Explorations

It is perhaps self-evident in this automobile- and petroleum-dominated age that energy sources and their uses shape culture and settlement patterns. What is less evident, but critical for the future, is the potential of renewable sources of energy to provide the foundation for new and more-equitable societies.

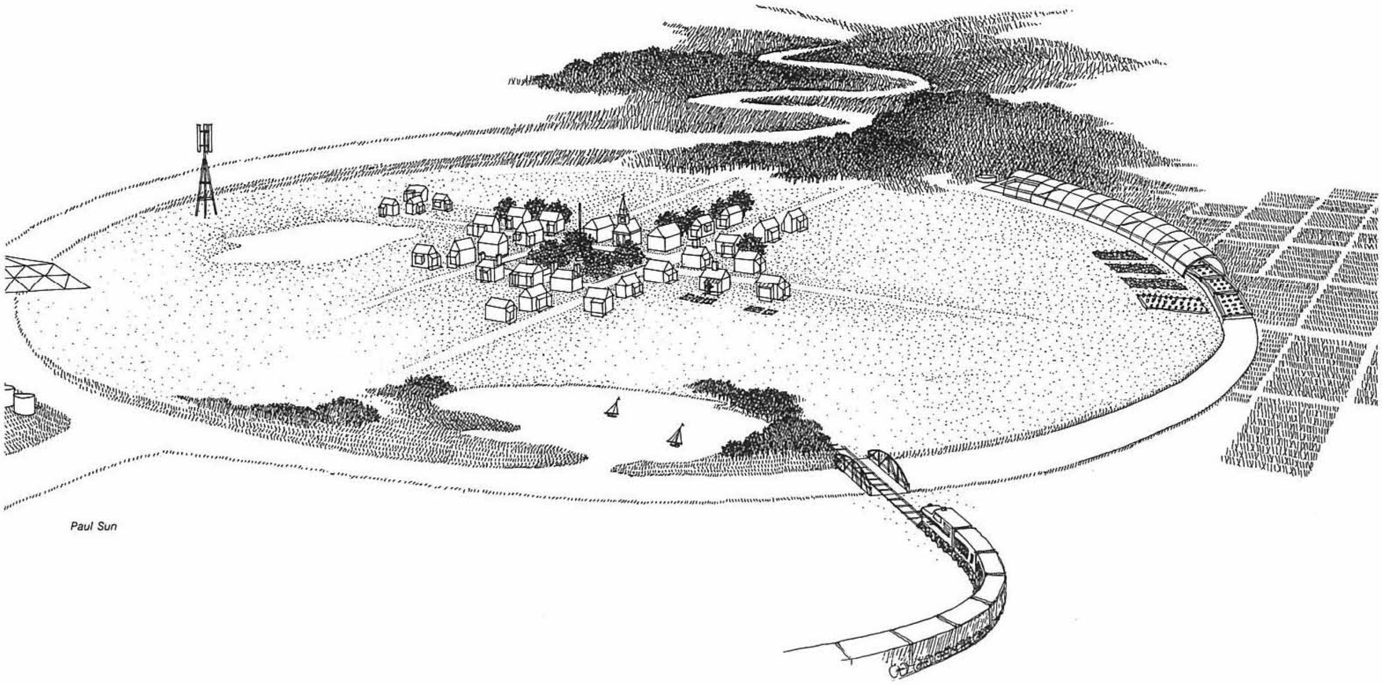
In the solar village, ecosystems will provide many of the bases for support. Climate will be modified and improved by them and market food economies will be integral to the overall design. Wastes will be treated in integrated heat-storage and nutrient-cycling systems. Even the landscapes will function to support the whole. Villages will be like earth ships.

The architecture of the future will be different in a number of fundamental ways. Bioshelters will be important. They will function as solar workhorses, heating and cooling, producing foods, and treating and recycling wastes. Unique new building materials will substitute for contemporary furnaces, air conditioners, fans, and motors. Energy needs will drop. Further, ecology will redefine solar and village architecture. It will become more indigenous and diverse. The very meaning of architecture will deepen. The following introduces this new architectural landscape.

The bioshelter is not a "monocrop" architecture. It is a state of mind and a way of rethinking how human communities can be sustained.

Bioshelters can be (1) alleys, (2) covered solar ditches, (3) wells with clear membranes, (4) greenhouses, (5) glassed roofs, (6) streets, (7) interconnected buildings, (8) domes, (9) glass-roofed barges, (10) ocean arks, (11) translucent tents, and (12) landscape microcosms. Bioshelters are the workhorses of a solar era.

N.J.T.



The VILLAGE as SOLAR ECOLOGY

Prologue

Nancy Jack Todd

In early August of 1978, three months before her death, John Todd and I spent several days at a conference with Margaret Mead. She was a staunch supporter of the work of New Alchemy and was anxious to see its implications extended to touch the lives of greater numbers of people. What she said in effect was: You've created and developed the bioshelter. It's a good idea and it works. But most of the people in the world will never be able to afford private houses. You must start to think in terms of villages and neighborhoods, and of how the bioshelter fits there.

Such a legacy from a woman.

We could not, of course, nor would we have refused. And so in April the following year, we convened a conference entitled The Village As Solar Ecology: A Generic Design Conference.

Calling the conference, even funding it, proved to be straight-forward in comparison with our underlying assignment from Dr. Mead: defining and articulating a vision of the solar village, and subsequently evolving from the vision a communicable and tangible epistemology. That our task was a complex one was clear from the beginning, as we tried to decide who should attend. That we needed solar designers and architects was obvious, but we felt it equally important to hear from anthropologists and sociologists. To lengthen and deepen our perspective we included as well a cultural historian, social activists, and artists. As a group, New Alchemists brought biological, agricultural, aquacultural, and conceptual skills for ecological design. With this assemblage we felt that we had some of the pieces of the puzzle in hand, but as many more were missing. We knew that well beyond our reach, in the accumulated wealth of human experience, lay great repositories of wisdom that we could only intuit and try to recover. To be haunted by a dream of union, of Oneness, is not uncommon. One friend of mine once told me that she often had a feeling of almost remembering a time just beyond memory, when we understood better our destiny, our place in the cosmos. More recently I heard a woman of the Wampanoag tribe say to a group of women, talking to us as representatives of our culture, "We don't understand you. We don't understand what your instructions are, how you have been taught to live. A seed, a flower, unfolds according to the instructions it has been given. We don't understand yours."

I guess we have forgotten.

To help us to remember, to reinvent and recreate a sense of the human place in the cosmos, we realized that as important to the conference as physical design was a sense of the sacred. As one of the participants, Keith Critchow, put it, "The necessity of the sacred attitude is one of remembering: remembering the larger context of one's existence, one's duties to one's environment and to the invisible principles that regenerate life constantly. What is sacred?" As another one of the participants, Sim Van der Ryn, put it, "What isn't?"

Because the question is such a difficult one for us, formed as we have been by modern secular society, we have given it considerable space in the pages that follow. A sense of the sacred is the bedrock, however buried or amorphous, on which we build.

The pieces are arranged, somewhat arbitrarily, under the headings "Conceptualizing the Village," "Energy and Architecture," "Ecological Cycles," "Early Manifestations," and "A Farm in the Year 2030." We began with William Irwin Thompson because his essay is at once a definition of the problem and an overview from a much broader scanning of time and culture. The piece by Keith Critchlow is an attempt to convey his very rich understanding of how the sacred has been and can be the underlying and energizing force for a culture. In describing the tradition of Feng-Shui in China, Paul Sun makes more tangible the principles that Keith discusses.

With Mary Catherine Bateson's observations of "A Single Shared World," contemplating the village as a place where people actually live, and Hunter Lovins's hard question, what life there will be like, the difficult journey from the abstract to the hypothetical to the concrete is begun. John Todd, looking at a specific area of land in southern Colorado, formulates guidelines for the questions that must be asked, questions of land ownership and tenure, energy, water rights and management, land and ecosystems, agriculture and forestry, and the incorporation of villages into the landscape as a whole. J. Baldwin describes a hypothetical dome, a kind of second-generation bioshelter. From Colleen Armstrong, Susan Ervin, Hunter Sheldon, and Ron Zweig come considerations for the sustenance, in the broadest sense, of the village. Then Steve Serfling, using the example of his own research with Solar Aquafarms, suggests an ecological method for village waste treatment. To all of the above Malcolm Wells adds comments, not exclusively from underground.

Toward the end of the conference, partly for relief after so much talk and partly to exercise our evolving principles, we set to work on creating the designs for three projects that are and were then in various stages of being actualized. Some sketches and designs are included.

The series of accumulated fantasies, rules, cautions, and designs concludes with an article by Wes Jackson from the imaginary vantage point of the year 2030. It seems comforting because it implies that we have—we must have—avoided nuclear holocaust, ecological disaster, and World War III to be living there among the prairie grasses of Kansas commenting and occasionally laughing at the follies of the present, long past.

Does such a conference, and the many like it, have meaning beyond that gleaned by the various participants? Perhaps through the slow integration of knowledge that is engendered and with subsequent further synthesis from fields as disparate as ecology, quantum physics, astronomy, religion, holography, anthropology, the contemplation of sacred art, architecture, geometry, and the study of *Gaia*, certain harmonies are being heard. Perhaps our sense of the world, rather than being cacophonous and diffuse with the claims of scientists and fundamentalists, economists and environmentalists, communists and capitalists, begins, at least intuitively, to make sense, to ring true. Perhaps a cosmology that is somewhere in Dream Time at once beyond memory and just out of reach of present knowledge yet still somehow alive within us is unfolding. Morphogenesis.

The Village as Solar Ecology

John Todd

This series of articles is an early attempt to prepare for a transition to renewable-energy-based societies. The reader is cautioned that the articles are not so much technical documents as introductions to some of the areas of knowledge that will permit a shift to a genuine solar age. What follows is not engineering detailing but a new and potentially significant way of approaching the age-old need to sustain human cultures in their diverse forms.

The first cities were built a long time ago. Jericho, begun in 8350 BC was walled and occupied ten acres. Catal Hüyük in Anatolia (Turkey) was constructed in 6250 BC and spanned thirty-two unfortified acres. Both had many attributes we could associate with a contemporary town. The cities would feel familiar. Now for perhaps the first time since the appearance of cities almost ten thousand years ago, human knowledge has reached a point where it is possible and timely to rethink the nature of human settlements.

Based on a current revolution in science we have a newly acquired freedom to redesign the way in which communities are sustained. A unified body of knowledge is being formed that will allow modern societies to move from a petroleum era to a solar age. The nature of living systems is the unifying principle of this knowledge. Ecology is providing an intellectual framework that can link the polymer physics of the materials scientist to the electronic information of the computer specialist, to structural forms of the architect, to the knowledge of experts in diverse energy systems, food culture, and waste recycling, and ultimately to the special information of the sociologist, anthropologist, and artist, who speak for the human condition.

This new science is bound less to the metaphor of the machine than to the image of the forest or the meadow. We are shifting from an age dominated by mechanics to one concerned with biology. It is my contention that the shift in perception will allow us to undertake a beautiful and, as yet scarcely dreamed of, turn in the course of human history.

The practical as well as the good news implicit in the revolution in science is that it can truly create a solar age. Through humanly derived ecological and technical pathways the energy of the sun can be directed to sustain human settlements as magnificent as the world has known. Sun and solar derivatives, the wind and biofuels exclusively can power, heat, and cool all manner of villages and towns if structured according to an ecological blueprint of the kind that underlies a forest or a pond. Within a village or town designed to an ecological blueprint, wastes generated by people and by microindustry are channeled into nutrient cycles that in turn trigger such biological cycles as diverse food production, including aquaculture and food forestry. Gas for fuels can be produced as a by-product. Further connections are possible. Solar-algae ponds at New Alchemy, for example, have several functions: trapping solar heat, producing fish, and irrigating and fertilizing adjacent gardens. And that is not all. We are currently finding out if they can become methane-producing gas plants as well.

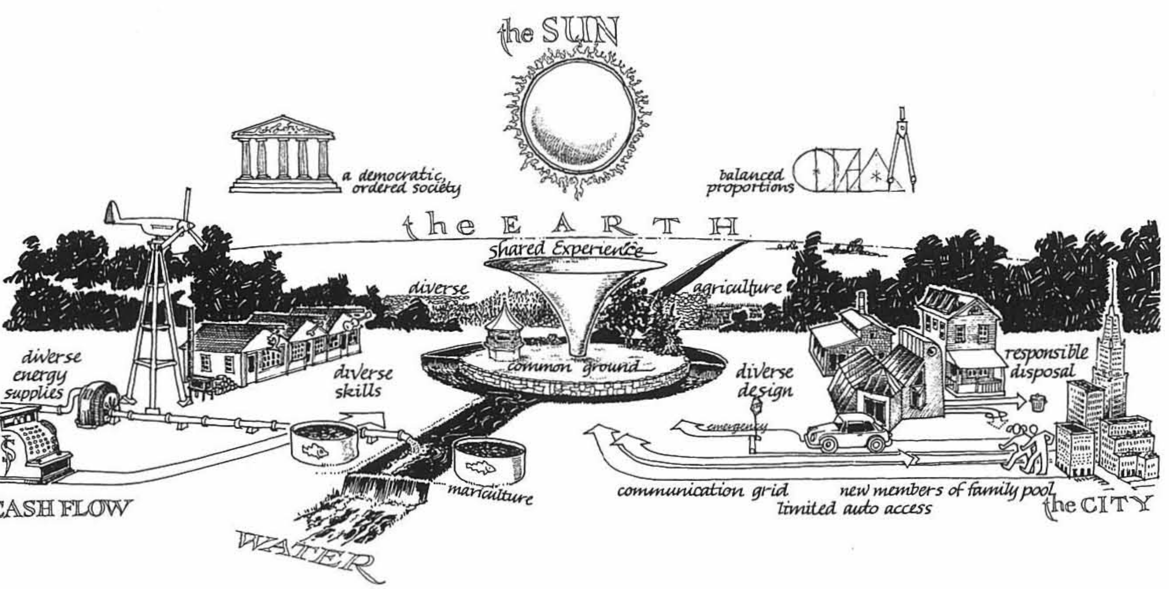
I make this point to illustrate how ecology can be a model for designers and to show that materials, ecosystems, and electronics together have a major role to play. Old divisions and specializations will break down in the process. Housing, manufacturing, educational facilities, market and government buildings may one day be connected to living elements and with each other in ways we are beginning to perceive for the first time.

It is rapidly becoming apparent that enough is already known to build solar-based settlements. It is further becoming clear in a period of increasing uncertainty about the costs and availability of petroleum, that solar economics, especially within the ecological framework, makes good sense.

These essays span a range of disciplines from the ancient siting techniques of the Chinese to advanced concepts in architecture and biology. A synthesis of this collective wisdom begins to come together in concrete forms, in the Cathedral, bioshelter, in a hypothetical village on the coast of Maine, in an agricultural village in the southwest, and in a California village of the sun.

As a document that is only a starting point. The "Village As Solar Ecology" will take many conceptual forms. Some will be retrofits of existing settlements and others will be new towns. If they combine practicality and self-reliance with powerful new notions of earth stewardship, they cannot fail to capture the popular imagination.

By the year 2000, sooner perhaps, our settlements will have begun to reflect the beginnings of a true solar age.



CONCEPTUALIZING the VILLAGE

The Need for Villages

William Irwin Thompson

I grew up in Los Angeles. Recently I had the misfortune to have to return there. As it turned out, the day of my visit was richly endowed with the worst smog in a quarter of a century. In addition, the foothills and mountains encircling the city were ablaze with forest fires. The first fires were natural, but they soon inspired arsonists to work in harmony with nature. As I flew over the city toward the airport, I remembered Nathaniel West's apocalyptic novel *The Day of the Locust*, in which the hero is obsessed with creating a painting called "The Burning of Los Angeles."

The ride on the freeway from the airport was equally unsettling. I sat in a five-mile-long traffic jam of cars, each with a single driver and each with its motor idling gently into the receptive air, and as I gazed out across the valley through the grayish-brown, thick flannel sky, I listened to the reports on the car radio of the sick and the elderly being rushed to the hospitals for oxygen. Looking at the freeway and wondering how anybody could be rushed anywhere, I remembered the excellent Pacific Electric mass transit system that Los Angeles had in the forties and early fifties, but, through the conniving of General Motors with the city fathers, had torn down to replace it with the more "modern" freeway system. Now there is talk of trying to rebuild the railway, but talk is cheap and capital is scarce. The dollar is declining, the international monetary system is disintegrating, and all our social systems are coming due for reconstruction at the same time: highways, railroads, hospitals, and ACBMs. People talk of rebuilding, but it is clear that we are entering a period of social and economic stagnation. The boom mentality that enabled the L.A. boosters to tear down the Pacific Electric railway system and build the freeways in the fifties cannot be conjured up again in the eighties.

People have been complaining about the smog in L.A. for thirty years, but when it comes down to a choice between the industrial values of development and high employment and the ecological values of conservation and public health, people in our society choose to buy more cars and build more freeways with their suburban appendages. As I sat in the car going nowhere on a freeway in L.A., I thought to myself: "And people think that Lindisfarne is a utopian community! This is the real utopian fantasy of freedom in an imagined consumer's paradise. Los Angeles is a historical mistake."

But if Los Angeles is the true nowhere city, where do we go from here, when the entire postwar world, from Long Island to Rio to Sydney to Tehran to Jeddah, has tried to imitate Los Angeles.

The answer is that we must turn on the historical spiral and approach the preindustrial village from the higher cultural level of postindustrial cybernetics and ecology.[1] But to tell a city planner that he should start thinking about villages is like telling a naval architect of supertankers that he should start thinking about sailboats.[2] It is a common cry among social activists that since so many people live in cities, all of our thinking and planning should be devoted to cities. Even to think about the village is for them an exercise in romanticism and escapism. The imperialism of this mentality is part of the problem, not the solution. But even beyond its arrogance, it is also ignorant. Two billion people, or roughly half the earth's population, live in villages.[3]

Even if one thinks that cities are the only cultural forms that matter, one needs to remember that historically cities, as Jane Jacobs has shown,[4] have often spun off their innovations to the countryside, where the landscape was more open to novel creations. The engineers may have gathered in eighteenth-century London, but they spun off their Industrial Revolution to Manchester and Birmingham. It is, therefore, part of the process of civilization for an urban intelligentsia to come together from New York, Boston, or San Francisco, but to spin off their metaindustrial villages from Manhattan to Crestone, Colorado, or coastal Maine.

Urbanization, nationalism, and industrialization have been the major forces that have shaped the modern world, but now that industrial world-system of warring nation-states is changing. Thermonuclear warfare in its mental form as an informational construct is eroding the traditional structure of the nineteenth-century railroad-consolidated nation-state. Industrialization is altering the global atmosphere and generating climatic changes that threaten the agricultural base of a postindustrial society like ours in which two percent feed the ninety-eight percent involved in the production of goods and service. And urbanization is straining the infrastructures of the vast megalopoloi that sprang up in the era of cheap fossil fuel. Cheap oil and gas allowed us to turn farmland into shopping malls and parking lots, and replace small nucleated towns with highway strips of gas stations and fast-food take-out joints. Now as the fuel crisis fuels the food crisis and both stimulate the currency crisis, we face a situation in which the postwar American way of life is simply not viable.

In 1800, more than ninety percent of the American population lived in rural areas; even as late as 1890, two-thirds of the American population lived in the countryside. By 1950, two-thirds of the population lived in cities.[5] Well, if a social movement can go that fast in one direction in an age of printed communication, it can move even faster in the other direction in an age of electronic communication. In point of fact, there is already evidence that the movement has begun to reverse and that people are moving out of the cities, not to the suburbs, but to rural areas.[6] But if we are not careful, this dispersal of the population could simply become the spreading of an oil slick of thin urban scum from Miami to Los Angeles. The trailer camps of Orlando, Florida, and El Monte, California, will move across the country to meet one another in the Ozarks. Clearly, we have to spend some time intuiting and thinking, not simply about cities and planned suburbs like Columbia, Maryland, but about villages.

Expressed in the move from an international, postindustrial city to a planetary, metaindustrial village is a shift from one world-system to another. It is a shift from consumer to contemplative values, a shift from an industrial mentality of the domination of nature and the mass production of culture to an ecological mentality of symbiosis, integration of the intuitive with the intellectual, and unique regional approaches to global processes. It is a shift from the coal-and-oil supported capital-intensive economies of the scale of the old factory systems of Detroit and Manchester to ecologically sound workshop-production for regional markets. Such an approach is already being pioneered by the multinational Phillips Company and its Utrecht Pilot Plant.

Nineteenth-century physics and technology created a way of seeing nature that influenced the way of organizing society, but now ecology is changing the way we see natural processes, and

[1]See William Irwin Thompson. 1978. The meta-industrial village. In *Darkness and Scattered Light*. N.Y.: Doubleday-Anchor, pp. 57–103.

[2]See John Todd, 1979. Ocean arks. *Co-Evolution Quarterly* 23:46.

[3]1979. Village economics. *The Economist*. p. 117.

[4]Jane Jacobs, 1970. *The Economy of Cities*. N.Y.: Vintage.

[5]See George Cabot Lodge. 1976. *The New American Ideology*. N.Y.: Knopf, p. 125.

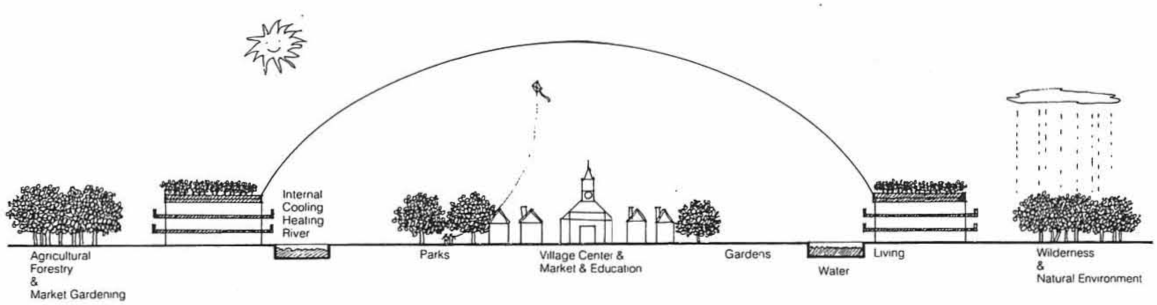
[6]1979. Back to the Land. *The Economist*:49.

therefore it will influence the way we will organize society in the transition from one world-system to another. In the union of ecology and microelectronics we are beginning to re-*vision* the relationship of culture to nature. As the world restructures itself into a planetary culture, the nation-state will destructure itself into more viable areas of regional identity; concomitant with this process is a destructuring of the megalopolis. In the rise of the ecological and electronic village, we will not see the disappearance of the city; rather we will see an intensification and miniaturization of the city. The highly civilized city, like Ficino's Florence or Goethe's Weimar, does not have to be a megalopolis. In the relation of village to city, America could follow the pattern of Switzerland, where rural areas, villages, and highly cultured cities like Zurich or Basel coexist.

The example of Switzerland is instructive for America in other ways. The valleys in Switzerland have been cultivated for thousands of years. Closed in by the mountains, the Swiss could not develop the pioneer mentality to exploit nature and then move on. We, however, created the Dust Bowl and then moved on to California, and now that California is fast becoming destroyed, the leaders of the aerospace companies of the West are saying that we are meant to exhaust the earth's resources and then move on to artificial colonies in space. In the hucksterism of this industrial mentality the earth is simply another piece of Kleenex: use once and throw away. The proponents of unlimited industrialization cannot accept the limits of the biosphere as the Swiss accepted the limits of the mountains. But as we move into the eighties, it seems clear that the boom mentality of the sixties is not in touch with our historical condition.

America is being forced to change and to think in new ways. We are like a succession-forest culture that is changing into a climax-forest culture. The waves of rapid development are over, and a new, richly diversified ecology is being called forth. Once again, Switzerland can teach America a great deal about how a country can be a federation of decentralized cantons, how a nation can have many languages side by side, and how a rich agricultural tradition can coexist with highly complex precision industries. Perhaps now that Quebec is moving in an independent direction and Spanish is becoming the language of tens of millions in the United States, we are already well into a new and rich cultural transformation.

As the monolithic mentality disappears from nationalism, the monocrop mentality will disappear from agriculture, and the monolithic Los Angeles will disappear from urbanization. The Los Angelization of the planet cannot take the place, for in the greenhouse effect nature has her own negative feedback mechanisms for shutting down the furnace of industrial civilization. If we do not re-vision the relationship of culture to nature through a new alchemy, then the villages of the future will not be planetary, metaindustrial, and electronic; they will be provincial, preindustrial, and sputtering with the dwindling light of a growing Dark Age.



Ourkind[1]

Keith Critchlow

What is the sacred? The simple answer is, What isn't? But we can define it if we wish. The sacred is that which is essential to our existence.

[1]A word that emerged during the conference. It means the totality of the human family: ideal and actual.

Essential to our existence means not only the physical supports of our existence but the things that are simultaneously essential to our intelligence and being, in brief: right-livelihood. Ghandi expresses it succinctly: "There is always enough for our needs and never enough for our greeds." This is the very definition of greed—more energy out than the system can stand. Ultimately the only possible "profit" is one *of attitude—a metaphysical profit* of well-being and understanding. All else is vanity, as some would say. The universal law seems to be that a workman be worth his hire; there are correct returns for effort. But "profit" is the spiritual reward of attentiveness, acknowledgment, and the wisdom of knowing that everything is a *rite de passage.* Each step is a footfall of the way.

Our feet "handle" the earth as our hands "handle" the air, water, green life, and animals. Our "contact" is our awareness and sensitivity—our intrinsic choice. Caring is the basis of all good relationships.

The desecrated could now be defined as that taken which was not correctly available—more energy out than the system could stand. Thus it is the breakdown of the system, eutrophy, the diabolism of greed that is based on the part feeding itself in rejection of the whole, the part refusing to acknowledge the whole of which it is not only inevitably a part but without which it cannot exist. As Philip Deere said at the conference, "You cannot destroy ourkind without destroying nature, and you cannot destroy nature without destroying the Creator." The conclusion is crystal clear; it is only a form of madness when a part even contemplates doing without the whole of which it is a part.

So what is our first move back from the periphery to the heart of the matter? The first move back from the desecrated to a sacred space?

The first move is the demarcation of our intention for that space. The crossing of the threshold in our intentions is in our hearts and minds and in our bodily contact when we set first foot on any intended site. Paul Sun reminded us so often of the door or entrance that was a well proportioned and crafted symbol. We enter a new space, both physically, socially, intellectually, and spiritually when we pass through the doorway. Our attention to that passage is our responsibility.

Our solar villages express our intention to move from the "energy greed" context of "modern industrial culture" into a new relationship between ourselves and our planetary homes. This new order will be based on a mutual dependence or reciprocal maintance in accordance with cosmic rather than merely human justice.

Within our intended space we aim to express a sanity of wholeness that is the mark of the natural world. Interdependent domains based on a dynamic balance will be our wisdom, our cosmology. Because what else is wisdom or cosmology but a balanced whole, just as a balanced mind is sanity, and a balanced body is health. The sacrifice of the part to the whole will be in the original sense of the offering of the part to the whole—from within. There will have to be an unfolding of significance between the domains and parts that is perpetually regenerative, both symbolizing the ultimate regenerative principle of the sun and the regenerative principle of the solar village as a solution to post (massive) industrial Western culture.

We must replace the attention on energy with attention on light (the sun) and matter, or better, what matters—Mother Earth. After all we can only see by the light of the sun, directly or indirectly, in every sense of the meaning of the word. And when all matters are put together we must arrive at the profound significance of the immanence of our planetary condition and our mother, the Earth.

To leave a place in the center of our village as *temnos* or a sacred common ground, would be an ideal symbol and practical way of insuring a central remembrance or recollectivity.

A communal sacrifice in the offering sense, a giving thanks for the bounty of nature and our being, this central "village green" would function in the same sense as common land in the English tradition, which ensures that land is set aside for any contingencies in the community. Should, for instance, economic difficulties befall any member, the common green was a refuge, a resource, a sanctuary in all senses. This central space would also be a refuge for the whole community, as it would represent a way in which we could raise ourselves from the mechanistic model of eating, sleeping, procreating, and working; it would be a place set aside for contemplating the mystery of existence and for being thankful for one's fortunes—whatever. The keeping of the green would be a communal responsibility and would express communal joy.

All conditions of existence have to become sacred:

Space: giving existence location, inner and outer.

Time: giving it duration and timelessness.

Form: giving it recognizability, a whereness, and orientation.

Number: giving it accountability of people, things, and relationships.

Substance: giving it measurability, concretely and understandably.

Sacredness can be found at the center of all the conditions of existence, as sacredness is the invisible heart of any matter.

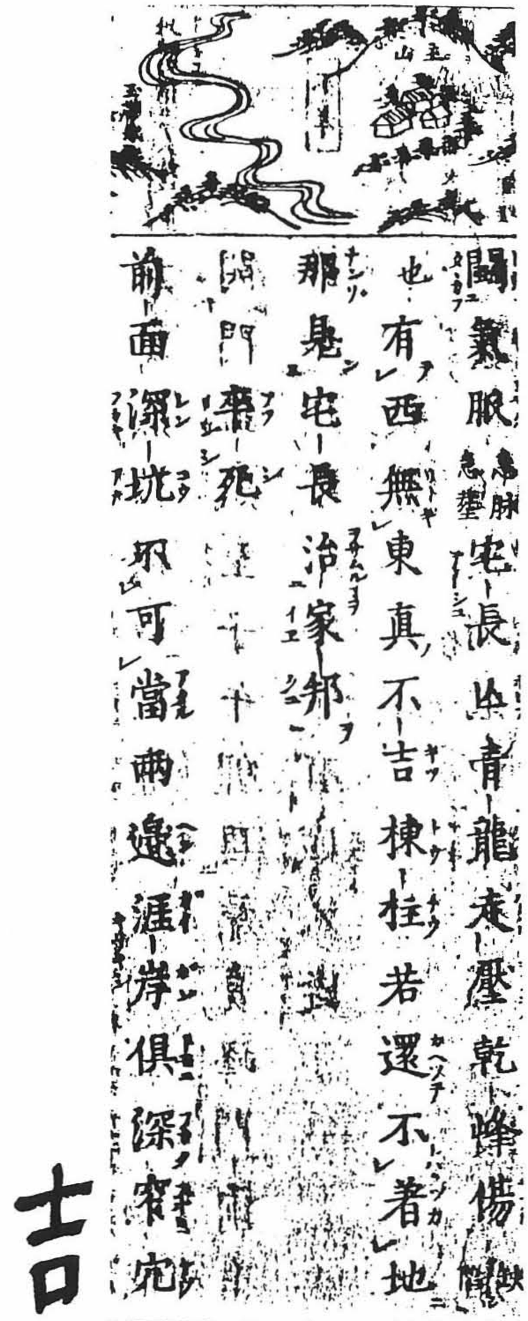
Feng-Shui: An Ancient Theory of Village Siting

Paul Sun (Sun Peng-Cheng)

Feng-shui, literally "winds and waters," is also known known by the more poetic name of *kanyu,* "the canopy of heaven and the chariot of earth." It evolved over centuries, in China as a set of seemingly superstitious principles governing the location and orientation of the residences of people both living and dead. In its broader sense, it is the art of cooperating and harmonizing with nature so that nature will shower wealth, health, and happiness on the inhabitants and their descendants in a given dwelling. The violation of these principles, it was believed, would bring ill fortune to individuals and families. As we will see, there is a rational scientific basis to the principles of *feng-shui.*

To understand why an early form of environmental science should be called *feng-shui,* winds and waters, one has only to ponder the overwhelming importance of these elemental forces in early China, or indeed in any ancient culture. The winds and waters had unlimited power to affect human life, and people felt helpless before such apparently capricious manifestations of nature's might. As a result, the ancient saying was true: "He who controls the water governs the empire." The cold northerly winds were a lethal threat to the people of North China, while southerly winds accompanied by rain could cause disastrous flooding in South China. Protection from winds, water management, and flood control were the very key to a better life for the people of China. Hence, the first priority in providing a comfortable dwelling and a happy homelife was to choose a house site that would be relatively free from natural disasters. According to *feng-shui,* therefore, the basic auspicious home site was a place surrounded by a horsehoe-shaped barrier of mountains to the north, with fresh water easily accessible, but no raging river near. In this and other practical examples, we see *feng-shui* as a conceptual system for understanding the physical environment and a method for selecting sites that will be harmonious with it.

In Western literature, we sometimes find the practice of *feng-shui* translated as "geomancy," a term that is quite misleading. According to the *Oxford English Dictionary,* geomancy means the "art of divination by means of signs derived from the earth, as by the figure assumed by a handful of earth thrown down some surface . . . Hence, usually, divination by means of lines or figures

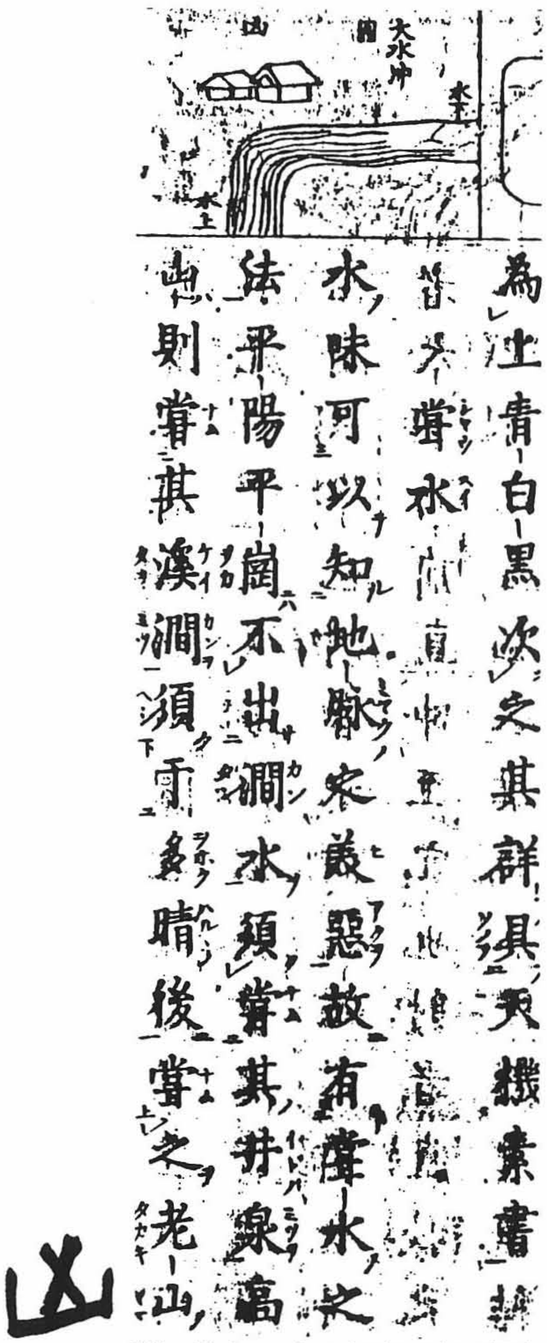


AUSPICIOUS — The northern mountain blocks the house from cold north winds. The winding river makes the water run smoothly so it can be used as resource without being dangerous. In addition it provides a nice view.

Figure 1.

formed by jotting down on paper a number of dots at random." Clearly, the Chinese practice of *feng-shui* has nothing to do with geomancy as defined by this dictionary. Steven J. Bennett wrote in his article "Chinese Topographical Thinking," that he considered *feng-shui* to be a systematic theory. A case in point is the topographical science of "siting," used to discover the flow of energy through the earth so that residences of the living and the dead can be placed in areas that have favorable energy conditions. A conceptual analysis of classical Chinese siting texts reveals that siting always was a rational activity, attempting to structure reality through a theoretical quasi-religious framework. In short, *feng-shui* was a nascent science, explaining hitherto phenomena on a level that could be understood by even the most superstitious country dweller. To gain popular acceptance and respect, it cloaked common sense and scientific truth with the awesome authority of mystic revelation.

Feng-shui originated from the *Dzang Jing*, the *Burial Book*, which concerns itself with the selection of burial sites and the orientation of graves. According to one source, the *Dzang Jing* dated back to the ancient Zhou Dynasty (722–480 BC), but became most popular during the Sung Dynasty (960–1126 AD). Because of traditional emphasis on filial piety (honoring one's parents), proper burial was an important concern of heirs and descendants. During the Yuan (1260–1368 AD) and Ming Dynasties (1368–1644 AD), *feng-shui* florished in architecture, and its influence is especially discernible in the design of the palaces and temples of Beijing. During the Qing Dynasty (1644–1911 AD), *feng-shui* was widely used, both to establish orientation and to select propitious dates for such activities as moving into a new house. At present, *feng-shui* is still being practiced, though it has become an honored tradition rather than an entranched superstition. What may once have been followed in fear is now respected in reverence to a rich and ancient culture.



EVIL — The house situated at the turning point of a river is in jeopardy when the water erodes the bank.

Figure 2.

The principles of *feng-shui* provide a scheme for understanding land forms, as in the theory of the five basic elements, *wu-xing*. According to this theory, the rough shape of everything in nature falls into the category of metal, wood, water, fire, or earth. For example, in Figure 1, we see the classification of shapes of mountains and waters. When objects in nature are classified and placed in combination they present evil or good fortune. From this juxtaposition, good sites for building are found, because according to the theory of five elements, the five interacting forces either produce one another or destroy one another. For example, earth produces metal—literally metal is deposited in the earth. Thus, they complement each other and are good. In scientific terms, flat terrain (earth) is suitable for farming and building; the tall mountains (metal) benefit the land by sheltering it from the wind and providing water resources. Similarly, water nourished wood; wood produces fire; fire produces earth. All these combinations are good. Using the same logic, water destroys fire—literally water can extinguish fire; they conflict with each other and are thus evil. In scientific terms, hilly terrain is not suitable for agriculture or building. It is also not difficult to find a reason for fire destroying metal—fire can melt metal. Fire destroys wood—wood burns in fire.

Hence, gradually sloped mountains and ribbon-like, winding rivers are thought to be auspicious because "earth" mountains could be cultivated and "earth" rivers controlled. Sharp and irregular shapes are considered evil because the "fire" or "metal" mountains often have rocky foundations, unsuitable for farming.

The drawings (Figures 1 and 2) indicate the auspicious or evil placement of dwellings on a site is from one of the many books of *feng-shui*. The diagrams are explained in poems as superstitious predictions. However, one can see the scientific basis to them. These drawings represent the dwellings in their physical relationship to water, mountains, and roadways, and their orientation to sun or shade.

In some cases, the *feng-shui* principles reflect the social situation of the time. For example, a house is defenseless if placed at a crossroad.

Feng-shui also encourages auspicious planting of particular types of trees. For example, it is beneficial to plant plum or date trees to the south, apricot trees to the north, willows to the east, and pine trees to the west. Plum trees love sun, apricot trees prefer cool shade, willows wave in the morning sun creating lacy shadows, and the low westerly sun is shaded by dense pines.

The application of *feng-shui* to building location and design was based on a belief that whenever possible the house should face a southerly direction, toward the warmth of the sun, and sit with its back to a large hill that would protect the dwelling from the wind. There also should be two smaller hills flanking the sides to form a special enclosure that would provide a sense of unity and security. The fron view should be clear and open for defense. Hills should not block the light. Water was necessary; however, it should be located in front and parallel to the house. These considerations have led to a particularly refined appreciation of the topographical features of any locality, and the efforts to achieve a favorable balance of forces have brought about a uniquely sensitive environment with dwelling places quietly nestled in the contours of the landscape.

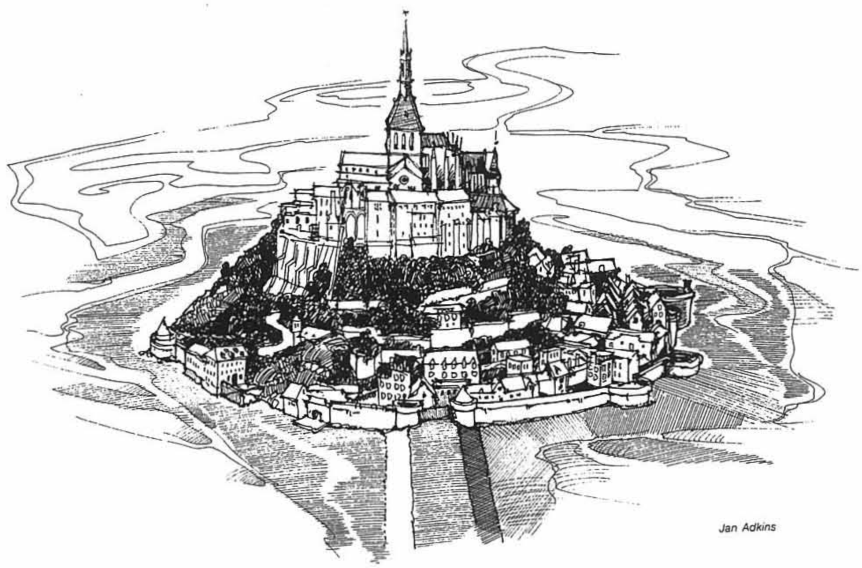
A Single Shared World

Mary Catherine Bateson

Traditionally, the village is characterized by a certain minimum level of diversity and a size that makes motion within it convenient. Although in complex societies villages live in awareness of urban centers, and villagers travel to the city to meet special needs, for pilgrimages or to petition authority, most of the day-to-day activity is carried on within the village. If the land is very fertile, the population may be large—say ten thousand. This is true in such places as Egypt, where small tracts of the Nile-fed land support large numbers of people. That number of people might live in a dense, compact cluster and be able to get up and walk to the farthest fields, carry on the necessary cultivation, and walk home, all between dawn and dusk. Alternatively, if the land is dry and hard, limitations of time and human and animal walking may mean that a village has only a few families, a hundred people or even fewer. A small village can support very few specialists, but it must have a few, usually a midwife, someone with some necessary healing or ritual skills, some pattern of leadership if only an elder who is habitually consulted, and one or more craftsmen such as a carpenter or metal worker who help in constructing housing and repairing tools. A large village can support a considerable number of specialists and can also have considerable diversity within its population, but even if village life is rich enough so that many inhabitants only participate in a part of it, a village is not a conglomeration of separate worlds but a single shared world.

This is all very different to think oneself back into today, and it is difficult even to find the appropriate characteristics of a preindustrial village to provide a model for the metaindustrial village. How much self-sufficiency are we concerned with, in food and energy and expertise? How tightly is the metaindustrial village integrated into a national power grid for its electricity, a national economic system that converts its crops into cash for buying merchandise produced elsewhere, and a national information system that subjects the opinions of the villagers and the music they can produce for their own festivals to the comparisons of the big time? In our discussions, we tended to assume a walking community with at least the capacity for self-sufficiency in an emergency, a bias toward producing its own foodstuffs, and at least one significant cash-producing activity.

Most difficult to think through are the social limitations. Every stable village society must solve

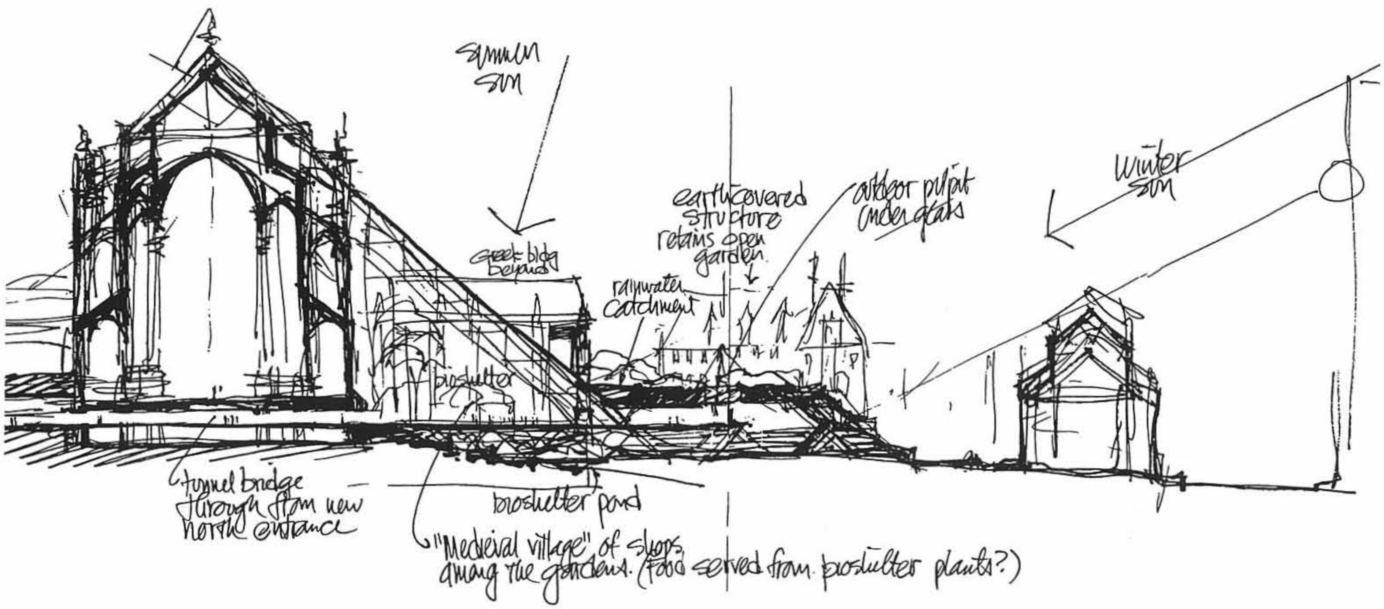


the problem of creating new households, and Americans are used to having a very large pool from which to select mates, even though the girl or boy next door is still a favored choice. In many cultures, however, villages are exogamous, and the importation of wives or, less frequently, husbands is one of the principal links to the wider society. This is true on the whole in Israeli *kibbutzim*, where the children grow up almost as members of the same family. Urban Americans are also used to living in a large-enough community to absorb severe perturbations and provide considerable privacy, so that when marriages split, estranged spouses do not keep running into each other at the same parties, and one is not marked forever by a notable piece of folly in the seventh grade. In most communes today, when a marriage breaks up, one partner leaves the community, which is too small to absorb the strain; this is one example of a general pattern of exporting individuals when they are discontented or their lives are disrupted, a common flaw of utopia.

Does village life inevitably have to be monotonous, so that regardless of who goes to start the village the next generations will become peasants? Unless this question is addressed, there seems to be little use in trying to swim against the tide that has made people through history anxious to *get away* from their villages, from the tedium of agriculture and from neighbors who know them all too well, and go to the city, where the range of choice of all kinds is so much greater, using old villages as, at the most, bedroom communities. It seems important that even if a village is able to be largely self-sufficient in food and energy production, it should not try for cultural self-sufficiency and it should have some specialties that are wanted by surrounding communities. Through history such exchanges as rotating rural markets have provided the moments of excitement. Most of us want to reduce the movement of people and objects in vehicles sharply, but not the movement of ideas and the stimulation of communication, perhaps through local and regional decentralized video.

It seems unlikely that small communities will be able to strike a balance between cultural openness and local generativity and to maintain the sense of common purpose and identity needed to balance the reduction in apparent choice that goes with leaving the city and reducing mobility without a shared sense of the sacred and common rituals. Over and over in our discussions, the sacred grove or meadow has seemed to be essential as a center to the community, bringing into focus a pattern of participation. Common rituals would have to address the ecological values that undergird the community and justify its basic choices. They would also have to address the transitions and steps in the life cycle that in America are so often dealt with by moving on. Closely linking to the centrality of a common sense of the sacred would be a provision for the very young and the very old, both groups a focus of common care, and neither segregated from the work and production of the community.

It is really only the automobile that makes us think of villages in primarily spatial rather than social terms. A village is not so much a place where a given house is located as the locus of a family, a festival, a garden, or a fish pool, a focus of the lives of many individuals, closely interlocked. In effect, we are talking about breathing new life into what we mean when we say that we *live* in a given place.



Malcolm Wells

ENERGY and ARCHITECTURE

Solar Village Principles and Construction Ideas

Malcolm Wells

Approaching self-sufficient living through reverence for life, using systems tested by America's experts in soft technology. Food. Land Husbandry. Shelter. Networks. Appropriate Scale. Wastes. Aquaculture. Sharing. Solar and Wind Energy. Privacy. Limits. Conservation. Fun. And Elephants.

Expressive

It must not need explanation. It must say "reverence for life." It must exhibit its dependence on rain, wind, sunlight, earth, and oxygen.

Identifiable

It must say "here we are" without recourse to the use of signs, lights, or arrogance of architecture.

Beautiful

(Unattainable, but always the goal.)

Wild

Over and over, we stumble on the obvious: if the habitat is provided, the wildlife will reappear. Can we afford to set aside ten percent of the land around the village as forever wild? Can we afford not to?

Secure

There may be no refuge from terrorism, but the village must offer shelter from storm and noise, and perhaps from vibration as well.

Consistent

Each village will inevitably develop a direction, an emphasis, at least slightly different from that of all the others. The more clearly the village expresses itself the better the design.

Contoured

Nothing says "husbandry" more directly than does contouring, following the design of the land, not fighting it.

Permanent

If trees and topsoil grow at a hundred-year pace, we can't be tearing up and rebuilding and tearing up again every ten or twenty years. Interiors, occupancies, these can change at will, but let the earth-platforms and the encircling land be at peace, untouched again for generations.

Flexible

Organic, growing and shrinking, responsive to new knowledge, new needs—not locked into whole, perfect forms.

Inevitable

Appropriate, local, right for its time and place. As if it grew there.

Earth-Related

Stable, horizontal, sheltered, permanent.

Continuous

No more dot-dot-dot architecture! No more parts instead of wholes. The village must flow out of the land and through time as well. As if it is growing there.

Linear

The wheeled vehicle, whether it be a pushcart or a self-propelled device, seems to dictate flow-through, as opposed cellular, circular, or stepped-floor spaces. Nonvehicular areas (living units, for instance) can line the linear parts and be delightfully stepped, sloped, and interrupted, but since the village, in order to be successful, must first of all *work*, the ease-of-work aspect, especially when combined with the need for contoured forms, seems to dictate linearness.

Diverse

From Jane Jacobs to the speakers at our conference, all seem to agree that diversity at all levels (occupancy, crops, life support, human insterests) is the key to long-range success.

Simple

Understandable, consistent, geometric.

Exciting

Filled with the unexpected, not with pitfalls and booby traps, but with changes of pace and scale; architecture without all the fun extracted.

World-Linked

Part of the growing information network.

Accessible

Accessible not only to visitors but to the kinds of work crews, machinery, and vehicles we hope will never be needed: emergency equipment, rescue teams, major structural replacement machinery, and so forth.

Educational

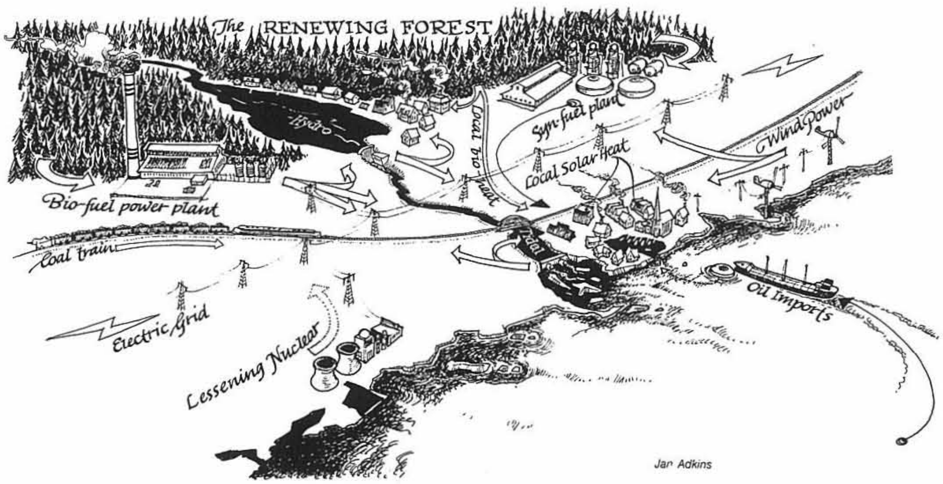
Of course. Life processes (and the processes of learning about life) always on display.

Democratic

With a few Republicans thrown in for balance, perhaps.

And what about these? Limits to growth? The use of chemicals and poisons? Private ownership? Private belongings? Inheritance? Existing structures (demolish, salvage, restore, retrofit, preserve?)? Evil? Imports (how much fuel, food, containers and wrappings; how many experts, specialists?)? Village characteristics and rules (how much should be *imposed* in the way of aesthetic controls, diversity, design; and who should do the imposing?)? Domestication vs. wildness of animals? What's the best way to hide the village dump?

More and more, I think a tools/models-book will generate a vast first-generation village-activity all around the world, and from *that* experience, from its successes and failures, will spring the really worthwhile villages we're all talking about. We can't begin to lay down all the rules at this time.



Soft-Energy Paths From Here to the Village

Amory Lovins

In any sustainable human settlement the renewable energies of sun, wind, water, and biofuels suffice to meet all reasonable human needs for energy—provided the energy is used very efficiently. Energy would be harnessed via various commercial technologies from the renewable energies that impinge on the area, and in the case of a city, on its environs. Economic efficiency, engineering elegance, and ecological benignity all seem to lead to the same combination of very efficient use with soft technologies or appropriate renewable sources. Supplying energy at a scale and quality appropriate to the task tends to minimize the economic and social costs of distribution and conversion respectively.[1]

Just what energy technologies make sense is a use-and a site-specific question. What tasks do we want energy for? What forms or qualities of energy will do these tasks most simply and effectively, with the best opportunities for integration and for cascading energy through successively lower-grade tasks? How little energy can we get away with, at what scale of unit use, with what distribution and variation in time and space? How low-tech, reliable, convenient, durable, and resilient do we want our supplies to be? How might these things change in the future or with different people? How precisely do we know these things?

These are the main things we need to know before we start asking what renewable energy flows are available to us and how to harness them. For each site, some forms of energy, or degrees of reliability, or scales of supply are much more easily achieved then others; no site is average or routine. Each needs ideas. Knowing the quirks, we can re-examine how hard we want to work to get the right kinds of energy to do the tasks we started with; maybe we don't really need a steel mill after all.

Important types of energy needed may include heat at low temperatures (say, below the boiling point of water), at medium temperatures (cooking and most other chemistry), and at high temperatures (metallurgy and ceramics); mechanical energy at fixed sites (to run machines) or in vehicles; electricity for the tasks that require this special, costly form of energy (electronics, electrochemistry, arc-welding) and for substitutable tasks (motors that can run instead on compressed air, lights that can run instead on methane, and so forth). Road and air vehicles can generally do with solid fuels (external-combusion engines or gasifiers), electricity stored chemically or in flywheels, the coolness of liquid air, or possibly other methods. The array of energy carriers and conversion devices available to marry a renewable energy form with a task is as rich as your imagination. Most of the things that look as though they ought to work do work, and many of the brightest ideas have come from ordinary people without special technical backgrounds.

[1]Soft technology is the friendliest name for what has also been called alternative and, by E. F. Shumacher, appropriate technology. Stewart Brand, the editor of *The Next Whole Earth Catalogue* and the *CoEvolution Quarterly*, has written, " 'soft' signifies something that is alive, resilient, adaptive, maybe even lovable." My own favorite description for the kind of technology we're talking about is that it is forgiving. Scale and locale are implied. It is not endlessly consuming of non-renewable resources. A bioshelter, a windmill, small scale farm machinery, a windbreak of trees, wind-driven commercial and passenger sailing ships could qualify as soft technology. Nuclear bombs and nuclear power, the wan Dam, the Four Corners Power Plant, and the private car are not. There are also intimations of sustainability, a possibility of a future in the term. And it is reversible. One can undo it.

N.J.T.

The most obvious soft technologies, each best suited to particular uses in very rough order or decreasing share of typical end-use needs include the following:

Passive solar heating, cooling, and crop drying.

Seasonal storage of ice or warmth from a solar pond.

Active solar heating and cooling (often integrated) at low temperatures (a need for active solar space cooling is a symptom of bad buildings, in any climate).

Active solar heating at medium temperatures, through mirrors (which can be aluminized plastic films), Fresnel lenses, or very selective collectors in a hard vaccum (these can yield 5,000 to 6,000 degrees Celsius under load on a cloudy winter day).

Active solar heating at high temperatures (over 1,000 degrees Celsius); this required high concentration ratios and direct (not diffuse) sunlight, though a low-tech, low-cost solar furnace on the Olympic Peninsula has given an impressive performance running a steam-engine generator.

Burning wood or farm or forestry wastes, taking great care to conserve soil fertility (and possibly adding steps like gasification or densification).

Converting such residues to liquid fuels (mainly alcohols or pyrolysis oils), using pyrolysis, acid or enzymatic hydrolysis, fermentation, and so forth.

Anaerobic digestion of some wet residues, expecially those rich in nitrogen.

Windpower to make electricity (with or without grid integration) or hydrogen, directly drive machinery (including water pumps), or compress storable air to run machines.

Existing, or low-head high-volume, or high-head low-volume, or run-of-the-river hydropower, or (in special cases) small-scale wavepower, again for electricity or direct mechanical drive.

Solar ponds operating tow-temperature heat engines (this appears to be the cheapest known source of base-load electricity in many climates).

Solar cells (photovoltaics), which may yield medium-temperature heat as a coproduct if they have concentrators—and cheap amorphous cells will almost certainly be here in the next few years before we know what to do with them.

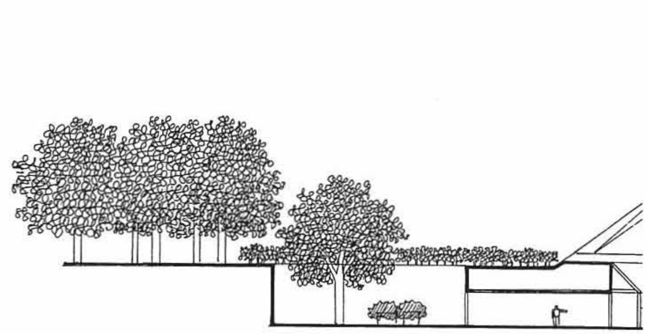
Hybirds of these technologies, such as a photovoltaic coating on a flat-plate solar collector, a bioconversion system driven by solar process heat or stirred by windpower, a plastic-film solar still/greenhouse, an integrated microhydro/wind/photovoltaic/electrolysis/fuel-cell system, or a small wood-fired co-generation/pyrolysis/district-heating plant.

Hybrids of these technologies (and others, including those we haven't yet thought of) with other processes, including water and nutrient recycling, food production, shelter, and manufacturing. The possible combinations are too numerous for a computer to enumerate in the lifetime of the universe.

Most of these systems are several times cheaper than alternative long-run replacements for dwindling oil and gas, and some are cheaper than oil and gas today if one uses the best present art—which the government has probably never heard of—cleverly built, well run, at the right scale, used efficiently, and done right. It is just as possible, though not as dangerous, to screw up a solar panel as a nuclear reator.

The first, second, and third priority is efficient energy use, far beyond the levels of improvement conventionally discussed. No kind of heating system makes sense if you live in a sieve. No kind of liquid-fuel supply system makes sense if you drive a Brontomobile. The "supply curve" for most soft technologies—measuring the increase in cost, difficulty, or nastiness with increasing volume of supply—rises discontinuously and, toward the top, very steeply, leading into hard solar technologies such as monocultural biomass plantations, solar power towers, and solar space satellites (which work better if you lay them on the ground in Seattle).

It is far better to save before the supply runs low, to try to make supply superfluous, and to retrofit one's house—using leak-plugging, heavy insulation (say, R-40 and R-60 ceiling in a cold climate), an airtight vapor barrier, good ventilation through a heat exchanger so that it's heated largely or wholly by people, windows, lights, and appliances. In a new house in our worst climates the net space-heating load and the extra capital cost can both be about zero. Any residual need can be covered by slightly oversizing the solar water heater, or if heating with a greenhouse, putting the water-heating panels inside it to avoid the costs of frost-proofing them. Efficient energy use is synergistic with cheap, effective soft-tech design: a tight house can get better performance from a five-to-ten-times-smaller active solar system, and a simpler one to boot, than can a sieve, because the heating load is tiny and unpeaky, the thermal mass of the house is much amplified by its slow heat loss, and no heat



distribution system is needed. No official study counts this essential synergism. Integration with food, water, shelter, and materials systems is equally essential.

We must remember that we are seeking not energy for its own sake, but energy services. There are lots of ways to skin an alternator. The objects of transport may be achieved by living where one wants to be, telecommunications, walking, riding a horse or bicycle or scooter or driving a super-efficient car, hitchhiking, taking public transport, airships, or out-of-body trips.

Even on the most barren/dull/cloudy land, there's abundant renewable energy, even wind in the High Arctic winter. The problem is the amount of trouble to get it. One can live better (materially) than the U.S. average on a total energy budget of two kilowatts (thermal), and in the U.S. that's the average rate of insolation on only twelve square meters; so even with collection, conversion, and storage losses, the areas needed aren't unreasonable. Urban densities improve solar economics. But that doesn't mean all forms of energy are equally easy to get at any given site.

For an existing settlement, we need to figure out present and long-term future (post-conservation) structures of end-use needs, to devise a matching soft supply system, then work backward to now to see what has to be built when and what policy instruments will be needed to do it.[1] The only important questions have to do with implementation—what happens in people's heads and how to help it happen from the bottom up by helping people see the energy problem as their problem.

In the long run, energy probably isn't a terribly interesting problem, because we already know conceptually how to solve it, and are starting to do so in practice. If we get out in one piece, then we can get on with some of the really interesting problems: water, soil fertility, food/population, climatic change, ecological resilience, social justice, and peace. In energy, technique is in a sense trivial: full or delights and traps for the techno-twit, but no longer full of deep, scary conceptual gulfs. But using energy to worthy ends, for right livelihood, is profoundly difficult, and is not a technical issue at all.

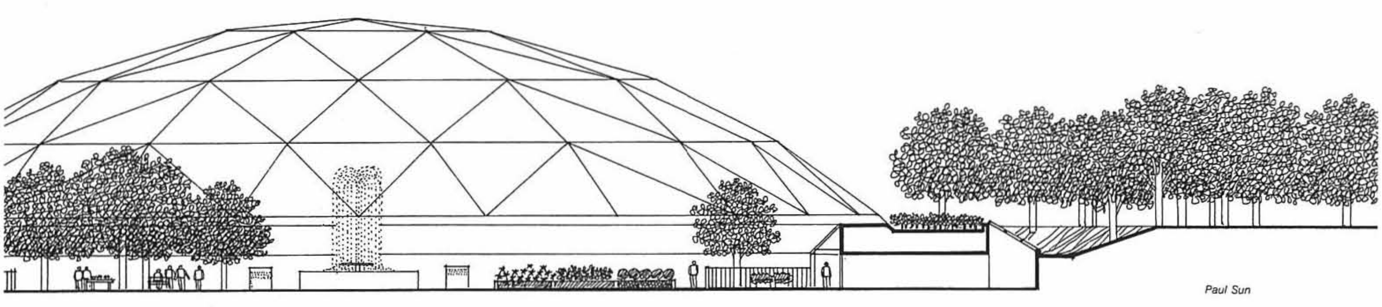
[1]For methods, see *Soft Energy Notes*, May 1979. Available from IPSEP, 124 Spear, San Francisco, CA 94105.

A Dome Bioshelter as a Village Component

J. Baldwin

Serious concern with energy efficiency in buildings requires a standard of performance and reliability rather better than the traditional norm. Many designers, including those aware of the need to conserve resources, do not have the regard for detail necessary to deliver long-term high net energy performance. If we are truly interested in saving energy and materials, we must analyze building design for energy savings in construction, use, and maintenance. Massive amounts of concrete, for instance, mean both a high energy cost in manufacturing the concrete and reinforcing steel, and energy-intensive transportation to the site. Structures that develop leaks due to warp, rot, caulk failure, and ultraviolet deterioration are not going to help society's energy difficulties in the long run. It seems clear that "life-cycle costing" demands a new attitude toward architecture. When the structure is sheltering biological systems, continuing mechanical reliability must be of a very high order lest a component failure result in loss of the cash crop or other function.

One strategy for achieving good performance and reliability is to develop a machine-made structure utilizing high-quality materials in precision components. Not only is quality control thus as-



sured, but the vagaries of construction crews are much less likely to result in poor assembly. Moreover, well-designed industrialized building systems are much faster to erect, thus reducing the critical time between cash outlay and cash return. Speedy installation also reduces the risk of work being interrupted by poor weather conditions, strikes, and inflation. Machine-made systems can also be designed to fit tightly into transport modules such as sea-land containers; parts can be nested and packed in a manner that minimizes transport energy and damage.

A likely candidate for such an architectural system is the geodesic dome. Domes lend themselves well to mass production techniques. Indeed, the reputation of domes for leaking and other weaknesses is almost entirely due to inaccurate preparation and assembly of handmade parts. Domes are also materials-efficient, typically using about 25 percent less material than a conventional structure of similar size. They are well known for easy, rapid erection by inexperienced crews. There are many instances on record of domes as large as 200 feet in diameter being put up in one day. Clever designs do not even require the assistance of an expensive crane.

Domes typically use many parts, but these tend to be of only a few different types. This means relatively low tooling costs and tends to maximize the economic advantages of mass producing a large number of similar items. It also means low inventory and storage costs both for domes awaiting utilization and for repair parts. This reduces both dollar and energy costs associated with stocking. In fact, many dome systems use materials that do not require covered storage, a further saving.

Perhaps the most interesting advantage of the dome is good thermal performance. This advantage arises from the geometry, rather than mechanical devices. Domes have superior surface-to-volume ratios when compared to most other configurations. A relatively low skin area means less skin to lose heat through as well as less skin to buy and maintain. This skin is smooth, offering little resistance to wind. A greatly reduced heat loss due to wind scrub is thus achieved effortlessly; it also imparts an unusually high resistance to weather damage. This, among other reasons, is why domes are used for radar enclosures, especially where weather is violent. The smooth shape has an advantage inside too; natural toroidal convection current patterns eliminate stratification, reducing differences in temperature between top and bottom and the consequent need for circulation fans and/or extra-high heating demands to insure acceptable temperatures at the floor. In the summer these air currents can be used to cool the structure, also without the need for fans. These naturally occurring air motions benefit plants by bringing needed carbon dioxide past them at no fossil fuel cost. Preliminary investigations suggest that control of the aerodynamics of boundary layers inside a dome may result in unusually good insulating effects.

Another benefit of the shape of the dome, which is essentially that of an inverted bowl, is that it can act to reflect radiation back into itself. This is especially important in a greenhouse, where the radiant heat losses can be very high. On the other hand, the dome's spherical section means that sun can penetrate the glazing at a 90 degree angle somewhere on the surface during the entire day. This reduces losses in the morning and evening, when the flat surface of a conventional structure reflects a significant percentage of the available sunlight. This holds true regardless of season. Domes tend to be self-snow-shedding too.

There are advantages to a circular floor plan in a greenhouse: a central mast can support a boom carrying irrigation nozzles and platforms from which the plants can be cared for and harvested without the necessity for space-wasting aisles (typically 20 percent of the floor area). Such a mast could also be used to speed erection of the dome's framework as well as aiding the pouring of the foundation. Circular concrete form-work is also much easier and cheaper, as it can be braced with tension bands instead of many stakes and woodwork. The boom could also ease window washing and other maintenance. Fish feeding could be accomplished from the boom as could tank filling and draining, harvesting, and cleaning. Such a boom could be very simple in concept and execution, in contrast to complex apparatus necessary in other floor plans.

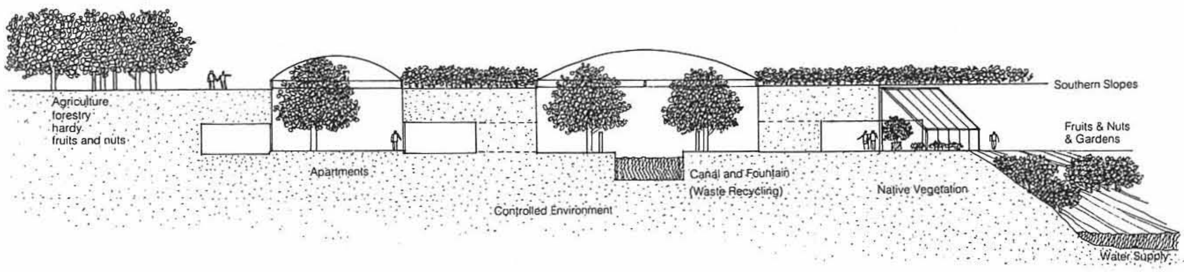
Assuming that the advantages of the dome are now apparent, what other possibilities exist for these structures? One is the potential for very large domes. Buckminster Fuller has proposed domes up to three miles in diameter; his suggestion for covering downtown Manhattan is one such proposal. Bucky estimated this dome would quickly pay for itself in snow-removal savings alone, not to mention the greatly reduced heat and air-conditioning loads that result when the "fin area" of hundreds of buildings is effectively reduced by having the membrane buffer the ambient weather. Such large structures have not been built, though there may be no technical reason why they cannot be. However, smaller structures usually seem to be much less threatening to many people and would be a good way to test such ideas. The capital outlay for smaller domes would be within the capabilities of groups of people; neighborhoods, even small towns or villages might be protected by a dome shelter with the inhabitants living in the perimeter of the structure, perhaps in earth-tempered housing overlooking the central shared space. Such a scheme would be ideally suited to the community-sized seasonal heat storage suggested by Ted Taylor. Consider a sample dome 300 feet in diameter. That gives us about 1.6 acres of climate-controlled space. If housing were in a raised berm around the perimeter and the housing units had a 30 foot frontage inside and outside the dome, there would be space for 30 homes—perhaps 120 people. A 1.6 acre bioshelter could supply them with all their food—except perhaps Twinkies—with a substantial cash crop left over. Hydroponics is another possibility. The synergistic interactions of a tuned bioshelter/Ark would be visible to the occupants. The maintenance of it would be divided. Thirty families is getting near the critical mass necessary for efficient methane production and could be served by a wind generator in the 50–100 kilowatt range, a size that has in itself advantages of being suitable for mass production and distribution. Load management reducing peaks and waste could result in very high performance and excellent efficiency, assuming that the machinery is built to last. This could be rather easily accomplished in such a compact "neighborhood structure."

High-quality hardware would be capital intensive, but it is absolutely necessary for reliability and long-term energy economy. There are several ways that the initial outlay could be managed. First, a cash crop could be used to make much higher mortgage payments than is usual. Second, running costs of such a structure, including the dwellings, should be very low. And third, food costs for occupants would be much less than store-bought food, which carries high costs of transport, packaging (and disposal of packaging), middleman costs, and the expense of fertilizers and pesticides. It might also be feasible to rent such structures through an arrangement comparable to the telephone rental system. This would ensure that the quality of the structure would not need to be compromised in order to meet first-cost market price competition. Such a compromise would reduce system reliability, just as low-quality telephone handsets would reduce the reliability of the Bell System. (If you don't think that this can be a serious matter, you must not have lived where the phone system isn't by Bell.) Competition in hardware marketing always results in the lowest common denominator being adopted as industry standard. It might be realistic for banks to amend mortgage policies to accommodate bioshelters, since high-quality, high-performance domes would only appreciate in value while maintaining reliability over many more years than is "normal." The average commercial building, including downtown skyscrapers, in the United States is torn down after 37 years. A properly designed dome/Ark could be dismantled and moved easily and without damage, except to the current crop. This could be yet another advantage, as the structures would then never wear out or have to be torn down and would make communities resistant to economic disaster arising from being located in increasingly undesirable locations, which is common. (One could conceive of a used-Ark market!)

Our proposed 300 foot dome community would be a true neighborhood. A good many bits of shared hardware besides the dome itself and the power system and sewage treatment would act as social cement. Shared workshops, recreation space, and laundry facilities would further reduce family expenditures and increase social interaction. Freezer space and facilities for repair and maintenance could be common. The 30 families could share a huge tape library, much larger than any single family could afford. Heavy transport such as Dodge vans could serve as mass transit at this scale with shared costs far less than those resulting from individual daily car use. Recent studies show typical cost of owning a Big American Car to be 38 cents per mile. Perhaps the families could support a modest fleet of identical economical cars to reduce maintenance costs.

The neighborhood dome idea offers the exciting potential of several such domes interacting with one another and the rest of the world in a way that would reduce transportation needs as well as strengthening a regional cooperation in larger enterprises including field farming and forest management. The domes could raise seed stocks, tree seedlings, cover crops for erosion control, and specialty crops such as herbs. They would permit an acceptable high-density housing without creeping "slurb." Properly spaced, a group could be serviced by electric vehicles using power generated by the domes. There is some evidence that domes greatly accelerate air movements in a way that is advantageous to wind generators.

It should be emphasized that the most desirable size for such proposed domes has not yet been determined. To do so would require an examination of economics including mortgage policy and payback periods, requirements of the housing systems, people's needs and demands, structural integrity, codes, fire safety, net energetics of specific systems, implications of materials supply with respect to pollution and other environmental degradation, politics, quality control, environmental effects of the Arks and of accretions thereof, transportation effects to avoid creating commuter communities, and various sociological aspects. What does seem clear is that a neighborhood-sized bioshelter/dome could be the basis for a community that really does tread lightly on the earth.



Paul Sun

Notes on An Agricultural/Cultural Solar Village in the American Southwest

John Todd

Ownership

In an ideal community, land should not be bought or sold piecemeal. In an ideal village, all land would be held in trust. As a result, there could be no land speculation. Buildings, roads, ponds, mills, barns, trees, houses, housing complexes, bioshelters, and offices could be bought and sold privately between individuals and the land-holding trust or corporation.

A bioregional plan would provide a map for development and determine the limits and relative proportions of activities. The plan would provide building and zoning codes.

The holding corporation would earn its profits from long-term agricultural lease/trust agreements with farmers, through the building, financing, sale, and leasing of the many village components and facilities, and from the leasing of energy-producing rights to private groups within the village and community, or through the direct sale of electricity, water, and other key elements. Sheer diversity of activities would ensure that it would not become a dull or oppressive company town.

Energy

Indigenous energy sources would determine the first set of limits of the scale of activities and the population. Apart from direct solar heating and cooling, I see hydroelectric, solar-thermal-electric, and biofuels from waste recycling as the principal sources of energy. After a certain population had been reached based on per unit or per person energy consumption under this regime, then an increase in population or activity could occur, but only with a concomitant increase in the efficiency of energy use or through further conservation of energy. If per capita energy use were halved, for example, then, in theory at least, the population could double.

Water

In semiarid zones, water is the ultimate arbiter of human activity and density. I would propose that the volume of surface waters, pumped at indefinitely sustainable volumes through turbines and shallow wells, would determine the absolute limit on development. Water would not be imported.

Water use in agriculture and aquaculture as distinct from wasteful spray irrigation would be intensified and given top priority. Gray water and sewage would be purified and recycled within the village. The more times the water can be safely reused in village cycles, the better. Drinking water would be fresh.

Land and Ecosystems

The existing natural biological carrying capacity and ecosystem structure in this region is climate- and water-limited. The region is semiarid with a long, cold winter. As a consequence, the ecology is very fragile. Except for paths, the woods on the hills and valleys reaching into the mountains above the existing settlement should remain untouched for all time. They act as sponges absorbing the otherwise rapid flooding of rain and melting snow. They store moisture for the ground table and protect the area from destructive floods.

Other sacrosanct areas should be the outwashes and the streams lined with cottonwoods. They are the only areas where intensive agriculture can naturally flourish. The outwashes should be saved for agricultural forests, orchards, intensive aquaculture, and for market gardens. I can't overemphasize how precious these lands are. These cottonwood areas will be the ones most sought after for houses. Their use in this way would amount to a real tragedy.

Topographic features also need honoring, particularly the tops of ridges where the hills comprise vertical shallow valleys and ridges. Drought-tolerant trees, including the piñon, should be planted on some of the ridges.

Agriculture, Aquaculture, and Agricultural Forestry

The economy of the area would be at least half agricultural. The farmers would live with the other citizens within the villages, not segregated. The village, or perhaps two or three villages each linked to a watershed, would be the hub for all of the people.

Food production would take place in five distinct biological zones. Overall, each of these would help strengthen the others through integration. The zones are (1) bioshelters; (2) the village, which would house fish hatcheries as well; (3) stream outwashes for intensive agriculture; (4) semiarid hillsides for extensive agricultural forestry; and (5) the valley for a mixed agriculture of tree crops, grains, fodder crops, and livestock.

To optimize energy use, materials, machinery, and especially moisture and nutrients, broad planning would be done to see that agriculture was dealt with as a system of interconnected parts. The land would be protected from salting or monocrop abuse. In the extensive agriculture and planting of perennial grains and grasses, drought- and cold-resistant strains would be emphasized following the ideas of Wes Jackson. Livestock breeds better adapted to ecological conditions would be investigated. Livestock would not range freely but would be rotated in order to "tune" the various forage ecosystems.

The Village(s)

The village would borrow a leaf from the book of native American pueblos and cliff cities and from various European cities and towns. Separate and isolated family housing would be stringently avoided. Instead the village would comprise connected and shared structural elements. Housing, bioshelters, schools and institutes, civic and religious centers, commerce, and even manufacturing would be combined into an integrated solar framework. The sun, walls, and materials would be shared and do double or treble duty. The level of crafts of the village would be extremely high, and building would not be rushed. A medieval or sacred attitude toward architecture as an expression of divine powers would be intrinsic to the enterprise. Some of the builders would be artists. Local materials would be used whenever possible.

I believe that bioshelters are going to be the key connective element in the Village of the Sun and in future solar villages. Recently, J. Baldwin and I began designing a 300 foot diameter (1.6 acre) shallow-aspect glass-covered geodesic structure that has 30 partially bermed, protected apartments around its periphery; they open out into a solar courtyard and the land beyond. In this design the bioshelter elegantly provides heating, food, and recreation including swimming for a population of up to 120 people at a cost that may be competitive with standard multiple-family dwellings.

I mention this to point out that bioshelters should not be additions to architecture. They should be central elements in the architecture of villages, for they will help heat and cool the inhabited structures and provide a basis for household and community food production.

Transportation

Transportation will need careful thought. Agriculture will require special energy-efficient machinery matched to the type of agriculture and the distances traveled. Initially much of this machinery may have to be imported from Europe or the Orient or be manufactured on site. Unlike the people, the equipment would probably be dispersed around the agricultural zones and housed and maintained in energy-efficient underground facilities. On the hillside farms and in the agricultural forests, horses would be used as principal sources of power. Cooperative arrangements between farmers could help minimize amounts of machinery, time in transit, repair and fuel use.

Private cars within the village would be banned. Narrow "back alley" roads would be for service and repair vehicles. The main thoroughfares within the village would be narrow roads for bikes and walking. Old or infirm people could use some form of electric transportation. The village would be linked with the agricultural zones by bike roads and horse paths.

Another alternative, with the least environmental impact, would be a small, fast train that would service the whole ranch and allow agriculturalists, hikers and picnickers, shepherds and cowboys/girls to move back and forth from the village.

Attention to transportation efficiency and to the development of a viable bicycle and horse network would quickly pay for itself in lessened pollution, reduced costs and noise, more pleasurable transportation, and lessened dependency upon petroleum.

Some Considerations for Agriculture in a Solar Village

Susan Ervin

Food production in a solar village would include both small home-scale production and larger-scale public production. Home-scale food growing would probably include winter vegetables in a solar greenhouse, fruit trees, and small vegetable and herb plots. Both cooperative groups and specialists would engage in larger-scale production. Cooperatives would include such groups as students and teachers, who would partially supply the food needs of their schools; neighborhoods or smaller groups primarily involved in other occupations, who would grow food as a part-time effort; and commercial cooperatives. Specialists would simplify overall food production by providing vegetable and tree seedlings, biological control agents, and locally adapted seeds. Certain crops like grains, beans, dairy products, meats, some greenhouse-grown fruits, and wool would in most cases be produced by the co-operatives or specialists instead of on a home-scale. Foods requiring special preparation such as tofu, cheese, baked goods, sprouts, wine, smoked fish, and medicinal herbs would also be offered by co-ops or specialists.

Food preservation would be done on different levels. Some people might use a large freezer co-operatively, while others would take their food to a managed freezer locker, and still others might purchase frozen food from a small commerical operator. Such a small business could either grow and preserve food or purchase crops from local growers. A cannery would be available for individual use, but co-ops could have their own canning equipment. There would be new jobs, involving such necessary activities as the management of a large root cellar in which root crops would be stored for the winter. The manager would check for spoilage, bring the vegetables out for distribution, and make sure storage conditions were proper. Technologies for solar food drying would be perfected; they would use adequately sized solar dryers with backup systems of small wood fires or wind-generated electricity. Depending on community preference, either small conventional businesses or co-ops could fill the functions described above.

Effective small-scale farm machinery would be used. Individuals and small groups would have access to good tools and machinery through co-ops or rentals. There would be an adequate supply of machines and tools and idle ones would be rare.

Various patterns for land organization could be used. Public buildings could be in the center, with the homes and their gardens in the next ring, the larger fields and orchards and food-processing areas beyond these, and woodlands ringing the whole scheme. Or with public buildings still grouped in the center, homes could lie beyond the agricultural areas, next to the wild lands. A combination would be possible, depending on the size of the village. A small community might decide that dwellings should be clustered so some land could be left open and wild.

Whenever possible, biology would take precedence over technology; rather than installing an expensive irrigation system, the village would achieve maximum water retention through humus building. When possible, a fish or solar-algae pond would be placed uphill from a garden plot, eliminating the use of a pump for irrigation. Crops would be rotated, and fields left fallow periodically.

Living leguminous mulches would be interplanted among heavy-feeding crops.

Imported foods would be expensive and considered to be treats, like oranges for Christmas. There would be a few luxury items like coffee, tea, and exotic spices for which people would be willing to pay the price.

The Need for Trees

L. Hunter Lovins

Village as solar ecology. Not city nor wilderness, we seek a settlement to harmonize ourselves and earth. We seek a metadimension from the rural-urban axis. Among the tools we have lacked has been a measure by which we may sense the scale we seek. As city visionaries have turned to urban forestry, so we need a village forestry. Our measure is, of course, the tree.

Trees give the scale, psychically and architecturally, of the solar village. The presence of trees—and more important, our involvement with them, propagating and caring for them—gently imparts a sense of the appropriate human role. Our trees reach beyond us, to remind us that the fertility of our soils and the freshness of our skies are gifts from those who touched this land before. The trees they planted now give us shade. With each tree we plant we are reminded of their perhaps inadvertent generosity, and minded to pass on a bit of our own. Martin Luther spoke of this when he said, "If I knew the world would end tomorrow, I'd plant a tree today."

Plant a tree—a thought
in biologic time.
To see the city as a forest,
green instead of gray; bark
for concrete. Leaf
leads consciousness of cycles.

Today we plant a tree
into a century beyond:
vision village forest—
biome—and I am
bonded to today, this earth and you.

L. Hunter Lovins

The very architecture of a tree should guide our own. Monoliths erected in the clouds overreach the scale intuitive to living things, imposing their linearity on both those who dwell below and those within. We should seek to settle more softly within the landforms about us, our skylines an ornamentation of the treeline rather than a negation.

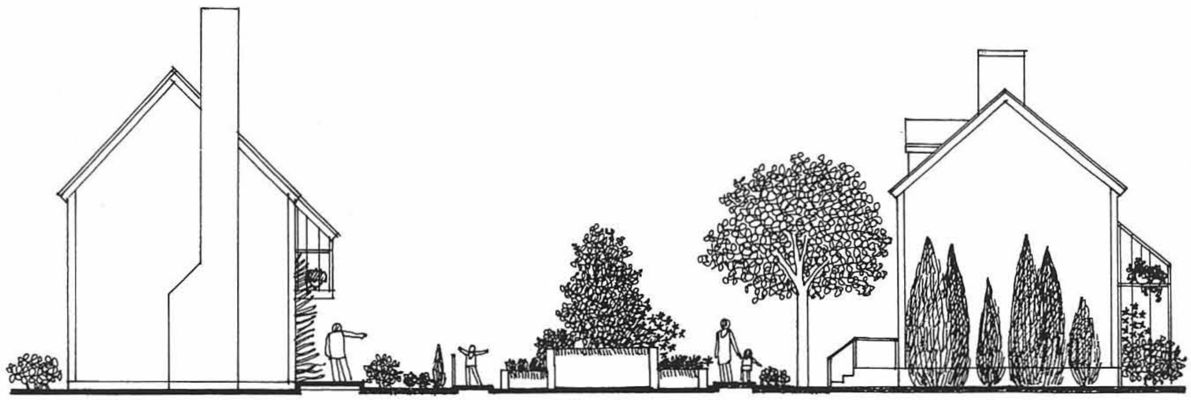
From the Druids to Gandhi, from the Buddha to E. F. Schumacher, trees have represented a spiritual and practical foundation for interaction with the earth. Because it makes a difference when you plant a tree. Perhaps it is the simple sense of giving something back—a joy our species little knows—perhaps the touch of soil and of life. Perhaps the bond is best left undefined: a mythic teaching, an essence of villageness and much more. In the words of the Southern spiritual, "Ain't you got a right to the tree of life?"

Walking through our village this right is everywhere embodied. We have reclaimed forestry, like the care of our bodies, from the technicians, and have invited the participation of all the villagers in creating and maintaining our woodlands. The bioshelters of the seedling nursery bubble about with children and excitement. The skills one needs to grow a seed into a young apple tree come mostly from the heart, and what's left is easily taught. The village forester is the steward of our efforts, and the hostess, but the trees are our own. Each day different villagers spend an hour or the day in the care of the seedbeds, orchards, woodlots, shelterbelts, and street trees.

The nurseries are part of our school, and particularly its responsibility. Older folk join the youngsters potting, pruning, and planting, both in the bioshelters and farther afield. Older classes are given the craft of logging, and learn the exhilarating arts of using saws, selecting trees for harvest, felling them, and skidding them out with care between the younger trees. Horses do this best, we've found, with less compaction. Our forest is diverse—young and old, hard and soft, old-snag habitat tree and ranks of heart-strong saplings—rather like the village; and a bulldozer can't discriminate.

In town, we've grown an edible village, richly endowed with fruit and nut trees. Rare and unique specimens abound where individuals have taken special interest. Many homes have arbors, crawling with fruiting and flowering vines. Village forestry is integrated with a general consciousness of green and growing things, and with the cycles, seasonal and nutritional, of which they are a part. Our celebrations follow the round of harvest and renewal. And because the lawyer has helped, the celebration is hers; because the shopkeepers, artists, plumbers, and bankers have each sprouted their seedlings, turned the compost, and taken a turn with the pruning shears, the festival belongs to us all.

In the same way there is no such thing here as



Paul Sun

a landfill: "refuse" rejigged to "re-use." Wastes that a city dweller would dispose of are our resources to be recycled. In Los Angeles County alone, between four and eight thousand tons of pure tree material—clippings, brush, downed limbs, and other such biodegradable "trash"—are daily dumped into increasingly costly landfills. In our village our somewhat more modest contribution is chipped by the student crews for easy use in our gasifiers. The urban biomass joins the woodlot slash as an essential energy feedstock. Much of our organic residues from the community farms and gardens, aquaculture, and even kitchen scraps are composted, but often they have spent an interim in a biogas plant, releasing their hydrogen and a bit of carbon as methane, before returning most of their carbon, their nitrogen, and all of their trace elements to the soil. The more cellulosic crop wastes are fermented into alcohols, and most of the wood wastes pyrolyzed. The paper is recycled separately, though, and returned to the little pulp mill with its hydropower rig by the river. Even the mill contributes to the town's energy, co-generating electricity off its process heat cycle, which is itself fired by its wood residues. As with all our systems, we have taken care to utilize what would otherwise be waste—cascading nutrient, fiber, and energy flows—and returning only clean residues to our village environment.

Some of the technology of this village forestry is modern: the integrated food and energy systems and the sophisticated microbial partnerships. But much is metamodern, concerned to nourish participation and satisfaction of the craft, not necessarily to expedite. The village forester and her interns teach the skills, but more, their role is to convey a larger curriculum of care: the poetry of trees, and the art. The efficiency of industrial forestry leaves shrubland and deserts, the desperation of primitive forestry denudes. We seek a greater balance of the earth's abilities and our own.

E. F. Schumacher said, "Tree planting is a very nonviolent technology and a very democratic one." I think we shall have to learn more and more to look out for and develop nonviolent, democratic technologies. By democratic I mean you don't have to have studied for years and years, you can do it yourself, you don't have to be rich, you don't have to have great equipment. It's something everybody can do, and something with which he can and she can enrich the country and for once do something for future generations, not only for themselves. My reading of the situation is that the technological development has become extremely antidemocratic. So I'm most interested in any technology, even to the humble and wonderful simple level of tree planting, that everybody can use.

Waste Water Reclamation Through Ecological Processes

Steve Serfling

Conventional sewage treatment processes that have proven adequate with no major design changes for over 50 years are now recognized as unable to meet the present Federal Water Pollution Control Act Amendments without extensive modification, additions, and extreme construction expense. They are also costly to operate, have high electrical demands, and consume precious natural resources including fossil fuels, chemicals, and water. Conventional treatment processes are incapable of removing or detoxifying the majority of the most harmful components of modern-day waste water, for example, pesticides, herbicides, phenols, heavy metals, and a host of complex domestic and industrial chemicals now recognized as potentially carcinogenic. In contrast, biological lagoon systems containing aquatic plants have proven capable of doing so. Furthermore, conventional technology was never intended or designed to fulfill the pressing need for water reclamation or resource recovery.

Most waste water treatment systems are essentially "biological," since even conventional, high-technology facilities such as trickling filters or activated sludge are entirely dependent on the growth, survival, productivity, and "harvesting" of bacteria to provide treatment. However, ecological theory and practice have clearly demonstrated that monoculture systems, for example, bacteria only, are inherently less stable and efficient than multispecies, polyculture systems containing a variety of bacteria, invertebrates, sludge grazers, algae, and plants.

Recent studies by the U.S. Environmental Protection Agency[1] evaluated 15 different aquaculture-type treatment systems utilizing polyculture lagoons containing a variety of algae, invertebrates, and fish. These were compared to four different conventional treatment methods (activated sludge and trickling filters), and in *all* cases where treatment objectives could be met, the aquaculture systems reduced projected treatment costs from 4% to as much as 94% of conventional technology methods.

The main advantages of the ecological system over conventional high-technology or lagoon treatment systems are as follows:

1. Reduction of Operating and Energy Costs. The system uses low-energy lagoon processes, including solar radiation for heating and oxygen production, inexpensive, air-inflated plastic films for insulation and control of the lagoon environment, efficient aeration systems, and water distribution methods using gravity to reduce electrical pumping requirements. Methane can be produced by anaerobically digesting the sludge, as well as aquatic plants raised in the system, to provide 50%–80% of the electrical energy requirements for the water treatment facility. The need for expensive chemicals is also eliminated.

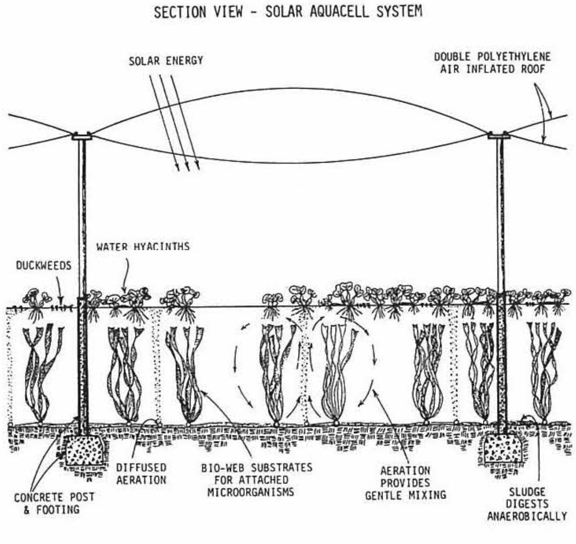
2. Less Construction Expense. For achieving secondary-quality water, the system is approximately 50% less expensive to construct and operate than conventional secondary-treatment systems. For achieving advanced-quality or potable water, an ecological system can save up to 75% of the cost of average conventional tertiary systems. Furthermore, because a plant can be located in each community for treatment and direct recycling of reclaimed water, expensive sewerage transportation lines and pumping costs are greatly reduced.

3. Reliability, Process Stability, and Flexibility. The system can be designed as a multiple series of AquaCells® that can operate in any combination of parallel or series flow, thereby allowing shutdown, independent performance monitoring, variation of effluent quality, or adjustment of any component without interfering with overall waste treatment. The two-to-six-day retention time and use of hardy species is designed to allow a large elasticity factor to handle wide ranges in nutrient loads (in contrast, bacteria or phytoplankton systems must receive relatively constant nutrient input to operate at designed efficiency levels). Finally, because the system is modularized, expansion can be made easily as needed.

4. Economizing Land Use. In spite of longer retention periods of two to six days, an ecological lagoon system requires little or no more land area than most conventional, high-technology treatment plants with retention times of only four to six hours. This may seem surprising, but it is due to the large open space required by conventional systems for vehicle access to numerous individual tanks for grinding, grit removal, clarification, air compression, aeration and biofiltration, sludge digestion, sludge thickening, disinfection, chemical storage, and so forth, and all the associated piping, valves, and process control equipment. Only one acre of pond area, plus one acre of pretreatment and posttreatment area is required for secondary treatment of 0.5–1.0 million gallons per day flow by the AquaCell process.

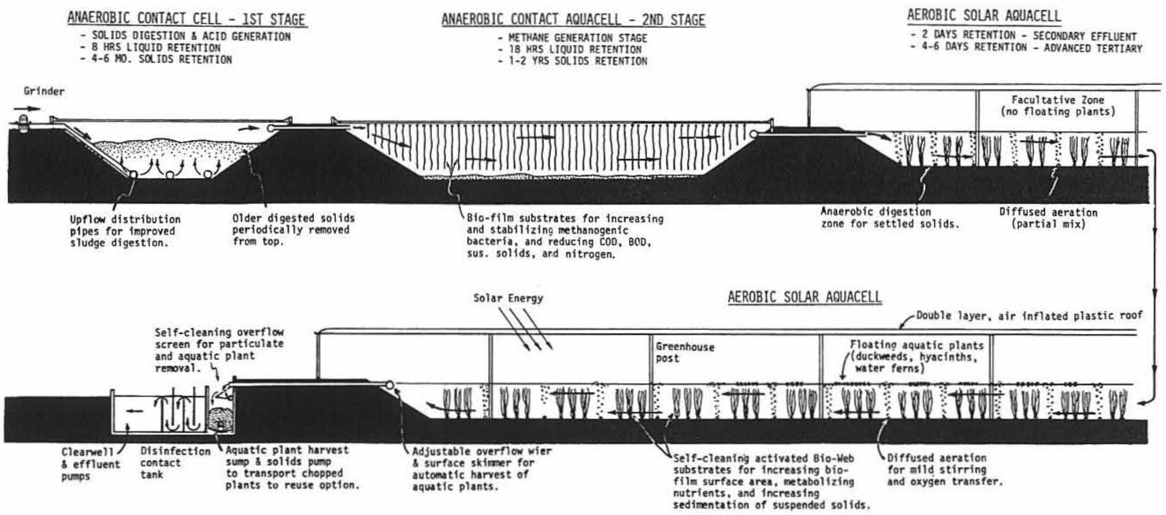
5. Year-Round Efficiency. Insulated solar greenhouse covers and solar heat exchangers provide for retention of heat in both the water and the air during colder winter months, thereby maintaining operating efficiencies of highly productive tropical species year-round. This feature also eliminates the need for expensive, oversized facilities designed to meet treatment requirements during the least efficient period of colder winter months.

SECTION VIEW - SOLAR AQUACELL SYSTEM



[1]Henderson and Wert, 1976; and Dufter and Moyer, 1978. References 1 and 4.

SOLAR AQUACELL SYSTEM PROCESS FLOW DIAGRAM



6. No Unpleasant Odors and Unsightly Ponds, Waste Lagoons, and Treatment Tanks. These are eliminated by the greenhouse covers and well-oxygenated, balanced ecosystem, thereby allowing location of the operation in urban areas.

7. Pathogenic Bacteria and Viruses are Eliminated Naturally. Natural biochemical processes of the polyculture system, including endogenous metabolism and food chain consumption, reduce the danger of disease and the amount of chemical treatment required for purification. Ozone, rather than chlorine, is recommended for disinfection after secondary treatment.

8. Byproduct Reuse. Aquatic plants high in protein and nitrogen are harvested on a regular basis, and can be used to provide a valuable, rich organic mulch or compost, used as supplemental livestock feed, or digested anaerobically to produce methane gas for process operation.

9. Reduction of Total Dissolved Salt (TDS) Content. Instead of a TDS increase such as occurs with conventional lagoon treatment, a TDS reduction can be achieved because of the greenhouse cover reducing evaporation and the cultured plants and invertebrate biomass removing minerals from the system.

10. Community Water Resource Planning and Recreation. The potential byproduct and reuse business and recreational-activity potentials can provide numerous opportunities for community benefits from an otherwise negatively viewed aspect of life. For example, in Santee, California, treated waste water is completely recycled for use in a beautiful series of recreational lakes and parks, now the major swimming, boating, fishing, picnicking, and golfing activity center for the community.

The Solar AquaCell System

The Solar AquaCell System consists of multicell, aerated lagoons covered by solar-heated greenhouses that contain aquatic plants and biologically active substrates. It has been designed to combine the best features—low construction and operation costs—of aerated lagoons with the control, reliability, advanced-treatment capability, and reduced land requirements of conventional, high-technology treatment plants. By trading off expensive concrete, steel, chemicals, and electricity for natural ecological processes utilizing earthen ponds, greenhouses, hardy pollution-consuming plants, microorganisms and invertebrates, and solar energy, this process has demonstrated the ability to convert raw waste water into high-quality, reclaimed water at substantially lower cost than with conventional treatment methods.

The system has the following characteristics:

1. *Multicell, aerated, earthen lagoons* provide inexpensive holding capacity to allow two-to-six-day retention times (1–3 acres per 10,000 people).

2. *Floating aquatic macrophytic plants*, for example, water hyacinth, duckweeds, azolla, and other hardy species proven to have the ability to remove and metabolize waste water nutrients and toxic compounds are used. The floating plant cover also provides the important advantage of shading out any growth of undesirable suspended algae, which are difficult to harvest and contribute to high biological oxygen demand and suspended solids in conventional pond effluent.

3. *Submerged activated bio-web subtrates*, a form of fixed biofilm substrates whose function is promoting an attached biological film of aerobic bacteria and protozoa are well proven in conventional trickling filter and biodisc processes. The low-density, vertically suspended bio-webs increase the biologically active surface area up to 50 times that of a conventional pond.

4. *A greenhouse and solar pond cover* are used to entrap solar heat during the daytime, even during cloudy pe-

riods, and to reduce pond heat losses at night. Biological rates of reaction are well known to increase by a factor of 1.5–2.0 for every 10° F temperature rise. This means a treatment pond or tank system maintained at 65° F instead of 55° F during winter months can treat up to twice the flow, or be constructed to one-half the size, saving construction and land area costs.

5. *A dual-aeration solar-heat-exchange system*, consisting of a simple diffused, submerged aeration piping system to provide a partial mixing and oxygen exchange, and modified surface aerators (operated during the daytime), is used to provide transfer of both oxygen and solar-heated air to the pond.

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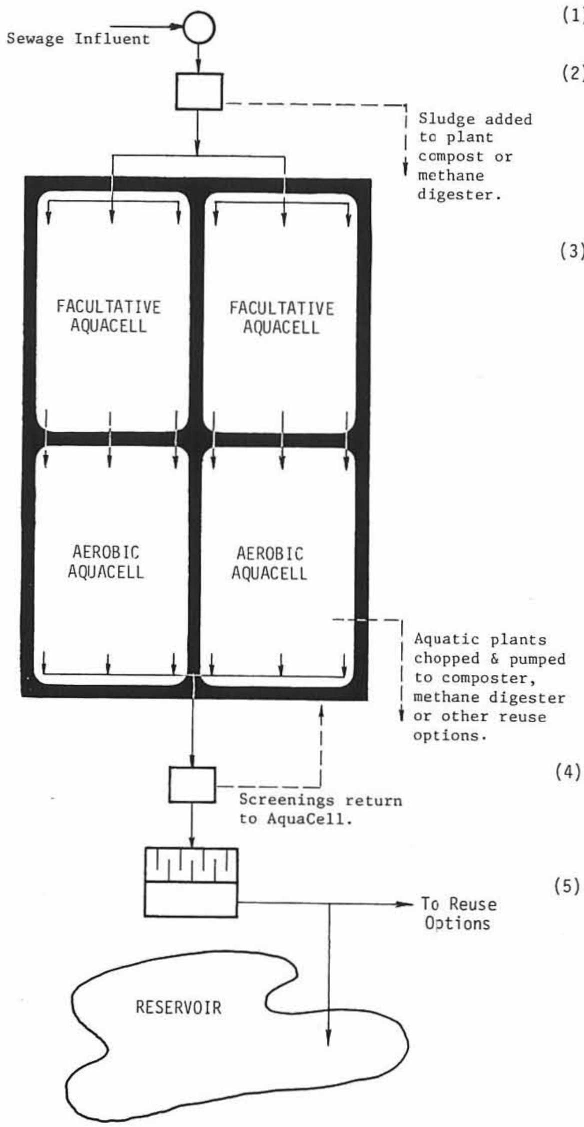
SOLAR AQUACELL – PROCESS FLOW DIAGRAM



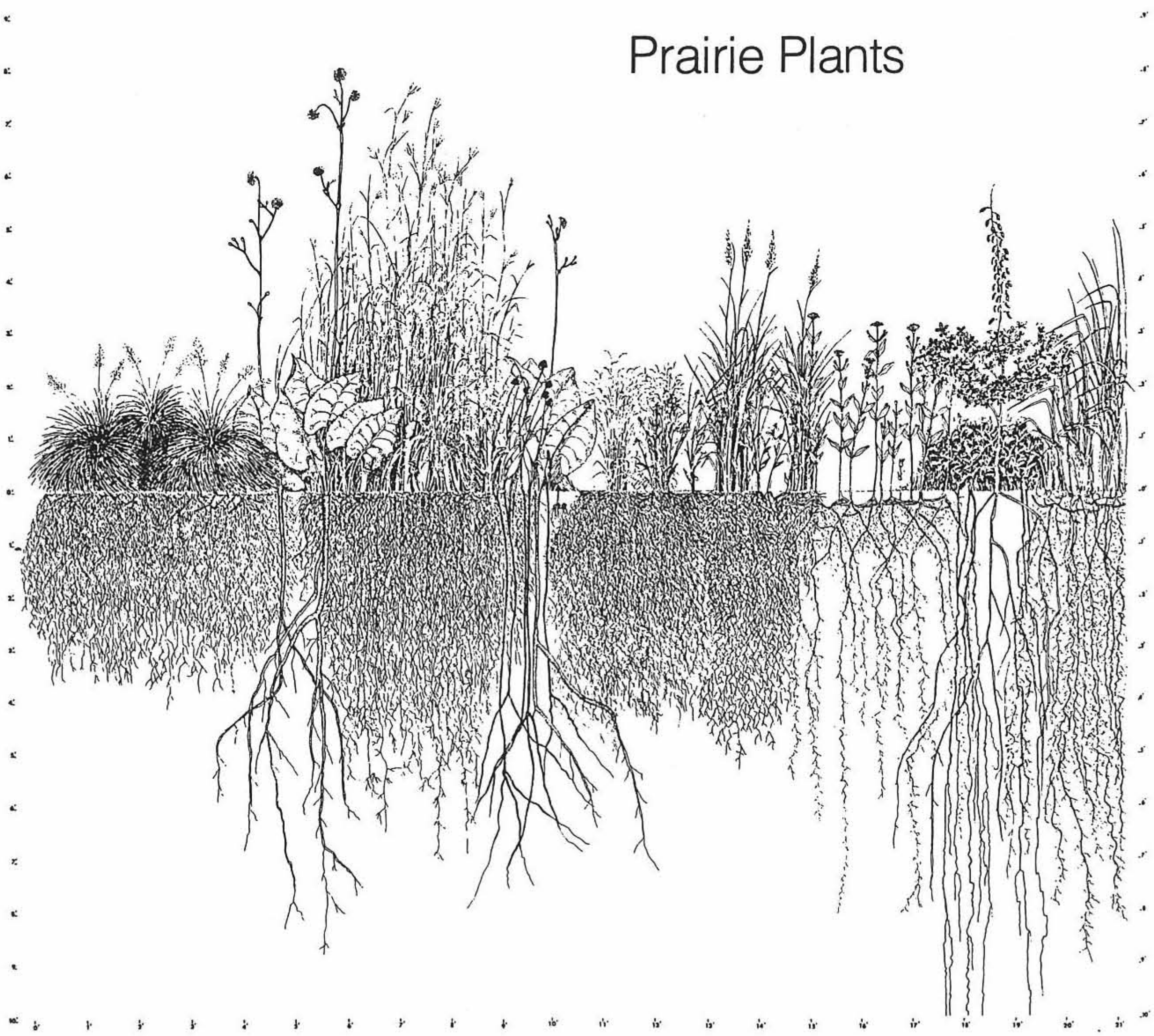
(1) GRINDER (Optional)

(2) GROSS SOLIDS REMOVAL
Optional conventional primary, 2-stage anaerobic pond, Imhoff tank, or screening (Roto-strainer)

(3) SOLAR AQUACELL, TWO-STAGE, FOUR CELL SYSTEM
- Secondary Treatment by 2-3 day retention.
- Advanced Tertiary Treatment
by 4-6 day retention time.
- Aquaculture Process
Includes: floating aquatic plants, bio-film substrates, aeration, solar heating, and aquatic invertebrate food-chain.
- Flow Equalization, Oxidation, clarification, nitrification, and some demineralization, all in one unit process.

(4) FINAL SCREENING (Optional)
Slow-sand filter or Roto-strainer for advanced tertiary treatment.

(5) DISINFECTION, CLEARWELL & PUMP STATION
Ozone or chlorine, then to reuse options.



Bobbie Fortun Lively

The Sustainable Farm

Wes Jackson

Assumptions

General

1. A viable nearby village and a distant city are necessary supporting elements for a viable farm. *Supporting* is emphasized, for the farm does not exist for the village or the city but rather land is the foremost and most highly protected of any component in the entire support system.

2. Though the farm described here is characteristic of a region of highly specific needs, the principles employed by the New Age farmer would be the same throughout the land, from New England to Southern California.

Religious Considerations

3. For humans, as well as for all species on earth, our planet is the best of all possible worlds. There is no meaningful escape valve for most of us.

4. In the long run, land determines more of the possible patterns of activity on the planet than humans.

5. Land is a community that includes the living and nonliving and is not just dirt.

6. The highest calling of an individual is to participate with the land in the promotion of a healthy and productive biosphere in order to meet, in Thoreau's words, "the expectations of the land." Holistic land stewardship is a way of life.

7. We are to encroach upon wilderness only as "strangers and sojourners." Wilderness is the standard against which we judge our agricultural and cultural practices. Therefore all natural ecosystems are to be protected. Such systems are the most reliable source of information for a sustainable future.

Institutional Consideration

8. Land is too important to be an item for speculation. Therefore, some form of land-trust system will be necessary to regulate its use.

An Agricultural Shift

9. Because a safe, sustainable culture must rely on sunshine, almost exclusively, the land will be called upon to be a sustainable and net energy producer for food, clothing, shelter, and transportation.

10. Because seeds are now, and have historically been, a central item in our diets, most alternatives in agriculture must include them. The closest approximation to the former natural vegetation in vegetative structure is a high-seed-yielding perennial polyculture. Therefore, the majority of the acreage would be devoted to this form of agricultural ecosystem.

Technological and Institutional Change

11. Essentially all the technology on the land should be powered from a sustainable energy source near at hand. Direct solar power, windpower, and hydropower should be used when possible.

12. Though machinery may be manufactured in a distant place, most repair should occur at the village level if not on the farm.

Equipment and Support Buildings

Operator-Owned Equipment

One 45 horsepower tractor run on alcohol. One multiple reaper combine (pulled and powered by PTO from tractor). One side-delivery rake. One baler for 1,000–1,200 lb bales. Windmill for pumping water. (Water tank is the accumulator.) Wind-electric power for refrigeration to store food. Freezing condition "accumulates." Wind-electric power with induction motor to put power on line. Ordinary wrenches and small tools.

Village Rental

Easy Flow Fertilizer (phosphorus and calcium) distributor. Chisel (attached to tractor) for breaking sod-bound soils. Annual seedbed-preparation equipment. Miscellaneous small tools and power equipment.

Support Buildings

Machinery and solar-heated tool shed and workshop. One hundred percent solar (passive and active) partially underground house set into bank. Solar and mobile hog and chicken pens.

The 160 Acre Farm

"The Fuel 40"

A six-species polyculture: five grasses, one legume. These seeds are high in carbohydrates, low in protein. The field averages about 20 barrels of crude equivalent per year. Livestock are cycled onto this acreage for a few weeks to enhance crumb structure of soil.

"The Multiple Purpose 40"

A six-species polyculture: four grasses, two legumes. Beef stock turned in for "finishing" on seeds. Some years seeds harvested for cash crop. Early vegetation to methanol still in village with limit of 2–5 barrels of crude equivalent per year. This 40 is "cushion" acreage, often using the poorest land.

"The Cash Grain-Hay 40"

A six-species polyculture: four grasses, one legume, one composite. Fall harvest for cash grain. Livestock pasture June 1–August 15. Hay in windows and large bales after seed harvest. Winter area for hybrid derivative of buffalo-domestic cow.

Windmill

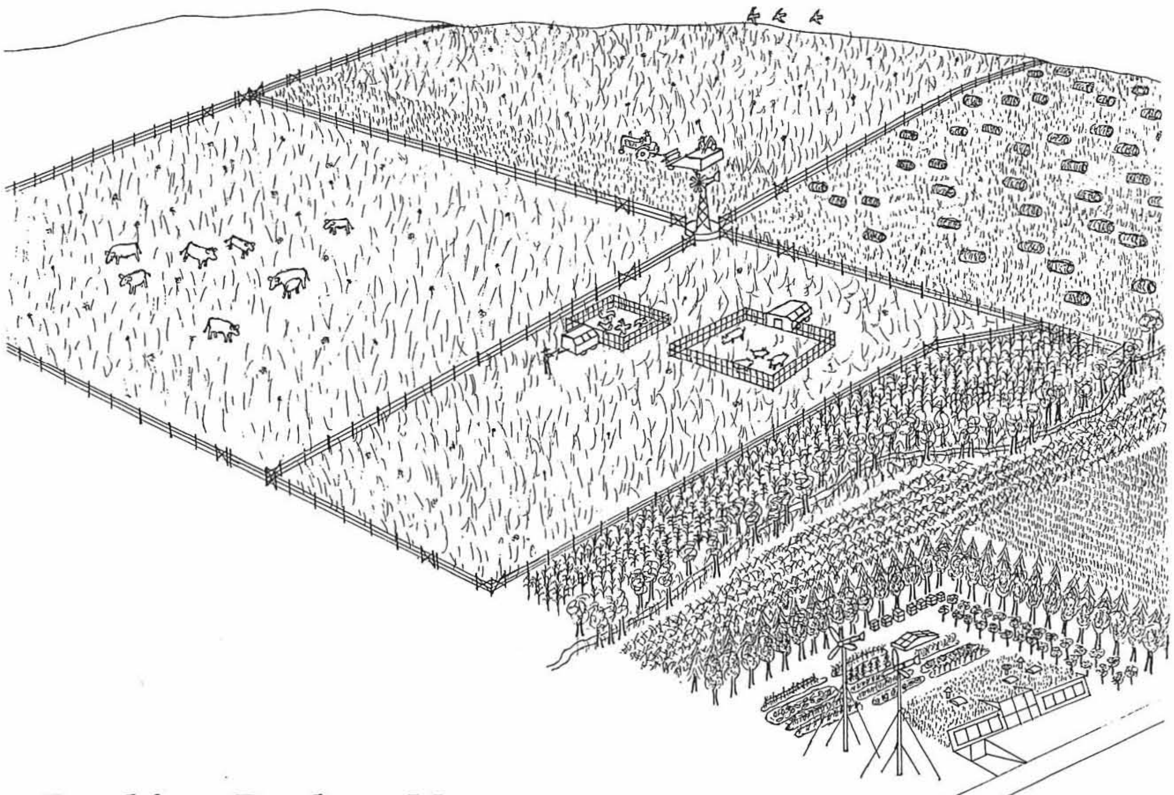
Carry-Over Native Pasture

Bottom Land Boundary

Creek bottom for garden and annual cereals (corn, wheat, soybeans, etc.). Managed mixed woodlot. Mixed orchard.

Bottom Land

Workshop, machine, and tool shed. House. Wind-electric machines for four families. Commons.



Looking Back to Now

Wes Jackson

The year is 2030 in a world with a heightened consciousness. People everywhere—on farms, in villages, and in cities—have sustainability as their central paradigm. They think globally and act locally. Regional semi-self-sufficiency is emphasized, but the principles of the New Age farmers are the same from New England to Southern California. Our utopian farm is in Kansas, below the 39th parallel and east of the 98th meridian. The area averages about 28 inches of rainfall each year, but the evaporation is in excess of rainfall. This is farming country that before being plowed more than a century ago was biotically rich. Stories handed down through the grandparents tell school-age children how the breaking of this virgin sod sounded like the opening of a zipper. A few miles east is the western edge of the vast Tallgrass Prairie, dominated by such species as big bluestem, Indian grass, and switchgrass. Scarcely 30 miles to the west are the mixed prairies dominated by bluestem and sideoats grama.

Because of the minimal landscape relief, the Great Plains is one of the few regions where it makes sense to divide the land into one-mile-square parcels. A road surrounds almost every square mile. This is a land that after the "Great Plowing" in the early 1900s supported such high-producing annual crops as wheat, sorghum, milo, and soybeans. Between then and 1990 only native pastureland and roadsides carried the principal grasses that were characteristic of the region before the Europeans arrived. Even so, this prairie, mostly because of forced grazing, had long since lost 20 or 25 native prairie species. What was left was not prairie but grassland. During most of the last century, wheat was an important export crop for the region; we are fortunate that even more grassland wasn't plowed. Church leaders, farmers, and grain men had said that we must sell grain to feed a hungry world. It was mostly a moral veneer over a basically economic consideration, but it was enough to discourage the initial development of mixed perennials. Traditional crops were proven producers regardless of their tremendous toll on finite energy resources, soil, and, for western corn growers, fossil ground water.

But now in 2030 the settlement pattern differs drastically from what it was in 1980. In this immediate area, each family lives on 160 acres, or four families per square mile (640 acres). The dwellings of all four families are near the middle of the square-mile section but on their own property. Therefore, within 200–300 yards of each other there are 16–20 people. Their small village and main trading center, which includes both school and churches, is 2½ miles away. No one in the rural service area of the village is ever any farther away. The village's service area covers 16 square miles (4 miles on each side), which includes 64 farm families totaling about 250 people. Westward, in the mixed prairie, one-half of a section (320 acres) is needed to support a single family, and nearly 200 miles west of the mixed-grass country, in the short-grass prairie, 2 square miles is usually necessary to support one family. Eastward and in some of the west, it is another story. Along the Missouri in Nebraska; the southwestern half of Minnesota, most of Iowa, in southeastern Wisconsin, northern Indiana, northwestern Ohio, east central Michigan, along the Mississippi, in western Tennessee and northwestern Mississippi, in much of the Sacramento Valley, as well as in numerous other localized areas throughout the country, often fewer than 10 acres but never more than 20 is enough to support a family. It is not that production is always higher than in our area, it is just that a combination of factors, including rainfall, makes a sustainable yield more assured. The carrying capacity of the land is so varied that when we say the average farm, nationwide, is 40 acres, we must immediately realize the limited meaning of that statistic.

Regardless of farm size, the village population seldom exceeds the farm population by more than a factor of two. An entire community in our region consists of around 750 people, including the 260 people on farms. Let us compare this to the distribution pattern nationwide. The population of the United States is around 300 million and is scheduled to stabilize completely in the next seven years, in spite of the fact that zero population growth procedures have been in effect since the early 1980s. The momentum of that past is still with us, though insignificantly so. But it is the distribution of the population that has been radically altered over the last 50 years. Most of the major cities have experienced drastic declines and the number of cities of 40,000 or less has greatly increased. Optimum city size was widely discussed in the last century. Many of the New Age pioneers concluded, though there was nothing like unanimous agreement, that much of the social pathology of our former urban areas could be attributed to the spiritual dangers that arise when people no longer know or feel their rootedness in the land. When heat comes from a furnace, food from a grocery store, building materials from the lumber yard, and the automobile from the showroom floor, the spiritual loss is devastating to the society. It doesn't necessarily take a city of a million, many concluded, to provide the "critical mass" necessary to help a large number of humans live up to a broad spectrum of their innate potentialities. A population of 40,000 seems to have a special associated energy. When the cathedral of Notre Dame on the Île de France was begun, the population of Paris was 35,000. Renaissance Florence had a population of 35,000–40,000. Regional cities now seldom exceed 40,000, and there are somewhat fewer than 4,000 such cities totaling fewer than 160 million people. Of course, some of the major cities still contain a few million people, but they are mostly emptied and much of the area now produces food, clothing, and shelter where concrete and stone formerly dominated the environment. The civilization was a long time learning that, by and large, the only people who really liked big-city life were merchants and intellectuals.

Of the 300 million people in the United States, some 20 million, or about one-fifteenth of the population, work in the rural areas not associated with rangeland and forestry. Nearly 10 million families, totaling about 40 million people, are living on 400 million acres of cropland. This amounts to a little over 13 percent of the total population, well over twice the percentage of 50 years ago and nearly three times the total rural population of that time. The rural villages, however, contain twice as many people as the countryside they support. I mentioned earlier that the land holdings vary drastically in size. For example, in much of northeastern Illinois, a family of four can live on 5 acres. This amounts to 128 small farms or 512 people per square mile. This is a very high density, but the productivity of the land is the determining factor. Over 8,000 people live within the 16 square mile rural service area. Its supporting village has over 16,000 people.

Our solar village of 500 or so is necessarily different from the northeastern Illinois village of 16,000. Aside from the differing political dynamics associated with different sizes and densities, there is a commonness of purpose best reflected in the numerous bioshelters that grow what might be described as a healthful diet, though not an abundance of calories. The fields provide most of the protein and carbohydrates for this society, and it is up to the people in the villages and cities to provide vegetables and fruits and a certain amount of protein, mostly from fish, in the passive bioshelters pioneered by the New Alchemists in the last century. The major differences among these villages have to do with the regional responses of village people in their work with farmers to meet the expectations of the land. A pluralistic society does not preclude the possibility of holding a common allegiance.

Neither does pluralism mean that certain patterns of both young and old cannot be similar everywhere. Throughout the country, older people have the option of living in the village, but their presence is cherished on the farm. Nearly all have chosen to live in the village, but most return to the farm daily to assist their families and neighbors in various chores. These are the people who play the most important part in the children's education.

Most communities now emphasize the value of history, and history becomes more real when adults tell personal stories that link the past to the present. The stories are about heroes, the prophets of the solar age, and the pioneers in the era of decentralization and land resettlement, and villains who were responsible for chemical contamination of the land and its people. The older people tell of a past in which nuclear power was tried, discovered to be filled with unresolvable uncertainties, and abandoned. Many of these older people lived during what is now called the "Age of the Recognition of Limits." These former doom-watching pioneers were like the children of Israel who had escaped the grasp of the Egyptians and then wandered in the wilderness for 40 years, saddled with their own slave mentality, waiting for a new generation of free minds to develop and be fit for life in the "promised land." Many of the pioneers have readily admitted their earlier addiction to all the consumer products of affluence, and work hard at teaching their young the true source of sustenance and health—the land. They are living reminders that this sun-powered civilization has arrived as the result of nothing less than a religious reformation.

The strong new land ethic has resulted in a different concept of land ownership. Under the land-trust system, land is not owned by individuals in the same sense that it was 50 years ago. Nevertheless, it can be passed on from one generation to the next, and people have a strong sense of ownership. They cannot do exactly as they please with the property. They cannot willfully pollute it with toxic chemicals, sell it off for housing developments, or in any way speculate with it. Such wasteful exploitation discounts too much of the future. Activity that is potentially destructive is prohibited by a board of nonfarming elders from the village and two from the regional city. Both sexes are equally represented.

On our farm, the well-insulated house is partially underground and is equipped with both passive and active solar installations for hot water and space heating. Though it is 100 percent solar, a backup system consisting of a wood-burning stove is in place. A water-pumping windmill and two wind-electric systems provide power for the farmstead. A combination of technologies from the past are appropriate for the farm's water system. A water-pumping windmill pumps water, which is stored in tanks for the livestock and household use. Trenching machines and plastic pipe are used to deliver the water wherever needed for human convenience. One wind generator takes care of all refrigeration needs and simply cools the freezer and refrigerator when the wind is blowing. Since the refrigerator itself is the "accumulator," no batteries are needed. The other wind-electric system consists of an induction motor that kicks in when the output of the wind-powered generator is greater than the load on the service line. The induction motor, which is similar to that found on washing machines in the 1930s, is plugged into the wall receptacle and runs the kilowatt-hour meter backward, giving the farmstead an electrical energy credit. A special meter records the numbers of hours generated. If this household wishes to break even on the utility bill, its unit must provide four kilowatts of electricity to a privately owned utility for each one it receives. There is just enough electricity generated in the area from both wind and low-head hydroelectric turbines to supply the needs of the countryside, village, and regional city. This is because in the last 50 years, solar power for space and hot water heating has become so widespread. In combination with the appropriate design and construction of new shelters, heating needs have been met with a modest amount of wood, grown for the specific purpose of backing up the solar systems.

In the 20 acres of creek bottom land, people grow such annual monocultures as wheat, corn, rye, barley, and oats. Orchards and vegetable gardens are near the houses. Canning of garden products takes place outside, using energy derived from concentrating collectors. Dried foods take precedence over canned foods, and root crops are very important.

A single solar hog house on wheels is large enough to accommodate no more than 2 sows and 20 feeder pigs. A similar solar chicken house, surrounded by a 25 square foot fence accommodates from 25 to 50 chickens. About half are frying chickens, which are eaten during the summer months. Unlike the chickens grown in closed confinement 50 years ago, these animals experience far fewer tumors, and the yolks of their eggs are a brilliant gold.

Pigs and chickens "graze" on fresh pasture during the growing season. Their mobile pens are easily advanced a few feet each day with hand levers operated by schoolchildren or grandparents from the village. The mobile pens allow for an economy of fencing materials. This managed migration simulates the migration of large animals in presettlement times. Only the breeding stock for pigs, the laying hens, and two roosters are maintained throughout the winter.

The one large outbuilding is devoted to covering the small amount of machinery. The expensive equipment consists of a small, multiple-harvesting combine, a 45 horsepower tractor, and a hay baler. The combine with a 7 foot cutter bar runs off the tractor's power take-off.

The traction and transportation fuel needs are met with alcohol, derived from crops grown on the farm. The "Fuel 40" is the principal energy producer. This is a six-species polyculture consisting of five grasses and one legume. These species are selected for their high carbohydrate content and relatively low protein yield. This 40 acre field averages about 20 barrels of crude oil equivalent per year.[1] Livestock are cycled onto this acreage for a few weeks each year to enhance the crumb structure of the soil

One hundred years ago, approximately 25 percent of the total acreage was devoted to horses and mules for traction purposes. Now, about eight barrels of crude equivalent, or only 10 percent of the total acreage on the farm, is devoted to farm traction. This is because horses and mules would burn energy just standing around being horses and mules, but the tractor can be turned off. However, the tractor cannot become pregnant and build a replacement on solar energy. A pregnant mare at rest is not really resting. Furthermore, parts wear out on the tractor and cannot be replaced by ordinary cell division as with the traction animal. Nevertheless, from the point of view of total energy expenditure, the tractor is used rather than the beast of burden, so long as other livestock are around to enhance the crumb structure of the soil. The other 12 barrel equivalents from the Fuel 40, representing about 15 percent of the total acreage, are sent to the village and city for their portable liquid fuel needs.

The alcohol fuel "refinery" requires some elaboration. Organic material produced at the farm is delivered to a privately owned or co-op still in the village. The production of portable liquid fuels is part of a fine-grained approach to our overall energy needs. It has become economically feasible as farming methods have become less energy-intensive and less capital-intensive. It wasn't economically feasible in the 1980s and produced a very low net energy yield, but the agricultural sector was enthusiastic about producing alcohol fuel from farm crops. Hundreds of on-farm stills were built and closed down in 18 months, after federal and state subsidies were withdrawn. Major stills costing $20 million and more were built, and many closed within three years, after losing the subsidies. In those years, each automobile would consume in calories what nearly two dozen people would consume in the same period. American farmers learned a valuable and painful lesson about the potential of alcohol fuel production to meet the enormous energy demands of that time. Soil loss accelerated during this period, and farmers gradually learned to curtail their alcohol-production programs to a very moderate level.

Another source of energy comes from the "Multiple Purpose 40." Leaf and stem material are harvested from a herbacious polyculture after the early summer seed harvest and are converted into methanol, equivalent to two to five barrels of crude oil each year. In the fall, some of the net wood production of the woodlot and orchard is also converted. Upon arrival at the still, all organic matter is weighed, moisture is determined, and nutrients are calculated. The farmer may sell some or all of his alcohol into the public sector, but the nutrients left over after distillation are returned to the farm and are usually spread on the field or woodlot from which they were taken. This is to prevent soil mining and reduce the amount of chemical fertilizer applied.

One concern that is constantly discussed and fine tuned has to do with what tools and equipment should be owned and operated by the farm and which ones made available through the rental place in the village. At this time the rental place provides an Easy Flo fertilizer distributor (for phosphorus and nitrogen), a chisel that is attached to the tractor to break sod-bound soils, seedbed-preparation equipment for the annual crops, and numerous other pieces of equipment that are used infrequently.

People on this land have a deep distrust of commercially produced chemicals being introduced on their land. It is amazing that this distrust began to develop some 40 years ago in the churches. In many seminaries during the 1980s, cadres of students began to debate the possibility that the Genesis version of the Creation had contributed to much of the environmental problem. During the 1970s, the question of *dominion* had been much discussed. Since most defenders of the Genesis

[1]Nationwide, roughly 25%, or approximately 100 million acres of cropland, is devoted to growing alcohol fuels. The yield amounts to about 50 million barrels of oil equivalent. An additional seven million barrels equivalent is gained in the form of methanol from the farm. In 1979, this would have amounted to only a three-day supply of oil, or less than 1% of the annual consumption.

story had insisted that *dominion* was not the current word, but that *stewardship* was implied, church people began to relax. That turned out to be a rather unimportant consideration. During the 1980s another discussion began, much more quietly. The emphasis this time was on the cultural impact of a subtlety in our religious heritage. The culture had fostered, however unwittingly, the belief that humans are a separate creation. After all, the biblical creation story held that the earth and the living world were created, and then there was a pause. Following the pause, in a special effort, came human beings. But our biologists in the last century demonstrated that the same 20 amino acids are in the redwood, the snail, the human, and the elm tree, as well as in the lowly microbe. Furthermore, the nucleotides that make up the code are mostly the same throughout. Native Americans had talked about Brother Wolf and Sister Tree long before these discoveries. Now in our churches it is frequently mentioned that our cells have had no evolutionary experience with such and such a pesticide, or that the concentration of a "natural" chemical much greater than our tissues have ever experienced is to be avoided. A toxic level is defined as a quantity beyond the evolutionary standards of our cells.

Because a sustainable agriculture is more important than one that is highly productive, upland crops consist of recently developed herbaceous perennial polycultures. The polycultures are ensembles of species developed by the land grant universities through the experimental stations. Perennials were selected because of their soil-holding capability. High-yielding, nutritious seed-producing perennials were first inventoried in numerous experimental gardens. Next, an intense selection program was initiated to increase the yields of individual species. Later, thousands of species combinations were tried. From then on, plant breeders sought to improve performances of individual species within the polyculture environment.

These perennial polycultures have several distinct advantages over the former annual monocultures.

First, soil loss has been reduced to replacement levels. We had expected this, for the reduction of soil loss was a major motivation behind the extensive research. Second, spring water has returned to the area. Many springs are now trickling all year, and the microhydroelectric capacity has increased, along with a rise in the water table. Land with perennial vegetation has become a huge battery for stored "electricity." A third advantage is that the energy required for maintenance and harvest after the initial planting is just 5 percent of that required by the former high-yielding monocultures of annuals. And finally, although the usual pathogens and insects are still around, they do not reach epidemic proportions.

Our particular farm has fields consisting mostly of grasses, a few legumes, and even members of the sunflower family. Some of the fields are harvested in early summer, some in the fall. The early summer or July harvest in one field includes descendants of intermediate wheatgrass, Canada wild rye, sideoats grama, tall wheatgrass, and Stueve's lespedeza. The fall harvest consists of four grasses, a legume and a member of the sunflower family. The grasses include descendants of switchgrass, lovegrass, Indian grass, and weeping lovegrass. The legume, wild senna, and a perennial soybean provide the nitrogen plus some seed, and a high-yielding descendant of the gray-headed coneflower produces seeds with two important oils.

Some of the early objections to harvest and separation of seeds from the polycultures were quickly dampened when agricultural engineers began to invent machinery. In fact, it is ironic, but the return to polycultures became possible only in our age of mechanization. Some have since made the argument that monoculture arose because of the need to harvest small seeds efficiently when all we had was hand labor. The age of mechanization, then, has allowed us to develop an agriculture with a vegetative structure that closely mimics that of preagricultural times. Much of the machinery has allowed our psyches to resemble those of hunters and gatherers again, but of course in a modern context.

The fossil fuels used during the transition era, 1985–2025, as we moved from mining and destruction of land as a way of life to the solar age, afforded us opportunities not only in plant breeding, but in animal improvement as well. This period gave us the chance to develop crops that were less dependent on humans. The same was true with the livestock. For example, the American bison was crossed with domestic cattle, and the thicker hides made the critters more resistant to severe winters.[2] In a way, we are now using solar energy (stored in grass) to maintain barns—the hides of animals. Protective shelter made of lumber for large animals is not necessary.

Livestock are moved from one polyculture to

[2]Grandparents amuse the children with stories about square tomatoes and featherless chickens. The featherless chicken was developed in the 1970s by reductionistic technologists who thought they would help corporate chicken growers and processors cut costs in cleaning chickens. The consequence was a funny-looking chicken that required such a warm environment that the energy costs were in excess of the cleaning costs. The moral of the story is that big money is a sure license for big foolishness.

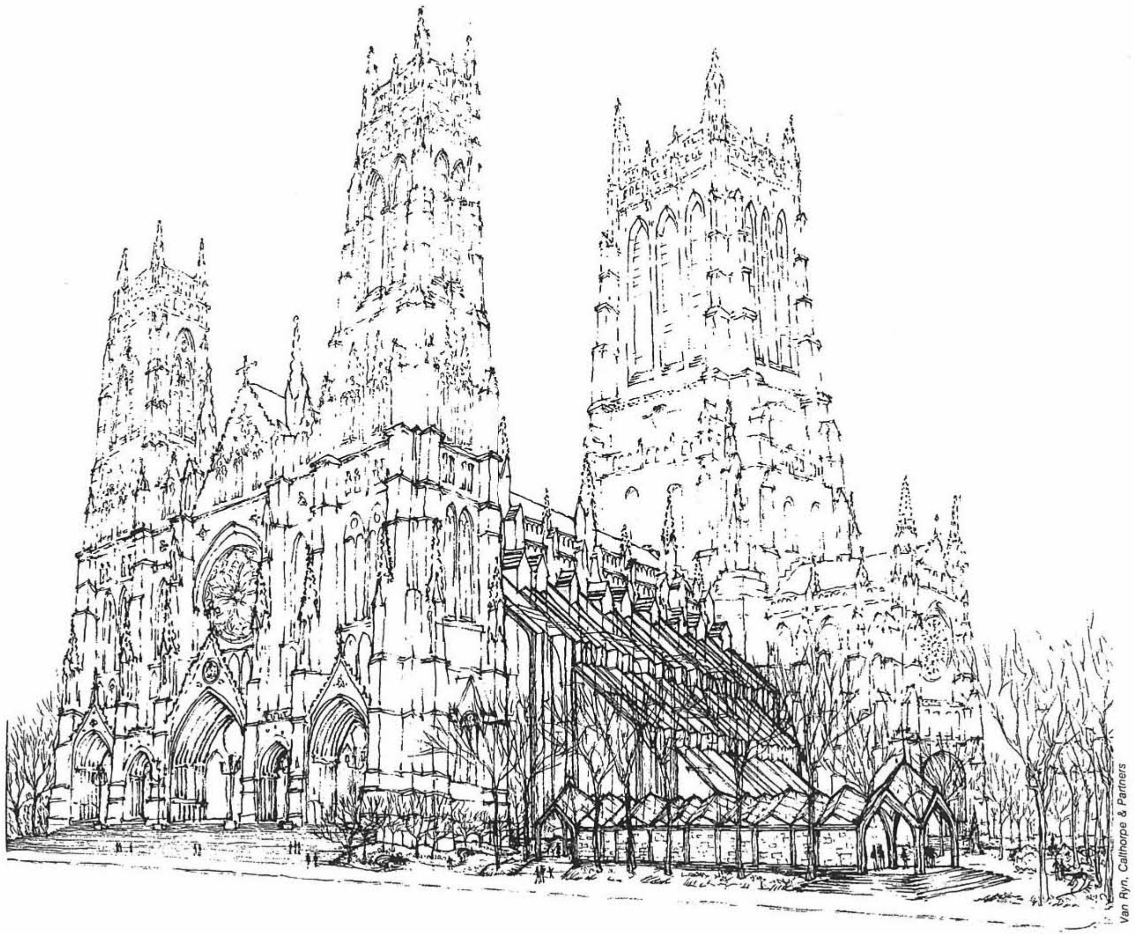
another in a rhythm that does not jeopardize flowering and seed set. Most grazing does occur in areas that produce seed for human consumption, but certain polycultures are grown for the livestock exclusively. A few weeks before slaughter buffalo/beef graze on mixed perennials that are setting seed. This is a weak simulation of the feedlot of former times. No hay is hauled to the barn for winter feeding, for there is no barn. Some of the hay is windrowed with a side-delivery rake and is left, but most raked hay is rolled into 1,000–1,200 pound bales and remains in the field. This system reduces the need to spend time and energy moving hay and manure, and the nutrients are left where they are most useful.

The movement of livestock on the farm turns out to be critical. In natural ecosystems there were no fences. Even though we are forced to use fences for all our livestock, our management program recognizes that animal wastes on the farm contribute to the crumb structure of the soil as mentioned earlier, which allows the soil to release nutrients slowly while holding moisture.

Many of the problems caused by farming techniques of the 1960s and 1970s have been solved in this new era. Seedbed preparation occurs mostly where the few acres of annuals are grown, and since tillage has been dramatically reduced, soil loss is almost nonexistent. Silting of streams is minimal, and more species and larger populations of fish thrive in the waterways. Energy-expensive terracing is no longer as necessary, and where check dams and small farm ponds exist, they serve the farmer mostly as pools for catfish culture. Irrigation is reduced, for the perennial polycultures slow the water so thoroughly that hundreds of thousands of springs throughout the country have been reborn. Fertilizer application is minimal because the diversity of crops has maintained a better nutrient balance with less nutrient runoff. The recordbreaking fish kills of the last century due to fertilizer and feedlot runoff are now only part of the legends about our unenlightened grandparents. Weeding is essentially a thing of the past, except in gardens and where annual monocultures are grown. Pesticide application is almost nonexistent because of both polyculture and a broader genetic base in our crops. A broader genetic base in livestock and the demise of high-density feedlots have made the use of antibiotics for livestock seldom necessary. The life of farm machinery has increased by a factor of 16 in the last 50 years. All of these changes have resulted in a drastic cut in energy consumption for farm production.

The major changes began to surface during the 1980s, when a few young agricultural professionals, having adopted a sustainable agriculture as their paradigm, looked for the sustainable alternatives rather than placing their bets on corporately controlled agriculture. In many respects, they were the true heroes of the era. Some took the theory of the quantitative gene developed during the 1960s and, using it along with the known virtues of hybrid vigor, made repeated breakthroughs in new crop development.

There was a unifying theme from Massachusetts to Kansas to California. People recognized that in the long run, and often in the short run, land is the determining factor. Citizens sought to meet the expectations of the land and to look at the natural ecosystems of different regions as the standards against which to judge their agricultural practices. Suddenly, as is so often the case with profound statements, there was a new meaning to the words that Thoreau had uttered from the Concord Lyceum in the mid-1800s: "In wilderness is the preservation of the world." The policy-makers began to take seriously the prediction of Charles Lindberg: "The human future depends on our ability to combine the knowledge of science with the wisdom of wildness." When this concept was applied to our farms, they became waterproof, diversified family hearths. Our fields are no longer vulnerable, oil-hungry monocultures, although they are not wilderness either. But without wilderness, we would not have developed a sustainable agriculture and culture.



EARLY MANIFESTATIONS

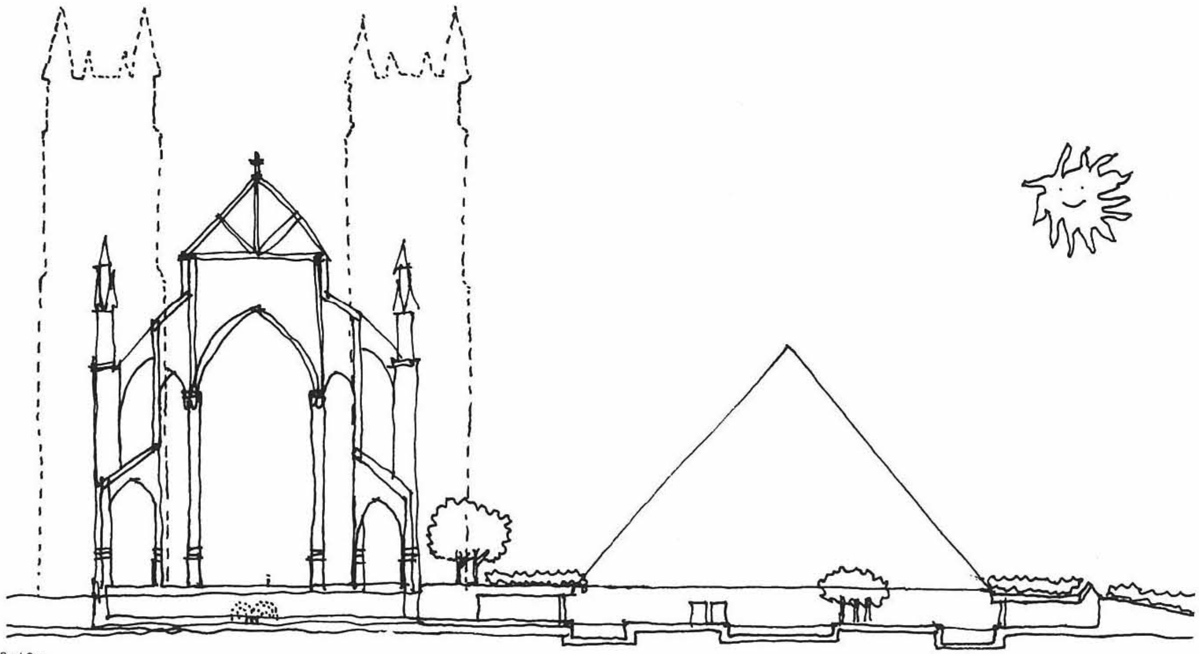
Project 1: The Cathedral Church of St. John the Divine

John Todd

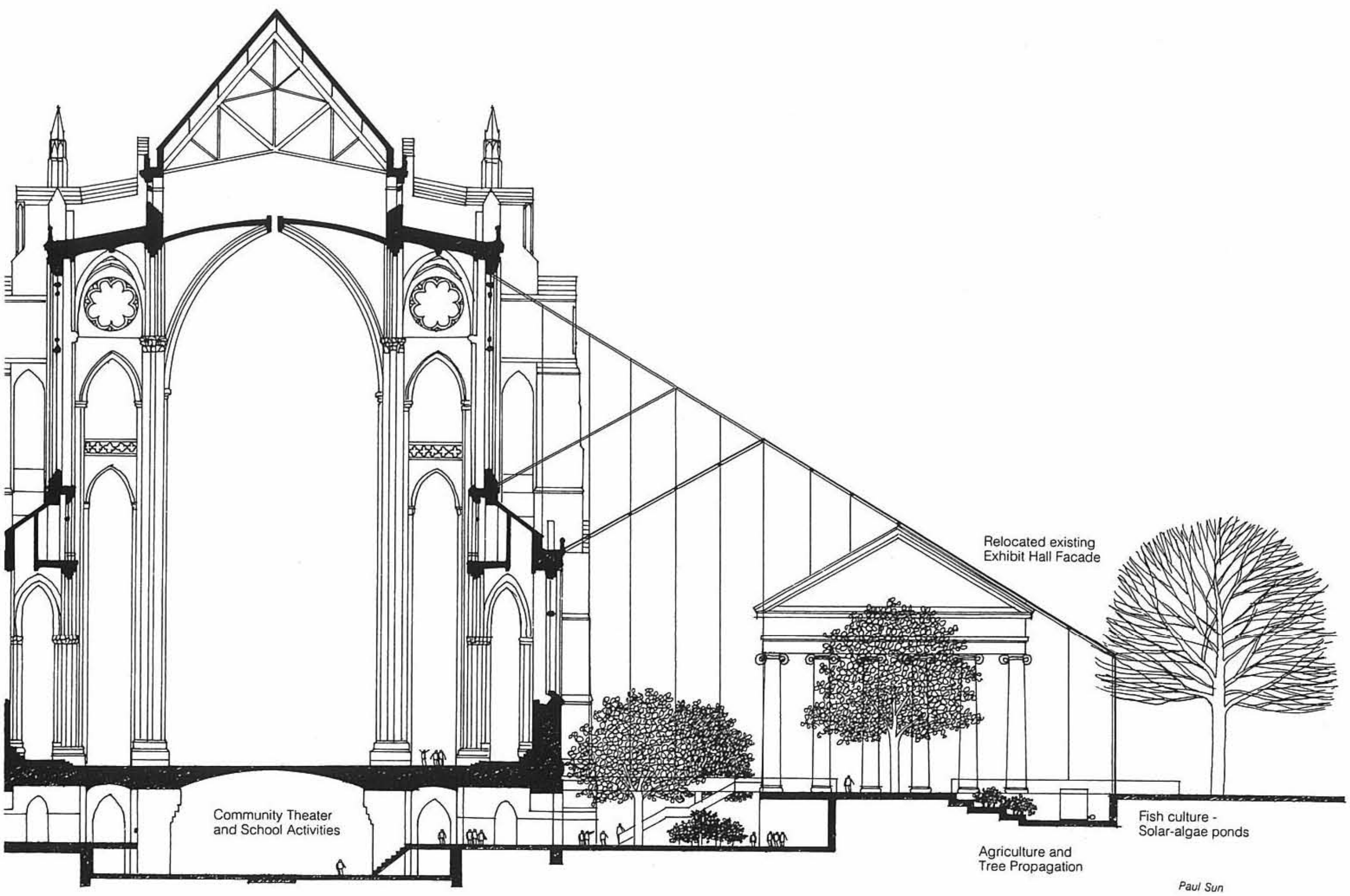
In most of its teachings, Christianity ignores ecology. However, within it are profound notions of stewardship for all living things that have been all but ignored in our secular age. The teachings of Christ may be given new meaning in a union of Christianity and ecology. For the Very Reverend James Parks Morton of The Cathedral of St. John The Divine in New York, this union is essential to the reinspiration of Christianity.

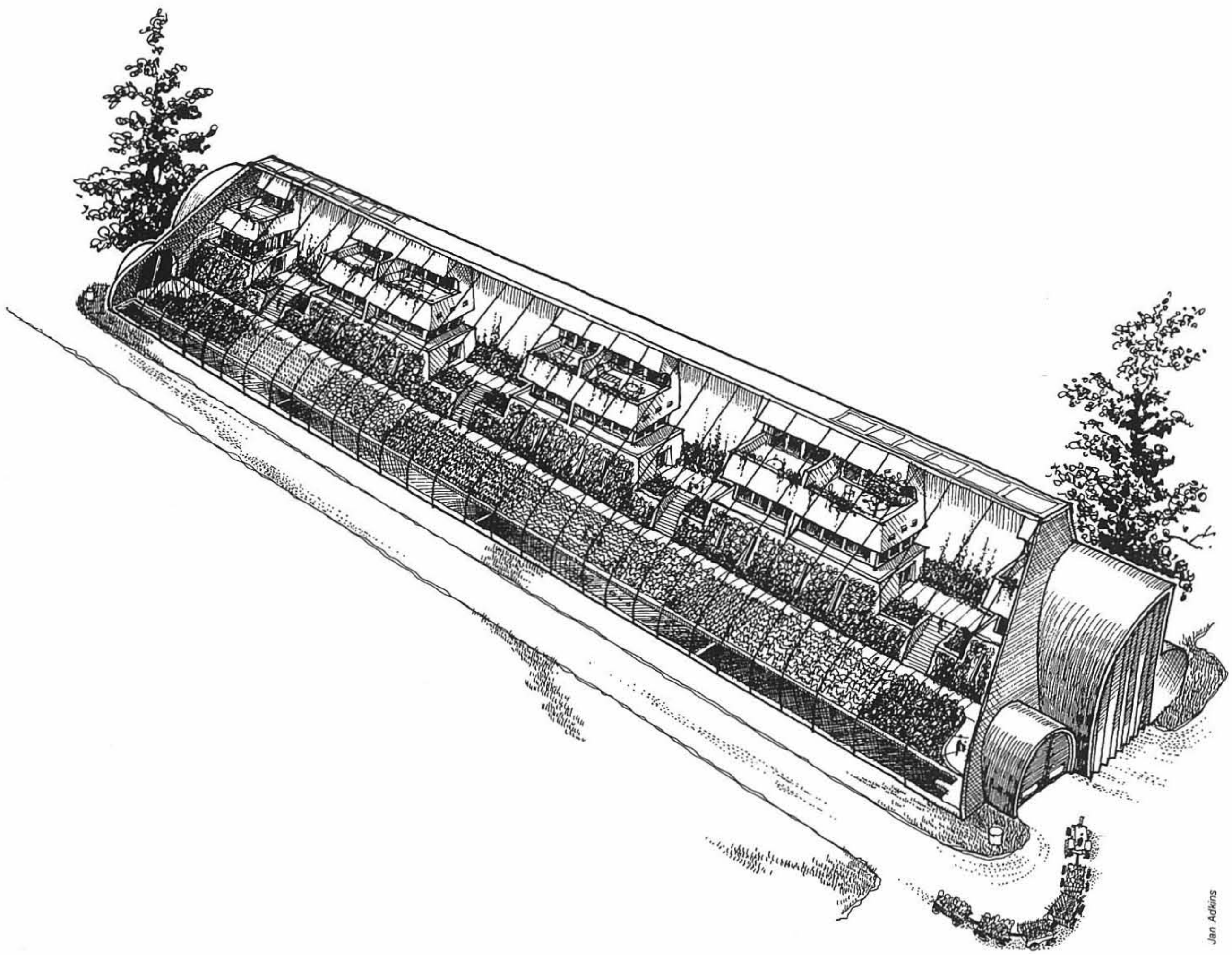
Cathedrals in medieval times were seats of culture as well as religious practice. They had their schools, hospitals, artisans, and crafts as well as music and theater. They were like whole towns woven into a religious economy.

This earlier vision of the cathedral inspired the bioshelter and school projects that follow. At the conference the bioshelter Ark and eco-school were conceived. Afterwards, with support from the Threshold Foundation, several architects were asked to continue bioshelter proposals on their own. Some of their ideas follow.



Paul Sun


Relocated existing
Exhibit Hall Facade
Community Theater
and School Activities
Fish culture -
Solar-algae ponds
Agriculture and
Tree Propagation
Paul Sun



Project 2: A Maine Coastal Village

John Todd

Acquaintances of ours owned a farm on the coast of Maine that they were considering turning into a community land trust. The community was to be based on the traditional economics of agriculture, fishing, and boat building but within a thoroughly modern context. It was to strive to create a symbiotic relationship with the nearest existing town.

This project created a lot of excitement at the conference as the dream seemed close at hand and would be most attainable by individuals cooperating in groups.

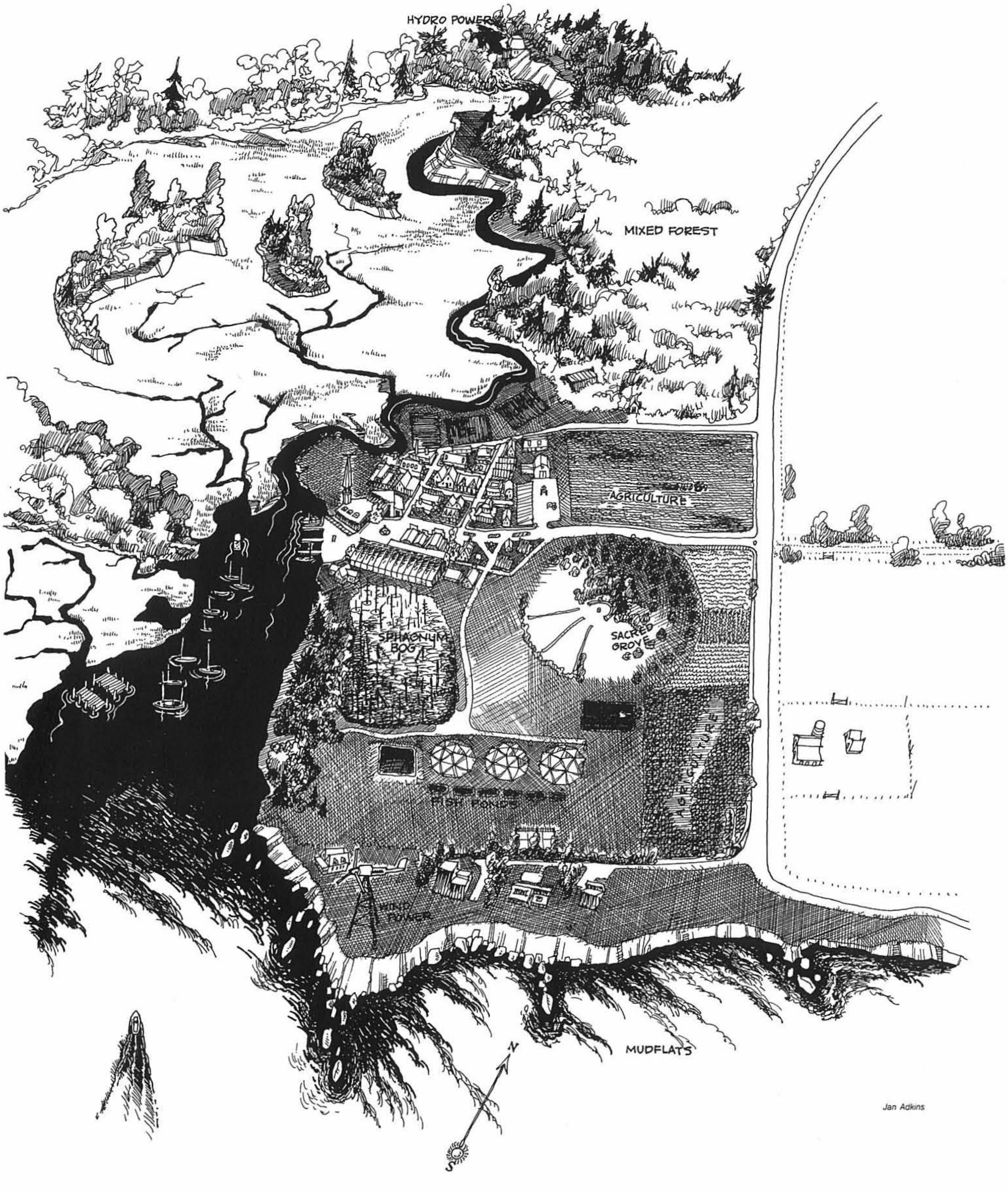
The community would be powered by traditional and modern renewable technologies. Hydropower and windpower would provide the electricity. The forest would be the source of biofuels. Ice would be cut in winter for the fishery. Bioshelters would be used for growing all-season produce. The main biological economy of the village would most likely be mariculture and sea products. Bioshelters would serve as hatcheries and as food-rearing facilities.

Inshore fishing vessels might be built by the community, combining traditional methods and advanced propulsion technologies including windpower.

The architecture was to be solar using a combination of traditional and modern ideas. A Maine village architecture—which we called arkipelagos—emerged from the conference.

Arkipelagos would be apartments within a solar bioshelter. Individual and community gardens would be part of the interior architecture. It was felt that arkipelagos might take some of the sting out of harsh Maine winters.

The Maine solar village would look to the sea, but like intertidal dwellers it would also be firmly rooted to the land of which it is a part.


HYDRO POWER
MIXED FOREST
AGRICULTURE
SPHAGNUM BOG
SACRED GROVE
FISH PONDS
AGRICULTURE
WIND TOWER
MUDFLATS
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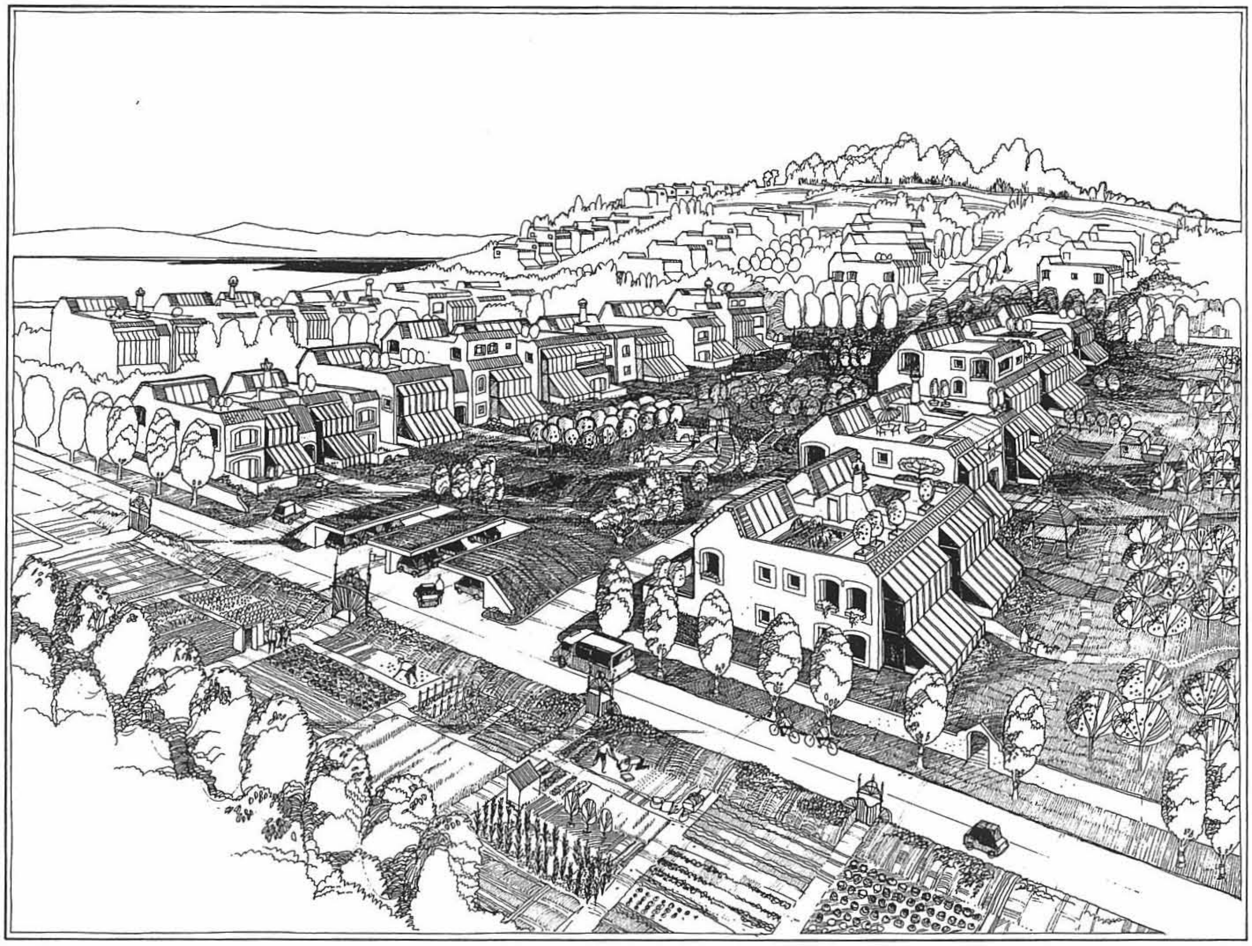

NEW SOLAR HOUSING

Project 3: Marin Solar Village

John Todd

Marin Solar Village, adjacent to San Francisco, is the brainchild of Sim Van der Ryn and his associates. It is a bold attempt to create from an Air Force base a village of the sun with wide public acceptance.

As of this writing, many of the political hurdles have been overcome. Underway now are the intensive design and cost-projection phases. The following text and drawings provide an overview of what may become the first village of the sun. It is also the beginning of a village as a solar ecology. It could well become an important milestone for us all.

The reuse of Hamilton Air Force Base is an opportunity to build the most modern community on the planet designed to sustain a high-quality life based on ecological balance and the efficient use of energy. It will provide 800 new solar dwellings, 1,500 new jobs in a corporate center and light industry, a transit center to ease freeway congestion, on-site food and energy production, and an open space for wildlife and recreation. Solar Village will be privately financed with no cost to the county, making Marin first in the nation with practical approaches to our problems of energy, economics, and environment.