginning involves the owner, the engineers and the architects. Maximum achievement in energy efficiency of a building can only be made when the owners and occupants of the building understand the design and manage the building in a manner to achieve maximum energy efficiency. Some of the early steps of the design process are altered to include new events in order to achieve structures that ultimately are higher energy-efficient.

A new cost effective process is the establishment of energy goals. Approximately 80% of all the decisions that will effect the energy efficiency of the building will be made in the first 10% of the design process. It is, therefore, absolutely essential that energy goals of the project be conceived, clearly stated and totally understood by the entire design team which includes the owner (see appendix for examples of energy design goals).

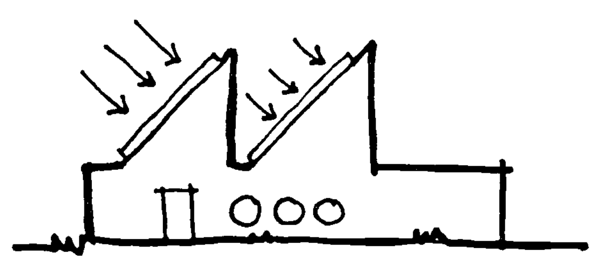
It is important to emphasize the need for the entire team of the architect, structural, mechanical and electrical engineer and the owner be involved in this process. The owner should be represented by more than one person and at the highest level. It is through the process of open dialogue in a joint session that cost effective, energy-efficient design is



going to be achieved and the reasons made evident. This conceptual approach develops a strong sense and understanding of what the design team is trying to achieve and how it is to be done. It truly establishes energy consciousness within the design team (owner, architects and engineers).

The design team must establish energy-design elements. These elements are specific items or techniques in the building design which will achieve the energy goals..such as use of extract-air windows, thermal mass, maximum daylighting, use of internal waste heat and many more. The conditions brought to bear in the design of a building to achieve maximum energy efficiency are varied. They must all work together in a very specific manner in order to achieve maximum energy efficiency. The form and shape of the building, working in concert with the machines and mechanical devices, achieves this (see appendix for list of examples of energy design elements).

It is important to comment on architectural beauty in relation to energy conscious design. Achieving the highest level of energy efficiency in no way has to preclude designing buildings of beauty. Often a building that is extremely energy-efficient will show no visible indication that it is different from any other structure. Today, we are seeing many buildings that overemphasize energy. The use of an old building shape in an attempt to make it energy-efficient with machines and devices seldom works. Buildings of the highest level of energy-efficiency should be quiet and graciously beautiful. If we examine some of the energy-efficient buildings of the past, we will see buildings with maximum architectural beauty as well as energy-efficiency.



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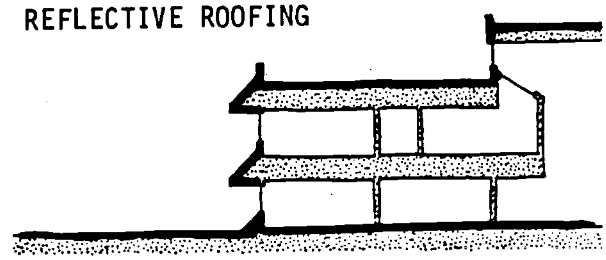
ENERGY DESIGN ELEMENTS ADAPTABLE
FOR EDUCATIONAL FACILITIES

BUILDING ENVELOPE:

A building may be thought of as a collection of elements, each performing certain roles in the general function of a facility. Elements such as heating, cooling and lighting require addition of energy to perform their functions. The building envelope consists of those elements (roof, exterior walls, and floor) which provide separation and protection from weather and other natural forces. The design of this envelope is immensely important in achieving an energy-efficient building. Many things can be done to improve the thermal quality of the building envelope, including: double glazing or triple glazing windows, earth berms, minimum fenestration on north or weather side, trees or vines on south, east and west sides, vertical fins on east and west windows, overhangs on south windows, etc. All these items can be used in various ways to make the building envelope more energy-efficient. Dramatic energy savings can be accomplished by carefully meshing together a proper selection of these elements for each building design.

BUILDING ENVELOPE DESIGN

R "20" WALL INSULATION
R "30" ROOF INSULATION
PERIMETER FOOTING INSULATION
INSULATING GLASS
PROTECTIVE OVERHANGS AND SHIELDING
VESTIBULE ENTRIES
REFLECTIVE ROOFING



ENERGY STORAGE SYSTEM:

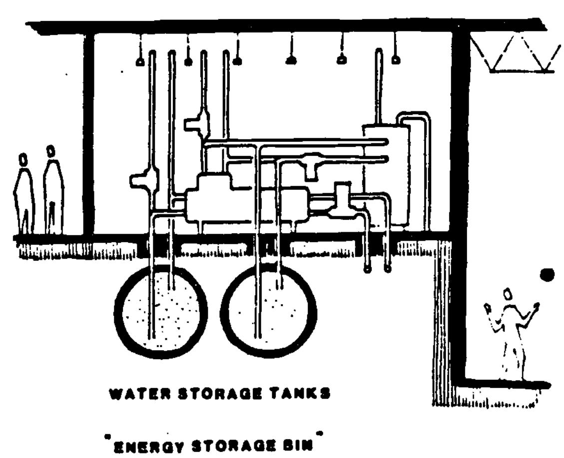
An essential ingredient in the design of a new building or modernization of an old one is inclusion of an energy-storage system.

If energy from the sun is to be collected and used, there must be a way to store excess energy for later use. Without a storage system, only direct use of the solar collection can be applied, which is minimum at best.

In buildings people, lights, equipment and computers may often be sources of wasted heat. High lighting levels and high concentrations of people contribute abundantly to waste heat in schools.

A typical well-lit classroom with 25 students generates approximately 20,000 Btu's of heat energy per hour. Most current schools waste this energy. In fact, they not only waste this energy, but they use more energy to cool this overheated classroom.

ENERGY STORAGE SYSTEM



If a school has an energy-storage system, this high concentration of heat can be collected and stored for later use. In many cases, this can be more heat than the school will ever need.

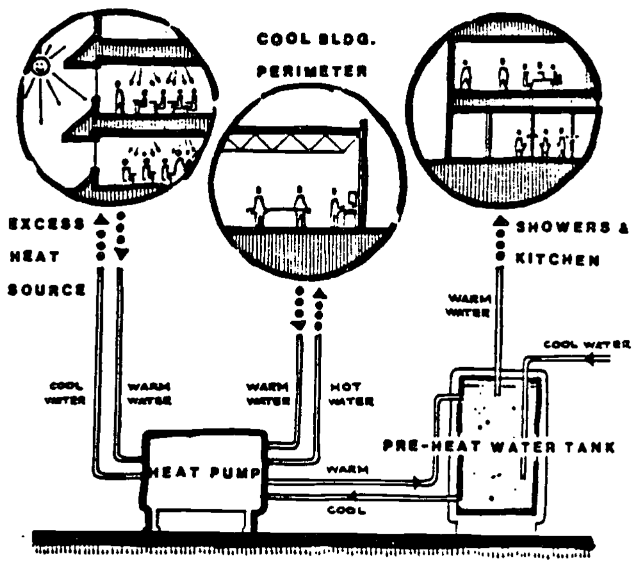
There are many advantages of a water-storage system. Heat can be gathered from those sources throughout the building that may be generating heat, then stored in the energy storage tank". Perhaps the structure is large and has a central core with excess heat that in the past would have been wasted. With water storage, this heat can be captured and stored for use at a later time. If the energy source is electric, the energy for heating can be purchased at an off- peak demand time, such as the middle of the night rather than 8:00 in the morning at high-demand time. This not only saves money because of less costs for electrical energy, but will also reduce the overall capacity needed for electric generating plants. This has a powerful effect on a national and international scale because total electrical generator needs are reduced.

Some buildings may work better with a forced- air system with rock storage. The principal concept of energy storage is the same (most adaptable to solar heat source of energy).

Eutectic salt storage is a more sophisticated storage medium. It is also the most costly, and we know little about its proven performance over a long period of time. It appears, however, to be a highly efficient means of heat storage.

Thus, a heat storage system is an essential element in the design of energy-efficient buildings. This approach may vary in priority depending on the region of the country or area of a state. This concept recognizes there must be sufficient "waste heat" to justify storage.

USE OF EXCESS INTERNAL HEAT



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HYDRONIC HEATING/COOLING SYSTEMS:

Using water as a means of storing and transmitting heat is an important energy saving concept. Once there is a storage system there also must be a way to transport stored heat throughout the building--in other words, a distribution system. It requires 10 times as much energy to move heat (or cool) in an air stream than in a liquid stream. Thus, a hydronic (water) heating/cooling system has many advantages.

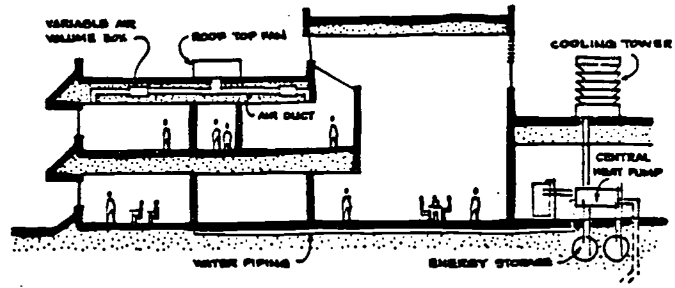
A water system makes it possible to use stored heat from storage often located at subterranean levels of the building. It is in this manner excess heat can be stored in water and then moved through the piping system to be used throughout the building where required.

The water-piping system will not only have its normal connections to its traditional source of energy, but also will have connections to water storage in subterranean spaces and the roof level for future solar-energy collection devices. Thus, a complete chain is established for energy collection, storage and distribution through the use of a hydronic heating/cooling system.

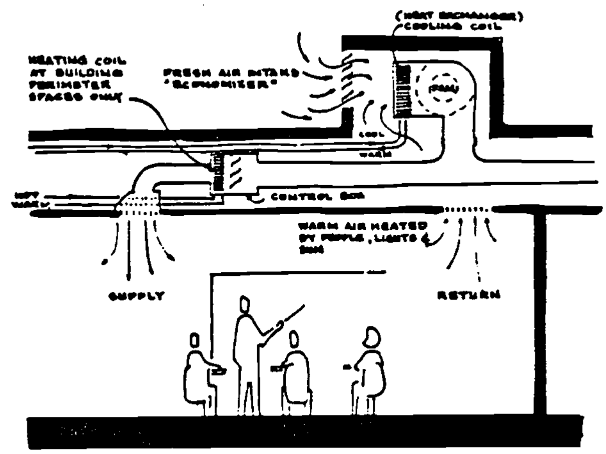
SOLAR ENERGY COLLECTION:

There are a variety of solar collecting devices on the market today. They are generally separated into two types: those that collect heat through a liquid system, and those that collect heat through an air system. There is much regional rhetoric about solar collection, which often tends to create the impression that solar collection is not practical in some areas of the country. The economic feasibility of active "solar collection" may for the moment seem out of reach in some geographical areas, but the "passive approach" (the use of the building itself as solar collector) will in most cases provide a viable alternative.

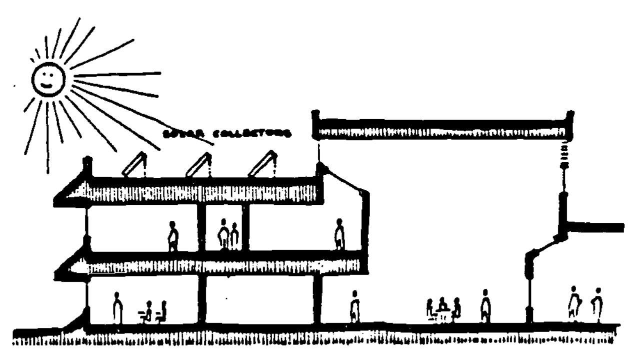
HEATING, VENTILATING & COOLING SYSTEM



HEATING, VENTILATING & COOLING SYSTEM



SOLAR HEATING & COOLING ADAPTABILITY



A confusing part of energy-efficient design is the concept that there are only one or two significant things that can be done to solve all the energy needs. This is simply not the case. An energy-efficient building can be achieved by doing many things. The combined total of these element brings about the dramatic and balancing achievement of a very fine energy-efficient structure.

Although many aspects of the energy problems do not have answers in the form of new technology, we do know much about design and operation of buildings utilizing energy-saving design practices, including solar energy.

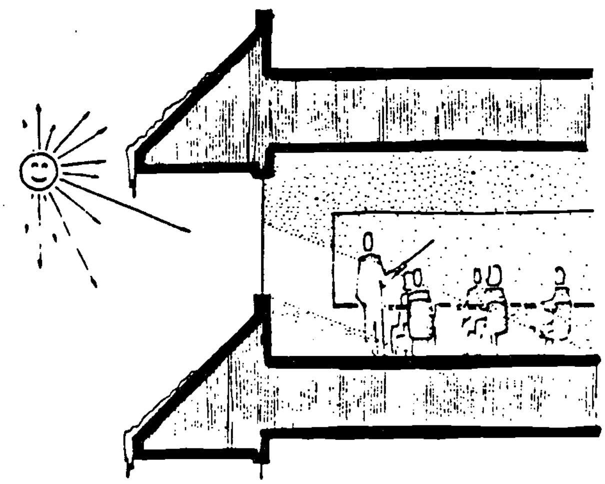
Economic considerations involving the use of solar collecting devices must be thoughtfully studied; however, it is essential that even though solar energy collecting devices might not be placed on new or modernized buildings today, designs should be such that they could be added in the future. The A/E design team should clearly determine what the energy issues are so that the proper solution is determined. For example: passive solar heating for classrooms in some areas of the country may not be effective--heating isn't the principal energy issue.

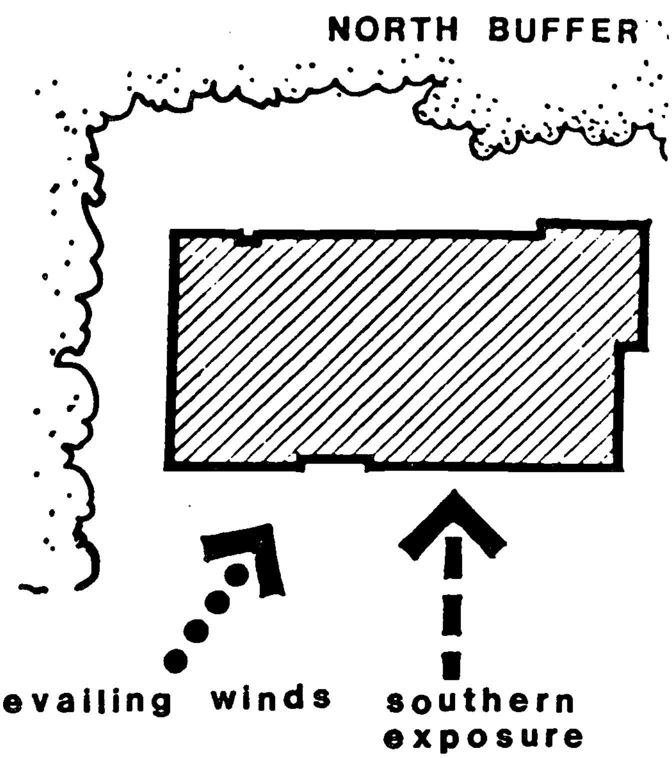
BUILDING ORIENTATION:

Some design features may seem self-evident concerning the orientation of a building on the site to conserve energy. In addition to these obvious areas, additonal site orientation study will often reveal further energy conserving features. Again, understanding solar geometry is essential. Require site survey information to include all aspects of solar conditions relating to the site. For example: True north, magnetic north, height of trees in the area surrounding the building, solar south, types of trees, solar plotting of sun, etc.

Another site feature is the use of earth berms. In the design of schools, using berms directly against the building often

DIRECT USE OF SOUTH SUN FOR HEATING "WARM" INTERIOR SPACES

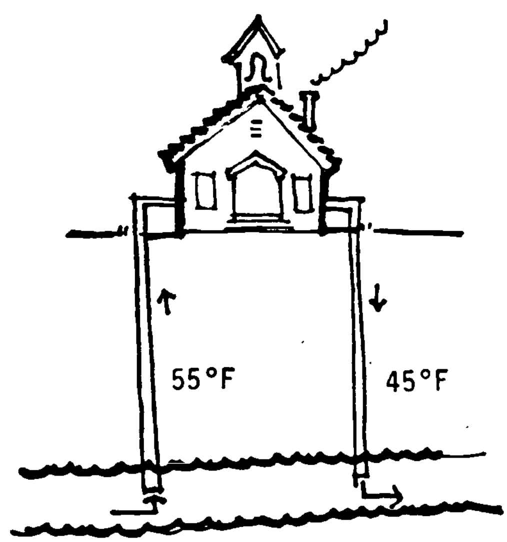




leads to heavy costs because of many required exits from the building. If the site is slightly rolling, serious consideration should be given to siting the building on a knoll to create a plateau for the structure. The actual berms in this case can be held some distance from the building where they will provide excellent wind breaks from colder winds, yet will not block entranceways or windows as desired in the main walls of the structure. Good water drainage can be obtained because of the location on the knoll.

ON-SITE WELL WITH HEAT PUMP SYSTEM:

The availability of ground water is an important item to check. If the use of wells are common in the area where the building is located, consideration should be given to use of an on-site well heat-pump system. Basically, the system consists of using well water as a heat source in cooperation with a heat sink to accomplish environmental needs.



WELL SYSTEM

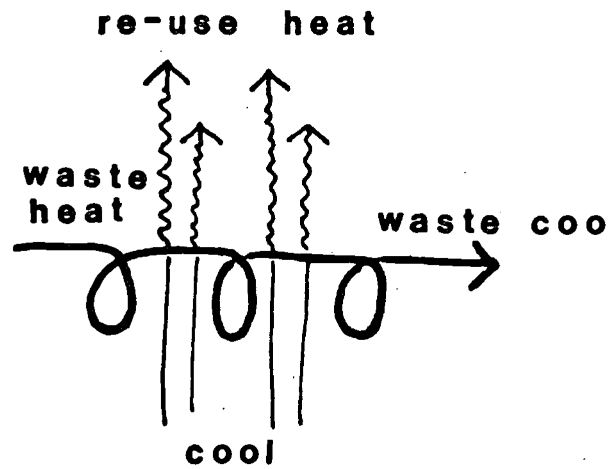
Two wells should be used located on the site near the building. Water is pumped out of the ground at approximately 55°F and returned to the ground ± 45°F in the heating season and ± 65°F in the cooling season. The water is circulated through a heat pump located in the building.

The reason for the second well is to reduce environmental impact. If everyone should carelessly use wells to heat and cool their buildings, it could change ground water levels and existing water table characteristics. Thus, an integral part of this system is the second well where water can be returned. The only environmental significance is that when heating, the water will be returned approximately 10° cooler and when cooling it will be returned about 10° warmer.

In this concept the well water (underground reservoir) becomes the energy storage system.

WASTE WATER HEAT RECLAIM SYSTEM:

It is important when studying the building to carefully construct, in a visible form, a model in which uses of energy are addressed. For example: in most high schools, approximately 25% of all energy is consumed to heat domestic hot water. With such a major portion of energy going toward this need, it becomes realistic to consider a way to reclaim heat literally going down the drain.

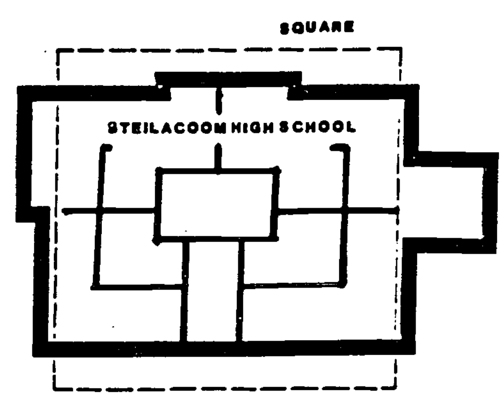


Reclaiming takes place in areas of heavy water use, such as showers. Basically, warm waste water flowing in shower drains is collected in an insulated water storage tank. Chilled water is pumped in closed piping through the warm waste water. As it passes through, heat will be transferred. A water chiller is used to transfer heat from the warm waste water to the incoming cold domestic water. With systems such as this, one can recover approximately 90% of the heat that would have been lost in waste water.

BUILDING SHAPE:

Educational facilities are unique because of the large occupant loads at one time. Students bring body heat into a structure. The educational process requires a reasonably high level of lighting; this also generates heat. By creating the shape of a building so that it is nearly a square, making a large central mass, (materials of high density-interior walls) it is often possible to literally capture all the heat needed for heating from within the building's core. This excess heat in the central core can be gathered and redistributed to the perimeter of the building for heating needs. Also, this heat can be gathered and stored in the building's storage system for later use if desired.

COMPACT BUILDING SHAPE



There is not doubt that simple building shapes with building mass have distinct possibilities for energy saving.

DESIGN TEMPERATURE ADJUSTMENTS AND NATURAL VENTILATION

Normal exterior design temperatures used for calculating heat loss will vary from region to region...while in the Puget Sound Area of the Pacific Northwest for example, use 15°F as the low design temperature and 72°F as the high. These temperatures are used to calculate equipment sizes. Actually outside temperatures of 15°F in this area are infrequent. Thus, it is reasonable to consider designing systems for an outside winter temperature of 25°F. The result is obvious--smaller equipment loads and less energy used.

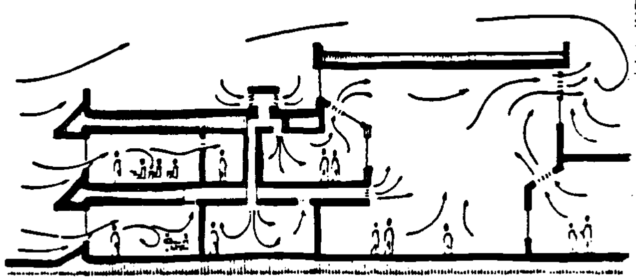
In the summer, it is quite possible to use 78° as the design temperature rather than 72°. There may be a few days when the interior building environmental conditions will not be perfect, but they will be tolerable. In almost every climate, some design temperature adjustments are possible.

Also consider the use of natural ventilation. In early history, enclosures were simple using natural forces for conditioning. Advances in various mechanical environmental controls and artificial lighting essentially severed the simple dependence on natural forces. Use of this technology and these conveniences has led to a tremendous rise in the clients' expectations of their environment.

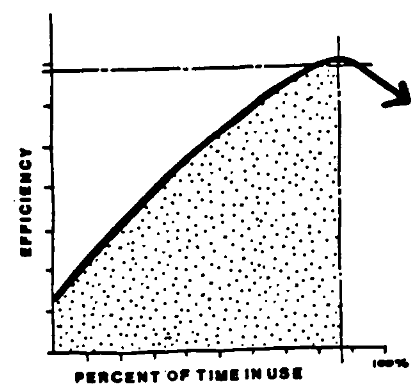
Creations of these environments and maintenance of expected comfort conditions within them have been accomplished with the expenditure of vast quantities of energy. The great and urgent need to conserve our finite energy sources makes it mandatory for us to reduce energy and re-examine how building systems should be designed.

Adjustment of design temperatures is a very logical thing to do.

USE OF NATURAL VENTILATION



DESIGN OF HVAC EQUIPMENT TO RUN AT HIGHEST AVERAGE EFFICIENCY

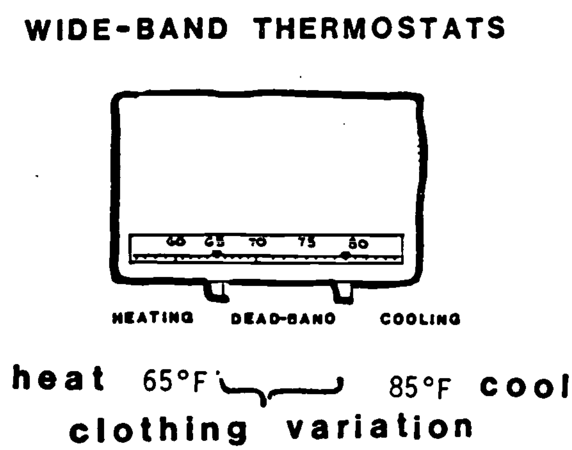


WIDE BAND THERMOSTATS:

Architectural history has shown that many buildings were designed without central heating systems. The building temperature was modified only slightly. For example: fireplaces in specific areas of a structure along with natural ventilation. People adjusted for the room temperature by layers of clothing such as sweaters, light jackets, etc.

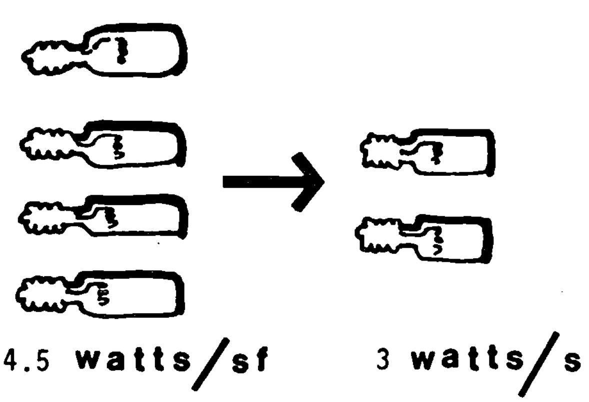
In today's man made environment, the expanding of the deadband range on thermostats from one to two degrees to six to eight degrees becomes an effective way to save energy.

Over the years, technology has become so exact that many new buildings keep heating, ventilating and air conditioning equipment operating almost continuously to maintain a given temperature. Many times, occupants are not nearly as sensitive as the equipment, and to expand the deadband (that portion of the time when the mechanical system does not need to operate), from one degree to six or eight degrees makes a tremendous difference in energy requirements. This is an excellent feature to embody in design concepts.



LIGHTING REDUCTION:

In most buildings, lighting is one of the major target areas for energy conservation. High lighting levels typically used throughout modern interior environments are very costly in energy consumption. High energy consumption results both from energy needed to operate lights and additional energy needed to cope with heat build-up caused by the lights. Often the need for air conditioning is forced because of the immense amount of heat generated by lights.



Further, adoption of other energy-saving design features can increase the seriousness of high lighting levels. For example: when the building envelope has been improved to provide outstanding protection from the elements, it also improves the structure's ability to contain heat. Thus, in the center of buildings, heat build-up of lights can be intolerable and often forces the need for air conditioning. Therefore, the return to more modest levels of lights is an important part of the energy-saving process.

There is no doubt that we must adjust how we provide light inside the buildings of America if we are to reduce their use of energy to acceptable levels. In building after building throughout our country, over 50% of all energy consumed in the building is consumed because of the lighting system.

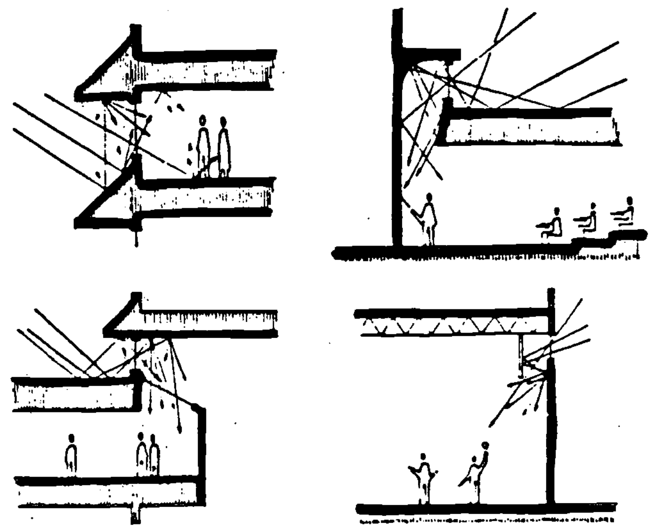
We have usually assumed that light should come from above. It is this way outdoors so it seemed logical to do the same indoors. This was a mistake, and we have paid a great price for the wasted energy. The days of simply placing endless rows of rectangular fluorescent fixtures in the ceilings of buildings is coming to an end.

Task/ambient lighting has developed rapidly in America. Indirect/ambient lighting is light that comes from a source faced upwards towards a light colored ceiling surface reflected back downward over the space. It is an extremely soft and beautiful form of overall lighting. It can provide a low level overall illumination of interior spaces in an extremely efficient manner. (Either by artificial or natural light sources).

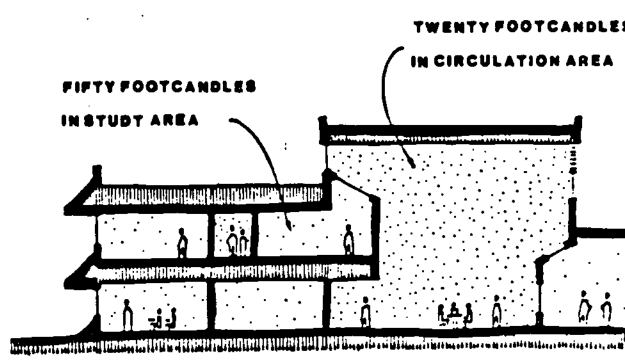
Task lighting is simply placing some form of light at a point where a task is being peformed. The quantity of light needed can vary greatly if the quality of light is appropriate for the required task. Higher levels of illumination are brought to task surfaces that need them, while reducing the overall room lighting level.

Often in the past, the quality of the light system was based upon the quantity

USE OF NATURAL LIGHT



LIGHTING REDUCTION



USE OF NATURAL LIGHT WITH PHOTO-ELECTRIC CONTROL OF ARTIFICIAL LIGHTING of light delivered. This was another mistake. What is important is the quality of light provided, not quantity.

Task/ambient lighting is a basic lighting concept that will become widely used in educational facilities of the future. This concept's impact on the quality of light generated is enhanced tremendously with the use of daylight and proper control systems.

UNOCCUPIED SPACE SHUTOFF:

When one leaves a room of a building, one uses a light switch to turn off the lights. The energy-saving concept suggested here is to broaden the idea of switching lights off and include turning off the entire building system for that area. This is a major energy conservation element for all educational facilities. Many schools are being heated when they are virtually unoccupied. It is suspected that large areas of educational space across the country is either heated or cooled when unoccupied.

Such a building design concept facilitates application of the unoccupied space shutoff feature. A building zoned into specific functional modules is used and in a broad sense each of these modules is a building within a building which is provided with a complete control system.

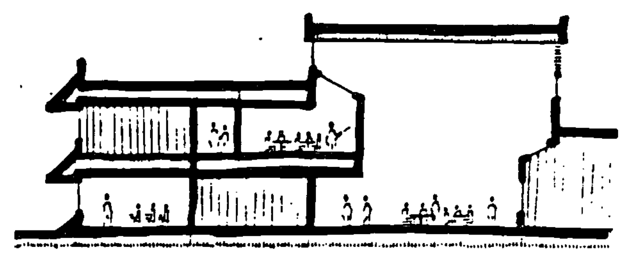
SKYLIGHTS TO REDUCE ARTIFICIAL LIGHT REQUIREMENTS

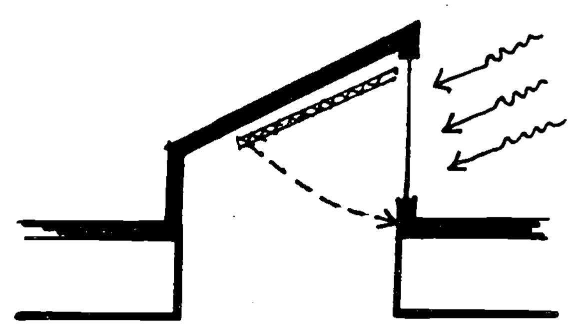
Double and triple glazed skylights with movable insulated closures should be considered in areas where energy use for lighting is high. The quality of the environment is enhanced with the mixture or daylight and artificial light.

It should be obvious that if used carelessly, the introductions of large areas of natural light may create greater energy loss than the energy savings gained from the use of daylight. Closing the

UNOCCUPIED SPACE SHUTOFF

MECHANICAL & ELECTRICAL





Insulated shutter

skylights in non-daylight hours is wise in most cases. In areas of extreme temperature variation, some form of thermally insulated closures for skylights may be a wise investment.

CENTRAL MONITORING OF EQUIPMENT:

A radio that is not properly tuned will not produce good sound. A car that is not properly tuned will not run very well and may consume more fuel than normal. Likewise, a building must be properly tuned in order to function efficiently.

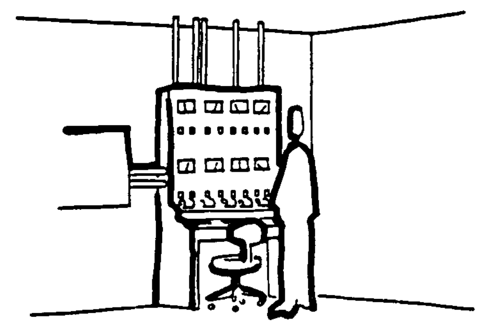
There are some elaborate and costly ways to monitor mechanical and electrical systems through the use of a computer. These systems are not always practical because of their heavy cost and sensitive operation. However, monitoring systems are available that are economic to install and simple to observe. These systems through electrical connections, keep track of mechanical equipment and indicate through visual and audio signals when a piece of equipment is not properly tuned. Central monitoring is an excellent energy-saving feature.

The level of sophistication of the maintenance staff may be an influence on the control and maintenance system design. Small rural schools, in particular, may be staffed by personnel unable to adequately utilize, operate or maintain a complex and sophisticated system. In such circumstances, simplicity may be the key note to efficiency.

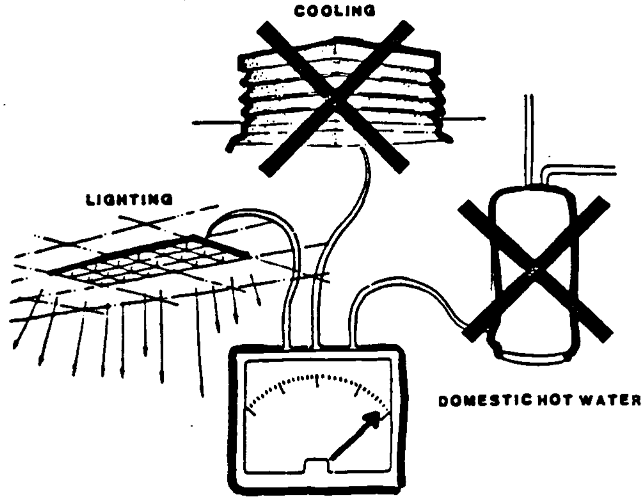
DOUBLE DOORS ON MAIN ENTRANCES:

The simple use of a vestibule can be an effective way to save energy in heating and cooling seasons. Often, the vestibule is not included in school design because it is a barrier to smooth traffic movement. The loss of this vestibule feature has caused an increase in the use of energy. It is simple and relatively low-cost way to conserve energy.

MONITOR CRITICAL ENERGY-CONSUMING DEVICES



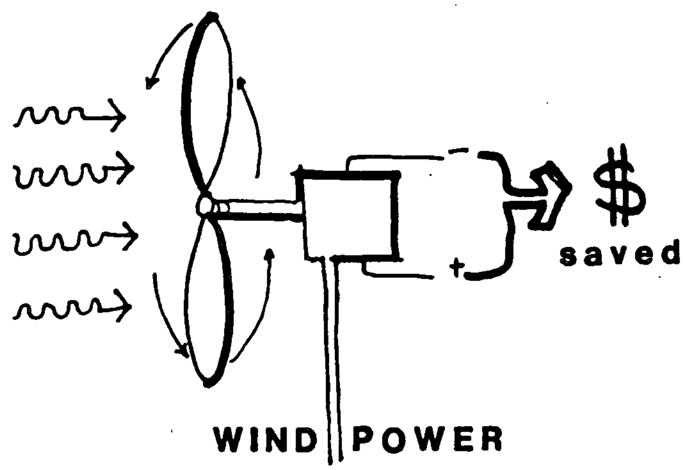
PEAK DEMAND CONTROL



UNDERGROUND BUILDINGS:

A properly buried building would maintain a constant temperature of approximately 56° regardless of outside temperatures. The results of energy savings are obvious. This way of saving energy must be a conservation item to consider.

Like many situations, an underground building is not always practical. Underground buildings usually have some windows. It is amazing what can be done with a few windows thoughtfully placed.



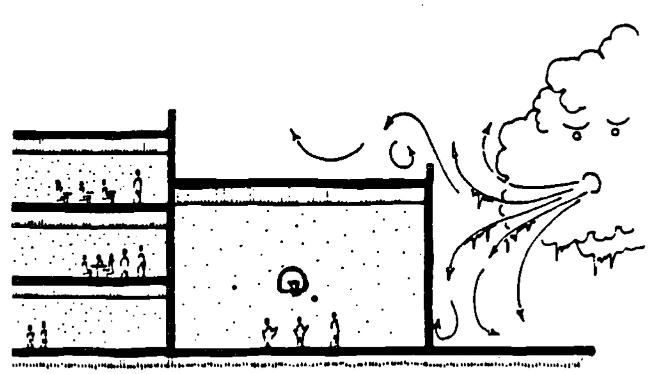
WIND GENERATION:

Wind generation can be used to generate electricity to run lights, or perhaps even easier, for heat storage. Naturally, wind conditions vary from location to location and from site to site. This is however, a viable means of adding another energy-conservation feature to a new or existing building. In the future, wind generation in some areas of the country may become more cost effective.

LOCATE LOW TEMPERATURE AREAS ON THE COLD SIDE OF BUILDING:

Often some areas within a building do not require the same degree of heating as other areas. Identifying such areas, and by placing them on the cooler side of a building, the side facing the prevailing wind, saves energy for heating. This is particularly true where it may not be possible to get full protection from cold winds. Thus, a rearrangement of functional areas within a building may bring about energy savings.

USE OF "COOL" INTERIOR SPACES FOR NORTH BUFFER



FLOW RESTRICTORS ON WATER SOURCES:

This is a simple way to conserve both energy and water. Flow restrictors are placed on faucets and showerheads. Tempertures can also be controlled to further reduce energy consumption.

GREENHOUSE USE:

A greenhouse can be used to provide heat for spaces in buildings. The use of glass enclosures has to be done with care because at times, the heat can become a distinct liability, unless there is a way to close it off. Double or triple glazed sliding glass doors can provide the necessary closure, yet let the beauty of the greenhouse be seen from the interior room.

Yes, a greenhouse is an excellent way to not only beautify structures, but to use the sun in a passive way to provide heat.

EXTRACT-AIR WINDOW:

Probably the windows in the building are often the weakest point in the insulation of exterior walls. Windows have a very poor overal heat-transfer coefficient, many times larger than that of the adjacent wall construction. This combined with heat leakage in winter conditions causes overall large heat losses as well as drafts. In summer, the opposite takes place, the sun's radiation that penetrates the window makes it necessary to install mechanical cooling systems.

The extract-air window is an integrated solution to solve a number of conditions. With it, traditional space heaters can be eliminated and the size of ventilation systems can be reduced. It is possible to omit mechanical cooling devices in some situations. The extract-air window automatically takes care of a large portion of the work done by customary heating and ventilating systems. The windows are especially suitable for hospitals, health centers, office buildings and educational facilities. This invention originated in Sweden, but it has been extensively studied, developed and used in Finland. This may be the most important energy-saving idea yet devised. (Note: The extract-air window is also referred to as an air-curtain window).

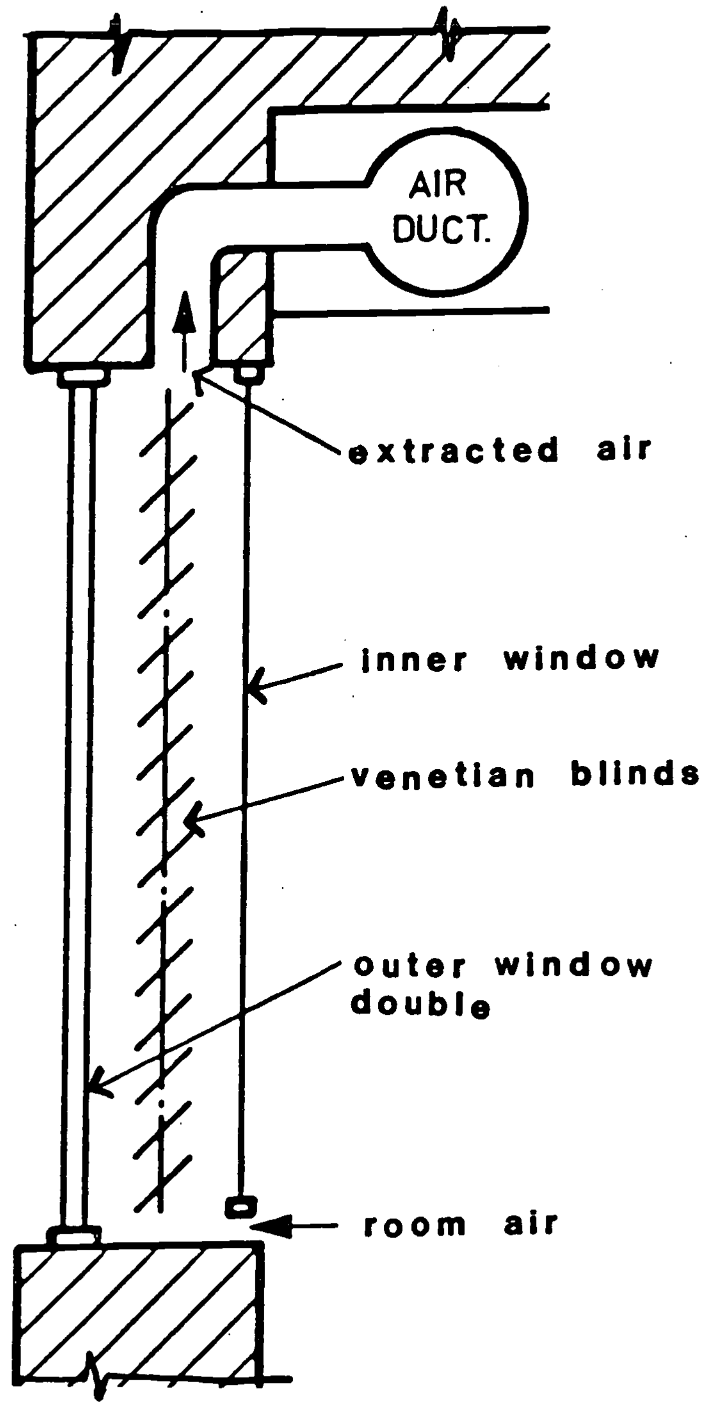
The extract air window consists of double glazing to the outside, then an approximate four-inch air space which contains a narrow-blade venetian blind--white on one side, black on the other. Lastly, there is another single glazing on the inside of the window. The bottom of this interior single glazing has a small opening where a flow of room air can be introduced into the cavity between the outer double-glazed pane and the inner single-glazed pane. The venetian blind installed in the window cavity serves the conventional function of modulating sunlight and daylight. When the black surface is tilted towards the outside to intercept direct sunlight, the blind serves as a solar-collecting surface. There is a fan and duct system at the top of the window to extract air in the window cavity. The moving air stream of the extract air window transports the thermal gain for redistribution, storage or rejection. In this manner not only is there a significant increase in the collection of solar energy but also the solar gain into the room is controlled and the clear glass of the window can be used for its full daylighting advantage.

The use of these windows brings about significant savings in the amount of energy used for the building and does so at a very small cost as compared to placing a full active solar collector array on the building.

SUMMARY:

In summary, there are many design features that can be used to achieve an energy-efficient building. The proper orchestration of all the energy design features is essential both from design and operation standpoints.

The fact remains that energy performance of a building is an integral part of the architectural design process. Virtually every basic design decision affects costs and energy conservation. Energy items can no longer be placed on the "back



EXTRACT AIR WINDOW

burner" as alternates on bid day. The energy design elements are just as important as the footings, foundations, handicap elevator, carpet or wood gym floor. Approximately 80% of energy design elements can be achieved with no increase of the traditional school construction budget.

The school district client is searching for cost effective solutions to energy efficient school design. It is the new challenging role of the architect to creatively design an energy-efficient facility within the traditional budget. The challenge is to design a balanced building meeting the defined educational program needs while being energy efficient for the foreseeable future.

ENERGY DESIGN GOALS:

A first step in the energy-conscious design process is to establish energy design goals. These goals have such an extensive influence on the entire building design that they must be created first and thoroughly understood by all involved in the design process. (Goals may vary from region to region in the country).

Examples of energy-design goals are as follows: (Not listed in priority of importance)

1) To design an educational facility that can continue operation during major energy cutbacks. A major energy cutback is defined as a loss of 90% of all energy services to the facility.

2) To develop a design that achieves major conservation of current nonrenewable energy resources.

3) To develop a design that prepares the educational facility to use new forms of energy in the future...to function in a post-petroleum world.

4) To initially start the concepts for the school as a totally integrated energy efficient design.

5) To utilize southern and eastern exposures for "warm" interior spaces. Warm interior spaces are those such as classrooms, offices and laboratories which need a warm temperature for occupant comfort.

6) To utilize northern exposures for "cool" interior spaces. Cool interior spaces are those such as the gymnasium and shops which do not require a temperature as warm as classrooms.

7) To utilize only a minimum number of windows on the western exposure with such windows shielded from the sun.

8) To use natural light to a maximum extent throughout the educational facility. Such natural light to be sufficient for operation during a major energy cutback.

9) To use natural ventilation to minimize ventilating and cooling requirements. Such natural ventilation to be sufficient for operation during a major energy cutback.

10) To collect and use, to the maximum possible extent, excess internal heat within the building, and also to examine the community around the educational facility for external sources of excess heat.

11) To use total climatic design, not just "active" or "passive".

12) To design the educational facility to function to a maximum extent in small modules. In so doing, to use automatic controls to turn off building systems...follow a concept of turning on services by human means and turning off services by automatic means.

13) To monitor and control all major energy-consuming devices or situations.

14) To create a peak energy demand limit and provide equipment to "shed" energy use to prohibit the building from exceeding the design peak demand.

15) To utilize a heating/ventilating/cooling system which in itself, and by its very nature, embodies energy efficiency.

SUMMARY LIST OF POSSIBLE ENERGY-DESIGN ELEMENTS:

Element	Energy Design Element
1	USE OF EXCESS INDUSTRIAL HEAT.
2	USE OF NATURAL LIGHT.
3	USE OF NATURAL VENTILATION.
4	DIRECT USE OF SOUTH SUN TO PROVIDE HEAT TO "WARM" INTERIOR SPACES.
5	USE OF "COOL" INTERIOR SPACES FOR NORTH BUFFER.
6	SHIELDED WEST WINDOWS.
7	MONITOR CRITICAL ENERGY-CONSUMING DEVICES.
8	UNOCCUPIED SPACE SHUTOFF.
9	PEAK DEMAND CONTROL.
10	ENERGY-STORAGE SYSTEM.
11	HEATING/VENTILATING/COOLING SYSTEM (HVAC).
12	USE OF EXCESS INTERNAL HEAT.
13	SOLAR HEATING AND COOLING ADAPTABILITY.
14	WIDE-BAND THERMOSTATS.
15	DESIGN OF HVAC EQUIPMENT TO RUN AT HIGHEST AVERAGE EFFICIENCY.
16	COMPACT BUILDING SHAPE.
17	LIGHTING REDUCTION.
18	BUILDING ENVELOPE.

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