## Case Studies of Low-Energy Homes and Sites in Northeastern Kansas and Kansas City Metropolitan Area

# EXECUTIVE SUMMARY

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### Low-Energy Homes and Sites

Low-energy housing is defined as housing that conserves both source energy (generated off-site) and site energy through a variety of strategies, including a reduction in the use of purchased energy and conscious use of materials and techniques reducing the embodied energy cost of the home and site.[1] In the book *Introduction to Energy Analysis,* Kornelis Blok summarizes residential building energy use:

"The residential sector is typically responsible for about two-thirds of the demand on primary energy in the building sector [of energy use]....Space heating represents far and away the dominant energy function in the residential sector.....Another important energy function is the [heating of] water....The rest of the energy use in the residential sector is scattered over [the following]:

- lighting
- refrigeration and freezing
- clothes washing and clothes drying
- dish washing
- air conditioning
- cooking
- TV and video
- information (computers and peripherals)."[2]

In addition to energy used in homes, stormwater runoff and sewage result in energy use at the point of water treatment, prior to waste water flowing back to water bodies. The critical observer must ask how water is obtained--from a city source, well, or captured from rain? …. how water is used--is the site irrigated? …are plumbing fixtures water efficient?....and how water leaves the site--is rainfall infiltrated for groundwater recharge, is rainwater harvested for use, or does it run to a storm sewer? Is sewage treated on-site, is wastewater reclaimed and reused, or does it flow to a treatment plant?[3]

While low-energy housing has been extensively studied by the US Green Building Council and others,[4] research tends to focus upon technologies used in the construction of homes, rather than the full optimization of site and building relationships.

### Involving Students in Research

To explore optimal site-structure relationships for low-energy housing and introduce early design students to fundamental case study research, Clement, Lewis, and Kingery-Page led a twelve-day study of three sites. The homes ranged in building cost from $150,000-$600,000 and employed a variety of both passive and active energy saving techniques. The cases can be characterized as: a high-design urban infill home, a rural 'earthship' home, and a suburban LEED platinum-certified retirement home; all are in the Kansas City and northeastern Kansas area.

Faculty expected careful analysis of a variety of environmental and energy-conserving design strategies and choices, with particular concerns for linkages between the interior and exterior environments. Students were very interested in the people responsible for designing and building the homes and wanted to know their stories and thoughts about living in these places after the construction process was complete.[5]

Case studies of buildings and landscapes are primarily humanities research, as they deal with the study of artifacts (sites and structures). The humanities are defined as the "...branch of learning concerned with human culture....The humanities are typically distinguished from the social sciences in...the use of interpretation of texts and artifacts rather than experimental and quantitative methods."[6] The low-energy homes and sites are the artifacts under investigation within this case study.

However, most landscape architecture and interior architecture case study approaches also incorporate knowledge, if not methods, from the sciences and social sciences. In studies of low-energy homes and sites, students incorporated scientific knowledge by considering the processes and states of natural systems and applied technology. As commonly practiced in the social sciences, students directly observed and interviewed the inhabitants of each case study.

### Case Study Methodology

The three case study locations represent a convenience sample based upon proximity to Kansas State University, popular press coverage of innovative, low-energy housing in the area,[7,8] and homeowner willingness to allow visits to their properties. As teams, students completed a case study of the Millstein,[9] Borchers,[10] or Borth-Iiams[11] residence. In the process of completing the case study, students first conducted archival research and a literature review; second, at the sites, a formal analysis of the home and site occurred; third, a limited amount of interview research was conducted while on-site; fourth and after returning to campus, continued analysis, interpretation, and evaluation; and fifth, communication of the findings and results of the study, as a team, through creating a coherent document and delivering a formal presentation (fig. 1).

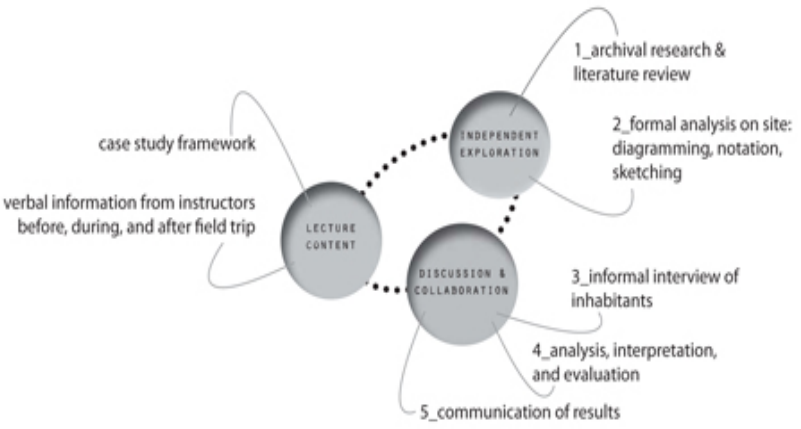


Fig.1. Five Case Study Steps in Relation to Passive and Active Learning (Kingery-Page)

*Analysis Framework*

The faculty simplified the rich complexity of the design environment by using a case study framework ordered by Image, Activity, and Technology within Context, an adaptation of the Vitruvian Triad: *venustas, utilitas, firmitas*[12] and very similar to the framework described by Francis D. K. Ching in *Architecture: Form, Space and Order*.[13] This framework suggested a clustering of the categories within the case study methodology described by Mark Francis in "A Case Study Method for Landscape Architecture."[14]

The teams of fifteen students were subdivided into four smaller teams according to this scheme; each team was assigned a framework heading from the four-part framework for analysis.

**Image** description and analysis included spatial relationships (particularly interior-exterior relationships), spatial hierarchy, path-to-space relationships, and other formal, spatial relationships.

**Activity** elements included circulation and activity zones and spaces; public, private, and service areas or zones.

**Technology** description and analysis included observations of the use of energy for heating and cooling space and water, for running electrical equipment, and for storm water and sewage systems.

**Context** included general information on the site and client, costs, timeframes and background knowledge. Some dimensions from Mark Francis' case study framework were assigned to all three categories of Image, Activity and Technology, because they simply could not be categorized in one alone.

*Field Trip and Site Visits*

On October 5 2012, faculty and students traveled to northeastern Kansas and Kansas City metropolitan area for site visits, starting off with a visit to the Anita B. Gorman Discovery Center[15] in Kansas City, to learn about low-energy management of water (fig. 2) and other sustainable systems.

Fig. 2. The 'Living Machine' inside the Anita B. Gorman Discovery Center, used to treat all waste water (Kingery-Page)

After a guided tour of the Discovery Center, the student teams conducted case studies of three residential properties (figs. 3-5) spending approximately two hours at each.

*Storytelling: Home-owner Stories*

At each site visit, home-owners guided students through their house and site with commentary about the design program and goals, construction decisions and activities, and ongoing concerns as inhabitants. Students listened, took graphic and written notes, and actively interviewed the home-owners. Field notes were later processed and refined as presentation strategies for the findings were discussed and developed by the three teams.

Team Passive Solar interviewed Vicky Borchers[16] at her home (fig. 3) in its suburban location. The Borchers home was built using Structural Integrated Panels (SIPs) installed by crane on a sloping site. Students learned about designing for flow through ventilation; a ductless split system for air conditioning and heating individual rooms; a butterfly roof designed for optimizing active solar panels and collecting rain water; a cistern used to store rainwater for eventual use in plumbing systems; and a green roof of sedum.

Fig. 3. Vicky Borchers' Home (Clement)

Students learned that a sloping site offers the opportunity for a rich entry sequence of spaces and events that can introduce visitors to water and energy conservation strategies. A cluster concept for spatial organization can be very efficient in terms of circulation and maintenance of interior spaces. City codes are not keeping up with technology; there is a need for persistence on the part of innovative home owners given the difficulties of obtaining a permit and mortgage loan for new construction methods and systems.

Team Three Seven One Six interviewed John Iiams[17] to learn about his LEED Platinum house, on its urban lot in an older, transitional neighborhood (fig. 4). They learned about contextual concerns of scale and alignment of facades and traditional use of front yards. They learned that a linear parti and east-west orientation of the structure permitted optimum passive solar gains; about geothermal heating and cooling system, radiant floor heating; a small wind turbine; and the ventilation and space utilization benefits of an open floor plan.

Fig. 4. Jenilee Borth-Iiams and John Iiams' Home (Lewis)

Additional lessons learned included observations on budget constraints and reductions that affected site design significantly. For example, the entry sequence was minimally developed and uninspiring, and exterior decks or terraces are still only hoped-for "future additions." The owners of this home face challenges in completing exterior spaces given the demands of professional work as a dual career couple.

Team Earthship interviewed David and Susan Millstein[18] at their rural home (fig. 5) near Baldwin City, Kansas, and learned about a labor-intensive, low-cost way of building. As the homeowners also built their house, students learned about the collection and use of salvaged materials and how construction experiments by the owner-builder affected the final design over several years. A shed was built first to study how soil and concrete mixtures would interact with stacked tires as the structural system for walls. Rammed earth was abandoned, replaced with a concrete mixture at this site and in this climate; reinforced ferro cement was used as a combined roof membrane and structure. This slow process of testing methods aided the Millsteins in their pursuit of building permits.

Fig. 5. David and Susan Millstein's Home (Lewis)

Students came away with knowledge that a strong personal form concept can inspire methods and details; and that form responding to local wind patterns reduces energy use and results in a more stable, comfortable home. The students gained appreciation of a southern exposure for passive solar gain; thermal mass as structure and creative use of recycled materials. They learned that there can be significant personal meaning drawn from a labor-intensive building process as well as in the occupying of completed space.

The faculty intention to study well developed exterior spatial sequences was only partially met by the subject properties. The Borth-liams residence[19] (fig. 4) has little if any site development, leaving its entry sequence lacking. The Millstein residence[20] (fig. 5) has minimally designed transition spaces between the interior and exterior environment. However, strong functional connections between inside and outside are evident, including a solarium with roll-up walls and an informal patio space for sitting and dining, surrounded by gardens for growing food and flowers. Of the three sites, only the Borchers residence[21] (fig. 3) has moderately well developed entry sequence, exterior decks, and other outdoor living spaces.

**Conclusions**

In addition to addressing the dimensions listed in the analytic framework (fig. 1), students were asked to draw conclusions about the subject. Conclusions were to include thoughts on the significance and uniqueness of the project; limitations or weaknesses; general beneficial features and lessons; and home-owners' future plans.

Eliciting critical observations of limitations and weaknesses of the subject residences from students was a challenge. Students were reluctant to be critical, perhaps due to their inexperience or perhaps due to their awareness of the significant investments of time, money and other resources made by the home-owners. Students appreciated the warm welcome given by their hosts.

Still, it is important to note that the three case studies contain differing degrees of exterior space development. Such spaces *can* have an enormous impact upon energy use, both by amplifying passive heating or cooling strategies of the house and by providing alternative, low-energy living spaces in spring, fall and summer months. Thus the overall lack of well-developed exterior spaces in one case study and weak to moderate development in the other two was a significant disappointment to the researchers.

The authors suspect that that this lack is not unique to the three cases studies, but instead represents a typical, Midwestern focus upon interior living space. Future case studies of low-energy housing should focus on documenting and analyzing historic Midwestern patterns of exterior living space, such as the porch, and its effect upon energy efficiency of the home. In addition, future research should examine the possible benefits of adapting warm-climate exterior living space patterns (for example, the interior courtyard garden) to the Midwestern United States.

The pages that follow this summary include all three case studies completed (illustrated, written, and compiled) by the student researchers.

*Acknowledgements*

The authors gratefully acknowledge the early design students enrolled in LAR 220 and IAPD 307; Kansas State University for support of the low-energy case studies; Professor Stephanie Rolley, Department Head of Landscape Architecture/Regional & Community Planning; Professor Kathy Ankerson, Department Head of Interior Architecture & Product Design; Jeremy Merrill, Ph.D. candidate in Environmental Design and Visiting Assistant Professor Will Yankey for classroom support; Professor Chip Winslow for his participation in the site visits; and most significantly, Vicky Borchers, David and Susan Millstein, Jenny and John Borth-liams, and the Anita B. Gorman Discovery Center director for generously opening their respective properties to students and faculty from Kansas State University.

The authors have published a more detailed paper about low-energy case studies with early design students in the proceedings of the 2012 National Conference on the Beginning Design Student: Realizing the Sustainable Imagination.

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[1] Definition of low-energy homes adapted from Litt, B. December, 1994. "What is a low-energy house and who cares?" Berkeley, CA: Lawrence Berkeley Laboratory, Environment and Energy Division. Available online http://www.osti.gov/energycitations/servlets/purl/10124613-dKmZGY/webviewable/10124613.pdf. Accessed June 20, 2011.

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[3] Ideas of sustainable water management adapted from Anisfeld, Shimon C. 2010. *Water Resources.* Washington: Island Press.

[4] U.S. Green Building Council developed the *LEED for Homes Scoring Tool*, available online http://www.leedforhomes.org/OST/Main-Nav/leed.aspx. Accessed June 20, 2011. See also Anderson, R. et al. November 2004 "Analysis of System Strategies Targeting Near-Term Building America Energy-Performance Goals for New Single-Family Homes: FY2004 Fourth-Quarter Building America Milestone Report." Golden, CO: National Renewable Energy Laboratory; and Sustainable Sites Initiative (Sites) guidelines at http://www.sustainablesites.org/products/. Accessed May 24, 2012.

[5] Homes were in different states of completion. One home was far from being finished and in that state provided several key lessons on design process and product.

[6] *Oxford English Dictionary: the definitive record of the English language*. http://www.oed.com/. Accessed August 15, 2011.

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[8] Chapa, J. June 5, 2009. "Studio 804's Student-Built Off Grid House." *Inhabitat* weblog. Available online http://inhabitat.com/residence-studio-804s-off-grid-house/. Accessed May 24, 2012.

[9] Millstein, S. and Millstein, D. "464 E 1750th Road." Baldwin City, Kansas Field Trip, IAPD 307 & LAR 220 Design Studios Field Trip by Kansas State University, Manhattan, Kansas, October 5, 2011.

[10] Borchers, V. "12411 E 72d Terrace." Kansas City, Missouri Field Trip, IAPD 307 & LAR 220 Design Studios Field Trip by Kansas State University, Manhattan, Kansas, October 5, 2011.

[11] Borth-liams, J. "3716 Springfield." Kansas City, Missouri Field Trip, IAPD 307 & LAR 220 Design Studios Field Trip by Kansas State University, Manhattan, Kansas, October 5, 2011.

[12] Vitruvian Triad: *utilitas, venustas, firmitas*—See: Weston, Richard (2011*) 100 Ideas that Changed Architecture*, London: Laurence King Publishing, p. 58.

[13] Ching, Francis D. K. (1996) *Architecture: Form, Space and Order*, 2d. ed. New York: VNR p. xi

[14] Francis, Mark. September 1999. "A Case Study Method for Landscape Architecture." *Landscape Architecture Foundation.* Retrieved from http://lafoundation.org/myos/my-uploads/2010/08/19/casestudymethod.pdf Accessed May 31, 2011.

[15] Davis, S. "Anita B. Gorman Discovery Center." 4750 Troost Avenue, Kansas City, Missouri Field Trip, IAPD 307 & LAR 220 Design Studios Field Trip by Kansas State University, Manhattan, Kansas, October 5, 2011.

[16] Borchers, V. "12411 E 72d Terrace." Kansas City, Missouri Field Trip, IAPD 307 & LAR 220 Design Studios Field Trip by Kansas State University, Manhattan, Kansas, October 5, 2011.

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# The Borchers Residence
# Team Passive Solar:
# LAR 220 & IAPD 307
# Fall 2011

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Team Passive Solar visited the Borchers residence in Kansas City, Missouri. The house is one of several single-family homes located in an urban neighborhood, yet it is the only one of passive solar design. Architect Vicky Borchers, who designed the house for herself and her husband, was able to push the limits of design because of the absence of strict construction regulations for the area. She designed the house as a retirement home for herself and her husband (Borchers, October 5, 2011).

The lot itself is a one-acre, west-facing slope that drops approximately thirty feet from rear to front. This natural slope provides privacy to the lower-level garage and enhances drainage away from the building. The house is oriented on an east-west axis taking advantage of sunlight to provide both light and warmth in the home. Stones excavated from the site are piled around the base of the home, allowing the house to nest into the site. Additionally, the stones construct several retaining walls on the site.

All of the landscaping is reused from the site or reclaimed. The Borchers used trees removed during house construction as firewood and mulch. Additionally, Vicky Borchers salvaged plants her neighbors removed from their own yards to plant in her yard. Remaining trees shade the house during the summer months and protect it from chilling northern winds during winter (Borchers, October 5, 2011).

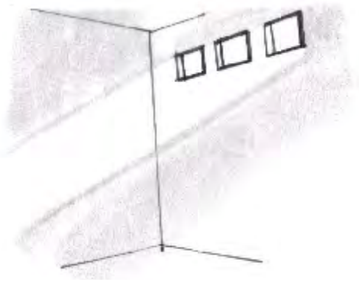

The Borchers residence is a passive solar home that uses both passive and active systems. Awnings, operable windows, and the natural slope encourage natural ventilation while decks are located to protect the home from sunlight. Solar panels located on the south face of the V-shaped roof supply approximately one-third of the residents' annual energy (Borchers, October 3, 2011). During the summer months, the panels provide all energy, and the owners sell any excess back to Kansas City Power and Light (Borchers, October 9, 2011). The roof also includes a two-foot-wide stainless steel gutter in the "V" that channels water to two cisterns (October 3, 2011). Currently, the owners water their plants with the collected water, but hope to eventually develop a gray-water system for toilets.

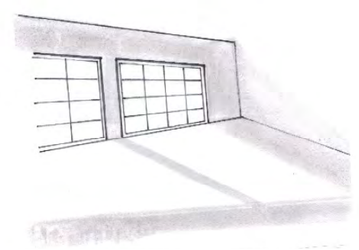
Energy-efficient SIP panels, consisting of polystyrene sandwiched between OSB, not only provide the building's structure, but offer insulation as well. Radiant heat flooring is utilized from November to March. Central ERV ventilation employs two HEPA filters and runs continuously (October 3, 2011). The owners consider the Mitsubishi air conditioning to be one of their best investments. This split system includes remote condenser compressors. Daily, beginning at two o'clock in the afternoon, the Mitsubishi A/C system switches to using only natural air conditioning methods (October 5, 2011).

Surprisingly, the vacuum is the driving design concept. The owner requires the vacuum be plugged in at one central location on each floor so that it is able reach and clean each room on each level. Main living areas encompass 2,800 square feet while the shop space comprises 2,500 square feet. The Borchers want to use every room in their home every day. Therefore, the house consists of a great room, a kitchen/dining room, study/guest room, and a master bedroom. The owners want to use this as their retirement home and therefore all aspects are handicap-accessible. A central shaft allows space for a future elevator to reach each level of the home. Concrete floors, three-foot-wide doors, low counters, and zero-entry showers are all wheelchair accessible (October 5, 2011).

All the low-E windows are arranged to maintain privacy rather than provide views. Natural lighting is a prominent feature in the home. Each room has a window, with additional clerestory windows in the main, central space, allowing light to permeate spaces during daylight hours. Natural light also floods the lower level through frosted glass panes in the garage doors. Open riser stairs also contribute to the dispersion of natural light throughout the home. Each of these features work together to help eliminate need for artificial lighting during the day.

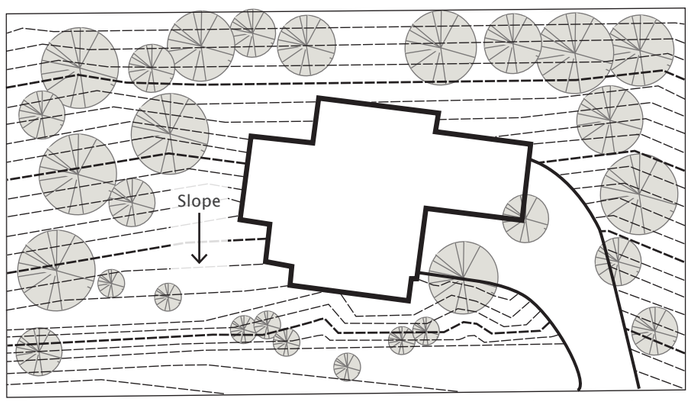
Students from Kansas State University visited this site to explore different aspects of energy efficient design within the house and surrounding landscape.





Drawings by: Anne Collingwood

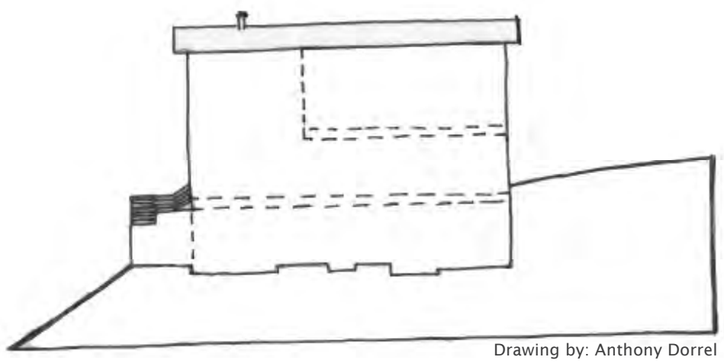
# Abstract




Drawing by: Wes Haid
Adapted from: Borchers

Site Topography-Plan

The house is placed on an irregular, sloped site. The house cuts into the hill and the land is built up with the use of retaining walls. Additionally, the natural slope enhances drainage away from the building (Borchers, October 3, 2011).



Drawing by: Anthony Dorrel

Site Topography-Section

The site slopes approximately 30 feet from rear to front. As such, the house is built into the land and “nests” into the site with the help of retaining walls constructed of stones excavated from the site (Borchers, October 3, 2011).

Drawing by: Xavier Gavin

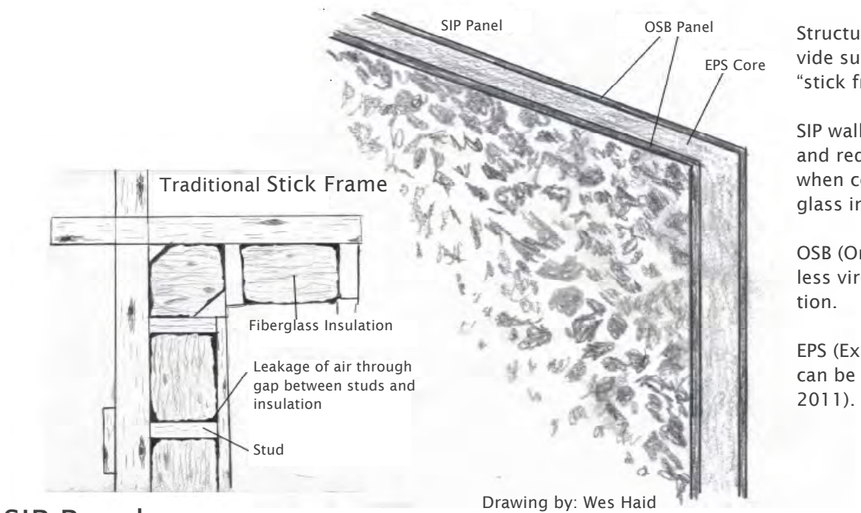
Nature Versus Structure

The original site was home to a large amount of limestone. Most of the stone was carried away, but the remainder was used in many ways, such as a barrier wall that defines the edges of the driveway and the backyard, and acts as a path leading from the stairs to the second floor (Borchers, October 5, 2011). It is also noteworthy that pre-existing trees line the paths, blocking the views of those passing by and creating private entrances with natural materials.


Drawing by: Cydnie Jones
Adapted from: Borchers

Hardscape Versus Softscape

The exterior hardscape features a driveway and a few areas on the front and side porches. The exterior softscape completely surrounds the house and consists of vegetation from within the site prior to construction of the house. There are also small patches of vegetation on the front porch and on the side porch—the green roof.




Drawing by: Wes Haid
Adapted from: Borchers

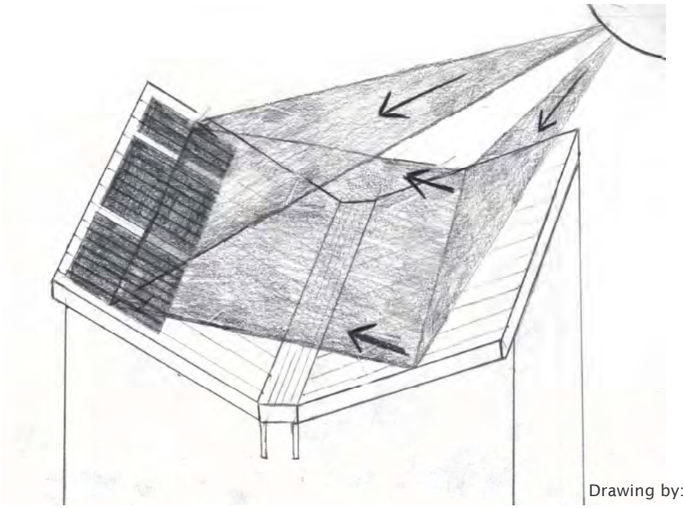
## SIP Panels

Structurally Insulated Panels (SIP) provide superior insulation over traditional "stick frame" construction.

SIP walls are up to 45% more efficient and reduce air leakage by up to 90% when compared to traditional fiberglass insulated walls.

OSB (Oriented Strand Board) requires less virgin lumber than 2x4 construction.

EPS (Expanded Polystyrene Styrofoam) can be recycled (Borchers, October 3, 2011).



Drawing by: Wes Haid

## Solar Panels & Metal Roof

The home uses (32) 16' x 15" lightweight uni-solar photovoltaic laminates capable of generating approximately 800 kw/month.

The roof is made of standing steam metal panels finished in a light gray to reflect solar rays during hot summer months.

This serves two purposes: reflecting sun rays, reducing heat absorption; as well as diverting the rays to the solar panels.

The design of the roof uses 6/12 pitch to optimize the angle of solar laminates (Borchers, October 3, 2011).

Photos by: Vicky Borchers

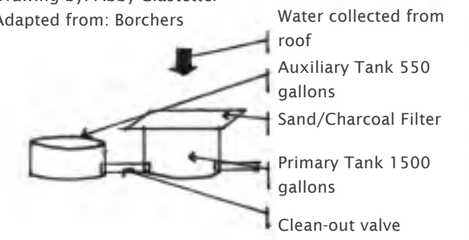
## Shell Construction

SIPs work as framing, insulation and exterior sheathing. They come pre-cut from the factory for specific jobs.

The exterior shell formed from SIPs provides a tight building envelope, which leads to fewer drafts and a decrease in operating costs, thus eliminating a need for traditional stick framing.

One drawback: SIPs are so effective at preventing air circulation that a ventilation system should be installed in house to reduce growth of mold (Borchers, October 3, 2011).

Drawing by: Abby Glastetter
Adapted from: Borchers

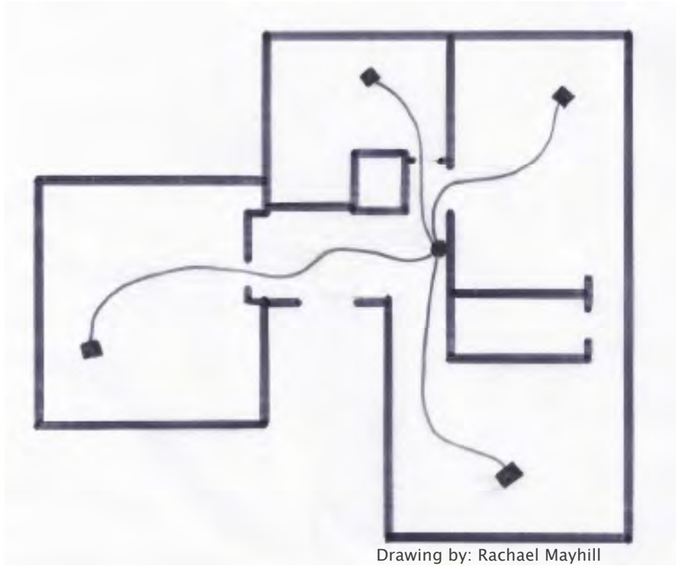



## Water Collection System

The rainwater collection system gathers water from the property and channels it through a passive filtering system that would otherwise drain into the storm-water sewer system (Borchers, October 3, 2011).

With this system, the residents can reuse the gathered water from the tanks for sprinklers and other maintenance systems (Borchers, October 5, 2011).

In the future, the Borchers hope to develop a water retention tank that will allow them to use the stored water for flushing toilets that does not need to be chemically treated (October 3, 2011).

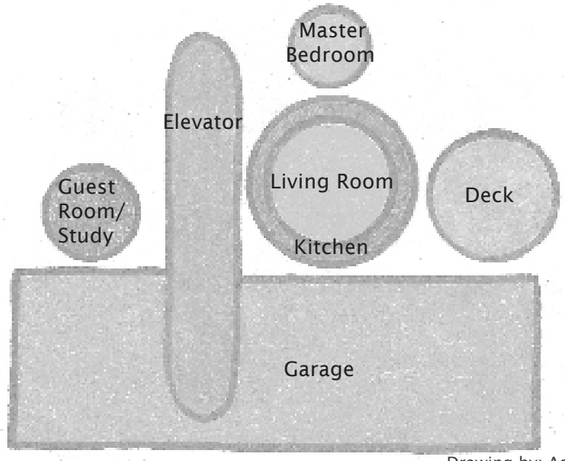


Drawing by: Rachael Mayhill

The Vacuum Concept

The driving concept for the design was usability. The owner required the vacuum cleaner to be plugged in at a central location within the home, ensuring that every room be cleaned without unplugging the vacuum.

Outlet Locations:
First floor: South side
Second floor: Closet

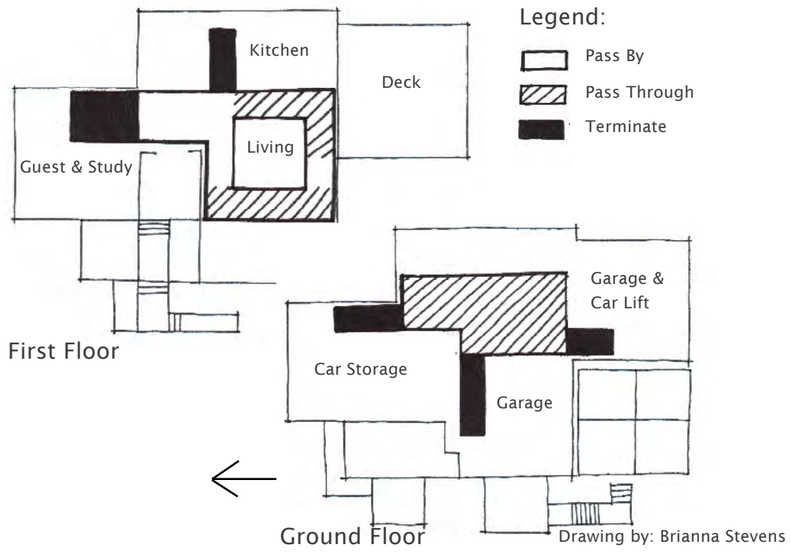



Drawing by: Ashley Brewster
Adapted from: Borchers

Proportion of Room Size

The rooms in the diagram are arranged according to importance of proportion. The garage is the largest space and the master bedroom is the smallest space.

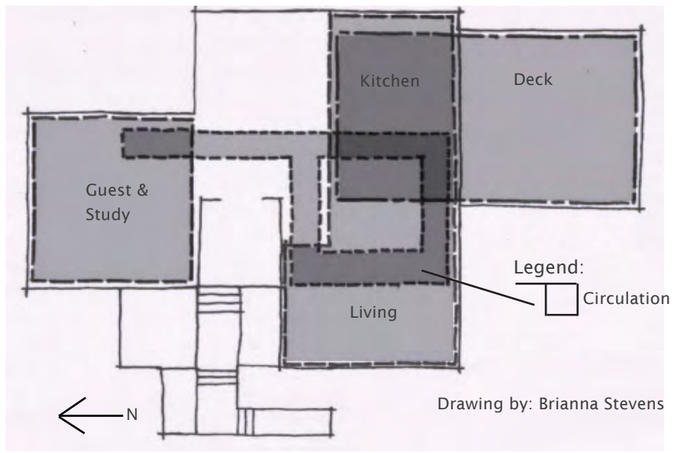
The entire house was designed around the clients' needs for the garage, workshop, and accessibility issues that may arise after the couple's future retirement. (Borchers, October 3, 2011).




Drawing by: Brianna Stevens

Path-Space Relationships

Because the Borchers' residence is a largely open floor plan, most of the paths pass through spaces. This allows a clean flow from one space to the next. The lack of pass-by paths allows for a reduction in residual space that only has one function. The spaces that have a path ending in them tend to be more private than the ones with circulation running through them.

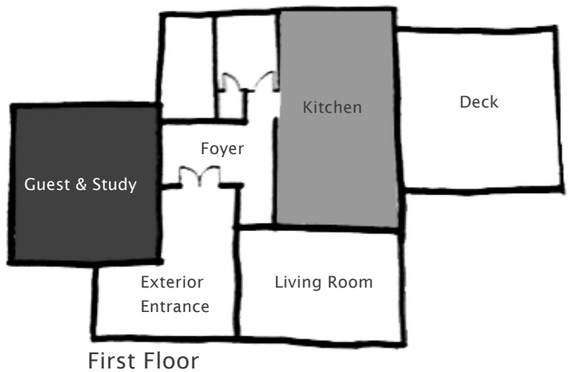



Drawing by: Brianna Stevens

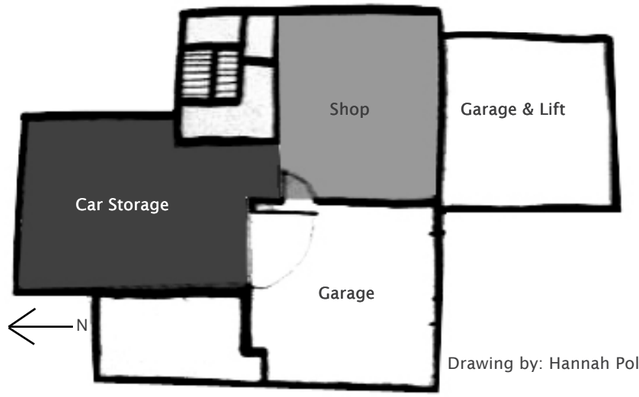
Spatial Overlap

The Borchers' open floor plan creates an overlap from one space to another. The kitchen, dining room, and living room all flow seamlessly into one another. On the main floor there is a continuous path that runs through each space, increasing the overlap. Also, the kitchen and dining area overlap with the exterior through the rooftop deck. This is not only an overlap of living spaces and functions, but a strong connection between the interior and exterior.


Second Floor




First Floor




Drawing by: Hannah Polys

Ground Floor

Legend:

- High
- Medium
- Low

## Degree of Enclosure

In general, private spaces are areas of higher enclosure. The bedroom is placed away from the general living area only accessed through the centrally located laundry room, a service area.

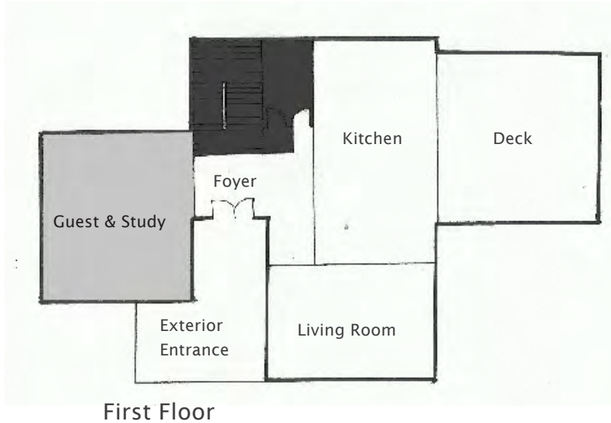
The living room and main entry is a double height open space that invites, whereas the kitchen becomes an intimate public area with lower ceilings.

The garage and workshop have lower ceilings and level changes. Its high degree of enclosure is intentional for privacy and to provide sufficient workspace.

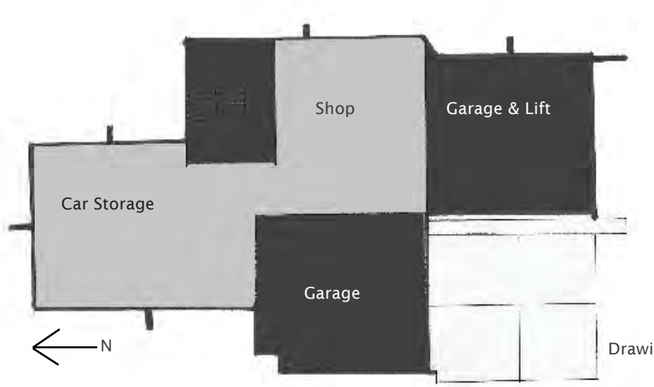

Second Floor

Legend:

- Private
- Semi-public
- Public




First Floor

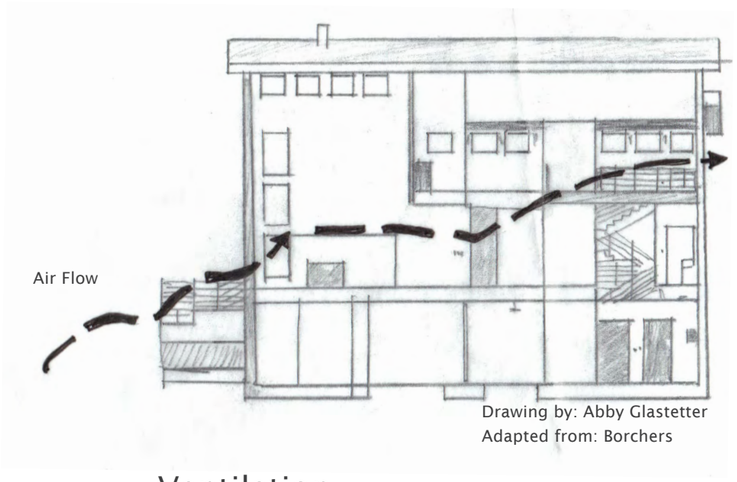



Drawing by: Caitlin Molenaar

Ground Floor

## Public Versus Private

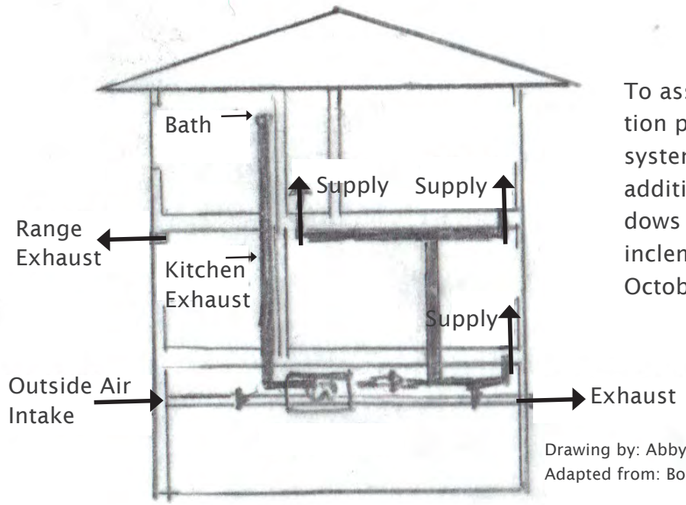
The majority of the spaces within the Borchers' house are meant for use by both the owners and their guests. The only designated private space within the house is the upstairs level, where the master suite is located. A few spaces, such as the study and shop, have slightly more private usage, but are still open to the public.




Drawing by: Abby Glastetter
Adapted from: Borchers

Ventilation

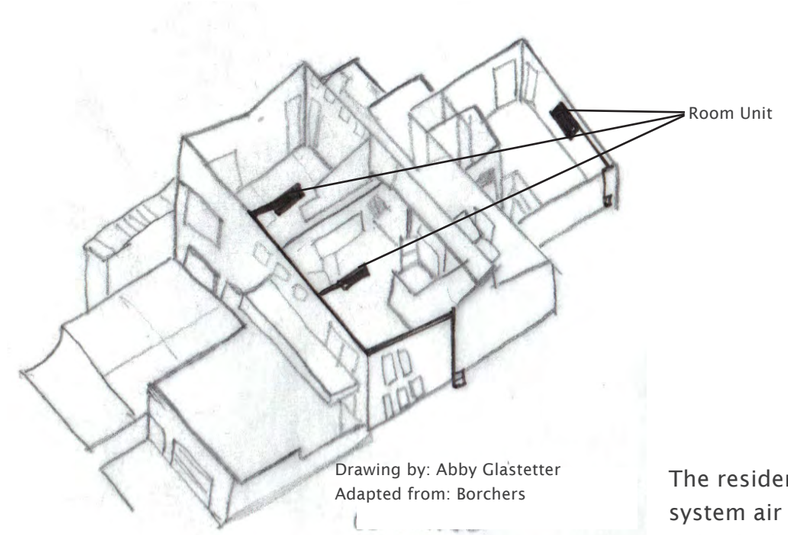
Window awnings on the west side of the first floor promote thermal wind gusts from the up-slope to the home that exit through the upper windows on the east facade (Borchers, October 3, 2011).




Drawing by: Abby Glastetter
Adapted from: Borchers

High Efficiency Recirculation and Ventilation System (HRV)

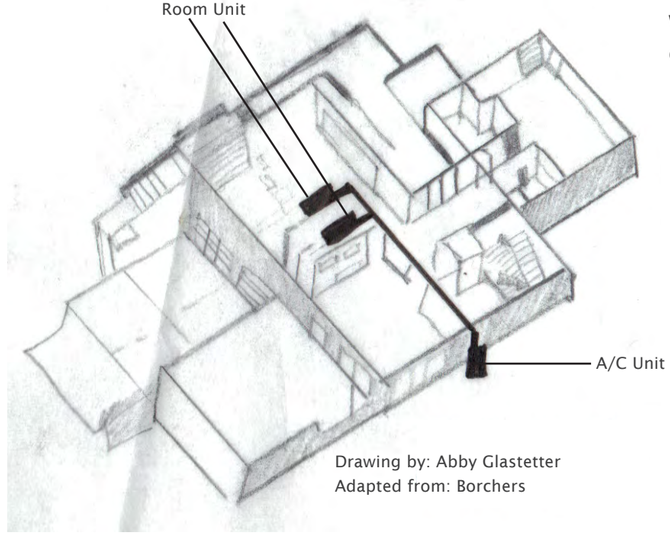
To assist the natural ventilation process is a recirculation system. This machine produces additional fresh air when windows cannot be opened due to inclement weather (Borchers, October 3, 2011).




Drawing by: Abby Glastetter
Adapted from: Borchers

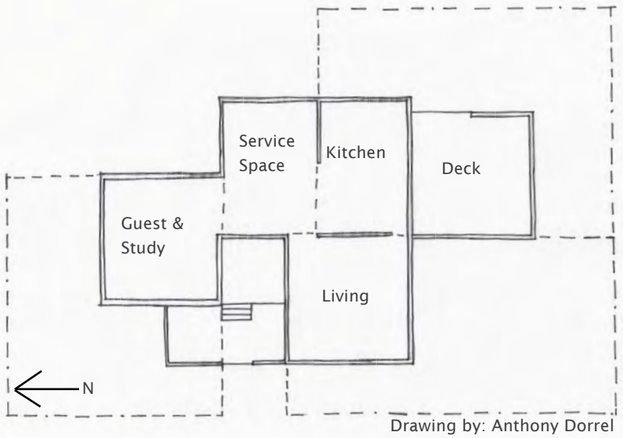
Second Floor Cooling Process

The residence utilizes a ductless split-system air conditioner combined with individual room units. Benefits of the ductless split-system include: security, versatility, easy installation and a relatively quiet functioning level; all while eliminating loss of cool air in the ductwork (Borchers, October 3, 2011).




Drawing by: Abby Glastetter
Adapted from: Borchers

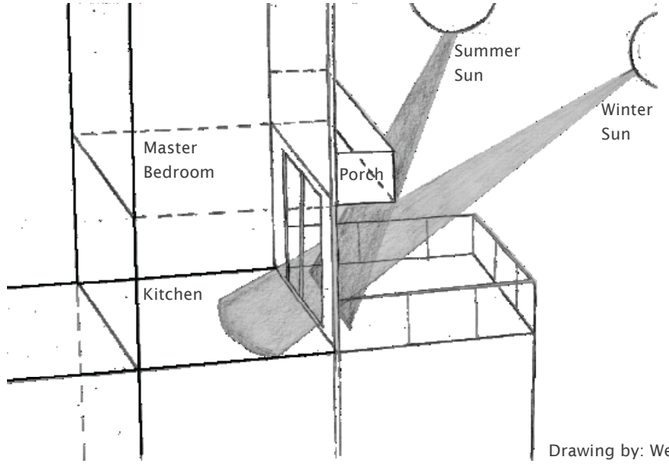
First Floor Cooling Process




Drawing by: Anthony Dorrel

## Spatial Extension

The interior-to-exterior spatial extension diagram shows the relationship between the interior rooms and exterior spaces as defined by walls, views and changes in elevation.




Drawing by: Wes Haid

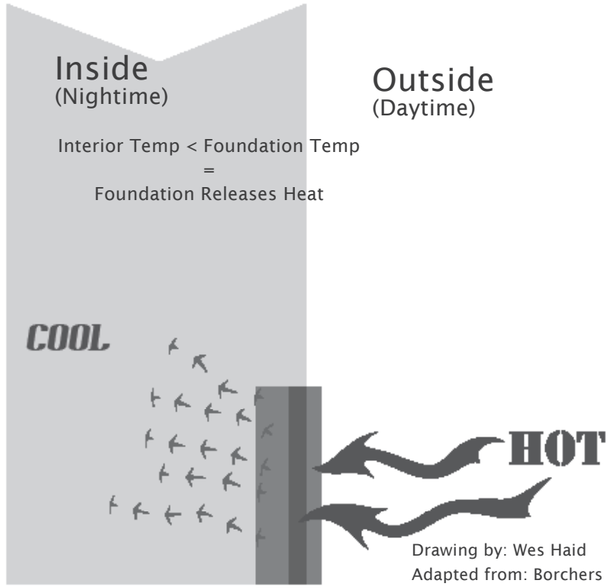
## Porch Solar Shading

The six-foot porch overhang blocks sun and heat in the summer. It allows sun to shine into the kitchen in the winter, reducing lighting and heating costs (Borchers, October 5, 2011).

Drawing by: Xavier Gavin

## Views Onto Site

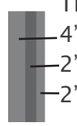
The Borchers designed this home for their retirement and privacy. As such, the extended overhangs of the balconies in combination with the usage of on-site trees prevent individuals from viewing activities occurring in outside spaces. The Borchers can utilize their exterior spaces while still maintaining a level of privacy (Borchers, October 5, 2011).




Drawing by: Wes Haid
Adapted from: Borchers

## Concrete Foundation

The thermal mass foundation wall absorbs heat from outside and releases it at night. During the day, the four inches of interior concrete warms up to the interior temperature. Once the home's interior temperature falls below the temperature of the wall, the concrete radiates this heat back into the home (Borchers, October 3, 2011.



Thermal Mass Foundation Wall
- 4" Interior Concrete
- 2" Styrofoam Insulation
- 2" Exterior Concrete


Photo by: Cydnie Jones

Lockers from high school

Photo by: Katie Leise

Limestone excavated from site

Photo by: Cydnie Jones

Doors from schools

Photo by: Cydnie Jones

Excess roof material

# Salvaged Materials

The project's nature presented an overall financing challenge and as with most projects, the Borchers dealt with several issues during the construction process. The SIP panels had to be assembled with a crane, which could only be used on one area of the site. Originally, a permeable driveway was to be installed, but it was too expensive and affordable options would not operate properly due to the freeze-thaw cycle of the climate (Borchers, October 5, 2011).

The Borchers' neighbors have mixed feelings about the home. Some find the concept of a sustainable home interesting and likeable, yet others dislike the residence because it is so different. Before moving in, the Borchers offered tours of their home to help dispel some of this controversy. The design world received the house fairly well, and it has had several write-ups, including the January 2010 cover of Green Design Magazine in Kansas City and an article in the May 2010 Kansas City Star Homes section. Though the house is designed to be LEED Platinum, the owners did not feel the fee was worth the official title (Borchers, October 9, 2011).

The Borchers feel they should have finished some aspects of their residence differently. For instance, they wish they would have used a hydronic system to heat their floors as the current electric resistant heat is not very efficient. Vicky Borchers also believes she should have waited a few years to adopt solar panel technology for her home due to rapidly developing technology (Borchers, October 5, 2011).

As of our visit on 5 October 2011, the Borchers' residence remains unfinished. The exterior and the lower level shop space were the first features finished. Currently, the Borchers are working on the interior during their free time. The next steps are replacing the construction stairs with the finished stairs. They will also install the elevator, add a back deck, and put the finishing touches on all aspects of the design. Though the Borchers' residence remains unfinished, it proves itself a commendable example of passive, sustainable design (Borchers, October 5, 2011).

References:


Borchers, V. (n.d.). The Vee House. Vicky Borchers PDF File. accessed October 3, 2011

Borchers, V. (2011, October 5). Passive Solar Home. (LAR 220 & IAPD 307, Interviewers)

Borchers, V. (2011, October 7). The Vee House. Vicky Borchers Email Responses. accessed October 9, 2011

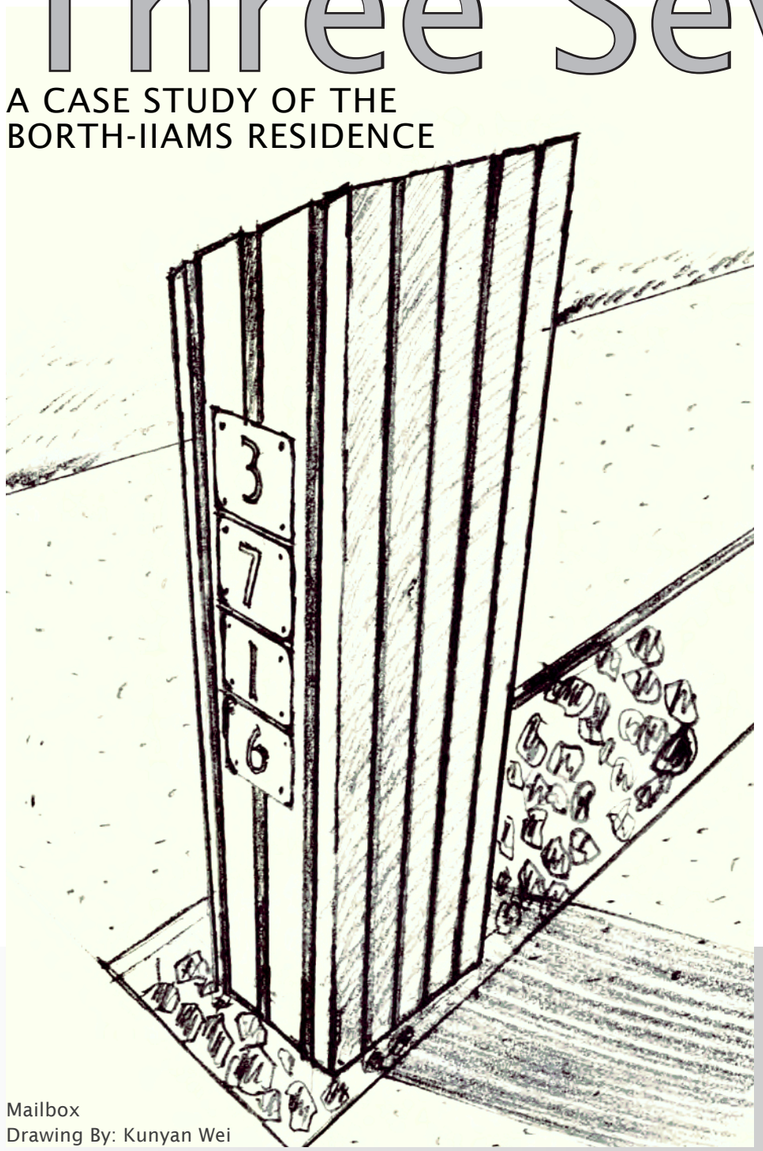


Photo provided by: Abby Buchmann

# Conclusion

# Three Seven One Six

## A CASE STUDY OF THE BORTH-IIAMS RESIDENCE




Mailbox
Drawing By: Kunyan Wei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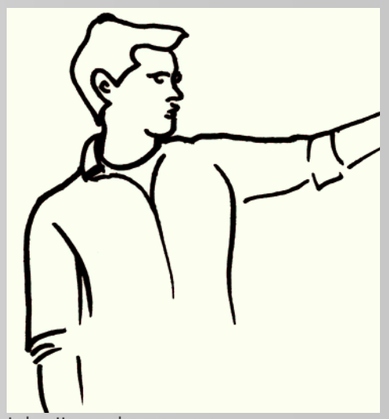


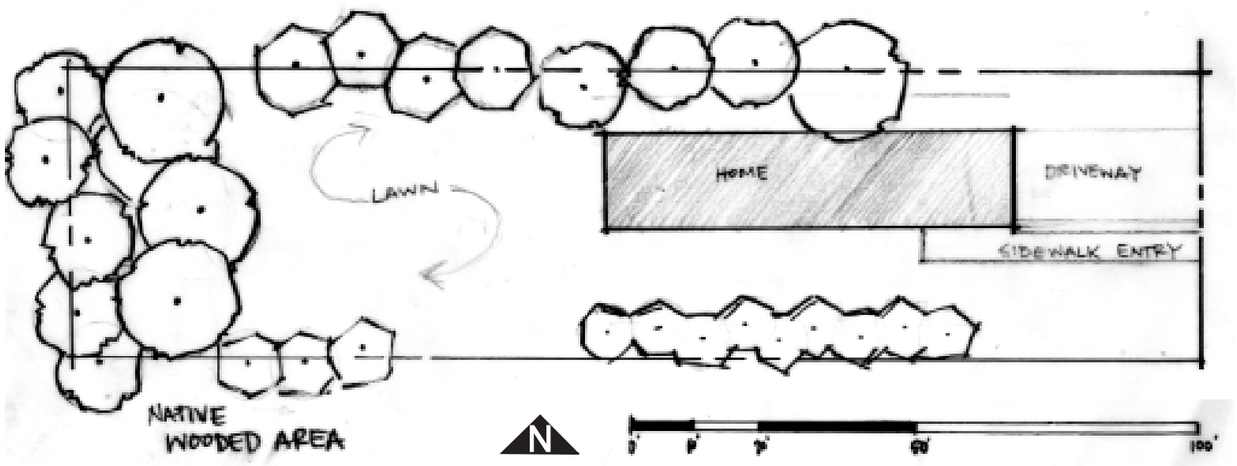
John Iiams, homeowner
Drawing By: Aaron Bisch

Borth-Iiams Residence
Drawing by: Dale Bradley

The Borth-Iiams's LEED Platinum certified residence in Kansas City, Kansas was designed with off-the-grid qualities in 2009. The house was a design-build project conducted by Studio 804 at the University of Kansas and implements several basic technologies for sustainable living. These include photovoltaic panels, geothermal heating, passive solar principles, water catchment and reuse, and a vertical wind turbine. Through a site visit and an interview with the homeowner, additional knowledge has been gained which coincides with previous studies of off-the-grid lifestyles.

Jenilee Borth-Iiams and John Iiams were the first to occupy the residence as renters, and currently own it. Both graduated from Kansas State University and in 2007 they moved to Kansas City. John currently works at 360 Architecture and Jenilee works as an accountant. Though she does not work in the profession, she, like John, still retains a passion for sustainable design. The house depicts the owners' personal taste through minimalistic design and neutral tones even without their involvement in the design process.

Studio 804's minimalistic approach of creating a freestanding mass leads to a single sculptural form on the site. Realizing that this approach would create a unique residence, the designers tried to incorporate features of the local vernacular architecture. Therefore, the contrasting figure blends into the neighborhood while maintaining its modern identity (Iiams, 2011).



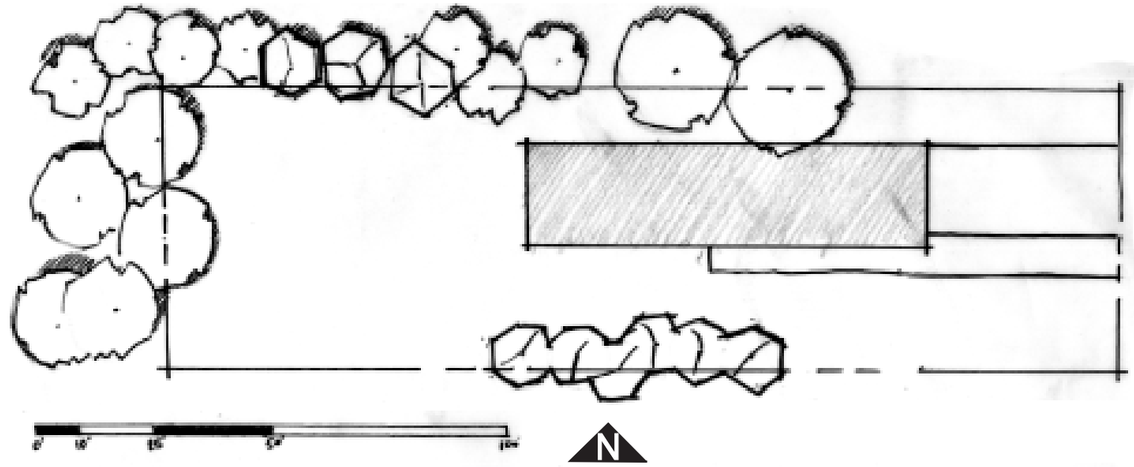

## SITE PLANS

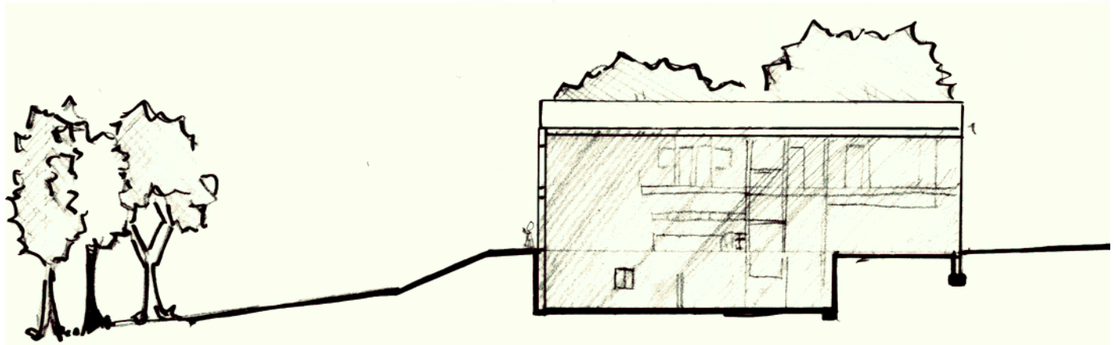
The narrow lot size influenced the strong horizontal design of the house.

Drawings By: Adam Bangerter

The residence is on a site that slopes downwards into a nature preserve. The designers placed the house lower on the slope to give a perceived volume height of a single story to match the neighboring houses. They also decided to relocate the power lines underground to continue the minimalist principles of the house to the site.

The home is located to take full advantage of solar power through panels on the roof and large windows on the south. Due to budget restraints a deck off the south end of the home was omitted. A deck would have connected the home with the surrounding landscape. Due to these omissions an opportunity was lost to create a useful transition space from outside to inside.



## EAST/WEST SITE SECTION, LOOKING NORTH

The house was placed lower on the sloping site to mimic a one story volume allowing it to better fit into the neighborhood.

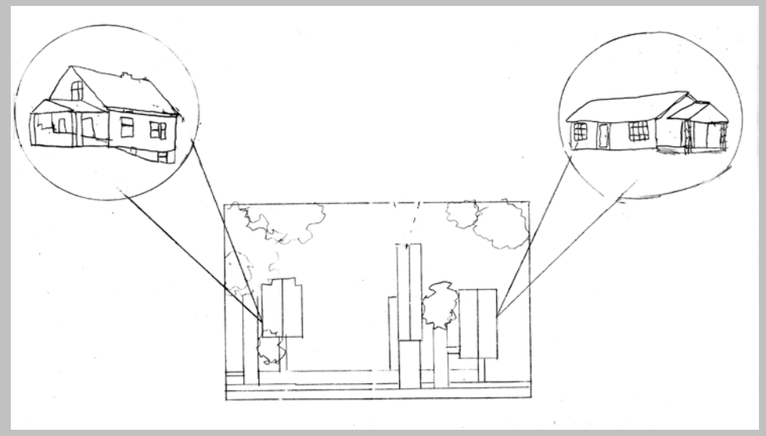
Drawing By: Adam Bangerter

## STREET VIEW

Red Brazilian Cumeru Wood subtly highlights the exterior facade.

Photo By: Aaron Bisch

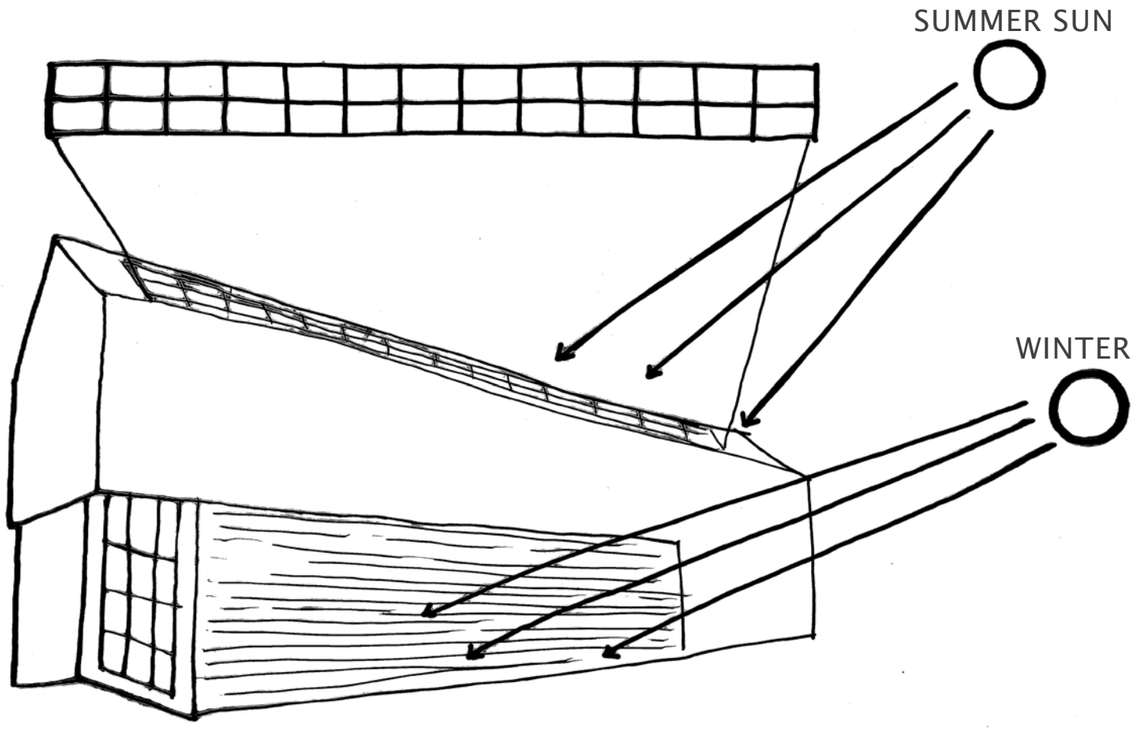
Modified By: Dale Bradley

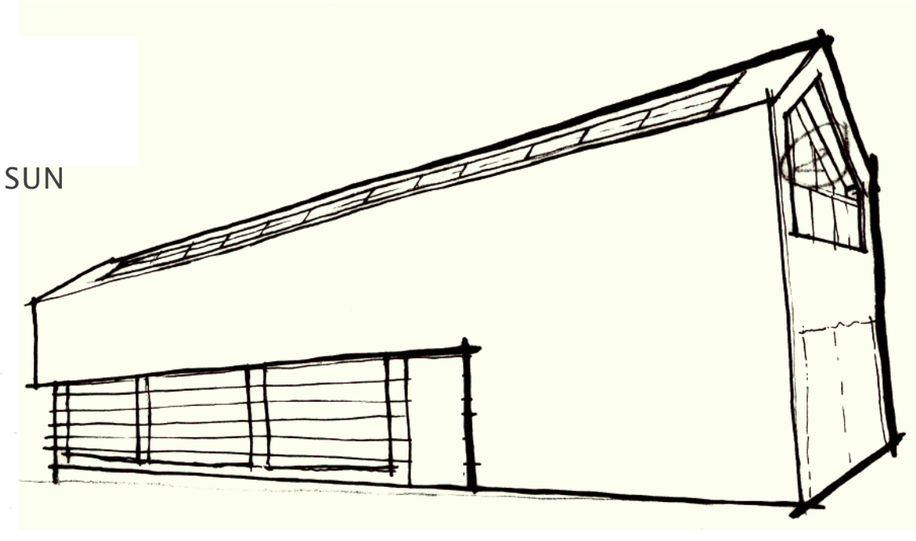


## NEIGHBORING RESIDENCES

The neighboring houses exhibit pitched roofs, deep porches, and overhead power lines.

Drawing By: Kat Nigus



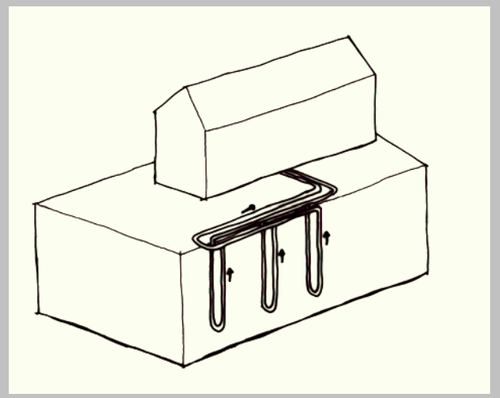



## PASSIVE SOLAR TECHNIQUES

Direct sunlight and photovoltaic cells harness energy on site.

Drawings By: Morgan Stafford and Josef Lang

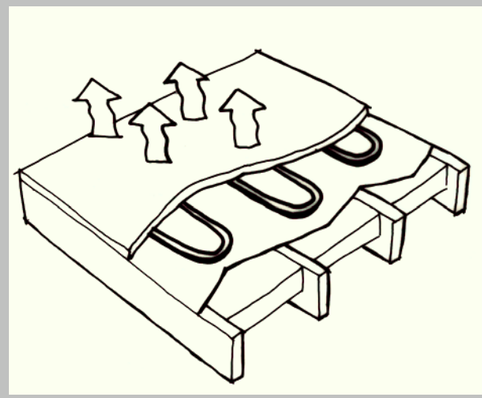
Adding green technology was a core component while designing the house. Several techniques were employed to achieve a LEED Platinum rating. Along with the East-West orientation, the design team also used photovoltaic cells and fixed shutters on the broad south windows to moderate temperatures during all seasons. Geothermal heating paired with a traditional heater helps to maintain a comfort zone throughout the year and lower energy use. By choosing a vertical wind turbine, the minimalistic design was carried throughout the site (liams 2011).



## GEOTHERMAL HEATING

Constant earth temperatures help to regulate air and water heat on site (Geothermal Heat Pump Technology, 2011).

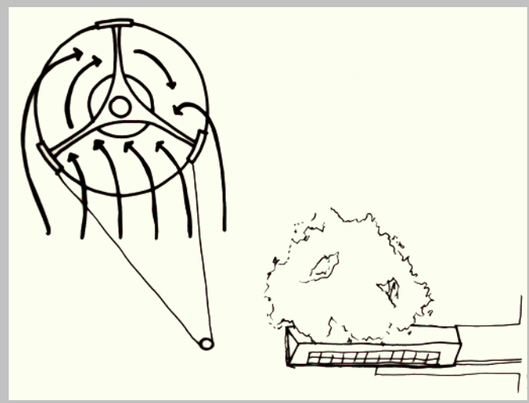
Image From: Geothermal Heat Pump Technology, 2011)
Drawing By: Morgan Stafford



## RADIANT FLOOR HEATING

Earth temperature combined with thermal mass creates a heat gain from the floor (Warm up the cool floor, 2011) (Bonnie, 2011).

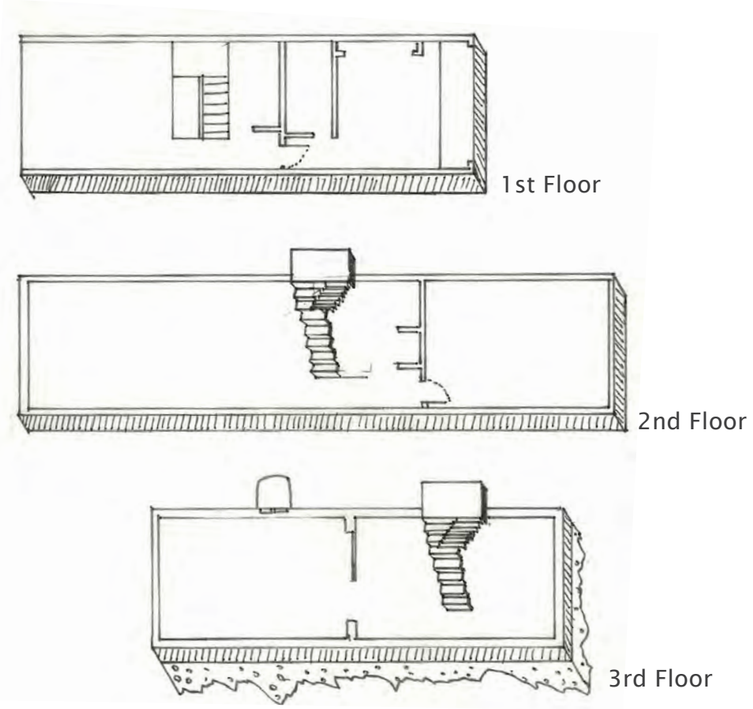
Adapted From: Warm up the cool floor, 2011
Drawings By: Morgan Stafford



## WIND TURBINE

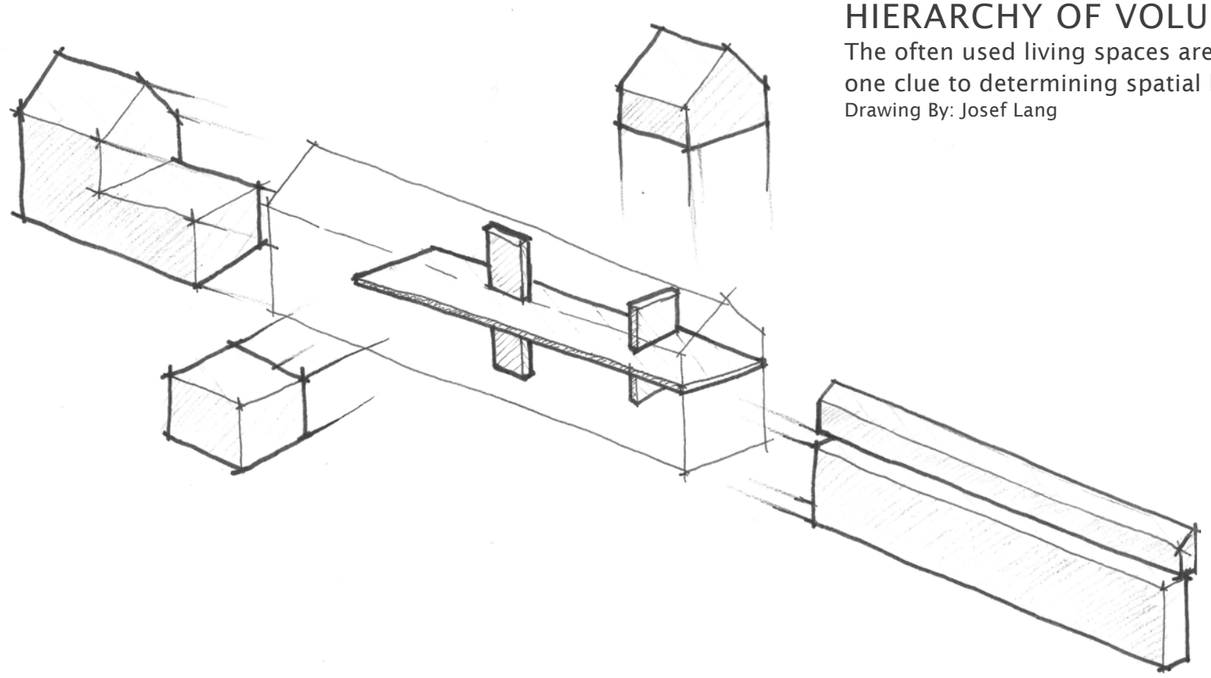
A vertical wind turbine provides on -site energy to the site while keeping the modern sculptural style of the home.

Photo By: Aaron Bisch




## AXONOMETRIC PLAN

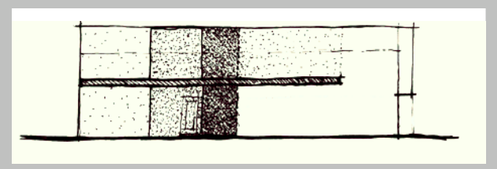
The vertical circulation, the central stairs, is evident in the plan.
Drawing By: Kunyan Wei



## HIERARCHY OF VOLUMES

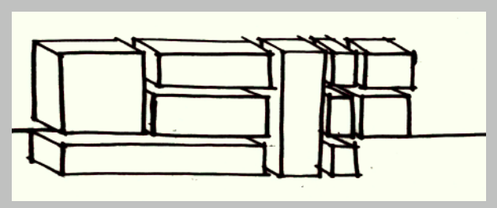
The often used living spaces are greater in volume, one clue to determining spatial hierarchy.
Drawing By: Josef Lang

While using a linear approach, the designers were conscious of the proportioning of the home. This influenced the volumetric division of the home into a clear hierarchy of spaces based on a fifths proportioning system. While constrained by this proportioning system, the designers utilized special techniques such as spatial compression to vary the spatial experiences.
Even though there is a clear horizontal axis, the vertical circulation is key in influencing the organization of spaces.



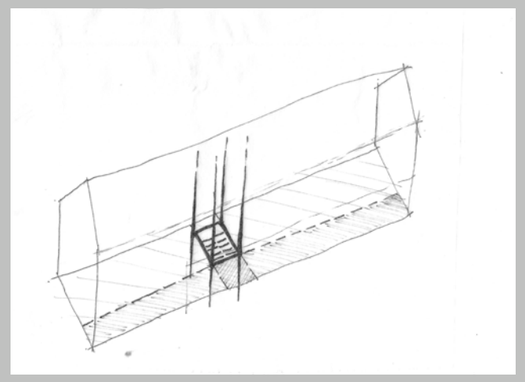
## SPATIAL COMPRESSION

Spatial compression helps define the hierarchy of spaces.
Drawing By: Josef Lang



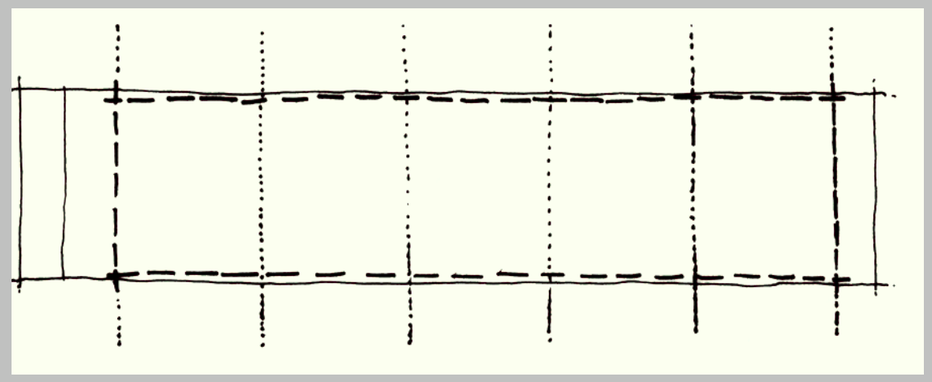
## MASSING

There is a clean division of volume in the home based on the fifths proportioning system.
Drawing By: Aaron Bisch



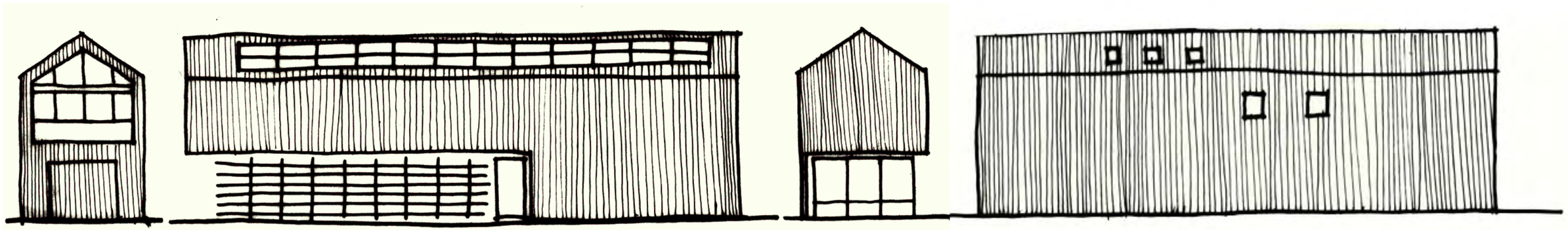
## CIRCULATION

There is a strong vertical circulation present throughout the house.
Drawing By: Josef Lang

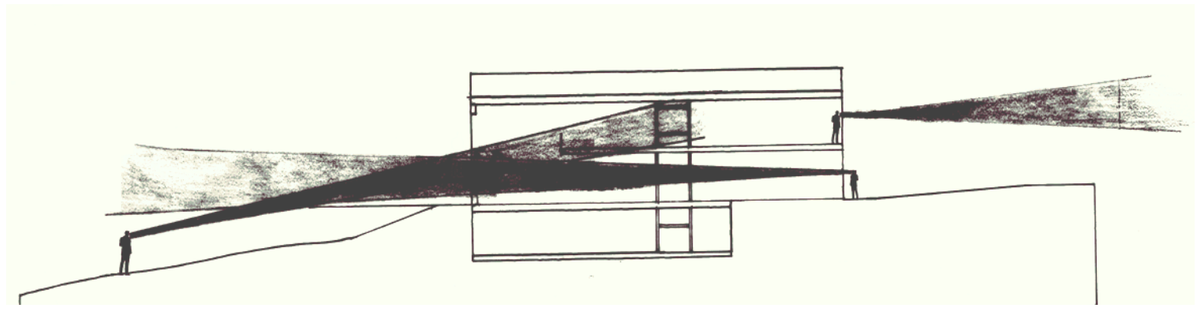


## PROPORTIONING SYSTEM

The home is proportioned in fifths.
Drawing By: Josef Lang

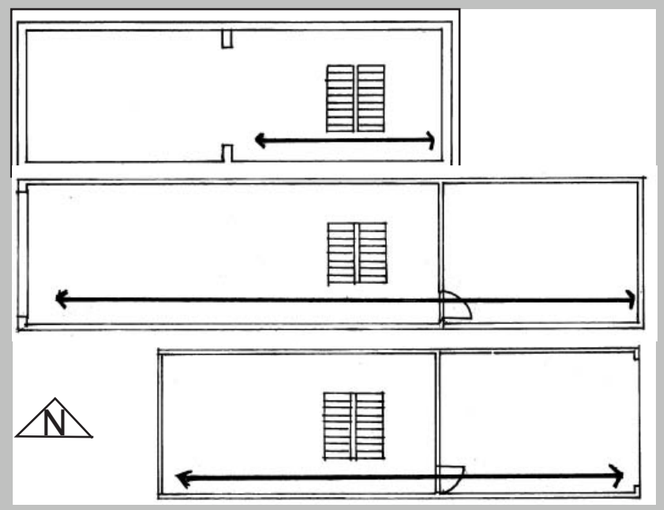


## FACADES
East, South, West, North
Drawing By: Aaron Bisch



There is a variety of visual experiences at the Borth-Iiams residence. This includes interior to exterior relationships based off of the strategically placed windows which follow the horizontal axis. From the exterior, one can view the living room and lofted areas as well as the east balcony. From the interior, there are spectacular framed views of the wooded preserve and the front entry.  Upon entering, one has a deep view of the main floor along the circulation axis; the circulation axes are unimpeded, providing good views on each level. The larger yard on the south side is shown through the elongated windows. Generally, these views strengthen interior-exterior relationships.

## INTERIOR/EXTERIOR VIEWS, CONTROLLED BY ENERGY-CONSCIOUS WINDOW PLACEMENT
These views help connect interior and exterior spaces while providing a sense of privacy.
Drawing  By: Gabriela Weber



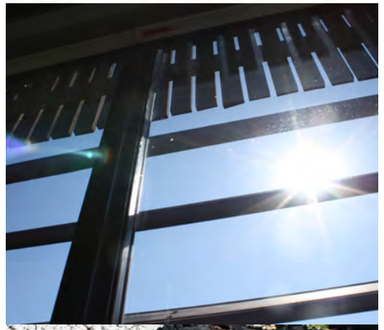

## AXIS
A strong horizontal axis is shown throughout the house which is especially defined through the corridor found running on the south side of the house.
Drawings By: Gabriela Weber

## VIEW OF KITCHEN
View from East.
Picture By: Aaron Bisch

## TENSION ROD

The tension rods minimalistic design keeps the space open while supporting the roof.

Drawing By: Kat Nigus



## SOUTHERN WINDOWS

The southern windows are strategically placed with stationary shutters to allow warm winter sun in the home.

Photo By: Aaron Bisch

## DRIVEWAY MATERIAL

University of Kansas students placed coal, emphasizing the entrance.

Photo By: Aaron Bisch

## MUNNIES

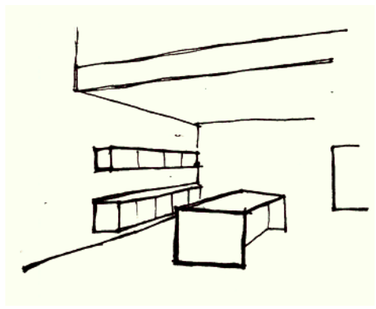
These mini sculputures are found through out the home and reflect the home and owners' minimalistic style.

Photo By: Aaron Bisch

## KITCHEN DETAILS

Sustainable materials are used throughout the space. Concrete floors were finished with gypsum and black epoxy to create a thermal mass.

Photo By: Aaron Bisch



## VIEW OF KITCHEN

Looking from south-west to kitchen.

Drawing By: Betsy Haddox

## RAIN GUTTERS

There is a rainwater catchment system located at the back of the house.

Photo By: Aaron Bisch

## RAILING DETAIL

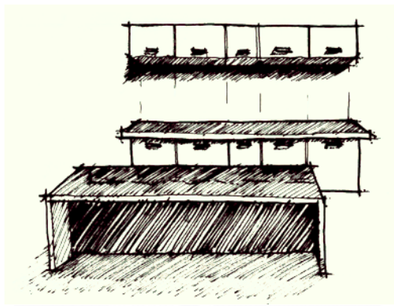
The exterior facade material is also found on the stair railing.

Photo By: Aaron Bisch

## VIEW OF STAIRS

Glass panels were donated to enclose the stairs on all levels of the home.

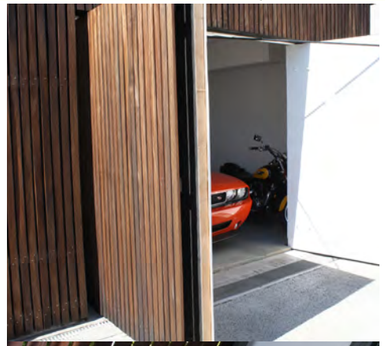
Photo By: Aaron Bisch



## KITCHEN MATERIALS

Sustainable appliances, countertops, and cabinets unify the kitchen.

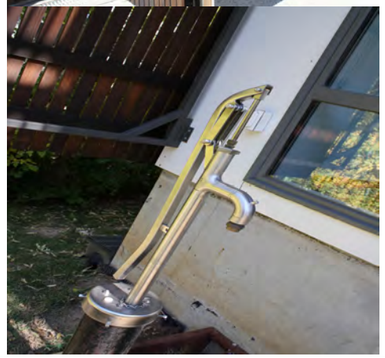
Drawing By: Josef Lang



## GARAGE DOORS

The garage uses door system commonly found in barns.

Photo By: Aaron Bisch



## CISTERN

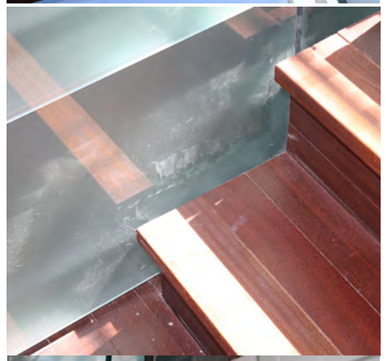
An on site water pump provides additional water for the home

Photo By: Aaron Bisch

## SHUTTERS

These stationary shutters allow the low winter sun in while keeping the summer rays from over heating the space.

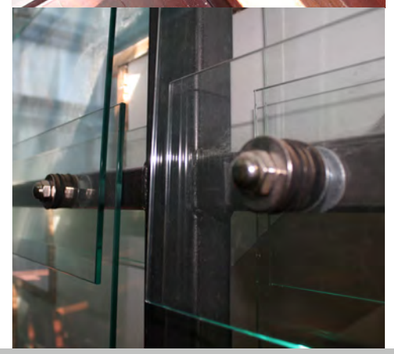
Photo By: Aaron Bisch



## STAIR DETAIL

Glass Panels and cumeru wood were used throughout the staircase.

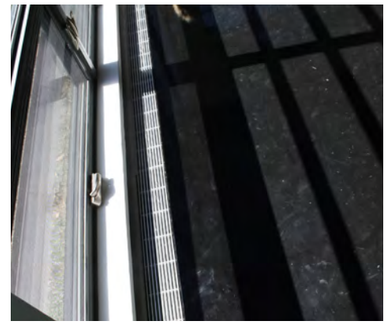
Photo By: Aaron Bisch



## PANELS AND BOLTS

These bolts were used for structural support on the staircase.

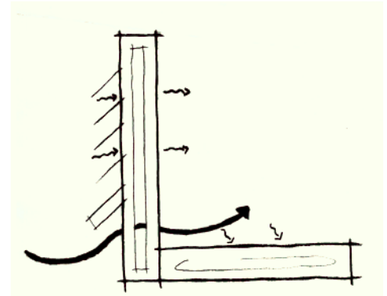
Photo By: Aaron Bisch



## OPERABLE WINDOWS

These floor-level windows on the south facade allow passive ventilation.

Photo By: Aaron Bisch



## PASSIVE/ ACTIVE HEATING AND COOLING

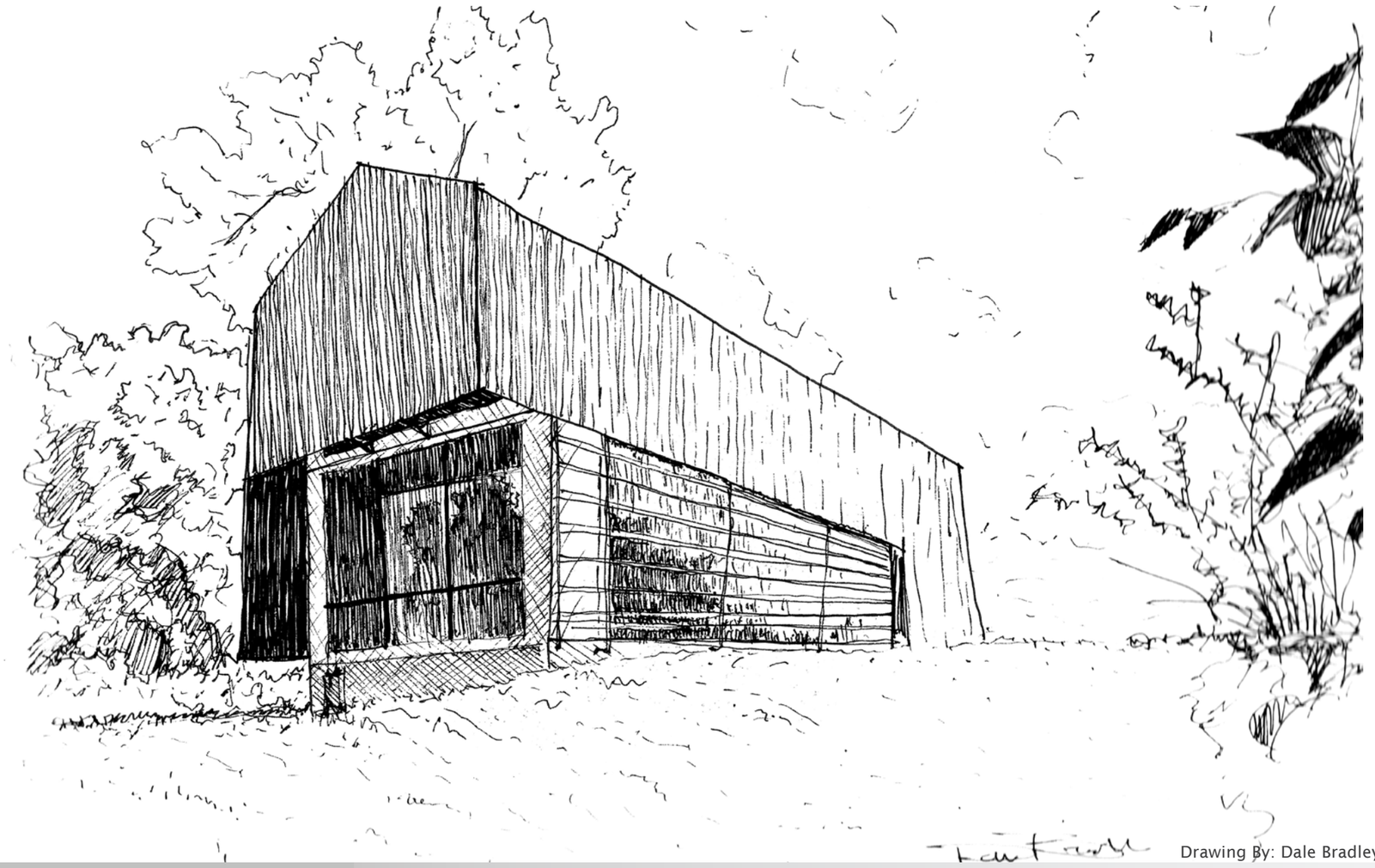
Fixed shutters work with geothermal heating while the operable windows permit cool breezes into the space.

Drawing By; Nichole Finke

## OVERHANG

Keeps weather off of the facade.

Photo By: Aaron Bisch



Drawing By: Dale Bradley

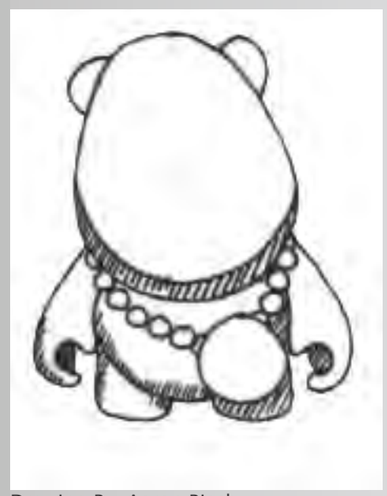
The Borth-Iiams residence, a design-build project, focused on sustainable living. The passive elements especially contribute to the minimalistic design aesthetic, which parallels with the owner's minimalistic design preference. Even with the proportion of volumes, the entertainment space was found to be lacking. Outdoor entertaining space could be added with the addition of a patio or deck on the south side. They would also like to have a collection of vibrant furniture to accent the neutral tones of the architecture.

While the home was set back on the site in an effort to match its height to the surrounding homes, it still stands out as unique to the neighborhood. One the site the home feels out of place, with no connection to the surrounding landscape. Due to budget restraints any efforts to connect the home with the landscape were omitted from the final project. We feel that this oversight lead to missed opportunities to extend the uniqueness of the home's interior to the outside. The current slop of the site combined with its landscape design makes the back yard virtually unusable.

Our suggestions for improvement would include a terraced deck, as wells as plantings of shrubs, annual flowers, and trees around the foundation of the home and perimeter of the yard. These additions would help bridge the space between the native woods and the unique architecture of the home and would make the backyard a functioning part of the home.

One comment that the owners made about changes to the house was to take out one of the bathrooms upstairs and instead use the space for a walk-in closet to create a more generous master suite. Also, future changes might address making the house truly off-the-grid; currently, the site generates energy and sells it back to the grid instead of using it for the site. Any effort to make the home truly off-the-grid would come at a significant investment to the homeowners. Overall, the Borth-Iiams residence successfully uses off-the-grid techniques on a small urban plot (Iiams, 2011).

Photo By: Aaron Bisch



Drawing By: Aaron Bisch

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# CASE STUDIES OF LOW ENERGY SITES AND HOMES: MILLSTEIN RESIDENCE

LAR220 & IAPD307
FALL 2011

Drawing By Dale Bradley


**Team Earthship**

| | |
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| Rudy Date | Ross Devault |
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| Rachel Botten | Nick Mercado |
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Edited by Alyssa Butler


## ABSTRACT


This case study focuses on one type of low energy home in particular. The Earthship concept is low energy housing. Earthships are dwellings that focus on low cost, efficient, environmentally responsible building. While low energy features are typically incorporated throughout the site, the original Earthship concept focuses upon the dwelling. The Earthship concept was conceived by Michael Reynolds in Taos New Mexico (Nachman-Hunt, 2011).Reynolds strived to create an affordable home that utilized natural and reclaimed resources. Earthship homes take advantage of naturally occurring processes, and use passive solar energy to heat and cool the house. The materials used in Earthship homes have low embedded energy, and are typically reclaimed or recycled materials such as old tires, reclaimed wood and glass, and recycled concrete (Earthship.net, 2011).

David and Susan Millstein's Kansas Earthship home is an adapted version of Reynolds' Earthship home (Millstein, 2011). The original bermed tire wall had to be abandoned for a free-standing, insulated tire wall because of wet Midwest weather. Located in rural Baldwin City, the Millstein residence is a surprising structure tucked back behind country dirt roads. Much as the name suggests, the Earthship home looks surreal. An organic sea foam green building contrasts with the earth-toned vegetation. When viewed from the sky the house takes form, creating an airplane shape whose aerodynamic contours counteract the harsh winds that run through the site. Earthship homes combine the functional processes of sustainability and the aesthetic properties of owner/builder's design.

Unlike many homeowners, the Millsteins have a unique personal connection with their house. Besides being the clients for the sustainable home they are also the designers and builders. The free organic form of the Kansas home is the brainchild of David Millstein. After reading about Reynolds' concept in Architectural Digest, David sought to create his own invention (Millstein, 2011). By becoming immersed in the design process and construction phases of the earthship, the Millsteins developed a feeling of affection for their home. The ideals of low energy design are evident in this earthship as well as the personalities of the clients.

# ORIGINAL CONCEPTS

Photo by Aaron Bisch

BIO

David and Susan Millstein are a happy couple edging their way into retirement. David was pursuing a degree in architecture from the University of Kansas before changing career paths. Even after the change, he still had an appreciation for design. When he and his wife decided that their wind tortured home was getting the best of them, they collaborated and designed a home on their own.

PARTI OF CONCEPT DEVELOPMENT

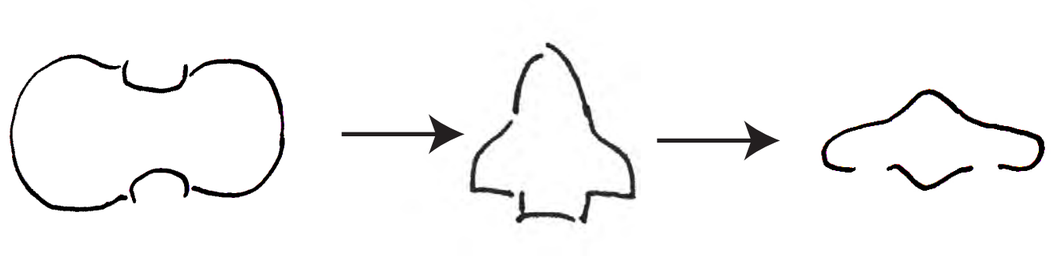
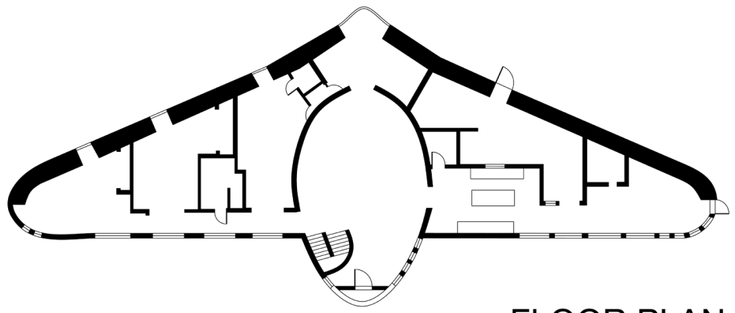


Diagram by Dylan Howe and Rachel Fox



FLOOR PLAN

Diagram by Ross DeVault (modified from Natural Home and Garden)

CONCEPTS

When the Millsteins first discussed the design of their new home, they wanted to focus on the plan (aerial) view. Because of the nearby airports, the family brainstormed numerous forms that could be recognizable from the sky and could provide humor for the airplane passengers. The initial design was a violin shaped home. Due to homeowner preference and complicated style and form, the concept changed to a rocket ship and finally they decided on an airplane-type form (Millstein, 2011).

FINANCIAL

The Millstein family had no specific budget for their earthship. Because the family insisted on using mostly recyclable materials, the final cost of the home came in at approximately $150,000 (excluding labor costs). Due to the labor intensive nature of their earthship project, David Millstein devoted nearly two years solely towards its completion. Adding to David's efforts, community involvement from the cross country team and other locals also played a major role in cutting labor costs (Millstein, 2011).

SITE PLAN

The floor plan can be separated into three distinct parts: two wings and a central gathering area. The house is located in an open, grassy field surrounded by natural vegetation. The woody vegetation surrounding the site defines the edge of the Millstein's property.

PLAN VIEW OF PROPERTY

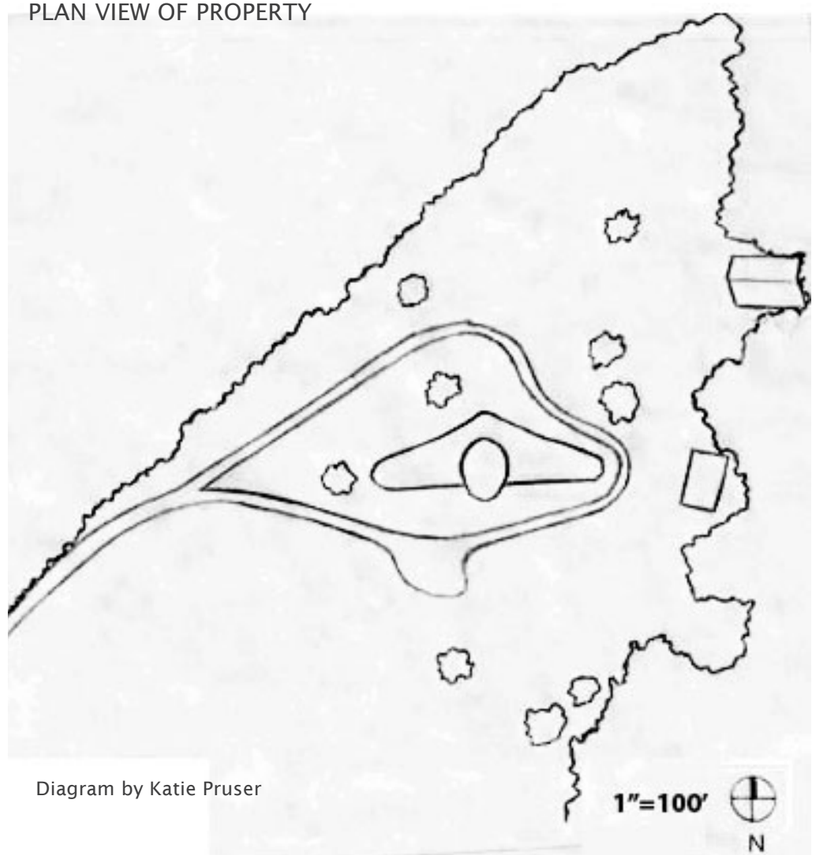



Diagram by Katie Pruser

# SITE AND PROCESS

Photo by Alyssa Butler

Photo by Alyssa Butler

RELATIONSHIP TO SURROUNDING COMMUNITY

The Millstein residence is approximately 800 feet from the main road and neighboring homes. This placement emphasizes the role nature plays in the entirety of the design and overall feel of the property. The structures are submerged into their surroundings and parallel the organic aspects of nature through the curves, colors, and recycled materials (Millstein, 2011).

RELATIONSHIP TO COMMUNITY


Diagram by Natalie Webb

VEGETATION

Surrounding the Millstein residence is an area of densely planted trees that offer protection from high Kansas winds. Personal gardens near the Millstein's home include annuals, perennials, and native plants, like sunflowers, that attract wildlife. Besides the planted gardens, the site is left to nature with no maintained lawn, scattered trees, and a gravel driveway.

VEGETATION

Diagram by Natalie Webb


GARAGE CONSTRUCTION DETAILS

Before the Millsteins constructed their Earthship home they designed a prototype structure that they would later use as their garage and storage shed. The structure is 20'x20' and composed of roughly 600 tires. Because tires are rubber, the Millsteins encountered a problem where when they constructed the wall it would "waver like jell-o". Due to this problem it took the Millsteins eight months to obtain a building permit and a sound way to stack the tires in a more solid manner. The method they used to solidify the tires is called "pounding." Each tire had to be filled with soil and concrete and "pounded" to compact the soil so that it could be used as a structurally sound building block. In contrast the roof is roughly 1.5 inches think. The roof was constructed by layering half inch rebar and half inch galvanized mesh for support then coated lightly in ferro cement to keep out water. This created a light weight yet strong covering for the family's storage needs. It was through these series of trial and error that the Millsteins attained knowledge of building a prototype structure, and were able to construct their actual home (Millstein, 2011).

# FORMAL DESCRIPTION

PUBLIC/PRIVATE SPACES

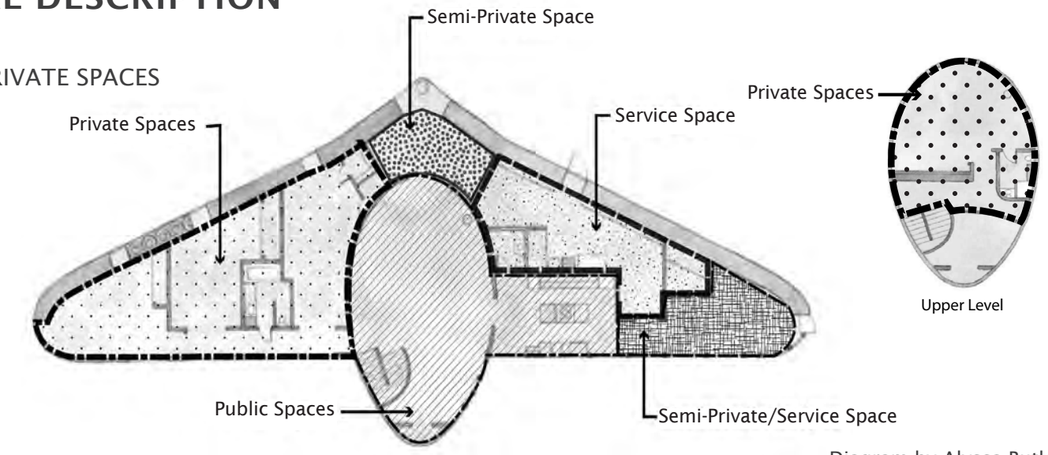
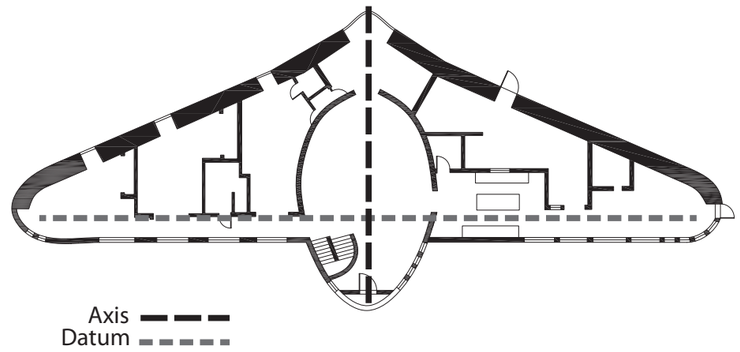



Diagram by Alyssa Butler

AXIS

The doorway and back wall of the Millstein establish the two points in space that form the North-South axis. A circulation spine that runs along the south side of the house and wall of windows acts as a datum in the home. This southern datum with its wall of windows allows for maximum absorption of solar heat into the house.




AXIS DIAGRAM

Diagram by Nick Mercado

PUBLIC AND PRIVATE SPACES

In the home, the foyer, dining room, and kitchen serve as public spaces. The rest of the house is divided into private, semi-private, and service spaces. Since the Millsteins are so proud to show off their creation, the whole house, at times, serves as a public space (Miller, 2011).

CIRCULATION

Paths link the main house to the garage, barn, and main road. While the exterior circulation encircles the house in an organic fashion, the interior combines linear and free-flowing circulation patterns.

INTERIOR/EXTERIOR RELATIONSHIPS

The primary interior/exterior connections at the Millstein Residence are between the greenhouse and the garden, the upstairs bedroom and the roof deck, and the front entry. There is also a strong relationship between the design of the home and the winds effects.

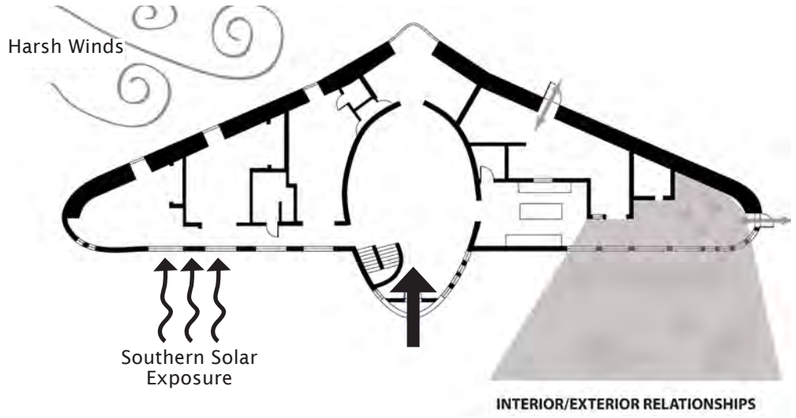



Diagram by Ross DeVaullt

CIRCULATION

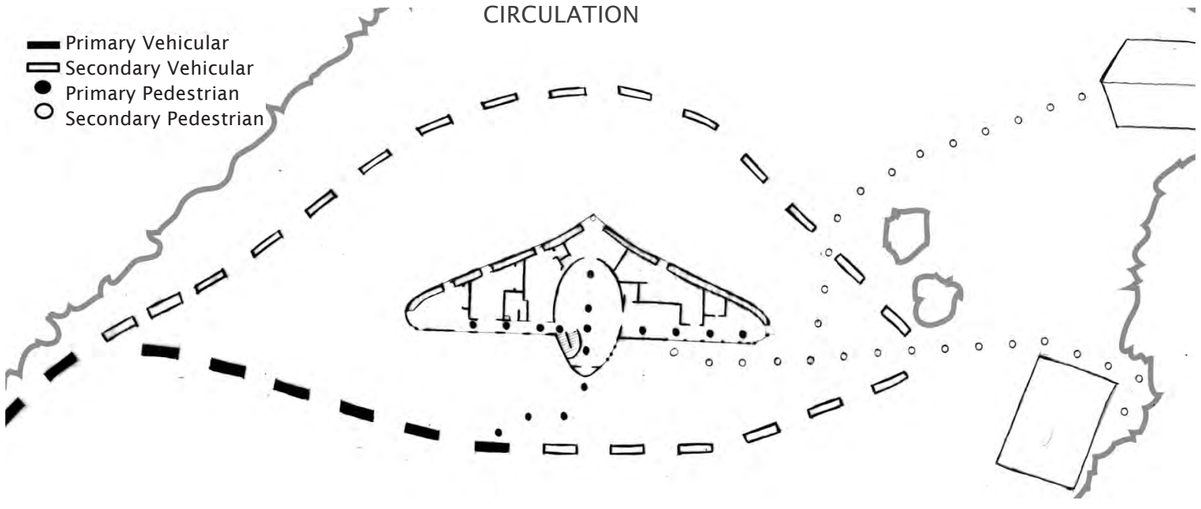



Diagram by Katie Pruser

ENTRANCE

The Millstein entrance is centered within the frontal facade to create a condition of symmetry around its opening. Its projected entrance provides overhead shelter and acts as a transitional space. Upon entering, a common space links spaces to the left and right. A U-shaped staircase is located to the left, positioned privately along the left hallway. The entry space is non-restricting, allowing visitors to circulate freely. This space is enhanced further by an elevated ceiling plane.

FRONT APPROACH

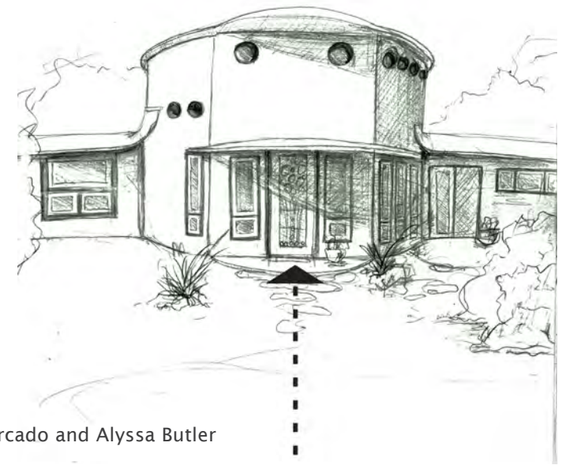


Diagram by Nick Mercado and Alyssa Butler

# FUNCTIONAL QUALITIES

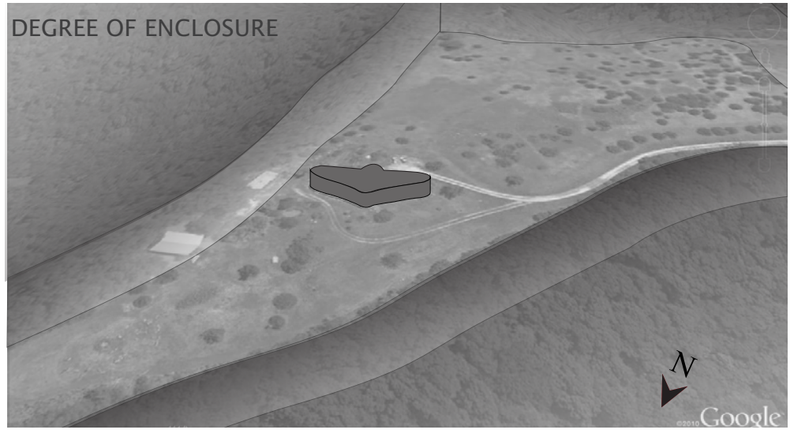



Diagram by Alyssa Butler

VIEWS

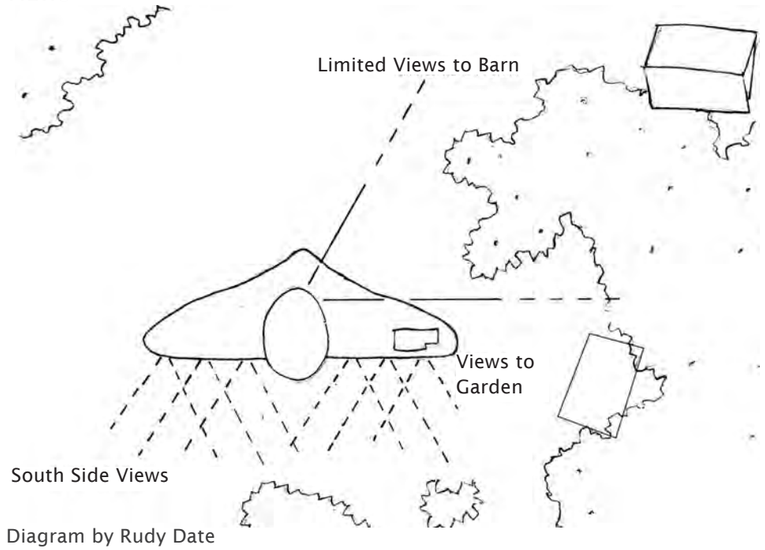



Diagram by Rudy Date

DEGREE OF ENCLOSURE

The Millstein residence is completely enclosed by the wooded area surrounding the site except for a long driveway entrance. There are no off-site views, making the site feel very secluded. The overhead plane is completely open however; allowing the space to still have a sense of openess, and provide pleasing scenic views of the skyline.

VIEW

Large, southern windows allow for more than just sunlight. Ground-floor southern views include the family's self-grown garden, patio, and the southern side of their land. Second story, north-facing apertures offer a limited view from their master bedroom of their self-designed and self-built barn that is nearly hidden behind a small grove of bamboo stalks. From any window in the house, the small "forest" growing around their plot of land is immediately visible, offering seasonally changing views of the serenity of nature.

THERMAL MASS

The materials that make up the spaces of an Earthship must be dense and massive in order to store the temperatures required to provide a habitable environment for humans and plants. The Earthship itself must be a sort of "battery" for storing temperature (Earthship biotecture, 2011). The Millstein Residence however, had to be modified with above ground insulated tire walls as a response to the wet climate.

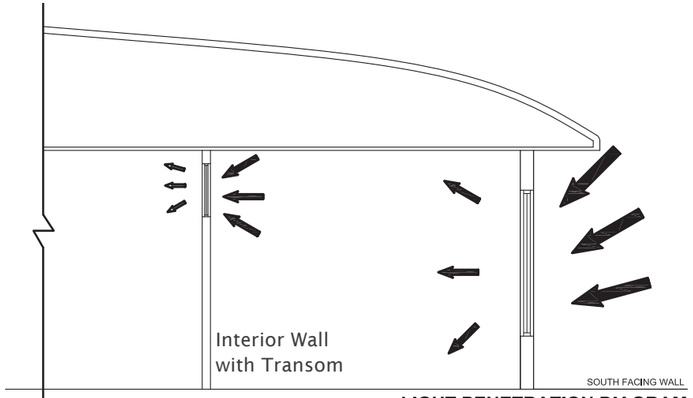



Diagram by Ross DeVault

SOLAR PENETRATION

In the average American household, 11 percent of the energy bill is solely dedicated to lighting (USDE, 2009). The Millsteins use strategically placed transom windows to allow natural light to filter into interior spaces, eliminating the need for artificial lighting. Not only do the homeowners save money, but less energy and resources are wasted.

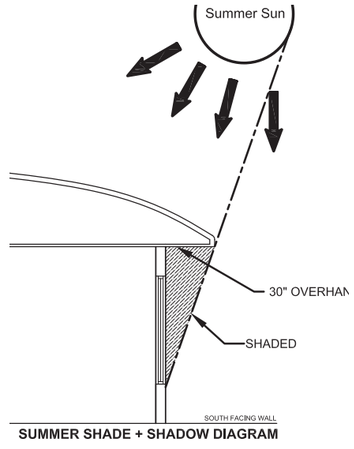



Diagram by Ross DeVault

SHADE AND SHADOW

The south-facing wall serves as direct solar gain, heating the Millstein home in the wintertime. In addition, on the same side, a 30 inch roof overhang blocks direct afternoon sunlight in the summertime (Millstein, 2011). The light colored roof reflects much of the solar radiation, keeping it cool.

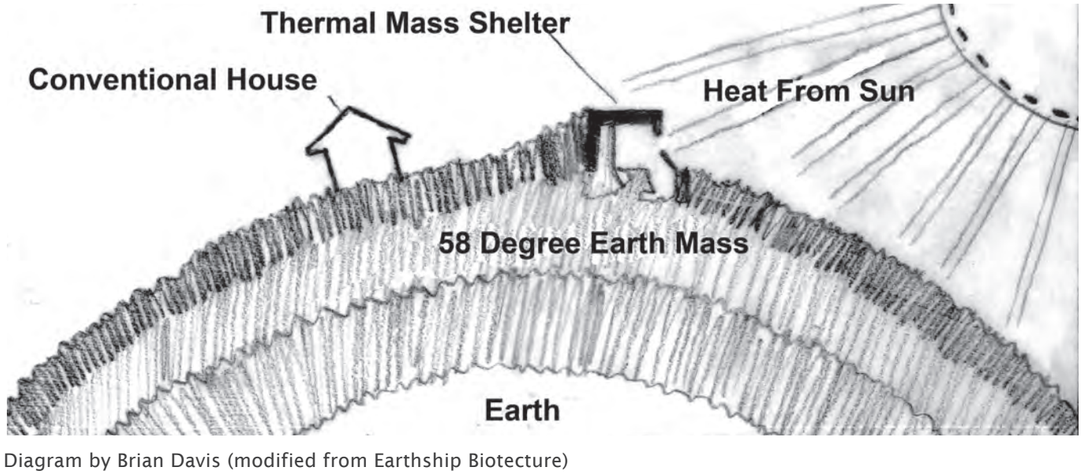



Diagram by Brian Davis (modified from Earthship Biotecture)

# MATERIALS & TECHNOLOGY

Drawing by Alyssa Butler

LATTICE
The Millsteins created innovative "living sun screens" out of lattice and vines that lean up against some of the windows providing shade and pleasant green views.

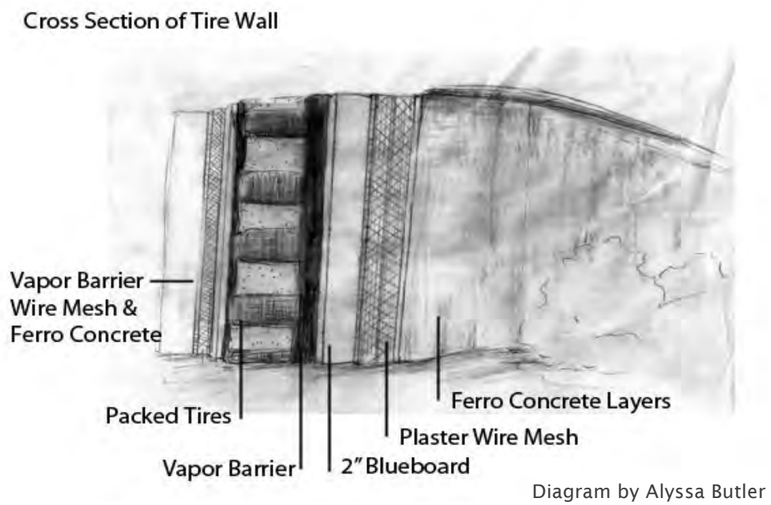



Diagram by Alyssa Butler

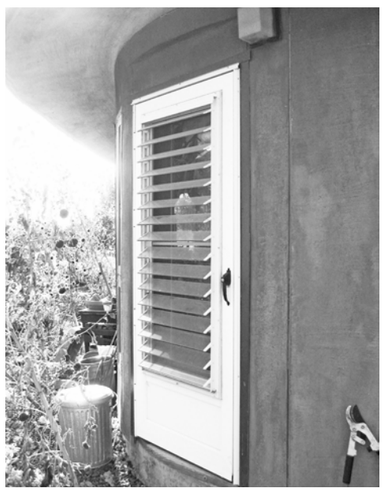
TIRE WALL CROSS SECTION
The North wall of the Millstein residence contains the typical earthship tire wall. To obtain its temperature moderating qualities, the wall is layered using different materials. These layers are the same on each side of the central packed tire wall (Millstein, 2011).

MATERIALS
In accordance with their goals for the whole project, the materials used in making the house and shed are all recycled, reused, repurposed or reclaimed. The Millstein family spent nearly 10 years salvaging a large variety of materials to use in all parts of their house. The north side wall is created based on the theme of the original earthship; automobile tires packed with dirt, mud, and encased in cement. The other walls are wood framed and finished with concrete poured on top of a steel mesh. The mesh causes the concrete to be more flexible, and resist cracking or infiltration of moisture. (Millstein, 2011). The floor of the dining/activity room is put together using wood from an old handball court from the University of Kansas while the living room utilizes wood from old tobacco sheds in Louisiana. The marble that can be found in the entry hall could have once been found in a hospital in Kansas City. Even the framing for the windows found around the house were once planks of cypress in a mushroom barn. The playful rounded porthole windows in the house and in the barn are all Navy surplus (naturalhomeandgarden.com, 2011). The whole house is evidence of their determination to live a "greener" life and have less of an impact on the earth.

Photos by Alyssa Butler and Brian Davis








## LESSONS LEARNED

The passive technologies used in the Millstein residence include a thermal mass wall, natural air flow, natural lighting from clerestory windows, and an aerodynamic house form. Active technologies include use of propane, artificial lighting, and plumbing. Although the Millstein house does not provide any on-site energy, it reduces the amount of primary energy used by integrating passive systems. Embedded energy is another factor to consider when analyzing the residence. The Millstein residence made use of manpower and salvaged materials collected throughout the years, such as portholes, bathroom stalls, and an old handball court floor. According to David Millstein, his only shortcoming with the structure is the mild condensation buildup which could have been prevented by simple ventilation systems (Millstein, 2011). One of the things Susan Millstein regrets is the choice of Ferro cement for the interior of the house because sound echoes off of the walls. If redone, she would have chosen a softer material to reduce this effect. This home capitalizes on the Millsteins' desire for both form and sustainability and complimented their ideals by reducing the carbon footprint.

Sun Room/ Greenhouse Photo by Alyssa Butler

View from Roof Photo by Alyssa Butler

The Millstein's Chicken Coop Photo by Alyssa Butler

Entry at Southern Facade Photo by Elizabeth Stadterman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