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# DESIGN STRATEGIES FOR GREEN PRACTICE

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## INTRODUCTION

*Should green buildings not only work differently, but also look, feel, and be conceived differently? The emergence of LEED accreditation as the leading form of environmental performance monitoring and its associated points and checklist format can mask the necessity for architectural projects to have focused and effective design strategies that integrate sustainability with the design process. Green accountability does not always go hand in hand with architectural quality: a good building is certainly not necessarily a green building, while a green building is not always a good work of architecture. So it becomes important to recognize the unique character and possibilities in each project and then to develop environmentally responsive concepts that support and enhance the form of the architecture. This article discusses the current context for “Green Design Practice” through a series of quite different design assignments where the focus is upon enabling the design to emerge from the recognition of the “environmental and sustainability potential.”*

## THEN AND NOW

In 1996 when the “Dimensions of Sustainability” conference was organized at MIT and the subsequent book published in 1998 [1], “sustainable architecture” was a new buzz word. The roots of this newly emerging concept of “sustainability” were fundamentally in the back-to-the-earth 1970s ecological movement; off the grid solar power, ecologically based materials, and construction techniques with a strong dose of “alternative-ism” but with little relationship to advanced design and sophisticated applications of new technologies or production methods. Norman Foster’s definition of sustainable architecture as “doing the most with the least means” [2] was not part of the general mentality as the problem was not perceived as a design issue but more in terms of a technical challenge. The urban dimension was missing almost entirely as sustainability was only discussed predominantly as being about alternative buildings and lifestyles. The environmental assessment method LEED program had been introduced, but few in the architectural profession knew what it was, let alone that it emanated predominantly from the British system called BREEAM several years earlier, the success of which stemmed from a swelling of user demand for better environments for commercial buildings. William McDonough, among a few others, was beginning to see the professional and business opportunities in a new environmental movement in architecture, relating it in his case to theories about lib-

erty and independence. At an urban scale, the new urbanists were beginning to discuss alternative solutions to suburbia and explosive urban growth, and the smart-growth concept was just over the horizon.

Dimensions of Sustainability set out to change the somewhat parochial nature of the sustainability discussion at that time. A group of leading practitioners and academics were invited to discuss their work and thoughts about how they were responding to environmental concerns, what processes they were using, and what the broader issues were that they saw emerging. But most critically, they were not just architects, they also included engineers, ecologists, landscape architects, space planners, urban designers, and architectural theorists. This created a multidisciplinary platform for exchanging ideas about sustainability and the new environmental challenges including energy and climate change, but most importantly about design. It is this concern for the fundamental design of buildings and urban environments that has continued to drive my interest in the notion of Green Practice—a form of practice that recognizes the contribution of other disciplines to designing, and the importance of identifying a project’s unique environmental potential and profile.

Ten years later and the picture has changed very significantly. Publications now abound almost to the point of market saturation, alongside multiple definitions or categories of environmental responsiveness.

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Often the same work is repeated in different publications but given a different spin. There are a plethora of books and magazines published internationally that not only advocate sustainable design but also many others which carve out their own piece of environmental turf as variations of the “S” word: green design, sustainable architecture, ecological architecture and construction, “eco-tech,” bioclimatic building, low energy design, energy-conscious design, zero energy design, zero carbon buildings, zero environmental impact, biomorphic architecture, sustainable development, and so forth. The popularity of being sustainable is now seen as being a major asset to the marketing of architectural practice and has, in some cases, become part of the branding of the architecture—an essential quality or parameter that gives otherwise ordinary work new layers of meaning and credibility. James Steele, in his book *Ecological Architecture: A Critical History*, [3] valiantly attempts to root ecological architecture into a broad review of twentieth-century modern architecture, which is one of the few examples of locating the intensity of the current sustainability movement into a larger theory and body of architecture. However, the book finds a means by which almost every branch of modernism, from LeCorbusier through to Foster, and Tadao Ando to Peter Eisenman, are dubiously roped in under an ecological agenda—a fact that seems to demand much deeper substantiation and attention. Once again, ecology is regarded as a form of green treatment but will little hard factual data or conceptual basis to back it up.

Numerous well known international design firms use the sustainability concept as an entry into the client market and promote it on their web sites as a unique quality of their work, and one that is supposed to connect to the environmental consciousness of the client market and of the world at large. However, it is typical that the sustainability label occurs on selected projects, but without substantiating data or an articulation of the specific design and technological strategies that make their work definably sustainable. Precious few practices seriously define why or how their work has a strong and believable environmental agenda, let alone publish as built performance data. Often one senses a desire to “look green” rather than to be fully green—the issue of image over substance and almost any project can pin a sustain-

ability label to it when it becomes a matter of visual or aesthetic representation. The world of the client or owner on the other hand has now adopted sustainability guidelines for their new architecture as a measure of their commitment to the environment or to respond to the demands of user groups for better working conditions (“well being”), air quality, and so forth. Government or institutional buildings programs frequently now have such quantitative sustainability criteria, thanks in part to the growth of the LEED program developed by the U.S. Green Buildings Council.

The growth of the LEED environmental assessment program in recent years is a success story with limitations. Most architectural offices now have ‘LEED accredited professionals or experts capable of calculating a project’s environmental potential according to the points based system—and it would seem there might be many more such professionals than there are good projects to monitor. Perhaps the USGBC might encourage practices to monitor the sustainability of their work over the first 5 years of a building’s life when so many things don’t work out as envisioned. The emerging practice of putting LEED after one’s name alongside professional registration and degrees has become a standard means of recognizing environmental solidarity. Nevertheless, in spite of having many critics, the U.S. Green Buildings Council has done an excellent job in putting a pragmatic and practical system in place for the building industry that raises the bar on environmental credibility and accountability.

However, the existence of sustainability is not a guarantee of good architecture, and in many cases it can and does become a bandwagon for somewhat mediocre design that emanates from a points-based approach to environmental stewardship that is too disconnected from innovation. The checklist forces the activity of points chasing but doesn’t identify and reward the bigger ideas in a project that change the form of the architecture or create greater design innovation in major ways. Just as you can have a fine building that has limited environmental performance credentials, you can also have a highly rated LEED building that is on the weaker side in terms of architectural concepts. Being qualified to evaluate for LEED performance is not a qualification for designing a fully integrated, environmentally or ecologi-

cally challenging and progressive building and one that is also architecturally sophisticated. Sustainable architecture still needs to be good architecture, which is where my interest in “Design Strategies for Green Practice” began.

The challenge for architects now is to merge the qualitative with the quantitative aspects of sustainability and green building and to expand the boundaries into other material and ecological systems issues. We need to develop a more sophisticated understanding of the design processes of merging high and demanding environmental objectives with interdisciplinary design practice that can be applied at the micro scale of a building or at the macro scale of urbanism and landscape where issues of density and symbiotic systems become essential. Sustainability is as much about enhancing culture, livability, health, and place-making as it is about the development and application of technology for reducing energy dependence, CO<sub>2</sub> production, and mitigating the abundant use of resources. It is about understanding the relationship of the design project to the conditions of a larger ecological system within which we operate and survive and where we understand our impacts on water resources and ecological landscapes. It is also about designing WITH the climate instead of AGAINST it so that the form, typology (the type characteristics of building), and tectonic (material) language of the architecture enhance the notion of passive or benign technologies. Architectural projects must adopt an attitude toward their lifespan and longevity, and be designed for permanence, disposal, or to be recycled, while at the same time be able to map their life cost, resources, emissions, and energy profile.

These factors and many others are all environmental agendas that have to be interwoven with design practice to make sustainability work effectively—and to make it work in a way that makes a significant difference to the experience of a product beyond that which is gained from checking off attributes. It alters the way we think and design, the way we practice, and the way we conceive and discuss good architecture. This article will address some of these issues by outlining and illustrating design concepts and strategies for four recent but quite different architectural design projects, three of which are as yet unbuilt and at a conceptual stage of design. They are a part of a

series of some 20 projects that explore this notion of ‘green practice’. Each project has been developed as a fundamental response to the unique design problem and the green design challenge, where each project has a primary design agenda, environmental concept, and a process that pursues the most effective strategies for achieving sustainability.

## **DESIGN PROJECT 1: HOUSES AT SWEETWATER MESA, MALIBU, CALIFORNIA**

### *Location and Site Context*

162-acre site in the rolling mountain landscape above the Pacific coastal city of Malibu, some 10 miles northwest of the Los Angeles greater conurbation. The site is a composite of 5 lots for the construction of 5 housing units. The vertical rise in elevation is approximately 500 feet with the upper most part of the site at 1500 feet above sea level. The site is a very varied landscape both in terms of the continuously undulating nature of topography, and the species of plants (predominantly chaparral) and wildlife. Together with the aspect of the cycle of the forest fires, it makes for a strong ecological context. The solar exposure of the site is severe with minimal areas for shade. However, the site has many different and dynamic views back to Los Angeles, the Pacific Ocean, or down to Malibu both during the daytime and at night when the lights of the city recall the classical images of the gridded city.

### *Design Agenda*

The design task was to develop a concept design study for 5 individual houses of about 10,000 square feet each. The celebrity client wants the project to be exemplary of a sustainable method for designing and building in the Malibu Hills, albeit within the scenario of ongoing sustainable development. The design brief calls for determining the site location for each property as well as the design of the local road access system. The program for each house will vary but will be centered around a concept of living in cultural sophistication within the nature and natural setting of the site. The program can be interpreted and sub-divided in multiple ways around concepts such as public and private elements, entertainment, fitness, creativity, music, guests, and family or simply

The landscape of the site looking towards Malibu and the Pacific Ocean.



by variable conditions of passive climate modification and shade from which one can move depending on the season and the mood. The notion of the overall landscape as a large accessible garden is highly important, both at the scale of the localized house and at the scale of the entire site.

### ***Green/Sustainability Concept***

A primary concern for the conceptual design study was to search for the symbiotic relationship between the architectural form and the environmental and ecological forces prevalent on the site that influence the architecture. In order to lay a foundation and agenda for evolving the sustainable design of the project, we produced a preliminary paper called “Principles of sustainable architecture for Sweetwater Mesa.” [4]

We identified four areas of design concentration that capture the range of potential symbiotic relations between design ideas, buildings and the environment:

1. Landscape and sequencing the approach,
2. Microclimate and space,
3. Typology and assemblies,
4. Ecology and resources

The first three topics address elements of the local context within which the project is situated:

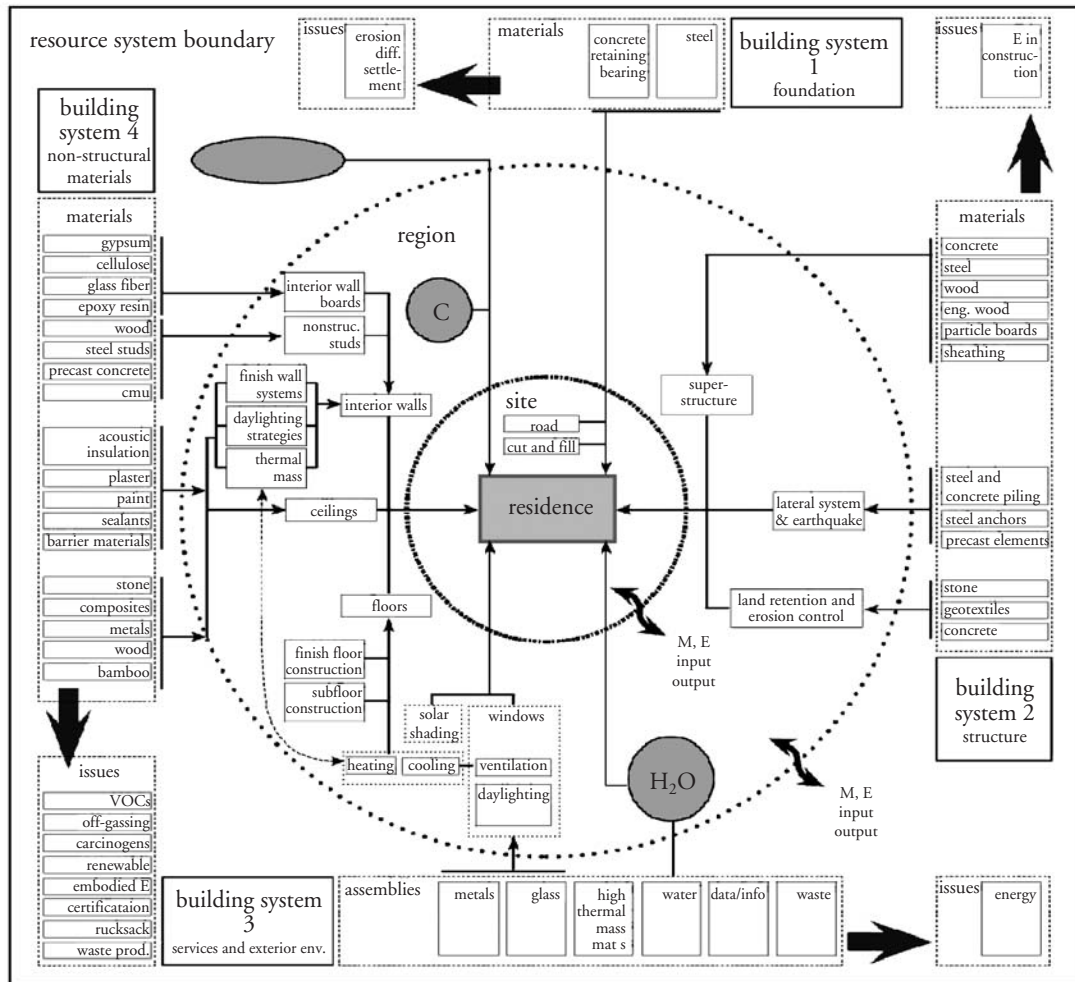
Landscape and approach refers to the fact that the architecture should spring from the land, meaning that the topography should be the first clue towards the organization of space, landscape views, solar exposures, and natural ventilation. It also references the relationship between the journey into the landscape, up, through, and down the mountains to arrive at a natural terrain that has been shaped by the settlement of the five residences. The symbiosis between building and mountain is critical, and the concern

for the integration of land and building form was seen as a key to the green design strategies.

Microclimate and space concerns the shape and design of habitable territories that begin to define the confines of the residential spaces of each house. Microclimates and their design can locally modify the severity of the prevailing climate using passive means to do so, thereby minimizing the energy needed for the active environmental control systems. In Sweetwater Mesa, we wanted the form of the architecture to realize the potential for introducing a series of microclimatic spaces in and around the houses, and for a more fragmented form of architecture that enables a porosity of the building skin for natural ventilation and daylighting as well as for shade conditions and passive cooling.

Typology and assemblies specifies the actual forms and physical “language” of architecture that organize public and private zones, indoor and outdoor spaces, and the variety of spatial volumes that constitute the architectural experience. Also, this third topic specifies assemblies and a design “tectonic” that are meant to mediate between interior and exterior space; thermal mass, solar shading devices, roof overhangs and forms, verandahs, courts, advanced exterior wall systems, and other elements. These first three topics specifically address the making of an architecture that springs from this land and collaborates with the climate to create a responsive and appropriate form.

The fourth topic, ecology and resources, addresses the fact that architecture is conceived, processed, manufactured, and delivered with an extraordinarily complex network of material and energy exchanges. The idea was to recognize that the development is part of a larger ecological system, the existence of which can be used to guide a series of decisions concerning resources of the site and for the buildings. Within this context we wanted to integrate a frame-



work of materials and resource ecology into the project design at all stages and be able to map the material resource network as the project progressed. We would attempt to source local materials that could be either recycled or had already been recycled as a prerequisite condition for construction, as well as eliminating toxic materials, volatile organics, and carcinogenic compounds.

The concept for the natural resources focused upon earth, water, sun, and fire. We discussed the possibility of using local aggregate from the site together with a local mobile material separation plant to sort sizes. The benefits of using materials found on the site for construction are considerable. Not only can we evolve a form of architecture using locally based concrete as well as non-load bearing rammed

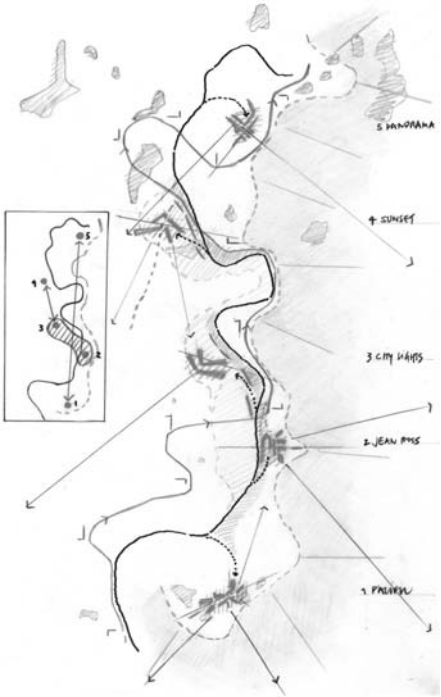
earth construction, but we save enormously on vehicle trips either to import new materials to the site, or to ship out unwanted excavated material. The results in terms of reductions in overall CO<sub>2</sub> emissions and other environmental benefits (noise, traffic, etc.) have yet to be quantified as this work will be further researched at MIT. Water is always an issue in the Malibu mountains due to the scarcity of annual rainfall (14–20 inches per year) and the necessity by the utility company to pump water to a high mountain position and then to let it fall to a site by gravity. Therefore, water conservation and retention has to be implemented through the integration with the landscape design and recycling of greywater. With regard to the solar exposure, there is clearly a potential for supplementing electricity usage with photovoltaics

systems (wind power is not permissible for aesthetic reasons), and we wanted to suggest that roof and layers for shading should be integrated with PVs. Finally, the issue of the inevitable Californian forest and brush fires posed an extreme risk but at the same time an opportunity for innovation. We were interested to discover how these fires, that typically occur every 12–15 years and which are essential for the ecology of the landscape and plant species, might be conceived as a part of the ecology of the architecture. Could we propose that some parts of the project might be actually sacrificed and rebuilt? Can we conceive of the buildings as a series of physical layers which both protect the inner core of the buildings as well as enable a transformation and shutting down of space as a fire approaches. And how can we enable a rapidly moving but very intense fire to pass over the houses because of the design of their shape?

### Design Strategy

The design work focused upon developing a concept for the project as a set of ideas and a framework for development that could be implemented in a variety

Site sketch diagram.



Site and landscape characteristics.

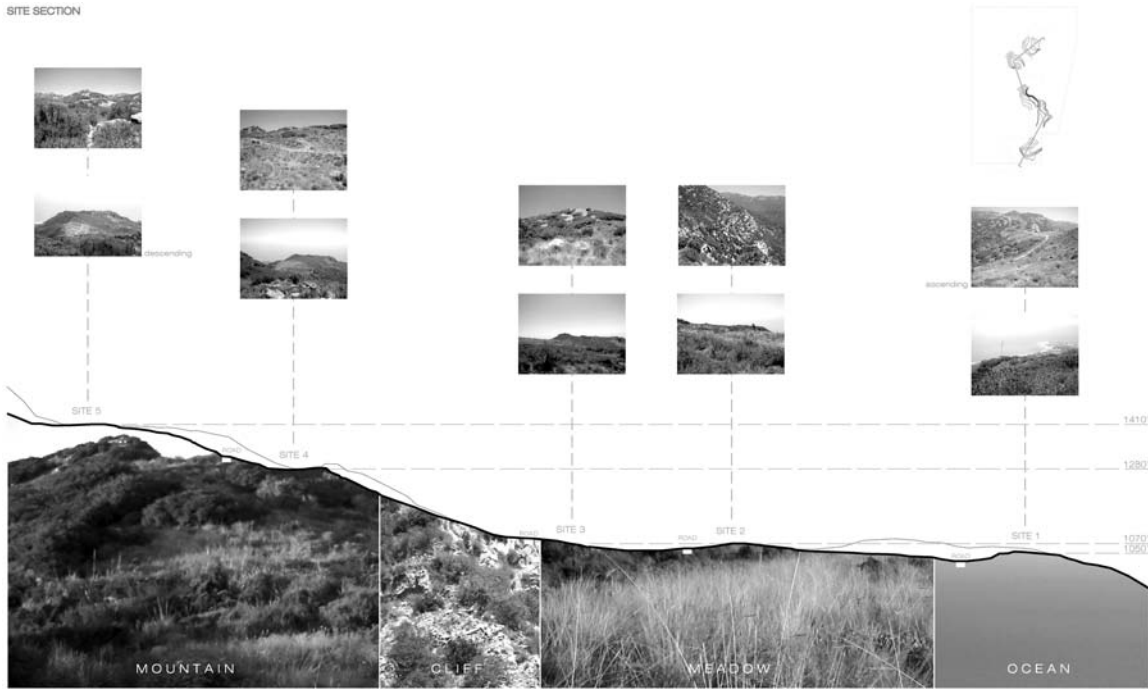
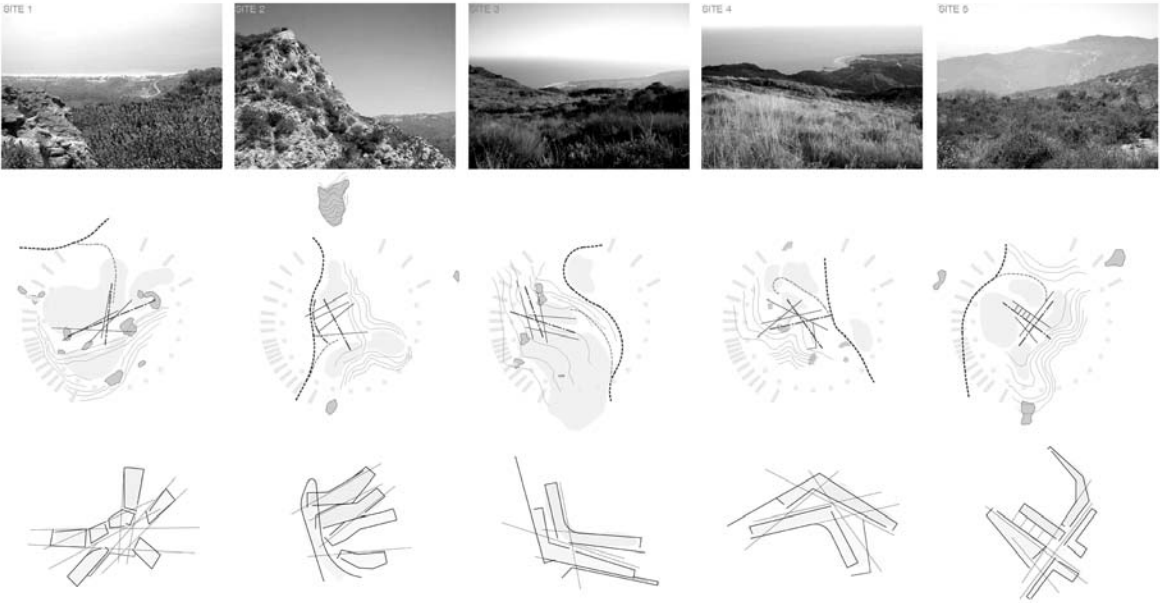


Diagram showing the development of house types in different landscape and site locations.



3-dimensional model studies of house types and forms.

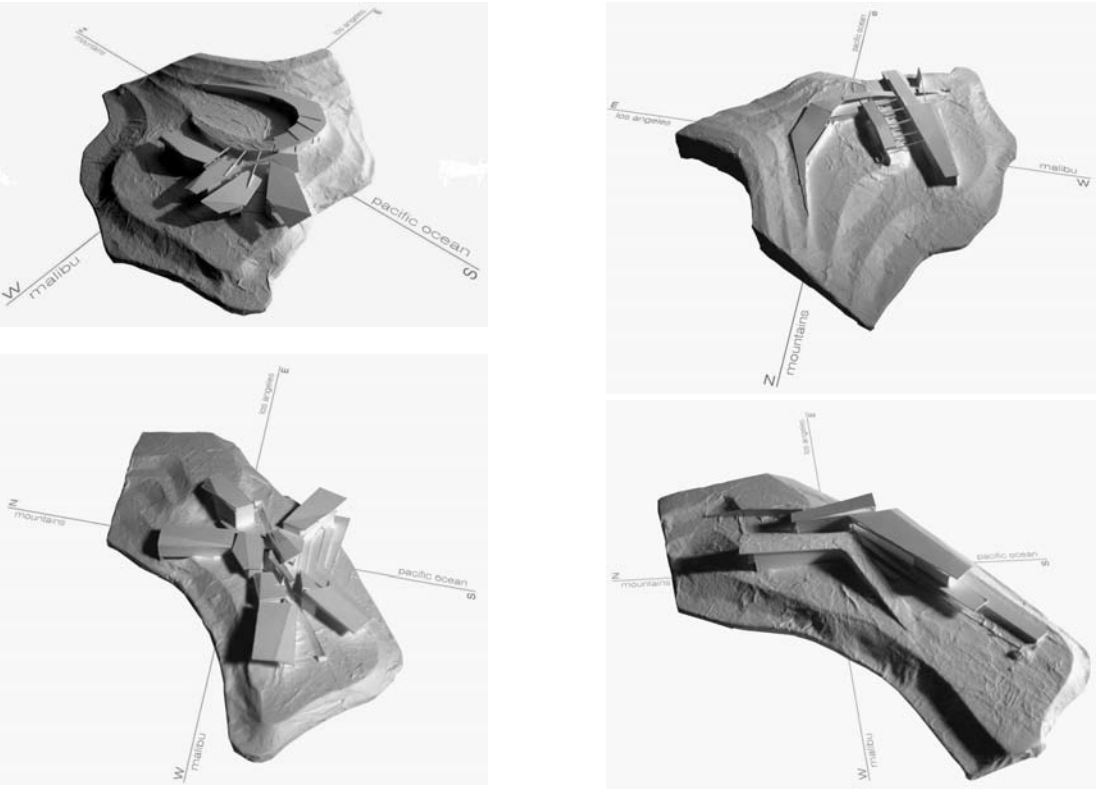
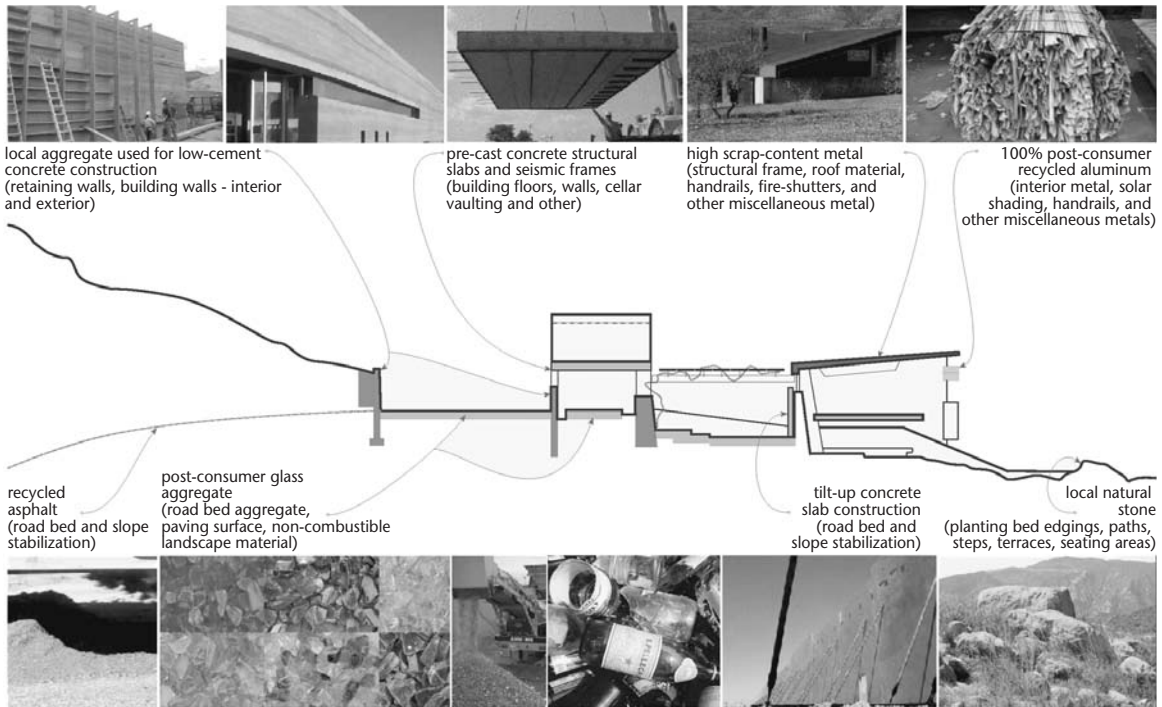


Diagram showing possibilities for materials selection and recycling: courtesy of John Fernandez, MIT.



of ways as the project moved forward. The three principle strategies were:

1. To integrate the principles of sustainable architecture into the comprehensive design of the project, with an emphasis upon climate, resources, and materials.
2. To conceive the project as one design (as opposed to just five houses) across 160 acres of exhilarating landscape where the design of individual houses is integrated and enhanced by the landscape architecture, civil and site engineering. A part of this strategy is to heighten the experience of the development and the site through the revealing of views and the passage up and down the mountain.
3. To develop a series of ideas for a family of house types that share common values such as natural landscape gardens; dispersed, layered, and fragmented forms; and passive systems that spread and reach out across the topography.

## DESIGN PROJECT 2: CALUMET ENVIRONMENTAL CENTER COMPETITION, CHICAGO

### *Location and Site Context*

The competition site was located in south Chicago on the edge of the Calumet River. The site is part of a substantial area of environmental landscape remediation resulting from many years of pollutants and toxicity seeping into the ground from local heavy industries including the nearby Ford car plant. The site for the building is set in a larger area of partial wetland and scrub landscape and sits between the industrial plants to the east and Calumet River to the immediate west.

### *Design Agenda*

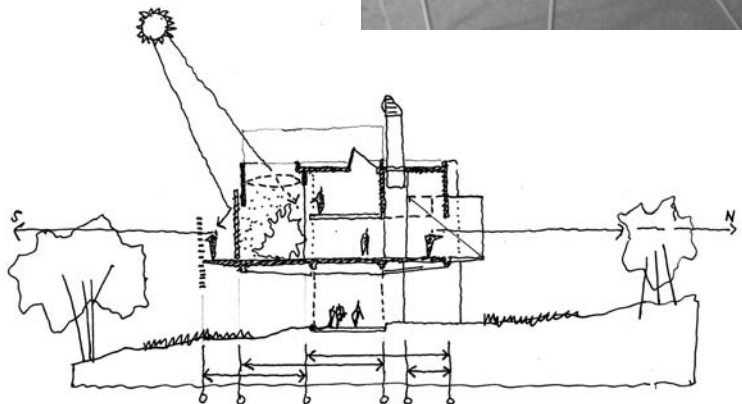
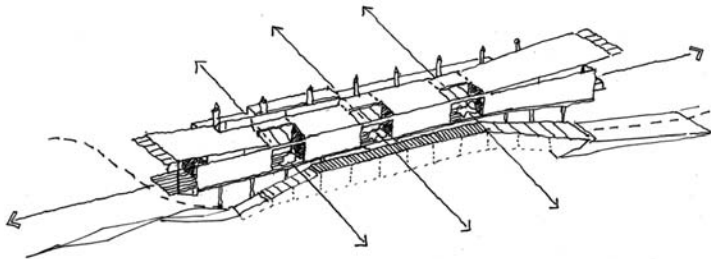
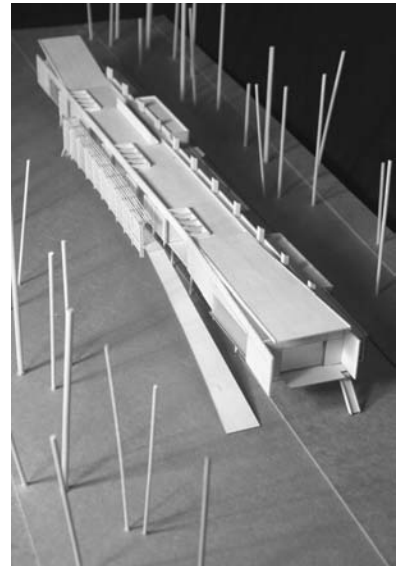
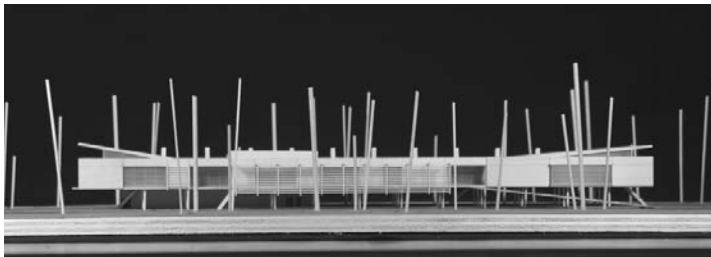
The environmental center is intended to act as an educational resource and communication facility for the ongoing environmental restoration work that is being carried out on the Calumet River watershed. A primary requirement was that it should have mini-





Calumet River building site plan.

Sketch diagrams of the design strategies.



mal environmental impact as a building and, as far as is possible, be self-sufficient in energy terms especially as its use is envisioned as being all year round. The building will have spaces for exhibitions, meetings, and changing displays; it should be an exemplary building for explaining the environmental restoration work of the region.

### Design Strategy

The building concept is raised completely above the land and functions at the level of surrounding trees. It takes the form of a prefabricated modular linear tube (to minimize on-site construction) and is oriented in an east-west direction so that the closed northern side is a buffer zone that protects against the winds coming off Lake Michigan, while the southern face can take maximum advantage of the solar exposure and is open and porous. The building is supported off the earth by as few columns as possible, and removable helical steel ground anchors are deployed to enable total site removal at some time in the future. The building is located such that it is a part of the walking sequence through the landscape to the river and the existing pathways circulate through and under the

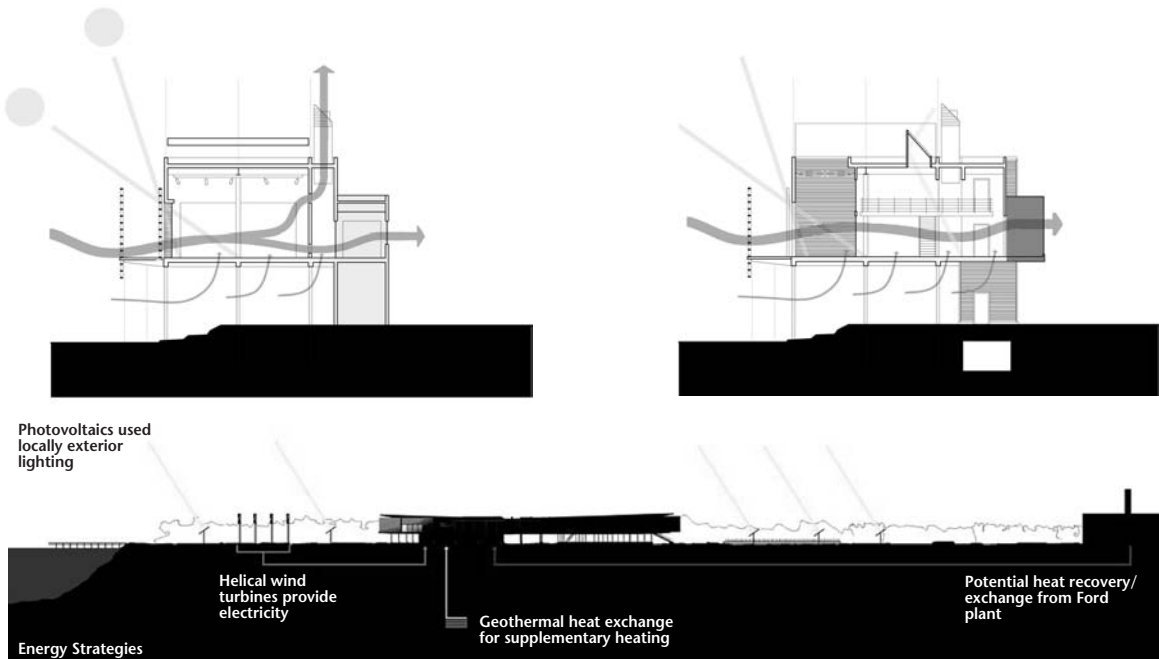
building. The landscape around the building is designed to show some of the systems that support the building, such as power generation and water recycling. The plan has a sequence of linear spaces broken up by a system of 3 courtyard terraces that enable the building to be more porous in summer while acting as insulated microclimatic spaces in winter when a removable roof is attached.

### Green/Sustainability Concept

In order to support the zero environmental impact concept, the project deploys multiple strategies for energy generation that work together with the passive systems for natural daylighting and natural stack ventilation, which in turn reduce the load and need for mechanical systems.

Heating energy is generated from a heat recovery system that diverts excess heat (that is normally discarded into the atmosphere) from the nearby Ford industrial plant, and a geothermal heat exchanger under the building that provides supplementary heating when needed. Electrical energy for the building is generated from a system of 5 helical wind turbines that are located as art objects in the landscape close to the

Sectional daylighting and ventilation diagram. Site energy strategies.



open river. A further system of photovoltaic installations in the landscape provides power for external functions and landscape lighting. The long, thin shape of the building enables excellent natural lighting, and air to waft through the building assisted by the stack ventilation in the form of a series of “chimneys” along the circulation corridor close to the north-facing buffer zone spaces. A further advantage of raising the building off the earth is that cooler air can be introduced at night at low level and used to cool spaces as well as the mass of the floor construction. A system of movable wooden shades to the south façade provides solar control to prevent the skin from absorbing excessive solar radiation. Finally, greywater is drained from the building into a series of remedial willow beds before returning to the building, while composting toi-

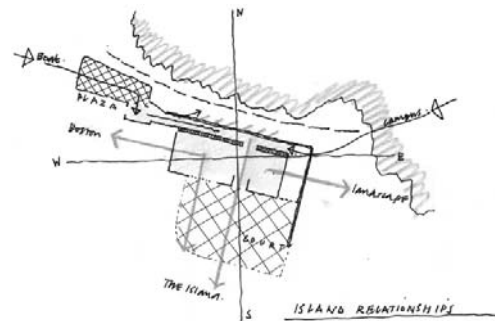
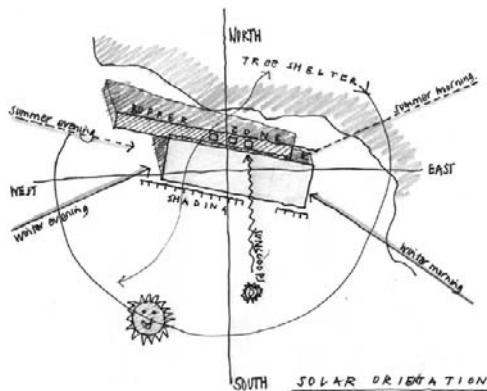
lets store effluent obtained through periodic removal from the building’s undercroft. All of these are systems are melded into the architectural form.

### DESIGN PROJECT 3: THOMPSON ISLAND EXPEDITION CENTER

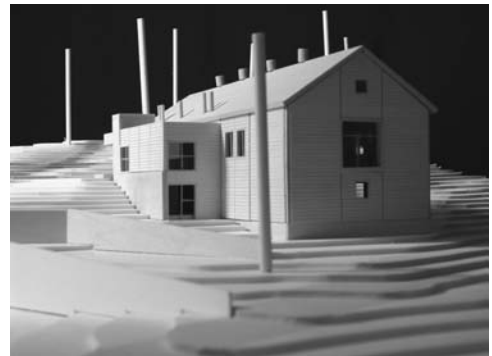
#### *Location and Site Context*

The expedition center is located on Thompson Island, one of the islands of the Boston Harbor group and owned and operated by the adventure learning non-profit group called Outward Bound. The island, which is about 1 mile x  $\frac{1}{4}$  mile and accessible only by boat, has been sparsely populated for several decades. It started out as a farm school serving the youth of Boston. The building site is in the location

Site environmental diagrams.



Model studies of the first and final building concepts.



of a large stone agricultural barn, close to the island's only dock, that burnt down about 40 years ago, but where the old stone foundation walls still remain. The site has spectacular views back to Boston about 2 miles away. The landscape is quite varied with areas of salt marsh, beaches, and woodland. The building is located on a south facing wooded slope between the island's dock and the small campus of plain faced red brick residential buildings.

### **Design Agenda**

Building on an island was a considerable challenge, especially when transportation access became limited during the project due to the security measures arising out of 9/11 and changed the project's direction between design and construction. In addition, we set ourselves the goal of designing a bioclimatic building that was sympathetic to its situation and landscape, and was low energy through not depending upon any forced mechanical systems. It had to work passively on this island and be resource efficient.

The Expedition Center is a multi-functional building that has two primary functions: to be a venue for meetings, larger gatherings, and assemblies;

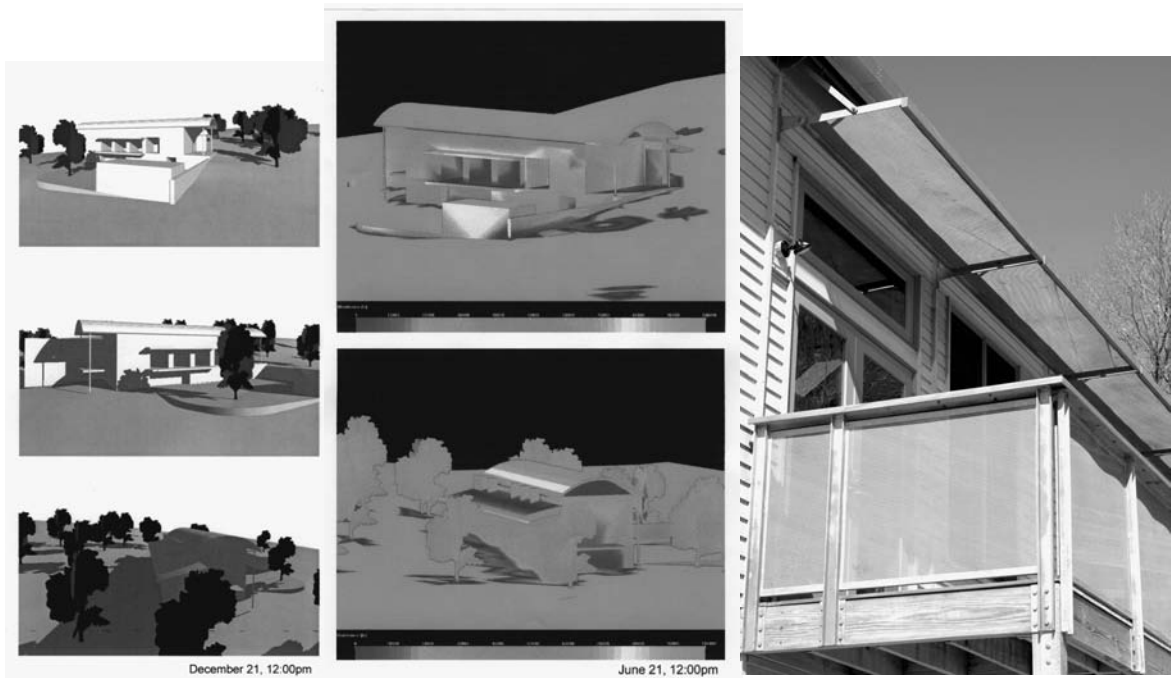
and to provide storage, service, and equipment facilities for groups that are about to go embark on or return from wilderness expeditions.

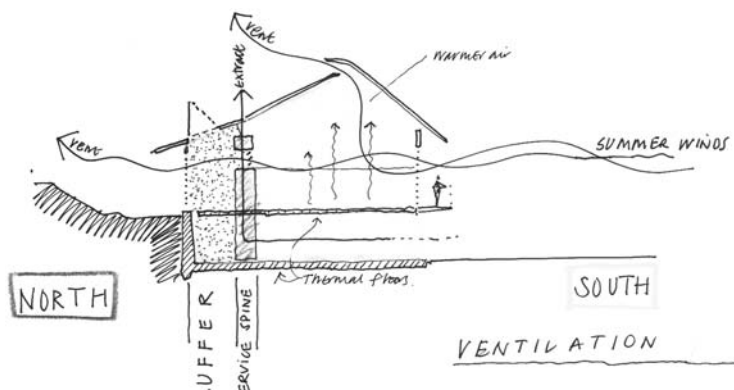
### **Design Strategy**

Several design options (4) were developed during the design phase in response to economic and constructional constraints posed by the selected contractor and then the transportation limitations imposed by 9/11. However, while each design concept became formally and constructionally simpler due to the cost premium incurred by the island construction, all of them were based upon the concept of trying to derive the building form from the site and prevailing climatic conditions.

In the earlier schemes, the sectional form and shape was a direct response to solar angles and wind flow. All of the design options were set into the hillside to use the thermal mass of the earth for insulation as well as enabling the two levels of the building to be accessed at the upper level for meetings and gatherings (with the views across the island back to Boston), and at the lower courtyard level for storage and equipment organization. The final built project

Shadow and solar radiation façade studies: Steel mesh solar shading to east façade.





Environmental ideas in section for initial building concept.

was oriented north-south and became a large timber barn-like wood framed structure reminiscent of the vernacular of the older rectangular forms that were built on the island several decades ago.

### **Green/Sustainability Concept**

The intention was to create a passive low energy building that was easy to adjust from summer to winter conditions—being open and porous in the summer and closed up and highly insulated in the winter. The climatic forces on the site drove the form of the building especially through an understanding of the effects of wind and sun on the building and its skin, and in the initial concept the roof shape was a direct result of the light angles and wind-flow. The northern side was always seen as a buffer zone to the winter winds coming over the hill, and it helped that this façade was dug over the hillside, while the east and south façades offered opportunities for controlled exposure to the sun for winter solar gain, accompanied by steel external shading devices to eliminate high-level summer solar gain and overheating. Radiance software was used to map the effects of solar radiation on the building skin and ascertain the effectiveness of the shading design, including depths of overhangs. Various forms of natural ventilation were explored including stack ventilation at high level through a clearstory lighting band. The relatively narrow width of the building (32 feet) enabled a good cross flow when windows were opened, and with a system of openable and shaded rooflights using a remote controller, the natural airflow during spring and summer was considerable.

The ruin-like walls of the older barn still remain on the site, and the new retaining walls of the lower level were seen as a replication of this idea of building on the island—mass retaining walls supporting a-braces, timber balloon frame structure with steel columns and roof trusses. If ever the new building were to be destroyed, it, too, would return to the state of ruin, as the foundation anchors for the wood frame are removable. However, the cast concrete retaining walls were an essential part of the strategy for thermal mass, plus using high levels of insulation in

The complete project: south and west elevations.



the wood frames construction together with high performance windows.

## DESIGN PROJECT 4: STARTER SOLAR HOUSING

### *Location and Site Context*

The location for the small starter solar house is flexible. These are prototypes for a series of concepts for houses that can be adapted to various site locations and conditions. It is also assumed that they can be replicated and form a small community or neighborhood cluster. For the conceptual design study the assumption was for a northern access and a southern exposure on a rectangular urban site.

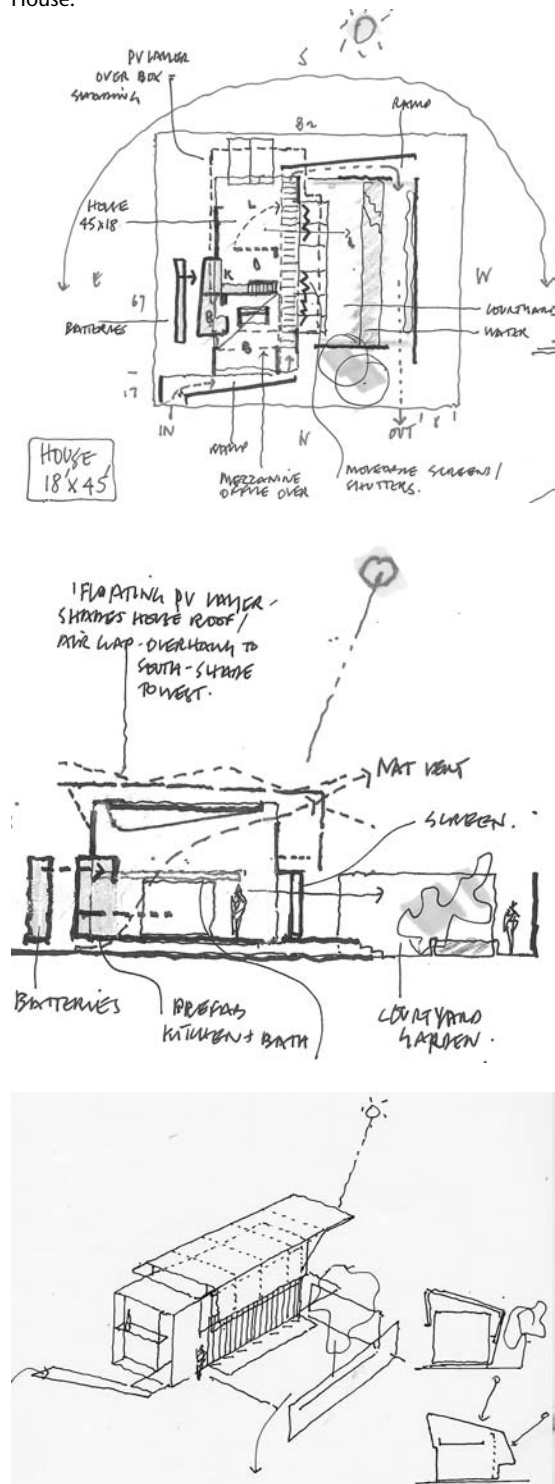
### *Design Agenda*

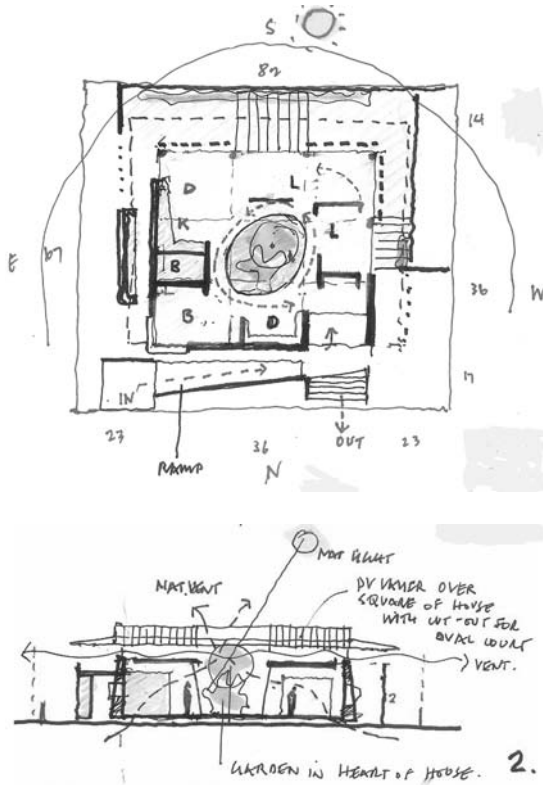
Although this work is ongoing, the original brief was to develop conceptual ideas for three house types for small-scale solar powered, off-the-grid, energy independent housing that could potentially be pre-manufactured off site and scaled up to form part of a new urban community. The size of each house is approximately 1000 square feet and has to engage some form of external private space as an amenity for the unit. Further considerations included the integration of PV power systems with the architectural form and considering modes of living such as arrangements for live/work for the two occupants.

### *Green Design Strategy*

The three concepts that were developed were deliberately very different in their form, orientation, functionality (plan), and the manner in which they integrate photovoltaic systems. A primary concern was for making these small units architecturally interesting while also developing innovative ideas about how they can be sustainable. Each house assumed a high degree of natural light and natural ventilation, thereby maximizing the passive environmental potential. Each house also developed a unique approach to how external space interfaces with the internal plan. House type 2 was further developed into a second plan option that also looked at the benefits of sharing and monitoring a power generation infrastructure as a community resource. Shared localized power generation seemed to suggest efficiencies beyond go-it-alone systems.

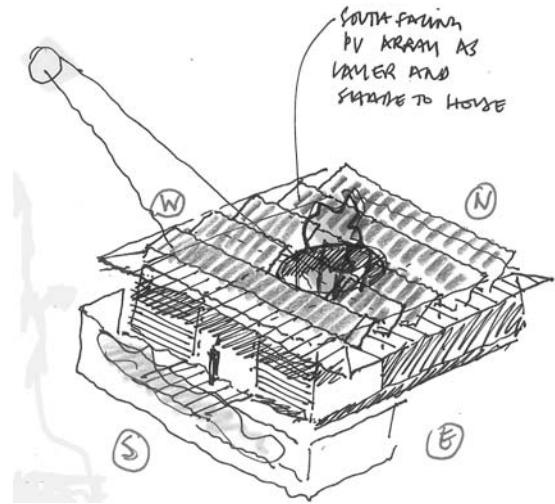
Plan, section, and 3-dimensional ideas for the Layer House.





**One—The Layer House.** This a rectangular unit oriented north-south so that the majority of daylight and air comes from the east and west. This is intended to minimize southerly solar gains. The house is entered from the north and works in conjunction with a west-facing walled courtyard. The house is a 16 foot high volume with a mezzanine office over the bedroom. A prefabricated service unit plugs into the volume and contains the kitchen, bathroom, and battery storage. The west façade would have a movable screen wall so that the courtyard is opened up to the living and eating spaces. It is called “layer house” because the house is a system of layers for environmental control with the air passing underneath. An undulating folded outer skin is draped over the roof and walls and contains the glass PV power system as well as giving shade to both horizontal (south) and vertical (west) walls where needed.

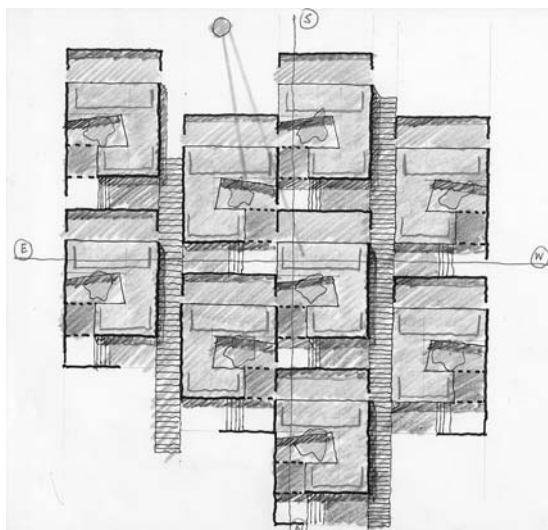
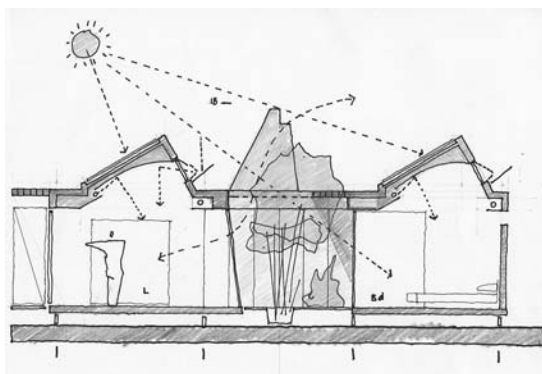
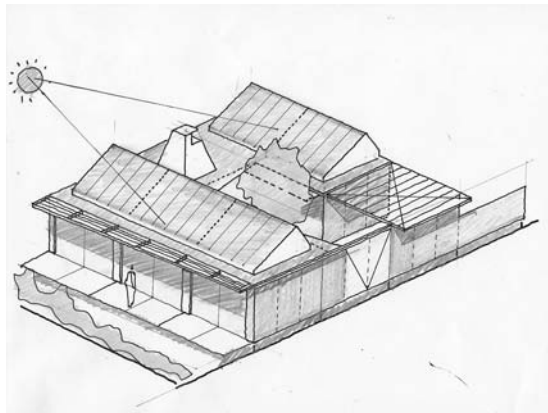
**Two—The Oval Court House.** This is a square house that theoretically contains the most volume for mini-



um amount of wall area. The house is quite internalized and revolves around an oval courtyard that is the environmental and social heart of the house. The external walls are thick to provide good thermal mass while the court is of glass. The courtyard is also a microclimate where the roof can be covered in winter to create a thermal buffer space. At other times it provides light, air, and landscaping in the heart of the plan. The plan spins around the court, with various living spaces being subdivided by a system of moveable internal walls or storage units. Hovering over the square plan is an independent layer of angled PV array set into a lightweight structure with the edges overlapping the walls of the house so as to shade them. This system enables the house to be serviced by approximately 1000 square feet of ventilated PV.

A further revision of this house type explores the notion of a three-sided courtyard house with an open side through which one enters. In this option the PVs are integrated into a saw-toothed roof form that also gives northern daylight, and a stack chimney is worked into the roof above the kitchen to create air-flow and natural ventilation. The external wall would be a complete system of transparent, opaque, and insulated glass.

**Three—Inside-Out House.** The concept for this house is to make the space and volume into a series of fingers—as interlocked hands that are turned in-



side out. So instead of one solid shape, the house takes the form of a series of angular shaped components, each able to respond to a different solar orientation and time of day and be shaped differently. So you will get spaces that work differently at different times of day and you can choose which to inhabit based upon your need for sun or shade. In addition, the shape of each of the parts varies but all are manufactured as part of a structural, insulated, folding, four sided skin with the PVs set flush into the roof and wall surface to create a highly integrated system of pre-fabricated assembly. Prefabrication also enables electrical and mechanical systems also to be constructed into the skin. Glass screens, shading de-

vices, light shelves, decks, or mezzanines are then cut into these angular shapes to relate to external views of the site and landscape.

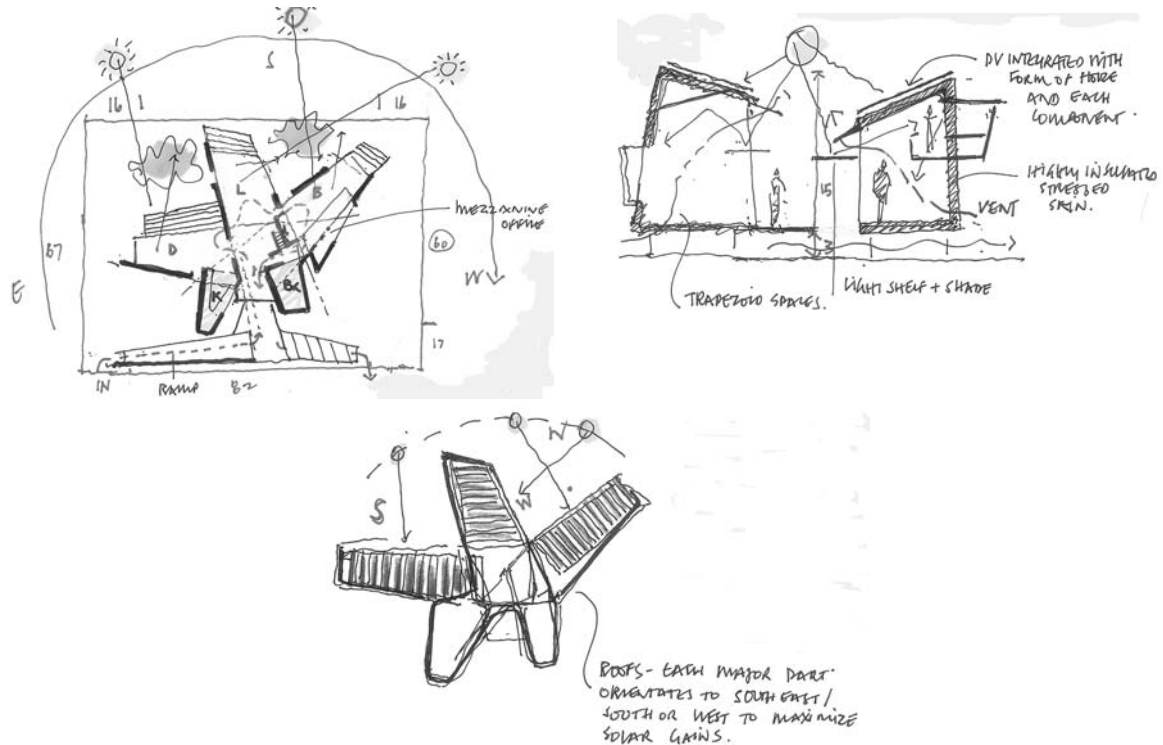
At MIT, the research program by Andrew Scott into SUPHA housing (Sustainable Urban Housing Prototype Assemblies) is continuing to design, test, and model these ideas with a view to developing a full-scale working prototype.

## SUMMARY

The projects that have been outlined are but a small part of a larger body of work that attempts to create architecture from an appreciation of the unique set of conditions and forces that can be called the “environmental and sustainability potential.” Here, we are working with the front end of design to identify what is special about a project, what are the unique sets of possibilities, and to carve them into a set of priorities that establish what design strategies will be most effective—and ultimately most sustainable. This approach may not always yield the best rating on a checklist or scorecard. However, what it will do is make a form of integrated architecture where the environmental aspects are finding a voice and a form in the design process and in the final product. So should green buildings not only look and feel different? Yes, of course, for it is important for occupants to recognize that this form of architecture is in the material, space, and flow of a building, and the ideas it embodies, as well as in the technology or systems that support it. But we also have to understand that buildings, and especially the green variety, have a



Ideas for the rotational Inside-Out House including the integral pre-fabricated skin.



long life span where they undergo many changes and adjustments. Therefore, we also have to be vigorous about monitoring and studying the life and performance of a green building—and understanding that these initial concepts that give rise to the design are but the beginning.

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## DESIGN PROJECT NOTES AND ILLUSTRATION CREDITS

Project One: Andrew Scott / John Fernandez /  
CUBE design + research

Project Two: Andrew Scott / Hubert Murray

Project Three: Andrew Scott / Hubert Murray

Project Four: Andrew Scott