

ABSTRACT

Title of Document: FROM PRINCIPLE TO PRODUCT:
EXPLORING PROCESS THROUGH THE
SOLAR DECATHLON

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Preservation

The premise of this thesis is to examine the process and development of the evolution of words into built form. The abstract principle followed through the design process is the inspiration of nature as seen in the University of Maryland's Solar Decathlon entry LEAFHouse. This abstract design principle guided the team to design and build a cohesive and inspired house.

The maturation process and development of this principle is studied in all aspects of the house from schematic design to materiality to detailing of the windows and doors. These elements combine to create an experience where this principle is evident in the final built form. These experiential and perceptive qualities are examined and documented.

FROM PRINCIPLE TO PRODUCT: EXPLORING PROCESS THROUGH THE
SOLAR DECATHLON

By

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
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Preface

This document has been prepared as a record for the accomplishments of the 2007 University of Maryland Solar Decathlon Team and fulfills the requirements of the Graduate School as a Master's Thesis Document. The appendix to the document was completed as a collaborative effort between team leaders, and serves to portray the design process that emerged and evolved, as well as the teams' participation in the Solar Decathlon. In addition, team leaders made individual observations and chose to focus on certain aspects of the project, reflected in the first section of the document. This collection of documents serve to assist future Decathletes and Solar Decathlon Teams through discussions on team building, project organization and process, using sketches, drawings, written material, design documents, and graphics, completed over the two year course of the project. These documents provide personal testaments to the importance of this project to not only architecture and engineering students but to the leaders of tomorrow.

Dedication

To my parents: For making me who I am.

And to Kim, Abun, Rachel and Brown: For helping them.

And last but not least, to Sue (and Motto): For sticking around and supporting me.

Acknowledgements

I would like to acknowledge all of the faculty, mentors and team members that worked on and supported this project. Without their guidance, work, and support we would have never made it to the Mall. “Bring a rake.”

Table of Contents

Preface.....	ii
Dedication.....	iii
Acknowledgements.....	iv
Table of Contents.....	v
Introduction.....	1
Chapter 1: Evolution of a Principle.....	1
Intellectual and Communicative Structure and Methods.....	3
Process and Development.....	8
Chapter 2: Execution of Principles and Physical Outcomes.....	14
Conclusion.....	19
Examining Effectiveness.....	19
Process Retrospective.....	21
Appendix.....	23
Introduction.....	23
Predesign.....	29
Introduction.....	29
Team Organization.....	29
Team Intentions.....	31
House/Team Branding.....	34
Target Market/Target Region.....	35
Public Outreach.....	37
Design.....	41
Precedent.....	41
Three Schemes.....	44
Design Development Documents.....	49
Construction Documents.....	51
Shop Drawings.....	54
The Design.....	57
LEAFHouse Larger.....	72
Construction.....	77
Construction Schedule.....	77
Construction Sequence.....	79
The Competition.....	99
Transport.....	99
Reassembly.....	101
Competition Week.....	104
Introduction.....	104
The Contests.....	104
Competing Teams.....	109
Public Tours.....	128
Media and Communications.....	132
Post Construction/Post Competition.....	136

List of Figures

Figure 1: LEAFHouse on the National Mall During Public Tours.....	1
Figure 2: LEAFHouse Team Brain Storming Session.....	3
Figure 3: LEAFHouse Team Working Structure.....	4
Figure 4: Team’s Iterative Design Process.....	6
Figure 5: Team Design Principles.....	7
Figure 6: Team Design Parameters.....	8
Figure 7: Plan of LEAFHouse from Construction Documents.....	11
Figure 8: Overall Evolution of Principles to Built Form.....	13
Figure 9: View of LEAFHouse Looking Southwest in Living Room.....	14
Figure 10: Zones of Layering on South Façade.....	15
Figure 11: Axonometric of Layered Elements on South Façade.....	16
Figure 12: Interior and Exterior Treatment of South Zone.....	17
Figure 13: South Slider Sill Detail.....	18
Figure 14: Perception of Space.....	18
Figure 15: Photo Looking West into Living Room.....	19
Figure 16: Photo of South Façade Layering.....	22
Figure 17: Photo Looking South From Kitchen.....	22
Figure 18: Solar Village on the National Mall.....	23
Figure 19: Houses chosen to compete in the Solar Decathlon.....	24
Figure 20: Chosen sites of houses on the National Mall.....	25
Figure 21: Ten contents with descriptions.....	26
Figure 22: Ten contests with descriptions (cont.’d)	27
Figure 23: Bubble Diagram of Team Organization.....	30
Figure 24: The team at the Green Building Institute in Jessup, MD.....	31
Figure 25: Diagrams examining the way we dwell.....	32
Figure 26: Intentions, Strategies and Tactics brainstorming session.....	33
Figure 27: Communications mentor, Peter Kelley.....	35
Figure 28: Potential Communications Strategies.....	36
Figure 29: LEAFHouse Team Website.....	37
Figure 30: Photographs of LEAFHouse Team Events.....	39
Figure 31: LEAFHouse Team Speaker’s Bureau Events.....	40
Figure 32: Michelle Kaufman GlideHouse, exterior.....	41
Figure 33: Michelle Kaufman GlideHouse, interior.....	41
Figure 34: Michelle Kaufman GlideHouse, exterior.....	41
Figure 35: Michelle Kaufman GlideHouse, interior.....	42
Figure 36: Charlie Lazor Flatpak House.....	42
Figure 37: Mies van der Rohe Farnsworth House.....	43
Figure 38: Mies van der Rohe Farnsworth House.....	43
Figure 39: Mies van der Rohe Farnsworth House.....	44
Figure 40: Scheme 1: Courtyard House.....	45
Figure 41: Scheme 2: Icon House.....	46
Figure 42: Scheme 3: Pavilion in the Landscape.....	47
Figure 43: Parti for the final design of the house.	48

Figure 44: Site Plan.....	49
Figure 45: Floor Plan.....	49
Figure 46: South Elevation.....	50
Figure 47: Transverse Section.....	50
Figure 48: Site Plan.....	51
Figure 49: Floor Plan.....	51
Figure 50: South Elevation.....	52
Figure 51: Transverse Section.....	52
Figure 52: Wall Sections.....	53
Figure 53: Details.....	53
Figure 54: Tradewood Shop Drawings.....	54
Figure 55: ATAS Siding Detail Shop Drawings.....	55
Figure 56: Shop Drawings for South Overhang Supports.....	56
Figure 57: Aerial View of Plan.....	57
Figure 58: View of South Façade.....	57
Figure 59: Interior Space looking at the living room and kitchen.....	58
Figure 60: Perspective of southern green wall.....	59
Figure 61: Perspective of southern wall of glass and louvers.....	59
Figure 62: Perspective of eastern elevation.....	59
Figure 63: Architecture Brief Contest Report.....	60
Figure 64: Architecture Brief Contest Report (cont.'d).....	61
Figure 65: Communication Brief Contest Report.....	62
Figure 66: Communication Brief Contest Report (cont.'d)	63
Figure 67: Engineering Brief Contest Report.....	64
Figure 68: Engineering Brief Contest Report (cont.'d).....	65
Figure 69: Lighting Brief Contest Report.....	66
Figure 70: Lighting Brief Contest Report (cont.'d).....	67
Figure 71: Market Viability Brief Contest Report.....	68
Figure 72: Market Viability Brief Contest Report.....	69
Figure 73: Website Brief Contest Report.....	70
Figure 74: Website Brief Contest Report.....	71
Figure 75: Early discussions on LEAFHouse communities.....	72
Figure 76: Townhouse adaptation.....	73
Figure 77: LEAFHouse garden flats.....	74
Figure 78: LEAFHouse villa.....	75
Figure 79: Existing LEAFHouse Plan overlaid with LEAFHouse Rationalized.....	76
Figure 80: LEAFHouse rationalized with modular extensions.....	76
Figure 81: Final Construction Schedule.....	77
Figure 82: Weekly schedule meeting inside the house.....	78
Figure 83: Foundation Sequence.....	79
Figure 84: Foundation Construction.....	80
Figure 85: Wall Sequence.....	81
Figure 86: Wall Construction.....	82
Figure 87: Roof Sequence.....	83
Figure 88: Roof Construction.....	84
Figure 89: Door & Window Sequence.....	85

Figure 90: Door & Window Installation.....	86
Figure 91: Siding Sequence.....	87
Figure 92: Siding Installation.....	88
Figure 93: Finish Roof Sequence.....	89
Figure 94: Finish Roof Installation.....	90
Figure 95: Rough-Ins Sequence.....	91
Figure 96: Rough-Ins.....	92
Figure 97: Insulation & Finishes.....	93
Figure 98: Insulation & Finishes Installation.....	94
Figure 99: Deck & Landscape.....	95
Figure 100: Deck & Landscape Installation.....	96
Figure 101: Solar Systems.....	97
Figure 102: Solar Systems Installation.....	98
Figure 103: Preparing the House for the Move.....	99
Figure 104: The House Traveling Through Campus.....	100
Figure 105: Siting the House on the National Mall, Washington, DC.....	101
Figure 106: Reassembly of the PV Racking System	102
Figure 107: Installation of the Rainwater Filtration System.....	103
Figure 108: A Deliberating Jury.....	104
Figure 109: Excerpt from Engineering Design and Implementation Brief Contest Report.....	105
Figure 110: Sample Event Calendar.....	106
Figure 111: Final Competition Standings	107
Figure 112: Maryland Final Competition Standings.....	107
Figure 113: The Maryland Team Celebrates Their Second Place Finish	108
Figure 114: The Team Gives Public Tours of LEAFHouse.....	108
Figure 115: Carnegie Mellon University 2007 Solar Decathlon Entry.....	109
Figure 116: University of Cincinnati 2007 Solar Decathlon Entry.....	110
Figure 117: University of Colorado at Boulder 2007 Solar Decathlon Entry.....	111
Figure 118: Cornell University 2007 Solar Decathlon Entry.....	112
Figure 119: Georgia Institute of Technology 2007 Solar Decathlon Entry.....	113
Figure 120: Technische Universitat Darmstadt 2007 Solar Decathlon Entry.....	114
Figure 121: Kansas Solar Team 2007 Solar Decathlon Entry.....	115
Figure 122: Lawrence Technological University 2007 Solar Decathlon Entry.....	116
Figure 123: Universidad Politecnica de Madrid 2007 Solar Decathlon Entry.....	117
Figure 124: University of Missouri-Rolla 2007 Solar Decathlon Entry.....	118
Figure 125: Massachusetts Institute of Technology 2007 Solar Decathlon Entry...	119
Figure 126: Team Montreal 2007 Solar Decathlon Entry.....	120
Figure 127: New York Institute of Technology 2007 Solar Decathlon Entry.....	121
Figure 128: Pennsylvania State University 2007 Solar Decathlon Entry.....	122
Figure 129: Universidad de Puerto Rico 2007 Solar Decathlon Entry.....	123
Figure 130: Santa Clara University 2007 Solar Decathlon Entry	124
Figure 131: Texas A&M University 2007 Solar Decathlon Entry.....	125
Figure 132: University of Texas at Austin 2007 Solar Decathlon Entry.....	126
Figure 133: University of Illinois 2007 Solar Decathlon Entry.....	127
Figure 134: Example of Nutrition Label in the House.....	129

Figure 135: The Signage on the Mall.....	130
Figure 136: The Brochure Handed Out on the Mall.....	131
Figure 137: Example of Bench Signage on Front of House.....	132
Figure 138: Film Crews at the Opening Ceremonies.....	133
Figure 139: Team Members give Steny Hoyer and Samuel Bodman a Tour.....	134
Figure 140: Awards Received.....	135
Figure 141: Proposed Site Location.....	136
Figure 142: Proposed Site Location.....	137
Figure 143: Proposed Site Location.....	137

Introduction



Figure 2: LEAFHouse on the National Mall During Public Tours

[Gardner]

This thesis explores moments in the design process from schematic design to construction completion focusing on the evolution and development of a design principle into built form. The product is examined at an experiential and perceptual level. The intention is not to explore the entire design process or to post rationalize design decisions to fit the initial principles, but rather to examine and explain how the design process led to the physical manifestation of these abstract ideas. Through this thesis, one element of the project and its intentional and accidental evolution will be examined in an effort to show how a somewhat arbitrary and generic design principle becomes built form and an integral part of the architecture. The eventual architectural form of this principle is also examined and analyzed in the context of the perceptual experience that results from the culmination of the architectural elements.

The medium for this exploration is the University of Maryland's entry to the 2007 Solar Decathlon competition. The Solar Decathlon is an international design build

competition sponsored by the Department of Energy and the National Renewable Energy Labs. Colleges and universities from around the world are challenged to build fully functioning solar powered houses focusing on the integration and innovation of solar technology. The houses are then transported to the National Mall and compete in a series of subjective and objective contests focusing on aesthetics, performance and innovation during which time they are on display for public viewing. (solardecathlon.org)

The University of Maryland's entry, called LEAFHouse, took its inspiration from nature's ultimate solar collector, the leaf. Mimicking the leaf both aesthetically and functionally in the architecture and engineering of the house, the house integrated both time tested and innovative materials and systems to create a livable house available today. (solarteam.org)

Chapter 1: Evolution of a Principle



Figure 2: LEAFHouse Team Brain Storming Session

[Gardner]

Intellectual and Communicative Structure and Methods

A working, cohesive structure was very important at the inception of the team. In order for the team to function properly and be able to make decisions and communicate, a working team structure needed to be in place. This organization allowed existing team members to work collaboratively and also allowed new team members to begin to understand the workings of the team.

The team structure was comprised of a flat hierarchy involving students, faculty, industry mentors and alumni from the 2005 University of Maryland Solar Decathlon entry. This structure was developed by the faculty and alumni to foster an intergenerational, interdisciplinary, collaborative educational process. As new

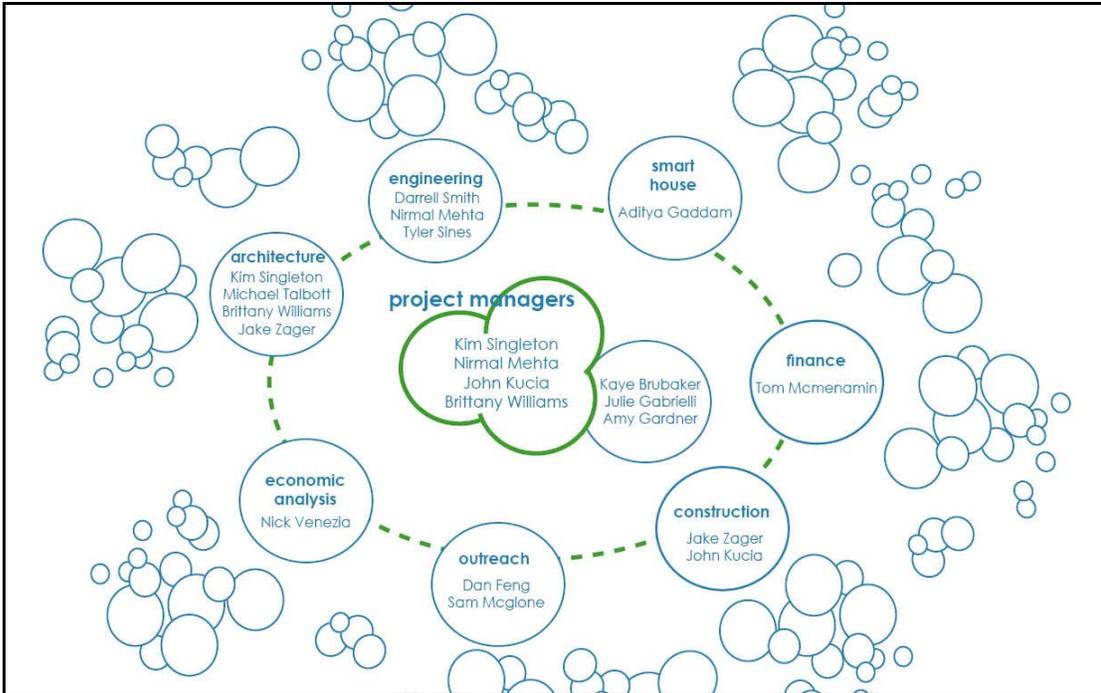


Figure 3: LEAFHouse Team Working Structure [LEAFHouse Team]
 While the team structure evolved and morphed over time, this is one example of the team structure during the process.

students and mentors joined the team, they fit into the structure or created new places within this framework.

While the structure developed and morphed over time, it was comprised of a core group of students representing a variety of different disciplines. These students worked closely with the faculty and mentors. This core took on the bulk of project management duties and decision making while also performing tasks to further the project. This core was supported by team leaders from all disciplines involved in the project. Each of these teams was based on a discipline within the project from architecture to finance to communications. These disciplines were paired with industry mentors and previous decathlon participants. The team worked very fluidly within this structure and consistency within the core group allowed students to come and go to the project.

The team's design and decision making methods were an integrated and iterative process. All disciplines worked together and made decisions collectively from the start of the project. Due to the integrated nature of the design approach, constraint and compromise were constantly a part of the design process, thus making it more iterative than a typical project in which the dialogue between disciplines is less constant and fluid. For instance, when coming up with the overall form of the house, instead of the architecture team working alone developing ideas and then consulting with the engineering team, the disciplines converged and were simultaneously examining the energy use, mechanical systems, architectural aesthetics, program, target market and target region, along with many other influences and making decisions based on all of those factors combined. This interdisciplinary approach was achieved in all stages of the project from schematic design through final design elements determined on the construction site. Starting more rigidly through assigned interdisciplinary groups focusing on various schemes or portions of the house, these teams were constantly informing one another and dialoguing about the integration and implication of systems. Later in the project during the construction phase, these interdisciplinary groups became more organic and formed as individual issues needed to be addressed and explored.

In a more detailed examination of how specific design decisions were made it is evident that the design process followed an iterative path that revolved around proposing solutions and then evaluating their implications against design parameters or outside restrictors. These explorations and decisions were made in the context of this overall interdisciplinary approach. As a solution was proposed and accepted, this decision would become another consideration the team would examine when designing other aspects of

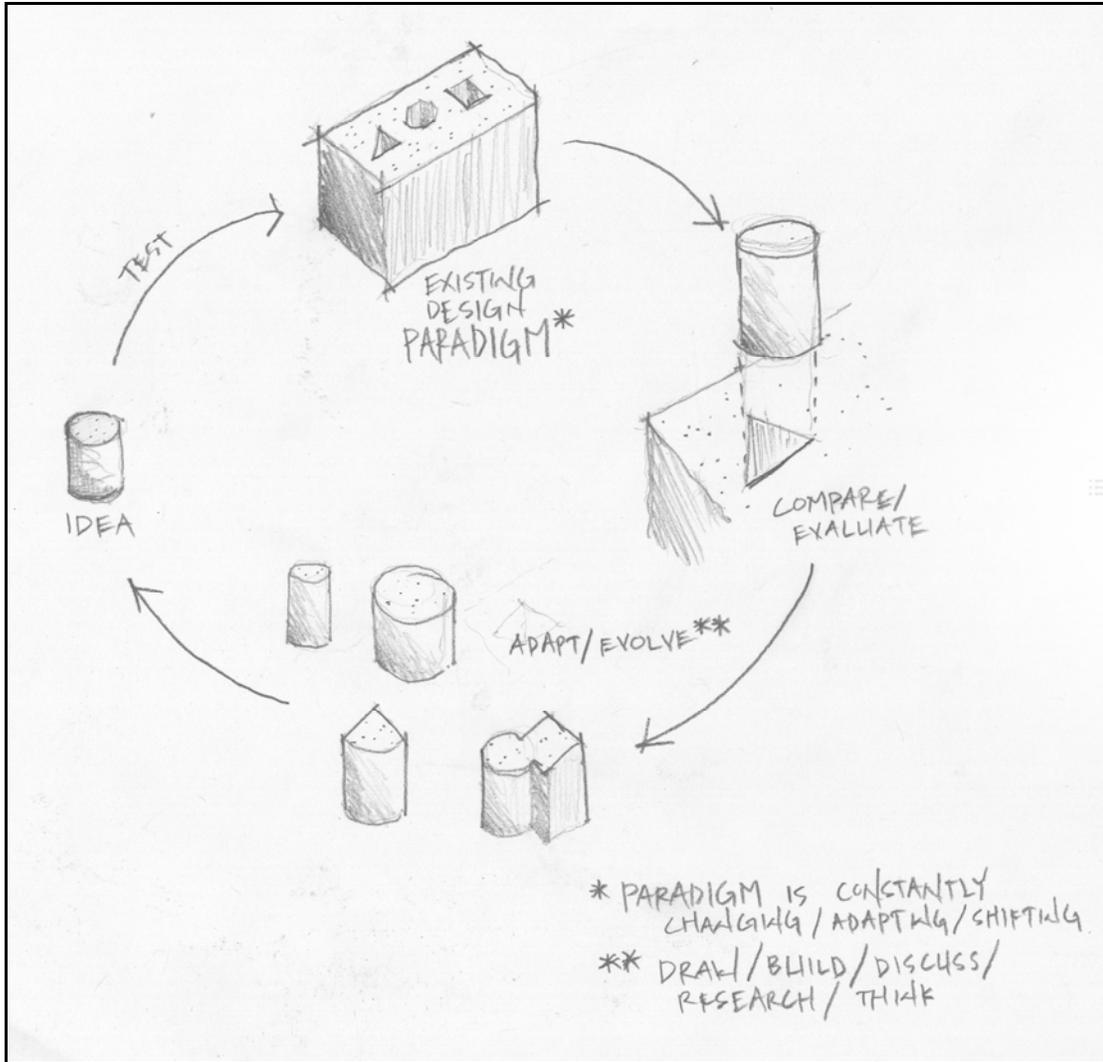


Figure 4: Team's Iterative Design Process

[Author]

This process repeated itself countless times over the course of the project. It was not necessarily as seamless, linear, or formulaic as this diagram, but the process followed the general evolution shown here.

the house. All of these decisions became the design itself and thus a paradigm developed that all other decisions must examine. As a hypothesis or idea developed, it was examined against this existing paradigm. This idea was then evaluated and morphed to fit within the paradigm and constraints developed. Sometimes this idea challenged or morphed the paradigm itself, thereby affecting and altering already established decisions. This scenario caused a ripple effect across the project as all aspects of the house directly

1. Use nature as inspiration and mentor.
2. Demonstrate the practicality of solar technology.
3. Change the design and build process.
4. Address the Chesapeake Bay Watershed issues.
5. Raise awareness about practical solutions and environmental stewardship.

Figure 5: Team Design Principles

[LEAFHouse Team]

The team developed these principles to guide the design process.

and indirectly influenced by this new decision would be altered or challenged. Future iterations of this idea would be examined and evaluated and this process would be repeated until a reasonable solution was chosen. Even after this decision had been made, it was not a permanent part of the paradigm until after materials had been ordered or it had been built. Some aspects of design involved countless iterations while others only involved a few. The design process did not always function in a seamless forward moving manner as described here. The design was constantly being altered and morphed as people joined the project, material availability changed, the construction schedule shifted and numerous other reasons. However, it always seemed to follow an iterative process based on a known paradigm within the project that considered inside and outside forces.

To allow the team to function and make decisions, they developed a set of goals and principles for the project that became the core of the design paradigm. Over the course of several brain storming sessions, the team explored and recorded its goals and expectations. The team spoke generally about what kinds of experiences and exposure they were looking to gain and also more specifically about the project and house itself.

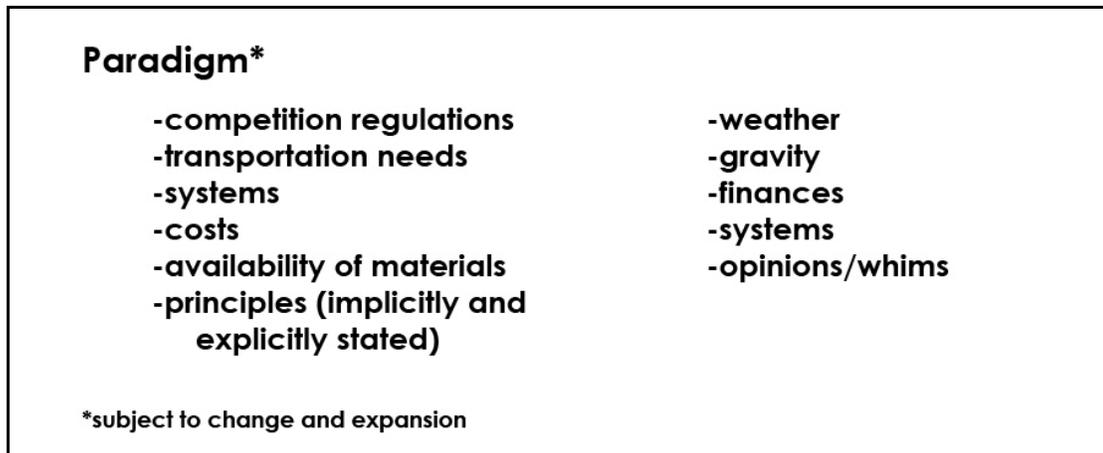


Figure 6: Team Design Parameters

[Author]

This paradigm of design was formed by all the design parameters and restrictions on the team and the design. The list became much more extensive than this as the design developed and also included many unquantifiable parameters.

What came out of those sessions were a list of abstract principles. While the team was not aware of how these principles would manifest themselves in their experiences or in the design, they became a baseline for the design and allowed the team to have a common mission. This list of principles also allowed the team to always have a touch stone to guide in making decisions about the design and the competition. These abstract principles ultimately evolved into the design as the team progressed further into the process of designing and building a house.

Process and Development

One of the principles developed was “use nature as inspiration and mentor”.

While this phrase is somewhat generic and not immediately applicable to architecture, it became a catalyst for the design as it developed from a series of words to built form.

This principle influenced design and ultimately manifest itself in the design as well as the team’s overall mission and attitude towards the competition. Elements of this principle

and its development are evident in the overall aesthetic, system design, material choices, form, the communications plan and overall house inspiration.

The idea of using nature as an inspiration was very influential in the initial design of the engineering systems of the house. The team wanted to mimic the redundancy of systems that exist in nature. With that in mind, the team designed their mechanical systems with back ups and reasonable redundancy to allow for efficiency in performance and effectiveness. For example, not only is the house equipped with a solar thermal system to provide domestic hot water, but it also has a flash electrical hot water heater in the event of particularly cloudy days or large amounts of water usage. This redundancy allows the system to function in a variety of conditions. This initial design decision was influenced by the way that nature behaves and was executed in the final systems chosen.

Another area where nature's touch can be seen is in the material choices used within the house. Both construction and finish materials were chosen for their minimal impact on the environment as well as their aesthetic, natural quality thus using nature and our effect on nature as inspiration. During construction, sustainably forested FSC certified 2x6 wood studs were used in the framing in the house. When choosing the finish materials of the house, both sustainably harvested materials as well as reclaimed materials were used. A portion of the countertop is made from a reconstituted fallen log. The aesthetic of this feature in the house evokes a connection to nature. Clearly, the finish materials pallet and construction materials were chosen in accord with "use nature as inspiration and mentor".

There are several other ways this principle can be see as an influence in the house design and construction. In many cases, this principle developed further and evolved

with the project. This evolution became an influence on the project at all stages, not just on initial systems choices or on the overall materials choices.

Based on the team's explorations into how nature can be an inspiration, they felt that one of the most significant ways was through an actual connection to nature. Thus, the team felt it was fundamentally important for there to be a connection to nature within the house. This resulting and evolving principle was explored extensively in many ways at the schematic level. It ultimately led the team to develop the form of the house with much emphasis on this concept. The team saw many ways to connect to nature through views and physical connections to the exterior, use of natural materials, mimicking nature in form and function, along with many others. In these ways, an abstract idea such as "connection to nature" began to take on a physical form and have an experiential meaning. These words and their associated meaning became a verbal catalyst for a physical, perceptual design. Each individual on the team had a personal association of a physical manifestation with the words "connection to nature" and the team used these personal associations to collectively inform and develop the tangible design.

Formally speaking, the design developed into a thickened bar on the north side of the house with punched openings to frame views to the exterior and a more open south side to create a direct connection to nature. This form and programmatic layout allowed optimal connection to nature and views that worked in accord with other design parameters. Additionally, it also allowed the admittance of maximum southern light for solar gain as well as a roof form that permitted an idealized angle for photovoltaic

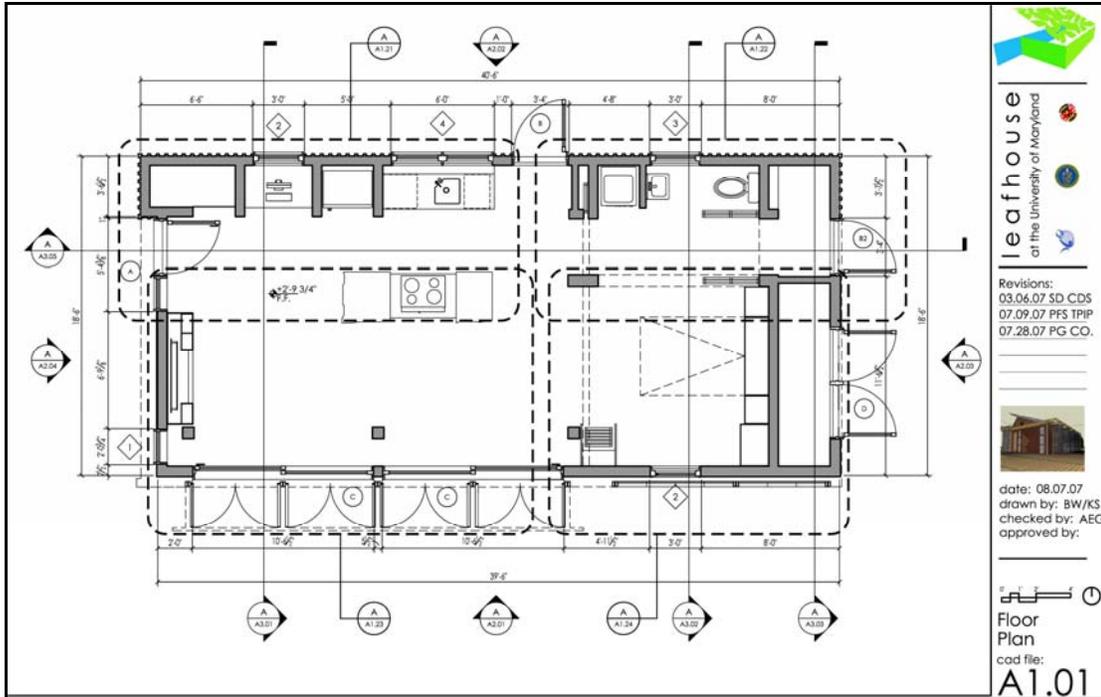


Figure 7: Plan of LEAFHouse from Construction Documents [LEAFHouse Team]
 The plan of the house shows the solid bar to the north and the open façade along the south-west. This expanse of glass lines the living room and dining room, allowing the public spaces to open to the exterior.

panels. While creating a connection to nature was certainly not the primary and only driver of design, this principle played a large part in the development of the form of the house and subsequent design.

The more open south side of the house is a compelling example of the development of the principle to “use nature as inspiration and mentor.” This area was in constant flux and design always revolving around the idea of creating a strong connection to nature. As this zone developed, the original strategy and diagram was fundamentally visible while becoming more enhanced and complex along the way. Many decisions about this area of design were made with many different principles and intentions in mind however; they all enhanced and developed the idea of a connection to nature.

Because of the design-build nature of the project, design did not stop with the submittal of construction documents. Design continued well into the construction process and as portions of the design were built the team evaluated the product and reexamined other unbuilt, affected portions of the house. As a result of this process, the team paid particular attention to enhancing the diagram of the house with each additionally construction element completed. In addition, many aspects of the project had not yet been designed and the team opted to change the design as they saw the physical manifestation of the design on paper. Often times, after seeing the physical outcome, the team would revisit an earlier decision.

One example of the evolution of design decisions throughout the design and construction process is evident in the flooring stain and decking material. The team had chosen the stain color for the solid Douglas fir windows and doors prior to the start of construction. The flooring stain color was not chosen until days before the floor was actually stained. Because of the similar colors between the window and door sill and the decking material, the team saw the flooring stain color as an opportunity to create a continuous floor plane through the use of similar colors. As a result, the team chose a flooring stain that was the same color as the sill stain. Despite the difference in materials, the colors of the floor created an opportunity to strengthen the diagram of the house with a strong connection to nature throughout the appearance of the flooring extending into the exterior. Without seeing this first hand and having the chance to make decisions during the construction process, the final result may have differed and not strengthened the existing diagram.

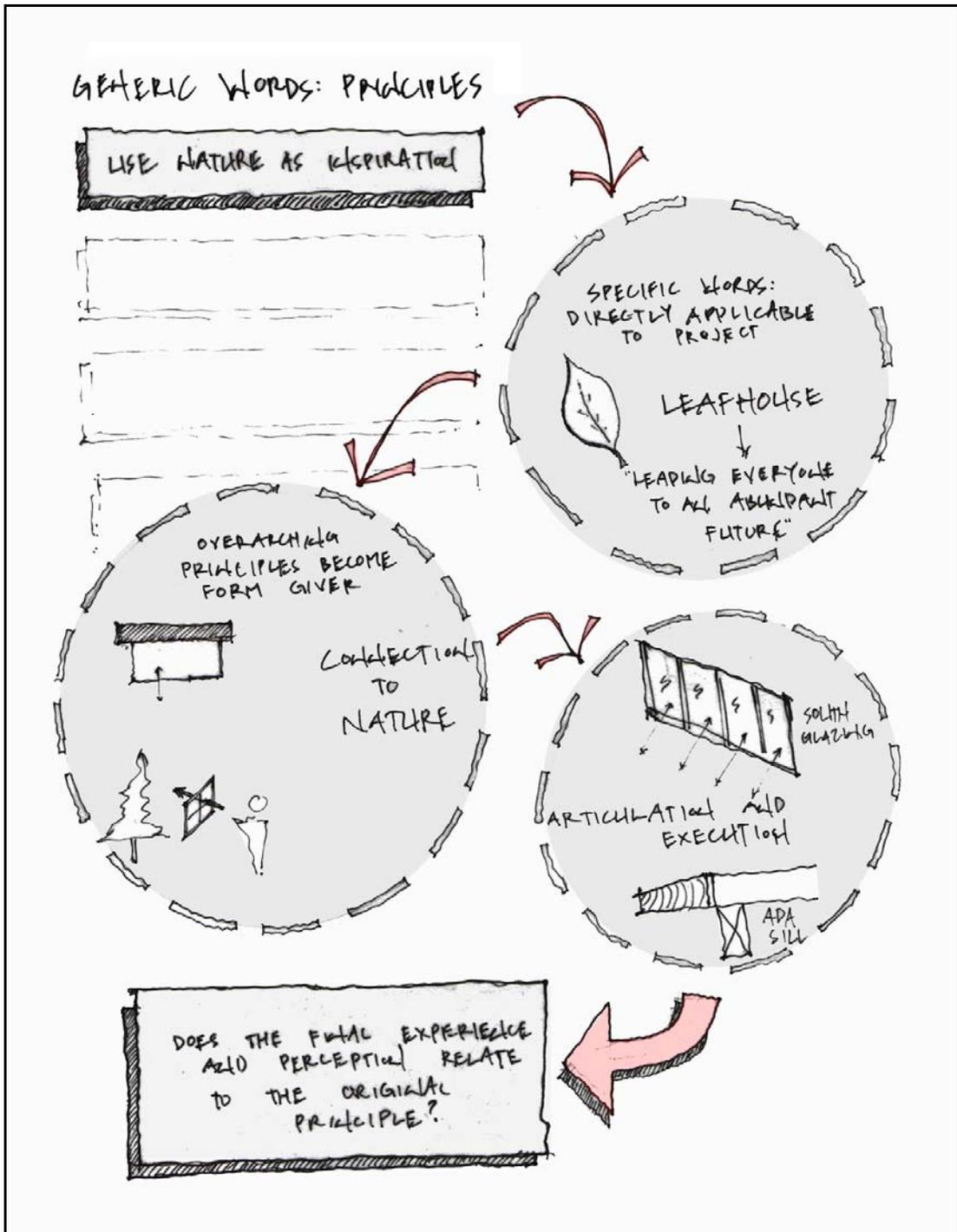


Figure 8: Overall Evolution of Principles to Built Form

[Author]

The evolution of this principle can be examined through moments in the design process and the overall maturation of the house design.

Chapter 2: Execution of Principles and Physical Outcome



Figure 9: View of LEAFHouse Looking Southwest in Living Room [Gardner]
When inhabiting the living room, the south zone of the house acts as an edge to the room and a buffer to the exterior.

The final product that resulted from the evolution of the principle “use nature as inspiration and mentor” occurred at all scales and in all aspects. A variety of factors contributed to the execution of this principle from the detailing of the sill to the window manufacturer to the colors of stains. The overall combination of material, connection, light, and space create an ambiguity and fluidity with the exterior.

This zone on the south-west façade of the house is marked by a 22 foot expanse of glass. The glazing system is comprised of four full height glass panels:

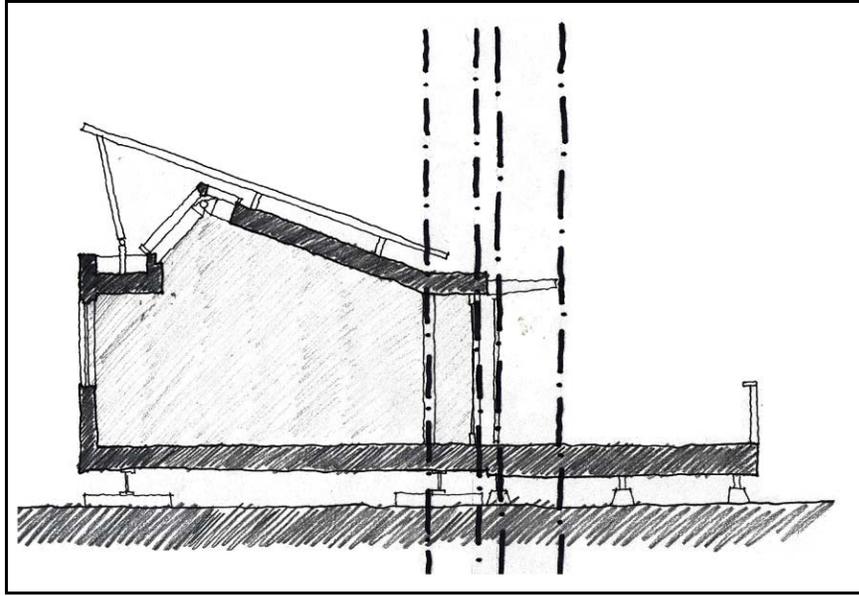


Figure 10: Zones of Layering on South Façade

[Author]

two are windows and two are moveable sliders. On the interior, this zone has a low flat ceiling clad in a dark, reddish wood called cupiuba, similar in color and look to the floor and doors and window casing. This soffit is detailed so that it slides past the sloped ceiling at the intersection of these two planes. This causes the soffit to appear as a distinct plane and not a fold in the slope. Aside from this overhead plane, the space is marked by a series of columns also clad in cupiuba. The slot space ends on the west with a full height window and on the east with a plane of cupiuba which makes up the side of a bookcase. On the exterior, a layering effect is achieved through a series of moveable, poplar wooden louvers. An overhead plane is implied through the use of a cantilevered overhang comprised of paired Douglas fir timber members connected at the end by a steel plate. The cantilevered members are supported by paired uprights that occur between pairs of louver doors. The simple diagram carefully articulated with a variety of materials and in a variety of ways creates richness in the reading.

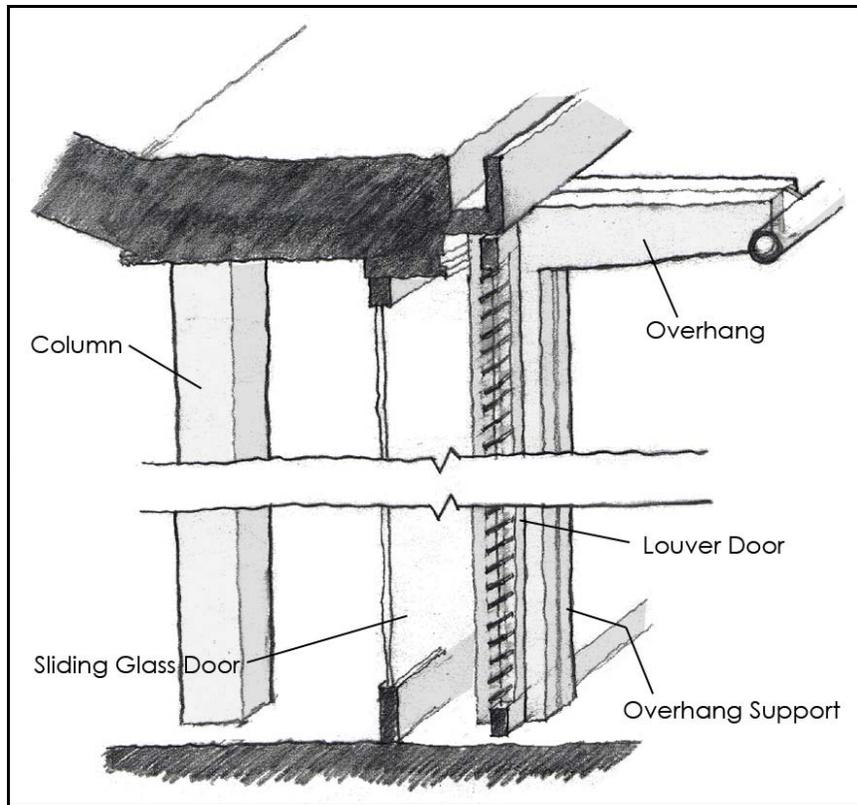


Figure 11: Axonometric of Layered Elements on South Façade [Author]
 This diagram highlights the different elements that comprise the layering of the façade. These elements help sculpt and define the spaces that mediate between the interior and exterior.

The combination of layers, objects in space, and treatment of planes create an ambiguous reading between the interior and exterior. This ambiguity enhances the reading of the connection to nature. By contrast, if the line of the building envelope was not blurred, the perception of space would be very clear and thus a connection would not be dynamic with depth and richness. In this case however, while the spaces are clearly defined by planes, objects and rhythm, the perception changes based on the position of the dynamic portions of the façade, the location of the user and conditions inside and outside the house. For example, if someone was standing in the middle of the house with the glass and louver doors closed, this south zone acts as the edge of the space. The connection to the outside is then regulated to the diffuse light and sound coming through

the louvers. If an occupant were standing in the zone on the interior with the glass doors open and the louver doors in an open position, the reading is much different and the occupant feels a stronger connection to the outside because the building envelope disappears in the vertical plane thus the connection is much more fluid and open. There are several configurations in which different perceptions of the space occur and these are further altered not only by these dynamic portions of the façade, but also by time of day, activity inside and outside the house, weather and other unquantifiable factors.

The details in this zone also add to the overall richness of the space. For example, careful attention was paid to the sill detail and the way the materials come together. The sill was designed to be an ADA sill to meet code requirements, but also intended to create a seamless connection between the interior and the exterior. The wood flooring on the interior is flush with the wood sill and also in the same plane as the exterior deck. Although different woods and materials are used, similarly colored stains and materials were chosen to create a cohesive look across the surface.

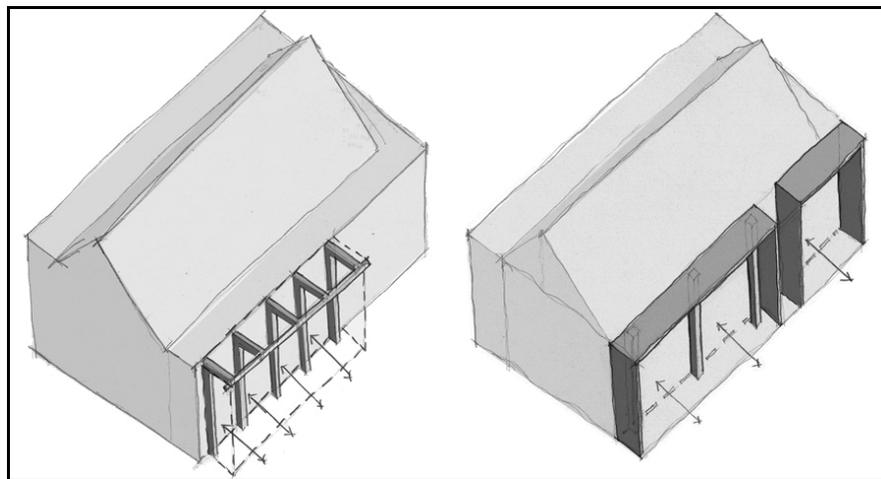


Figure 12: Interior and Exterior Treatment of South Zone [Author]
The exterior space is defined by a cantilevered overhang and uprights. This perception of an overhead plane is a reinterpretation of the interior space which is defined by a dark wood soffit.

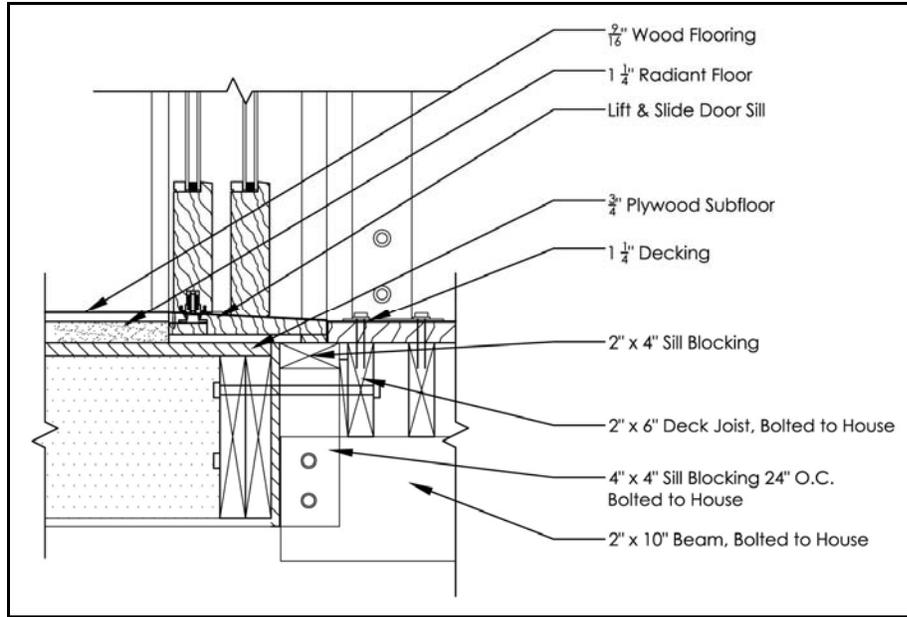


Figure 13: South Slider Sill Detail

[LEAFHouse Team]

This detail highlights the relationship of materiality between the finish floor, door sill and decking materials. The planar nature of these materials creates a seamless connection between the interior and exterior.

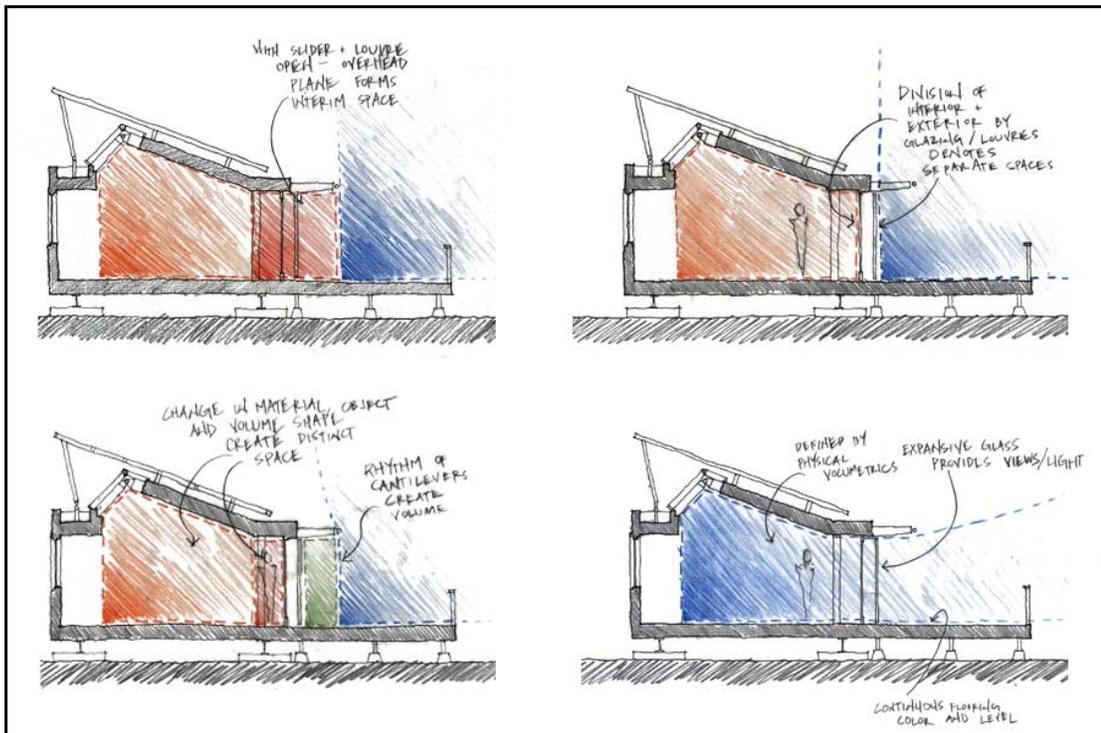


Figure 14: Perception of Space

[Author]

The location of the inhabitant and the configuration of the space allow for different perceptual readings of the space.

Conclusion



Figure 15: Photo Looking West into Living Room

[Gardner]

Examining Effectiveness

There is much knowledge to be garnered from this process that can be learned through retrospection and examination. In trying to follow the evolution of principles, examining the design process and inspecting the final perception of built form, many lessons can be derived from these experiences.

While utilizing principles to inspire and sponsor design is a rather generic design process, the testing ground of the Solar Decathlon adds to the uniqueness of this experience. Over 100,000 members of the public visited the houses on the National Mall and the LEAFHouse saw countless visitors each day. These visitors either interacted

with members of the team to find out more about the house's design and features or explored the house on their own. Many of these visitors discussed and conversed with the team members about the house, its livability and its effectiveness as a house. Without using scientific methods of measuring visitor's perceptions, it seemed that the house was overall successful in conveying this initial principle in the final design. In listening to architects, the juror members, and lay people discuss the design, it became evident that visitors understood this connection to nature on the south side of the house. This area became one of the richest zones on the façade and inside the house.

One of the reasons for this success may be attributed to the democratic nature of the design process. The flat hierarchy of the team structure and intensely iterative nature of the project created many checks in the design process. Rarely in the process did one person make a decision and then execute the design without collaboration and consensus. The team met and discussed the design and its relationship to the overall whole exhaustively. This constant group consensus allowed the intention of the team to be that more evident because the design ideas had to gain so many people's approval and be tested in so many different disciplinary realms before being executed. The team also benefited from the interdisciplinary nature of the team in that the design team was not just architects. Although the architecture team made the final decisions in the design of the house, the design team truly encompassed all disciplines. Thus the team could test the design ideas and their relationship to the principles within a broader audience before the Decathlon even began. Another reason that this principle was so effective in its translation into design can be attributed to the successful branding and communications message the team developed. Although developing integrated principles, goals and brand

may seem fairly mundane in terms of a design process, it is important to note that these principles and goals were not a post rationalization of decisions or a message the team developed in the middle of or after design. The infusion of this principle early on in the design and spirit of the team allowed the team to all have common goals and intentions. Clearly, a retrospective of the design process and reasons for its effectiveness reveal many processes and methods that can make design more rewarding and successful.

Process Retrospective

While the initial intention was to create a connection to nature architecturally through the zone on the south façade, when the team started this endeavor they could not have anticipated the eventual manifestation. Even as this zone developed, the drawings and physical models could not correctly convey the actual physical experience of being in this zone of the house. Because of this inability to foresee the eventual outcome and the opportunity to continue design through the construction process, the team was afforded a unique situation of partaking in and taking advantage of a true design-build process. As the diagram developed through the construction process, portions still left unbuilt could be refined and reconsidered to fully detail and sculpt the space.

Clearly this experience allowed the team to explore different methods of process and their effect on all aspects of the design process from schematic design through the construction process. The integrative, iterative nature of the project afforded the team the opportunity to fully explore and develop the principles and diagrams developed in schematic design and then to retrospectively examine their influence on both the process and final physical execution of the house design.



Figure 16: Photo of South Façade Layering

[Gardner]



Figure 17: Photo Looking South From Kitchen

[Gardner]

Appendix

Introduction

The Solar Decathlon is a design-build competition sponsored by the Department of Energy and the National Renewable Energy Lab. Proposals from twenty universities from around the world are accepted as part of this international competition to design and build an 800 sq. ft. completely solar-powered house. The competition takes place on the National Mall in Washington D.C. and consists of ten contests in which the teams partake while open to the public for tours.



Figure 18. Solar Village on the National Mall

[Richard King]

The goals of the competition are to “challenge the student competitors to think in new ways about energy and how it impacts our everyday lives,” as well as to “provide students with a way to show and tell the world what they have learned,” and to “push research and development of energy efficiency and energy production technologies in order to encourage all of us to act responsibly when making energy choices”

<http://www.solardecathlon.org/purpose.html>).

The universities chosen to compete in the 2007 Solar Decathlon were:

Carnegie Mellon University

Technische Universitat Darmstadt

Cornell University

Texas A&M University

Georgia Institute of Technology

Universidad Politecnica de Madrid

Kansas State University/University of Kansas

Universidad de Puerto Rico

Lawrence Technological University

University of Colorado at Boulder

Massachusetts Institute of Technology

University of Cincinnati

New York Institute of Technology

University of Illinois at Urbana-Champaign

Penn State

University of Maryland

Santa Clara University

University of Missouri-Rolla

Team Montreal

University of Texas at Austin

Figure 19. Houses chosen to compete in the Solar Decathlon.

After being chosen to participate in the 2007 Solar Decathlon, the twenty universities were asked to choose a site for their house along Decathlete Way on the National Mall. The site orientation served as a basis for beginning design of the house.



Figure 20. Chosen sites of houses on the National Mall.

[www.solardecathlon.org]

In addition to choosing a site, teams were also asked to use the Rules and Regulations established by the DOE and NREL as a set of guidelines for designing the houses and as a means for beginning to strategize about each of the ten contests. These contests include both subjective and objective contests ranging from architecture and engineering to hot water and energy balance and were judged on a series of criteria established in the Rules and Regulations. The criteria are as follows:

Solar Decathlon - The Ten Contests

Contest 1 – Architecture: To be architecturally sound, a home’s design must not only satisfy human comfort needs, it must also be well organized and visually pleasing both inside and out. The Architecture contest is intended to demonstrate that solar-powered, energy-efficient homes can be designed to meet enduring architectural standards. A jury of architects will judge each entry on the overall aesthetics and the successful design and integration of the solar, energy-efficiency, and other technical features of the house. The jury will evaluate the houses early in the week of contests and will not be influenced by the objectively measured performances of the houses.

Contest 2 – Engineering: Although architects are critical collaborators in the engineering design of well-integrated high performance homes, engineers and other technical experts possess unique skills that are required to design, specify, install, and maintain the house’s systems. A jury of technical experts in the residential building industry will judge each entry on the functionality, efficiency, innovation, robustness, and economic value of the house’s building envelope, environmental control, mechanical, electrical, and plumbing systems.

Contest 3 – Market Viability: An important objective of the Solar Decathlon is to prove that homes containing solar and energy-efficient design and technologies are market ready and belong in the world’s diverse neighborhoods. Experts from the building industry will compose the jury for this contest. Judging will take place early in the week of contests and will not be influenced by the objectively measured technical performance of the houses.

Contest 4 – Communications: The Solar Decathlon is a competition and a public event. The Communications contest challenges teams to communicate their experiences in this project to a general audience. Through Web sites and public tours, the teams will share the knowledge they have acquired. Their experiences and their houses will serve as living demonstrations of the viability of solar energy and energy efficiency technologies in the home. Panels of judges with expertise in communications and public relations will award points based on subjective evaluations of the teams’ Web sites and house tours.

Contest 5 – Comfort Zone: Well-designed houses provide a safe and comfortable indoor environment for occupants through heating, cooling, humidity, and ventilation controls. In this contest, the teams will be evaluated objectively on their ability to maintain temperature and relative humidity within prescribed set points. Other aspects of indoor environmental quality will be evaluated in Contest 2: Engineering.

(http://www.solardecathlon.org/pdfs/sd07_rules_regs.pdf)

Figure 21. Ten contents with descriptions.

[www.solardecathlon.org]

Solar Decathlon - The Ten Contests

Contest 6 – Appliances: A house is not a home without kitchen appliances, laundry facilities, and electronics such as personal computers and TV/video players. This contest requires the teams to demonstrate that their houses can provide the necessary energy to effectively operate appliances and electronics. The teams will store food in their refrigerators and freezers, host a dinner party, wash dishes, and do laundry during the week of contests. The teams will also be required to operate their personal computers and TV/video players a set number of hours each day. All points for this contest will be awarded based on task completion and objective performance evaluations of the required appliances and electronics.

Contest 7 – Hot Water: This contest demonstrates that the teams' houses can provide all of the energy necessary to heat water for domestic uses. Teams will receive points for performing tests that simulate the average time and temperature requirements for two showers each day of the contest week. Twice per day, teams will have to deliver 15 gallons (56.8 liters) of hot water (at least 110°F [43.3°C]) in no more than 10 minutes.

Contest 8 – Lighting: Sunlight, moonlight, and electric light all contribute to the livability and environment of a dwelling, inside and out. Lighting systems should be designed to minimize energy use by maximizing the contribution of daylighting and by using controls to minimize the use of electric illumination. This contest evaluates the quantity and quality of the lighting in the houses both day and night. Points will be awarded on a team's ability to provide acceptable lighting levels for specified durations. A jury of lighting experts will award points on the basis of subjective evaluations of the teams' lighting system designs.

Contest 9 – Energy Balance: is to produce as much or more energy than the house consumes over a defined period of time to demonstrate that the house and its systems function sustainably. Points will be awarded based on each team's ability to use their solar electric systems to produce as much electrical energy as they require during the contest week.

Contest 10 – Getting Around: Because the amount of energy households use to meet their personal transportation needs is so significant, this contest is designed to demonstrate that a house itself can be used to provide that energy. The contest evaluates how much "extra" energy the houses can generate to provide transportation for the teams in street-legal, commercially available electric vehicles, which will be provided by the organizers. All points for this contest will be awarded based on objective evaluation—the more miles the teams drive, the more points they get.

(The complete document of Rules and Regulations can be found on the Solar Decathlon website at: http://www.solardecathlon.org/pdfs/sd07_rules_regs.pdf)

Figure 22. Ten contests with descriptions (cont.'d)

[www.solardecathlon.org]

Using these criteria as a framework for designing, the twenty chosen universities spent approximately two years designing and building their solar-powered houses, and then transported them to the National Mall in October of 2007 where they were completed and open for public tours. The ten contests were judged over the course of a week and subjective contest winners were announced each day. Final scores and standings were announced on the last day of the competition in an Awards Ceremony in which all teams were congratulated on their concerted efforts and outstanding achievements over the course of the project.

In order to accomplish the goals set forth by the Solar Decathlon, teams developed their own organization, strategies and ideals for designing and delivering a solar-powered house; aesthetically pleasing and functional, using available, off the shelf technologies as well as new and innovative means by which to live sustainably and energy efficiently.

Pre-Design

Introduction

Design of the University of Maryland 2007 Solar Decathlon entry began in January of 2006 in a graduate level studio. The goal of the studio was to design and detail the house to the level of Design Development Documents; the first set of deliverables judged by NREL. Before these deliverables could be completed, the studio, comprised of graduate students, faculty advisors, industry mentors and members of the 2005 Solar Decathlon Team, established principles, goals, and intentions for the house, separate from those set forth by the competition. These goals and intentions consisted of both individual and team goals and intentions as well as goals and intentions for the house ranging from discussions about how to tell the story of the house and communicate the message to the public, to the desire to have the design of the house reflect the principles established by the team. A means for making design development and competition decisions was developed by way of a team organization consisting of a flat hierarchy of students from a variety of disciplines within the university.

Team Organization

The team consists of a cadre of eager, intelligent, insightful, committed students from disciplines including architecture; mechanical, electrical, structural, environmental, computer, and aerospace engineering; computer science; economics; accounting; English; journalism; communication; finance; chemistry; physics; neuroscience; geography; and landscape architecture. The group of faculty, professional colleagues and mentors represents an equally broad spectrum of knowledge and expertise.

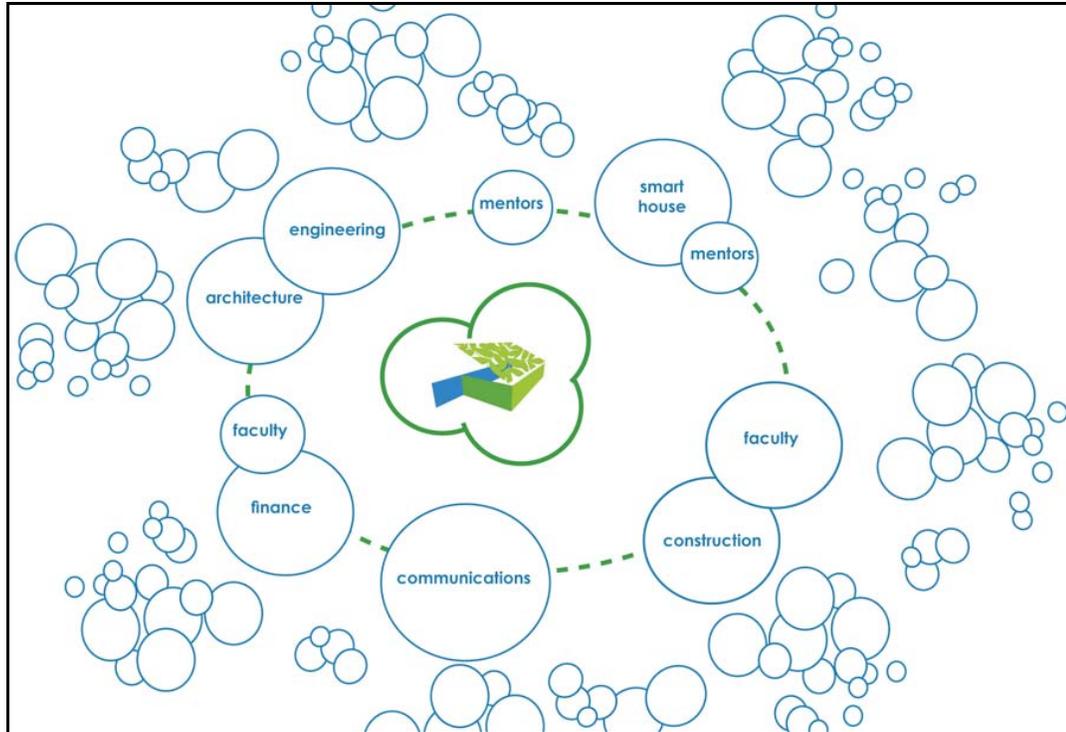


Figure 23: Bubble Diagram of Team Organization.

[LEAFHouse Team]

The organizational structure is a matrix of interdependencies with clear leadership, but not a traditional hierarchy. This fosters communication and collaboration, rather than emphasizing individuals. Everyone involved in the project, from students to professionals, has the benefit of learning from each other. From the beginning of the project, the team established the importance of having architecture and engineering students work together on different aspects of the project. In fact, one of the goals set forth by the team was to change the means by which we design, encouraging a number of disciplines to collaborate from conception to completion, working alongside each other rather than separately.



Figure 24: The team at the Green Building Institute in Jessup, Maryland. [Gardner]

The University of Maryland entry was created through interdisciplinary teamwork, resulting in an integrated whole in which architecture and engineering elements complement and complete each other. The architecture is intricately linked with the systems and the systems reflect the diagrams, thoughts and intentions of the team as a whole.

Team Intentions

The Maryland Team viewed the Solar Decathlon as an opportunity to ask, and answer, questions about the way we live. How do our actions affect the environment and impact the future? What makes a “house” a “home?” What do the Vitruvian ideals of firmness, commodity and delight mean for the 21st century? How do we integrate

technology into our lifestyle? These inquiries led to an exploration of the very nature and meaning of the form and use of the house, its place in society, and its relationship to the natural environment.

The team began by studying the way that we “dwell”, establishing intentions, strategies and tactics for changing the way we “dwell”. Diagrams were made to reflect the ideals of dwelling, provoking a thought process for designing the house that reflected the way we *should* “dwell” in the 21st century.

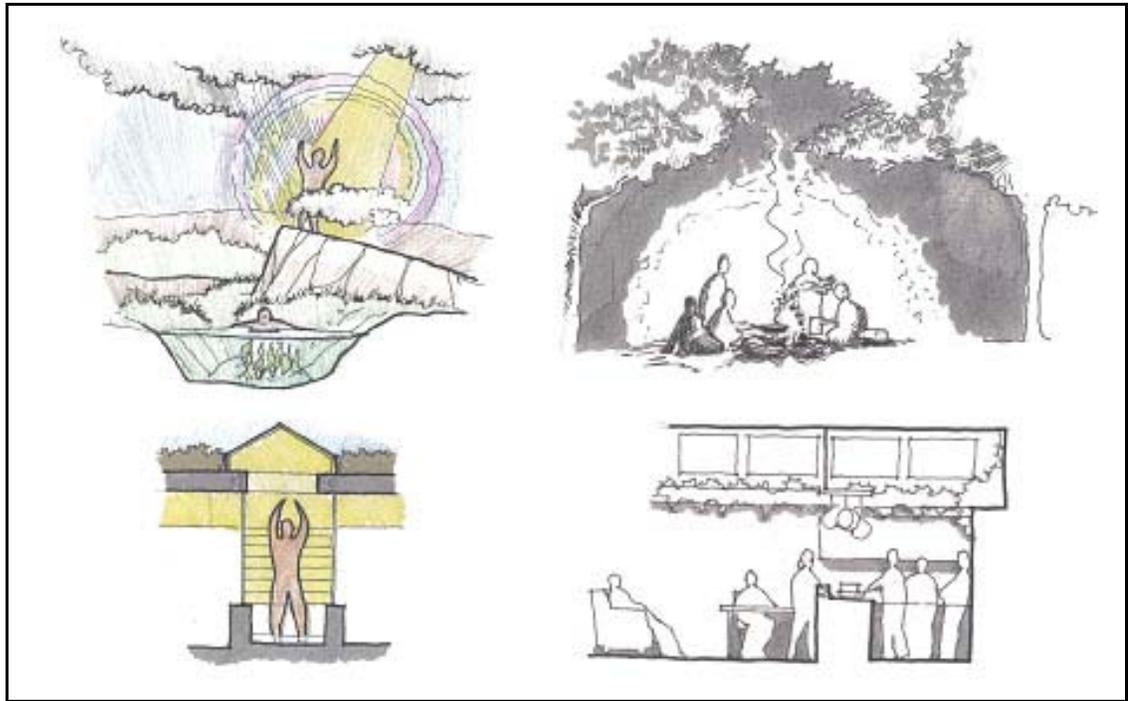


Figure 25: Diagrams examining the way we dwell versus the way we *should* dwell. [Mike Binder]



Figure 26: Intentions, Strategies and Tactics brainstorming session.

[Amy Gardner]

The intentions established for the house ranged from minimal impact on the landscape, to the re-establishment of a connection to nature, both visually and experientially. Strategies and tactics were developed to ensure the reality of the intentions. These included designing in such a way to minimize the footprint of the house on the site, locating the house thoughtfully on the site and designing with a “complete life-cycle mentality” – suggesting the use of recycled materials, and materials that are easily recyclable and sustainable.

The goals of the team became to demonstrate that through multidisciplinary design, a more responsible and sustainable architecture can be produced. The following five principles became the framework that guided the project from start to finish - use

nature as inspiration and mentor, demonstrate the practicality of solar technology, change the design and build process, address the Chesapeake Bay Watershed issues, and raise awareness about practical solutions and environmental stewardship.

Five design principles were also established as a result of team meetings and collaboration which the team used as a checklist which students used to begin the design process. These principles acted as the conclusions that students made about the design of the house; that the house be livable, transformable, bio-inspired, connected to nature and sustainable.

House/Team Branding

Based on the 5 principles of design, the team had multiple brainstorming sessions on what the name of the house would be. The team wanted the name to be one which relayed a strong message to the public, and a name that also mimicked the design intentions of the house.

Several brainstorming sessions were held with communications mentor, Peter Kelley, to determine the target market and target region of the house, in addition to the brand, or label for the house. The name LEAFHouse was widely accepted by the team, in that it held true to the goals and intentions set forth by the team; nature as an inspiration, and was clearly able to portray the message of the team: that through interdisciplinary, sustainable and environmentally friendly design, we can accomplish the ultimate goal of “Leading Everyone to an Abundant Future.”

Target Market/Target Region



Figure 27: Communications mentor, Peter Kelley

[Gardner]

In addition to giving the house an identity, the team also defined a target market and a target region. After several brainstorming sessions identifying the goals and missions of the team, they defined the target market as early adopting baby boomers. This market can be characterized as empty nesters looking to downsize. They are easily adopting of sustainable and solar technologies and want to incorporate these innovations into their house in a way that is integrated yet also affordable. The target region was determined as a result of the team's building location, competition site and anticipated final resting place. Thus the team wanted the house to fit in aesthetically and systematically to the Chesapeake Bay region. The Chesapeake Bay watershed encompasses much of the east coast and is plagued by issues that the team found important to address through the design of the house. Some of these pertinent issues included water usage, erosion and humidity.

The team also discussed the ways which the LEAFHouse message and story could be relayed to the public in order to gain support and interest in the project as well as educate the local public about the issues found in the Chesapeake Bay region to improve the conditions of both the natural and built environment.

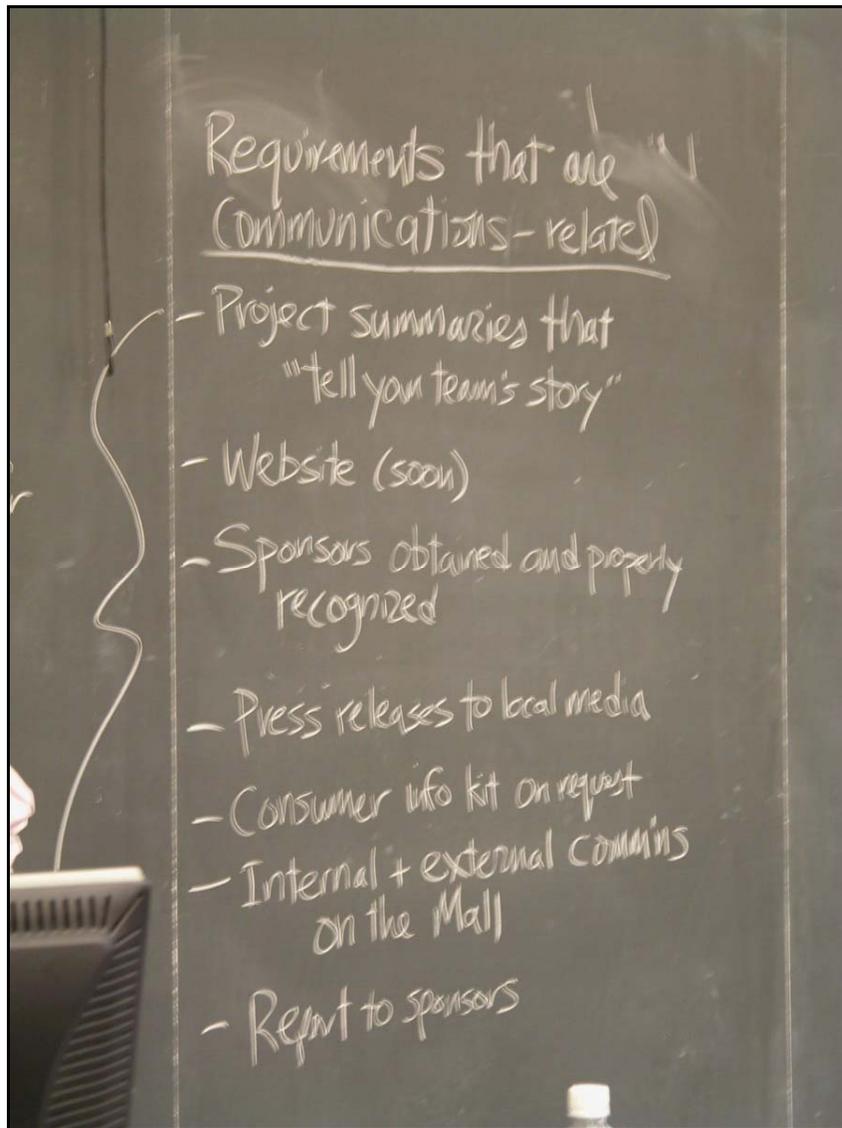


Figure 28: Potential Communications Strategies

[Gardner]

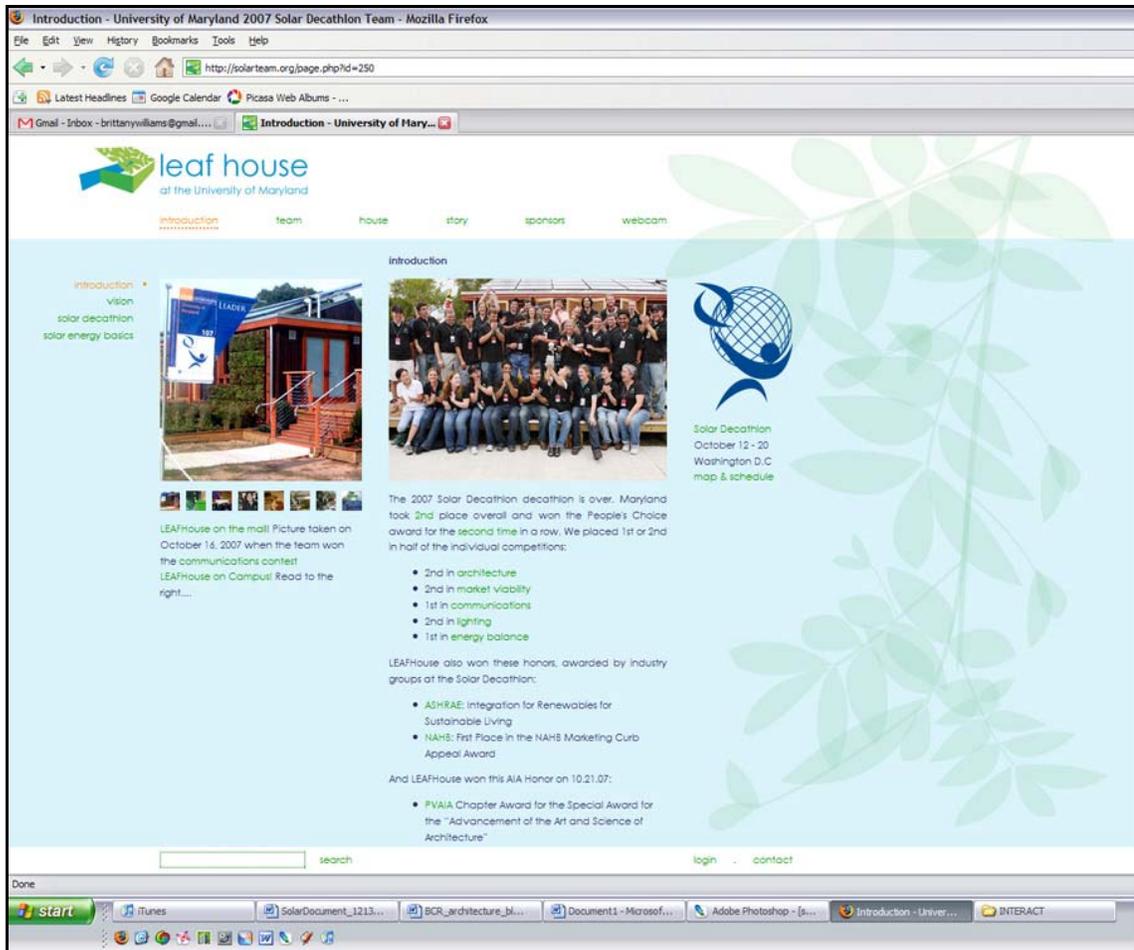


Figure 29: LEAFHouse Team Website

[www.solarteam.org]

Public Outreach

The team saw it as their mission not only to build an innovative and sustainable house, but also to educate the public about their journey and the things they learned along the way. This mission was achieved in many ways including face to face meetings and presentations with professionals and local organizations, the team’s website, and celebratory events. All of these methods were equally important as the team saw spreading the word of the project as worthwhile and educational as building the house itself.

In order to tell the story of LEAFHouse, the team developed a website that was updated every week, showing the progress of the team. The website outlined the development of design and construction through a Photo Journal that contained images and text. The website also contained information for consumers about different aspects of LEAFHouse as well as information about how the public can apply technology and solar techniques to their own home. A webcam provided live feed of construction and meetings on site. Another portion of the website contained extensive information recognizing sponsors. This section showed the donations and services as well as guided the public in how they could implement these technologies and materials into their own lives. The website was an interactive and important part of the team and its outreach mission.

In order to spread the mission of LEAFHouse to as many people as possible, the team also made presentations to local organizations and professional practices. Through these presentations, the team hoped to gain support and raise awareness of the issues the team chose to address as well as learn from these organizations.

Through the process of design and construction, the team held events to promote the house, fundraise and celebrate the progress. In fall 2006, the team held an event to promote the house called Equinox. Held at Community Forklift, a second hand construction materials exchange, the team unveiled the house design and solicited support from the trades people, professionals and other members of the public in attendance.

Several months later to kick off the start of construction, the team hosted another event called Ground Raising. Members of the university, professionals and the media all

gathered at the School of Architecture, Planning and Preservation to celebrate the start of construction on LEAFHouse.

To celebrate the nearing of construction completion in September 2007, the team held an event just before moving the house for the competition. The event showcased the house and also gave an opportunity for the team to speak about their goals and wishes. University President Dr. C. D. Mote and Maryland State Senators were in attendance as well as students, team members, local media and the Mighty Sound of Maryland marching band.



Figure 30: Photographs of LEAFHouse Team Events

[Gaddam]

Speaker's Bureau Speaking Events

- * Baltimore Green Week / EcoFestival 2006, 2007
- * AIA Chesapeake Bay Presentation
- * Women in Engineering, University of Maryland
- * Art Farm at Red Wiggler 2006, 2007
- * Greater DC Tour of Solar Homes, 2006
- * Marks Thomas Green Futures Presentation
- * Society of Women Engineers / INCOSE
- * College Park Rotary Club
- * County Engineers Association of Maryland Conference
- * Green Building Institute Workshop
- * Regional Leadership Conference on Green Building
- * University Park Historic Preservation Group
- * OPX
- * IEEE Adcom
- * American Association of University Women
- * CSBA May Green Happy Hour
- * Stampfest, University of Maryland
- * Baltimore Building Congress and Exchange
- * Urbanite Beyond Sustainability Presentation
- * Bradley Hills Presbyterian Church
- * Baltimore Engineers' Club
- * DCAIA Design DC 2006
- * UMD Master of Real Estate Development Program Presentation
- * Bonstra/Haresign
- * Emerging Engineers, University of Maryland
- * William McDonough and Partners
- * Architecture 170: Introduction to Architecture course, UMD
- * University 100: Introduction to the University, UMD
- * UMD Sustainability Lecture Series 2007
- * Council of Scientific Society Presidents, Washington, DC

Figure 31: LEAFHouse Team Speaker's Bureau Events

Design

Precedents

Precedents which reflected the goals and intentions of the LEAFHouse were chosen and analyzed by the graduate studio. A sample of these precedents included Michelle Kaufman's Glidehouse, Flatpak, and Farnsworth House. All of the precedents studied were houses of a comparable size to LEAFHouse. The team studied the houses looking at treatments of programmatic layout, connection to nature, transformability and a variety of other aspects.



Figure 32: Michelle Kaufman GlideHouse, exterior.



Figure 33: Michelle Kaufman GlideHouse, interior.

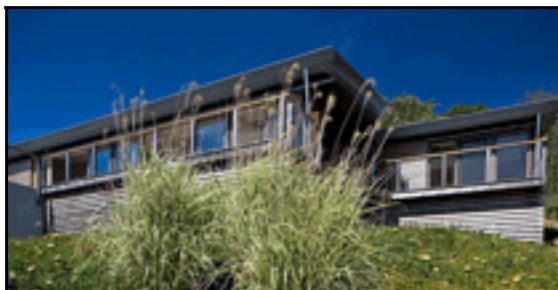


Figure 34: Michelle Kaufman GlideHouse, exterior.



Figure 35: Michelle Kaufman GlideHouse, interior. [<http://www.mkd-arc.com/homes/glidehouse/tour/tour.php>]

In Michelle Kaufman's GlideHouse, the team examined the house's connection to nature as well as the basic programmatic layout. The house is relatively open and takes advantage of the connection to the exterior. Along the south side of the house, there are layers of sliding glass doors and panels that allow for a seamless connection to the outside.



Figure 36: Charlie Lazor Flatpak House. [http://www.treehugger.com/files/2005/01/flatpak_house.php]

Through an examination of the Flatpak House, the team explored the modularity of the design. The team also observed the way that the pieces of the houses were put together both on site and ahead of time. This exploration ultimately led the team to explore partnering with a modular home builder or panelizing the house itself.



Figure 37: Mies van der Rohe Farnsworth House.



Figure 38: Mies van der Rohe Farnsworth House.



Figure 39: Mies van der Rohe Farnsworth House. [<http://www.farnsworthhouse.org/photos.htm>]

The team also examined the Farnsworth House. Through diagrams and research the team observed an open layout as well as strong visual connection to the exterior. This precedent provided an example of architecture touching lightly on the earth. The house also contains overlapping spaces which the team could apply to their own design.

The precedent studies done in preparation for designing the solar house were exhaustive and informative. Through observation and analysis, the team created a catalogue of ideas and techniques directly and indirectly applicable to LEAFHouse.

Three Schemes

Based on precedent studies and earlier established principles, students worked individually on a scheme and were then paired based on similar ideas about the design of the house. From this came three different schemes for the solar house which were then discussed, determining which features best represent the goals of LEAFHouse, and finding a way to incorporate them all into the final design of the house.

The three schemes that were developed were:

Courtyard House



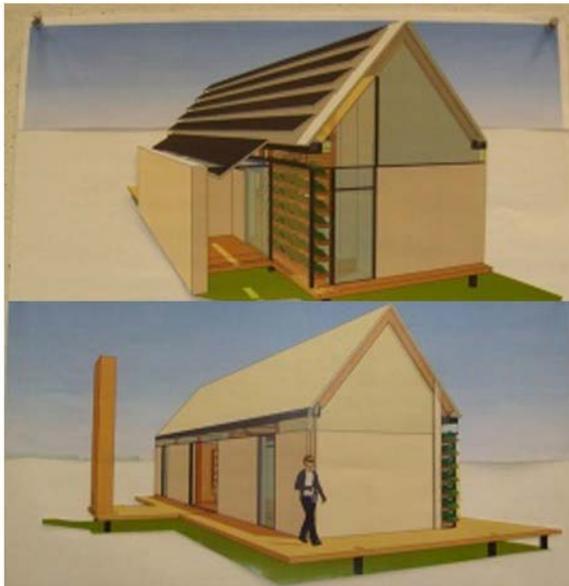
The design of the courtyard house focused on using multiple modules to create outdoor spaces. The bathroom module was connected to a green wall water filtration system and to the kitchen, creating a bio-mechanical core. This linear core divided the entry court from the private bedroom deck. The interior design also stressed openness and modularity. A pergola extending from the roof helped emphasize the horizontality of the roof.



Figure 40: Scheme 1: Courtyard House

[Mike Binder and Huijun Shang]

Icon House



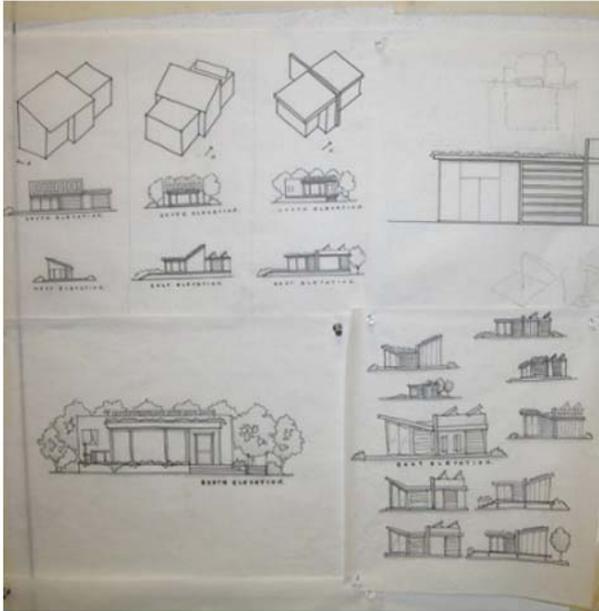
The design concept featured a symmetric gabled roof, very iconic in residential architecture. The plan stressed flexible use of interior space and a simple, straightforward bar parti. The south façade incorporated a green wall to moderate temperature and connect the residents to the natural world.



Figure 41: Scheme 2: Icon House

[Debbie Bauer, Devin Kimmel, Jef Zaborski]

Pavilion in the Landscape



The group's design for the pavilion in the landscape was centered on the vision of touching lightly on the earth; the south pavilion essentially being a glass box, housing the public areas of the house. The north pavilion was a much more solid box housing the private parts of the program. The two were united by a thick wall that housed much of the mechanical equipment. This wall created a strong datum that extended the house into the landscape, becoming an object in the landscape.

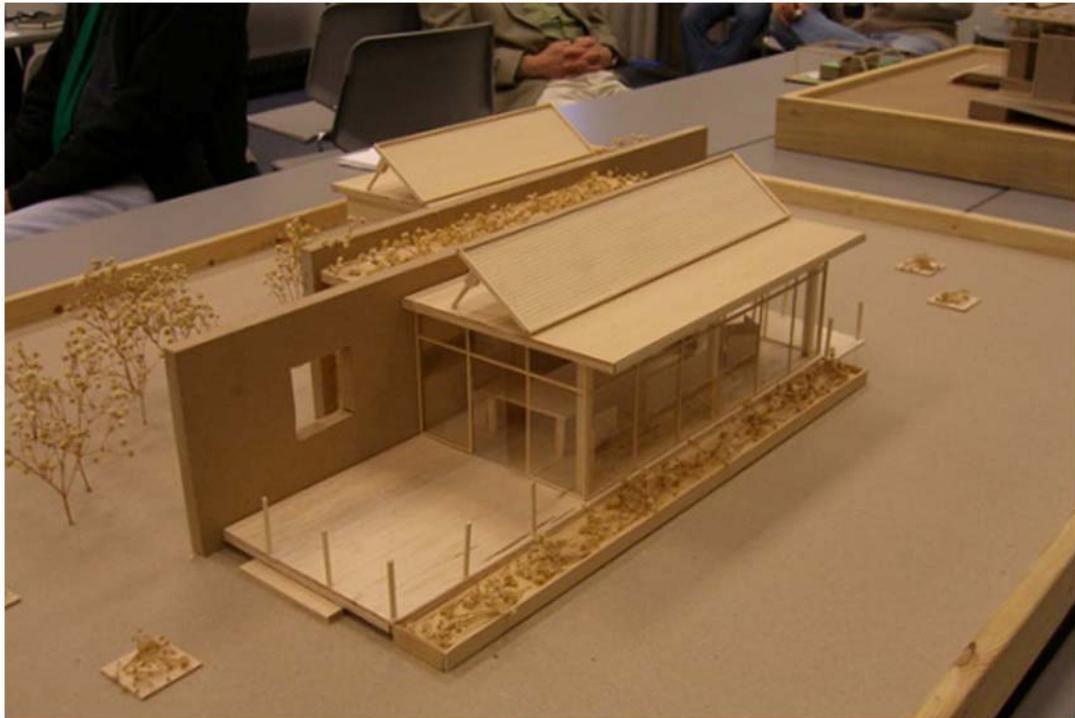


Figure 42: Scheme 3: Pavilion in the Landscape.

[Kim Singleton, Brittany Williams]

After the three schemes were developed, students, mentors, and industry professionals analyzed the house designs, and chose different elements that they believed should be present in the final house design. The students then took these design elements and principles and developed a diagram which encompassed all of those ideas. The parti which resulted embraced the five design principles developed at the beginning of the semester. These principles were expanded upon and became a set of goals toward which the team worked in the detailing and completion of the house.

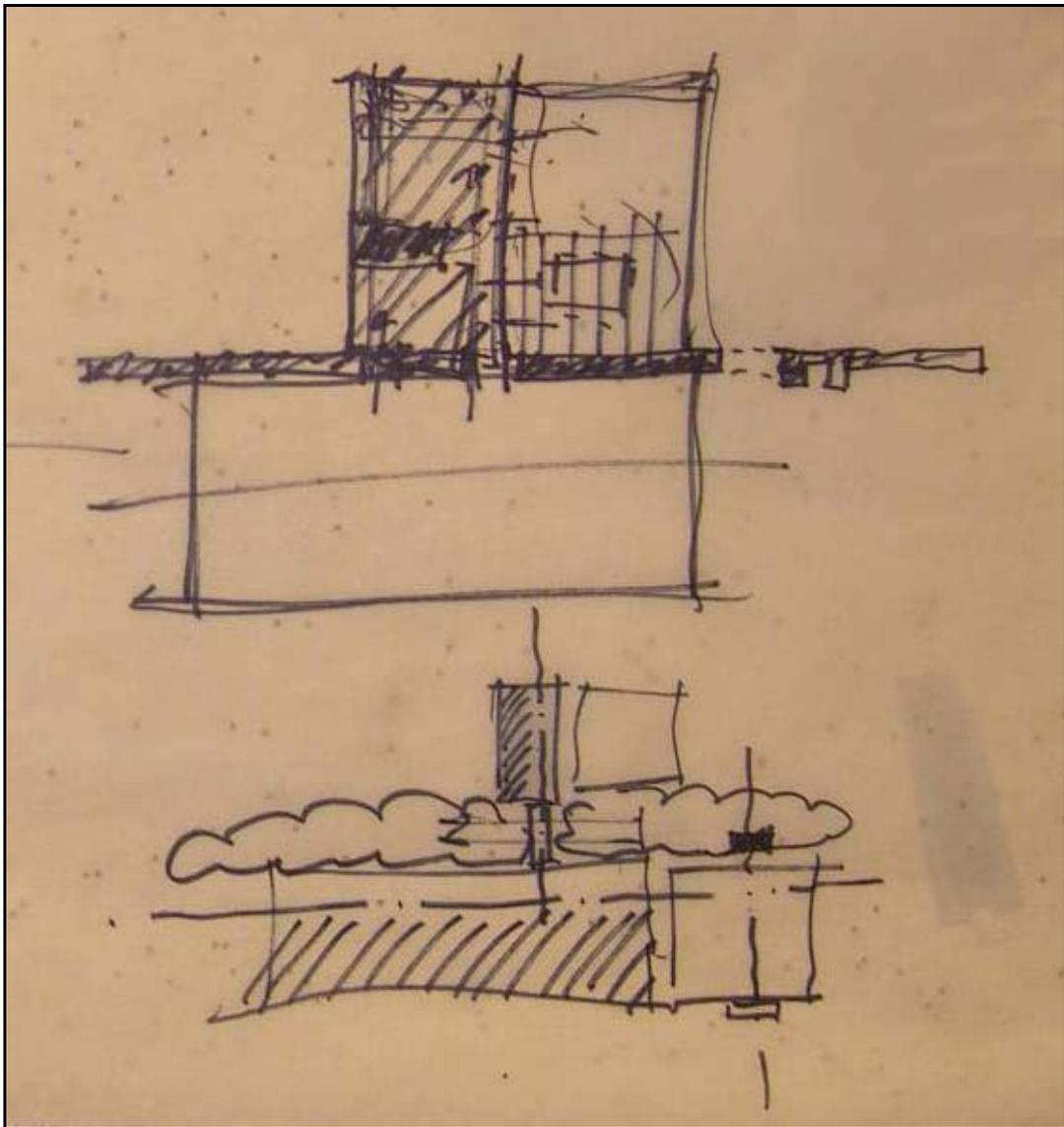


Figure 43: Parti for the final design of the house.

[LEAFHouse Team]

Construction Documents

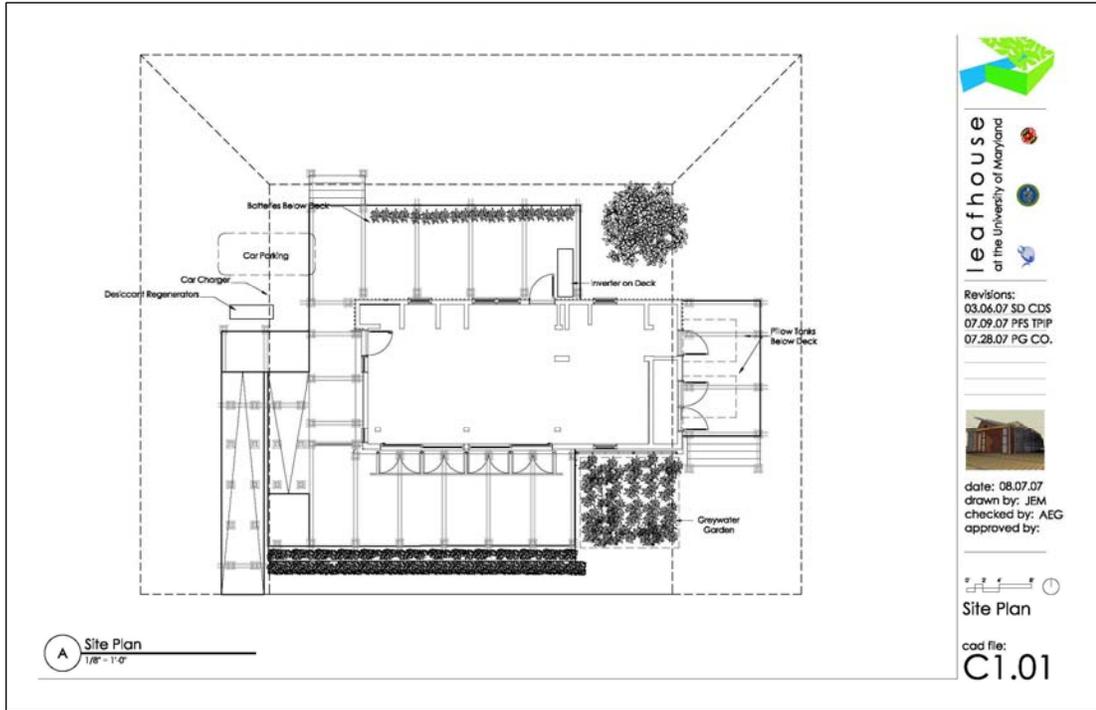


Figure 48: Site Plan.

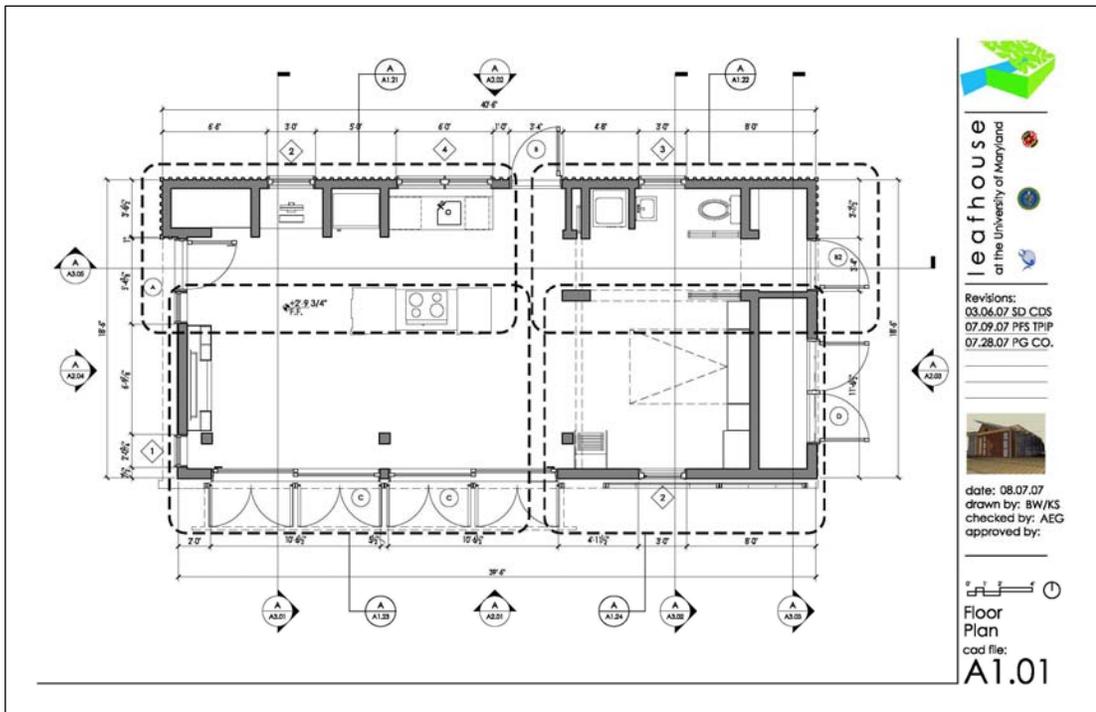


Figure 49: Floor Plan.

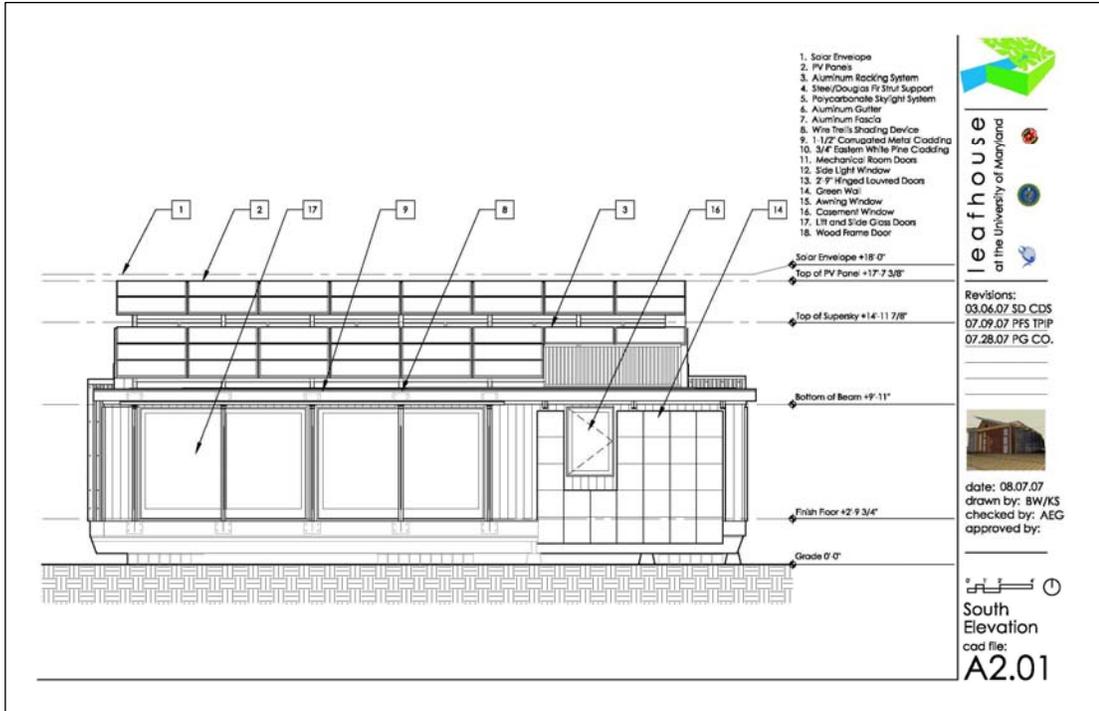


Figure 50: South Elevation.

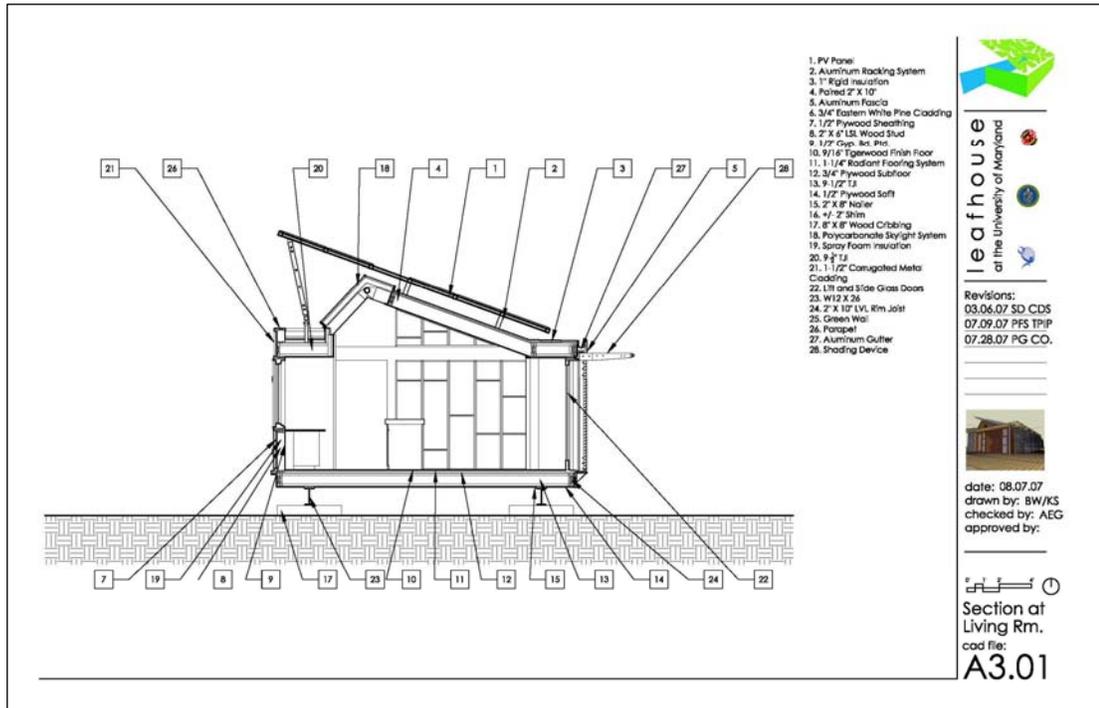


Figure 51: Transverse Section.

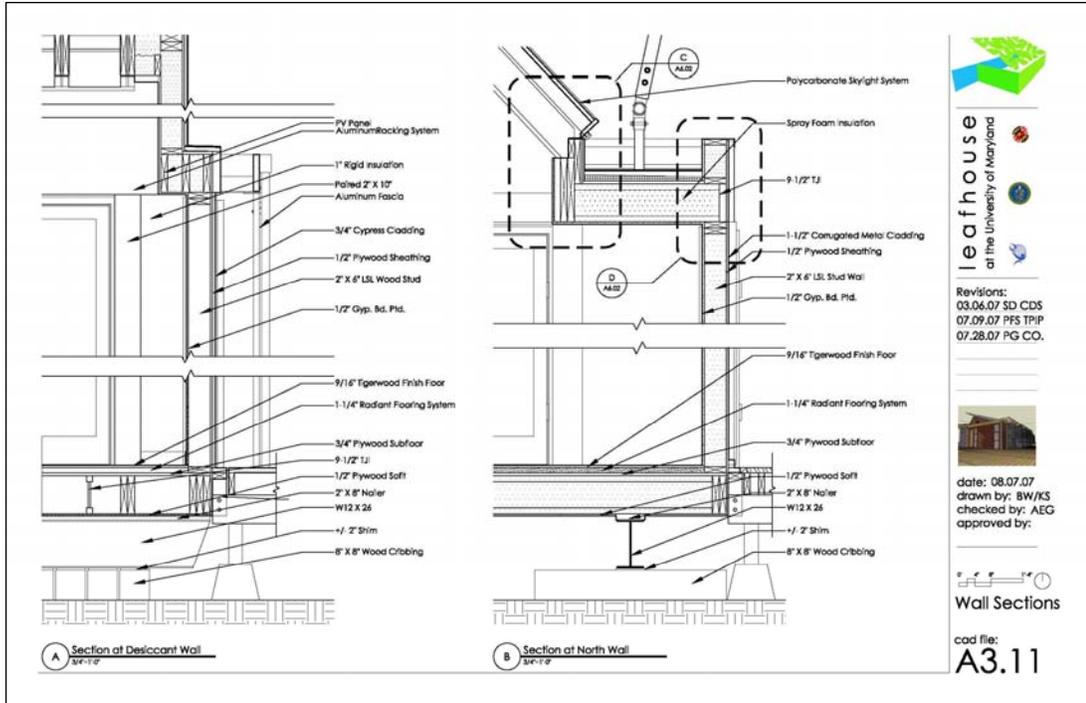


Figure 52: Wall Sections.

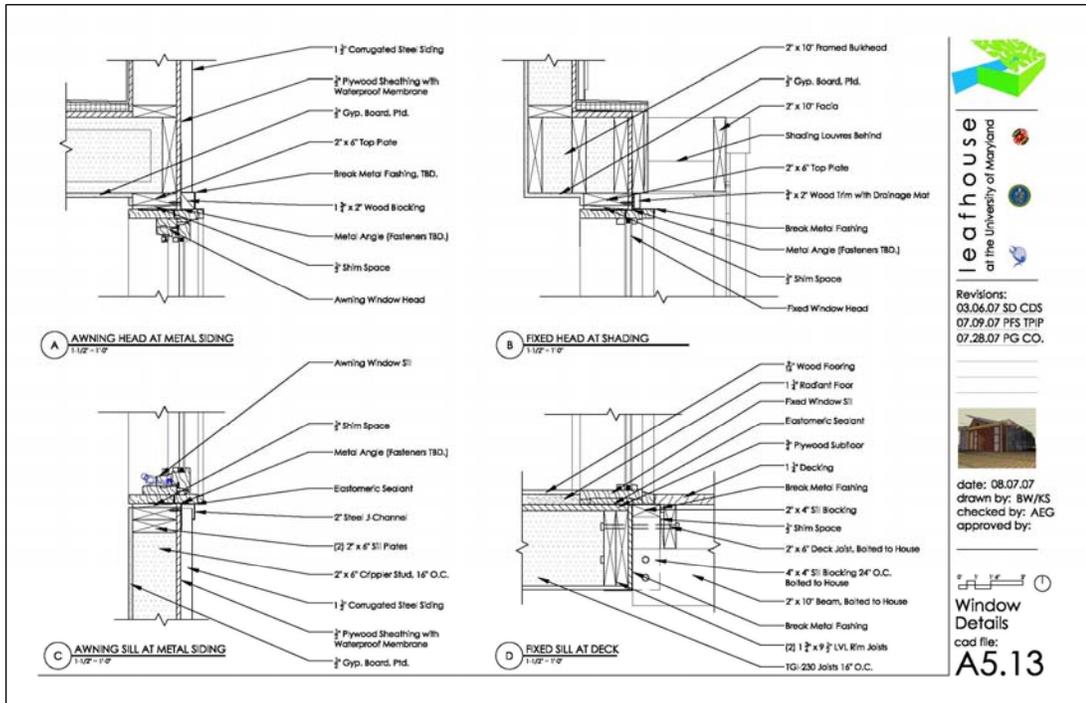


Figure 53: Details.

Shop Drawings

Throughout the entire two year design process, the team worked towards compiling, detailing, and describing drawings in packages that were sent out to the various manufacturers and trades people. Over the course of ten months, packages and shop drawings were sent out for everything from the roof and exterior finishes of the house, to insulation, interior casework, and finishes.

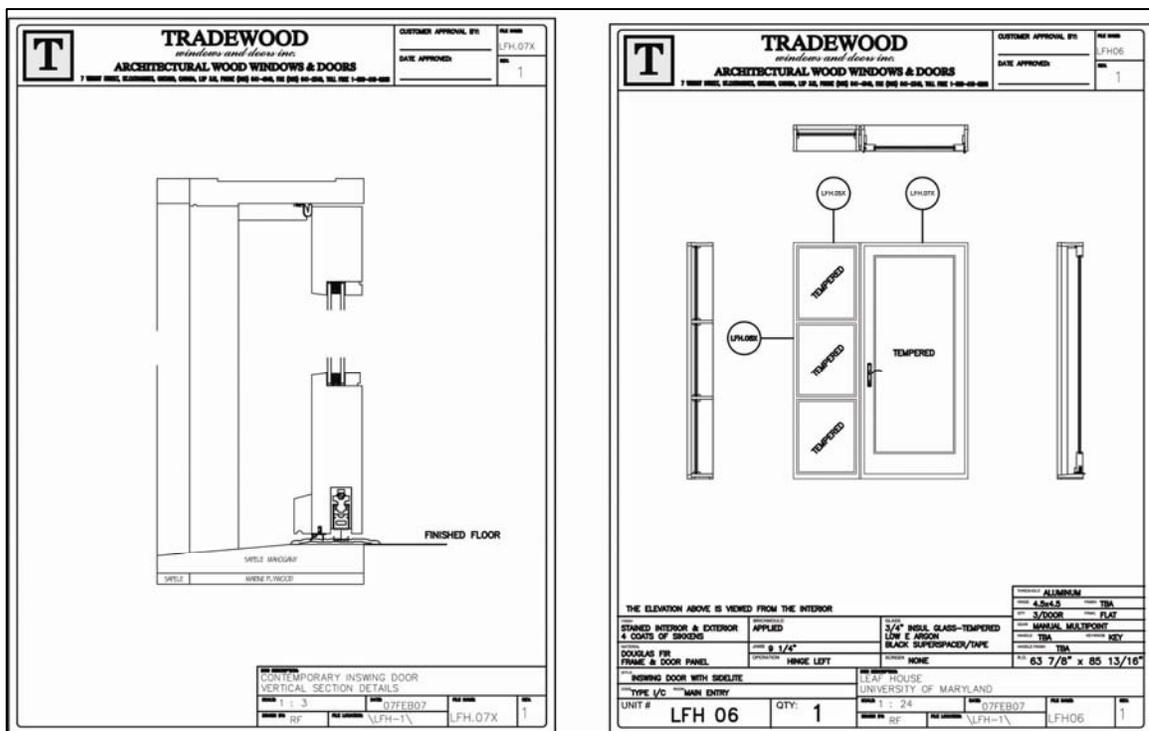


Figure 54: Tradewood Shop Drawings.

[Tradewood]

Packages changed as design decisions changed, and everything continually had to be re-detailed and re-checked to ensure it was correct. At these critical times, it was vital that the entire team was involved and collaborated to ensure that each team member was aware of the changes being made and how those changes affected the work of each composite team. Clear and concise discussions were had with mentors, suppliers and

suppliers/manufacturers, and the process continued for weeks depending on the depth of detail and precision necessary for that part or system.

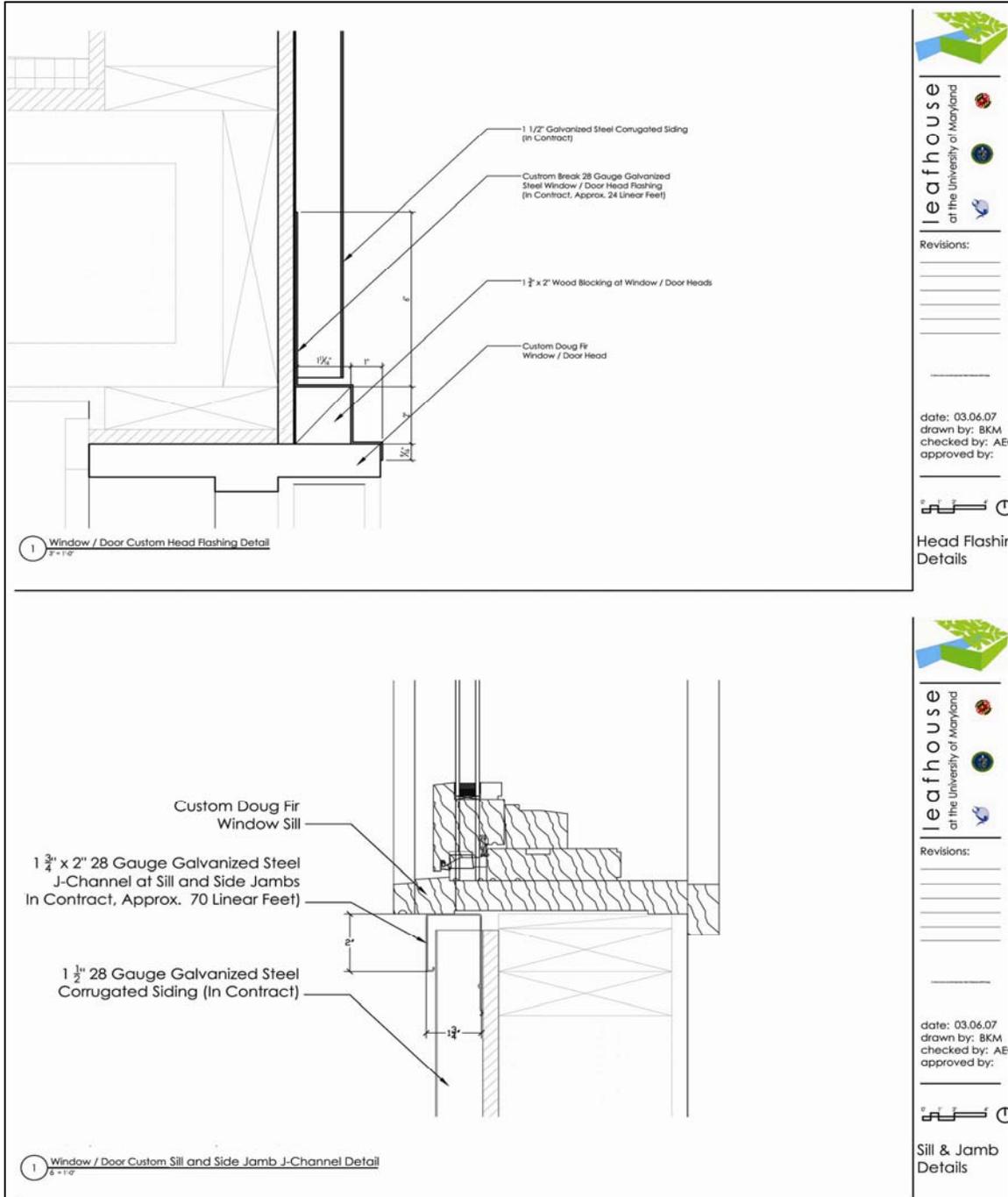


Figure 55: ATAS Siding Detail Shop Drawings

[LEAFHouse Team]

The process of completing the shop drawing became a back and forth between the team and the manufacturers. This learning process had an effect on the schedule, of course; however, the team gained valuable experience and expertise in this realm in their dealings with all of the various manufacturers, as each subsequent package, as a result became more and more succinct and well described than the previous

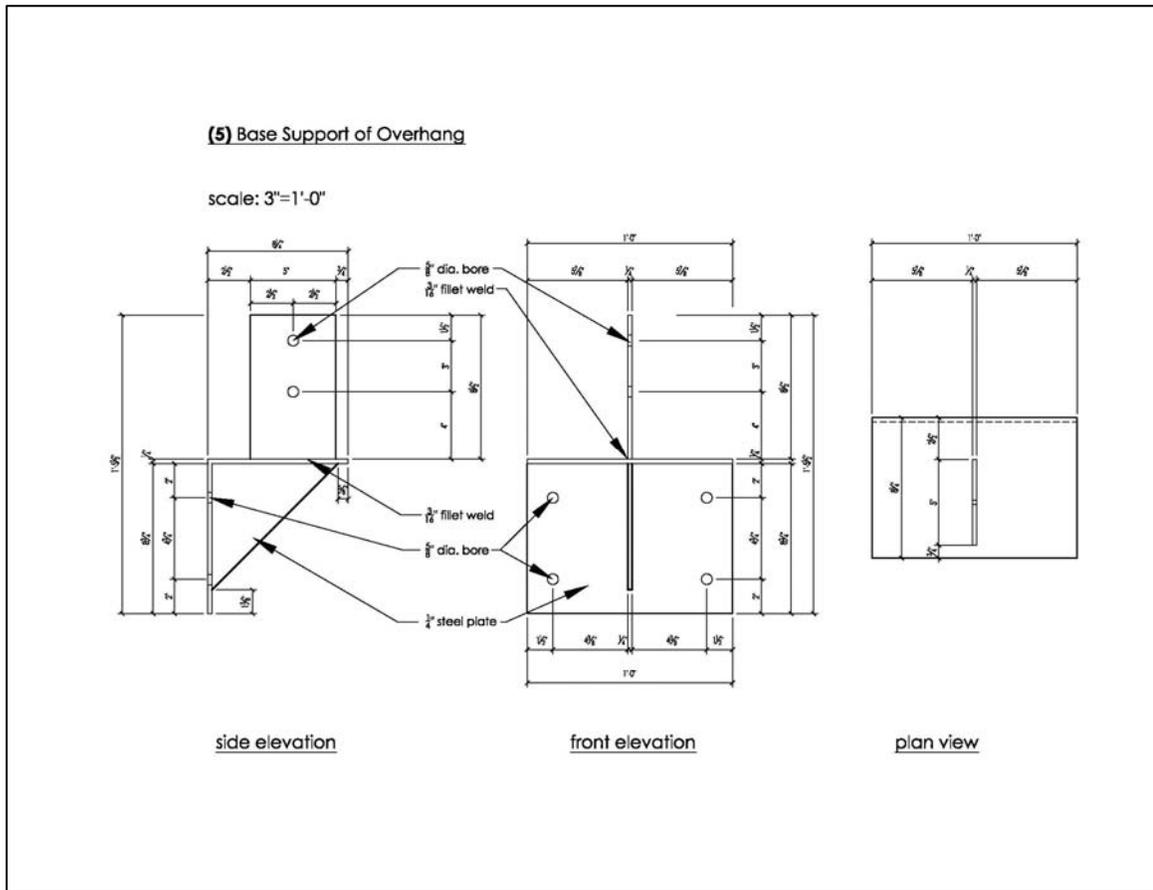


Figure 56: Shop Drawings for South Overhang Supports.

[LEAFHouse Team]

The Design



Figure 57: Aerial View of Plan

[LEAFHouse Team]



Figure 58: View of South Façade.

[Williams]



Figure 59: Interior Space looking at the living room and kitchen. [Photo by Amy Gardner]



Figure 60: Perspective of southern green wall. [Photo by Amy Gardner]



Figure 61: Perspective of southern wall of glass and louvers. [Photo by Amy Gardner]



Figure 62: Perspective of eastern elevation. [Photo by Amy Gardner]



The design of LEAFHouse is a marriage of interdisciplinary team work, resulting in an integrated whole in which architecture and engineering elements work in accord with and compliment each other. The architecture cannot be discussed without the inclusion of other systems and ideals. The overall design strategy is born from three central principles: the intent to connect to the natural world; to create a home that is transformable at many scales, and that in order to Lead Everyone to An Abundant Future, energy efficiency is understood as a central form-giver.

Engineering Integration

The LEAFHouse design process is founded on the premise that architectural and engineering design inform each another, with the focus of integrating emerging technologies with time-tested passive techniques.

The engineering features became integral parts of the design that informed both broad ranging architectural concepts as well as details. A liquid desiccant wall is a focal point in the living room and melds both architectural and engineering design through the interaction of the equipment, casework and space. A similar synchronicity between architecture and engineering exists in the design of the roof. The roof was explicitly designed with a structural strategy that simultaneously provides a daylight spine that illuminates and organizes the space and and structure. The solar panels and evacuated hot water tubes soar above the roof on an extruded aluminum racking system that follows the slope of the roof. The PV panels become a second skin that cantilevers over the skylight system and is grounded by a delicate steel and wood strut system. Other integrated systems can be found throughout the house.



Nature as Inspiration

LEAFHouse strives to work in tandem with nature. By studying and working with nature, the team has incorporated both passive design strategies as well as innovative bio inspired elements into the house. These features range in scale from small details to overarching ideas that informed the design.

LEAFHouse is modeled after a leaf both in function and in appearance. As nature's ultimate solar collector, the architecture and engineering aspects come together to approximate the leaf. Architecturally, portions of the house are designed so that the skin reveals the structure of the house itself. On the interior, the finish material is pulled away at the ridge of the roof to reveal alternating paired rafters sandwiching a steel knife plate system that connect to a delicate steel pipe. The steel pipe runs the length of the house and is framed by a translucent skylight that sits above. This skylight highlights the structural and architectural feature of the house and also provides diffuse light through out the house. This feature alludes to the veins of a leaf.

Organizational Strategies

As a response to solar orientation and programmatic challenges, LEAFHouse is divided into a public and private zone. These zones are articulated architecturally through differing fenestrations and through exterior skins. The two major use zones are



Figure 63: Architecture Brief Contest Report.

[LEAFHouse Team]



then tied together with a biomechanical zone that runs along the north portion of the house. This zone houses much of the mechanical equipment of the house and is a solid bar with volumes carved away to create different areas of use within. The house is thus conceived in layers, from the organization of spaces to the concept of the roof. The north and east zones are the "bio-mechanical layer", nestling the "living zones" in their embrace and rendering them largely free of fixed walls.

The roof structure is another example of layering: LEAFHouse roof design draws from the concept of tropical "double" roofs, which encourage air flow between the house roof and the upper roof, thereby passively cooling the house roof as well as the back of the PV panels. It also shades the lower roof, deflecting radiant energy gain. The PV array is the upper canopy, -- an aesthetically pleasing grid that can support a variety of PV configurations, solar thermal systems, or can be used as a trellis/shading system when extended past the boundaries of the house proper.

Transformability

Transformability is integral in the design of LEAFHouse. The design is flexible, to expand based on the needs of the inhabitant; needs that may change from day to day, seasonally, or over a period of years. Moveable panels within the house allow transformability of the spaces to provide the most efficient use of the spaces. These translucent moveable panels, while closed, create intimate spaces. Yet they can be configured in many different ways that allow the space to take on different qualities depending on the activities occurring in the house. This transformability is not limited to within the interior of the house and extends to the exterior as well. Large sliding glass doors that line the south public portion of the house can open up and users can take advantage of the deck area and surrounding site. At an even smaller scale, the house design includes many transformable features that aid in the ideals of living. Interior walls that serve double as tall pullout cabinets, a Murphy bed and a nesting dining room table that can allow for expansion are all ways that LEAFHouse can adapt to the needs of the user.

The house is also transformable at the scale of the community. LEAFHouse is designed to be extended into expanded models and communities, by virtue of adding modules or aggregating into larger building types. These various models and communities encompass a variety of densities and lifestyles from apartment complexes to single family homes.

Connection to Nature

Seen as an extension of the house, the site design follows the intentions of the architecture and engineering concepts. The south side of the house is the more public of the several outdoor "rooms".. A large spacious deck with strong physical and visual connections to the interior create a place to socialize and call the front porch. The north side of the house is more private and intimate. A landscaping, including a full sized tree, create carefully framed views from in the house as well as sculpt outdoor spaces. The north side of the house is also a place where the site and engineering concepts come together. The desiccant regenerators, solar power inverter, and condenser all help to shape the exterior spaces and extend the logic of the interior spatial organization.

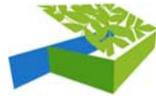
The house and site are conceived as a system in other ways, as well. They are linked through the water management systems. Rain- and grey water gardens join the house to the landscape. One of the most important features of the landscape is the "building integrated storm water management system" -- a vertical rain garden on the south side of the house. This green wall of plants is not only aesthetic, but it also filters water run off from the roof. This green wall joins the house to the grey water garden located adjacent.

Materiality

Aside from the especially innovative items in the house, LEAFHouse is built with time-tested, readily available materials used in innovative ways. From sustainably harvested local woods to recycled corrugated metal siding, the materials in the house were chosen for their beauty, ease in construction, and environmental appeal.

Figure 64: Architecture Brief Contest Report (cont.'d)

. [LEAFHouse Team]



A robust communications and outreach program is critical for the Solar Decathlon to have the impact it deserves at a critical moment for the development of U.S. solar energy. As the "hometown team," we have taken on several tasks meant to magnify the impact not only of our entry in the contest, but of all the teams' efforts. Our communications and outreach program is showcasing the contest's broader goals, as well as the LEAF House, in the Washington, D.C. media market and in Congress—and in the Maryland State Legislature, the major research university that hosts us, and our community of suppliers and supporters.

Public events

As the "hometown team," we are organizing a Lobby Week from Sept. 10-14 during which team members will meet with Members of Congress and staff members to describe the Solar Decathlon and educate them about the value of solar energy. During that week, on Sept. 11, we will also provide a pre-Mall tour of our entry for members of the Maryland State Legislature, in the form of a "send-off party." Then on Thursday, Oct. 18, after closing hour on the Mall, we will hold a VIP reception for major donors and suppliers, university leaders, and congressional staff, featuring a "100-mile dinner" that will consist of Maryland food and beverages all obtained within 100 miles of the National Mall, and prepared at the house.

We previously held a well-attended opening kickoff party last fall at the Community Forklift, a local supplier of recycled building materials; and, a "ground-raising" ceremony to launch construction this spring. Both were covered by local newspapers, radio, and TV.

Media outreach

The above events have been promoted to local media as opportunities to cover the students' community service, the novel features of solar houses and the LEAF House in particular, and the broader goals of energy independence and reducing pollution. Our most recent media "hit" was a feature in July on the evening news program of the local CBS affiliate, WUSA-TV, mentioning our "edible" soy insulation, the interior desiccant waterfall, and other elements, and interviewing several team members and mentors. We have partnered with a local green PR firm, Kelley Campaigns (the DC representative of the RenewComm renewable energy communications practice), to obtain professional coaching and University of Maryland communications interns who produce press materials and call the media on our behalf.

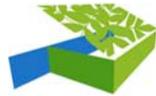
Printed materials

Our commitment to a broader impact is shown by our flyer for the Mall, which includes a postcard for house visitors to mail to their member of Congress in support of solar energy—and a tearoff slip to let us know they sent the postcard, and make other pledges to energy savings at their own homes. (It also collects their email address for follow-up.)

The color flyer shows an exploded view of the house and explains the main systems, as well as illustrating other LEAF House configurations as an urban villa, a townhouse, a garden flat, or larger solar homes of up to 2,400 square feet. It is being printed at cost by a local union printer on recycled stock that is Rainforest Alliance- and FSC- certified.

Figure 65: Communication Brief Contest Report.

[LEAFHouse Team]



Video interview series

A series of short videos of team members are appearing on our website and on YouTube from Labor Day through the contest period. The video shorts portray team members' motivations, explain their favorite house features, and describe breakthroughs during the process of design, construction, and outreach. Team volunteers are editing the videos into slightly longer versions to be shown on the television in the Maryland house while it is on the Mall, to take every opportunity to entertain and educate visitors about the people behind the house and unique features that might not be readily apparent.

House interpretation

Interpretive signage features "nutrition labeling" in the style of shipping labels attached to the various items in the house, showing their energy savings and respective payback periods, as well as a running series of signs on the deck (to make the most of waiting time), and the house walls and fixtures. In addition, house visitors will be invited to use their cell phones to hear a recorded message at any time, day or night, explaining the Decathlon and the Maryland entry, for those who miss one of our regularly organized tours or prefer a self-guided tour.

House tours

We are coordinating tour guide recruitment efforts on campus with the leaders of the University of Maryland "First Year Book" program, who this year have asked that all freshmen read the book *Ravaging Tide*, by local author and organizer Mike Tidwell, about the potential impacts of climate change and sea-level rise on America's coastlines. (Maryland is the second state most at risk, after Louisiana.) Fresh from reading the book, freshmen are being invited to form a team of tour guides to be extensively trained to give tours on the Mall and supplement the core team of house builders. Additional campus visibility efforts have been coordinated through a class of undergraduate communications students who took on the Maryland entry as a semester-long project in planning a promotion campaign.

Speakers bureau

We have recruited and provided message and media training to a panel of knowledgeable team members and mentors who can represent the goals of solar power and sustainability to the Washington media and in group presentations. Their names and contact information appear on our website as a solar house speakers bureau, and bookings are being obtained.

House furnishing

A "retro metro" look has been selected for our house furnishings and incidental items to illustrate its appeal to the initial target audience we identified for the initial 800-square foot model of LEAF House: downsizing baby boomers, and affluent twenty- or thirty-somethings buying their first home or just starting their family. Further marketing materials are adopting this look and feel, as well, to make the house as appealing as possible to its core target market.

Team branding and messaging

The leaf motif of the Maryland team's logo and house name connotes nature's perfect solar collector, the leaf—as well as being an acronym for the number one project goal that emerged early during our branding process, namely, "Leading Everyone to an Abundant Future." The leaf is used in our logo and throughout our house and materials. Message-rich team T-shirts convey the bright future of "pure energy" from the sun, and tour guide uniform shirts are made from a sustainable bamboo fabric that is soft to the touch. Support from the University's First Year Book program has enabled all our tour guides to wear these shirts on the Mall, and help us convey the Decathlon's messages to the widest possible audience.

Figure 66: Communication Brief Contest Report (cont.'d)

[LEAFHouse Team]



In an effort to fuse sustainability and livability, the University of Maryland LEAFHouse utilizes a wide range of unique engineering techniques. With its blending of biological sensitivity and cutting-edge technology LEAFHouse creates a living experience like no other. The LEAF House was designed not only to cater to its inhabitants but also to minimize the footprint on its own environment. Through the hard work of many, the LEAFHouse is proud to present unique methods of powering, heating, and controlling your home.

Building Envelope

The building's skin is made up of wood, glass, vegetation, and corrugated metal applied to 2x6 wood stud walls filled with soy based spray foam insulation. There is a twenty-two foot, four-panel sliding glass door system which allows the sun and the environment to enter the household. There is also a translucent polycarbonate skylight running the full length of the ridge of the house in order to provide diffuse light into the house.

Indoor Environmental Control

One of the most unique aspects of the LEAFHouse is the application of its desiccant dehumidification. In order to decrease the normal electrical load associated with traditional dehumidifiers, LEAFHouse utilizes a liquid desiccant dehumidifier. This system uses very little electricity and is a highlight of the indoor décor. The desiccant that is used in the LEAF House is a Calcium Chloride solution that is a safe, odorless chemical that naturally absorbs moisture. When moisture is absorbed from the air, the compound heats up and is pumped to a reservoir near the roof of the house. Here it releases its heat and regenerates around 170 F (76.6 C). The desiccant dehumidification system is located in the living room of the house and is the focal point of the room.

In order to control the environment of the house, the LEAFHouse is equipped with a Smart House Adaptive Control System. This system gives the occupants the ability to interact with the house and track the house's conditions from a web based interface. The conditions can be viewed in real time and adjustments can be made in order to optimize energy use, humidity, light, and water consumption. SHAC allows the house to be maintained efficiently and economically through its automated control system that performs tasks and monitors the house based on collected data.



Figure 67: Engineering Brief Contest Report.

[LEAFHouse Team]



Mechanical

The LEAF House uses radiant heating to control the temperature in the house. It has heating panels in the floor in order to take advantage of heat rising. This system uses PEX tubing imbedded into MDF panels. This system enables efficient heating of the house at a low cost and takes advantage of thermodynamics to control the living environment.

The house is cooled by a ductless mini-split system. This system is set up as an auxiliary heat pump, which utilizes refrigerant lines and a fan to cool or heat the air. It will be set for 74 degrees Fahrenheit, causing it to heat or cool the air when necessary. The ductless mini-split system is run off of ozone friendly refrigerant, R410a. There will be two fans, one on the west facing wall of the mechanical wall and the other is on the south facing wall of the kitchen.



Electrical

The key to the success of LEAFHouse lies in the photovoltaic cells that convert solar energy into electricity. To make LEAFHouse fully self-sustainable the design maximizes the effectiveness of the solar arrays. Thirty-four solar panels are arranged across the entirety of the roof in three independent circuits. The panels on the east side form one circuit, the panels in the middle form another, and the panels on the west form the third circuit. The division of panels maximizes power production during sunrise and sunset when the intensity of light on one side of the roof will be much higher than the far side.

The design calls for thirty-four panels, each rated to produce a maximum output power of 205 watts. Each panel weighs 31 pounds and produces a maximum open circuit voltage of 68.7 Volts. The panels are rated for an overall efficiency of 17% making them sufficient for LEAFHouse's needs and budget requirements.

Batteries and Inverters comprise two other key elements to the electrical system. LEAF House has 48 twelve volt batteries stored under the deck that are capable of powering everything in the house for four full days. The sealed lead acid batteries are divided into groups of four, connected in series, to produce a total voltage of 48 volts, thereby maximizing the efficiency of the inverters. Thirteen of these groups of four are wired together in parallel strings to increase the amount of current that can be drawn by the system at any time. LEAFHouse's have a low hydrogen leakage and can each steadily produce 250 Amps for 20 hours.

PV cells and batteries produce and store electricity as direct current, but almost all appliances are designed to run on alternating current. LEAFHouse uses four Flexware 100 power inverters to provide the appliances with usable alternating current. The inverters are compatible with fully off-grid systems as well as grid integrated systems.

Plumbing

The plumbing of the LEAF House is oriented around the green wall. Rainwater is collected and re-circulated through a series of vertical and horizontal rain gardens. These gardens filter and retain the grey water which reduces the waste produced by the LEAF House.

LEAFHouse is focused and committed to the retention and collection of rainwater and greywater on site. Greywater from the house is used for irrigation in a grey water garden. Run off from the roof is plumbed in to the vertical green wall, a prominent feature on the house's south façade.

Figure 68: Engineering Brief Contest Report (cont.'d)

[LEAFHouse Team]



While using clean, environmentally-friendly solar power is important, it is as equally important to ensure the use of the energy is productive and efficient. LEAFHouse blends architecture and engineering to maximize the light afforded its inhabitants with creative use of glazing, energy efficient fixtures and an innovative twist to traditional electric light dimming systems.

The house lighting is an integral part of LEAFHouse's design and the architectural intent. Programmatic function, solar orientation and volumetrics of inhabitable space all contribute to LEAFHouse's marriage of functionality and aesthetics. A public area requires considerable light, and LEAFHouse is provided with large expanses of glass that wrap around the house and afford gorgeous views. Private areas need lower levels of light, and use smaller windows to offer more privacy. The north-south orientation of the house allows for superior energy gain with larger south-facing windows in the living spaces, paired with smaller north-facing windows in the biomechanical zone minimizing energy loss. Solar gain through the south-facing doors is controlled with shutters that are specially louvered to provide ideal shading during the summer while allowing maximum light and heat gain during the winter. An exterior overhang helps boost the efficiency of the louvered doors. Though the smaller north-facing windows reduce the available daylight in the northern zone of the house, an innovative roof-ridge skylight allows diffuse sunshine to filter through its highly insulative, nanogel-filled panes.

SHAC, LEAFHouse's smart house system continually monitors interior lighting levels and responds to environmental conditions by balancing electric lighting with natural light. This system helps control energy usage and enhance the user's experience in the house. Homeowners can individually control dimming levels according to who is in the house, what time of day it is and what type of activity they are engaging in. There are more than a dozen Lutron SeeTouch® multifunction button stations designed to control lighting functions and levels in all of the places one would expect to find a traditional switch as well as a central control system located at the house's workstation computer. SHAC's web-based interface also allows remote control of LEAFHouse's lighting system.

Electric light is produced using two of the most efficient sources available on the market: fluorescent and LED lighting. The strict environmental sustainability requirements of the Team is reflected in the use of Philips Alto II low-mercury fluorescent lamps, and the ceiling plane becomes an oversized reflector for a series of Elliptipar fluorescent fixtures. Local task lighting is supplied using LED lamps mounted inside low-voltage recess lighting fixtures that are carefully aligned within the grid of the house. To illuminate LEAFHouse's

Figure 69: Lighting Brief Contest Report.

[LEAFHouse Team]



mechanical features, flat-panel LED fixtures are utilized in the liquid desiccant wall and the mechanical room. Wall mounted low-voltage fixtures are retrofitted with LED lamps on the exterior to provide lighting at the entrance, north, and east doors, while miniature LED downlights emphasize the south overhang and provide additional lighting at the two large doors. LED fixtures around the site provide a welcome entrance to guests while highlighting the beautiful landscaping. All of the fixtures are wired to a Lutron Grafik Eye® 3000, a centralized dimming and switching system that permits flexible lighting control as well as delicate finely-tuned adjustment. This system is divided into three dimming controllers with six zones each, for a total of 18 zones of lighting for the house.

The Solar Decathlon is not just about the team with the largest photovoltaic array, but the team that can use the power given by their solar panels the most wisely. By bringing the sun's energy, electric light and the house design into harmony, LEAFHouse blends nature and technology into an efficient piece of architecture.

Figure 70: Lighting Brief Contest Report (cont.'d)

[LEAFHouse Team]



Defined Target Market

The target market for LEAFHouse is the present population of green-thinking baby-boomers—the early adopters considering downsizing or a second home—to the future, when LEAFHouse can be replicated and combined to form larger, multi-family dwellings. LEAFHouse will make it clear that everyone can live in a solar house like this one. LEAFHouse is leading everyone to an abundant future by showing the way—solving tomorrow's problems, today.

Everyday Livability

Everyday tasks are able to be performed efficiently and in a home built of firmness, commodity, and delight. Simple circulation paths, relationships of rooms, and transformable spaces allow inhabitants easy movement and multiple options for the use of spaces. Abundant natural light and an electric light control system provide ample light for activities of all types, from socializing to cooking to working. Spaces integrated with the landscape connect the inside to the outside as well as the reverse. The kitchen is the hearth of the home, while the north mechanical "bar" provides a clear zone of services allowing the living spaces to be as open and spacious as possible.

Lighting receives special attention in LEAFHouse. Lighting control is a very important part of energy usage in the United States. By incorporating several Lutron Grafik Eye® systems, the homeowner can have the choice between many different levels of lighting in the house. Instead of having only two choices – on/off – the resident can control dimming levels according to who is in the house, what time of day it is, and what type of activity they are engaging in.

The house can be operated and maintained efficiently and economically, due to the overall organizational strategy of "service and served" spaces; the management of comfort zone and total electric loads; and to the SHAC system. A "cost to compare" website provides a figure of 750 kWh/month listed as a monthly electricity use for a typical home. If that home had the LEAFHouse PV capacity, it would produce a surplus, in addition to paying for its utility bill. The Smart House / Adaptive Controls System (SHAC) offers the owner a management system for "simple living", with an emphasis on the efficient use of energy.

Americans are growing increasingly concerned about the impact their excessive energy consumption is having on the environment and on their energy bills. Most people, however, lack the time and technical knowledge necessary to monitor and control their homes effectively, to achieve both comfort and efficiency. The SHAC system is being developed to provide this service with an automation package that efficiently manages resources in the house such as lighting, air conditioning, etc. It automatically explores strategies for reducing consumption, especially during those days when solar income is limited. Over time, it builds a profile of house performance and resident preferences in order to optimize the balance between energy conservation and comfort. SHAC provides a user-friendly graphic interface to help people become aware of their energy consumption patterns and strategies to reduce waste. SHAC also monitors the operation of the house systems, detects problems that impact reliability and efficiency, reports these problems to the residents and to the technicians who help service and maintain the house.

Figure 71: Market Viability Brief Contest Report.

[LEAFHouse Team]



Video interview series

A series of short videos of team members are appearing on our website and on YouTube from Labor Day through the contest period. The video shorts portray team members' motivations, explain their favorite house features, and describe breakthroughs during the process of design, construction, and outreach. Team volunteers are editing the videos into slightly longer versions to be shown on the television in the Maryland house while it is on the Mall, to take every opportunity to entertain and educate visitors about the people behind the house and unique features that might not be readily apparent.

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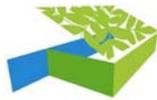
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Figure 72: Market Viability Brief Contest Report.

[LEAFHouse Team]



In "leading everyone to an abundant future," as our mantra states, education is extremely important in achieving this goal. The LEAF House team website <http://www.solarteam.org> is one of the many communications tools used to reach visitors of all ages, solar interest levels, and experiences with sustainable technology. LEAF House uses the website not only as a way to educate the public, but also allows those who are interested to follow our process and learn alongside with us.

Website Organization

The website is organized in easy to interpret and quick to access sections. It is deliberately designed to distribute all the information the LEAF House team intends for the public to a variety of audiences. They include:

- Home
- About
- House
- Updates
- Sponsor
- Webcam

Home

The home page contains a brief description of the Solar Decathlon competition and the goals, history, and mission statement of the LEAF House team. This page is intended for new visitors to the site to gain a broad understanding of the Solar Decathlon and the LEAF House team. For repeat visitors, special feature links allow them to go directly to new LEAF House updates since their last visit. The feature links are available through the website for easy navigation throughout.



About

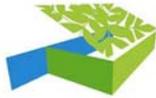
The website is a way for the LEAF House team to distinguish our team from others, but much more important than winning the Communication Competition, LEAF House wants to achieve the Competition overall goal to education the public and promote the understanding and use of solar and sustainable technology in their personal or professional lives. The "About" section features our team, courses offered, the unique process LEAF House team used, and basic solar references. The LEAF House team includes the students, advisors, and the dedicated mentors all highlighted on the website. To foster collaboration between students from various departments on campus and encourage and reward students for their interest in the project, LEAF House offered academic credit as mentioned in the courses and detailed in the process sections. The About section includes team members' reflections on what they have gained from working on LEAFHouse. The basic solar references section is a collection of website links for visitors to learn about alternative technology, how they can install it in their homes, and various incentives from their local government. It is not intended to answer all questions that visitors may have, but to guide them toward reliable sources of information on sustainability.

House

Sections following the "About" section are all unique to the LEAF House team. The "House" section contains information about our construction process. As our team works toward house construction, details about the current construction stage are revealed to allow visitors to follow our progress. This section also describes the basic

Figure 73: Website Brief Contest Report.

[LEAFHouse Team]



technology employed in the LEAF House. Additionally, it includes an interactive map that not only visualizes the house interior, exterior, and construction stages but also allows users to learn more about the materials and technologies used along with LEAF House sponsors who contributed those items. Sponsor recognition rewards those corporations or individuals who are interested in promoting sustainability and directs visitors local to the Maryland, Virginia, and DC area to local corporations who can help bring sustainability into their lives.

Updates

As mentioned in the introduction, in an effort to educate and entertain visitors, the "Update" section contains a picture gallery, construction videos, and press information related to the LEAF House team. The picture gallery captures our everyday endeavors whether it is team design meetings during the initial design phase, house construction during the final stages, or public speaking events throughout the entire process. Sprinkled in the picture gallery are out-take photos of the team members at their best. This section brings out the personal side of the team and the project. The entire updates section is easy to understand, entertaining to visit through and is great for visitors of all ages.

Sponsor

LEAF House would not be possible without the generous donations that our sponsors have provided. Whether it is monetary, material, or services and regardless of the amount of the giving all of our sponsors are important to us. This section is updated daily with our sponsors and their profile. The major sponsors are featured on the home page. For those interested in sponsoring our team, the sponsor kit and levels of giving sections provide all the information they would need to make the decision to join our team in leading everyone to an abundant future.

Webcam

The last major section of the website is the webcam page. This page is unique to few teams in the Competition. It provides the ultimate up to the minute progress report. In educating the public it is paramount that the information is correct, relevant as well as engaging. This is a key goal that the LEAF House website team has maintained.

Statistics

Internally, the LEAF House team has been monitoring information on visitor statistics. Currently, the website has 82,341 hits and 7,964 unique visitors as of August 5, 2007. This translates to approximately 45 unique visitors per day and approximately 10 page views per unique visitor per view. These statistics indicate that our website continued to attract new visitors, and for those news visitors our website has been engaging enough for them to return. This is additionally supported by the corresponding graph showing increases in unique visitors since the website came live in January of 2007.

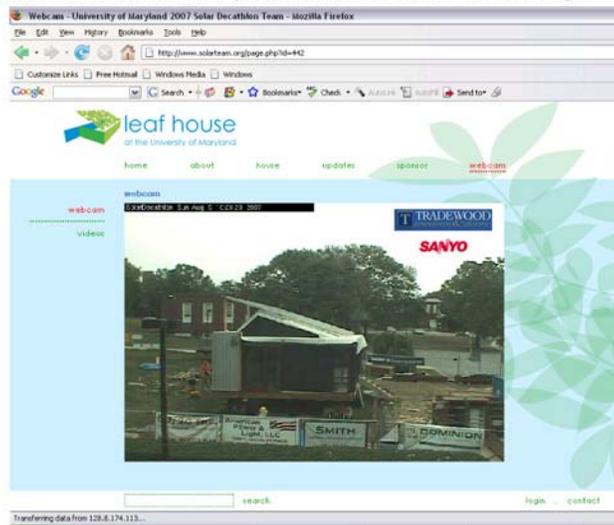


Figure 74: Website Brief Contest Report.

[LEAFHouse Team]

LEAFHouse Larger

From the conceptual stages of LEAFHouse, the team wanted to make the design of the house such that it could be incorporated into larger units or homes as well as communities. The team believed that the 800 sq. ft. house stipulated by the competition, although sustainably designed with green materials, was not sustainable as far as the global community and environment was concerned. This therefore, became one of the teams' guiding principles. The competition houses were designed to stand alone as a single family dwelling on a private lot, a situation that has the potential to lead to suburban sprawl and the overtaking of green fields throughout the United States. The systems and materials of the house may be sustainable and green, but the one-off prototype houses were not. The LEAFHouse team thought of the house in a different way in terms of master planning, in which densities could be increased and sprawl could be reduced.



Figure 75: Early discussions on LEAFHouse communities.

[LEAFHouse Team]

In the spring of 2006 the team set out to formulate ways to incorporate LEAFHouse into larger communities. Many of these early concepts were straightforward, simply using the basic LEAFHouse module and plan, and incorporating them in various configurations to form larger communities. These investigations provided a launching point for intense and detailed studies and designs, looking at ways to incorporate the principles inherent to LEAFHouse into communities.

‘LEAFHouse Larger’, a phrase coined by the team, took earlier studies to a new level, trying to use the original LEAFHouse design and design principles to create higher density living which could be incorporated into existing urban environments. The goal was to achieve approximately thirty dwelling units per acre, which was deemed effective land planning. In addition, ways to mitigate impervious surface and parking, control water runoff, increase landscaping, and incorporate as many green technologies and strategies into the designs was strongly desired and encouraged. The open plan of the original design allowed for a lot of flexibility during this stage, and the early established guiding principles continued to help the team during this studio exercise.



Figure 76: Townhouse adaptation.

[Adam MacDonald]

A successful adaptation of the original house design was found in its transformation into an urban townhouse. The townhouse design took the approach of a

more rationalized, modular floor plan of LEAFHouse creating three-story row house/townhouse sited in downtown Baltimore. The first floor of the townhouse was a one bedroom apartment based on the enlarged LEAFHouse floor plan. To one side of the plan were stairs which led to the two-story townhouse apartment above. In the center of the plan was a large two-story atrium with a skylight.



Figure 77: LEAFHouse garden flats.

[Florence Ho]

Another increase in LEAFHouse density was accomplished in a three to four story garden flat apartment complex which achieved 29 dwelling units per acre on the Inner Harbor in Baltimore. This design focused on an interior rainwater/grey water collection courtyard surround on two sides by 35 apartment units. In addition, the section of the design was stepped to utilize existing site topography. The southern apartment block was sited lower than the northern block, and the courtyard width was determined by sun angles in an effort to allow as much sun as possible to enter the courtyard and the north apartment units.

A third effective re-design using the guiding principles and the original LEAFHouse module was the urban villa. This design incorporates the original plan into a new zero-lot-line urban villa which can be scaled up based on the needs of the owner or the size of the family. This is done through the flexibility of added stories, as well as an

added wing that can be incorporated into the house and which utilizes the original LEAFHouse module for its base plan. Unlike the previous two examples, this design is not quite as dense and urban. The main house block and the optional wings create a protected yet elegant inner courtyard for owner that allows for plenty of sunlight into all the rooms of the house. In addition, there is a lush front yard which helps mitigate street noise, yet still creates an inviting entrance.



Figure 78: LEAFHouse villa.

[Liz Maeder]

Finally, an investigation was undertaken to try to rationalize the existing plan of LEAFHouse. Due to some of the constraints of the competition (height, solar envelope, and square footage), as well as lack of team experience in design and construction of buildings, the original plan for LEAFHouse was not one that worked well with traditional framing material's dimensions. As a result, a lot of waste was produced on site during the construction process as studs were cut eight inches shorter and plywood was sawn to be three foot wide instead of four, for example. In this exercise, termed *LEAFHouse Rationalized*, attempts were made to transform the original LEAFHouse plan into one that could be modularized and produced much more effectively, and efficiently than the original.

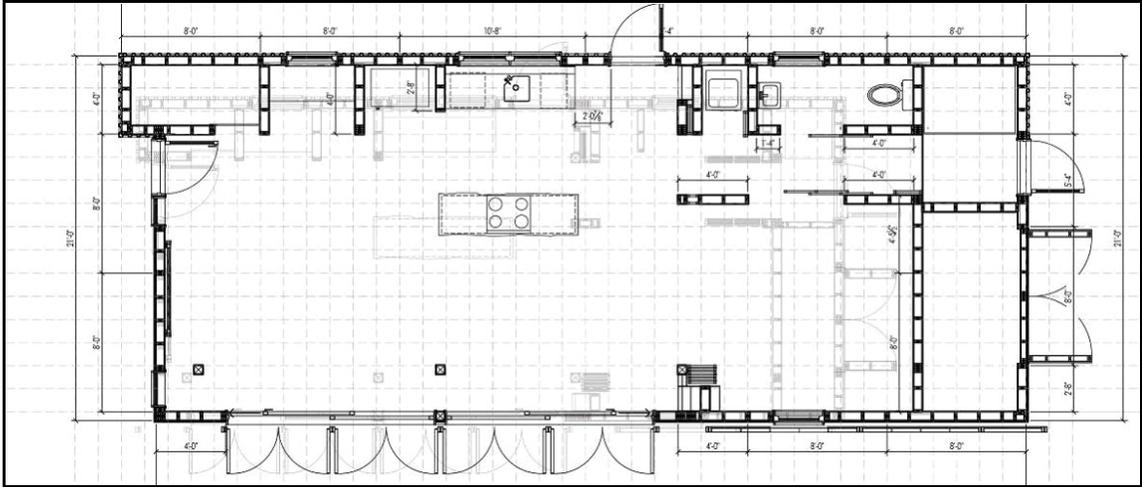


Figure 79: Existing LEAFHouse Plan overlaid with LEAFHouse Rationalized.

[Morris]

The entire plan was first laid out on a sixteen inch interval for wall framing, and then a twenty-four inch grid was overlaid for roof framing. Every attempt was made to make these two grids meet the floor, wall, and roof, to maximize material usage and minimize material waste. With the grid now in place, a module was created, and it was this module that would become the basis for the extensions of the original plan into a 1200 square foot house (1 bedroom), a 1600 square foot house (2 bedroom), and a 2400 square foot house (3 bedroom). The team thought of these rationalized plans as something that could be ordered, efficiently manufactured, and sold to customers like a modern day Sears catalog home of the early 20th century.

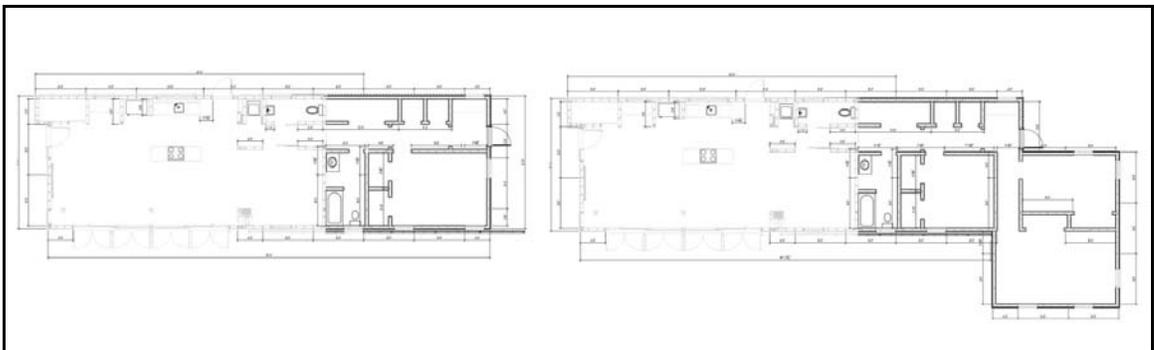


Figure 80: LEAFHouse rationalized with modular extensions.

[Morris]

Construction

Construction Schedule

The construction schedule for LEAFHouse became a project in and of itself. Throughout the project, the schedule was constantly being adjusted to account for construction and material delays. Mentors were available to aid the team in making schedule adjustments, working with the team to make decisions based on the constraints of the schedule. The project pushed forward despite the constant schedule adjustments and seemingly constant setbacks.

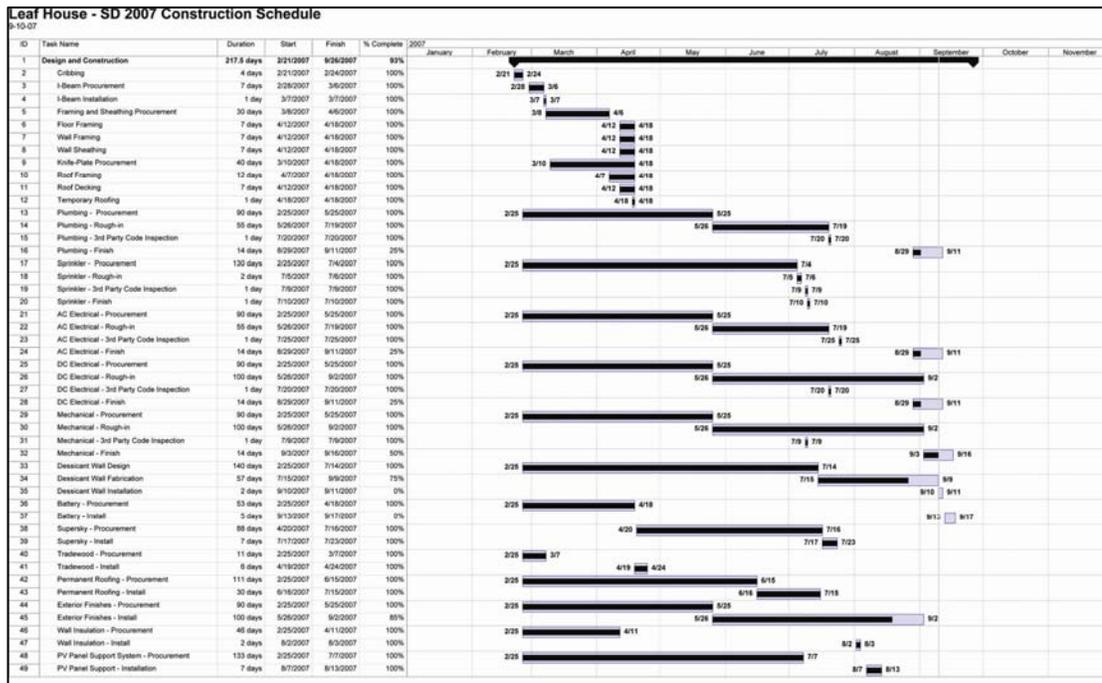


Figure 81: Final Construction Schedule

[Dale Leidich]

The schedule was based on the amount of time that the team estimated that each task would take, from design hours and procurement, to the actual installation of the item. Each proceeding task relied on the one prior to it to be completed before it was activated in the schedule spreadsheet. Through this method, the team could keep a detailed account of everything that was going on in the project, and how long its subsequent items

would be delayed if previous tasks were not completed on time. Constant team meetings were held in order to remain on schedule, keeping all team leaders aware of the state of construction on different aspects of the house. Once the house was enclosed, meetings were regularly held inside so that team members could see and understand how each task was related and would affect the next.



Figure 82: Weekly schedule meeting inside the house.

[LEAFHouse Team]

As a result of these constant conversations, the team could easily see how any delay in the task they were working on was adversely affecting many more tasks to come. Scheduling of the project was often discouraging and difficult, as no student involved had much in-depth experience with such a monumental task. In the end, however, each student was able to gain a new appreciation for the scheduling of a project and how vital it is in moving a project along efficiently.

Construction Sequence

Foundation and Floor

In mid-February 2007, students arrived on site to begin construction by laying down the six gravel beds that were to support the cribbing for LEAFHouse.

The pea gravel footings were first set on a layer of filter fabric which was surrounded by a wood frame to help

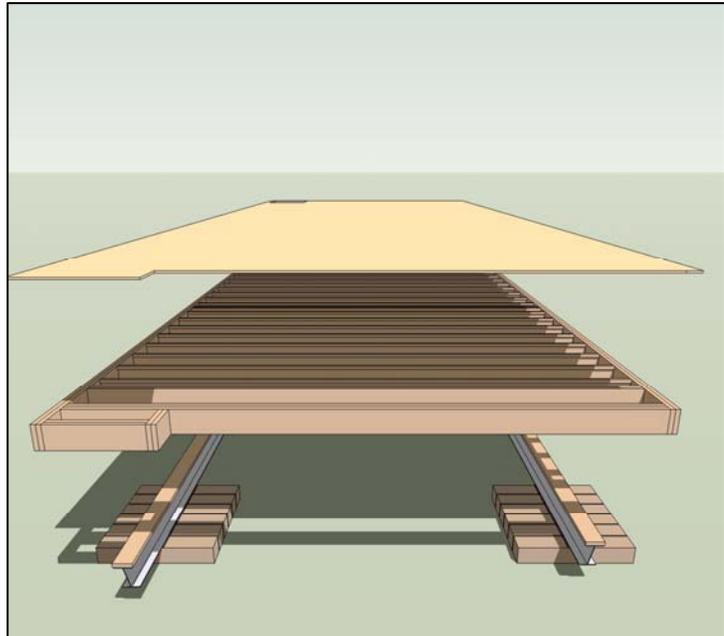


Figure 83: Foundation Sequence.

[LEAFHouse Team]

contain the gravel on site. Each pad was then individually leveled. A week later, the 8”x8” poplar wood cribbing arrived from the sawmill and was laid into place on the gravel pads. Each “foundation”, which consisted of 10-14 pieces of interconnected cribbing, was designed to allow for specific load bearing capacities as regulated by the National Park Service and determined by our structural engineer. Since the gravel beds had already been leveled the week prior, setting the cribbing in place was straightforward and went quickly. Eventually, all the cribbing would also be tied down to prevent shifting of the foundation piers.

Two weeks later, during the first week of March 2007, the 2-40 foot W12 beams arrived on site. With the aid of a forklift, the team placed the two beams on top of the cribbing piles. The following weekend one of our structural mentors arrived on site with

a transit level to aid the team in squaring and leveling the two beams. Over the course of a Saturday, the team shimmed the beams into place. The beam was then locked into place on the cribbing, and tied down to the site by an innumerable amount of 18 inch soil anchors and cable. A treated 2"x8" wood plate was then bolted to the steel beams through specified factory drilled holes, and the team was ready to begin framing for LEAFHouse.



Figure 84: Foundation Sequence.

[LEAFHouse Team]

Walls

With the foundation and beams leveled and securely fastened in place, the LEAFHouse team set out to construct the exterior walls during the first week of April 2007. The team enlisted the help of subcontractors since there was not enough student labor and experience available to get the job done efficiently. However, it was stipulated that the framing process would be a



Figure 85: Wall Sequence.

[LEAFHouse Team]

teaching one, and thus any interested student could show up and help or learn. With the help and guidance of three more of our construction mentors, students erected the exterior shell of the building over the span of two days.

The exterior framing for LEAFHouse was somewhat conventional, utilizing 2"x6" studs (FSC certified) spaced 16" on center with 1/2" plywood sheathing on the exterior. This allowed for a rapid construction pace since it is a well established method. It also provided the needed flexibility in the placement of the systems later in the rough-in process. All of the walls were first built and squared on the deck (complete with plywood), and then lifted, leveled, and secured into place by the team. Once all the walls

were up, additional leveling was done, and braces were added throughout the interior to keep the structure square until the roof framing and sheathing were constructed the following week. During the final stage of the wall construction process, the window openings were cut out, and the LVL structural rim was also added in preparation for the roof structure.



Figure 86: Wall Construction.

[LEAFHouse Team]

Roof

In the second week of April 2007, the team set out to erect the roof of LEAFHouse, again with the aid of our three construction mentors. The roof had three components: the open steel ridge and skylight, the sloped roof for the photovoltaic array, and a series of flat roofs. The steel ridge was composed of a custom, team designed and specified, steel pipe with welded knife plates. This design allowed for the polycarbonate skylight.

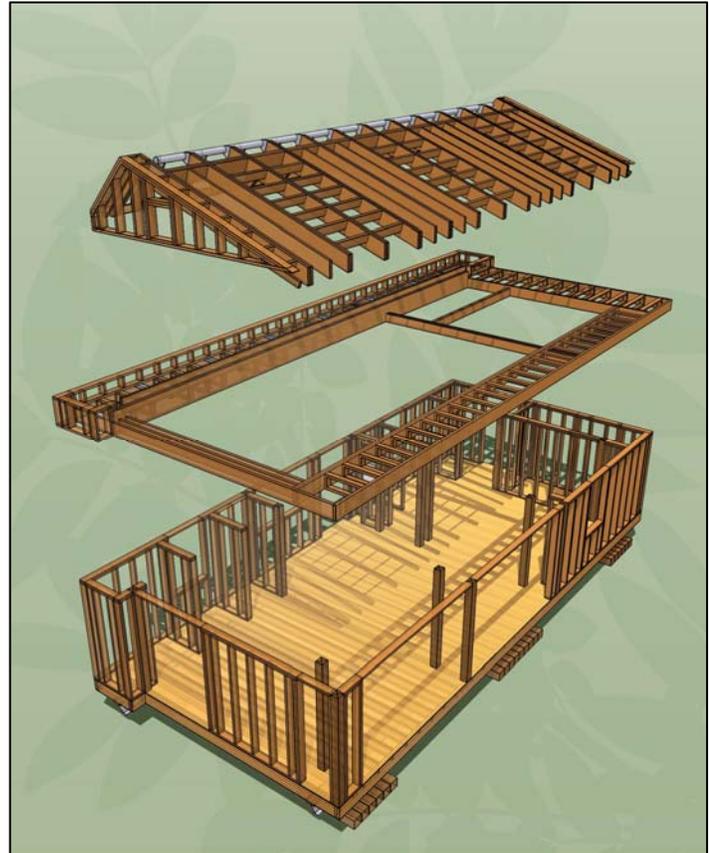


Figure 87: Roof Sequence.

[LEAFHouse Team]

During the first day, the team set out to erect the flat roofs which surround the structure. The flat roof was constructed with 9-1/2" wood I-joists spaced 16" on center and covered with 5/8" plywood. The flat roof contained all of the electrical, mechanical, and plumbing systems for the house, and the wood I-joists allowed the team to easily drill through the web for these rough-ins. Originally open web trusses manufactured off site were specified, but due to the small span, the leftover I-joists on site were utilized. This portion of the roof was supported on one side by the exterior walls, and on the interior by paired 9-1/2" LVL beams supported by posts. These posts provided not only the support,

but also allowed for the open plan of the house. During the next three days, the team erected staging to temporarily hold the steel knife-plate pipe in place. With the pipe in place, paired 2"x10" Douglas Fir rafters were bolted to the knife plates on the ridge. These rafters were eventually covered with 5/8" plywood and would become the supports for the photovoltaic array.



Figure 88: Roof Construction

[LEAFHouse Team]

Doors and Windows

Following the completion of the rough framing for the walls and roof came the installation of the high performance, solid Douglas fir doors and windows. The doors and windows had arrived in April 2007 and had been waiting in storage due to construction delays. Prior to ordering the windows and doors, the team had worked with the

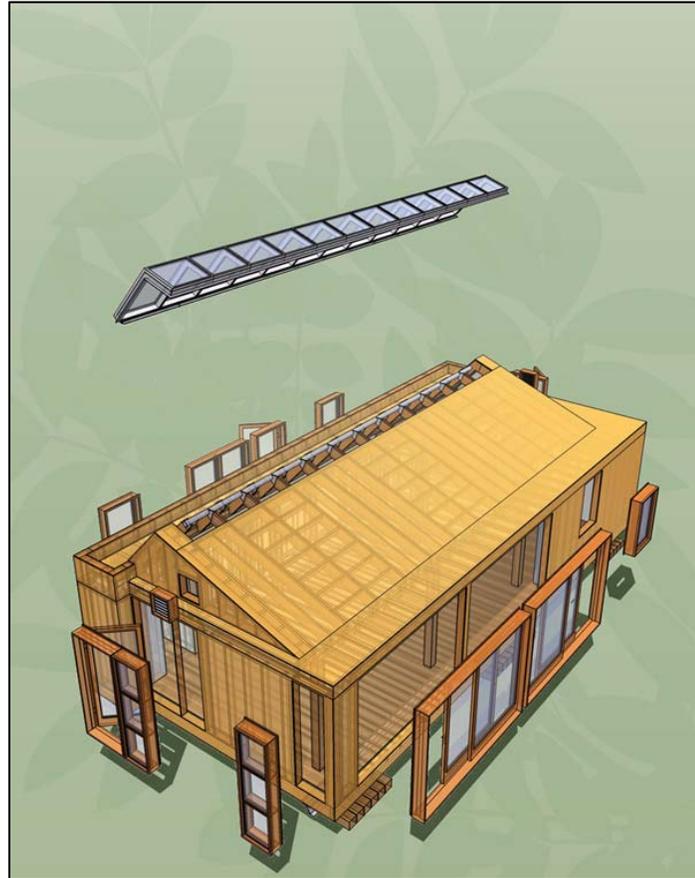


Figure 89: Door & Window Sequence. [LEAFHouse Team]

manufacturer on the shop drawings and detailing. The windows and doors were custom designed and manufactured specific to the project.

The first step in the installation process was to wrap all the openings in a rubber membrane to prevent water infiltration and rot around the opening. Metal nailing flanges were then attached to the heads and jambs in order to fasten the windows to the house. Once in the designated opening, the windows were centered and checked for square. They were then leveled vertically and horizontally, and shimmed as was deemed appropriate, with the final attachment occurring at the nailing flange. Additionally, the doors were set in caulk to seal at the sills. Months later, after countless delays, the

polycarbonate skylight from SuperSky arrived and was installed over the span of a week. Team members installed the skylight with the aid of a mentor from the factory. They assembled the prefabricated, specially design pieces in place and then sealed the opening. With the skylight in place, the envelope was now sealed and the team could finally install the siding and begin systems rough-ins.



Figure 90: Door and Window Installation.

[LEAFHouse Team]

Siding

In mid-June 2007, once the windows and doors were in place, it was time for the corrugated steel and FSC Eastern White Pine siding to be installed. Overall, the installation process took approximately two weeks, with the majority of the work occurring on weekends during that time. The team had obsessed for months over every detail of



Figure 91: Siding Sequence.

[LEAFHouse Team]

the siding, including trim profiles, directionality, and profile. The team detailed the siding and the way that it met other materials and parts of the house to reflect the overall ideas and goals of the team.

Prior to the siding installation, however, the entire house was first wrapped in HomeSlicker. This was a drainage matt product similar to the Tyvek product typically seen in residential construction locally. The difference comes in the profile of the HomeSlicker, which keeps the siding approximately ¼” off the drainage matt in order to allow for water drainage as well as air circulation. This product was most vital in order to ensure the longevity of the wood siding. After the HomeSlicker had been installed around the entire envelope, trim profiles for the corrugated metal siding were then installed around the windows and doors, as well as the drip edge at the bottom. The steel

corrugated siding had arrived first and was therefore installed first. The wood siding arrived a couple weeks later, and had to be stained and sealed before installation. This was one of the most impressive tasks completed on the exterior, as all of this work was done solely through student labor. With the installation complete, the exterior was taking shape and the house construction was starting to come together.



Figure 92: Siding Installation.

[LEAFHouse Team]

Finish Roof

Also occurring in mid-June 2007, concurrent with the siding installation, was the installation of the finish roof system, which consisted of rigid insulation topped off by a TPO membrane. As a result of specifying a commercial roofing system unfamiliar to the team, the team put this part of the project out to bid through the



Figure 93: Finish Roof Sequence. [LEAFHouse Team]

University system. However, after a couple weeks of waiting, no bids were returned and the team still did not have a roofer. After an additional strenuous and tumultuous month of searching, a professional roofing specialist was eventually found. He agreed to guide the team in the installation of the roof, with team members providing much of the labor under his watchful eye and constant supervision.

The first step in the process was the installation of the rigid insulation, which served several purposes: adding R-value to the roof, providing taper on the flat roof for water drainage as well as adding an extra layer to raise the dew point and keep the roof sandwich dry. With the rigid insulation installed, a ¼” fiberglass board was then installed and screwed to the roof deck using fasteners and metal plates. With these two elements in place, the final TPO membrane was finally laid in place, glued and then

finally sealed to the fiberglass board. Over the next three months, and over the course of countless weekend work sessions, the roof mentor continued to work with the team and the roof slowly came together. After the concealed gutter was built around the perimeter of the house, the roofing membrane was integrated into the gutter and the house was finally sealed and watertight.

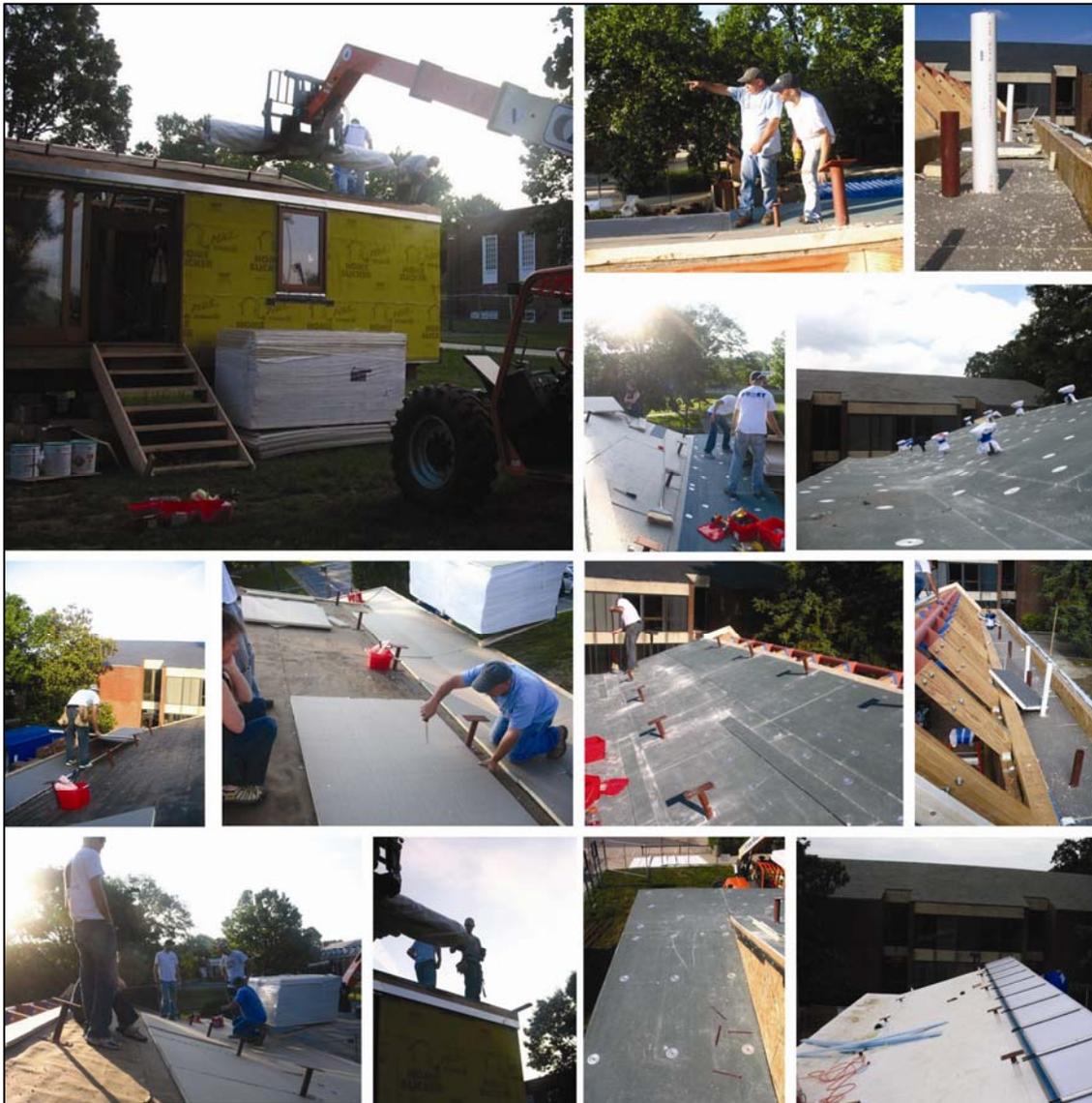


Figure 94: Finish Roof Installation.

[LEAFHouse Team]

Rough-Ins

After much delay and anticipation, the rough-ins for LEAFHouse finally began in late - June/early-July 2007. The first trade to rough-in was the mechanical system. This was by far the easiest of the rough-ins, as the house only had one-30 foot



Figure 95: Rough-Ins Sequence. [LEAFHouse Team]

duct run through the north bio-mechanical zone which would provide for ventilation. In addition, two vents were cut into the exterior siding in the east wall of the mechanical room for supply and return to the house's ERV system.

With the flexible duct and register boots in place, the plumbing rough-in could commence following the conventional rough-in order of HVAC, plumbing, then electrical. This portion of the rough-in also included the installation of the radiant floor system. The team worked with the system manufacturer to create a radiant floor layout. Unlike traditional radiant systems, the panel used has 1-1/8" thick plywood panels covered in aluminum with pre-cut tube runs. The team used the Warmboard drawings to lay out the system. Installation began slowly, but as the team began to understand the system, the process sped up. Finally, the pex tubing runs were put in place in the channels and then run under the floor and into the manifold in the mechanical room. During this time, and with some aid from a professional plumber, the plumbing fixtures, risers, vents, and waste drains were roughed-in, and the house was ready for its complex

electrical components to be installed. With the constant supervision of our master electrician mentor, many hundreds of feet of wire, conduit, and data cable were pulled and boxes attached to the wall. Over the following month, rough-in work would continue at a hectic pace as runs and locations were finalized, trying to ready the house for our August 1st insulation installation appointment.



Figure 96: Rough-Ins.

[LEAFHouse Team]

Insulation and Finishes

On August 1, 2007, the insulation installers arrived from Virginia and immediately began to prepare the house for the soy-based spray-foam insulation the team had chosen. This insulation is unique to the industry, as it uses water as the blowing agent for the insulation instead of the normal



Figure 97: Insulation & Finishes. [LEAFHouse Team]

HCFC chemicals. This makes this insulation (BioBased 1701) much more environmentally friendly and thus appealing to the team.

One of the first tasks prior to blowing the insulation was to seal and caulk around all of the windows and the bases of the wall to reduce the air infiltration in those critical areas. Once that was complete, all openings were covered with plastic sheeting to keep the over-sprayed foam off the windows and doors. With the house now sealed and critical areas taped off, the installers took the next two days to blow 5" to 5-1/2" of insulation into all of our wall, roof, and floor cavities, giving the exterior envelope an R-value ranging from 27.5 to 30.25. The standard blowing process was lengthened to two days for this project because of the depth of insulation the team had chosen. In a normal application, insulation of this type is sprayed three to four inches thick. The depth the team had specified therefore had to be installed in two passes, with the second layer being blow once the first layer had dried substantially.

In early-August 2007, immediately following the completion of the insulation, interior finishes were installed. In one week, the drywall installers had hung, taped, and finished all of our interior drywall, and the walls and ceiling were now ready for a coat of paint. In addition, our wood floor installers came in and put down the wood floor in a day, with finishing coming much later in September. Finally, our tile installers arrived and installed the recycled glass tile in the shower over the span of three days.



Figure 98: Insulation and Finishes Installation.

[LEAFHouse Team]

Landscape and Decks

With the interior of the house almost complete, the team turned its attention once again to the exterior. Design and detailing of the deck and landscape elements had been progressing since February 2007, and the team



Figure 99: Deck & Landscape.

[LEAFHouse Team]

had finally determined a solution to the function, aesthetic, and transportability aspects that were needed. The team investigated alternative framing materials, but in the end, pressure treated lumber was chosen.

The landscaping elements and deck that surrounded the house were always an important aspect in the design in terms of creating a connection to nature. The decks and deck structure had to be designed so they could be easily disassembled and assembled many times for the competition. For this reason, the deck system was built very unconventionally using a panelized approach set on temporary concrete pier footings. Every attempt was made to design the deck so that each part could be managed by three to four team members during the assembly process. First, the 2"x10" deck beams were erected on their piers, leveled, and squared. Finally, the individual deck modules were constructed of 2"x6" pressure treated joists, with the final decking installed once all the panels were complete. The construction process continued during the months of August and September.

The second most visible landscape element to be installed was the green wall on the southeast of the house. The system the team chose was already a modular system, and thus it fit well into the design and transportability that was needed for these elements. The modules had been growing at a local nursery. In the first weeks of September 2007, the team brought them to the site to be installed on the paired 2"x4"s Doug Fir wood structure.

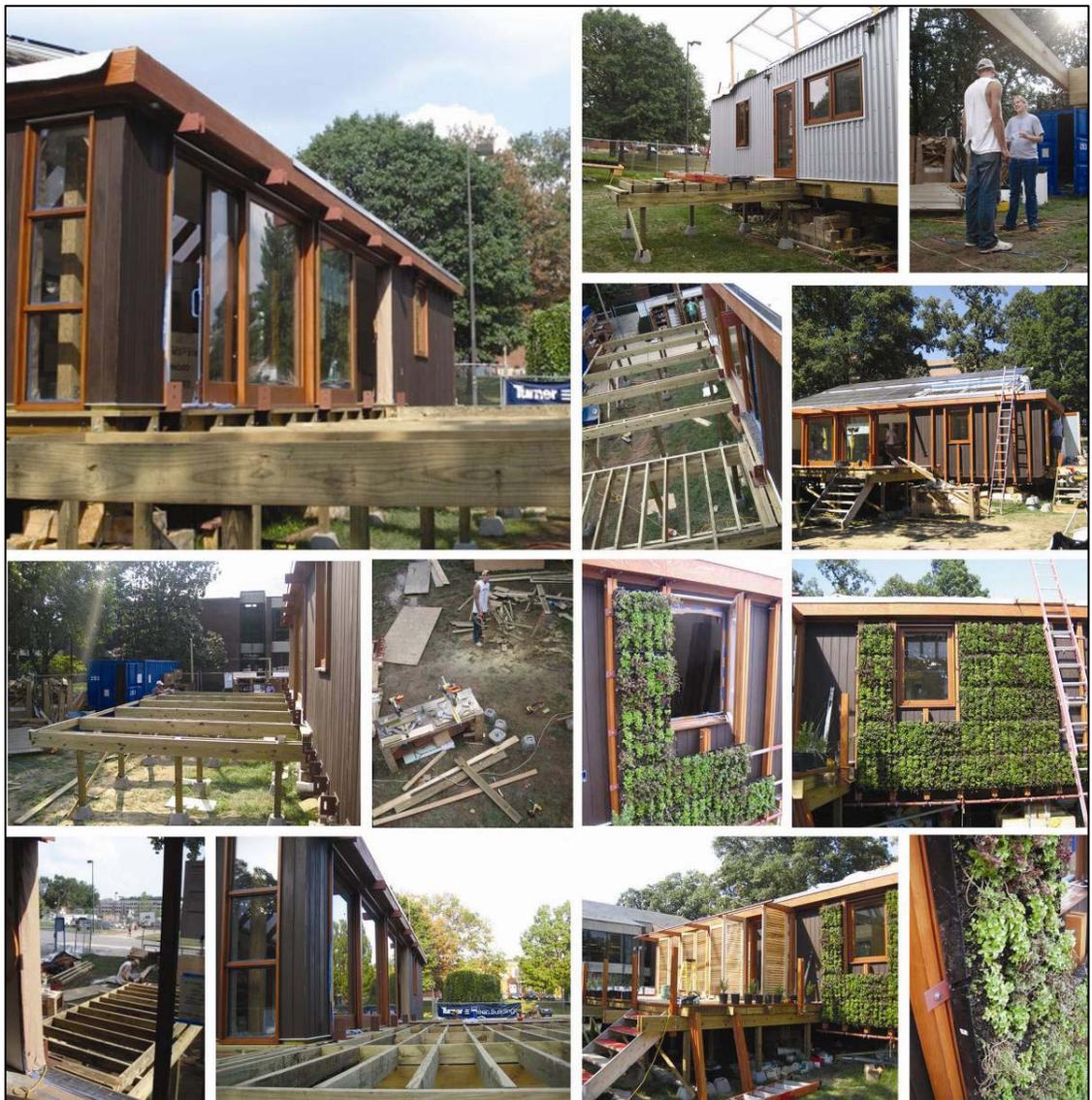


Figure 100: Landscape and Deck Installation.

[LEAFHouse Team]

Solar Systems

During the final weeks of August 2007, and on into September, the team installed the solar systems for the house. The first step of the process was to erect the extruded aluminum grid on the sloped portion of the roof. The system was chosen because it provides the flexibility needed for the attachment of the various systems. This aluminum racking system was designed to be the support and attachment for the

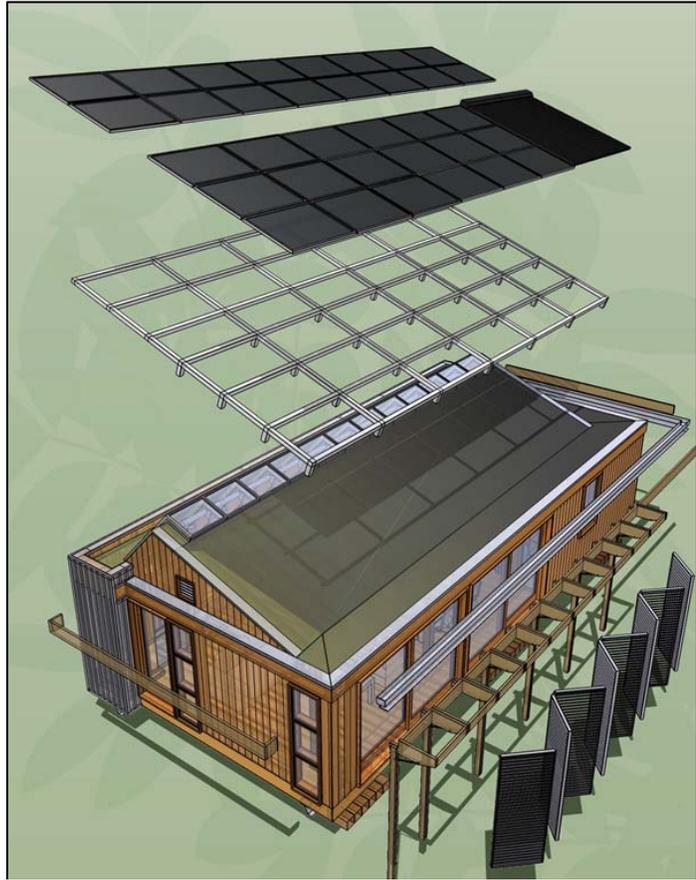


Figure 101: Solar Systems.

[LEAFHouse Team]

photovoltaic array, as well as the solar hot water tubes still to come. The team first planned out the installation on the ground, and then moved the installation to the roof piece by piece.

With the grid in place, and despite brutally hot weather, the solar panels were quickly installed. A team of four students installed the solar panels on the roof, as well as the batteries that were under our north deck. Our master electrician was also constantly on site, tying together wires and batteries to get our electrical system up and running as quickly as possible so that we could begin to test and troubleshoot our equipment.

At the same time, a team of two mechanical engineering students were working hard to install and plumb our solar hot water system and all of its related components in the mechanical room. Work was now proceeding at break-neck pace in an effort to finish the house and various components before moving day in the first week of October 2007.



Figure 102: Solar System Installation.

[LEAFHouse Team]

The Competition

Transportation

After completing construction on campus, the team then packed up the tools and readied the house for transportation to the National Mall, Washington, DC. The need for the house to be transported was constantly a part of the design process. Because of the close proximity to the National Mall, the team was afforded the opportunity to ship a very oversized load to the mall. The house was shipped intact as one piece with only the solar panels and associated racking system removed for transport. The exterior of the house was left exposed.



Figure 103: Preparing the House for the Move

[Brittany Williams]

Expert House Movers were in charge of the move. They began preparing the house for the move early in the morning. The house was transported on the two steel beams that were included as part of the house construction for this reason. After raising the house on jacks, the movers backed the truck under the house and installed steel outriggers to carry the steel beams of the house. The house was then lowered onto the outriggers and began its move across campus.



Figure 104: The House Traveling Through Campus

[Brittany Williams]

The house was taken through campus and then taken onto state roads at night. The house traveled at approximately 10-15 miles an hour and arrived safely on the mall around 1AM.

Reassembly

Before the start of the competition, the team had to reassemble the house and get it ready for public tours and the competition. A crew of approximately 20-30 students, faculty, mentors and friends of the team worked around the clock during the reassembly process.



Figure 105: Siting the House on the National Mall, Washington, DC.

[Amy Gardner]

First, the team had to site the house and set it on its cribbing foundation before any other work could begin. This took the entire effort of the team and the house movers. After the completion of siting the house, the team was able to start work on various aspects of getting the house ready to open to the public. There were various groups of the

team working to get the house completed and ready. Two of the first priorities during set up were completion of the deck and site items as well as the installation and re-hookup of the solar system including the assembly of the racking system and solar panels. This process moved fairly quickly and LEAFHouse was one of the first houses on the mall to be running off of solar power. After completion of these items, team members worked to complete and install the remaining casework, recharge the mechanical systems, complete landscaping, finish interior details, assembly house exterior house accessories and finish installing the smart house hardware and computer.



Figure 106: Reassembly of the PV Racking System

[Brian Borak]

As these items were completed and the house was further completed, a series of inspections were required. They were carried out by representatives of the competition.

These inspections were based on code compliances of our AC and DC electrical systems as well as compliance with building code and National Parks Service rules. In addition to code inspections the house was equipped with monitoring equipment to allow us to compete in the competition.



Figure 107: Installation of the Rainwater Filtration System

[Brian Borak]

Competition Week

During the competition week, the team had to complete contest activities including jury tours, driving the car, cooking a meal, and washing and drying clothes while also giving tours to the public and talking to the media.

The Contests

The competition spanned 7 days and included both subjective jury tours and objective tasks the team had to complete. The subjective contests involved giving a tour to judges and the results were announced each day. The subjective contests outcomes were tallied as they happened in real time. At the end of the week the overall winner was announced.



Figure 108: A Deliberating Jury - Kaye Evans-Lutterodt/Solar Decathlon

[www.solardecathlon.org]

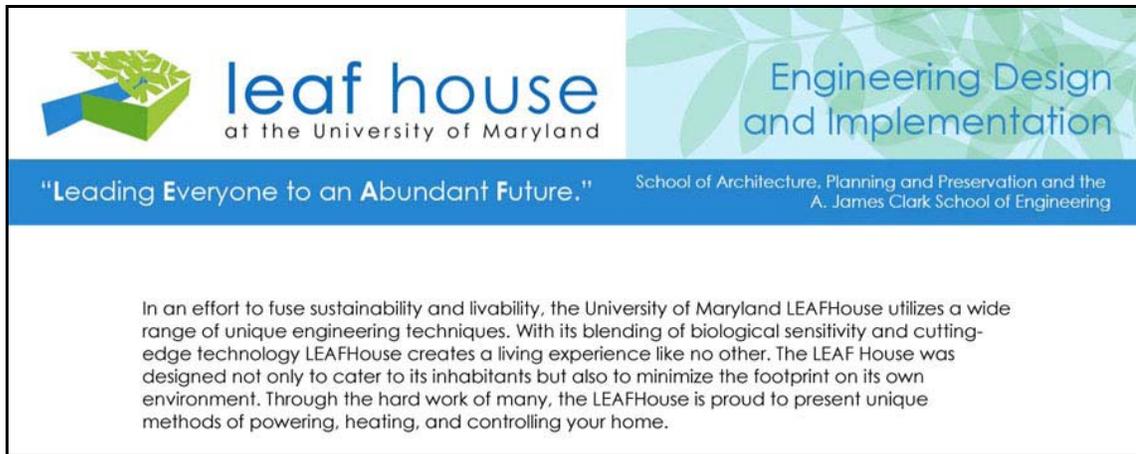


Figure 109: Excerpt from Engineering Design and Implementation Brief Contest Report [Team]

The jury tours were conducted over two days periods where the house was shut down and the team given the opportunity to allow the judges to tour the house. The tours lasted approximately 20 minutes. Prior to coming to the mall the team submitted Brief Contest Reports which were given to the judges before visiting each house. This allowed the judges to have a general understanding of the house and its overall idea and component and give the team an opportunity to be more detailed in the tour.

The jurors were instructed to look for specific things within each house. For example, the architecture jury is supposed to evaluate the houses based on the principles of firmness, commodity and delight.

Each of the five juries was comprised of successful individuals in their respective field. For example, Gregory Kiss, from Kiss Cathcart, a prominent architectural firm that focuses on the integration of solar technology and architecture, served on the Architecture Jury.

The LEAFHouse team paid the most attention to the jury tours portion of the competition. The team used the tour time to explain how the unique aspects of the house

as well as talk about the integration of the house systems and how the overachieving principles applied to all aspects of the house.

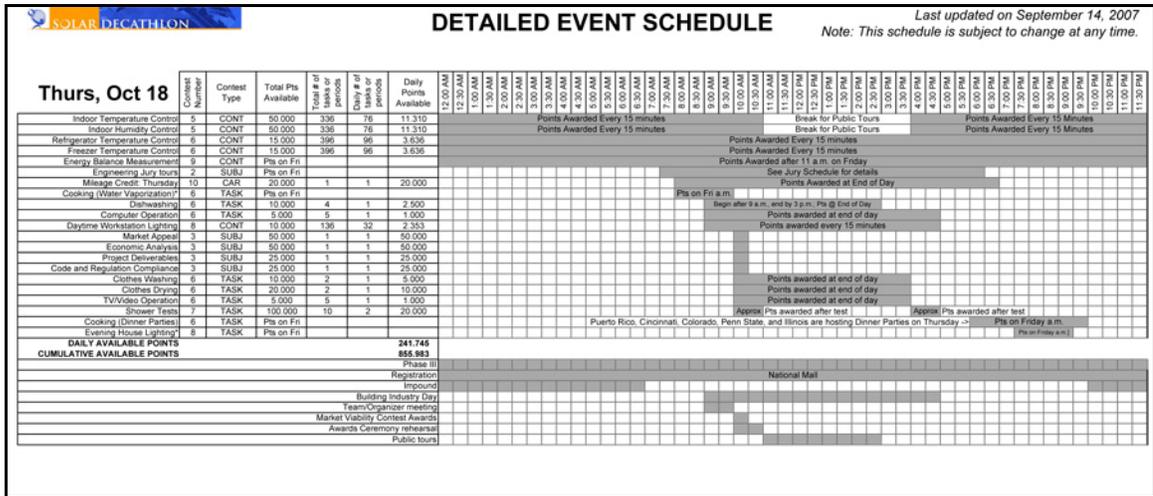


Figure 110: Sample Event Calendar

[www.solardecathlon.org]

Also during the competition week the team had to perform objective tasks each day and night. The tasks ranged from washing and drying towels to driving the electric powered GEM car to keeping a constant temperature and humidity level in the house. A team of students kept a constant strategy during the competition week. Despite the simple nature of the contests, the team faced challenges in the areas of washing and drying towels, boiling water and driving the car. In the face of adverse outcomes in some tasks and contests, the team still held first place during the competition for much of the week.

Ultimately, the German team from Darmstadt out played the LEAFHouse and in the end, the team placed 2nd over all while placing in the top two in 5 of the 10 contests. The competition concluded with a closing awards ceremony that took place on the last day of the competition. At this ceremony, the winners of the engineering contest were

announced in addition to the overall winners of the competition. Santa Clara took third place, while the Maryland team placed second overall.

Team	Overall Points	Overall Standing
Darmstadt	1024.85	1
Maryland	999.807	2
Santa Clara	979.959	3
Penn State	975.432	4
Madrid	946.298	5
Georgia Tech	945.183	6
Colorado	943.369	7
Montreal	906.835	8
Illinois	886.956	9
Texas	877.503	10
Missouri-Rolla	869.179	11
NYIT	852.775	12
MIT	833.302	13
Carnegie Mellon	832.506	14
Cincinnati	830.865	15
Puerto Rico	819.502	16
Texas A&M	808.765	17
Kansas	807.049	18
Cornell	780.440	19
Lawrence Tech	691.350	20

Figure 111: Final Competition Standings

[www.solardecathlon.org]

Maryland			
Current Overall Points	999.807	Current Overall Standing	2
These are the final scores for the 2007 Solar Decathlon. The results were announced on Friday, Oct. 19, 2007, at 2 p.m.			
Contest	Miles/Current Points	Current Standing	
Architecture	189.50	2	
Engineering	127.35	6	
Market Viability	112.50	2	
Communications	98.200	1	
Comfort Zone	75.215	4	
Appliances	56.626	17	
Hot Water	92.900	8	
Lighting	92.750	2	
Energy Balance	100.00	1	
Getting Around	/54.766	13	

Figure 112: Maryland Final Competition Standings

[www.solardecathlon.org]

The awards were presented by Samuel W. Bodman, the Secretary of Energy.

When speaking about the Maryland team he said:

“At the beginning of the week, people wondered if the Maryland team would have a home-field advantage because they are so close to Washington, D.C. As the week progressed, and Maryland won the Communications contest and was second in Architecture, Market Viability, and Lighting, it became clear that Maryland didn't need any advantage. The Communications Jury praised their excellent Web site and house tour. The Architecture Jury said the house definitely belonged in the top tier. The Lighting and Market Viability juries also had high praise. They were one of seven teams to score a perfect 100 points in the Energy Balance contest.”



Figure 113: The Maryland Team Celebrates Their Second Place Finish

[Al Santos]



Figure 114: The Team Gives Public Tours of LEAFHouse

[Amy Gardner]

Competing Teams



Carnegie Mellon University

Much like adding a new "plug and play" device to a computer, the Carnegie Mellon home can be upgraded with smaller or larger rooms. All the rooms are arranged around the home's central core, which contains all the home's mechanical systems. Connections to mechanical supports are installed in the core and are easily accessible and adjustable.

"We want to encourage the housing industry to use our design system to create homes that families can design around their needs and change them as their needs change, like when they have a new baby or empty nest," said student Ben Saks.

The plug and play design works well with solar energy technologies, too. These include a day lighting design that reduces the need for electrical lighting; a 6.88-kW solar electric system on the roof; and a solar water heating system located above the bathroom.

Sustainable materials such as high-efficiency insulation and native white oak from Pennsylvania for the exterior were used as much as possible. To reinforce the sustainable living message, a "green-scape" composed of plants was added to provide insulation. It literally grows from the land, up the walls, and onto the roof, where the plants keep the home cool in summer.

A common space connects the Carnegie Mellon home with the home of the Decathlon team from Germany, softening the edges of the house and reinforcing the sense of community and neighborly interaction.

"This solar home is a fantastic educational tool for the public and the team," says student Rosemary Lapka. "I can't get the hands-on experience in the classroom I get working on this project. I work with real people, real time tables, and real budgets. It makes it very educational."

Carnegie Mellon worked with two other universities on this project. The Art Institute of Pittsburgh helped students design the furniture. The University of Pittsburgh helped with construction and will install the house permanently after the event in the Powder Mill Nature Reserve, an outdoor educational center affiliated with the Carnegie Museum of Natural History.

[http://www.solardecathlon.org/2007/team_carnegie.html]

Figure 114: Carnegie Mellon University 2007 Solar Decathlon Entry

[www.solardecathlon.org]



University of Cincinnati

The main living area of the University of Cincinnati Solar Decathlon home is a single airy space that has no walls to divide cooking, eating, and dining areas. Innovative walls, however, are key to the home's inventive design. The living space is particularly airy because the whole south-facing wall separating it from the home's courtyard is glass. That glass wall also lets in warming sunlight in the winter and provides great daylighting. The wall's specially produced triple-pane, low-e glass maintains excellent insulation, and louvered shades keep out unwanted summer solar heating.

Ingenuity is evident in the rest of the home's walls as well. All have clerestory windows at the top to complete the home's daylighting system. They are all also clad with a Formica rain screen separated by 3 in. (7.6 cm) from the main walls to reduce pressure on them—a novel use of a material normally found inside a home. "Novel, environmentally friendly, and efficient material use was a main goal," says architectural graduate student Christopher Davis.

The most distinctive feature of the Cincinnati Decathlon home, however, is a wall that stands separate from the house. A "fence" of 120 evacuated tube solar thermal collectors forms the outer wall of the courtyard. Hot water from these collectors is used and reused to heat and cool the house as well as to provide domestic hot water.

Hot water from the solar collector tubes flows into a "hot" storage tank, from which it goes to either the absorption chiller or a heat exchanger for the home's forced-air heating and cooling system, depending on the season. The "spent" hot water then flows to a "warm" storage tank to be put to work again. Both the domestic hot water system and a radiant floor heating system draw from this tank.

[http://www.solardecathlon.org/2007/team_cincinnati.html]

Figure 116: University of Cincinnati 2007 Solar Decathlon Entry

[www.solardecathlon.org]



University of Colorado at Boulder

When you're the two-time champion at the Solar Decathlon, you have two ways to go: either try to perfect your previous entry to maximize your winning potential or take another approach altogether. Never ones to take the easy route, the team from the University of Colorado at Boulder is striking out in a new direction, with a focus on creating a marketable house.

"We're looking at it from a broader perspective," says Michael Brandemuehl, an associate professor in the Department of Civil, Environmental, and Architectural Engineering. "We're designing and building a full-size house to make our story more relevant to homeowners as well as the building industry."

Because the Colorado team considers the Solar Decathlon size guidelines too limiting, they've actually designed a much larger house, at 2,100 ft² (196 m²). To make this work in the competition, the 700-ft² (65-m²) central core of the house works as a home in its own right and will be built and brought to the competition in October. Decking around the house will demonstrate the outline of the full house.

"We have designed it as a full house, with just a piece that detaches," says Sara Hrynik, who recently graduated with a degree in environmental design. But for this team, the work is not complete when they return from the Solar Decathlon, because that's when they'll build the remaining 1,400 ft² (131 m²) of the home, including three more bedrooms, two more baths, a breakfast nook, and additional living space.

On the plus side, though, that plan is also a major source of funding for the team. The enterprising Colorado students have already sold the final structure to the team's primary sponsor, Xcel Energy, which will use it as a permanent facility for research, education, and outreach to both the building industry and the public.

[http://www.solardecathlon.org/2007/team_colorado.html]

Figure 117: University of Colorado at Boulder 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Cornell University

How do you keep more than 100 students from architecture, engineering, and business disciplines focused on building a futuristic solar house? "Streamlined teams, flexibility, continuous meetings, and consensus building," says Andrew Chesson, who leads the business team.

Cornell's organizational strategy is reflected in the unique construction of a "Light Canopy," which is adapted to their solar house. The Light Canopy's streamlined framework of steel trusses serves as a support for PV, evacuated tubes for solar water heating, and a series of vegetated screens that provide shade in the summer. This framework allows homeowners a great deal of flexibility in how they integrate renewable energy systems because it can be set up independently of an existing structure. For example, they can add, remove, and rearrange components without having to modify the house. Raised flooring allows ductwork and wiring to be easily upgraded.

Cornell has a reputation for being particular—the team performed strongly in the 2005 Solar Decathlon and brought home second-place honors. "Cornell didn't need to build another house," says David Bosworth, who leads the architecture and construction team. "But we do need to raise public awareness and encourage residential solar energy." Honoring this commitment to educate their peers and the public, the team initiated educational activities in their community: introducing students in city schools to solar energy and energy efficiency; collaborating with Cornell's Ecology House on an Earth Day event; and setting up demonstrations at the local Farmers Market.

"This hands-on experience has shaped career directions of many of our students and changed the way they view the environment," says Faculty Advisor Matthew Ulinski. Bernardo Menezes, engineering team lead, agrees. "The independent nature of the team is what made this experience so valuable. The students decided the direction of the project and this gave us a sense of ownership." Controlling their destiny and their desire to raise public awareness on sustainable living is fundamental to the team's creativity.

[http://www.solardecathlon.org/2007/team_cornell.html]

Figure 118: Cornell University 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Georgia Institute of Technology

The Georgia Tech house is all about sunlight. These students are bringing on the sun... playing with light to see how it can transform and open up a living space. "We've placed a great emphasis on light and bringing light into the house in unique ways," says Jason Mabry, a recent architecture graduate and co-leader of the construction project. "Visitors will be able to see how the house works within itself. They'll see all the technologies we're putting into the house to make it more livable and efficient."

The approach is most obvious in the use of translucent walls, made of two sheets of polycarbonate that enclose an aerogel filler. Aerogel, sometimes referred to as "solid smoke," is the lightest solid known. The material is an excellent insulator and is translucent, allowing filtered light to enter the home. Even the building's roof transmits natural daylight. Made of translucent film, the lightweight roof comprises two layers—one of aerogel that insulates and another on top of that to shed water and drain the roof. Architecture student Alstan Jakubiec did the design drawings for the custom-built roof. "It's really exciting to have it on the house—this product is normally used for big installations like football stadiums," he says.

Joe Jamgochian, a recent Architecture graduate who co-leads the construction project with Mabry, relishes the opportunity to work in close collaboration with university professors, engineering students, and specialists in the construction industry. He is particularly proud of the team's work ethic. "There's been a real commitment by a core group of students and faculty to take individual responsibility for our project as a whole," he says. "They think of the potential issues ahead and address them."

Mabry echoes that notion. "You can sit in a design studio all day long, but the reward is to actually build it... to realize your design, build what you've drawn, and see what it's like in the real world."

[http://www.solardecathlon.org/2007/team_georgia.html]

Figure 119: Georgia Institute of Technology 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Technische Universität Darmstadt

"Made in Germany" is a phrase that applies well to the Solar Decathlon entry from the Technische Universität Darmstadt, because the team wants to present the German way of building, showcasing German technologies and materials in their solar house, including German oak.

The emphasis on "Made in Germany" products and technologies is apparent in the team's collaboration with German companies and manufacturers, such as Bosch, which provided three-month internships for two Darmstadt students. That arrangement provided a test bed for the students to study the performance of the systems that will provide hot water and climate control for the house.

"It was very interesting because we had all those experts right next to us, and when we had specific questions, we always got very good answers very quickly," says Toby Kern, an architecture student who was one of the interns.

After the Solar Decathlon, the house will return to Germany to be used as a solar power plant, as part of the university's project of a Solar Campus ("Solare Lichtwiese"), through which all buildings on campus will be equipped with building-integrated photovoltaics, feeding electricity into the German power grid.

Germany has a "solar feed-in tariff" that provides a guaranteed price for any solar power that is fed into the German power grid. Because the feed-in tariff is high enough to more than cover the cost of the installation over the long term, the university is selling shares to the public to finance these photovoltaic systems. This yields a return for the investors as the revenue from selling the power is split among them. The Solar Decathlon house will be the first piece in this ambitious project—continuing to showcase the potential of building-integrated solar power generation.

[http://www.solardecathlon.org/2007/team_darmstadt.html]

Figure 120: Technische Universität Darmstadt 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Kansas State University/University of Kansas

"Go mobile"—one of five points in the Kansas team's mission statement—gives a good start at characterizing this home. Transporting their homes to Washington, D.C., is a major challenge for many of the teams, but the virtually fully assembled Kansas entry fits on one truck.

"It can be unloaded from the truck and set up in a matter of hours," says engineering student Brad Lutz. "On the way back from D.C., we will be stopping at major Kansas cities to display the home."

The home's extensive use of structural insulated panels makes it very "low labor." "We were able to build the home in just eight days," says architecture student Matt Teismann. The narrow shape is ideal for showing off its efficiency and renewable energy features. A facade of solar panels easily attached to standing-seam metal roofing covers most of the south wall, right at eye level and tilted at 64° to maximize winter sun. Three additional sets of panels on the roof are mounted on two-axis tracking systems to maximize energy capture.

Another point in the Kansas mission statement is to "redirect expectations," and the home challenges visitors to do just that. It demonstrates that you don't necessarily need heat or artificial lighting for common household tasks. The centrifugal clothes dryer uses a fraction of the energy of a conventional heated dryer. An induction cooktop heats only the cookware and the food inside it, never getting hot to the touch. A mix of daylighting and indirect fluorescent lights provide most of the light, with only a few LED can lights for task lighting. A key task for the home's sophisticated utility monitoring and control system is to know what systems to turn off first if the energy supply is tight. As a backup though, batteries hold three days worth of energy.

[http://www.solardecathlon.org/2007/team_kansas.html]

Figure 121: Kansas Solar Team 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Lawrence Technological University

For some teams coming to the Solar Decathlon for the first time, the challenges of designing a home, raising funds, procuring equipment, and actually building it and bringing it to the National Mall are enough to deal with. Not so for Michigan's Lawrence Technological University, which is aiming to achieve far more than the competition's requirements. "All of the design choices that we're making and all of the technical choices that we're making are really taking into consideration not only what's good for the competition, but what's good for the environment," says Christina Span, an architecture student.

That includes drawing on locally sourced, sustainable materials, such as decking material made of a composite of rice hulls and polymer. It also means packing the small house chock-full of technology. To achieve this mix required the close collaboration of engineering and architecture students, most of whom had never worked together before.

Lawrence Tech's cross-disciplinary team has generated four senior projects for undergraduates, as well as one graduate project. For the architecture students, nearly all are now considering graduate schools with design/build programs, because they realize the benefits of seeing a project through to its final construction.

"That's across the board, as far as the architecture students that have gotten involved," says Span. The project also has the strong backing of the school, and most important, the school's alumni. A special campaign sparked the interest of the school's alumni and yielded significant funding for the team. "We had one of the largest alumni-giving campaigns ever," says Assistant Professor Philip Plowright, who teaches in the College of Architecture and Design. "We've had people give to the university who have never given anything before, because they heard we were doing this."

[http://www.solardecathlon.org/2007/team_lawrence.html]

Figure 122: Lawrence Technological University 2007 Solar Decathlon Entry
[www.solardecathlon.org]



Universidad Politecnica de Madrid

The 26-member team from the Universidad Politécnica de Madrid is not the largest one competing in the Solar Decathlon, but it may be the most diverse. Most of its members are from Spain, but there are also graduate students from Brazil, Chile, Ecuador, Mexico, Peru, Puerto Rico, and Venezuela. "The points of view from so many countries brought out the best in everyone and inspired everyone to work harder," says Maria Perez, architecture student. "Our objectives are to demonstrate innovation in energy efficiency that is applicable to single- and multi-family homes, develop a prototype for commercial manufacturing, and advance the social conscience on sustainability and the environment," says Professor Sergio Vega.

To achieve these goals, they used light construction materials and manufactured-building techniques. The house incorporates water-saving technology and solid-state lighting. Electrochromic windows (which darken or lighten to either block or let in the sun's rays), a double envelope, and phase-change gels in the foundation help regulate the temperature. The home's south side can be opened directly to an ample outdoor deck that has seating and vegetation.

The team's social-awareness campaign included an exhibition of a prototype of their house at the SIMA 2007 Property Fair where they received about 4,000 visitors. At an official ceremony coinciding with the España Solar Exhibition, Spain's President, Jose Luis Rodriguez Zapatero, and two ministers were honored guests. Madrid's house is an ongoing project. After the Decathlon, the students will continue to refine the systems to improve the technologies further and aim for even greater efficiency. For the Solar Decathlon, the team feels confident that they have blended energy efficiency, functionality, and aesthetics in a way that will appeal to the average American consumer, which for them is a very important goal.

"We built on the lessons learned from the last Solar Decathlon and shifted the design concept from Mediterranean to one that will appeal to the average American," says Eva Gomez, interior design student.

[http://www.solardecathlon.org/2007/team_madrid.html]

Figure 123: Universidad Politecnica de Madrid 2007 Solar Decathlon Entry

[www.solardecathlon.org]



University of Missouri-Rolla

What happens when your university has entered three Solar Decathlons, producing three distinct solar houses? In the case of the University of Missouri-Rolla, an on-campus solar village happens, replete with student housing and unparalleled research facilities. "Our overriding goal every year has been to focus on the public and present solar energy in a way that appeals to them," says Jacob Colbert, one of the student team leaders. But the team also seeks to investigate something new each year and establish research opportunities for current and future students and faculty.

They share the view that architecture is important, but their goal as a team is to further solar and renewable energy. "To do that, we are seeking to optimize both energy efficiency and energy production to reach a balance," says Travis Brenneke, student and building project manager. "This is about showcasing not just what solar energy can do or a futuristic design, but striking a balance that will appeal to the masses and not go overboard in either direction." Automated systems have captured the attention of the 2007 Missouri-Rolla team. Integral to this is a home automation system with indoor and outdoor sensors that control air-conditioning, lighting, and windows. The house takes advantage of natural light by incorporating many south-facing windows. A 12-ft (3.7-m) folding glass wall brightens the main living space. In the center of the glass is a door for egress—or the entire wall can be opened so the interior spaces join up with the deck.

The exterior is finished in Paperstone rain screen, which is UV resistant, easy to install, available in a multitude of colors, and 100% recyclable. Countertops are 50% recycled materials, and the floors are eucalyptus, which is harder and more resilient than bamboo flooring. A great source of pride for the Missouri-Rolla Decathletes is that everyone understands the entire project. "We've gotten everybody involved with design, fundraising, building... everything," says finance student Adam Smith. "This is a real-world experience that makes us more marketable when we graduate."

[http://www.solardecathlon.org/2007/team_rolla.html]

Figure 124: University of Missouri-Rolla 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Massachusetts Institute of Technology

Mens et manus — mind and hand. From adopting their historic university motto as a guiding philosophy to exercising the engineering institution's penchant for analysis, the MIT team incorporated their history, culture, and setting into their Decathlon house.

An MIT architecture class reviewed and analyzed all the 2002 and 2005 Solar Decathlon entries. Determining that the 2002 heat wave is more likely than the 2005 rainstorms, the team designed with the assumption of at least one sunny day for the week. In this spirit, the team sought to make minimization statements wherever possible—employing an efficient solar array, a small battery footprint, complete waste mitigation, and maximum use of passive solar design.

Although this is MIT's first Decathlon entry, it is by no means its first solar home. The team refers to the home as "Solar 7," because MIT has built six solar homes in the past, going back to the 1930s. Studying the history of these homes helped inspire the new home's primary technological feature, which is an innovative use of solar thermal systems. Passive solar thermal energy storage was a key feature in one of the historic homes. The new MIT Decathlon entry features a Trombe wall of translucent tiles that are used to passively convert sunlight into stored heat.

If you cannot make it to Washington, D.C., for the Solar Decathlon, you can still tour the MIT home on the virtual reality Web site secondlife.com. Another high-tech feature to help explain the home to visitors is a touchscreen computer coffee table that interfaces with software controls for the home's utility systems.

Graduate student Corey Fucetola speaks for himself and his teammates in summing up the Solar Decathlon experience. "It is a powerful opportunity to engineer, design, build, and finance the creation of an energy-efficient home," he says.

[http://www.solardecathlon.org/2007/team_mit.html]

Figure 125: Massachusetts Institute of Technology 2007 Solar Decathlon Entry [www.solardecathlon.org]



Team Montreal

Team Montréal is starting a Polar revolution to make solar energy popular in cold northern climates. The biggest challenge for the students is convincing their northern audience that solar technology works well in very cold climates. "The most important thing for us was to focus on the building envelope," says Joanna Rosvalt, an architecture student from McGill University. "It had to be both functional and aesthetic."

The building envelope starts with a special structural steel frame that is easy to assemble and disassemble. The walls are "clipped" directly to the steel frame and are insulated with polyurethane made from soybeans and recycled plastic to trap heat inside the home. Windows are triple glazed, low e, and have automated shading to further trap heat. On the roof, 40 PV panels producing 8.2 kW will also be clipped to the structure, so they won't need any other roofing under the PV system, reducing the cost and use of unnecessary materials. Two solar thermal collectors heat enough water for the radiant floor and household use. The team tried to integrate as many locally made and raw materials into the house as possible to reduce the environmental impact caused by shipping. For example, most of the furniture in the house will be made of reused materials.

A unique feature of the home is the use of artificial intelligence for temperature control and energy use. The "house" will search the Web for the weather forecast to predict the amount of energy it will be able to produce in the days to come and how much it will need for its occupants. The system will recommend energy use choices to meet upcoming demands. The system controls heating, cooling, lighting, shading, and ventilation, all with one interface.

"I always dreamed of living in a smart home that could be autonomous and ecological," says École de Technologie Supérieure student Michael Chapman. "Isn't it amazing to be able to build one?"

[http://www.solardecathlon.org/2007/team_montreal.html]

Figure 126: Team Montreal 2007 Solar Decathlon Entry

[www.solardecathlon.org]



New York Institute of Technology

Students from the New York Institute of Technology named their dwelling "Open House" for two reasons. First, they are targeting beachfront homeowners to show them how an open solar design can complement shoreline properties. Second, the term "open house" is an expression of the team's ideal home: a home with influence extending beyond its physical walls... a home that is one with its community and nature. Integration with nature and the community begins with the architecture: a unique southern wall opens completely to the beach, blending the line between sand and walls. A white ceiling helps to maximize natural light. A contained pond on the roof reflects light back into the open space.

On the roof, an evacuated-tube solar thermal system collects solar energy for water heating and space heating. A geothermal heat pump uses the roof pond (rather than the more typical underground installation, which can't be used on the National Mall) as a heat source to provide extra heating. A building-integrated 7.7-kW PV system doubles as the shading overhang for the south wall. Despite the home's advanced solar technology, the team was surprised at how tough it is to sell solar to the public. "We didn't realize how much more still needs to be done to have the public embrace solar," says student Daniel Rapka. "People don't realize a solar home operates like a normal home." Another layer of integration is the home automation system or "smart house" feature. This system allows people to get real-time data on energy use. The home automation system serves as an educational tool by giving the public a user-friendly way to view a home's energy use.

"The smart house feature ties into our open house idea where not only homeowners learn about the house, but homeowners could put their energy-use information up on a blog so the community could share in the information," says student Matt Mathosian. "People could log on to a Web site where they could comment about energy use."

[http://www.solardecathlon.org/2007/team_nyit.html]

Figure 127: New York Institute of Technology 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Pennsylvania State University

When abundant opportunities and possibilities are on the horizon, people often get stuck deciding which ones to pursue. Not so for the Penn State Decathlon team. This high-energy group of students is taking them on one after another.

The Penn State students were inspired by the challenge of the Decathlon's Market Viability contest and decided to build two homes to test themselves and their market concept. The competition home is called MorningStar Pennsylvania. After the Decathlon, it will serve as a renewable energy research lab and educational residence on the Penn State campus. Its sister home, MorningStar Montana, will house visiting faculty at Chief Dull Knife College on the Northern Cheyenne Reservation. This affordable version of the MorningStar concept will help advance the use of solar energy in another climate and culture. "We see our Solar Decathlon home, and the one in Montana, as prototypes where people can learn," says member Sal Gimbert. The team used a hybrid construction process with a mix of prefab and site-built elements. The "Technical Core" of the house (kitchen, bath, mechanical components) is shipped to the home's location, and locally available "materials of opportunity" are used to complete the home.

An "Energy Dashboard" monitors and displays energy consumption and production to teach the inhabitants about how they are "spending" their energy. A curtain wall system with PV-powered LED lighting glows in different colors depending on weather forecasts. Pennsylvania bluestone and reclaimed slate shingles provide thermal mass. The students saw the talent and expertise available at Penn State as yet another opportunity. "From the beginning, we wanted to engage as many university programs as possible. So, we kept the design process open to a range of disciplines throughout the university. Close to 900 Penn State students have been involved in the Solar Decathlon," says member Andreas Phelps. "We want to be outstanding representatives for the Penn State community by using the Solar Decathlon as a catalyst to reach our long-term goals," says member Gretchen Miller. "There's no stopping us."

[http://www.solardecathlon.org/2007/team_penn.html]

Figure 128: Pennsylvania State University 2007 Solar Decathlon Entry [www.solardecathlon.org]



Universidad de Puerto Rico

Biomimicry was the genesis for the Universidad de Puerto Rico's motto: Technology and Ecology: Partner for the Future. Biomimicry is the study of nature's best ideas, enabling astute observers to imitate design and process solutions provided by the natural world.

The team took its inspiration from a single cell. The simplest unit of a living organism, the cell produces energy, recycles waste, adapts to changing conditions, functions independently, and communicates with other cells. This is also an apt description of Puerto Rico's solar house. Sustainability was fundamental to all design and building decisions. "Because we are transporting our house [to the National Mall] by sea and land," explains architecture student Fátima Olivieri, "the house was built using lightweight materials, and divided and shipped in two pieces. One half incorporates all the electrical equipment including PV modules and batteries, and the other half, the water components such as its solar thermal system."

Also contributing to the house's energy efficiency and sustainability are a unique louvered screen that provides shade when the windows are open; an insulated exterior reflective siding that softens and diffuses daylight entering the house; and recycled wood for flooring and walls. Media attention helped the team reach its audience. The project was written up in two magazines and covered monthly by local TV news stations. According to Professor of Architecture, Jorge F. Ramirez, the project has not only raised the consciousness of the students and the community, but that of the university. "Sustainability is no longer an elective, but a required course in the School of Architecture." The team feels that their house demonstrates that energy efficiency and sustainability are practical options for comfortable, livable dwellings. "Using the cell as a model for our home put us in touch with the environment and ecosystems and has taught us how to lead cleaner, better lives," concludes Olivieri.

[http://www.solardecathlon.org/2007/team_puerto_rico.html]

Figure 129: Universidad de Puerto Rico 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Santa Clara University

Design with purpose. This succinct philosophy guided the Santa Clara University team in its quest to build a sustainable solar house that is functional, elegant, intelligent, and innovative. "Our house is dynamically smart. Its computers sense interior and exterior conditions and make automatic adjustments for thermal comfort and efficient energy usage," says Team Manager James Bickford.

It's not surprising that students from Silicon Valley would take this approach to operating their innovative house—starting with the electrochromic windows. With a flip of a switch, the glass darkens to block sunlight or lightens to let it in, depending on the temperature desired inside the house. Another innovation is a prototype solar thermal unit (with absorption chillers) for space and water heating as well as air-conditioning. The house was built to operate off the utility grid using the PV modules with backup batteries during the Solar Decathlon event. However, when it returns to campus, the house can easily be connected to the grid using an appropriate inverter, and its excess power sold to the utility provider.

To measure and certify the house's sustainability, the team uses a unique meter that quantifies the power used for heating and cooling and measures the amount of carbon emissions the house saves. In the future, this meter could be instrumental in the selling of carbon credits to carbon emitters, which could motivate people to save energy and accumulate carbon credits that can be turned into cash.

Purpose drives the Santa Clara students to innovate, and gratitude inspires them to share their knowledge with the community. "Our community has given us enormous support," says Communications Director Meghan Mooney. "We wanted to give back, so we organized a mini solar decathlon competition among three local high schools." The event resulted in greener schools and a heightened awareness of the environment and the importance of sustainability.

[http://www.solardecathlon.org/2007/team_santa_clara.html]

Figure 130: Santa Clara University 2007 Solar Decathlon Entry

[www.solardecathlon.org]



Texas A&M University

Imagine instead of just moving furniture around when you wanted a change, being able to switch rooms around. The Texas A&M Decathlon team's vision is for a totally modular "plug-and-play" home. "You could swap the position of the kitchen and the bath without a problem, buy an extra kitchen on eBay, or sell off a couple of rooms after the kids move out," says recent architecture graduate Thomas Gerhardt.

The A&M "groHome" concept is based on interchangeable and interconnected "groWall" units, some of which will have all of a home's kitchen, bath, or entertainment utilities built into them. "All the electricity and plumbing is easy to get to, and the plug-and-play approach will give the homeowner great flexibility, but it made things challenging for us," says Environmental Design student Josh Canez.

Another distinctive feature of the Texas A&M home is that it is like an animal with two skeletons. An inner skeleton of steel columns and beams provides the basic structure to which a skin of groWall units and structural insulated panels attaches. Then an outer skeleton of cables set 2 ft (0.6 m) to 3 ft (0.9 m) apart from the walls provides support from which the home's PV panels (or other features such as flower trellises) are hung. Just as extra rooms can be easily added, so can extra PV panels to provide power for them. If a hurricane is forecast, the envelope of PV panels can be replaced with "armor."

Hot water for both space heating and domestic water comes from a set of vertical evacuated tube solar collectors on the north side of the house. Lighting features paper-thin, bendable CeeLite light-emitting capacitors (as opposed to diodes) that can be cut into any shape. The "healthy home" landscaping includes a reflecting pool—complete with fish—a wetland to treat the pool water, and even a "bat tower" to provide fertilizer and get rid of insects.

[http://www.solardecathlon.org/2007/team_texas-am.html]

Figure 131: Texas A&M University 2007 Solar Decathlon Entry

[www.solardecathlon.org]



University of Texas at Austin

This house is about life and its boundless possibilities; it's also about a budding solar way of life. In fact, the name symbolizes a home that "blooms" like a rose under the sun.

"All the houses use solar. We wanted to take the technology out of the house and make people aware of their surroundings," says Russell Krepert, faculty advisor. The building's "skin" responds to the wind through shutters that allow for enormous flexibility in terms of light, heat, fresh air, and privacy. While solar collectors on the roof heat water for the home, the excess heat from the hot water system warms a hot tub outside. "The innovation is using a thing of joy like a hot tub as a technical amenity as well—it takes heat out of the system so you don't pay for heating the tub," says student Jack Wingerath.

A 7.6-kW PV system, together with a roof brim, invites people inside the home with its butterfly shape and proudly displays its technology. Interior materials are both sustainable and Texas-influenced to create an inviting interior. Although the home is high tech, the students used standard materials found in most home improvement stores. "We wanted to take the fear of using the technology out of the system and give people a starting point," says Krepert. "It's technical, but you can do creative things with it."

The struggle is to make the house livable and appeal to the general public and still be efficient, says Krepert. "People don't buy ugly things. The problem we're running into is that Europeans are more advanced as far as energy efficiency. We can get those things here, but we run into a problem with code compliance, etc. So what we've tried to do is be conscious design wise. If it's ugly, people aren't interested no matter how energy efficient."

[http://www.solardecathlon.org/2007/team_austin.html]

Figure 132: University of Texas at Austin 2007 Solar Decathlon Entry

[www.solardecathlon.org]



University of Illinois at Urbana-Champaign

When the unpredictable Midwest climate interfered with building their house outdoors, the University of Illinois team simply built it in a warehouse. "We set up an assembly line, a rail system, to construct the home in three modules—we can roll modules out of the warehouse and onto the truck," says student Bob Kinsey. "We have demonstrated our ability to mass-produce these modules in a large-scale environment."

The concept of modular design is not something new, but people may think of it as low quality. "This is not true for us," says architecture student Nora Wang. "We designed the building to be flexible, comfortable, and livable. And you can customize the interior space, which helps engage the user's imagination." When it comes to making the house comfortable and easy to live in, the team has this covered, too. "This area may be the most innovative element for us," says student Ben Barnes. Cooling and heating is all radiant via ceiling panels—no forced air is used. The team's approach to lighting was also carefully conceived. Placement of windows and doors for daylighting was designed in parallel with the artificial lighting plan. They are using dimmable fluorescent lights and LED bulbs for task lighting. "The LED was invented by a graduate and current professor at the University of Illinois, so we take great pride in using this technology," says student Susan McKenna.

Every piece of furniture and cabinetry in the home is student-designed and customized with inhabitants' activities in mind. A local firm, which is headed by an Illinois alumnus, built the kitchen cabinets from 100% recycled particleboard. "Our industry contacts are excited to get their products out there. One of the greatest things is the way people have stepped up to the plate," says Wang. The team members feel certain that the modularity and flexibility of their design translates well to the consumer. "This is about the affordability of a solar home for everyone. It's the Volkswagen of homes," says Kinsey.

[http://www.solardecathlon.org/2007/team_illinois.html]

Figure 133: University of Illinois 2007 Solar Decathlon Entry

[www.solardecathlon.org]

Public Tours

During much of the competition, the Solar Village was open to the public. The members of the public ranged from knowledgeable professionals to school groups to eager-to-learn adults. Approximately 200,000 people visited the houses and the public spent approximately 20 to 30 minutes visiting each house. During peak hours, the wait to get into some houses averaged around one hour.

The Maryland team wanted to give a concise and cohesive tour that allowed people of all learning levels to get the most of the tour. Thus, the team decided to have tour guides stationed throughout the house. Visitors to the house were encouraged to wander and browse as they pleased and the tour guides either volunteered information to curious members of the public or answered questions as needed.

To reinforce the team and allow some team members to focus solely on competition tasks, the team recruited and trained new team members to act as tour guides. These team members were trained before the start of the competition and learned information about the house through a series of talking points and from listening to other team members interact with the public.

Energy Facts

Serving Size About 1 Average House
in Baltimore, MD

Amount Per Serving

Total Energy	7,806 Kwh
Energy from foreign oil	0 Kwh

% Yearly Value*

Heating	77%
Water Heating	22%
Cooling	42%
Appliances	48%
Small Appliances	26%
Large Appliances	74%
Lighting	56%

Energy From Sun **100%** • Fresh Air **100%**
Daylight **100%** • Recycled Water **100%**

*Percent Yearly Values are based on an average house in Baltimore, MD (18,835 KWh per year) and average climate conditions between 1961 and 1990. Your daily values could be higher or lower depending on your location, behavior, and current, globally-warmed climate conditions. Information based on the Home Energy Saver Website.

Household Yearly Operations	Avg. House	LEAFHouse
Yearly CO2 Emissions (lbs)	24,683	0
Major Appliances	4,011	0
Heating	4,370	0
Cooling	4,879	0
Lighting	1,448	0
Yearly Energy Cost	\$1,526	\$0
Major Appliances	\$322	\$0
Heating	\$255	\$0
Cooling	\$284	\$0
Lighting	\$84	\$0

PV System

80/20 Inc. **80/20 Inc.**
The Industrial Decathlon

Contribution Aluminum racking system for PV panels
Website www.8020.net

Sanyo Electric Co. **SANYO**
LTD Global

Contribution Photo-voltaic panels
Website <http://us.sanyo.com>

Outback Power System **OutBack**
Power Systems

Contribution Electrical system materials
Website <http://www.outbackpower.com>

Ingredients: 34 Sanyo HIT-205BA3 panels (205 watts each), 80/20 extruded-aluminum racking system, 3 OutBack Power Systems MX60 charge controllers (60 amps of DC output current for battery systems ranging from 12 to 60 volts), 48 East Penn Deka S8D SLD G LTP batteries (265 amp-hours at 12 volts each), 4 OutBack Power GVFX3648 Sinewave Inverters (48 volts DC, 120 volts AC at 60 amps continuously, and 3600 watts continuously). **Contains products using: renewable resources, cutting-edge technology, and bio-inspired design savvy.**




leaf house
at the University of Maryland
SOLAR DECATHLON 2007

PV System

Figure 134: Example of Nutrition Label in the House

[LEAFHouse Team]

In addition to the tour guides, LEAFHouse also utilized various print materials in the house tour to provide more information to guests. The team felt it was necessary to provide information on all levels ranging from pictorial information about the building process to signs highlighting the house systems and materials to sponsor recognition to information about LEAFHouse at different scales. The media was integrated into the house as well as added to the architecture itself.



Figure 135: The Signage on the Mall

[LEAFHouse Team]

The team used nutrition tags to provide more information about the house at a detailed level as well as recognize sponsors. These tags were placed around the house so that visitors could gain even more knowledge about specific portions or equipment in the house. They also provided energy facts comparing an average home in Baltimore to an energy efficient home.

LEAFHouse incorporated signage within the landscaping of the house to provide entertainment and information to those waiting in line for house tours and to entertain the public before and after public tours each day. There were a series of signs located at the front of the house that provided generalized information about the house, the team and the process as well as displayed a photo montage of the construction process.



Figure 136: The Brochure Handed Out on the Mall

[Lynsey Ring]

Another series of signs were located on the ramp and integrated into the site plan as well. These signs contained more detailed information and had information about the engineering systems and materials used in the house.

The team also handed out brochures to the public. The brochure was used to provide information about principles of the team, the house systems and the members team. It also told visitors about LEAFHouse at different scales and in different locations. In addition to information about the house and team, the brochure also encouraged visitors to write to their local government officials and take more energy efficient measures in their daily life.

In addition to print material and the tour itself, the team also offered a audio tour. The audio tour was a four minute tour describing the house and its systems that could be accessed over cell phone. This entertained guests waiting in line for a tour of the house and provided base information that tour guides could then elaborate.

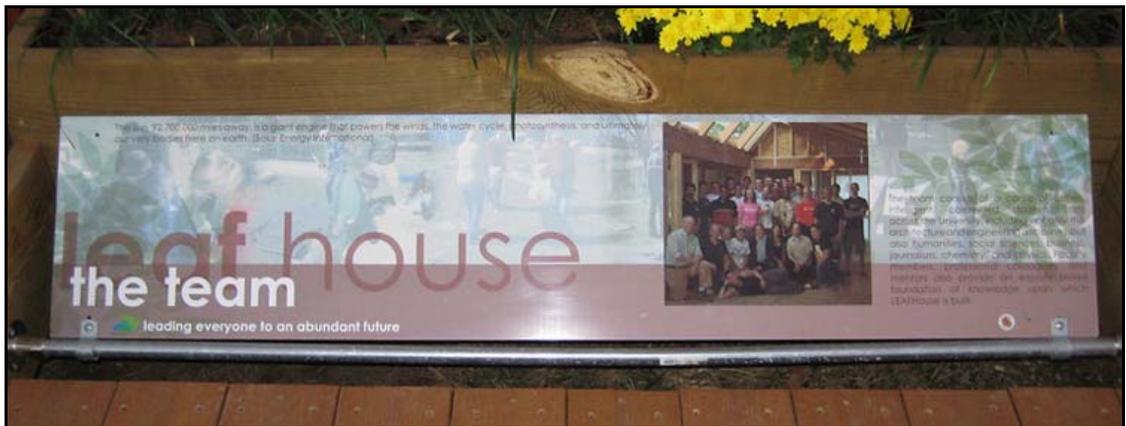


Figure 137: Example of Bench Signage on Front of House

[LEAFHouse Team]

Media and Communications

In addition to the competition and giving public tours, the team was constantly interviewed by media. The team engaged in constant interviews for print media, online podcasts and blogs, local and network televisions and radio. Prior to the competition, the team had media training sessions to prepare them for the kinds of questions the media would be armed with.

The team was followed by Beyond Production, a film crew taping a special for the Discovery Channel, from the beginning of the summer through the competition. The one hour special focused on the University of Maryland team, the University of Colorado team and the Carnegie Mellon University team and aired on the Discovery Channel's Planet Green network.



Figure 138: Film Crews at the Opening Ceremonies

[Brittany Williams]

The team also gave tours and took advantage of media opportunities with government and university officials. University President Dr. C. D. Mote visited the house as well as U.S. Secretary of Energy Samuel W. Bodman and House Majority Leader and representative of Maryland's 5th congressional district Steny Hoyer.



Figure 139: Team Members give Steny Hoyer and Samuel Bodman a Tour

[Aditya Gaddam]

Solar Decathlon 2007 Awards

2nd place overall

1st place in the Communications Contest

2nd place in the Architecture, Market Viability and Lighting Contests (1st place in the Lighting Subjective Contest)

One of seven teams to score a perfect score in the Energy Balance Contest

Solar Decathlon Other or Industry Awards:

Solar Decathlon's BP People's Choice Award

ASHRAE: Integration for Renewable for Sustainable Living

NAHB: First Place in the NAHB Marketing Curb Appeal Award

Other Awards:

10.20.07, award from the PV AIA annual awards program: Special Award for the "Advancement of the Art and Science of Architecture"

Figure 140: Awards Received

Post Construction/Post Competition



Figure 141: Proposed Site Location

LEAFHouse was designed and built for use as a house; however its final location will be for a different more public use. After the competition, LEAFHouse returned to the University of Maryland campus and is intended to serve as the chapter house for the Potomac Valley Chapter of the American Institute of Architects and become the Potomac Valley Green Design Information Center. The house will be converted into an office while trying to preserve the integrity of the design and systems.

While LEAFHouse will be a working chapter house, it will also be open to the public for visits and tours. Members of the LEAFHouse team will also continue to work on the house and continue research and development on aspects of the house. The Potomac Valley Architecture Foundation which will own the house holds the mission "to

educate the general public about the importance of livable communities and sustainable architecture to improve the health, safety and welfare of the public," and "to educate architects, both professional and intern, about how to better deliver safe, sustainable and beautiful buildings and communities to the public"(Unsell).



Figure 142: Proposed Site Location



Figure 143: Proposed Site Location

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