DOCUMENT RESUME

ED 125 858 SE 019 348

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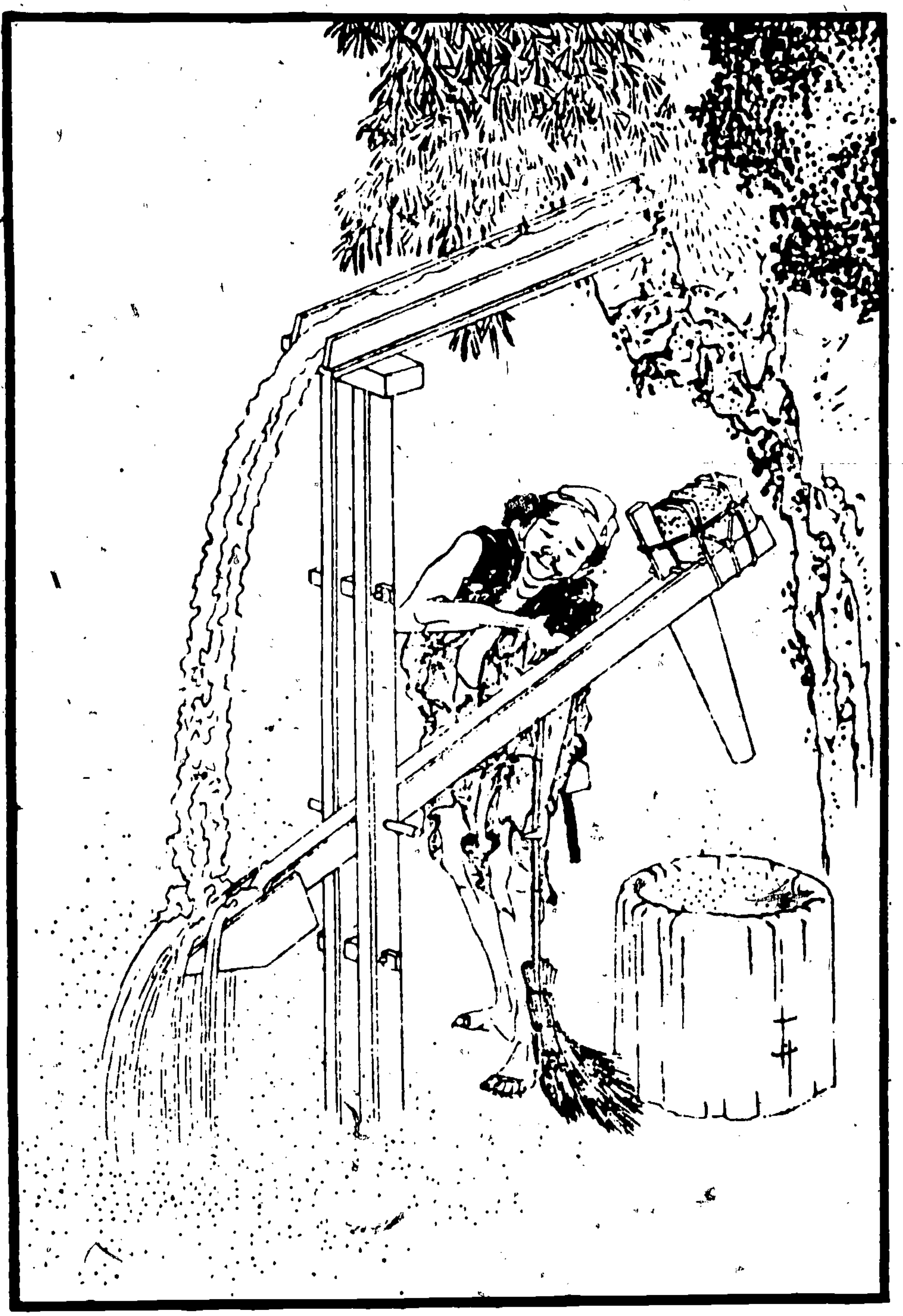
TITLE Living Lightly: Energy Conservation in Housing.
PUB DATE Oct 73
NOTE 38p.; Marginal legibility throughout

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS *Architecture; *Depleted Resources; Energy; *Energy Conservation; Environment; Fuel Consumption; *Housing; *Natural Resources

ABSTRACT

This publication contains a series of papers which promote the concepts of energy conservation and offer safe and convenient ways of handling all aspects of our lives affected by energy without having to depend in any way on fossil fuels or nuclear power. These changes, which can be brought about in homes and in energy flows affected by the individual, can reduce the energy consumption of our society by 90%. Among the topics discussed are: means of minimizing heat loss in houses, cooling, food storage and cooking, water conservation, wastes, home structure and furnishings, lighting, sod roofing, the utilization of wood as a fuel, and Ouroboros (an experimental house designed and constructed by an Environmental Design class at the University of Minnesota). (BT)



Living Lightly:

Energy Conservation In Housing

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October 1973

Within the last century our culture has taken an unprecedented form, centered on the premise of unlimited, cheap energy, and on the desirability of its unqualified use. As a result, all aspects of our culture and our lives have developed forms which can only be supported by massive energy consumption and which can only be considered valid from within those assumptions. These forms are not necessarily better than other ones, and are coming to be seen as having considerable negative effects that often outweigh their assumed advantages.

Growing realization of the limited nature of our present energy sources and of the environmental degradation caused by their use are bringing us to reconsider the wisdom of our cultural and technological premises. We are beginning to see the great and unnecessary waste in our ways of doing things, and to discover ways to accomplish our dreams with less need for energy.

Our assumptions about energy deeply permeate our thinking, and so far we have mostly concerned ourselves with trying to continue our present ways a bit more efficiently, rather than asking if they are perhaps basicly wrong. We have not looked carefully to see if it is possible to escape our dependence on energy (particularly fossil fuel energy) and if it is possible and perhaps more desirable to live lightly and more simply.

Our attitudes towards what we think is possible and towards how we wish to live are the most important factors in determining how much energy we use (and waste), the nature of our energy use, and the quality of our lives which result from its use.[1] Our complete immersion in our current way of using energy and our lack of knowledge of the existing and proven alternatives[2] prevent us from developing other, and perhaps more pleasant, ways of living which have considerably different energy implications and effects upon our lives.

There are perfectly safe and convenient ways of handling ALL aspects of our lives affected by energy without having to depend in any way on fossil fuels or nuclear power. This should be obvious, as there have been many cultures in our world equally as refined, luxurious, sophisticated, and comfortable as our own - some even more so - without our dependence upon energy.[3] It is not obvious to us because we are only familiar with fossil fuels and nuclear power, and are unfamiliar with the different patterns of benefits and problems associated with other ways of doing things.

The projected exponential growth in our energy use and its attendant problems are entirely unnecessary as well as undesirable. It is possible to live quite comfortably on a fraction of the energy we consume today. We CAN choose to live wisely and gently in our world, and the changes possible through that are not insignificant. It is possible today, without hardship, to reduce the energy consumption of our society by 90%, and live happily on less than one-tenth of the energy we now use, while at the same time enriching our freedom, our enjoyment, and our lives.

Changes which we individually can bring about - in our homes and in the energy flows which are affected by our actions there - can, in great measure, bring about such changes.

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1. See study on attitudes and energy underway by The Energy Policy Project, Washington, D.C.
2. See V.I.T.A. Village Technology Handbook, Tools for Progress by the Intermediate Technology Group, etc.
3. See The Ancient Khmer Empire, by Lawrence Briggs for information on the culture that built Angkor Wat, etc. Also, Joseph Needham's Science and Civilization in China has a wealth of information on the ingenius technology of China.

The Problems With Bricks In Your Toilet

Most of the information we are deluged with concerning our use of energy is either of a crisis nature or persuasive literature suggesting that all will be well if we only turn down the furnace a couple of degrees, fix the leaking faucet, put a brick in our toilet tank, or put smaller wattage light bulbs in our attic. Because they are unwilling to question or change any of our accepted practices and attitudes, these "save-a-watt" suggestions studiously avoid any of the central issues of our energy problems. They make us feel we're "wringing every last bit" out of our energy, when possible improvements are actually several orders of magnitude greater. Many suggestions are designed only to shave demand peaks for the utility companies, even out loads, or protect the industry's interests.

For instance, the U.S. Government booklet, "7 Ways to Reduce Fuel Consumption in Household Heating....through energy conservation", put out by the Special Assistant to the President for Consumer Affairs and the National Bureau of Standards, suggests things like repairing leaking faucets, closing draperies at night, cleaning furnace filters, etc. All of these offer savings, but are hardly significant relative to the 60% loss of heat energy occuring when electrical heat is used, the general overheating of buildings, the potentials of solar heating, the subsidized costs of fuels, etc. The booklet, "60 energy savers that make cents", put out by Northern States Power Company, has quite a few good suggestions on economizing on energy use in the home, and suggests ways of using your air conditioner more efficiently - but doesn't mention that there are other means of maintaining summer comfort in a home that use less energy.

Minnegasco sends out energy saving tips in its billings, but at the same time advertises gas patio lights and other frivolous uses of gas. It also doesn't mention that the 600,000 households in the Minneapolis area that heat their homes with gas pay their gas company $6 million to $10 million every summer and waste more than 5,000,000 cubic feet of gas in the process, solely because they don't know enought to turn off the pilot lights in their furnaces at the end of the heating season. Few are aware that the pilot light burns $3-4 of gas a month, and many don't even know there is a pilot light.

None of the utilities mention the inverted nature of their rate structures which generally give discounts to large energy users and charge you more per unit of energy the less you use. NSP charges 5.1¢/kwh for the first 60 kwh of residential use per month, but if you use more than 800 kwh/month, they only cost you 1.65¢/kwh.[4] If you use a lot of electricity (electric heat or hot water), you pay approximately 20% less than that. If you are a commercial or industrial user, your rates are even more subsidized by residential users. Obviously, such rate structures do little to encourage efficient energy use.

The electric and gas utilities are beginning to realize that even their own interests are not necessarily best served by promoting higher energy use, and are becoming somewhat more responsive towards energy conserving suggestions and policies. They still have far to go. The argument is made that they can produce power more cheaply if done at a constant full-load rate (thus agreeing to "peak-shaving" conservation but still offering lower rates to stimulate off-hour use). As far as spreading capital costs over the greatest possible production, that is true. However, every pound of coal or barrel of oil consumed is gone - whether at peak or off-peak hours.

Changes in a person's life style - even fairly minor ones - can have a much greater impact on energy use than most "save-a-watt" ideas. Not using electric heat, not using air conditioners, using solar water and space heating, living near where you work, and consuming less can quite significantly lessen fuel consumption. Living where you work saves not only gas but highway construction and maintenance costs, auto depreciation and replacement costs, parking space, etc. It is also better for your health. Sharing a car saves energy, but using trains and busses saves much more, and staying home eliminates the problem. Use of unprocessed foods can eliminate huge energy expenditures by industry that don't seem related to household energy consumption though they are totally determined by the attitudes and lifestyles occuring there.

Our attitudes towards energy underlie many of the problems of our culture and support unreasonably inefficient institutions. We spend $78 billion a year on academic education, while other learning processes produce rather than consume goods, time, and energy.[5,6] Our agriculture uses more energy than it produces, and our industry, transportation, entertainment, etc. are all energy-intensive. If measured on any broader criteria than our traditional economics, they are incredibly ineffective in both energy use and the fulfillment of their intended purpose.

Unnecessary activity involves a far greater energy loss to our society than inefficient use of energy - and is more easily eliminated. Our major energy wasters include war, early obsolescence, unnecessary work, advertising, industrial waste heat, private transport, inefficiently used public transport, attempts to heat or cool large volumes, industrialized agriculture, bureaucracies based on irrelevant tally, our processes of obtaining energy, non-reused or recycled materials, and the style in which we live. If we were in a totally independent country with truly unlimited and undamaging energy resources, this incredible waste would be less serious - though still damaging to our personal growth and vitality. In an interconnected world with limited fuel reserves, it brings serious questions of political independence between fuel producing and consuming nations. In economic competition with countries with wiser energy policies, such as China, our energy waste will inevitably bring us severe and damaging trade imbalances, monetary adjustments, and worsening of our quality of life. Perhaps its most damaging product remains the effects on our heads of careless lack of concern and understanding of the people, processes, energy flows, and situations in which we are involved.

Direct waste of energy in homes is relatively minor in comparison to wastes in these other sectors of our society. However, the greater wastes are all within energy flows that originate or end in the home or are determined by our actions there, and considerable leverage exists in energy practices in the home to change larger ones as well. Quite substantial amounts of energy CAN be saved within the household, and in the process we can move to some more satisfying ways of living.

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4. See N.S.P. Rate Schedule, Jan. 1972.
5. U.S. Statistical Abstract, 1972.
6. See Ipelengeng - School for Mahalapye, Botswana, Stephen Murray. 1973 thesis, Univ. of Minn. School of Architecture for good discussion of productive rather than consumptive learning processes.
7. See "City Planning in China", Graham Towers. ARCHITECTURAL DESIGN, 7/73, for discussion of Chinese regional planning policies.

Don't Solve Problems – Avoid Them

It is wiser to avoid energy use than to maximize the efficiency of its actual employment. In order of decreasing effectiveness and increasing cost and involvement, energy use can be avoided by determining the following:

1. Is the activity for which the energy is to be used necessary? Can it be avoided, thus totally saving the energy necessary for its accomodation and operation?

2. If the activity is necessary, where is the most desirable climate for it? Ought it to be located where substantial energy is necessary for heating, cooling, transportation, etc.? Can it move south in the winter more economically than heating and shoveling snow around it all winter?

3. Where are the most favorable micro-climatic conditions? They can considerably minimize the heating, cooling, and other climate tempering energy needed. (Seattle has a very wet winter, while across the Sound, in the rain shadow of the Olympic mountains, the sun almost always shines. In Toronto there is a 30° difference between winter temperatures along the lakefront and those in the river valley.)

4. Develop a lifestyle, or ways of performing the activity that consume least energy and place least demand upon the surroundings. The variations in the way we do things can easily double (or halve) the energy used.

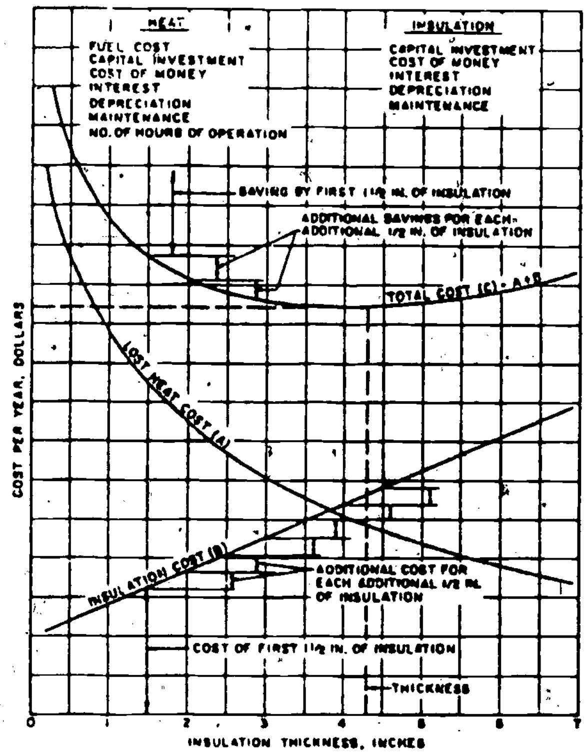
5. Design buildings, when buildings are necessary, that minimize energy demands for construction and operation.

6. Find the most efficient means of obtaining and utilizing the right energy necessary to fill those needs. It is only this last question, and that usually only in part, that is asked when considering energy conservation. Its effectiveness is rather low, as it can only hope to more effectively satisfy conditions which were perhaps unnecessary to begin with.

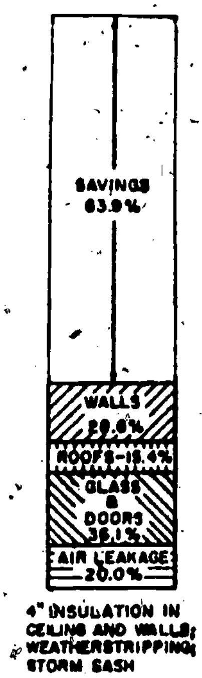
Energy Flows Through The Home

SPACE HEATING

Space heating is usually the largest energy flow through a house in its normal operation. Minimizing heat loss from the house and choosing and economizing on the sources of make-up heat offer the most substantial means of removing our dependence upon fossil fuels for space heating. The economics of insulation are tied to the costs of fuel - the higher the cost of fuel, the greater the fuel and dollar savings through added insulation.[8] Conventions of house construction and the material and insulation costs of insulation also affect the economics of minimizing heat loss from a dwelling. A substantial rise in fuel costs over present rates would, in addition to making much more heavily insulated homes desirable, entirely change the relative economics of solar heating or wind-electric heating.



Determination of economic thickness of insulation.



Fuel savings by conventional means of preventing heat loss.

Conventional practices of minimizing heat loss are fairly widely known, though not universally applied. Wall and ceiling insulation, minimizing infiltration through weatherstripping of windows and doors, double glazing or adding storm windows to window and door openings all offer substantial savings in almost any part of the country except the extreme south. Even weatherstripped and double-glazed, windows are often the largest single factor in heat loss from a house. Southern windows are, however, also a potential source of inexpensive solar heat. In combination with insulated panels, shutters, or curtains which can be closed over the windows at night to change the heat loss, they can offer considerable benefits - both in minimizing heat loss and in gaining very low cost solar supplementary heating. Careful design of overhangs and landscaping to minimize heat gain in the summer can make such windows a considerable benefit to the energy flows through a house.

Numerous architectural factors can affect the heat loss of a structure - its geometry, the amount of surface area of walls and roofs, the relative orientation of windows and large wall surfaces to the sun and wind, the color of surface materials, the heat transmission of structural and surface materials, the design of landscaping to minimize wind speed, etc. The use of earth berms or building beneath the ground level can offer considerable heating and cooling savings, as the ground temperature a few feet down remains at a stable 45-60°F, and can do much to minimize the great temperature fluctuations that a normal heating system must deal with. Some moisture and condensation problems arise in that kind of construction, but can be avoided through careful design.

Another means of minimizing heat loss is through maintaining a lower temperature in the spaces. Many homes today are heated to 75° or above, yet keeping the temperature at 68° in the daytime and five degrees lower at night is mroe healthful, comfortable, and saves about 3% of heating costs for every degree lowered. Spending more time outside, or in spaces open to the outside also can acclimate us to either colder or hotter ambient temperatures than we would choose if kept in constant temperature surroundings. This can allow us to be comfortable in cooler winter room temperatures and warmer summer room temperatures, lessening the energy necessary for comfort.

Composition of Residential Power Usage in a Military Housing Project

		kWhr		%
Lights and small appliances		3,926		14.6
Range		1,019		3.8
Clothes dryer		1,156		4.3
Water heater		8,572		31.9
Subtotal			14,673	54.6
Heating				
Bathroom resistance heater		1,122		4.2
Heat pump				
Compressor	4,855			
Supp. resistance heater	182	5,037		18.7
Subtotal			6,159	22.9
Cooling			6,060	22.5
Total annual kWhr use			26,892	100.0

Projected reduction in electricity demand resulting from doubling cost of electricity.

Case	Population assumption	Electricity price assumption	Electricity demand (Tkwh)			
			1975	1980	1990	2000
A	BEA	FPC	1.98	2.38	3.01	3.45
B	BEA	Double by 2000	1.88	2.07	2.11	2.01
C	ZPG 2035	FPC	1.98	2.37	2.95	3.29
D	ZPG 2035	Double by 2000	1.88	2.05	2.07	1.91
E	BEA	Constant	2.02	2.54	3.56	4.56
F	BEA	*	2.14	3.05	5.66	9.89

* Average prices decline 24 percent from 1970 to 1980, and 12 percent each 10 years thereafter until 2000.

The energy that is lost from water heaters, furnaces, and other household appliances offers a mixed benefit and problem. The energy used and lost from those appliances should be minimized to begin with, but what heat is lost can go towards space heating, and can minimize the need for additional energy. In the summer, however, the same heat put into the occupied spaces makes them less comfortable and requires several times the energy expenditure to cool the spaces again. The keeping of furnaces, water heaters, and appliances in occupied spaces rather than crawl spaces, garages, or basements, can retain their heat in more useable form, and get almost double use out of some of the heat. Furnaces can be turned off at the end of the heating season, and other appliances located in well-ventilated places where their waste heat can be vented to the outside in the summer months.

Ventilation heat recovery can be used to transfer the heat from exhaust air to incoming ventilation air where mechanical ventilation is necessary. The use of entry vestibules can help minimize the heated air lost through the comings and goings of people. In much modern construction the infiltration losses are actually lower than necessary ventilation needs, but some further conservation can be made through the evening out of the time and location of infiltration. The correct design of fireplaces, with tight dampers and with control of combustion air, can both minimize loss of heated air when the fireplace is not in use and also improve the operating efficiency when it is in use. Most homes also maintain the same temperature in all rooms, or lower temperatures in quiet rooms such as bedrooms, when actually the more active rooms require less heat.

If we take a tip from heating practices in China, Japan, and other traditional cultures, we could think in terms of keeping the people warm rather than the space, using more insulated clothing rather than buildings, and keeping lower temperatures in places of active work or where clothing or activity can keep a person warm.

After the sun, people are actually our best energy source. We are always giving off heat from our bodies, and the conservation of that heat loss can go far towards maintaining comfort without additional heating. Sleeping, we give off about 280 BTU/H per person, which rises to 400 BTU/H for quiet sitting, and 800 BTU/H for housework. Spaces containing many people, and some small, well-insulated spaces may require no additional heat beyond that given off by the people in them.

For mechanical work, also, we are often among the most efficient energy sources. Assuming we would be alive and eating anyhow, we only have to pay for the extra energy expended during the work considered, while for draft animals we have to consider their entire energy consumption whether working or not, and before becoming old enough to work. Mechanized energy sources are almost invariably less efficient when their total energy use is considered.

Income energy sources for heating, which don't deplete our energy reserves, include solar heating; solar electrical heating; hydro, wind, and perhaps geothermal and tidal electricity; wood heat; methane, alcohol and hydrogen from agricultural wastes, algae production, wood, etc. Solar heating has probably the greatest potential for minimizing our dependence on other energy sources for space heating - both through complete heating systems, and through very low cost means of tempering, saving, and evening out the normal heat rhythms in our surroundings.[9,10] Although intensive work on using income energy sources is only beginning, there are several techniques and systems that even in prototype state are marginally competative with fossil fuel systems. Commercially available, mass-produced systems for 100% solar heating, hot water, and air conditioning should be available on the market within two years.

Commercial electricity generation from methane, and the use of waste heat from the generation process to operate heat pumps for space heating offer possibilities of gaining greater efficiency out of the process of transforming and distributing energy. Other possibilities of improving efficiency of heating processes include the use of infra-red reflective heating systems for greater efficiency in warming people while maintaining the actual air temperature at a lower level.[11] The improvement of present heat-pump and heat-pipe techniques promise considerable increase in efficiency of energy use and transfer. Careful design of gravity, specific-density, and other heating systems that require minimal operating energy can make solar-based space heating almost, if not totally, free of need for auxiliary energy sources.[12] Combination of solar-electric and solar-heat collectors presently under development promise a more complete use of the energy falling on a collector, and can provide operating energy as well as a heat source.[13]

Wind-electric energy can be added to a solar heat sink through resistance electric heaters to store excess energy not needed to operate appliances, etc.[14] Improvements in wind-generators currently being tested promise greater simplicity, lower cost, and greater output and efficiency - making them a much more competative electrical source for isolated dwellings.[15] The increased consideration of microclimatic conditions and ambient energy availability such as solar and wind energy suggest considerable regionalization in energy systems design because of widely varying conditions.

COOLING

Air conditioning specifically based upon income energy sources is not nearly as well developed as solar heating systems, although at least two solar operated air conditioning systems are under development. Incorporation of air conditioning in solar designs is considered attractive because it gets double use out of the collectors and use them in their most productive period. Developments in storage of summer heat are making these economics unnecessary and allowing the need for incorporating air conditioning to be decided upon from other factors such as benefits of acclimatization vs. air conditioning for psychological and physiological health.

There is also considerable variation in the efficiency of currently available air conditioning systems, and room for more improvement in their efficiency - when they are considered necessary. The real desirability of mechanized air cooling systems appears somewhat questionable except in specialized situations such as hospitals, some industrial processes, etc. It is invariably a high energy-consuming process, and of questionable psychological and physiological benefit. Where mechanical ventilation is necessary, attic fans can often achieve better results than air conditioning.

The careful utilization of natural micro-climatic conditions, use of landscape cooling, architectural devices, and the naturally available heat sinks and heat rhythms for tempering summertime temperatures can offer in most places a quite satisfactory environment except for a few peak days.[16] Our specification of invariable, year round working conditions could perhaps be more called into question, vs. the energy efficiency of not working on the few hot days and a more relaxed attitude towards work regularity.

FOOD

Ouragricultural practices are actually energy sinks - consuming considerably more energy than they produce, and are more than 6000 times less efficient than Chinese rice agriculture.[17] Inorganic fertilizers, extended food chains involved in meat production, over-processing of food products all pyramid food costs, energy use, and substantially lower food freshness and nutritional quality. A change to a dominantly vegetarian diet would require only about one-tenth the farmland, production, and energy consumption we presently employ.[18] A wider use of unprocessed foods can eliminate considerable waste and energy use in preparation and packaging, and give the home fresher and more nutritious foods. Recycling the nutriments and energy in our bodily waste onto the fields can eliminate waste purification costs, lessen water pollution, and lessen the dependence upon artificial manufactured fertilizers.[19] Different farming methods (local farming, less mechanization, elimination of monoculture, companion planting, organic soil conditioners, etc.), shortening the food chain by eating less meat, minimizing processing, and recycling the wastes can substantially lessen the energy consumed in the flow of food through the home. Substantial benefits also develop - fresher, healthier foods, less water pollution, less demand for land for farming, less industrial intrusion into the environment, and more humane work opportunities and control of processes affecting us.

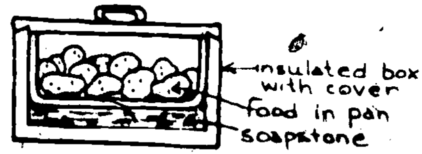
The actual food storage and cooking in the home consume only perhaps 8-10% of the power consumed in the home, but can offer interesting savings. Cooking requires high temperature, controllable heat, and the alternatives to fossil fuels or electricity seem harder to find than in some other sectors of the home. The use of organic methane or hydrogen; of charcoal or wood; or wind-, methane-, or hydro-electricity seem possible in addition to presently rather awkward solar cookers.

ENERGY INPUT-OUTPUTS OF SOME FARMING SYSTEMS

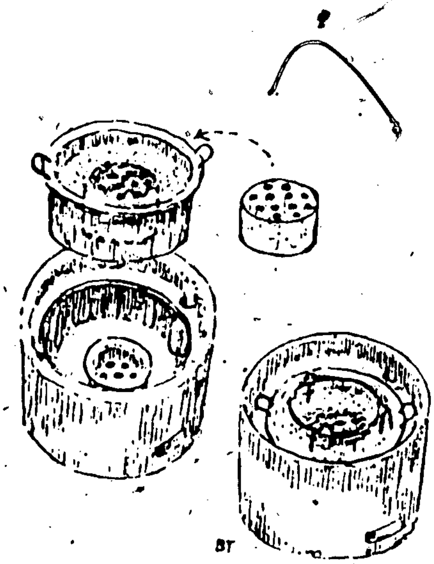
Type of Agriculture	For This Many Calories Expended in Growing Food . . .	. . . This Many Calories Are Harvested
Slash and burn (Tsembaga tribesmen of New Guinea)	1	16
Wet rice farming (China)	1	50
Factory Farming (United States)	20	1

Direct energy efficiencies of farming processes.

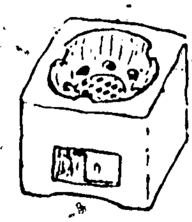
Some low energy consuming cooking stoves.

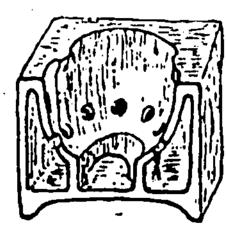


Fireless Cooker



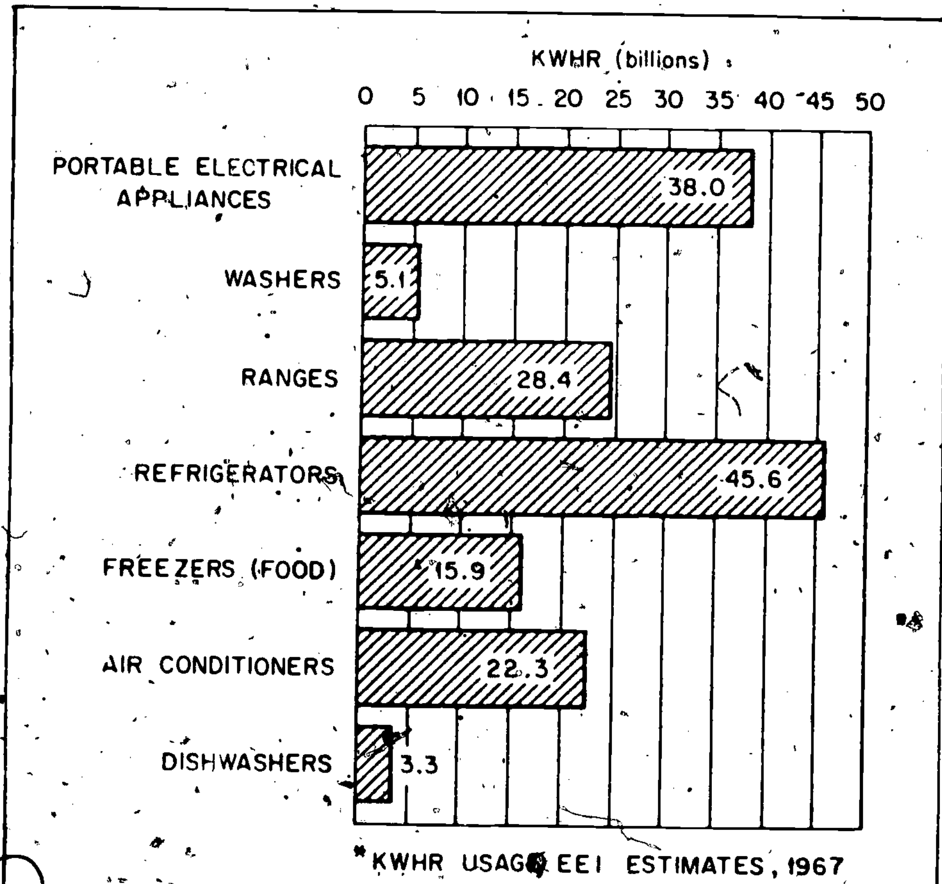
The *Rentan* Stove





The *Konro*, a Cooking-Stove

Electrical consumption of household appliances.



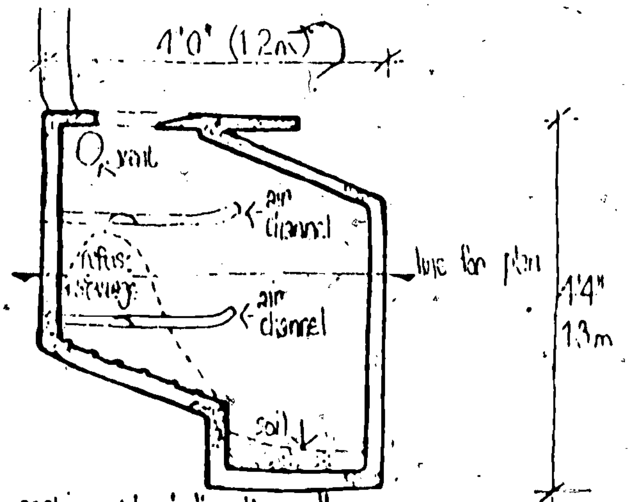
During the heating season, energy used in cooking and baking ends up heating the house, and actually gets additional use out of the energy. In the cooling season, however, kitchen heat loads add considerably to the need for and cost of cooling. The Rentan and other charcoal stoves used in Japan and China were extremely efficient in the use of heat and ability to control and change temperature.[20] The use of woks and other similar devices for cooking require less heat, as do pressure cookers, which cook in considerably less time. Thermos cookery, fireless cookers, etc. also minimize energy use, as do a number of traditional cooking practices of other cultures such as the use of pan breads rather than baking, chopping food so it will cook faster, etc.

Refrigerators consume from 80kwh for conventional models to over 200 kwh per month for side-by-side frost-free models. The refrigerator is always pumping heat from inside into a room that is at at least 70°F, while the air temperature outside the home is actually lower than the inside of the refrigerator for much of the year, and the stable ground temperature 3-4 feet below the surface stays at a steady 45-60°. The use of alternative food storage means and the development of better refrigerators can save considerable amounts of energy.

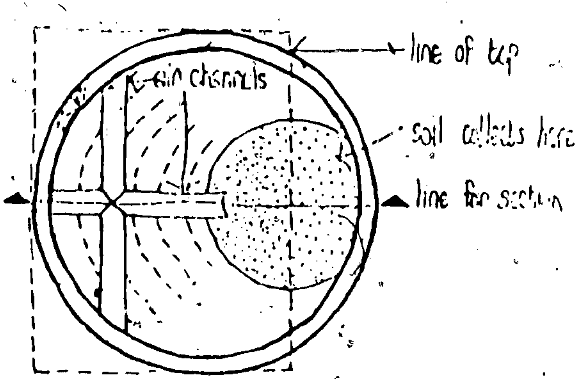
WATER

The conservation of water seems only tangentially related to energy conservation unless carefully considered. In areas where water is freely available it seems questionable to be miserly with its use. However, it still involves collection, purification, distribution, heating, sewage collection, purification, and dilution.[21] These processes involve expenditure of energy related to quantity as well as merely to access. The processes also use considerable land, cause detrimental effects in our rivers and lakes, and put unnecessary restraint on the form and nature of our cities. Unnecessary use of water also breeds attitudes of waste which carry over into other aspects of our lives. It is easily possible to reduce water consumption in a home by over 70% with no reuse of water other than flushing toilets - and in the process gain some more pleasing experiences.[22] Mist sprays and other devices can reduce water use even further, making a home entirely self-sufficient in regards to water supply and waste.[23]

Forty percent of the water used in the home is used for flushing the toilet. The normal American toilet requires 5 gallons per flush, though toilets in Britain are designed to operate on 2.5 gal/flush, and less for urine.[24] The use of compost toilets or storage toilets require negligible amounts of water, and have the added advantage of lessening the quantities of sewage that need to be processed. By merely reversing the valving arrangement in the toilet tank so that it fills and flushes only after the handle is pressed, the waste water from sinks and showers can be used as flush water in the toilets. The use of foot operated faucet valves on sinks and wash basins, combined with location close to water heaters, can lessen by perhaps a third the water used for dishwashing and lavatory use. The water used in bathing can similarly

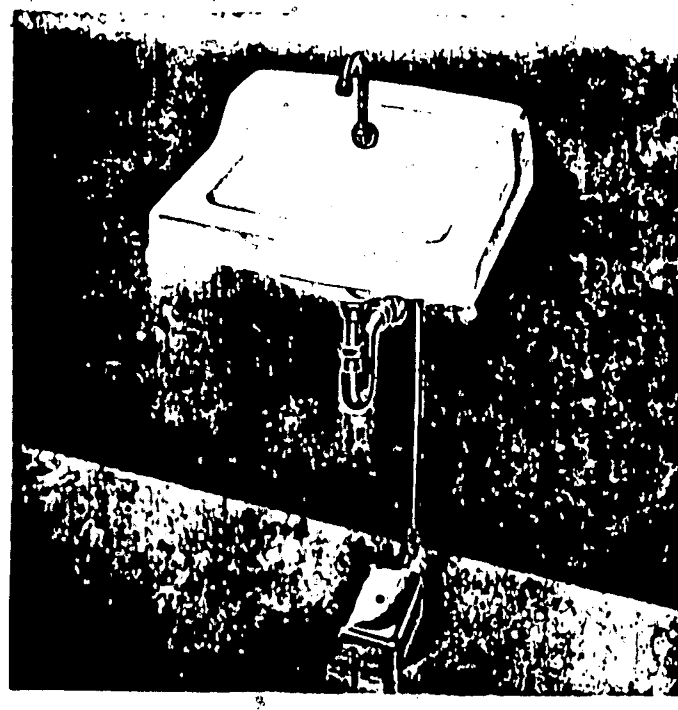


section thru' "multrum"

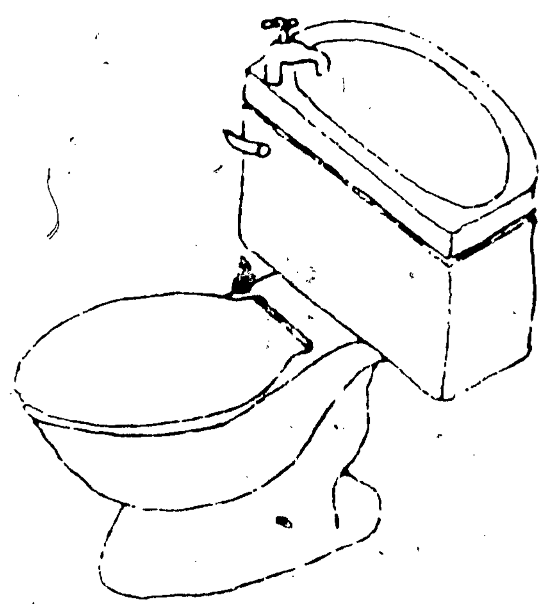


plan of "multrum"

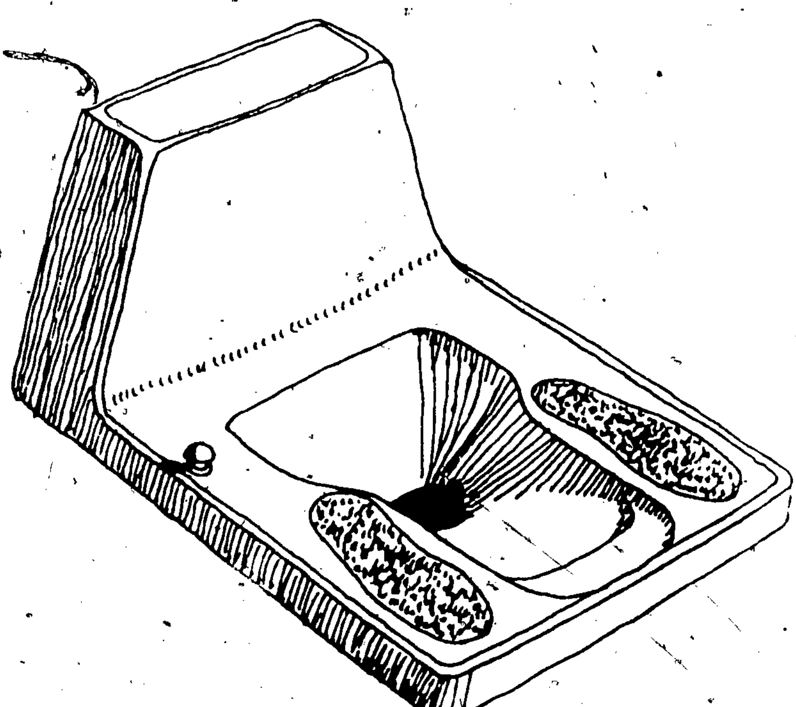
Simple aerobic composting toilet.



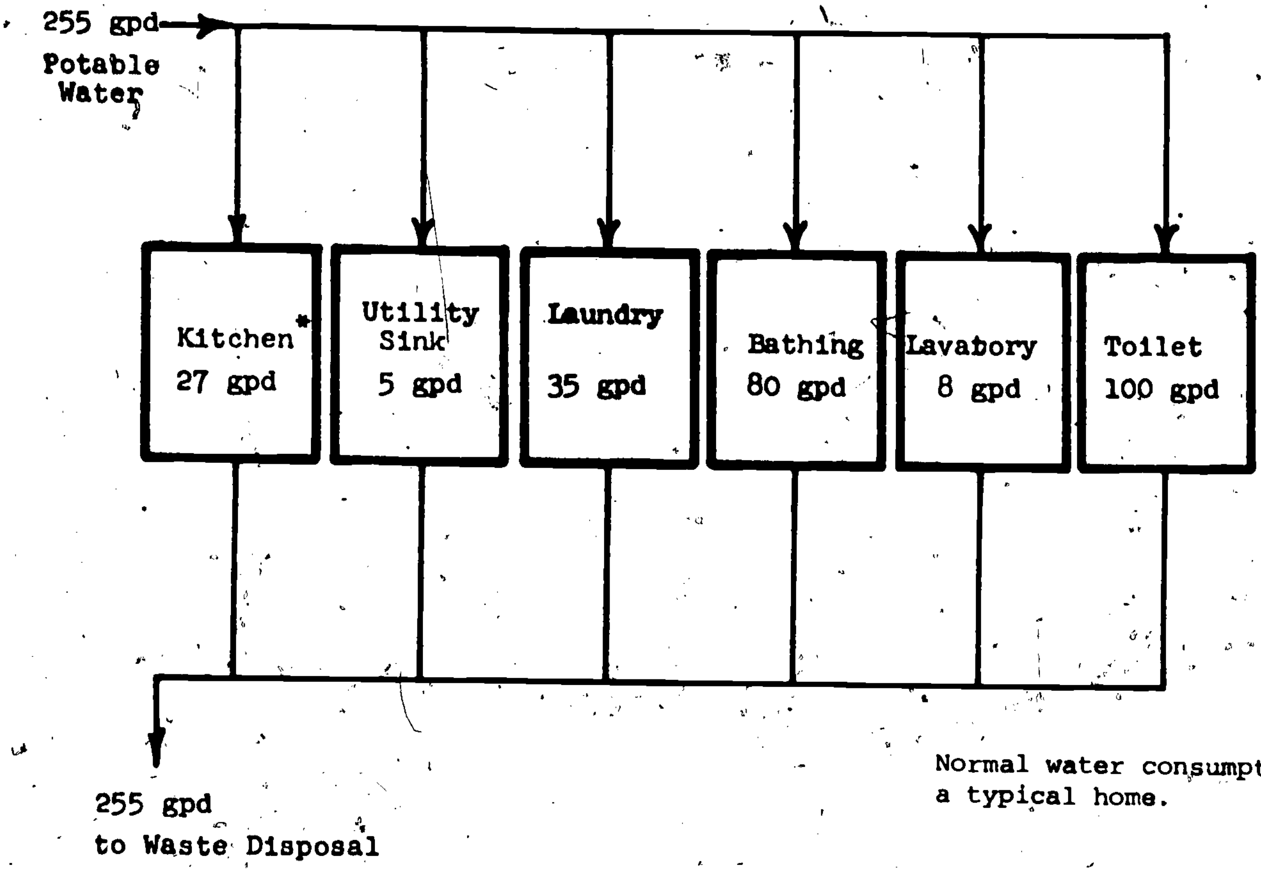
Foot pedal operated lavatory faucets.



Reuse of waste water to flush toilets.

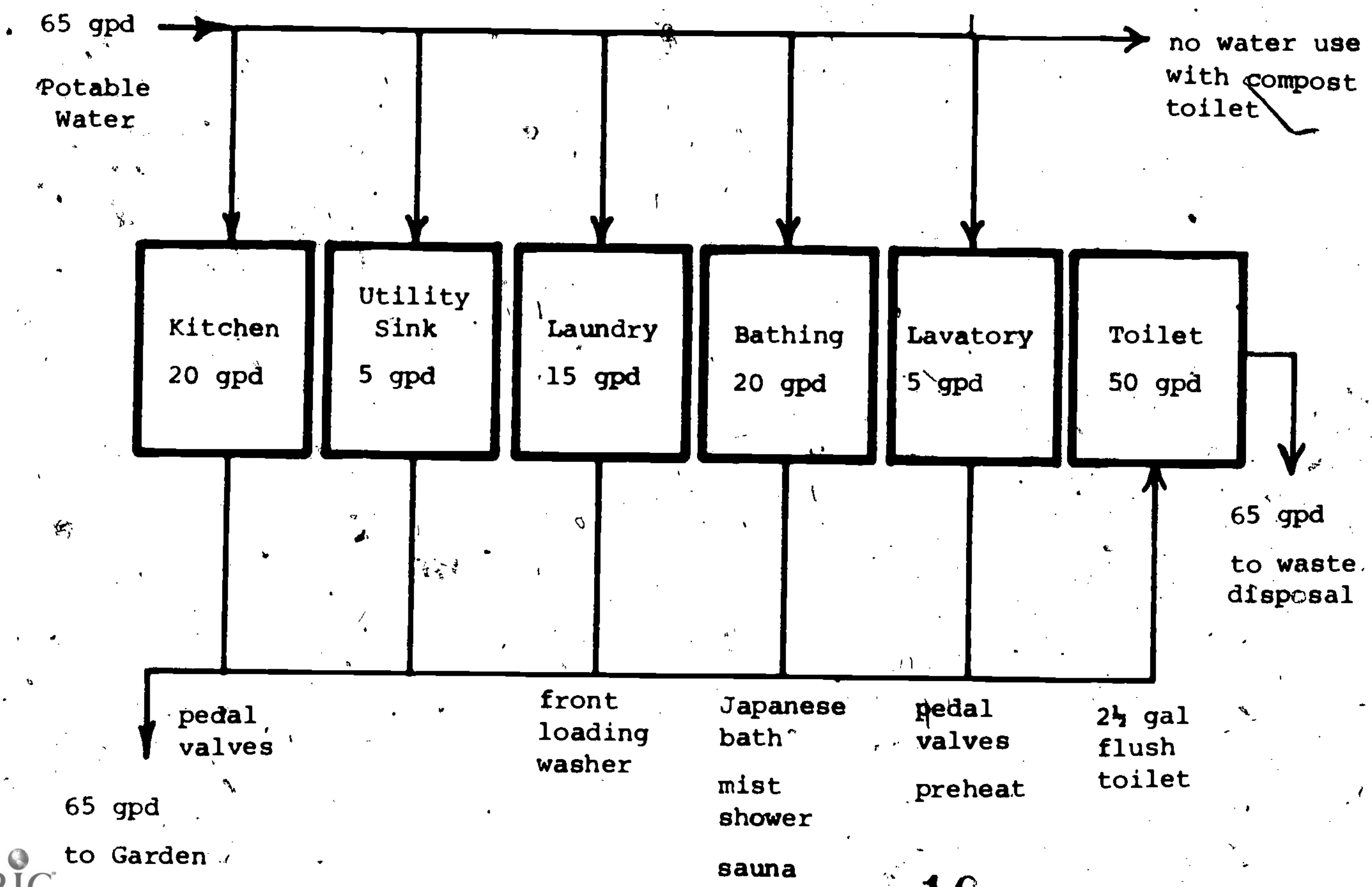


French "squat" design flush toilet.



Normal water consumption in a typical home.

75% reduction in water use.



be reduced by perhaps an average of 75% through the use of pressure-regulating shower heads, use of Japanese baths (where you rinse off before soaking in the tub, allowing the water to be used for several days), or use of a sauna.

Clothes washing and drying provide other opportunity for energy and water conservation. The choice of the kinds of clothes and materials that a person wears, along with his attitudes towards hygene influence substantially how often clothes need to be washed. Light colored clothes look dirty quickly, and clothes that wrinkle easily and show wear often need washing for esthetic rather than hygenic reasons. Permanent press clothes require considerably more water for washing than other materials. Normal washers require 20-33 gal/cycle, while "suds-miser" design, which reuses rinse water for washing, uses substantially less, and front-loading machines use 50% less water than top-loaders. Fabrics, detergents, and laundry aids have far more effect on water use than the machine design itself. Hand operated washers designed by V.I.T.A. offer substantial savings in addition to lower costs. Solar clothes dryers (commonly called outdoor clotheslines) save 80 kwh of electricity per month over an electric dryer. Automatic dishwashers use 13-20 gal/day in addition to the water used for rinsing dishes.

Substantial reduction of water use has additional benefits in releasing the home from the costs and dependence upon connected systems. Low water use more easily accomodates to ambient water supply (rain water, wells, etc.), and reabsorption (gardens, leach fields, etc.) within the natural systems of the land.

Most of the household water and at least 75% of bathing water will also be heated. Water heating is usually the second greatest energy consumer in the home, consuming up to 25% of the energy used. Solar water heaters are probably the most perfected and widely used solar heating device, and can perform the majority of domestic water heating - either as a seperate unit or integrated with a solar space heating system. The use of solar water heating has the added advantage that it is a year around need rather than winter only, and can use solar heat when it is most readily available. On conventional systems, location of the water heaters in heated spaces can reuse the 10% or more heat lost from the heater for space heating. More heavily insulated units can also offer savings in traditional installations.

WASTE

The way we treat our bodily wastes, kitchen wastes, and refuse offer us some of the more significant possibilities for energy conservation within the household. Our kitchen and bodily wastes are plant material taken from the soil of our farms, and are constituted of the nutriments necessary for further growth of food. Instead of returning them to the fields we commonly dillute them 98 times with water, flush them through the sewers, treat and sterilize those huge quantities of sewage, flush the soluable nutrients on into the rivers where they cause eutrophication, and either bury the solid waste sludge or allow it also to pass into the rivers. We then attempt to restore the soil vitality with manufactured chemical fertilizers. All this consumes great quantities of energy and causes considerable degradation of our environment.

The septic tank systems common in suburbia offer a poor alternative, being expensive, having high maintainance and causing widespread pollution of groundwater. The simplest and most valuable alternative is composting the wastes to remove disease problems, and then applying the compost to the fields as fertilizer and soil conditioner.[26] Fairly simple and inexpensive aerobic compost toilets are available and offer a good solution for isolated dwellings.[27] Their size and need for basement space make other alternatives beneficial in more heavily settled areas. Storage toilets, with either mechanical traps or recirculating chemical flush, store the wastes in 55 gal. drums or similar containers. Lime or other chemicals are added to change the pH and prevent decomposition and methane formation. The containers are periodically collected or pumped, and the wastes taken to a central facility where the pH is reversed by adding ashes, etc., composted anaerobicly, producing useable quantities of methane gas, and the compost slurry taken to the fields after stabilization for use as fertilizer. More complex aerobic and anaerobic systems are available for high density application.

In the process of learning more about the nature and value of our wastes and changing our systems that process it, we begin to move out of the blind attitudes we have held towards hygene. With that, our bathrooms change from an embarassing sanitary facility to something more akin to the Japanese toilet or benjo - more a shrine than a disposal site.

Refuse is somewhat more difficult to deal with in its end form, due to its complex composition. It generally can be considered a sign of improper processing - being largely the result of overprocessing and packaging and energy-inefficient delivery systems (such as throw-away beverage containers). The best, and only really valid way to deal with refuse is to prevent its accumulation. Examine where your trash comes from and why, and see where simpler and more direct sources of supply can be substituted. Reuse of many containers is possible. One of the largest accumulations is paper - mostly newspaper. Newsprint can be recycled - but have you ever tried getting along without newspapers? The minimal amounts of worn-out goods remaining after reduction of refuse accumulation can more easily be recycled by traditional methods.

APPLIANCES AND TOOLS

With the exception of televisions (a color television uses as much energy in a month as an electric range), most small appliances and tools consume relatively insignificant amounts of energy in their operation. Their more important influence on energy conservation lies in the energy consumed in their production, advertising, sales, repair, and maintenance, and in the effects they have on our attitudes and abilities. They often instill the feeling that it is better to have a machine do something for you than to do it yourself, and they are skill-replacements - preventing the development of our own innate abilities. Other than that, they are often merely a clutter and bother to our lives, and something we can more happily do without.

LIGHTING

Lighting accounts for only about 10% of the energy use in the home, and energy conservation in that area is perhaps fairly hard to come by. The safety benefits of electric lighting over other available lighting techniques suggests the desirability of electric lighting, though some efficiencies can be found in its use. Florescent lighting produces five times the light output of incandescent bulbs consuming the same energy. The advantage is not quite so clear-cut though, as incandescent lighting can usually be more easily used as spot lighting and directed onto where it is needed. The size of florescent tubes usually means spreading light where it is not needed. The use of PAR (reflector) incandescent lamps offers a useable efficiency similar to florescents - one 30 or 50 watt PAR bulb provides quite comfortable light for most situations, without raising background light levels too high. Most homes are overlighted, and lighting placed where it works most inefficiently. Care in the location of lights, and the proper use of reflectors and focusing lenses can give considerably more useable light for the energy used. Natural lighting, of course, is the obvious solution to daytime lighting needs, and provides considerable psychological, heating, and health benefits over artificial illumination.[28] Selective switching, fewer and higher wattage bulbs, elimination of shades and lenses can all assist in improving the lighting obtained from the energy used.

STRUCTURE AND FURNISHINGS

The building a home occupies, and the equipment and furniture put into it account for quite substantial consumption of energy. The energy used in manufacture and assembly of the materials commonly used in a house is equivalent to that consumed in one or two years of its operation. Studies have shown a possible 80% reduction in the energy/materials consumed.[29] Change in space use can offer additional savings. Our living patterns are quite space-consumptive - with the private bedroom for each member of the family being the American ideal; with separate rooms for eating, "living","family", etc. in addition to multiple baths, garages, etc. Considerable space is used solely to store the large amounts of equipment accumulated by our lifestyles.

Much of the space in a home becomes unnecessary if different approaches are taken to space use and furnishing. Up to 50% of the floor space in a house is commonly taken up with fixed, heavy, and bulky furniture that has only single use potentials (beds, tables, chairs, sofas, bureaus, etc. Much furniture functions only for esthetics ("that wall really NEEDS a nice little table!). Most families spend a considerable sum on the purchase and replacement of furniture - expenditure that represents energy and unnecessary work.

Living patterns of other cultures suggest approaches that are more comfortable, use less space and energy, and are less expensive. The Japanese, instead of lining furniture up around the edges of a room, use the floor for sitting and sleeping - adding a table in the center for eating, leisure, etc. The same room can be used for sleeping, eating, leisure, work, etc. In India, even in very wealthy periods, furniture was almost never used - the people prefering to sit on rugs on the floor. The sitting rooms in traditional Turkish houses are quite small, and lined around the edge with wide sitting platforms which can be used for sleeping at night, and with the addition of a table in the center, for eating. Many cultures find it strange to sleep alone in separate rooms - prefering to sleep close to other people they are close to.

Change in our living habits can result in need for less space, with consequent reduction in energy used to build, maintain, heat, cool, and light it. Change to less processed, local materials and simpler building processes can save energy in construction. The elimination of most furniture, and the use of simple sitting/sleeping platforms, homemade pillows, etc. can reduce to a fraction the amount of energy going into the furnishing and upkeep of a house.

The energy involved in manufacture and processing of building materials and in construction and maintenance of buildings is fairly complex to calculate. Aluminum requires incredible amounts of electricity to be processed from ore. The actual energy efficiency differs depending on whether the electricity comes from hydro or fossil fuel generation. The amount of scrap recycled in the manufacture of the material also affects the energy consumed - less than one fifth the energy is required to recycle aluminum than to refine it from ore. Changes in manufacturing processes, as we become more energy conscious, can substantially change the relative "energy merit" of different materials. However, some general guidelines can be considered. The less processed a material, the less energy involved in its making (but possibly the more required in its assembly or application). The more traditional or "natural" the material, the more economical. For instance, roofs traditionally were surfaced with slate, wood shakes, clay tile, metal, thatch, or sod. Those roofs today cost two to four times what an asphalt shingle roof does, but also last several times as long. Asphalt roofs last from 15-25 years, sod 60 years or more, slate or tile more than 100 years. Thinking in any other than short terms, it is both wiser and more beautiful to use the traditional materials.

(TABLE I) MATERIALS AND ENERGY USE FOR CONSTRUCTION

	Yearly Materials Consumption 1967-69 Average *	*Energy Inputs* †		*Additional Environmental Impacts*
Cement	17×10^6 tons	1800 kWh/ton	27×10^9 kWh (Cement, Concrete, Concrete block & pipe)	Localised air pollution. Demand for aggregate—beach damage etc.
Concrete	30×10^6 tons	~500 kWh/ton		
Concrete block & pipe	1.5×10^6 tons	~400 kWh/ton		
Asbestos cement	520×10^3 tons	2200 kWh/tons	1.2×10^9 kWh	Asbestosis of processing workers. Local asbestos water pollution.
Bricks (All types)	7×10^9 bricks	0.2 kWh/brick	3.4×10^9 kWh	150 acres/year dereliction of brick earth zones§
Plastics	4×10^3 tons	2400 kWh/ton	10×10^6 kWh	Localised water & air pollution.
Slate	22×10^6 tons	500 kWh/ton	11×10^9 kWh	Large transport component.
Plaster & Gypsum	900×10^3 tons	300 kWh/ton	270×10^6 kWh	Localised pollution; waste disposal dereliction.
Steel & Iron	1.5×10^6 tons	3.5 kWh/lb‡	4×10^3 kWh	Water & air pollution. Raised outflow of iron compds to sea.
Copper & Brass	83×10^3 tons	5 kWh/lb	900×10^6 kWh	Local air & water pollution. Mine dereliction. Raised run-off.
Aluminium	3×10^3 tons	8 kWh/lb‡	56×10^6 kWh	Fluorosis pollution.
Glass	470×10^6 sq ft	6 kWh/sq ft	3×10^9 kWh	Localised air pollution.
Timber	1.6×10^6 cu metres	70 kWh/cu.m	110×10^6 kWh	Much imported. Linked to overrapid forest clearance etc.
		Total energy use:	$\sim 40 \times 10^9$ kWh	

TYPICAL MATERIALS AND ENERGY INPUTS FOR STANDARD HOUSING UNITS (Parker-Morris standard 3-bed semi-detached. 100 m² floorspace)

Materials	*Energy Inputs*
Bricks: 16,000	3200 kWh
Steel: 1.2 tons	9200 kWh
Glass: 320 ft²	2000 kWh
Concrete: 10 tons	5000 kWh
Cement: 2 tons	3600 kWh
Plaster: 3 tons	900 kWh
Timber: 4.3 cu. m.	310 kWh
Plastics: 250 lbs	300 kWh
Paint: 4700 sq. ft.	500 kWh
Copper & Brass: 500 lbs	2500 kWh
Others: —	4000 kWh
	31,510 kWh

Site Preparation

Excavation/Handling: 2000 cu. ft = 6000 kWh

Cement mixing and Miscellaneous machinery:

100 gals fuel = 4200 kWh

10,200 kWh

Materials Transport

Bricks 60 miles at 1.5 kWh/ton mile:	3200 kWh
Timber 250 miles at 1kWh/ton mile:	1100 kWh
Cement 40 miles at 1.5 kWh/ton mile:	400 kWh
	4700 kWh

Total inputs 31,500 + 10,200 + 4700 = 53,700 kWh

Alternative 1: 10% soil-cement blocks	
8 cu. yds. cement and handling:	12,500 kWh
Soil: 50 tons (hand labour):	50 kWh
Localised wood supply:	150 kWh
Glass:	2000 kWh
In situ rendering materials:	100 kWh
Metals:	1500 kWh
Others	2500 kWh
Total	18,800kWh

Alternative 2: Rammed earth	
80 cu. yds earth, 70 men days:	100 kWh
160 cu. yds. earth invert:	150 kWh
Glass:	1500 kWh
Timber:	150 kWh
Rendering:	50 kWh
Metals	1000 kWh
Others:	2000 kWh
Total	4,850kWh

The energy costs, as well as the dollar costs of building can be altered substantially by changing the context of building. Building to last 200 years rather than twenty stretches the energy used more than 20 times. The reuseability or recyclability of materials and building components also affects the yearly energy cost of a building. If we would build houses like the Chinese, that can be disassembled, the timbers sold, and reused in another building, the energy costs would again be stretched out. The actual amount of material going into a building is not as important a factor as the lifespan, reuseability, finance, and other secondary costs. The need to finance rather than to build as money becomes available increases the "energy" costs of building by involving more people's work and profit - which is true of other secondary costs of building. Craft-building rather than industrialized building processes can produce better building for less cost and energy.

The spatial organization of buildings also affect the energy consumption in their operation. High-rise buildings require energy-operated elevators, mechanical ventilation, etc. Tall buildings often generate higher transportation costs. Depending on insulation and surface materials, large buildings may or may not have greater heat loss and gain. The energy cost of building also needs to be considered on somewhat wider grounds than just physical comfort and minimal cost for enclosing space. Our needs in terms of psychic space are both more difficult and more expensive to satisfy than those for our physical existence. The most economical house from an energy standpoint would probably be spherical, as it would have least area to lose heat; it would be windowless because most heat is lost through windows; and it would be underground to take advantage of the constant temperature. Unfortunately, it wouldn't be a very nice place to live, and wouldn't take into account our need for stimulus, information, challenge, and growth. The balancing of many complex factors suggests that we don't want the optimization of energy conservation, but rather a knowledge of the energy costs of various alternatives so we might better weigh their relative advantages and disadvantages in assisting us towards the kind of life we wish to live.[30]

CONNECTED SYSTEMS

We tend to think of the energy flows through a home as a thing separate from the context in which we choose to build, locate, and use the home. In reality, they are quite interdependent. The cost of moving people, information, fresh air, water, waste, work, and recreation to and from a home form a more considerable part of our national energy consumption than the energy flows necessary to sustain and operate the home itself. Meaningful consideration of means to conserve energy in the home must include consideration of its connected systems.

Energy-Efficiency for Urban Passenger Traffic

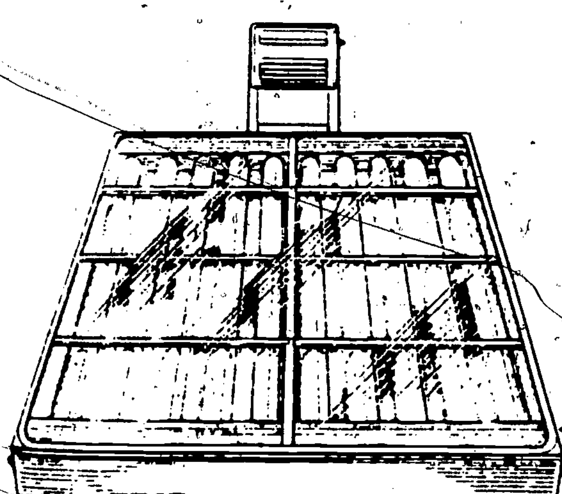
	Vehicle-miles / Gallon	Passengers / Vehicle	Passenger-miles / Gallon	Btu[b] / Passenger-mile
1. Bicycles[c]	—	—	756	180
2. Walking[c]	—	—	450	300
3. Buses	5.35	20.6	110	1240
4. Automobiles	14.15	1.9	26.9	5060

Energy-Efficiency for Inter-City Passenger Traffic

	Passenger-miles / Gallon	Btu[b] / Passenger-mile
1. Buses	125	1090
2. Railroads	80	1700
3. Automobiles	32	4250
4. Airplanes[c]	14	9700

Energy-Efficiency for Inter-City Freight Transport

	Ton-miles / Gallon	Btu[b] / Ton-mile
1. Pipelines	300	450
2. Waterways	250	540
3. Railroads	200	680
4. Trucks	58	2,340
5. Airways[c]	3.7	37,000



The glass pipe type solar water heater.

Compost toilets are available now which cost only $100 or so more than a normal flush toilet, which produce fertilizer rather than water pollution, and which consume no water, require no sewage hookup or sewage treatment. With options available, our normal pattern of hooking homes up to sewage systems, and their attendent costs, must become a part of our consideration of household energy consumption.

Our practices of separating the home from the workplace generate a considerable part of the 24% of our energy consumption employed for transportation (in addition to highway construction, maintainence, automobile manufacture, etc.), and they also involve duplication of water, sewage, power, gas, police and fire systems, and additional building and operating costs. The use of unshaded asphalt streets and parking areas absorb 97% of the sun's energy striking the pavement, causing temperatures near the ground of often more than 50° above normal. That in turn causes more use of air conditioning, which in turn expels more heat into the outside environment, generating additional need for air conditioning.

Our building and living practices are based on an assumption that urban living is more desirable than other, that separation of different parts of our lives is desirable, and that the city is an efficient, desirable place to live. On the contrary, a city is inherently inefficient in supplying people with their daily needs. Once the natural capacity of the land is overtaxed, expensive artificial systems have to be introduced to cope with what the natural systems of the environment take care of automatically at lower densities. The city is efficient only in terms of communication, people relationships, and the more complex luxuries of modern living practices.

The institutionalization of our social relationships also increases substantially the dollar and energy costs of housing. The separation of elderly people into special "complexes" rather than caring for them at home creates additional needs for facilities, services, etc. The separation of learning from the home generates duplication of facilities and additional transportation. The energy consumed for street lighting for "safety", rather than dealing with the causes of social problems could well be considered an inefficiency. The absence of lifespan costing in investment building, and consideration of city infrastructure costs in changes in land use all create increased costs and energy consumption in indirect ways. The networking costs of delivery of urban services to decentralized areas are considerable, and involve considerable energy losses as compared to autonomous housing and neighborhoods. Property tax structures penalize the maintenance of buildings as well as preventing good construction.

A change in fossil fuel availability and a change to predominantly income energy sources will bring about a considerable change in city location and form - income energy sources are basicly disperse sources, as opposed to the concentrated forms of oil, gas, and coal. They are generally more easily collected and used at the point of use, and lessen the desirability of centralized power and fuel sources.

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8. See The Value of Thermal Insulation in Residential Construction, John Moyers, Oak Ridge, Tenn. 1971. The economically feasible insulation values are not projected beyond present norms, however.
9. See "The House that Has Its Furnace in the Sky", POPULAR MECHANICS, June, 1973 for a recent discussion of the Thomason solar heating system.
10. See "The Solar Era", MECHANICAL ENGINEERING, October 1972 for a discussion of Harold Hay's simple heating and cooling designs.
11. See "Experimental Cooling-Heating System", C.A. Mills, ARCHITECTURAL FORUM, Nov. 1950.
12. See "Sun Heated Ski Lodge Slit into Mountain Slope", Paul Jacques Grillo. INTERIORS, Jan., 1951, and recent work of Steve Baer for simple, unmechanized systems.
13. See SOLAR ONE, Institute of Energy Conservation, University of Delewa
14. See Ouroboros Project, School of Architecture, Univ. of Minnesota.
15. See recent designs by Allan Sondak at the University of Minnesota and by Windworks, Mukwonago, Wis.
16. See work of Harold Hay, Paolo Soleri, Climate Near the Ground, by Rudolf Geiger, Micro-climate section of Energy and Architecture: Sources for numerous ideas.
17. "Factory Farming is not Efficient", Jeff Cox, ORGANIC GARDENING AND FARMING, June 1973.
18. Diet for a Small Planet, Frances Moore Lape.
19. Farmers of 40 Centuries, F.H. King, 1911, and Composting, Harold Gotaa W.H.O. Monograph #31.
20. Houses and People of Japan, Bruno Taut. pp.25-26.
21. See Environmental Design Primer section on Waste and Energy for discussion of comparable costs of waste treatment in Shanghai and Minneapolis.
22. A Study of Flow Reduction and Treatment of Waste Water from Households 11050 FKE 12/69. U.S. Dept. of Interior.
23. See The Ecol Operation, Minimum Housing Group, School of Architecture McGill University, and earlier studies by Buckminster Fuller.
24. Stop the Five Gallon Flush, Minimum Housing Group, McGill Univ.
25. Water Supply for Rural Areas and Small Communities, Wagner and Lanoix. W.H.O. Monograph #42.
26. Composting, Harold Gotaas, has a comprehensive bibliography on pathogen destruction studies.
27. Stop the Five Gallon Flush, McGill University.
28. "Health Requires Natural Light", PREVENTION, September 1973.
29. "Low Energy Housing", Andrew MacKillop, THE ECOLOGIST, Dec. 1972.
30. See Energy and Architecture: Sources, and ALTERNATIVE SOURCES OF ENERGY, #9 for fuller references.

Ouroboros

THE BENEFITS OF AN IMPURE APPROACH

Ouroboros was the mythological dragon which survived by eating its own tail and its own feces, and was a symbol of a world that survived by endlessly devouring itself. It serves today as a model of the systems of life operating on this planet - closed systems, undulating in waves of energy that pass through cycles of alternate life and death. It is also the name of an experimental house constructed in the spring and summer of 1973 by the students in the Environmental Design class of the School of Architecture and Landscape Architecture of the University of Minnesota, which is testing many of the above energy conservation ideas along with other approaches in building and learning.

Perhaps the most valuable lesson learned in the design of the structure was the benefits of an impure approach - instead of focusing solely on a single method of energy conservation, or single income energy source, or taking a purely engineering approach to the study of energy systems, it attempted to take advantage of the many different rhythms and flows of energy through our environment and to design interactive systems to use those energies compatibly. The accumulated savings offered by many techniques linked together have made possible the design of a house that is 100% solar heated in Minnesota's chilling 8000 degree-day winter, with temperatures which drop sometimes to -35°F.

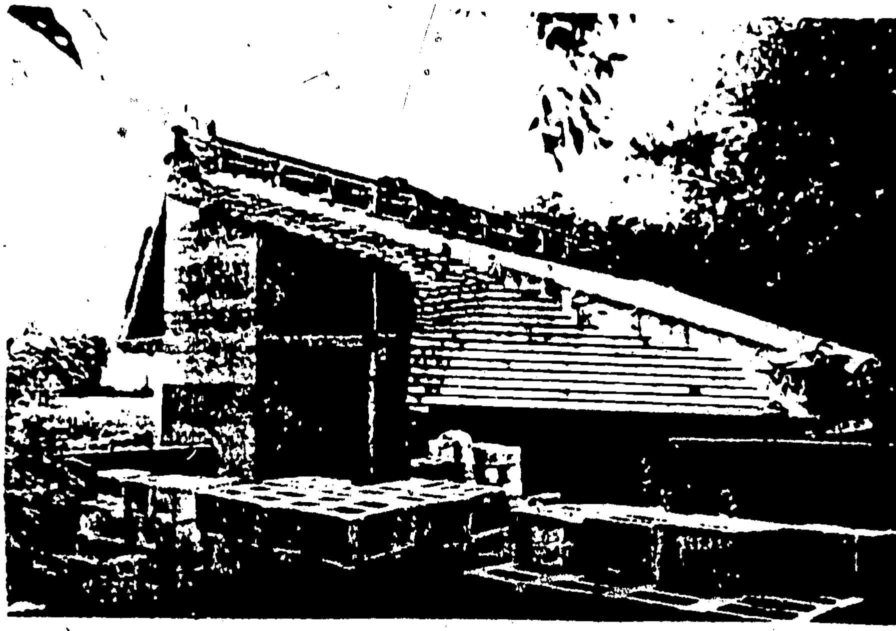
The approach taken recognized that most existing studies on energy conservation and income energy sources for homes were single-system studies - few evaluating combinations of systems, and few recognizing that life style, attitudes, architectural and landscape considerations, and connected systems outside the home had a perhaps more significant role in the total energy flows through a home than a single heating, waste, or other system. It also recognized that energy conservation was only one element in designing a living place that was spiritually and psychologically good as well as soundly engineered. It was felt that these various systems, considered together, offer economies and benefits not apparent in single-system studies.

The project began in fall 1972 with a study of income energy sources and energy conservation techniques, followed in the winter by a design competition among the students, with construction beginning in the spring. The 160 students in the class brought together many interesting ideas, many of which were incorporated in the design of the initial structure: The building itself was based on craft rather than industrialized building processes, and relied as much as possible on natural materials and the reuse of materials salvaged from buildings undergoing demolition. The design and erection of the structure also acted as an experiment in alternative learning processes - learning through actual design and building rather than theoretical academic exercises.

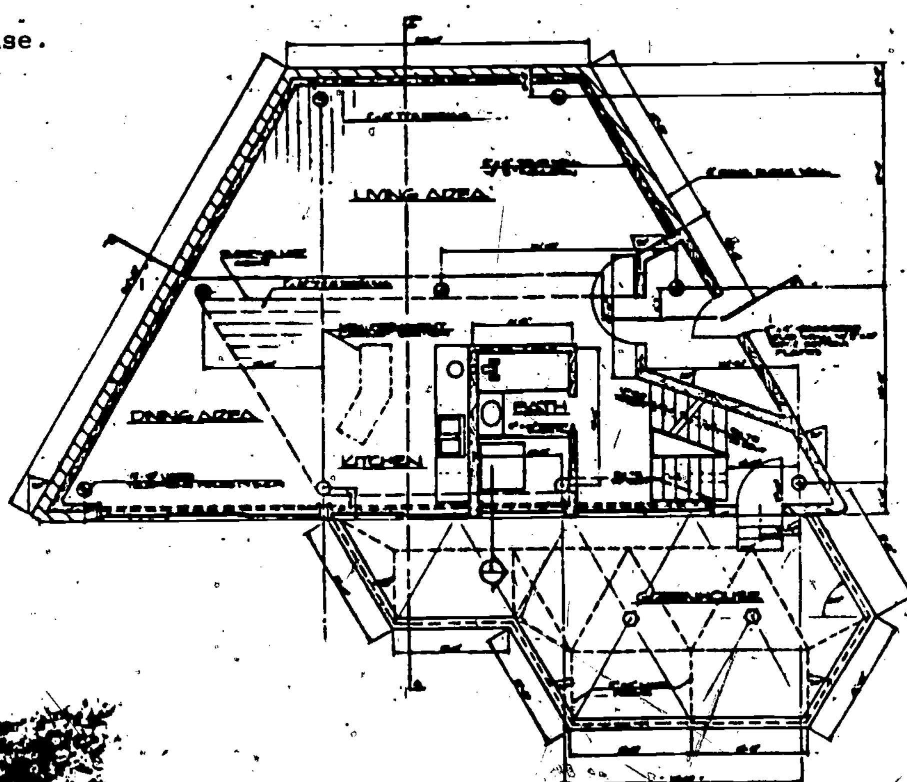
Although many experts had advised that solar heating was not feasible in Minnesota, there were a number of indications that the economics and efficiencies had changed significantly enough to justify development. Existing and projected increases in fuel costs made increased thermal insulation and the higher initial investment of solar systems both more competative. The long Minnesota winter can expect a ground cover of snow over at least four months, giving more than a 30% gain in energy hitting a solar collector through reflectance off of the snow. The development of low emmisivity coatings offers perhaps a 15% increase in collector efficiency. Microclimatic and architectural contributions to minimizing heat loss from the structure had not been fully explored in earlier studies. Windows, for existance, can be insulated at night so they can act as one-way valves, allowing sunlight and heat in during the day, then preventing its loss at night. They provide very low cost solar heating, along with the psychological benefits of sunshine and view, and permit a smaller conventional solar collector to store heat during the daytime for use at night. A change in design temperature from the common 72-75° down to 68° gives both physiological benefits and heating savings. The development of lower cost heat storage through either water or saturated earth reduces the costs of energy storage, and the development of techniques of summer heat storage can eliminate the need for duplicatory back-up heating systems. The combination of the domestic water heating, which operates all year, with the space heating system can offer further economies.

Combined with other developments improving systems efficiencies and reducing collector costs, it was possible to develop a design which offered both 100% solar space heating and 100% solar hot water for the house in an architecturally and psychologically satisfying design. The original feeling of the possibility of solar heating in severe climates has since been reinforced by news that a major heating system manufacturer was developing a solar operated heating/water/air conditioning system for domestic use.

Other features of the house include trapazoidal building shape to minimize heat loss surface while maximizing south exposure for solar windows and collectors, earth berms to take advantage of constant heat within the ground, avoidance of air conditioning through design of ventilation and insulation systems (including a sod roof for summer cooling), investigation of efficiency of downdraft wood burners, low energy furniture and space use design, a 4 kw wind electrical generator, insulation of all surfaces to 0.03 U-value, an aerobic sewage composting system, reduction of water usage by 70%, Japanese bath and mist shower, a greenhouse for nutrient, water, oxygen, and heat conservation, and energy conservation in cooking, lighting, and use patterns.



Exterior view of Ouroboros house.



Main floor plan (loft above).

Plans for later investigations include methane production from domestic and plant wastes, determination of support capacity of natural systems of the land related to water supply, repurification, etc., radiant heating, heat pump and heat pipe studies, utilization of waste heat from electrical generation, and low energy cold storage for food.

Information from this project and the perhaps 100 other experimental "ecology" houses currently being designed and built in this country alone should fairly thoroughly document the nature of improved systems efficiencies and rather considerable energy savings possible through careful consideration of energy source and consumption.[31] The changes in our attitudes, lifestyles, governmental policies, planning programs, connected systems, etc. that are responsible for the greater inefficiencies of our culture will require a deeper and more careful introspection and understanding of the problems and benefits involved.

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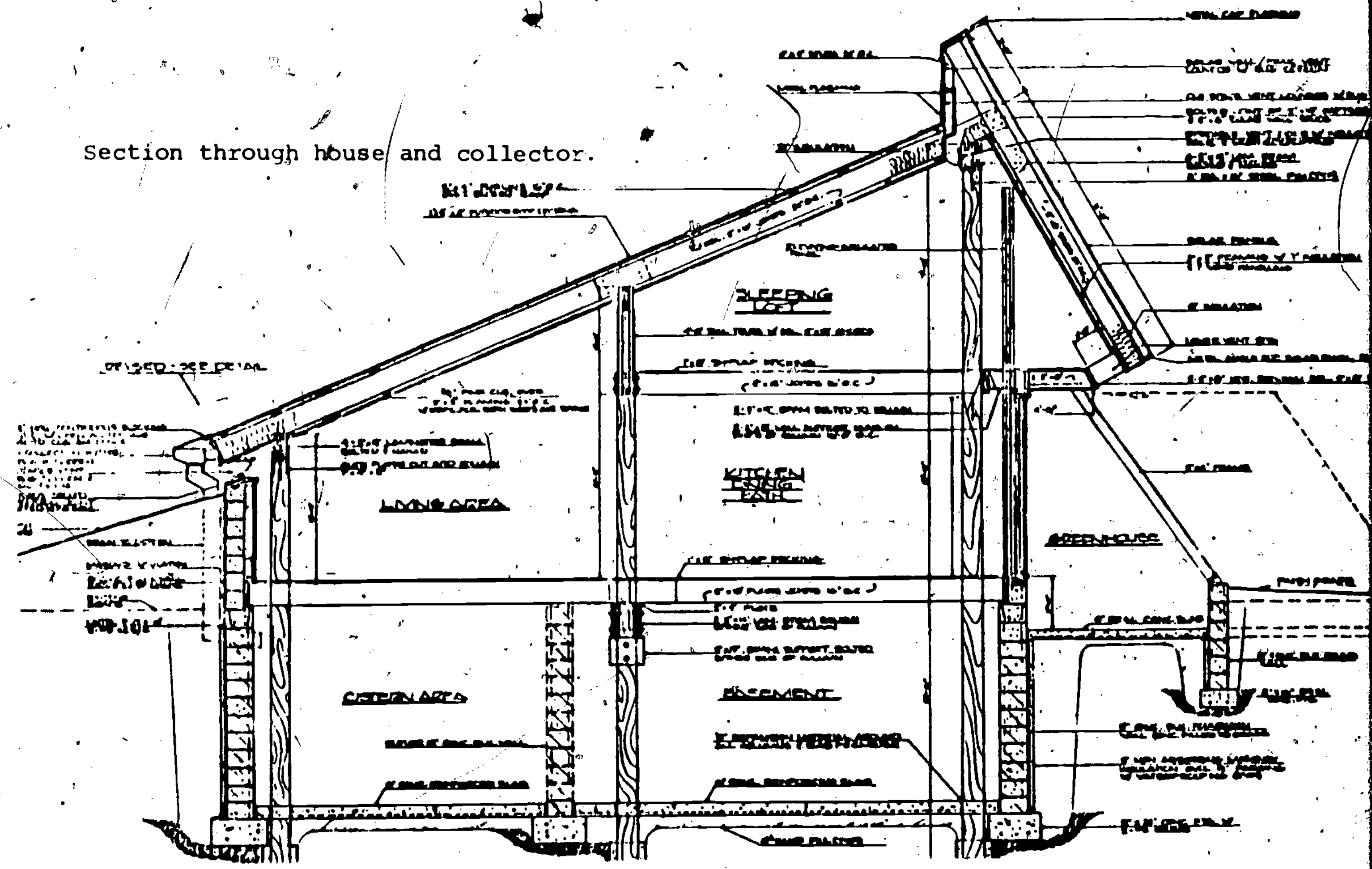
31. See The Ecol Operation, McGill University; studies by the Technical Division, University of Cambridge on autonomous housing, work at New Alchemy Institute, New Paltz, N.Y., Santa Barbara, Univ. of Texas at Austin, etc.

Section through house and collector.



Sod Roofs And Wood Heat

BROADENING OUR MEASURES OF "ECONOMIC"

Over the last few decades the main concern of architects, the building industry, and the heating and appliance manufacturers has been in designing more sophisticated, more automated, and more expensive ways of living. The discovery that "air conditioning" was possible was taken to mean that air conditioning should be used everywhere and for everyone. Development of devices to control room temperature within a fraction of a degree led us to assume that such "optimum" temperatures were desirable, when in fact desirable room temperatures vary from individual to individual, and also depend upon a person's activity, mood, time of day, state of health, etc. As a result, we have inadvertantly made it increasingly difficult for people who wish to live simply (with privies and wood heat and wells and small bungalows and gardens) to do so - regulating simplicity out of existence and replacing it with expensive transportation, sewage, electrical networks, and building codes. Yet simplicity, when chosen freely, can offer alternative uses of a person's and a place's energy flows which give quite valuable physical, psychological, and spiritual benefits.

SOD ROOFS

Many traditional ways of building and living are actually more efficient than current ones, and often offer substantially greater beauty and psychological benefits. Sod roofs have been commonly used in many parts of the world, particularly in northern climates where fire hazard makes thatch dangerous and freezing conditions make tile roofs less practical. They continue to be used in Scandinavia today, particularly on sauna roofs, but anywhere where the spiritual, ecological, and traditional aspects of the building process are important. Mention of sod roofs in this country brings the inevitable response "but they are heavy and require twice the cost of structural framing", or sometimes, "but how do you mow them?" - then forgotten. Looked at more thoroughly, they, like many other traditional practices, offer many more benefits than apparent at first glance, and can compete quite favorably in economic terms with the now common asphalt shingles.

The traditional Scandinavian sod roof was laid in two layers of sod over a layer of birchbark shingles. Birchbark is one of the most rotproof natural materials available, and formed a waterproofing layer for any water that seeped through the sod. The sod itself was laid in two layers, each of which was from 3-5 inches thick, in order to gain the thickness necessary to keep the grass from drying out. The first was laid with the grass down, the second staggered so the joints didn't coincide, and laid with the grass up. The grass on the lower layer held the dirt together until the roots of the upper layer penetrated the lower, and eased the cutting and laying operations, as well as keeping water penetration to a minimum. The edges of the roof were held in place with logs to retain the soil. Traditional sod roofs were expected to last at least 60 years - theoretically forever, but nutrient leaching required either occasional fertilization or replacement every 60 years or so.

Modern, super-cautions sod roof design replaces the birch bark with a layer of roll roofing, a coating of selvage cement, a layer of 6-mill black polyethelene, and another layer of selvage cement.[32] The primary cause of deterioration of such a waterproofing membrane is in root penetration in search of water (no problem if you keep the water on top of it!) and some deterioration of the asphaltic compounds through acidic root conditions.

Because of our inexperience with it, it is difficult to precisely evaluate the installation cost of a sod roof. Some rough comparisons can be made, however. An asphalt shingle roof costs about $35/square, and has a life of from 15-26 years. Slate or clay tile roofs cost around $125-130/square, but have a life of from 60-100 years. The cost of a sod roof will vary depending on whether you do the work or hire it done, and whether you use native sod or purchase commercial sod. Normal meadow sod is fairly good for roofs, being commonly broome grass and bluegrass. Broome grass propagates through underground stems, which gives considerable strength to the sod. Meadow grass does have a tendency to lay down when long, losing some of the shading potential of the sod. Prarie grasses such as sheeps fescue and red fescue are stronger and also more drought-resistant. Mineral soil sod rather than organic soil sod should be used if purchased commercially, as the organic soil sod dries out very quickly and does not retain water well.

Material and installation costs of the roll roofing/selvage/poly/selvage should run fairly comparable to that of asphalt strip shingles. Added structural costs and the installation of the sod itself would add to the cost. Based on an expected 60 year life, a sod roof would outlast an asphalt roof four times. Over the 60 year period, $105 would thus be available out of the equivalent cost of replacing asphalt roofs to pay for the added structure, sod, labor, and amortization.

The sod roof slows water runoff, creates oxygen, provides living places for other forms of life, has an insulative value equivalent to half its thickness in fiberglass insulation (6" sod would equal 3" of fiberglass). It has a more beautiful appearance than asphalt shingles, and contributes substantially to keeping the house cool in the summer. The surface of an asphalt roof can be easily 50° hotter than the surrounding air in the summer, and attic temperatures under them often climb to 140-150°. The temperature at the soil surface in sod is rarely more than 2° higher than surrounding air temperature. The tall grass shades the actual roof and dissipates the heat to the air better. It also cools through the normal evaporative processes of the grass. This, combined with the natural insulative ability of the soil, substantially eliminates one of the major heat gain sources that make houses uncomfortable in the summer, thereby eliminating considerable demand for the use of air conditioning. Together, these benefits make sod roofs desirable and even economically competative for anyone concerned with more than merely first cost of construction. They require, however, that we consider more than just the narrow economics of lowest first cost.

WOOD HEAT

"Wood heats you twice - once when you cut it, and once again when you burn it." Thoreau

Wood has been the dominant fuel for cooking, space heating, and industry throughout history. Even today, taken on a world-wide basis, it is still one of the most widely used fuels. It is rarely used in our country for a variety of reasons, but still has considerable advantages for isolated dwellings, in forested areas, and where the fuel costs are high. Some individuals are even able to harvest and burn the considerable number of trees that die or are removed each year in our cities for freeway and building construction. Recent advancements in the design of wood burners considerably improve the efficiency of combustion and lessen the bothersome work of periodically adding fuel to the burner. Today, many burners will operate from 12 to 24 hours on a single loading, and can be thermostatically set to maintain even temperature in the home.[33]

The role of green plants in solar energy conversion is often overlooked in searching for massive energy supplies. The use of green plants for methane production is receiving study, but the use of wood is still fairly ignored. The actual efficiency of energy conversion from sunlight is not as great as other processes, but the fuel potentials of wood and agricultural wastes are merely a useful byproduct of other beneficial processes. The methane potential of agricultural wastes remain after the grains are harvested, and the soil conditioning properties remain after methane production. Similarly with wood, the fuel wood is often a byproduct of shade, oxygen production, soil building and retention, aquifer recharge, building materials, etc.

Fuel wood can be grown in relatively inaccessible places without causing the labor expense of alternative uses of the land. Fireplaces give only perhaps 8% burning efficiency, and many stoves only around 15%, but modern downdraft, thermostatically controlled burners such as the Ashley get more than 50% efficiency. (Which compares to about 60+% efficiency on a home oil or gas furnace) Burning green wood gives much less heat than wood that has seasoned for six months or more - up to 30% of the heat energy in the wood is used to evaporate the excess moisture in the wood. Most woodlots yield about one cord of wood per acre per year, with 6-12 cords needed per year for heating a house (depending on size, location, construction, kind of wood, etc.) The BTU content of one cord of wood varies from 24,600,000 for hickory to 12,500,000 for aspen.

Wood heat is generally less expensive than convenience fuels such as oil or gas, and is becoming relatively cheaper as the cost of fossil fuels increase. A cord of air dry hickory has the heating equivalent to 1.1 tons of coal, 154 gallons of #2 fuel oil, or 25,000 cubic feet of natural gas. Proper managing of woodlots, efficient handling in the cutting and storing, maintenance of interior chimneys in good condition, proper seasoning of the wood, and burning in a proper type of heater or furnace can contribute to the economy and efficiency of wood heat and make it one of the many techniques for living simply and economically without heavy pressure on our land.[34]

BTU CONTENT OF ONE CORD OF VARIOUS WOODS

Kind of Wood	BTUs per cord
Hickory	24,600,000
White Oak	22,700,000
Beech	21,800,000
Sugar Maple	21,300,000
Red Oak	21,300,000
Birch	21,300,000
Ash	20,000,000
Red Maple	18,600,000
Elm	17,200,000
Yellow Pine	18,500,000
White Pine	13,300,000
Aspen	12,500,000

Sod roofs, wood heat, and compost toilets are a few examples of effective alternatives to high cost, high energy consumptive processes that we are more familiar with. They require a broader understanding of economics which can reveal the hidden costs of our high-energy technology. In the long run, all economics are energy economics, and because natural systems are based on energy flows, energy-based economics can develop environmentally sound and efficient actions. Our current economic policies have been tied, like all aspects of our culture, to short term availability of cheap energy through using up our capital reserves of fuels. Consequently, they introduce massive amounts of outside energy into our processes, allowing us to ignore their nature and possibilities. They make our thinking short-term, which is almost always environmentally harmful or energetically wasteful.

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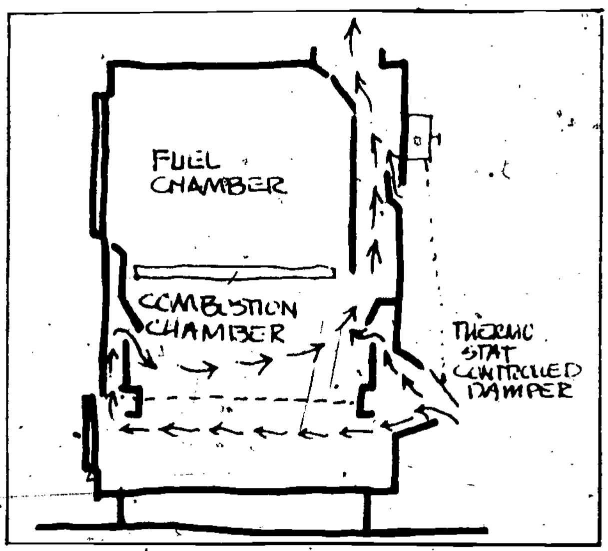
32. "The Return of the Sod Roof", MOTHER EARTH NEWS, #18.
33. Ashley Thermostatic Wood Burning Circulator, Ashley Automatic Heater Company, Sheffield, Ala.
34. Forestry Facts: Wood as Fuel for Heating, No. 6, Code 831. Dept. of Forestry, University of Wisconsin. Also "Wood Fuel Combustion Practices", L.H. Reineke. U.S. Forest Service, and "Heating Your Home without Harming Nature", ORGANIC GARDENING AND FARMING, March 1973



Downdraft wood burner.

Why Live Lightly?

Our concerns with energy conservation have arisen almost entirely because of current limitations in fuel availability and the environmental effects of energy usage (automobile pollution, power plant siting problems, etc.). We continue to assume that if those problems could be overcome we would wish to use even more energy. We are interested in energy conservation because we have to be, not because we feel there is intrinsic benefit in it. Yet we have not inquired if there are intrinsic benefits in simpler ways of life common in all other cultures and times, and if there are perhaps some intrinsic disadvantages to the high energy consumptive culture we have developed in the last century.

The obvious and direct problems with high energy consumption are well known. Resource depletion, environmental damage, pollution-caused health problems, radiation health threats, etc. are common knowledge. Yet the more significant negative aspects of energy use are indirect, long-term, rarely visible, and deeply intwined with the value systems we hold. Many of them are not side-effects, but inherent in the substitution of machine energy for our own in our activities.

Machines prevent our personal growth and the development of our faculties.[35] Many of the machines that we have developed to supposedly assist us in our activities and make them easier actually prevent our gaining the inherent benefits that we seek in those activities. The Winnebagos that we take with us to the wilderness bring with them familiar ways of doing things that prevent us from becoming aware of simpler and more meaningful ways that would emerge from living closer to the existing surroundings. Power tools turn a peaceful task that requires and develops skills into a noisy, screaming ordeal. Machines substitute for development of skills and the self-respect, confidence, and knowledge they bring. They generally prevent us from having opportunities to work ourselves and thus to learn. They occupy our time with their maintenance and repair.

High use of energy limits the ability of an individual to either understand or control the forces affecting his life.[36] Low energy use limits the energy which can be applied to our ends to the energy flows inherent in our ecosystem. The application of esoteric energy sources removes that limitation and leads to imbalance and destruction of ecosystems. Low use of energy leads to independent economies. High energy use leads to interdependent economies. Interdependent economies destroy craft work and the political and personal independence of self-controlled work, materials, and markets. It takes wisdom to live well with little use of energy - but wisdom is what we ought to be seeking. High use of energy permits ignorance to be hidden over a short period of time, but in the long run that ignorance outruns even the masking power of high energy use. Poverty does not allow carelessness. Simplicity keeps men honest. Poverty breeds wisdom.

High energy use separates us from the processes and information in nature. Artificially heated and sealed buildings; windowless, artificially lighted spaces, processed foods, water and sewage systems all minimize the visibleness of our relationships with nature. When all we see of our water supply is the six inches between the tap and the drain, the knowledge of the burden we place on our surroundings through excess use is difficult to obtain, and the need to preserve areas for aquifer recharge is a purely abstract concept. When all we know of the processes that should be returning the nutrients in our bodily wastes to the fields they came from is a flushing sound behind our backs, it is difficult to know that the processes we use are polluting streams and lakes instead of fertilizing fields, and that we are paying many times the cost of proper processes.

Places created by man can only express the knowledge HE has, which we all know is quite limited. Close contact with the richer and vaster processes of nature is important both to give him opportunity to discover more about the forces of our world, and to allow him to test and realize the limitations and effects of the processes he employs in his world.

High energy use prevents us from receiving important information from each other and from our surroundings. We are deeply interconnected with each other and with our surroundings through interaction of electromagnetic fields which communicate information aligning our bodily rhythms and processes with that of our surroundings.[37] Those fields are drowned out and blocked by the great energy fluxes that we surround ourselves with. Even the electrical wiring and lighting of our homes can create fields disrupting normal information flow. The steel frames of modern buildings act also to block out information, which leads to a vague sense of separation and alienation from our surroundings.

Replacement of craft-work by machine-energy prevents the expression of a sense of care in our surroundings. The elimination of craft-work both prevents the personal satisfactions of the craftsman and substitutes a mechanized, meaning-less product for the care-fully wrought work of the craftsman. Our surroundings reflect no sense of the people involved in their making, and of the joy, frustrations, and insights of those people. The relations between the makers and users of the artifacts of any culture are far more complex and profound in meaning than the simplistic exchange mechanisms of our industrialized society can express. A sense of love and care in our surroundings is essential feedback to the attitudes we take towards others and an important factor in what our cities convey to us about the interdependence and value of people to people.

High use of energy creates intrinsically bad environments. Low cost and high availability of energy make it cheaper and easier for a builder to keep a building cool by mechanical refrigeration than by planting a tree to shade it. We end up with closed-in buildings, no shade, no evaporative cooling of outdoor spaces, less oxygen, fewer dollars, less aquifer recharge, loss of the birds and other creatures harbored by trees, and loss of all the pleasant psychological and spiritual benefits of vegetation in our surroundings. High energy use permits high rise, high volume, and high density building - all of which are inherently inefficient as well as psychologically damaging. It makes easier the insensitive and careless alteration of our surroundings, and allows us to ignore the unique qualities and natures of those surroundings.

High energy use generates greed and competition. Most energy sources are limited in supply, and questions of their ownership and control bring inherent conflict - all the way from individual to international levels.[38] Moreover, a feeling of dependence upon them brings a sense of desperation to the conflicts which does little to encourage the nobler instincts in man.

Waste has been inherent in our patterns of energy use - from heating buildings with the windows open to leaving lights burning all night to wasting all the energy inherent in our sewage. Our actions and attitudes carry over into other aspects of our lives, and we lose the ability to carefully know our needs and minimize the demands we place on others. A wasteful society rarely understands the nature of the processes and events in which it is involved in anywhere near the depth that a careful society does - and doesn't even realize the reduction in its effort if it were to minimize the energy and work flows through it.

High use of energy creates inefficiencies in other areas of our lives. Energy wasteful automobile transportation encourages separation of living, working, learning, and leisure - generating redundant city services, unnecessary building, unnecessary educational systems, etc. Lack of exercise in an energy-servant culture generates need for unnecessary medical care facilities and recreational facilities. High energy use has brought about the urbanization of our population - and cities are inherently inefficient.

Our energy attitudes affect what we gain from our work and leisure. "Labor-saving" machines and appliances remove much of the need for skill in many kinds of work. Rather than being a benefit, this robs us of opportunity to develop our abilities and gain finer control of our thoughts and actions. The development of unrewarding work results in the need to gain satisfaction elsewhere, and thus the growth of "recreation" to fill the emptiness in our lives and the lack of healthy exercise. High use of energy in our work generates the need for other work or action to gain the benefits normally inherent in work. The need to substitute recreation for work not only generates additional costs, energy use, and environmental deterioration by itself, but also lessens the insights we gain through work about the processes involved and aobut life itself. It also lessens the amount of time we have available for useful, meaningful work.

Bodily tensions caused by energy use generate alienation from our world and our neighbors. The adrenelin-filled pace of modern high-energy society builds up mental tensions while preventing the release of muscular tensions. The interconnected mental, muscular, sexual, and spiritual tensions built up make us strongly aware of the muscular and physical separation between what lies within our skins and what lies outside, generating a real sense of alienation from our world. Complete relaxation of those tensions removes such barriers and merges the awareness of inner and outer states and events, allowing us to become aware of and develop concern for the processes outside us as well as within.

There are technologies available to us other than the energy-intensive ones we are familiar with that can offer us different opportunities for personal and cultural growth. There are energy sources available which can easily satisfy less extravagant needs than our own. There are ways of living which can avoid the alienation and separation resultant from our own, while generating more positive work and learning.

There is a joy of living lightly and a peacefulness of working directly with the processes of which we are a part which are entirely missing from our culture. Many things that have been developed by our energy intensive culture we are coming to recognize as generating subsidiary problems, dependency, energy consumption, and prevention of our growth and development - filling our lives with unimportant and meaningless activity, and bringing degradation to our surroundings. Choosing to live lightly, in ways that consume little energy, can be an opportunity to live a more rewarding and interesting life, rather than a hardship.

Happiness comes from generating energy rather than consuming it.

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35. See The Indian Craftsman, Ananda Coomaraswamy; The Long-Legged House, Wendell Berry; "Brain Power Should Increase With Age", PREVENTION, June 1970.
36. See "The Flow of Energy in an Agricultural Society", Roy A. Rappaport, SCIENTIFIC AMERICAN, Sept. 1971.
37. See "Feng-shui", Environmental Design Primer, Tom Bender, and "Electricity - A Natural Force for Health", PREVENTION, Nov. 1970.
38. Some relationship exists between the massive oil reserves offshore of Southeast Asia and the U.S. involvement there.
39. Farmers of 40 Centuries, F.H. King, gives a revealing picture of the inbred concern and understanding of the farmers for their land and the energy flows through it.

Opening Options In How We Live

Living lightly, with little consumption of energy and resources and little demand upon other people and places requires some incentives to change from conventional patterns of waste and overconsumption. Knowledge of the intrinsic harmfulness of high energy consumption, and knowledge of the limitation of our fossil fuel resources can provide some incentive. It remains that we are, for a while, a wealthy nation, and we often personally have incomes greater than that necessary to sustain us comfortably. The disposal of that wealth in our traditional living patterns almost invariably involves unnecessary work or production, energy consumption, and damage to our resources, land, and selves. We can easily live well on considerably less energy than we now consume, and live an exciting, comfortable, and meaningful life doing it. The question remains as to what we do with the rest of our time and money.

Our conventional pattern is to spend 40 hours a week from the ages of 20 to 65, at a fairly high wage, in usually boring, frustrating, and non-creative work. Money produced in this way is saved to live on in retirement and to pay for recreation in non-working hours. Our general pattern is to earn much and spend much - unwisely and rather wastefully. Living on less can open up several options to that traditional pattern.

We can keep at the same kind of work and retire much earlier - becoming completely free to do the kinds of creative things we desire to do.

We can keep at the same kind of work, but not work continuously. Taking a year or so off to do something special, then working a couple of years, then taking some more time off, etc.

We can get into more exciting and creative work that pays less than the usual exploitive kinds of work.

We can work less per day or week or month and enjoy more rewarding use of the rest of our time.

We can live simply and save and use the money to finance our own ventures - starting a business we always wanted to do but couldn't get financed, writing a book we couldn't afford time to do, learning other skills we would like to have, etc.

Or we can totally change the way we work, accepting less money per hour of work in return for the opportunity for the creative work that turns our places and things into beautifully crafted, loved, and cared for things. Often the only way we can do things right, yet do them so people can afford them is to earn less doing them than we have been led to accept as proper by normal business standards. Yet we find that doing so is often the most creative use of our time and exchanges inflated, exploitive work situations for meaningful and enriching ones.

It is possible for us to live richer and more rewarding lives on a fraction of the energy we now use. The means are available, and the benefits great. It requires only the belief that it can be accomplished.