Hypothesis | Project Description

My project is a design strategy for low-cost housing that produces no construction waste.

The project is a prototype for an ultra-affordable and customizable single-family home that identifies and tests and integrated system of materials and construction methods that eliminates waste typically produced during construction.

My project will be developed because the largest single source portion of waste produced in the United States is from building-related construction and demolition (30%, 135.5 million tons)* and because the average construction project yields 3.9 pounds of waste per square foot of building area.+ With a palette of compatible materials that can be assembled together with little-to-no waste during the construction period and a set of design guidelines, these residents of low-cost housing can each have their own style while being able to take pride in their home’s environmental achievements. This includes the size, style and arrangement of their home, as well as their budget, in order to “assemble” all of their desired programmatic elements to their home that fits their lifestyle. The materials and design guidelines will also take into consideration the length of life, so that the maintenance throughout ownership can be to a minimum.

Hypothesis | Project Goals

1) The construction methods and material choices will result in homes that require minimal maintenance and upkeep in order to retain their appearance, performance and value over 100 years or more.

2) Customizable components will allow for individuality in the design and configuration of each home, in spite of its low cost, without adding more time or waste to on-site construction.

3) The project will serve to prove that a systematic approach to materials and construction results in efficient and low-cost, without adding more time or waste to, on-site construction.
Hypothesis | Project Goals

4) This idea will decrease the amount of time spent on site during construction to customize materials by at least 50%.

5) This idea will be successful by raising awareness to the amount of waste produced during new construction.

6) This idea is important because it will maintain individuality and expression within the design process for low-cost housing.

GUIDING PRINCIPLES:

1) A home can be a personal expression of an individual or family’s personality and lifestyle.

2) The design of a home can reflect individuality regardless of its construction schedule.

3) A systematic approach to the designation of materials and construction methods can result in an efficient, affordable, and easily constructed home while also allowing for the expression of individuality.

[http://www.neo.ne.gov/home_const/factsheets/const_waste_min.htm]
Hypothesis | Stakeholders

1) Direct
   a. Families and individuals who occupy the homes

2) Indirect
   a. Consumers who are environmentally conscious
   b. United States Green Building Council
   c. Neighbors surrounding the construction site
      i. Less noise because there is limited sizing of materials
   d. Manufacturers of eco-friendly products
   e. Managers of landfills
      i. Requires less work for them to dispose of it
   f. Construction companies
      i. More planning involved
      ii. Big changes with the overall construction process
      iii. Will it be more efficient?

3) General
   a. Environmental organizations
   b. Architects
   c. Public

wasteLESS modular housing

Melissa Brodmarkle-Emerson
The location within a city or state is unimportant as each house is catered to its site and the owner’s needs specifically.

The site should be located in either a residential or a mixed-use neighborhood.

It should be a location that gets a decent amount of pedestrian traffic so that this modular housing unit can inform the public of its limited waste during construction.

The zoning should be scheduled for residential or small-scale mixed-use projects.

The natural landscape of the site itself does not need to be specific as the modularity of the project should be able to cater to whatever the site has to offer.

The surrounding neighborhood should not have building heights higher than 6 stories, unless the modular housing being built on the site is of similar height to the surrounding buildings.

The site should have the possibility, with its orientation and surrounding context, to have direct sunlight into the house.

The site chosen does not need to cater to a specific income of the families occupying these homes.

The site does not have to specify the family size occupying these homes.

The site does not have to specify the population density of the neighborhood.

The temperature variation of the site does not need to be a factor of consideration when choosing a site, as each individual home will be designed for the site and owner’s needs specifically.

The rainfall, snowfall and prevailing winds do not need to be a factor when selecting a site, as each individual home will be designed for the site and owner’s needs specifically.

Several cities throughout the United States can compare the items that do not need to be site specific, such as the different climatic conditions of wind, rainfall amounts, snowfall amounts, etc.

This list of criteria can help me identify how the construction and design of waste-less modular housing can change throughout the nation and I can follow-up with how this design problem can be solved.

Melissa Brodmarkle-Emerson
Represented in both the light blue and dark blue, this climate zone encapsulates nearly a third of the United States.

This area has the potential for severe winters months, including snow, negative temperatures and wind chills to account for.

Cities such as Chicago, Minneapolis, Cincinnati, Boston, and Washington DC are included in this climate zone.
Represented in yellow, this climate zone encapsulates nearly a third of the United States.

This area has the potential for extremely dry conditions, with high temperatures during the day and low temperatures during the night.

Cities such as Las Vegas, Denver, and Phoenix are included in this climate zone.
BluHomes have spaces that are strategically designed to overlap space uses which allows for a reduction of required square footage, which results in a reduction of construction costs.

This particular design strategy gives the amount of gross to net square footage to be 90% / 10%. This is a very efficient use of space.

The space programming for this project will follow a similar strategy. Overlapping the program of living areas with the necessary circulation spaces significantly reduces the amount of square footage necessary for comfortable living conditions.

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<thead>
<tr>
<th>Names of the Space</th>
<th>SF</th>
<th>Net SF</th>
<th>#</th>
<th>Total Net SF</th>
<th>Total Gross SF</th>
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<td>Dining/Living Area</td>
<td>21' x 25'</td>
<td>556'</td>
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<td>556</td>
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<tr>
<td>Kitchen</td>
<td>21' x 9'6&quot;</td>
<td>200'</td>
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<td>200</td>
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<tr>
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<td>Bedroom 3</td>
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<td>127</td>
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<td>Mech</td>
<td>6' x 9'</td>
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<td>1</td>
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<th>Total Gross SF</th>
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<td>600</td>
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<tr>
<td>Master Bedroom</td>
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<td>1</td>
<td>250</td>
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<tr>
<td>Master Bath</td>
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<td>1</td>
<td>60</td>
<td>55</td>
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<td>75</td>
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<td>W/D</td>
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<td>1</td>
<td>20</td>
<td>18</td>
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<tr>
<td>Mech</td>
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<td>1</td>
<td>50</td>
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</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>1600</td>
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Around 90% of all residential construction in the United States is made with wood. This type of construction is probably the most common because it is relatively quick to construct and is fairly cheap, especially in comparison to the alternatives.

Often times, with wood construction of residential buildings within the United States, the opening for windows and doors are simply cut out after the material is placed onto the framework.

Knowing this, certain architectural moves can be done to reduce this unnecessary waste with how the openings within the framework are addressed.

wasteLESS modular housing

Melissa Brodmarkle-Emerson
These pre-manufactured homes have a variety of styles. They also have “started homes” that can be added onto later if the size of the family increases. Their commitment to eco-technologies is also something to take note of.
These pre-manufactured homes offer many ways to individualize homes based on their lifestyle and preferences. Items from the color of the material used on the facade to the type of basement are all parts of the customization this firm gives to their clients.
SHORT DESCRIPTION
Part of a larger movement in the between the 1940’s and 1960’s that was trying to develop affordable, easy to construct housing for the general public because many architects were frustrated with the lack of designed homes of this time period.

SOURCES OF INFORMATION

This is a classic case study house that focused on developing a program that the average american citizen would like an architect to be able to design at an affordable price. This particular one had a center core that doubled as living space and circulation space.

Melissa Brodmarkle-Emerson
SHORT DESCRIPTION
The Rapson Greenbelt designs (modernized from the original case study) are the perfect balance of design, value, and expandability. Greenbelt configurations range from 576 to 2,660 square feet, and are available with a wide variety of interior and exterior finishes.

SOURCES OF INFORMATION

This is a modern take on the Rapson Greenbelt Case Study house. The large open floor plan allows for less necessary square footage without sacrifice. It also allows every american to have a designed house catered to their specific lifestyle.
Precendents | Modern Rapson Greenbelt [program separation]

wasteLESS modular housing

Melissa Brodmarkle-Emerson
Create **sustainable** residential options for Americans with the ability to **personalize** for each individual’s lifestyle.

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**The Three Spheres of Sustainability**

[Diagram showing the three spheres of sustainability: Social, Environmental, Economic.]

---

**wasteLESS modular housing**

Melissa Brodmarkle-Emerson
Why pre-fabrication?

- faster assembly
- better quality control
- climate controlled environment
- waste control
- cheaper labor costs
Why wood construction?

- nearly 90% of all residential construction in the USA is made with wood
- cheaper material
- sustainable forest management

- 1 yard$^3 = \downarrow$ CO$_2$ emissions by $\approx 1.1$ tons
  + CO$_2$ stored in wood $\approx 0.9$ tons

saves a total of 2 tons of CO$_2$ emissions
Why modular?

- can move into home faster
- customization does not considerably delay move-in time and is typically still faster than custom designed homes
- may not be able to afford a designed home otherwise
Connection points

The biggest issues for modular design are the module connection points and the foundation.
Design Criteria

No single-use spaces:

Flexibility of spaces:

Circulation flow:

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Design Criteria

Balance of private + public:

Integrated kitchen, dining and living areas:

Solar orientation:

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Design Criteria

Usable wall space:

 MEP Efficiency Integration:

Surface to volume ratio:

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Design Criteria

Ability to change over time:

Materials selection:
(LCA, recycled or reused?)
Design Criteria

Adherence of materials within the module:

Connection points:

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Exterior Panel Sizes

STANDARD
4' 0” and 8’ 0” modules

Half Panel
Full Panel

SHORTENED (corner)
3’ 2” and 7’ 2” modules

Short Half Panel
Short Full Panel

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Panel Customization

Component Types:
- PV panels
- Translucent (optional to be operable)
- Transparent (option to be operable)
- Living wall
- Rain screen?
- Operable louvres
- Solid wall

Sizes:
- 2' x 4'
- 4' x 4'
- 8'

South (Most common)
- 2 transp.
- 1 transp.
- 4 solid

East
- 4 transp.
- 6 panel
- 1 solid

West
- 2 transp.
- 6 panel
- 1 solid

North (Least common)
- 1 transp.
- 4 panel

WasteLESS modular housing modules can be reconfigured into a different structure.

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Process | Panel Customization

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Climate Zones of the USA:

Northwest Pacific
*(Includes states like Oregon and Washington to the crest of the Cascade Mountains)*
This is the perhaps the wettest part of the country. There are scattered rain showers all year round. Temperatures are mild averaging around 40 degree F. (32.2 degree C). The summer months are pleasantly warmer but never too hot. You can see fog along the coast during the warmer weather but the fog is less dense during mid-day.

Mid/South Pacific
*(Includes states like California, Idaho, Montana, Wyoming, Colorado, Utah and Nevada)*
These states have generally dry and delightful summers. California has excellent weather all the year round, with the northern part of the state somewhat cooler (quiet chilly in the winter but seldom freezing). There are very few places in California that experience snow, and the state is known for its nice weather. Mostly all the cities have tolerable winters. The winter months in the other states like Montana, Idaho and Wyoming can be very cold, with temperatures dropping well below 0 degree F. Colorado, Utah and Nevada are known for their excellent skiing.

Midwest
*(Includes states like Dakotas, Kansas, Illinois, Iowa, Minnesota, Wisconsin, Michigan, and Indiana)*
This region is moderately dry. Precipitation occurs mainly in late spring and early summer. Summers are pleasant but winter time can be harsh, with lots of snow and heavy chilly winds. Extremes within the Midwest can drop down to -50 degree F.

Northeast
*(Includes states like Ohio, Pennsylvania, Washington DC, Maryland)*
This entire area is moderately rainy. In winter, the region experiences heavy snow and freezing rain. Summers are usually pleasant, sunny and warm. The fall is especially beautiful in wooded areas.

Southeast
*(Includes states like portions of Arkansas and Louisiana, Kentucky, West Virginia, Virginia)*
Like the Northeast, this entire area experiences moderate rains fairly evenly throughout the year. The Spring, Summer and Fall seasons are all very pleasant. Some snow and freezing rain falls in winter but for the most part, the winters are quite mild and short lived. Southern Florida, like California, usually has excellent weather all the year round.

Southwest
*(Includes states like Arizona, New Mexico, Texas, Oklahoma and western portions of Arkansas and Louisiana)*
This is the hottest and high rainfall region of the US. You must be prepared to face heavy rains accompanied with thunder storms, dangerous lightening and occasional tornadoes. The winters are generally short but some freezing rains do occur. The spring and fall seasons are quite long and temperatures are generally excellent. The summers are very hot with temperatures approaching and exceeding 100 degree F on many days.
Midwest Catalog of Exterior Panels

LIVING AREA PANELS

BEDROOM PANELS

BATHROOM PANELS

KEY:
- Solid Rainscreen
- Translucent
- Louvres
- Glass Window (many are operable)
- Living Wall
- PV Panels

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Homeowner Customization

Each homeowner can customize the exterior aesthetic that fits their style:

The rainscreen panels can have texture, reflectivity, perforations, or color.

The transluscent glass windows can be frosted, colored, or fritted.
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Melissa Brodmarkle-Emerson
Upper Level

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Upper Level | Modules

Garden
Outdoor Patio

Master Bedroom
Walk-in Closet

Living Area
Closet

Bedroom
Bath
Closet
Mech

8’ 12’
Panel-to-Panel

Window Sill
Bolt Connections
2” x 10” Timber
(trimmed to fit)
Waterproofing / Adhesive
Insulation
Window Jamb
Operable Window
Caulking

EXTERIOR

INTERIOR
Roof-to-Panel

- Flashing
- Blocking
- Roofing Membrane
- Roof Bolted to Wall
- Exterior Paneling
- Ceiling Panels
- Insulation
- Interior Paneling
- Operable Window

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Foundation-to-Floor-Panel

- Exterior Paneling
- Floor Panels
- Insulation
- Blocking
- Floor Bolted to Wall
- Foundation 
  *(varies depending on soil conditions)*

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Prototype Home

ONE PANEL

- PV Panels
- Operable Windows
- Translucent
- Interior Paneling
- Solid Rainscreen

ONE MODULE

consisting of 8 panels

wasteLESS modular housing

Melissa Brodmarkle-Emerson
ONE CUSTOMIZED HOME
Consisting of 4 Modules and 32 Panels

Melissa Brodmarkle-Emerson
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wasteLESS
modular housing

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