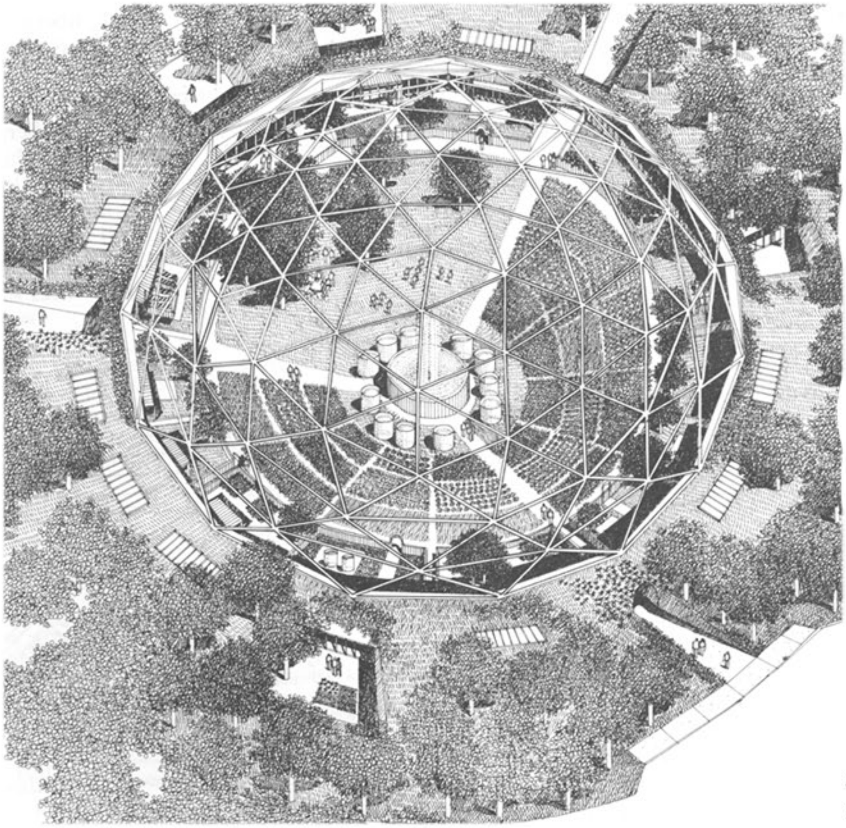

A Dome Bioshelter as a Village Component

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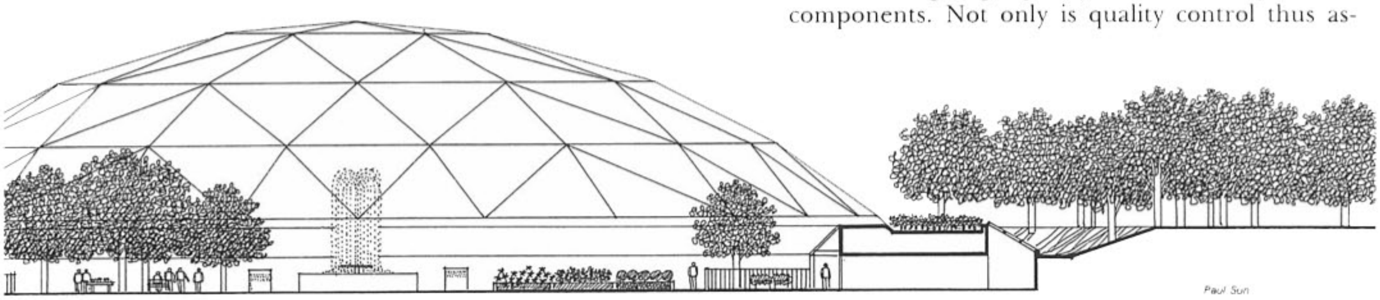
Serious concern with energy efficiency in buildings requires a standard of performance and reliability rather better than the traditional norm. Many designers, including those aware of the need to conserve resources, do not have the regard for detail necessary to deliver long-term high net energy performance. 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.