ENERGY CONSERVATION

Indian Myths and Realities

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While the urgency for energy conservation is recognized today, experimental energy Conserving buildings though technically successful, have proved To be commercial failures. The author gives a personal view of why we as a nation have failed to translate the idea of energy conservation into popular practice, and what changes in outlook are required if we have to come t terms with the grim predications on future energy availability in India.

In the wake of the oil crisis of the seventies, a great deal of interest was generated worldwide for energy conservation in buildings. It was calculated that a country like USA spent nearly one third of its total energy for heating & cooling of buildings and with due care in design a substantial part of this energy could be saved. Gradually the idea came to India also even though we spent only a small part of our energy budget in heating and cooling. Philip Stead man's book Energy, Environment & Building and the project on The Autonomous House by Robert and Brenda Vale created tremendous interest in architecture schools in India and abroad. The rediscovered sources of sun, wind, water and biomass fired the imagination of students everywhere and the newly coined American term Solar Passive Architecture was added to the architectural vocabulary. In some schools of architecture special courses on energy use in buildings were introduced. The possibility of building Autonomous houses, Autonomous building complexes and Autonomous settlements began to look real. The Indian scientific community joined in when they discovered the potential of this new field of study for generating research funds. New centres of learning came to be established in different universities and experimental building projects were taken up to verify the 'new' ideas. Those who professed good building practices for providing thermal comfort, discovered the new emphasis and started talking of energy conservation. In architectural competitions in India and abroad, 'Energy and Environment' found their rightful place and the idea of low-cost, environment friendly, energy conserving projects was established. To promote solar cookers, solar water heaters, bio-gas plants etc. as also the use of non-conventional energy sources, the government set up several agencies to provide financial subsidies. New books on Solar Architecture appeared at regular intervals. Some institutions commissioned architects to incorporate solar architecture in their new buildings. New projects by students of architecture were focused on solar energy. Seminars, workshops and training programmes were by several institutions and many research projects on "solar passive architecture" were undertaken.

During these heady days the Indian Architect continued to work with a business as usual approach. The technical successes in the research institutions remained confined to journals and seminars, and the Indian construction industry responded to these developments marginally only. Architects and engineers who built the majority of buildings, branded these interesting developments as expensive and impractical.

Over the years the International interest in solar architecture waned as its potential as well as its limitations became well known. After the initial shock, people accepted the new oil prices as a reality and started living with less energy by adopting simple housekeeping measures. The results of the experimental buildings showed technical successes but practical and commercial failures. Field studies in India showed a low survival rate for the early alternative energy devices.

Today the relevance of the idea of energy conservation is no longer questioned. In most schools of architecture "Solar Passive" has replaced `Climatology' in the regular courses. The gains of this widespread interest are few as we continue to consume energy at the same rate as before. What follows is a personal view of why we have failed to translate the ideas into practice and what changes in outlook are required if we have to come to terms with the grim predictions on future energy availability in India.

The rules for designing energy conserving buildings are now well established. The checklist used by the practitioners of such architecture (the author included), runs as follows:

1. Reduce energy consumption in construction by using low energy natural materials such as earth, stone and wood, and avoid use of manufactured energy consuming materials like brick, cement and steel.

2. Avoid mechanical cooling and heating or at least reduce the cooling and heating load by using solar passive techniques such as proper orientation of building, sunshading of windows, earth shelter etc.

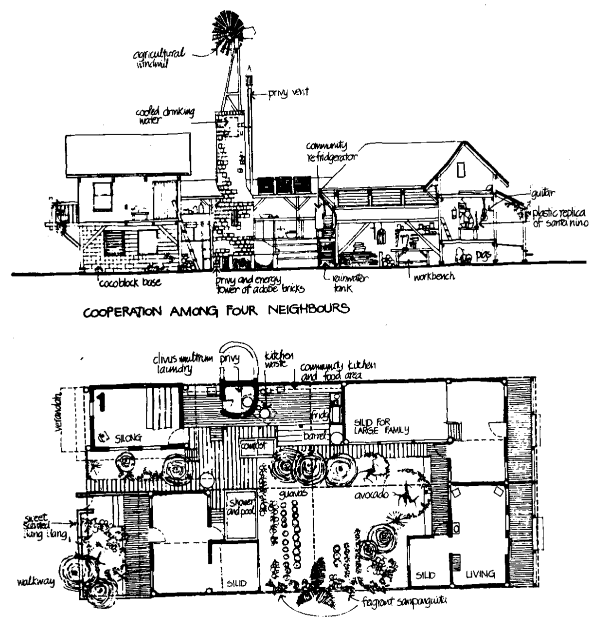
3. Use alternative sources of energy- solar cookers and water heaters, windmills, bio-gas plants etc.

4. Avoid wastage of energy while building is in use. Provide day lighting and energy efficient equipment for all uses in the building. Switch off gadgets when they are not needed.

I intend to go through this checklist to show why the architectural profession at large does not take this seriously.

Solar Passive Architecture

The idea of solar passive architecture has come to us from the cold countries where heating rather than cooling is the issue. Since energy was available cheaply in these countries, architects and builders could afford to disregard simple things such as insulation or building orientation and still manage to provide thermal comfort. Glass and insulation were expensive and the sun as a source of heat and light was largely unacknowledged. The major energy expense in buildings in the cold climates was therefore in heating. Two ideas, first of building structures without windows and second of building very large structures with limited windows on the periphery were seriously explored as these could ensure better-insulated buildings. Artificial lights provided to compensate for the absence of daylight helped heat the building at no extra energy cost. In fact the typical American office building became so large and deep that in mid winter, the interior had to be cooled and not heated. At the same time, the other American building prototype, the suburban house, was no more than a poorly built cardboard box. Buckminster Fuller's idea of the



Alternate energy for the poor-architect Ian Athfield's award winning design for the Manila competition (1974-76)

Dome as a means of providing a shelter with the minimum external surface area made sense only for a building with artificial heating. He took this idea to its logical conclusion by suggesting a single cover over a whole city so that the cold weather could be kept out of the whole city. If this idea were to be applied to a warm climate, the heat generated internally by people, machines and the greenhouse effect would be so great that an enormous air-conditioning plant would be required to deal with it.

In a cold climate Solar Architecture calls for using the sun as a source of heat (and light). Ordinary window glass has the property that it is transparent to sunlight but opaque to internal heat. The early Solar Buildings therefore looked like unearthly glass boxes, not houses. These solar buildings required that one face of the building (south in the northern hemisphere) be glass and the other be well insulated. To even out the wild temperature fluctuations, which come about in such buildings, it was necessary to provide heat storage as well. Soon it was discovered that if the building was well insulated and provided with artificial lighting, no solar or other heating was required in the relatively milder climates. In many European countries where the winter is

The ultimate solar house-buckminister Fuller rescues New York with a vast air-conditioned dome.

largely devoid of sunlight, the super insulated house became the norm. Very substantial energy savings are possible in such houses. Energy conservation thus became synonymous with Solar Architecture. A parallel development for space heating was to first harvest solar energy through "solar collectors", and then to store and pipe it to where required in the building. The term Passive Solar Architecture was coined to distinguish the first method of building from the second approach to Solar Heating, which merely replaces the oil, fired heating plant with solar heating system without making any major changes in the building design. These developments took place with some excellent but largely unused work on climatically appropriate buildings in the background. Victor Olgyay had earlier classified different climates for which he had suggested regional prototype house forms. The works of Baruch Givoni, Van Straaten, Felix Trombe' and others on building construction were also available but while energy was cheap, it was not necessary to worry about heating costs. With the interest in Solar Architecture came also the awareness that buildings ought to respond to the outdoor conditions rather than act as thermal barriers only. It is important to realize that since mechanical heating is relatively

Trombe wall in residence at Leh, Ladakh.

New, there were no authentic early examples of well-constructed centrally heated buildings. The archetypal Red Indian dwellings in the USA and the domestic buildings in Europe incorporated nothing more than a fireplace.

The confusion between Energy Conserving Architecture and Solar Passive Architecture is one reason for the lack of enthusiasm for both of these amongst builders and practicing architects. The major difference between a building in a cold climate and one in a warm climate is that while the former can actually use the sun to its advantage, the latter can only reject the heat of the sun to stay cool. While it is possible to use wind and water, there is no way to use the sun as a means of removing heat from the building. Solar Passive Architecture is therefore a misnomer so far as warm climates are concerned.

In the case of air-conditioned buildings there are no suitable early models available to us as air-conditioning itself is a new technology. But for non-air-conditioned buildings, every region in India has excellent examples of naturally cooled buildings developed over thousands of years. Where the context has not changed, these archetypes can be profitably used even today. For new situations, architects need to modify and adapt the original concepts. So long as one is talking about buildings which are not normally air-conditioned, it is clear that Solar Architecture or even the traditional cooling methods can be used to enhance thermal comfort in buildings but in no case will it be possible to conserve energy by using either of them. Tinted glasses in cars save energy only if the car is air-conditioned.

Architects have to build for their clients and before they build their designs have to be sold to the building owners. No building Owner has difficulty in accepting an idea that provides either greater thermal comfort or saves costs. The Owner does however resist the use of ideas and technologies that sound good but whose performance is not assured. If an idea adds to the capital cost, the Owner wants to know the additional cost and the payback period and will generally accept it if funds are available to cover the additional cost and if the payback period is no more than a few years. There is no point in trying to sell the idea of greater thermal comfort to someone who has no money to pay for it, just as there is no point in trying to sell a less than comfortable building to someone who needs air-conditioning and can pay for it. Passive Solar Architecture costs money and it can provide thermal comfort equal to that provided by air-conditioning only in the mildest of Indian climates. To those who doubt this, I would like to refer the case where a knowledgeable mechanical engineering consultant had a difficult time explaining to his client why he wanted to revert back to conventional air-conditioning after the owner had accepted the proposal of a roof evaporative cooling system for a building in Hyderabad in which air-conditioning was required for computers.

Solar architecture is difficult to apply in real life situations where the architect is not free to choose even such basics as building orientation or building form. Architects usually blame the town planners for the poor layout of housing schemes and the resulting poor orientation of plots. One can appreciate the limitations under which the planner has to work only when one has tried to layout a housing scheme without having any control over the architectural design of buildings. To implement more complicated solar passive ideas such as roof cooling systems or earth-air tunnels is nearly impossible on tight urban sites. The architect enjoys much greater freedom on a typical suburban house plot in Europe or USA, which measures at least a 1000 sqm. And many of the passive solar techniques, which we are talking of today in India, are suitable only for the American or European house. The dense urban situations where houses and offices are built in India restrict the number of potential beneficiaries or users of passive solar. It is only in institutional complexes with land to spare that solar architecture can be practiced and it is no coincidence that most solar architecture is limited to such institutions. Even without solar architecture, these institutions are not great consumers of energy as they operate only during daytime and the use of air-conditioning limited to small areas only.

Natural Building Materials

Throughout history of mankind earth and stone are the two most commonly used building materials. Even today the number of buildings that are built with these two materials is probably many times more than those built with other manufactured materials. However, most of these buildings are located in rural areas where these two materials are locally available and even more important, the organised building sector (architects, contractors and builders) is absent. Contemporary buildings are required to perform many more functions than traditional self-help buildings. The traditional building materials, with all their virtues, are often unable to provide the kind of performance in terms of durability, weathering quality, maintenance and speed of construction that is demanded today. Every architect knows and has probably used with advantage the wonderful qualities of stone walls, and if he still does not use stone in place of brick, it is because he also knows that stone is cheap only where it is locally available and that it becomes very expensive when transported over long distances. Inspite of its great strength, stone cannot be used for tall buildings either. I would look at earth construction in the same way. This is not to say that earth and stone have no relevance in today's situation but merely to point out that earth and stone cannot be used to any great extent by architects who are required to build in the urban areas.

Most calculations of energy intensity of building materials, are made without taking into account the energy cost of transportation and the human or animal energy required to put the building together. I suspect, that when all the energy costs are calculated, these materials will be considered energy efficient only in limited areas and situations. A case worth mentioning is that of the relative energy efficiency of cement and lime as bonding materials. Cement is manufactured in a few big factories while lime is produced in small kilns spread over the entire country. Some years back, when cement was not available easily, it was shown that lime was less energy consuming than cement. Over these years cement plants have been modernized while limekilns continue to operate at their old level of energy consumption. Given the resources required for modernization, lime could be produced more efficiently but in the present situation cement is less energy consuming than lime. The conclusion that can be drawn therefore is that simplistic calculations of energy required for production of materials do not reflect the true status and perhaps the only way to build with energy efficiency is to use locally available materials.

MILESTONES

Publications

Energy, Environment & Building, Philip Steadman, Cambridge University Press, 1975.
The Autonomous House, Brenda and Robert Vale, Cambridge University Press, 1975
Domebook-II, Portola Institute, New York
Solar Houses, Stephen Szokolay

Conferences/Workshops

Habitat Conference at Vancouver, UNCHS, 1972
International Solar Energy Congress in Delhi, 1978
Passive and Low Energy Architecture Conferences
Energy and Habitat Seminar, IIT Delhi, 1982
Training Programme for Architects, CBRI, Roorkee,1983

Solar Passive Building Research Projects

Leh hotel
Pondicherry house(Eco House)
Baroda house
Jodhpur hostel
IIT Delhi hostel
Srinagar dispensary

Architectural Competitions

Squatter Housing, Manila
CMC Limited, Hyderabad
NEDA Solar houses, UP
GEDA Housing, Baroda
GEDA Renewable Energy Centre

Alternative Energy Devices

While there are many alternative energy sources that can be used in general, the only ones that are of relevance to architects are solar cookers, solar water heaters and biogas plants. It has been amply demonstrated that in suitable climates solar cookers and water heaters can

Save energy used for cooking and water heating. A large number of these devices have been installed in hotels homes and institutions. In many cases the only reason for installing these was to avail of government subsidies. Since the government department controlled the quality, the owners had no control over it and in most cases the solar devices stopped functioning soon after installation. Without going into the allegations and counter allegations that are made by the users and the government departments to explain the reasons for large scale failures, it is clear that the mere installation of solar devices in a building does not ensure energy conservation.

Let it be clear that the issue is not the technical success or failure of solar devices but the effectiveness of these devices in conserving energy. Many solar water heaters are installed with an integral electrical backup element. If the solar collector stops functioning and the electrical backup come into operation, the owner does not know about it. Since the electrical heater maintains at a high temperature, a large volume of water in an exposed though insulated tank 24 hours of the day, the solar system actually ends up consuming more energy than a simple electrical water heater. There are buildings where the solar water heating system is maintained in a functional condition and no electrical backup has been provided, but these are mostly buildings, which would not have had any heating system normally, and therefore their effect is to improve the availability of hot water and not to save energy.
Photovoltaic cells are other devices that people are installing in buildings to overcome power shortages. Used for lighting at night, these come complete with a storage battery. In urban areas where electrical power is available, solar cells make sense only if the government subsidizes the cost. The battery backup would adequately take care of power shortages, even without the solar cells. If our aim is to conserve energy, it can be reached only if the production and installation of alternative energy devices is organized on a sound commercial basis, no distinction is made between private and institutional users, and the subsidies are provided only where energy saving is actually achieved. In a government controlled supply system this idea is impossible to implement but it could be easily done if the devices actually saved energy (and therefore cost) and were usable in real life situations.

Energy Efficiency

Before an economist can tell you how to save money, he will need to know how you spend your money. If you have no money to spend, you do not need the economist either. Energy efficiency is to be viewed in the same way. It is necessary only where energy is spent.

"Mr. Thin and Mrs. Thick were discussing energy efficiency. Mr. Thin explained that he is a changed man. Instead of running around in his car seven days a week, he now uses the car on two days only, on two days he uses the car pool, two other days he cycles to work and one day he either takes the bus or stays put. Mrs. Thick had a hearty laugh for she never went out of her house except on foot."... Who is more efficient?
The scientific definition of efficiency is: Output per unit of input. If no output is required obviously there is no input either, but the mere absence of input does not automatically make for a highly efficient situation or system. In fact when the input is absent, neither the efficiency nor any improvements in efficiency can be computed. Unfortunately, energy efficiency in solar passive buildings has often been stated as high, when there was no output required. If Mrs. Thick and Mr. Thin both did the same work, Mrs. Thick would be much more efficient, but if the nature of their work was different, their efficiency cannot be compared. Someone who consumes less energy does not automatically become more efficient. Our failure to think of energy efficiency in this way is another reason why builders and architects do not accept the idea.

Energy Conservation in Use

The last of the energy conserving ideas relates to energy management and the use of energy efficient devices in the building. This idea is applicable to old as well as new buildings and because the base consumption is known, the idea has a good chance of actually reducing energy consumption. Unfortunately, neither the architect nor the building owner has any real control over it. The building users in whose hands lies the efficiency of energy use in offices, institutions, hotels and industries, do not have to foot the energy bill and energy conservation measures are difficult to implement in these buildings. Users do try to save energy costs in residential buildings because they pay for energy directly. It is good to see that in the public awareness programme launched by the Ministry of Energy, the role of the user is recognised and the emphasis is on saving money by energy conservation. Many good ideas have been implemented in the so-called energy conserving buildings. The success or failure of these really depends upon their practicability, usability, and ease of maintenance. The users need to be motivated to perform certain tasks by educating them about the potential benefits. They must also be informed of the penalty for non-performance. A common saying is that people, who use 'passive solar' buildings, have to be very 'active'. It is unfair to expect people to do something unless they are directly benefited by it, and it is unreasonable to expect them to live with discomfort without some form of compensation for it. Many good ideas fail because these basic human traits are not recognised. As mentioned in the accompanying article on energy efficiency in office buildings, people do not perform even the simple task of withdrawing curtains or raising Venetian blinds when daylight is available. Provision of Energy saving devices in buildings is useless unless their operation can be ensured. It is better either to automate controls where the additional cost of controls can be justified, or to assign them to specific persons. The idea of energy conservation does not go well with unwilling or insensitive users. No amount of careful planning and design will work unless the user is ready for it. As a designer of naturally cooled buildings, I have seen several times that even before the users moved into the building, i.e. before they experienced the comfort or the discomfort of the naturally cooled building, they installed air coolers and air conditioners. This is the same sort of attitude that makes building users paint or plaster exposed concrete or brick surfaces, even when the original surface is perfectly serviceable.

The Realistic Programme

Having talked about all the problems associated with our present approach, what does one do to achieve the goal of energy conservation. The first thing is to redefine the objective as 'Energy Conservation' and not solar architecture. We need to think about energy use and conservation in existing buildings. For new buildings we need to come to terms with real building programmers on real sites with all their limitations. We need to broaden the scope of energy conserving buildings from special projects for motivated clients to everyday buildings. Institutional complexes as energy saving places have their value in generating new ideas but we need to focus our attention on the big fish, the common commercial building and the ordinary house that is being built and used everyday. We need to apply mundane common sense ideas even if they do not generate great architectural concepts. We need to implement ideas by which energy conservation will pay for itself. We need to define simple standards by which owners will be able to judge for themselves whether their existing buildings and the proposed new ones are energy efficient. We need to create a new professional (architect or engineer but not a scientist) who can advise builders and architects on energy conservation issues.

I propose a simple checklist that any owner or architect could use for new as well as old buildings. It includes only those ideas that are likely to result in demonstrable energy savings and it is classified not according to building type but according to the major areas in which energy conservation is required.

CHECKLIST

GENERAL

- Use locally available materials in construction
- Provide day lighting in all areas, including toilets and passages
- Provide insulation in roofs and walls of all air-conditioned areas
- Use efficient mechanical & electrical devices
- Provide separate energy meters for major equipment
- Put security and emergency devices on separate circuit and provide master switches to shut off lights and fans
- Train & motivate building users
- Appoint energy management team in large installations
- Monitor energy consumption on a regular basis
- Provide for future installation of solar cookers and water heaters
- In housing schemes, provide for garbage sorting in the house and for recycling of usable components like lass, metal, paper and plastic
- In offices, establish a method for paper re-use and recycling

DAYLIGHTING

- Improve daylight distribution by using light shelves outside the building
- Avoid excessive glazed areas
- Avoid tinted glasses in new buildings
- Provide fixed external sunshades on north & south sides and movable sunshades on other building faces
- Provide light coloured finishes on ceilings and walls
- Avoid full height opaque partitions in offices

ARTIFICIAL LIGHTING

- Provide low general illumination and task lighting where better lighting is needed
- Use efficient lamps- flourescent, PL, & SON
- Avoid use of incandescent lamps
- Use efficient ballasts for discharge lamps
- Avoid indirect lighting, upward directed lighting and acrylic sheet diffusers
- Use efficient light fixtures
- Provide controls (manual, time based or electronic) for turning lights off when not needed
- Ensure turning off of lights when not needed

AIRCONDITIONING

- In partially air-conditioned buildings, avoid placing air-conditioned areas near hot spots such as, top floor of building, exposed west walls, kitchens, machine rooms etc.
- Place air-conditioned rooms together, away from heat loads
- Insulate periphery of air-conditioned areas
- Provide airtight windows
- Provide self closing doors
- In existing buildings reduce cooling load by insulation, by blocking unnecessary windows, and by sealing tight external windows
- Provide ceiling or other fans for air circulation even in air-conditioned rooms
- In hot/dry climates provide air cooling for the dry season and air-conditioning for the humid season
- In large installations with 100% fresh air requirement, use heat recovery systems on exhausted air
- Provide mix matched chillers to make up the required plant capacity
- Provide automatic controls on plant
- Ensure regular maintenance of plant

AIRCOOLING

- Provide timers for automatic shutoff in houses
- Use efficient fans & pumps

VENTILATION

- Provide natural ventilation in all areas
- Provide chimneys in kitchens
- Use efficient regulators for fans
- Provide controls for automatic shutoff when not needed

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