THE SUSTAINABLE
SINGLE-FAMILY HOUSE

Bridging the gap between the typical single-family house
and the new standard of sustainability.

Isabella Hartsig

To start the acknowledgments, I would like to thank all of the people who helped me through my research at the University of Detroit Mercy, School of Architecture and Community Development. Professors including , but not limited to, Julia Kowalski-Perkins and Claudia Bernasconi. They have helped drive this thesis through to the end for concise and comprehensive research. As well as all of the peers I have encountered that have stood by me through all five years of Undergraduate and Master's education.

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AUTHOR'S NOTE

The concept of the Sustainable Single-Family House can be thought of as an obvious, self-explanatory architectural idea. However, it is not. The information involved with this study have only skimmed the top of what could be the future of sustainable housing.

The research within this thesis frames the concepts of how to transform a 'Typical Single-Family' house into an environmentally friendly 'Sustainable Single-Family' house. Touching on topics such as; Energy Impact, Carbon Emissions, and Material Analysis. Intertwining the found data to adapt an existing house to today's sustainability standards.

The Sustainable Single-Family House explores the connections and solutions that bridge the gap between the typical single-family house and the new standard of sustainability.

Sincerely,

Isabella Hartsig

THESIS STATEMENT

Beginning with the idea of mitigating the mass production of houses, tract housing, into a more sustainable method, and soon realizing that the real problem lies within the single-family house itself. There is a major gap in reality to laymen and professionals on the impact that a single home can have on the environment. There are 97 million detached, single-family houses in the United States alone which is very close to equating to the same environmental impact as the 5.9 million commercial buildings. There is a very clear impact through carbon emissions, however, through research in this thesis, there will be an even greater impact of the simple changes within the single-family houses that can be made on the pre-existing homes to impact the environment by a significant amount.

As of today, the typical single-family house is of no comparison to the new standard of sustainability. The general construction of these houses are expected to be based on the concept of maximizing profits. There is a lack of balance between the triple bottom line; People, Profit, Planet. Through interview data and observation of construction of the single-family home, it can be seen that there is an extreme interest in profit over any other aspect of efficiency, affordability, and sustainability.

The sustainability of single-family housing alone could create a significant impact on the environment. There is a preference in architecture and construction of the sustainability of a commercial building. Transforming 20 houses, similar numbers to one subdivision would create the same sustainable impact as one commercial building. A typical subdivision in Michigan is about 12+ houses. This means that if a community was to be educated on this topic and were to make a change within their single-family house, they could make the same impact of an office building in Detroit. There are many aspects of this concept and why it is not in use yet, such as, social, cultural, and economic. The social aspect of this is that there is an expectation from the HOA in neighborhoods that every house meets its aesthetics to look the same and in unison. No one person feels that they should step out of line to create a sustainable change as they would stick out from the uniform house. The cultural aspect is mostly based on the age of the community. Mostly based on generations, there is a lack of education and strong beliefs that the sustainability of a house or sustainability, in general, is non-existent and does not affect the environment. Lastly and most importantly, there is the economic aspect. This creates the greatest impact in this thesis as developers and builders tend to choose the products and construction methods that are the cheapest. Through research it is found that they chose these methods because it is what is best for them at the time, there is no interest in considering sustainability and efficiency, only affordability. This is where the question arises of, how can one convince the developers to change their methods without losing the profits?

The goal of this thesis investigation is to explore how to bridge the gap between current and past single-family housing development standards and new standards of sustainability. Expected outcomes include the definition of a strategy for re-imagining the single-family house to achieve increased sustainability.

Issues related to the housing market are being overlooked in terms of impact on climate change and sustainability. There are 97 million single-family, detached houses in the United States alone that have a cumulative effect comparable to that of the 5.9 million commercial buildings. There would be a great impact of change on this topic if people were to become more educated on these numbers. This thesis will help educate communities on what their houses impact is on the planet through infographics showing the impact of each sustainable method and going deeper into which one is the most efficient and affordable for their region, Michigan.

This investigation approaches the topic of sustainability in single-family housing through a pragmatic and realistic approach and will adopt a post-positivist framework, relying predominately on quantitative analysis and objective data.

There is a plethora of information already known on the topic of individual residences within a neighborhood, but there is a lack of knowledge found on the idea of specifying individual housing sustainability. Tract housing developments are a form of neighborhood characterized by the idea of having a simple plan for a house and building in mass around the area. The most notable example is found at where they began in Levittown, New York. In the book, "Levittown", by Richard Wagner, the history of the mass production of the single-family house is explained as a way to house the veterans coming home from World War II. It was known to be a 'solution' and William Levitt was known to be 'nothing but a visionary'. Yet, over time, there was no longer a reason to need a quick house for a true reason of community and there began the problem of the lack of balance within the triple bottom line.

Then taking a look at a wider scope of the city themselves, the book, "The Death and Life of Great American Cities", by Jane Jacobs gave great incite into the strict separation of district, city, neighborhood, and street layout. The largest takeaway from this thesis of the sustainable single-family house is the idea of salvaging projects. Taking what is pre-existing learning from the mistakes and creating solutions from what is built. This led to a need for a smaller look into what these houses and communities had and needed. There is a concept of taking houses and putting them into smaller units attached as a way of sustainability and taking up less space on the earth, but there is a con to this idea in both a sustainability and occupant health point of view. "A Pattern Language" by Christopher Alexander studied the housing community and described a person's needs for living as "an identifiable spacial unit to belong to". People need to own the space they are living in for their living health. The understanding of tract housing characteristics and sustainability shortcomings and the study of individual units are central to understanding planning aspects and how sustainability can be more efficiently integrated at both scales. Through this research, it was quite clear that there was a deeper problem rooted within the tract housing industry: the single-family house.

Through the process of observation and interviews the ideal process of building can be found through builders and developers. They can be compared to a sustainable way of building that can be found in the singular sustainable houses.

Methods will include annotative bibliographies, literature review, precedent studies and research on existing case studies, and census and environmental data diagramming. Other studies may include interview processes, observation of sites, and mapping. From the annotative bibliographies and literature reviews the outcome should become a framework for the next steps in my research, filling in the blanks from what has not been looked into for sustainable single-family houses. Within the precedent studies the goal is to take what is previously discovered and re-imagine the ideas to fit the idea of an efficient and affordable sustainable single-family house that meets the needs of a suburb in Michigan. The census and environmental data diagramming is the most important aspect of this thesis research as it will allow for the analysis of what is built today and what sustainable method creates the largest impact for the typical single-family.


01

INTRODUCTION

Housing trends in the United States have been influenced by societal needs of the time. As the climate crisis continues, how can building standards reflect this need for sustainability? This thesis seeks to develop a strategy for re-imagining the single-family house to achieve increased sustainability. As of today, the typical single-family house is of no comparison to the new standard of sustainability.
Currently, the environmental impact is double what it should be according to the 2030 baseline and the carbon emissions are over by a minimum of half a million. Through the interview data and observation process, it is shown that there is an extreme interest in profit over any other aspect of efficiency, affordability, and sustainability. Contractors, builders, and developers are cutting corners, using cheap, poor-quality materials, and once again ignoring the ideas of efficiency. Looking at the lifespan of materials through physical modeling, poor-quality materials stand out when compared to the expected lifespan of a house. This now raises the question of:

Can sustainability be affordable?

ABSTRACT

Within Residential Architecture, bridging the gap between the typical single-family house and the new standard of sustainability is a particular concern. Mass production of houses, including tract housing is one of the most unsustainable building methods, as this approach to residential development is usually coupled with the lack of attention to best practices of sustainable design, for example, the orientation of buildings in relation to site and climatic conditions and its relation to program and materiality. It is therefore important to find new solutions/approaches/strategies to mitigate this issue and embrace a more sustainable construction/building method.

The idea of selecting one house design and of employing it repetitively within the same plot of land to build identical or almost identical houses is not acceptable from the lens of sustainability. The issue does not merely lie in the repetition of the same spec house, but also within the single-family house template in itself. Issues related to the housing market are being overlooked in terms of impact on climate change and sustainability.

In fact, there are 97 million single-family, detached houses in the United States alone that have a cumulative effect comparable to that of the 5.9 million commercial buildings. Transforming 20 houses, which corresponds to one typical subdivision, would create the same sustainable impact as retrofitting one commercial building. There would be a great impact of change on this topic if people were to become more educated on these numbers.

As of today, the typical single family house is of no comparison to the new standard of sustainability. The construction of these houses is expected to be based on the concept of maximizing profits. Contractors, builders, and developers are cutting corners, using cheap, poor-quality materials, and once again ignoring the ideas of efficiency. There is a lack of balance between the triple bottom line; People, Profit, and Planet.

This investigation explored the gap between both current and historical single-family housing development standards and new standards of sustainability within the United States to develop a proposal for sustainable single-family housing in Michigan. Preliminary interviews and the analysis of the construction methods, materials, and designs of single-family homes, shed light on the extreme prioritizing of profit over other aspects of efficiency, affordability, and sustainability driven by the market.

Methods included literature review, precedent studies and research on existing case studies, and the analysis and mapping of census and environmental data, as well as interviews and in situ observations of the construction process. Combined, together, interviews and observations allowed for the in-depth analysis of what is built today and for the identification of which sustainable methods can create the largest impact. Outcomes of the study included the definition of a strategy for re-imagining the single-family house to achieve increased sustainability.

Additionally, findings can be used to help educate communities on impacts on the planet of their house through infographics showing the impact of each individual sustainable to communicate which are the most efficient and affordable for the region of Michigan.

DEFINITIONS

Tract Housing:	When a Developer or Builder purchases a large plot of land, divides it into smaller parcels, and then builds the same or similar houses multiple times around the land to create neighborhoods.
Sustainability:	Minimizing the negative environmental impact of buildings.
Single-Family House:	A free standing (detached) residential unit that houses one household or family. Typically ranging from 1,500 S.F. to 2,500 S.F.
2030 Baseline:	Energy Consumption anticipated for a modern building - 2030.
Carbon Emissions:	Amount of CO2 released during the life cycle of building materials
EUI:	Energy Use Intensity - Amount of energy per S.F. annually.
Construction Process:	Supplying, fixing, installing, fabrication, composition, etc. needed to execute the building of the house.
Post Occupancy:	After construction of the house, the evaluation of the house after the house is built and ‘lived in’.

PROGRAMS

Rhinoceros:
Rhinoceros is a 3D modeling computer program used to design, model, and render products. This program is used in this thesis to create a form of a single-family house to transfer into an energy modeling program.

Grasshopper:
Grasshopper is a visual programming software that works with 3D modeling programs to both model and generate information.

Cove.Tool:
Cove.Tool is a program that works closely with 3D modeling softwares to break down models and designs to assess the sustainable generative methods allowing for changes in location, energy usage, and carbon impacts.

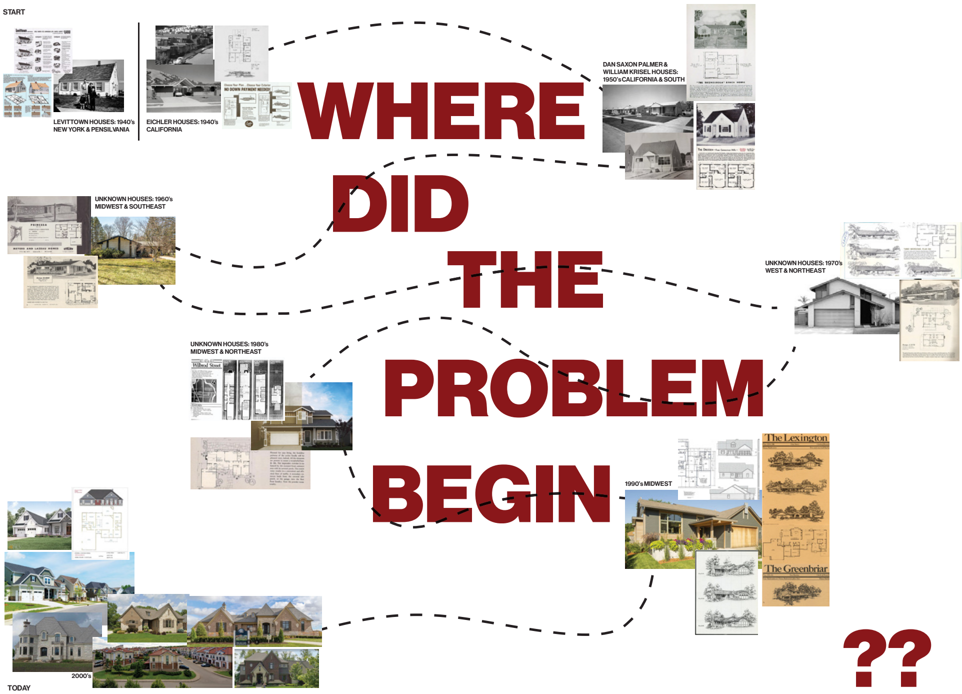
02

BACKGROUND

When imagining the issues within residential architecture, it is easy to think of the mass production of the single-family house, the tract housing industry. Presenting the idea of sustainable tract housing comes with some difficulties. Nonetheless, it is a relevant issue in today's society and has the potential for multiple solutions.

The houses within these developments have begun to increase in size at an alarming rate. There is a want for bigger and better houses each year. This past year, there was an all-time high of the average single-family house square footage at 2,500 s.f. Which is almost 10% larger than the previous years. With the growth of the houses, the overarching question is; is it the development of the houses or the single-family house itself that is having the greatest impact?

The History of Tract Housing



Tract housing arose in the 1940s with the construction of Levittown. William Levitt designed and built the one single-family house that was accessible to the masses and built quickly, and affordably. The idea came about from the lack of housing for the soldiers and their families coming home from the war. The creation of a community, a neighborhood. There were plenty of other ideas as such that followed Levittown. Some include; Sears Houses, Eilicher Houses, Palmer and Kriesle Houses.

This approach to housing was a revolutionary idea at the time of creation. Tract Housing, also referred to as “cookie-cutter houses”, is popular in the suburbs because of time and cost efficiency in addition to the ease with which profit margin increases. These houses, however, have caused many debates in the architectural field. The argument against this type of building is that the developers give little to no attention to sustainability. Their focus remains on financial gains. That being said, most houses need to be illuminated and conditioned at all times. It adds considerable cost to the homeowner’s bottom line and is creating small, yet impactful damage to the environment as each new build contributes to the next.

Somewhere along the line, changes were made with the intentions of the houses. The houses once built to grow families and communities are now built with the priority of profit and ease of development. The builders and developers who are building these neighborhoods’ first concerns are what is in their best interest rather than the future homeowner.

Assumptions

During the beginning process of this research, one of the most valuable driving factors was the assumptions on the topic of single-family housing. In this thesis, six assumptions came about from the beginning of the idea. These assumptions were as follows; Distribution of Efforts, Previous Developed Methods, Maximized Profits, Fear of Price Increase, Lack of Education, and Out of Date Policy.

First is a lack of distribution of efforts from the developers who are building these houses to design and think sustainably. Leading to the questions:

Where did the problem begin?

Why did the efforts shift out of focus?

Second and third being that there is already a predetermined method that the developers have that allows them to maximize their profits. Guiding the conversation to become more of:

How can sustainable methods be integrated into today's housing design without disturbing developers' existing methods and profits?

Fourth, the developers are worried that the sustainable methods will increase the price of materials and production.

How to find alternative materials and methods that would be more sustainable and affordable for the production of a single-family house?

Can sustainability become affordable?

Fifth and most importantly, there is inadequate education of the developers and even architects. Dominating the discussion in this thesis with the questions of:

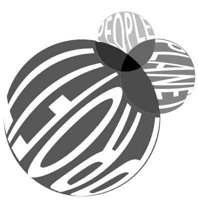
How can education begin to meet the needs of new sustainability standards?

How to educate the older generation that sustainability needs to be implemented now?

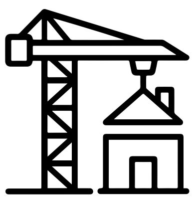
Lastly, the policy created for the construction of houses is out-of-date. This originally led to the question of:

What would entice developers to change their building methods without increasing the policy standards?

With these questions, the thesis on the sustainable single-family house was created and became a concept of developing a method to not only make the existing single-family houses more sustainable, but also convince developers to think more sustainably during the construction of new and existing homes.



DISTRIBUTION OF EFFORTS



PREVIOUS DEVELOPED METHODS

MAXIMIZED PROFITS

FEAR OF PRICE INCREASE

LACK OF EDUCATION IN SUSTAINABILITY

OUT OF DATE POLICY

People, Profit, Planet

Balance

The Triple Bottom Line: People, Profit, Planet. A sustainability framework that was originally used to measure business success, but could potentially be used to measure the balance of efforts in the construction of houses.

People: Social Inclusion
Profit: Economic Growth
Planet: Environmental Protection

When all three of these efforts are equally accounted for the construction of a house should be both affordable and sustainable.

Imbalance

As of today, it is presumed that there is an imbalance of the triple bottom line. After years of observation, the assumption is that developers, builders, and even architects are more focused on profit rather than the people and planet.

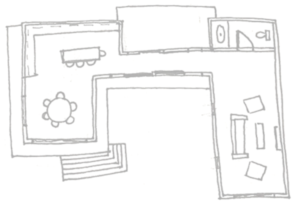
Precedence: Sustainable House

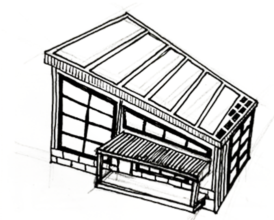
During the development of the idea of creating a Single-Family house that is also sustainable, the first step was to look into existing sustainable houses.

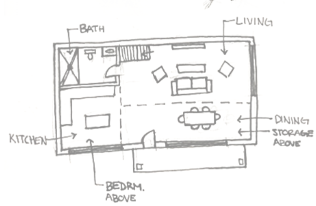
In order to do so, a predominant method of assessing the houses was sketching to truly understand the form and concept. As seen in the graphic, the sketching process allows for creativity of the mind. For interpretation of each project from the eye of the artist. It best represents where the research understanding is coming from and highlights the aspects that stand out the most to the one who drew them.

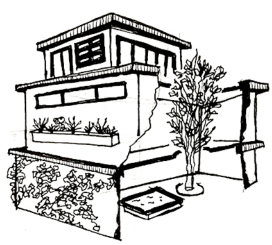
Originally the research started with interior analysis. Looking into the layouts of many of the houses, including the ones in the graphic, to see what the impact of interior walls and placement has on the health of the inhibitors. Quickly the layouts started to form a pattern of open spaces and biophilic integration. With that being said, there was no interior spaces that had the ability to affect the sustainability of a house in the way that it would greatly benefit the exterior environment.

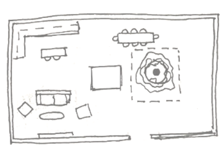
The facade of the houses and the make of the construction components were found to be the most impactful after first glance of the precedence. Looking at the houses found, it was clear through the exterior that a major impact of these houses were their form. Each one was simple and modern. Mainly in a box formation and it was clear that each were specifically oriented to maximize sun integration. Exercising the use of large windows on all faces of the building for better interior health. Along with flat - low angled roofs for solar panel energy utilization. Each of the sustainable methods listed have the potential to be integrated into the typical single-family house, but the questions are, is it affordable to use these methods in typical homes and can a single-family house sustain modern methods and materials?







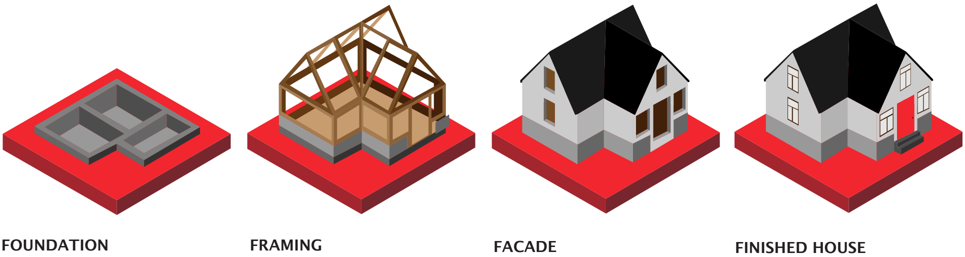




How Houses are Built Today

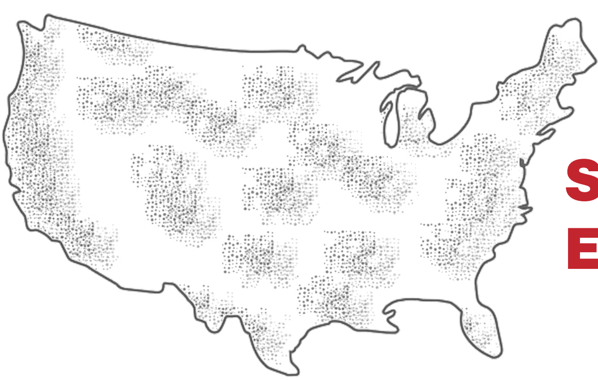
In order to understand the abilities that a single-family house has to become sustainable, one must understand how they are built today.
The initial objective of a house was to provide shelter from weather, animals, and create privacy from others. There was little to no thought on aesthetics or grandiose motions to create 'lavish' conditions. This was the most sustainable way of building as everything was locally source and constructed.

Assumptions aside, it is known that not all houses are built in the most sustainable way. Yet, assumptions lead to the idea that little to no single-family houses in suburbs are built to be sustainable at all.
Starting with the idea of mass production leading to the larger problem of the houses within these development themselves. The single-family house holds more sustainability issues than where and why they are built.



Integration of Sustainability

What is the future of housing?
Sustainability is a major driving factor into the future of housing. But, how do houses go from where they are now to becoming more ecologically friendly?
Assuming the focus is within existing houses, the integration of sustainability will come with limitations. Incorporating conditions into the reconstruction where materials, elements, and structure are analyzed and kept or replaced in the house based on their energy usage, carbon impact, and material lifespans.



SUSTAINABLE EXPANSION

03

TOPIC

This thesis is focused on the sustainable rehabilitation of existing single-family houses. Exploring conditions of energy usage, carbon emissions, and material lifespans to see where the greatest impact is created by the houses. Researching both the negative and positive effects of each.
Proposing a location of research along with a illustration of the 'typical' house to be studied and manipulated.
Utilizing modeling as a majority method of research. Operating out of Rhino, Grasshopper, Cove.Tool, and physical crafting to demonstrate ideas and discover new information on the sustainability of the proposed house.

Relevance

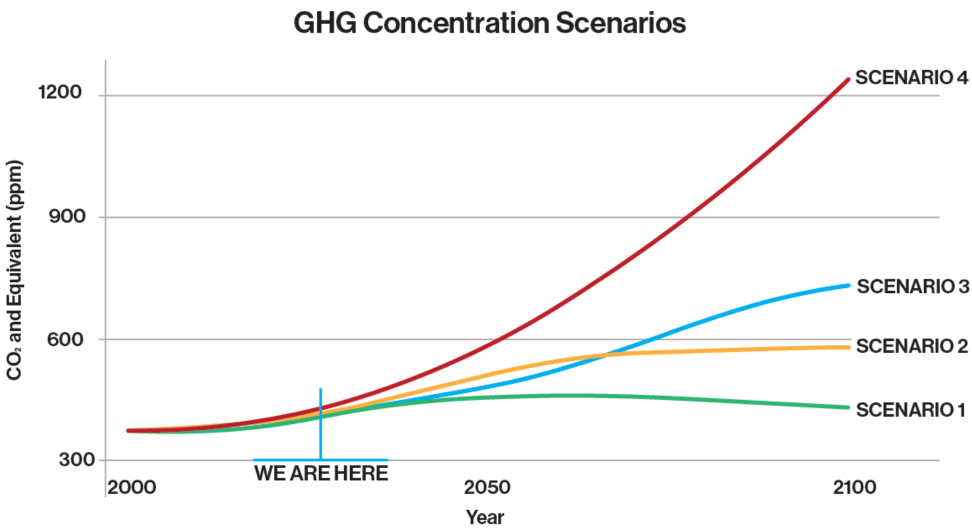
Climate Change

In order to understand and fully accept what impacts buildings as a whole are having on our environment, one has to look at the excessive climate change to come in the near future. Today, 2024, the world is at its tipping point. People can either begin to appreciate the environment and change for the better, or they can continue to ignore the changes happening and within 100+ years result in the worst case scenario. There is still a chance for humans to keep the planet habitable.

In the charts below, there are four scenarios in which the greater Detroit area can change based on the people who live within the cities. Showcasing the green house gas concentration per 50 years. Green house gases are emissions produced by man made products. In simple terms, it is a pollution rate.

Almost everything in the world today creates a negative affect on the environment through these gases.

One of the major ways that people are creating negative impacts is through buildings. A way that could combat this change is through the built environment. Focusing on utilizing what is already existing and re-imagining it to have a minimal impact of a building through different aspects of sustainability. The smallest change can create a great impact.



SCENARIO 1- The earth is Durable, Fast action

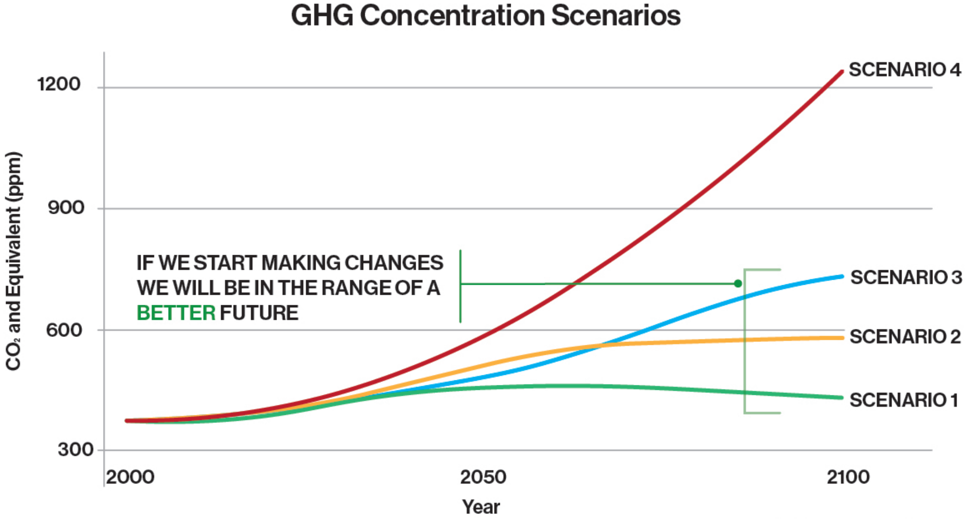
SCENARIO 2- The Earth is Fragile, Fast action

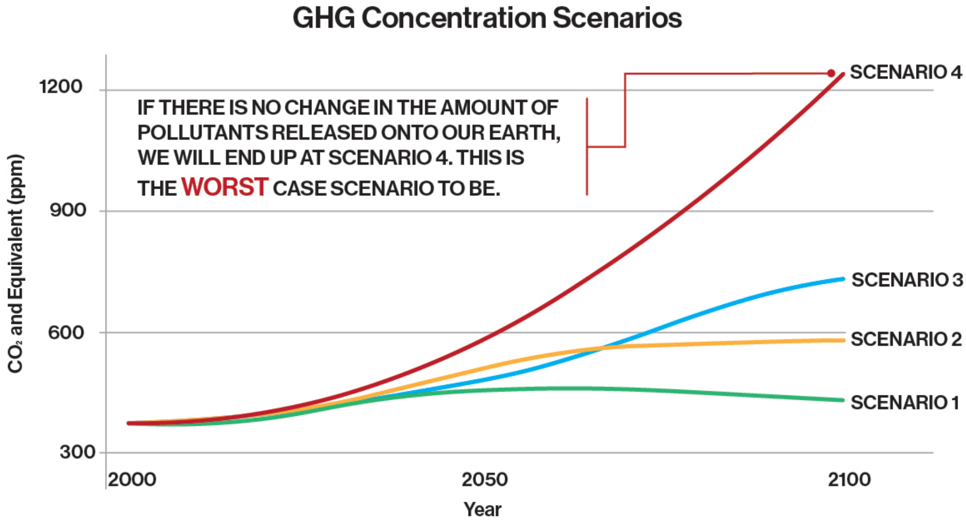
SCENARIO 3- The Earth is Fragile, No Change in action

SCENARIO 4- The Earth is Fragile or Durable, Slow action

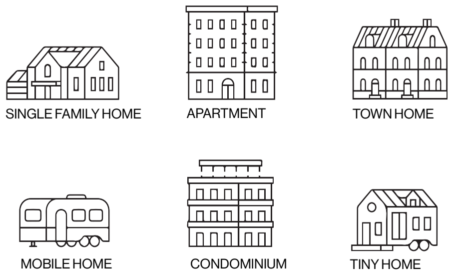
GHG - Greenhouse gasses: the gasses that are trapped inside the earths atmosphere. They are caused by the warming of the earths elements by the sun.

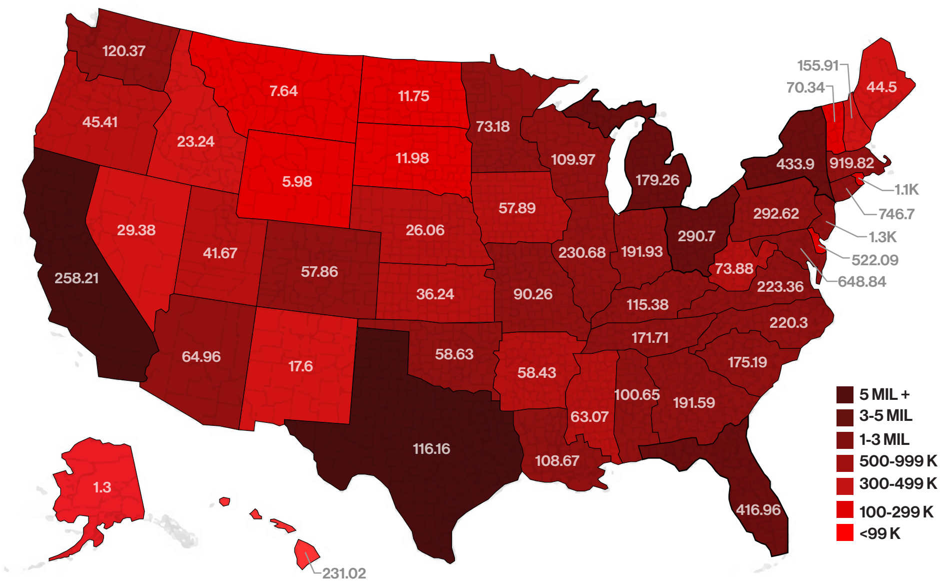
RCP - Representative concentration pathway: a prediction of how the climate will change over time.


GHG Concentration Scenarios
CO₂ and Equivalent (ppm)
1200
900
600
300
2000
2050
2100
Year
SCENARIO 4
SCENARIO 3
SCENARIO 2
SCENARIO 1
IF WE START MAKING CHANGES WE WILL BE IN THE RANGE OF A BETTER FUTURE


GHG Concentration Scenarios
CO₂ and Equivalent (ppm)
1200
900
600
300
2000
2050
2100
Year
SCENARIO 4
SCENARIO 3
SCENARIO 2
SCENARIO 1
IF THERE IS NO CHANGE IN THE AMOUNT OF POLLUTANTS RELEASED ONTO OUR EARTH, WE WILL END UP AT SCENARIO 4. THIS IS THE WORST CASE SCENARIO TO BE.

As of today, 2024, there are 145 million housing units in the United States alone. This is including all types of houses. As expected, more than half of these housing units are single-family. Specifically, 67% are single-family houses. That equates to 97 million single-family houses in the United States.
The graphic shows the density of single-family housing in the United States compared to the population density of each state. One of the more obviously dense states is Michigan.





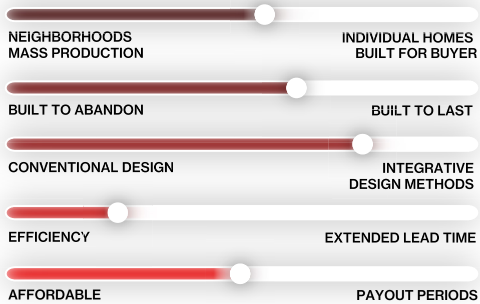
145 MILLION HOUSING UNITS IN THE U.S.

67% OF HOUSING UNITS ARE SINGLE FAMILY

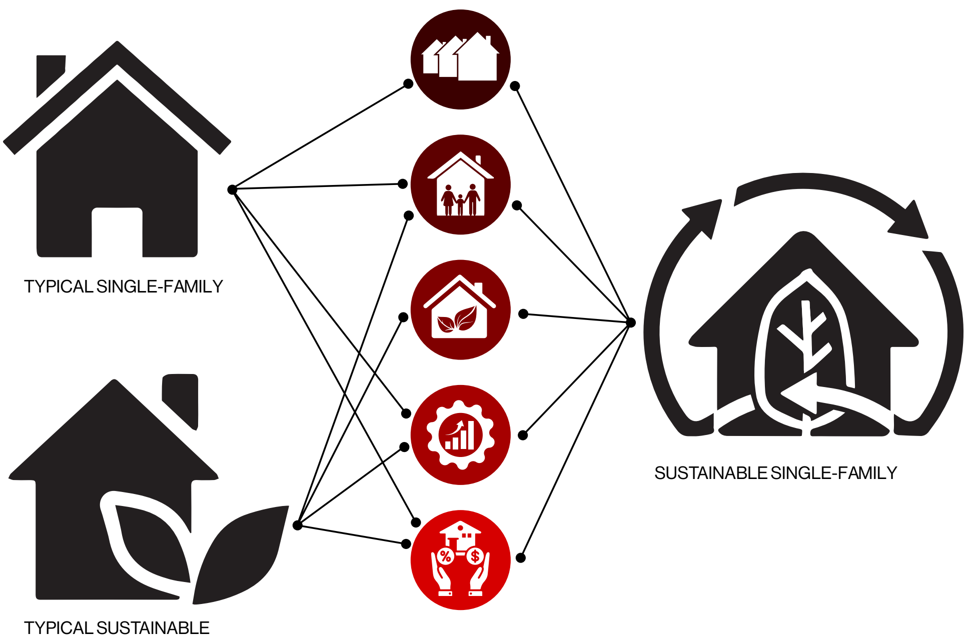
Affordances

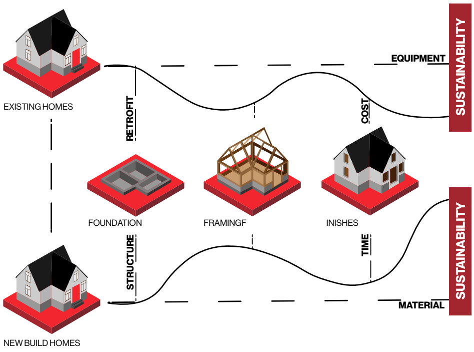
An affordance of a concept is what somethings original intent is versus what it is actually used for. This means that there is a balance between the two intentions of a building. This thesis uses the precedent studies of both a 'typical' single-family and sustainable house. Forming affordances of the beneficial aspects of each type of house to create a scale in which this thesis will decipher where the sustainable single-family house will lie within each comparison.

Looking at each house, there were 5 points that stuck out for the best outcomes. The intention of build, lifespan, design methods, timeline, and budget. These particular prospects are thought out with every project from the beginning, which gives every reason to explore other options and opinions when deciding where to move towards in the future.



When scaling each of the components, it is important to note that no aspect has the ability to 'fix' the issue by itself, nor will it be valuable when it is overpowering the other scales. The graphic is showing this thesis' placement of each element is used to give an overview of goals for the Sustainable Single-Family house.





At this portion of the research, the sustainability of both an existing and new build single-family house seemed equivalent. Needing the same research and information to form a solution to their environmental impact. This lead to the comparison and affordances of the two types of builds rather than sustainable versus unsustainable. As shown in the graphic, there are similar details along the transformation of the houses such as the foundation, framing, and finishes. Some of the differing elements are the structure, materials, time, cost, and equipment. In a new build house, all of the elements of a house are open to evaluate and change. Whereas in an existing house, there are only certain portions that can be manipulated in the favor of sustainability without exceeding the affordability aspect shown prior. It was clear that the construction types needed to be separated in research. Which lead to the decision to study the retrofit of existing houses in order to solve the pre-existing problem before finding a solution for the future.
Circling back to the affordances created now and previously, the application of these findings will be crucial in this portion of the thesis research. Finding how to integrate the scale of elements into the houses.

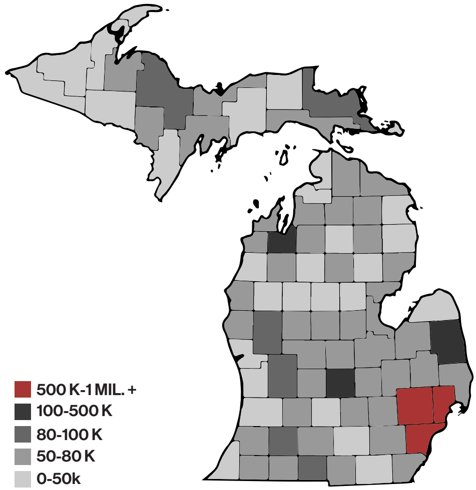
Location

As pointed out, Michigan has an extremely dense population of single-family houses. Michigan specifically takes up about 3% of the single-family houses in the United States with 3 million units.

Focusing more on this, one of the more densely populated areas of Michigan is in the Metro-Detroit cities. Just under half of the population of houses are located here. Taking this into consideration, this thesis will be based in a city within Metro-Detroit, Berkley, Michigan.

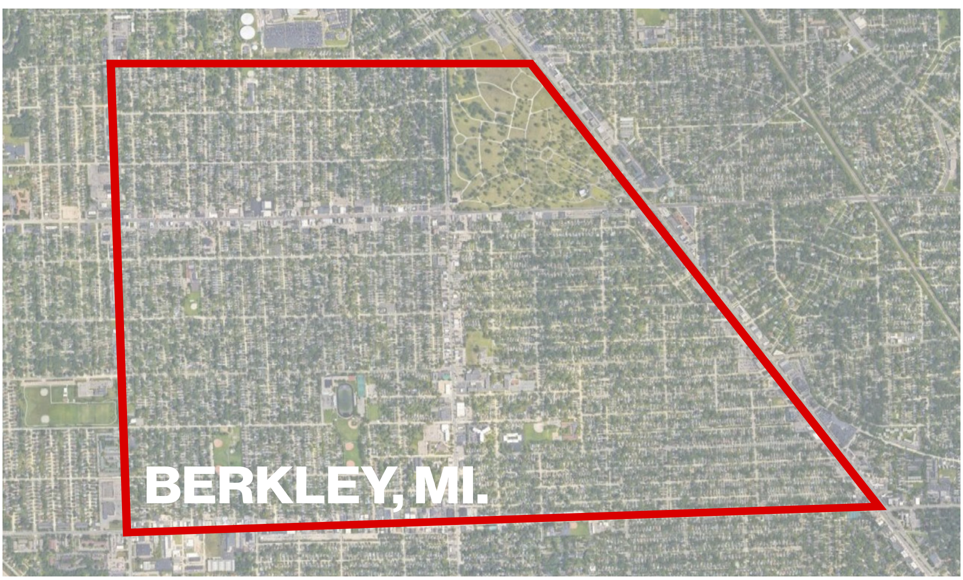
Located Northwest of the city of Detroit, Berkley is a small place populated with a majority of houses that specifically meet this thesis' definition of single-family with detached units ranging in size from 1,000-2,500 S.F.

The exact house that will be utilized is at an average of 2,000 S.F. and located centrally in the city on the cross roads of 12 Mile and Prairie Street. This house will allow for neutral data to apply for most of Michigan's existing houses.



3 MIL.

SINGLE-FAMILY HOUSING UNITS IN MICHIGAN



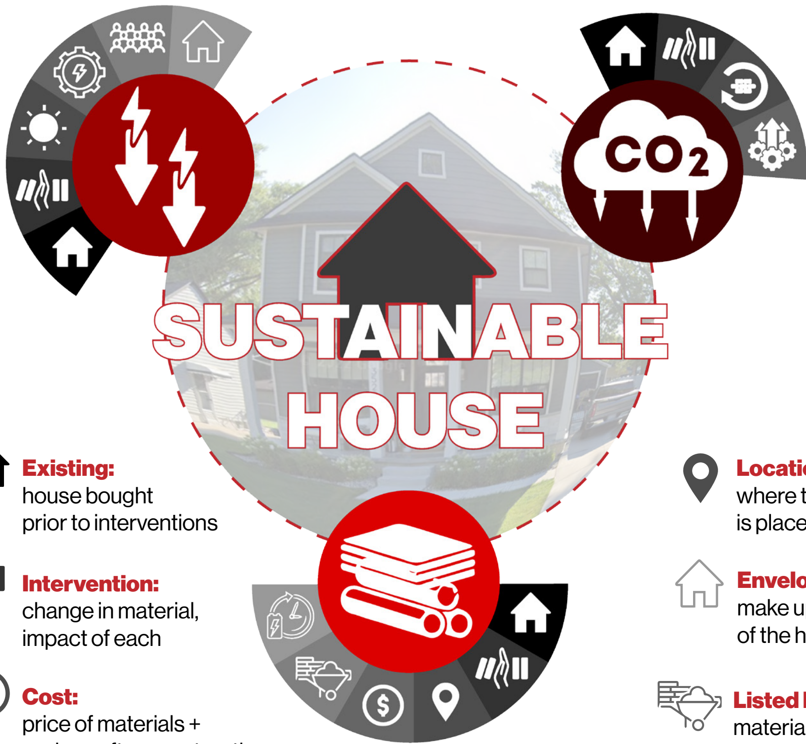
ANALYSIS:

CONNECTION

Connection

Material, Carbon, Energy

CARBON IMPACT **ENERGY USAGE** **MATERIAL SELECTION**



Existing:
house bought
prior to interventions

Intervention:
change in material,
impact of each

Cost:
price of materials +
savings after construction

Embodied:
the manufacturing,
transportation, installation,
maintenance, and disposal

Operational:
due to energy consumption
post construction

Occupancy:
desity of people within the
home, time of house energy
useage per person

Lifespan:
amount of time a material
is expected to last

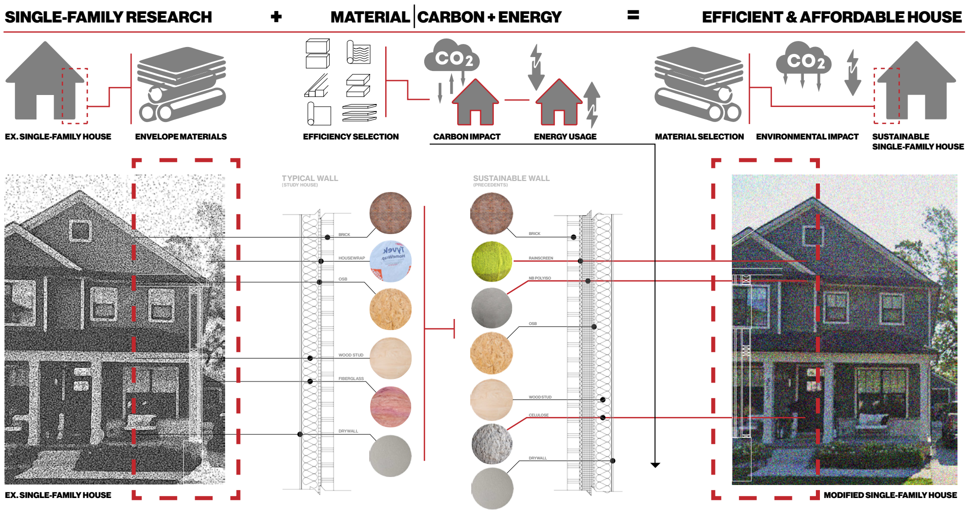
Location:
where the project
is placed

Envelope:
make up of the walls
of the house, material

Listed Materials:
materials within the
wall sections to create
positive impacts

Daylighting:
amount of natural light
let in to the house + the
effect it has on the EUI

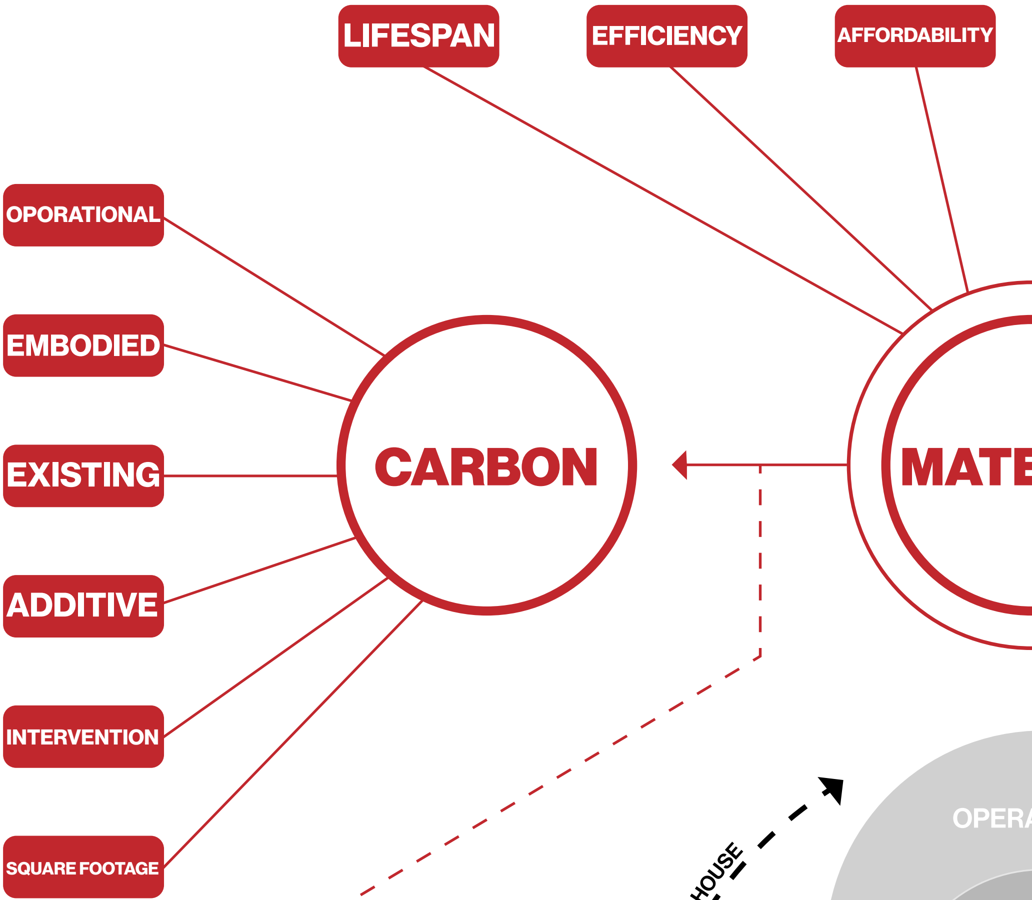
Generation:
creating energy for the
house to sustain itself

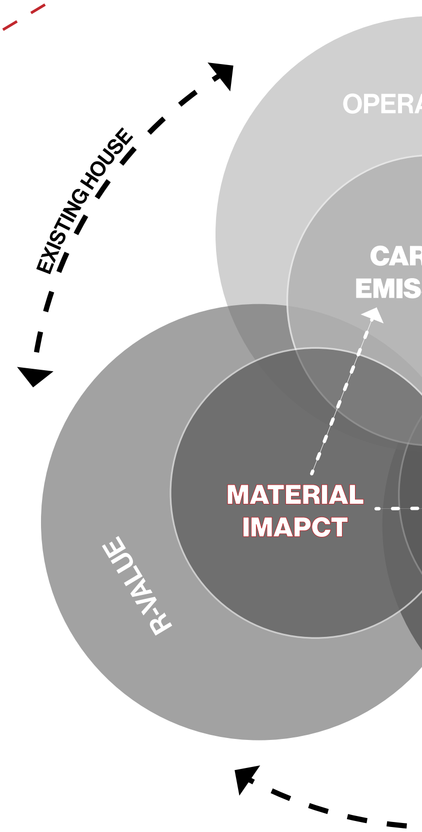


In general terms, this thesis follows a fairly simple process of analyzing the existing single-family house through the wall section. Looking at each material layer and then conducting a study on which materials create the greatest positive or negative impact through carbon and energy per year.

Taking a step back and looking at the three topics within this thesis, carbon, material, and energy. It was found that material is the driving quality that changes both the carbon and energy. However, when looking at just the carbon and energy, it is shown that when the energy changes, so does the carbon, but does not go both ways. Carbon has no affect on either material nor energy simply because it is not a factor that can be incorporated in the sustainability analysis numbers.

In addition to the topic qualities, there are elements that assist in the understanding of what impacts they each have. The only overlapping elements within the topics are the existing house of study and the interventions made to the house. These are the two elements that will be studied the more in depth through this thesis.





Rate of Change

Material to Carbon

As the material changes per layer of the envelope, the carbon is either increased or decreased by the following aspects:

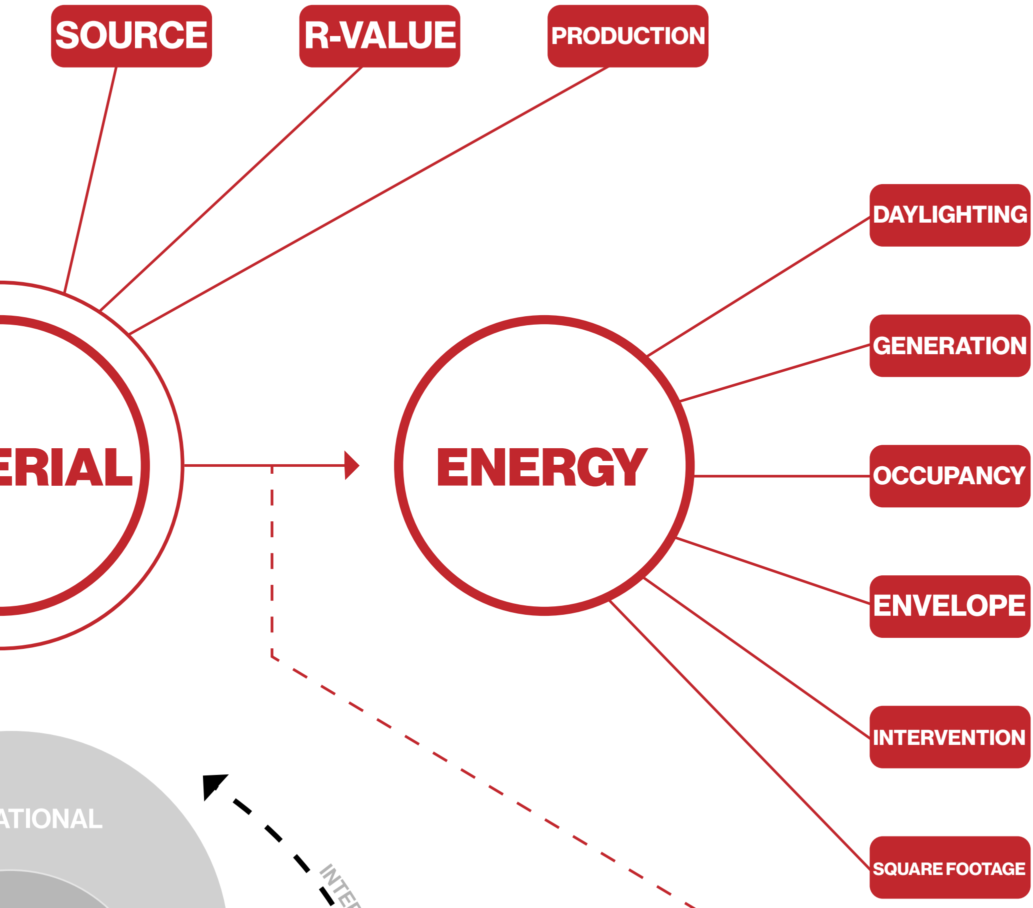
- Ingredients
- Manufacturing
- Transportation (to and from)
- Installation
- Maintenance (lifespan)

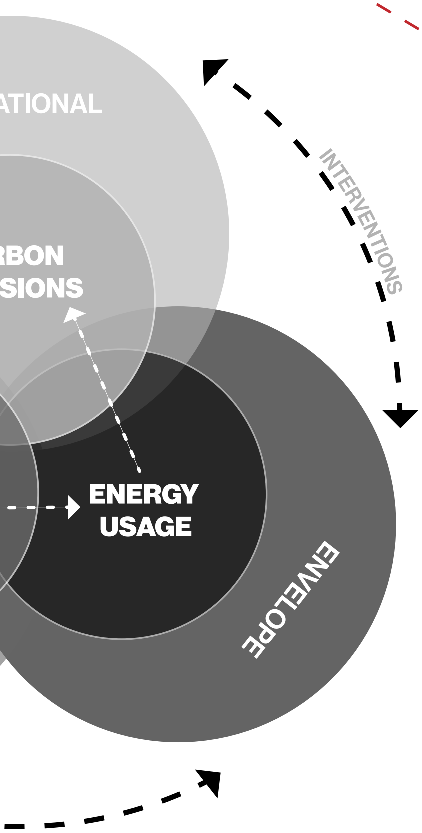
- **Energy POST Construction**

ENERGY IMPACTS CARBON
MATERIAL IMPACTS CARBON

Carbon does NOT impact other aspects of Material and Energy outside of the selection process

CO_2





Rate of Change

Material to Energy

As the material changes per layer of the envelope, the energy is either increased or decreased by the following aspects:

- Manufacturing
- Transportation (to and from)
- Living energy usage (occupancy)
- Installation
- Maintenance (lifespan)

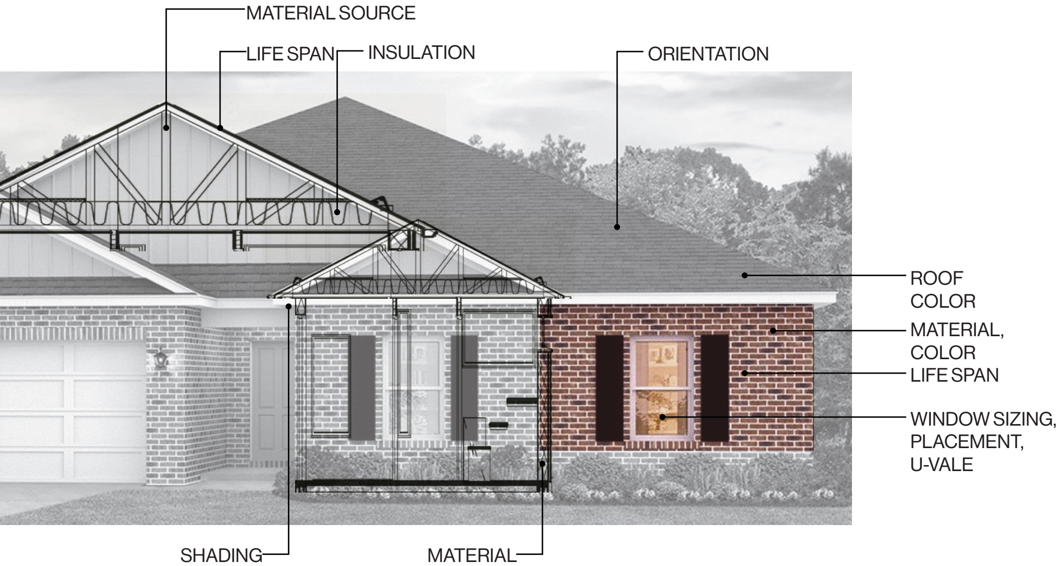
- **Energy POST Construction**

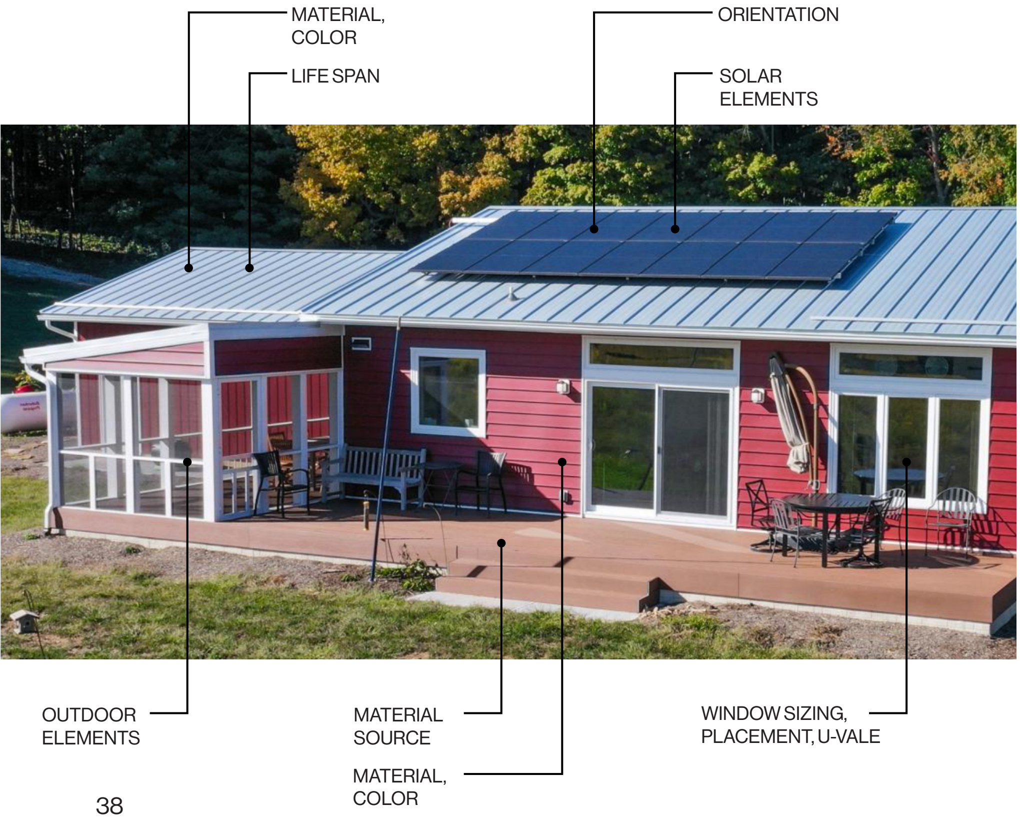
MATERIAL IMPACTS ENERGY

Energy affects Carbon, but does not affect the Material outside of the selection process

ANALYSIS:

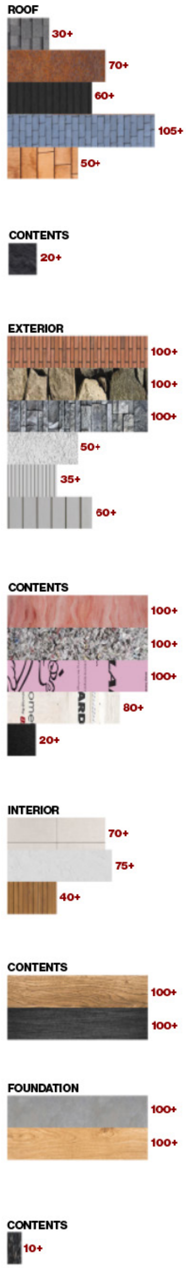
MATERIAL


MATERIAL SOURCE
LIFE SPAN
INSULATION
ORIENTATION
ROOF COLOR
MATERIAL, COLOR
LIFE SPAN
WINDOW SIZING, PLACEMENT, U-VALE
SHADING
MATERIAL


MATERIAL, COLOR
LIFE SPAN
ORIENTATION
SOLAR ELEMENTS
OUTDOOR ELEMENTS
MATERIAL SOURCE
MATERIAL, COLOR
WINDOW SIZING, PLACEMENT, U-VALE

Material Study

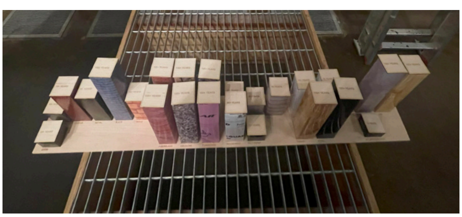
Sketch Problem I



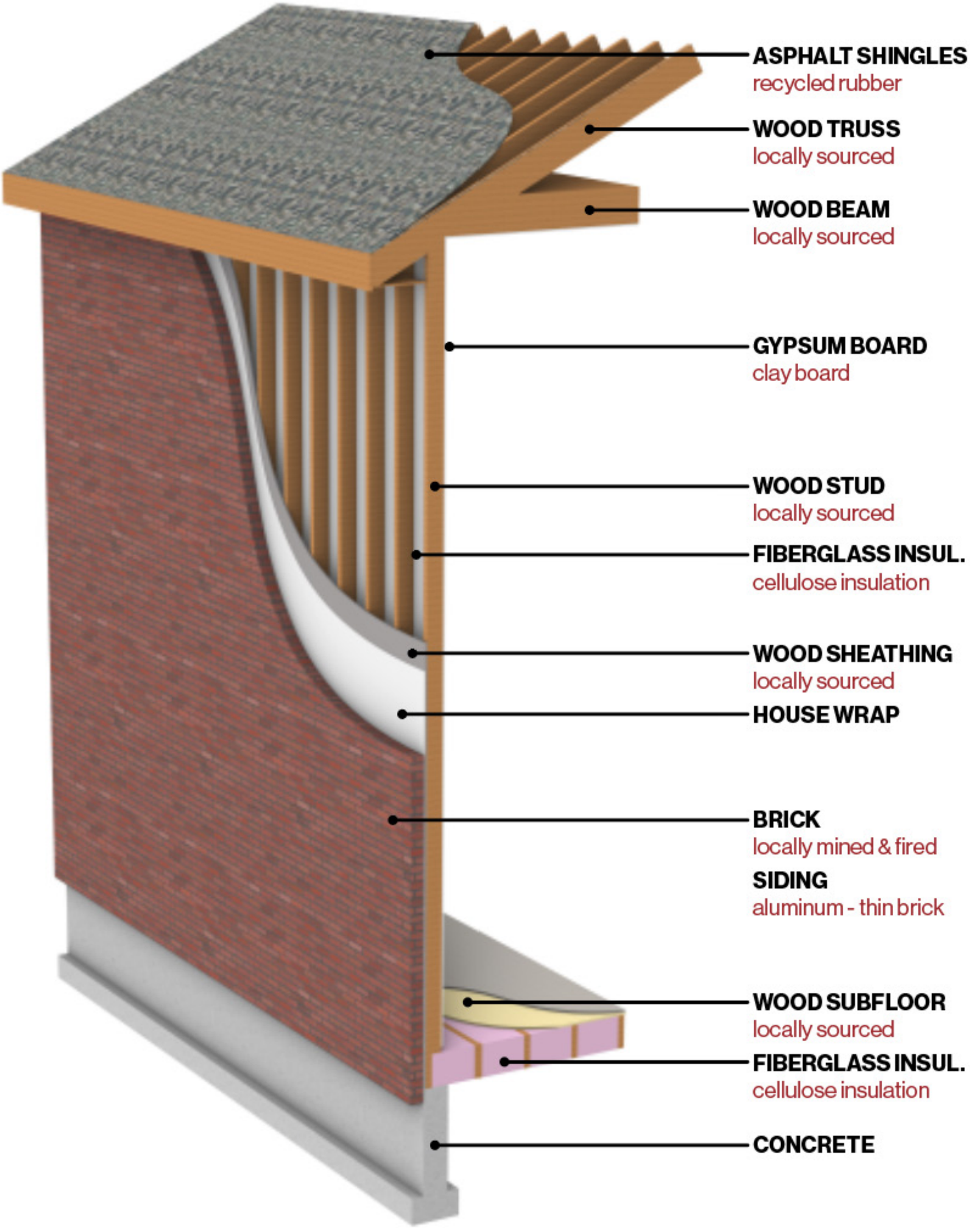
Material Lifespan Comparison

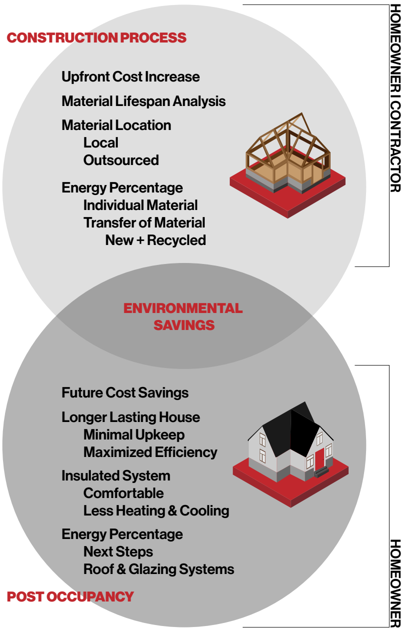
Studying building elements' lifespans to visualize and decipher which materials are best suited for a sustainable home.

The intent of this study is to analyze the building elements of a home and decipher which are best suited for a long-lasting home. An important aspect of a sustainable home is the idea that the house is built to last 'forever' and not to be abandoned like many of the homes built today.
The main focus of this model is to pull out the core elements that make up a house and extrude them to their lifespan. Implementing the 3D aspect of this graph uses a method that creates a visual effect for the viewer to clearly point out which elements will last the longest and then decipher whether or not these elements will be suitable for a sustainable home in terms of their impact on the environment.



Single-Family House Wall Section





Thinking materialistically, going into the innards of the walls of a house is an extremely important step. Each of the materials that come together to make up a wall have their own impact on the environment. Each different in their own way. Some may already be sustainable, some not so much.

The graphic illustrates a 'typical' single-family house wall section. Showing fundamental elements in comparison to their more ecologically friendly materials.

Asphalt Shingles: Recycled Rubber
Wood: Locally Sourced
Gypsum Board: Clay Board
Fiberglass Insulation: Cellulose Insulation
House Wrap
Brick: Locally Mined & Fired
Siding: Aluminum - Thin Brick
Concrete

ANALYSIS:

ENERGY

Energy Impact
Baseline

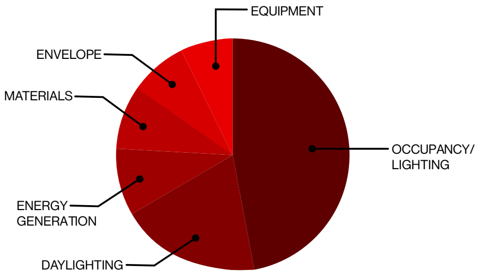
Energy usage of a single-family house creates an impact on the environment. Through multiple elements of energy including, but not limited to, the envelope, energy generation, daylighting, and occupancy.
The energy usage is measured as EUI, energy usage intensity. The baseline EUI expected for the year 2030 is 49.77. The 2030 target EUI is 9.95 which is significantly lower than the baseline for the year.

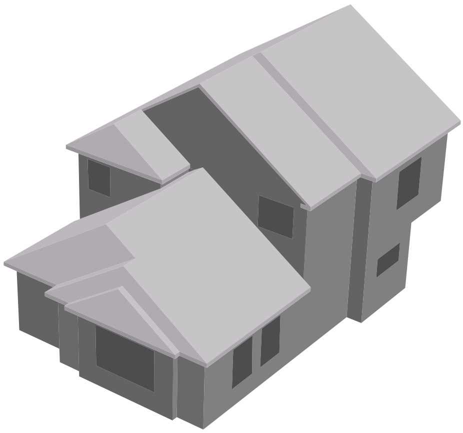
49.77 : 2030 BASELINE EUI

9.95 : 2030 TARGET EUI

Original House

The energy impact can be manipulated through the Energy Generation, Daylighting, Occupancy, and Envelope. The following graphics are showing each manipulation made to the original house and the percentage of impact it made on the EUI.





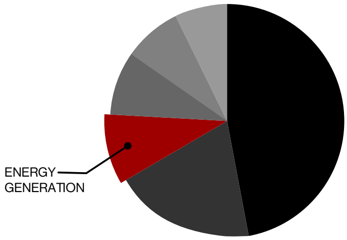
66.27

ORIGINAL HOUSE:

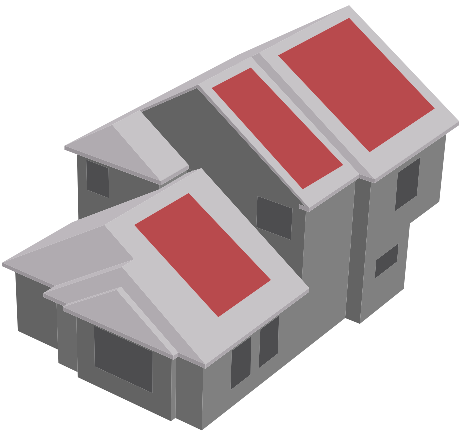
Single-Family I 2-Story

West Facing I Berkley, MI

Energy Generation



One of the most common ways of creating a sustainable impact on an existing house is the addition of products that generate energy. This would include the rise of solar panels being placed on houses and garages in the suburbs. Although this is a step in the right direction for home owners to take action, it does not produce enough of an impact to study further within this thesis.



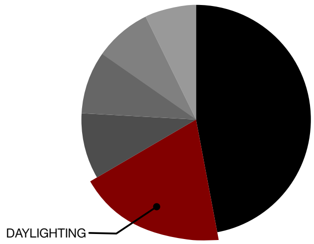
62.59

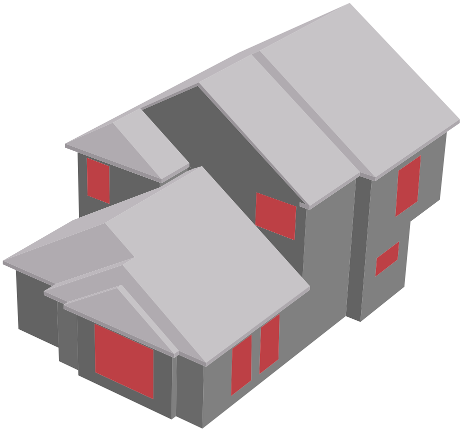
ENERGY GENERATION:

6% Improvement

Daylighting

Another important aspect of sustainability for the interior of the house and energy usage is daylighting. Many houses do not have adequate natural lighting which causes the home owners to turn on lights and have to heat their house more often.
Although daylighting does create one of the largest impacts within this study house, it cannot be assumed that it will have the same affect on every house based on orientation.

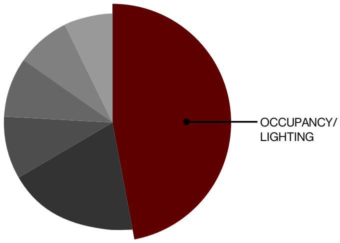




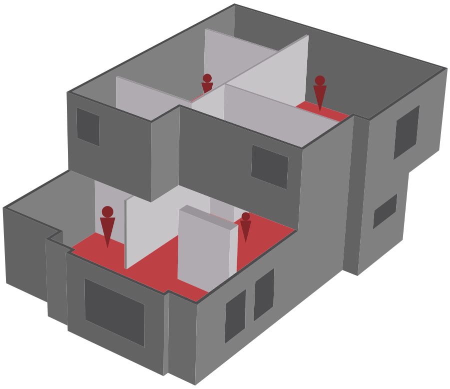
60.00

DAYLIGHTING/
10% WINDOW INCREASE:
+9% Improvement

Occupancy



Following the lack of daylighting, occupancy and lighting takes up majority of the energy usage in the study home. What makes up the occupancy energy load is lighting, heating and cooling, and general electricity usage of televisions, fridges, and miscellaneous electrical items.
As stated before, one cannot expect the homeowners to stop using their houses as intended.

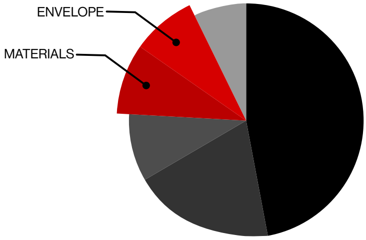


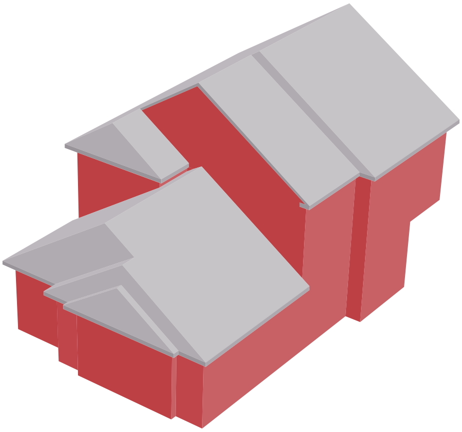
60.40

OCCUPANCY:
9% Improvement

Envelope

When looking at the envelope, the initial conclusion was that there was not a great enough impact to look into it. However, when continuing the research of what creates the envelope, the material life span, carbon, and energy not only creates a large negative impact on the environment, but also is a realistic expectation for this thesis to expect the homeowner to change.





62.94

ENVELOPE:

5% Improvement

ANALYSIS:

CARBON

Carbon Emissions

There is a misinterpretation of what a large impact residential architecture has on the environments. In today's society, it is very common for architectural firms, builders, and laymen to think of sustainability efforts only towards commercial buildings.

In order to show how great of an impact there is through the single-family houses, the graphic compares the carbon emissions of commercial buildings in the two single-family houses in the United States to illustrate the equality of the issues.

On the left, there is the impact of commercial buildings, starting with the number of buildings in the United States at 5.9 million. Each of these buildings produce 140 tons of carbon which in total equates to 826 million tons. Which may seem like an excessive amount that a house simply cannot compare to.

However, on the right, the diagram shows that there are 97 million single-family houses at 7 tons of carbon per house. This adds up to 679 million tons.

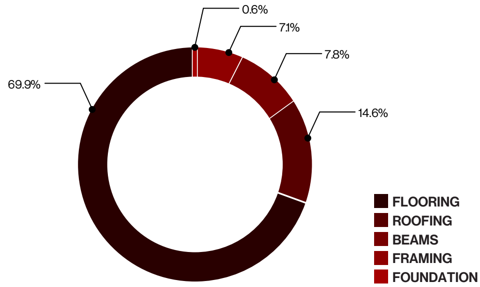
In turn, single-family houses are less than 200 million tons away from having the same impact as the commercial buildings and it is growing every year as the houses get larger. For every 20 houses retrofitted, the carbon impact would average the same as one commercial building. This is the average subdivision size, meaning that one subdivision can make the same carbon impact as an office building.

Taking this information into account, it is critical without even looking into one house specifically, to start looking into the sustainability of a single-family house through its carbon impact.

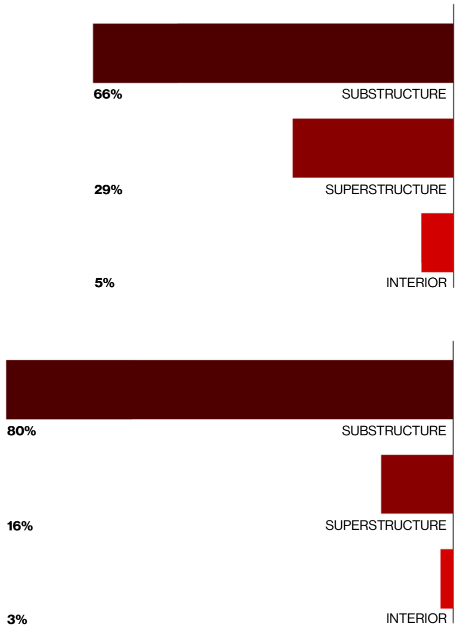
After affirming the sizable carbon impact that single-family houses have on the environment, this thesis turned towards diving into finding a solution. Answering a similar question from previously in the energy impact of, what in a house is creating the largest impact and is it feasible to fix within an existing home?

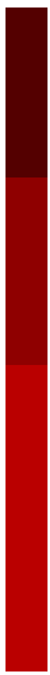
In response to the search for the greatest carbon impact within a single-family house, a review of the structural systems was needed. The carbon emissions are broken down into substructure, superstructure, and interior. The diagram demonstrates the impact of every element within the superstructure that can be

manipulated.
Before making any changes to the Rhino model, the substructure was obviously creating a much larger impact than the other influences and overall they started with 1,209,126 kg total carbon.
Surprisingly, this was not far from the baseline carbon emission for a house in this area. With only a 2% decrease, the example single-family house could potentially fall below the baseline with a carbon total of 1,185,418.



CARBON EMISSIONS BREAKDOWN:





STARTING CO_2 EMISSIONS:

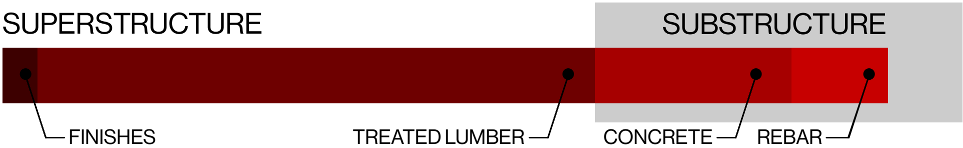
1,209,126 TOTAL CARBON

BASELINE CO_2 EMISSIONS:

1,206,684 TOTAL CARBON

2% ACHIEVABLE CO_2 REDUCTION:

1,185,418 TOTAL CARBON




04

RESULTS

After evaluation of the existing house as a whole. The final consensus was that the envelope would create the largest impact holistically through energy and carbon using a material analysis.
Within this section, this thesis follows an in depth analysis of existing material selection along with a proposal of materials that potentially would provide a more sustainable method of building.
Each of the proposed materials also referenced in the up-coming pages with measurements of impact on carbon and energy.

Winter Design Brief

Computational Housing Components in collaboration with Sean Clifford

Coming from the two concepts of a sustainable single-family house researched by Isabella Hartsig and the integration of computational methods into affordable housing systems researched by Sean Clifford, the creation of the computational housing components project began.

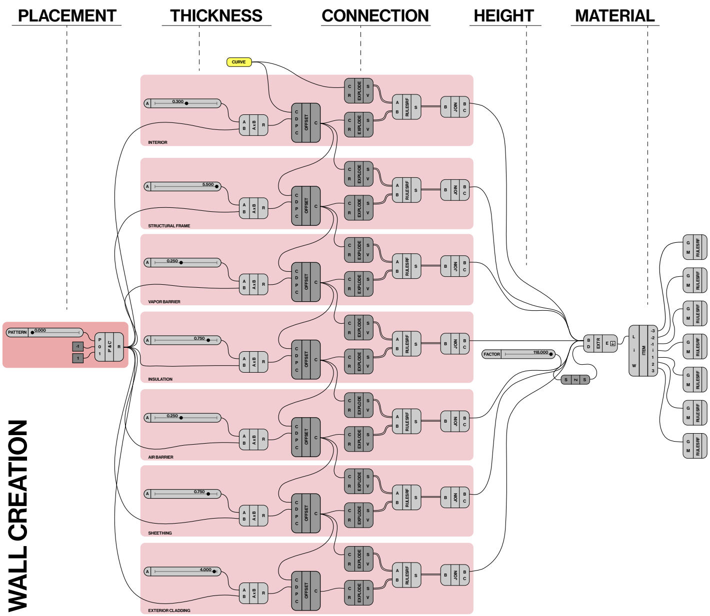
As a collaborative project, the intention was to computationally model a single-family house using Rhino 3D modeling software in addition to Grasshopper to analyze the components of the roof and envelope. Starting with the exterior of the house, looking at the materials within the wall. Grasshopper was used to build up and layer out all the components. The model was then passed through to the design of the roof of the house.

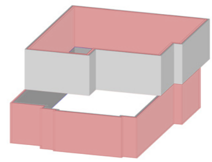
Finally, putting all of the efforts together, the team used grasshopper to generate an analysis of the house's EUI, structure, and internal thermal comfort percentages.

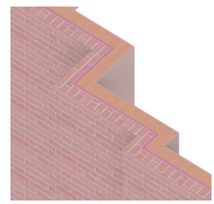
In the end, when considering the modeling techniques and collaboration efforts, the scripts were almost impossible to connect to one as a whole. The numbers of the EUI and thermal comfort levels were quite off due to this fact as well. Overall, the lesson within these modeling softwares and systems of work taught the team that efforts of modeling would be best done within one Rhino model with multiple scripts running. First from the envelope creation and structure analysis, baking the script, then ending with the EUI and thermal analysis in order to create the most accurate outcomes.

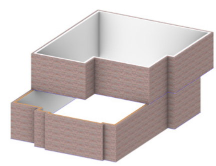
(Shown within this thesis book are the scripts and models created by Isabella without the additional work of Sean.)

WALL CREATION

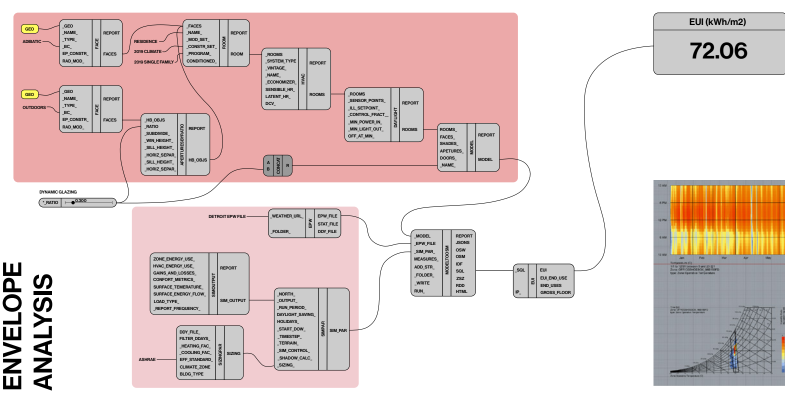


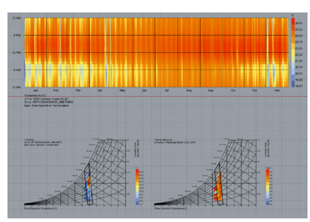






ENVELOPE ANALYSIS

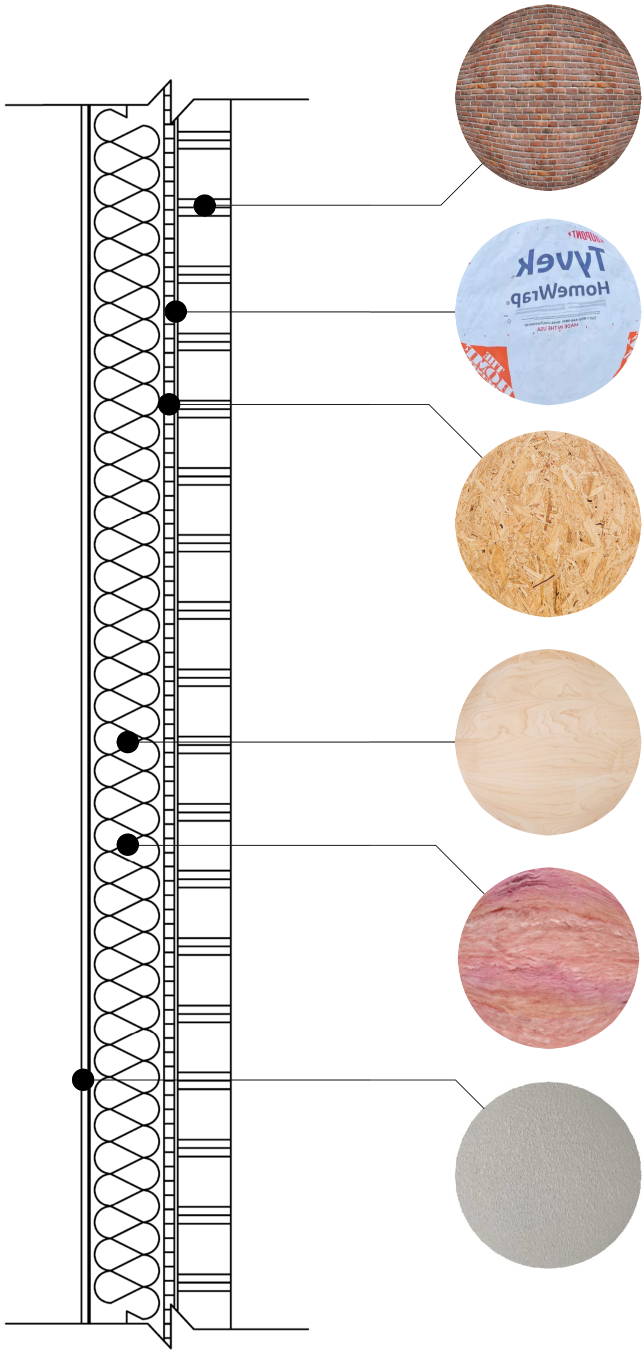




ANALYSIS:

MATERIAL

(STUDY HOUSE)



Existing Material - Wall Section Study

In order to proceed with a proposed wall section, there needed to be an understanding of how existing houses are being built. This lead to the dissection of the 'typical' single-family house.

Previous to this section of the study, each material was studied for its lifespan. Within this portion, it was important for the thesis to study the material by hand as well. A half scale, physical model was made to research the material for durability, sustainability, and general usage.

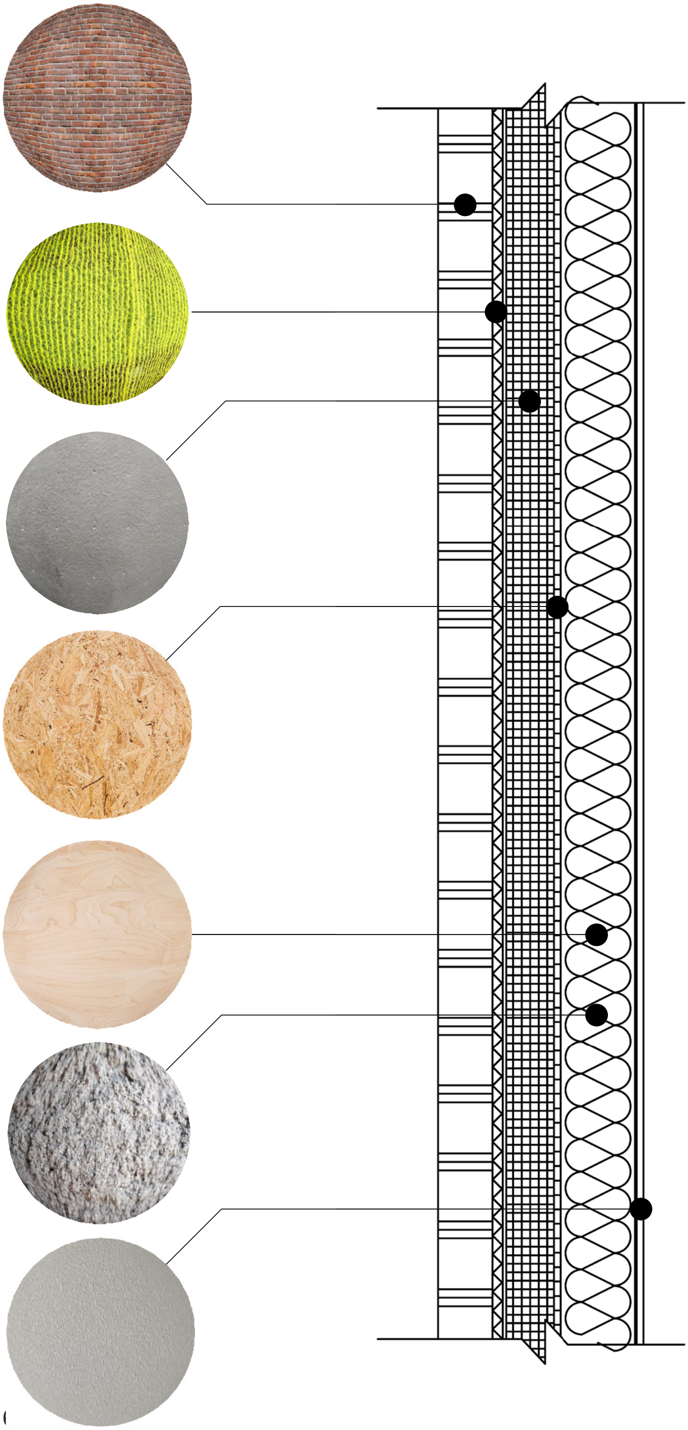
This model was also created for the use of homeowners. It was designed in a way to act as drawers with information of each material stated on the side. The intention is for the owners to be able to educate themselves on what is hiding within the walls of their existing house. They have the ability to touch and move materials as needed based on their intentions of change in the future. Which then leads to the next pages of the proposed wall section study of the new materials that are expected to create the largest positive impact on the environment.

Material Study

Material Drawers - Observation of Materials within the Typical House


2X6 WOOD STUD + FIBERGLASS INSUL
OSB SHEETING
HOUSE WRAP
R=0.62
R=4.17
100+ YEARS
60+ YEARS

(PRECEDENCE)



Proposed 'Sustainable' Material - Wall Section Study

Once the existing house had been studied, the proposal of substitiution material began.

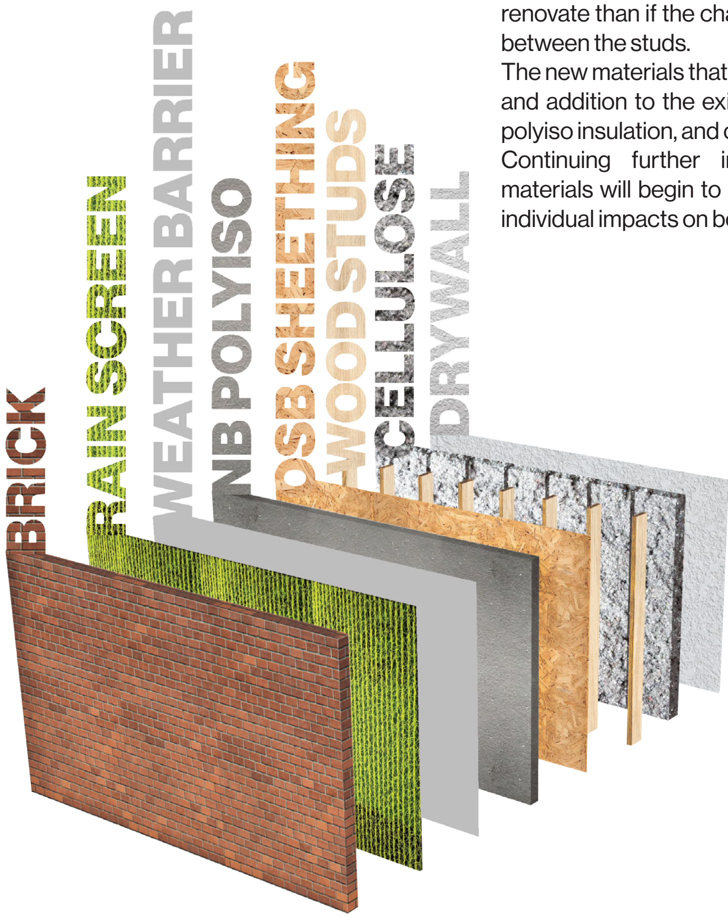
At this point within the research, there has been material studies on the lifespan of existing and potential proposed materials of the house. Yet, there had not been a study on what the proposed materials can improve within the home. In this study, similar to the existing material physical wall section, this was done with the intentions of allowing the homeowner, builder, and architect to interact with the material before deciding. Built in the same way as the previous model so that the materials can be interchangable with a switch of a 'drawer'.

After the creation of the model at half scale, the conclusion of the findings is that with these proposed materials, majority of the changes are introducing extra R-value thorugh insulation and that the wall section itself is wider with the addition of two layers. It was also interesting to see that majority of the problem areas lie on the outer shell of the home, which makes it much more difficult to renovate than if the changes were made from between the studs.

The new materials that are both in substitution and addition to the existing are a rainscreen, polyiso insulation, and cellulose insulation.

Continuing further in this thesis, these materials will begin to play a large roll in their individual impacts on both energy and carbon.

SELECTIVE WALL SECTION



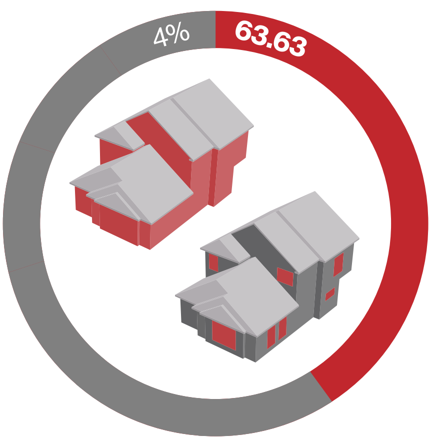
Material Study
Material Drawers - Observation of Materials within the Sustainable House

ANALYSIS:

ENERGY

Energy Impact

During the discussion of energy impacts through the envelope, it was brought to attention that the envelope comprised of more than just the materials. Majority of homeowners do not think to look within the wall when thinking of the envelope rather their mind goes to not only the exterior material, but also the windows and the roof of the house. These are also two very common renovations to single-family housing.
While the envelope in terms of material stayed the focal point of this thesis, the integration of impacts made by the roof and widows began. Finding that together the impacts can create a significant change when working with the renovation of the envelope as well.
Aside from the window and roof research, as said previously, most of the changes made in the proposed wall section were to the insulation. This is because most of the house's enery is being depleted though the walls of the house. Creating a wall section with a higher insulation rate will allow for less of the energy to transfer out of the house and for more to stay where it is needed. This is in terms of heating and cooling as well.
Looking through Cove.Tool's options in the envelope section, it was clear that the R-value of the wall not only makes the biggest difference, but it also works in unisin with the windows and the roof as it does not make a large enough impact alone.
Together, the wall, window, and roof renovations will get this study house to a much lower EUI of 53, closer to the 2030 baseline of 49.

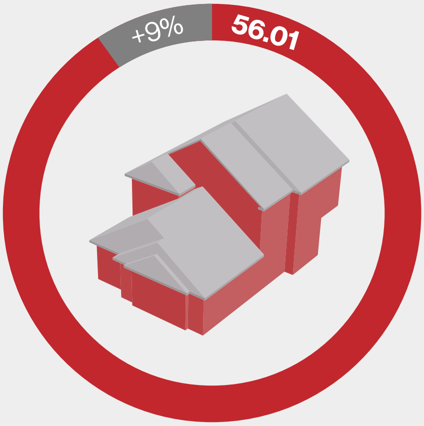


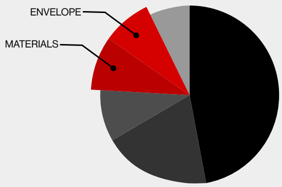
WINDOWS:
3% Improvement

ROOF:
1% Improvement

WINDOWS - ROOF:
4% Improvement

ENVELOPE - WINDOWS - ROOF:
19% Improvement **(53.90)**





ENVELOPE:
+9% Improvement

ENERGY SAVINGS THROUGH ENVELOPE

Roof R-Value

Cellulose	R=3.50/inch
Fiberglass	R=3.10/inch
Asphalt Shingles	R=1.30/inch
Rafters	R=12.70

Wall R-Value

Rainscreen	R=0.50
NB Polyiso	R=6.50/inch
Cellulose	R=3.50/inch
Brick	R=0.20
Housewrap	R=4.17
OSB	R=0.62
Wood Studs	R=12.70
Fiberglass	R=3.10/inch
Drywall	R=0.45

Spandrel U-Value

Glazing U-Value

Single Pane	U=1.00
Double Pane	U=0.50
Triple Pane	U=0.23

Glazing SHGC

Single Pane	0.84
Double Pane	0.62
Triple Pane	0.43

Envelope Heat Capacity

Heavy: High Insulation,
Temperature Controlled / Absorbtion

Blinds/Curtains/Shades

Internal Shading Devices (blinds)

Wall Emissivity

Mid-High percentage: little to no energy emitted thermally

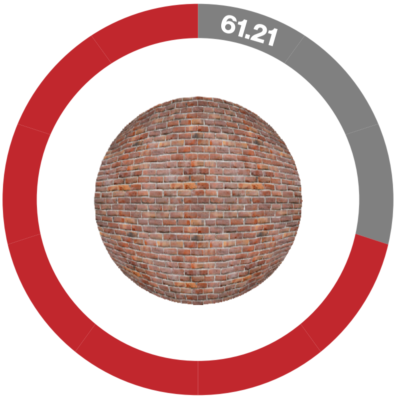
Roof Emissivity

Mid-High percentage: little to no energy emitted thermally

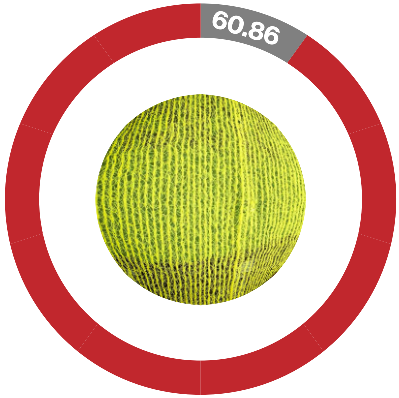
Ground Floor Area
Below Grade Area
Below Grade Depth

Isabella Hartsig

MATERIAL - ENERGY IMPACTS

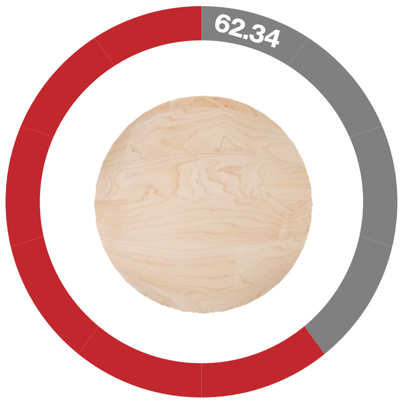


BRICK
8% Change



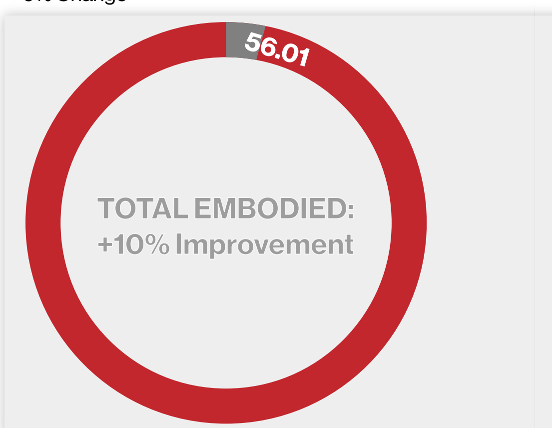
RAINSCREEN
9% Change

NB POLYISO.
+10% Change



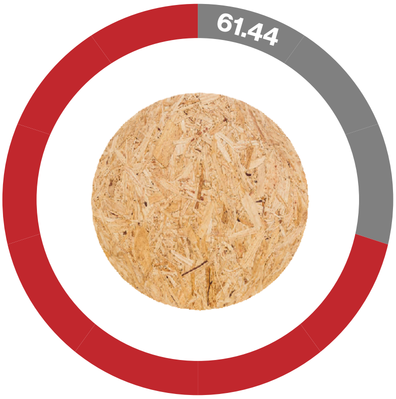
WOOD STUDS
6% Change

CELLULOSE
10% Change

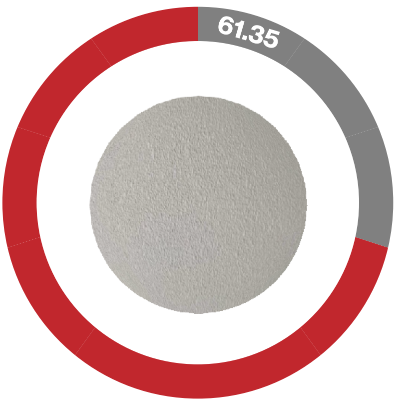


ORRIGINAL IMPACT:
Expected to lower as interventions are made

EMBODIED



OSB
8% Change



DRYWALL
8% Change

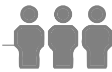
PERCENTAGE OF CHANGE:
Embodied impact on orriginal house based on specific changes made per graph

Rate of Change

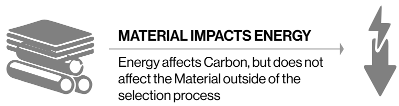
Material to Energy

As the material changes per layer of the envelope, the energy is either increased or decreased by the following aspects:

- Manufacturing
- Transportation (to and from)
- Living energy usage (occupancy)
- Installation
- Maintenance (lifespan)



- **Energy POST Construction**



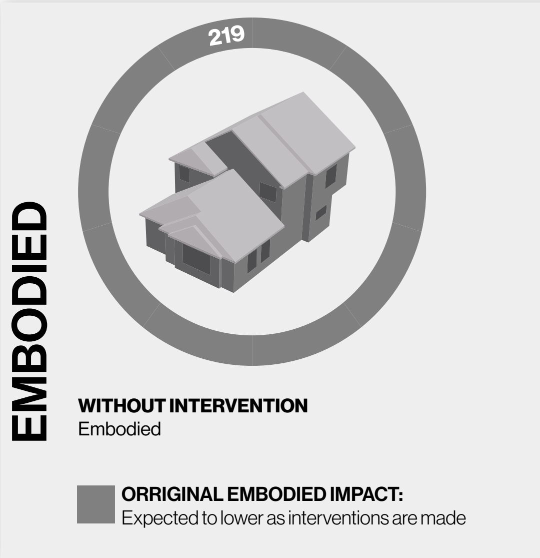
Breaking down the energy impacts through individual materials, it was a quick finding that each material has a different type of impact on the house whether it be positive or negative.
As stated previously, it is aparent that the insulation of the house creates the largest impact when changed, however, it is important to note that although these materials do have the largest positive impact, they have a peak of R-value to where if the whole wall goes above 30-40 the material will no longer make a change in the energy impacts. This is why it is just as significant to look into the other materials within the wall.
Next, from the proposed wall section is the rain screen. While this added material does not make as great of an impact as the insulation, it does have other benifits outside of just energy savings. It is utilized for not only environmentally friendly intents, but also for rainwater collection and gives the exterior material a gap from water damage from behind.
Many of the materials in reality have a positive embodied impact within the house, yet it is smarter when thinking of the opperational to keep them in the existing house. These materials are the ones that stayed the same through the whole process as to not veer from the goal of sustainable renovation.

ANALYSIS:

CARBON

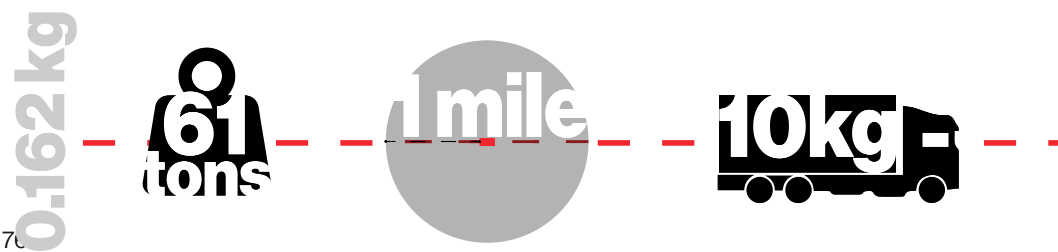
Carbon Impact

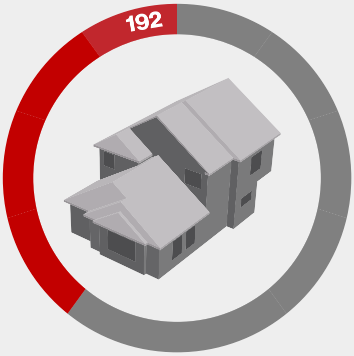
The carbon impact of the house has two variables, embodied and operational. While these are also variables in energy, the carbon separation is essential. This is because every material has an excessive amount of carbon that it produces before, during, and even after construction.
When calculating the carbon impacts of the existing house, the operation of transportation and construction is not included in the numbers as it is only looking at the existing materials themselves.
In this thesis, although embodied is heaviliy favored and focused on, the operational was quickly calculated. This is because you cannot claim that a material, or the house itself, has a minimal impact on the environment without looking at every aspect. The operational alone is over the 2030 baseline and since this thesis is bringing in new and taking out old material, the majority of the operational production is coming from the construction of renovations.
After observation of material and implementation of the proposed wall section, the carbon embodied impacts decreased by 3 tons, yet again, the operational had an increase from transportation and construction that evened out the numbers to being almost equivalent to the existing house.
With this in mind, although the carbon did not change for the better, it did not go over the existing. This means it is still creating a positive impact through energy while not exceeding the existing carbon effects.



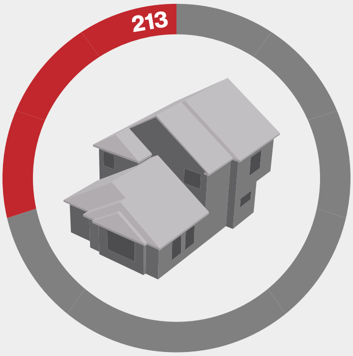
CONSTRUCTION

AVERAGE TRUCK IN THE U.S. = 0.162 kg OF CO2 / TON / MILE



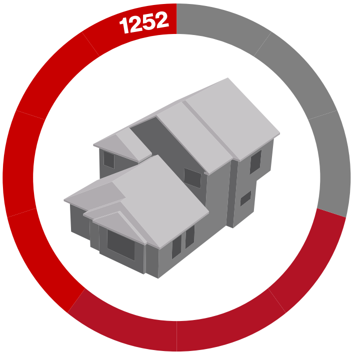


WITH INTERVENTION
13% Improvement

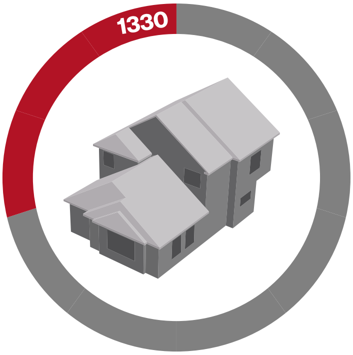


AFTER CONSTRUCTION (MAX)
3% Improvement

PERCENTAGE OF CHANGE:
Embodied impact on orriginal house based on specific changes made per graph

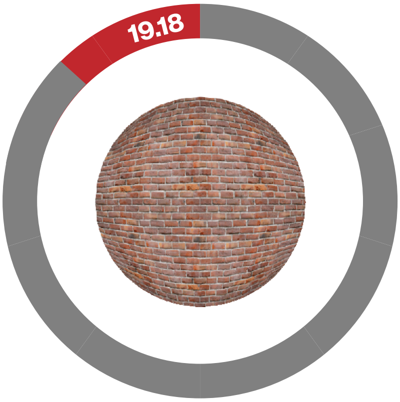


WITH INTERVENTION
7% Improvement

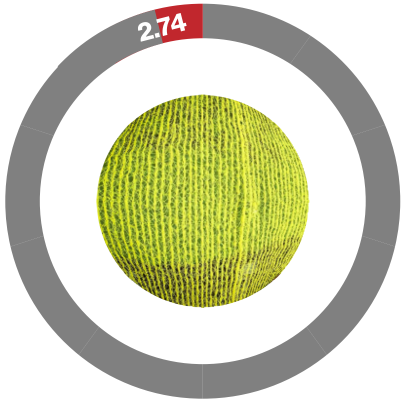


AFTER CONSTRUCTION (MAX)
3% Improvement

MATERIAL - CARBON IMPACTS

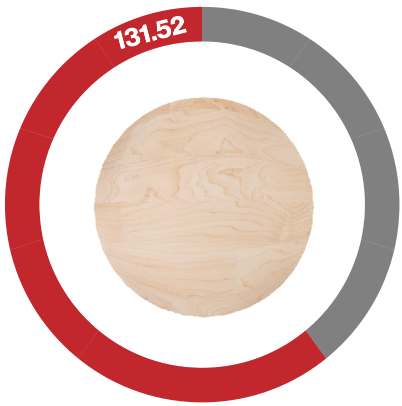


BRICK
8.7% Change



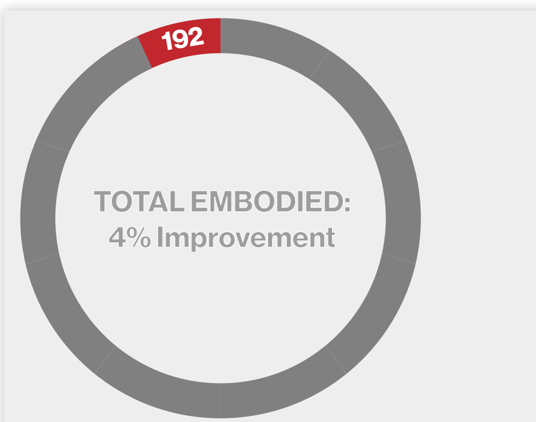
RAINSCREEN
1.2% Change

NB POLYISO.
7.5% Change



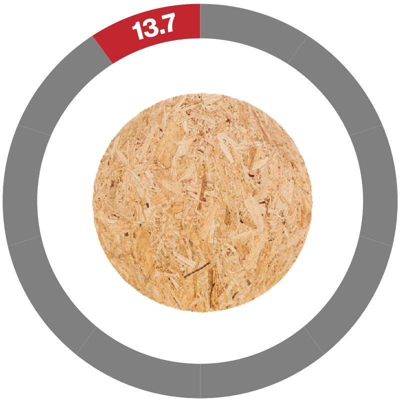
WOOD STUDS
59.9% Change

CELLULOSE
6.2% Change

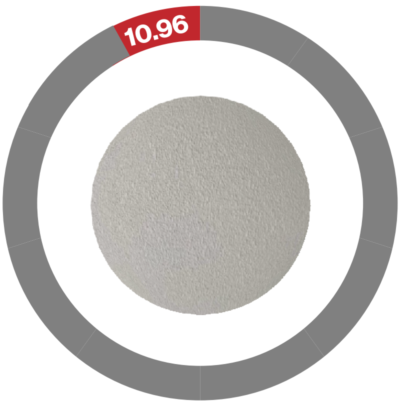


ORRIGINAL IMPACT:
Expected to lower as interventions are made

EMBODIED



OSB
6.2% Change



DRYWALL
4.9% Change

PERCENTAGE OF CHANGE:
Embodied impact on orriginal house based on specific changes made per graph

Rate of Change

Material to Carbon

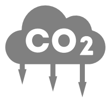
As the material changes per layer of the envelope, the carbon is either increased or decreased by the following aspects:

- Ingredients
- Manufacturing
- Transportation (to and from)
- Installation
- Maintenance (lifespan)

- **Energy POST Construction**

ENERGY IMPACTS CARBON
MATERIAL IMPACTS CARBON

Carbon does NOT impact other aspects of Material and Energy outside of the selection process



When evaluating the carbon impacts of each individual material, it was found that majority of the numbers change based on weight and availability of the product. If the material is lighter or is available locally from a distributer / manufacturer then the truck that is transporting it creates less of a negative impacts through carbon emissions.

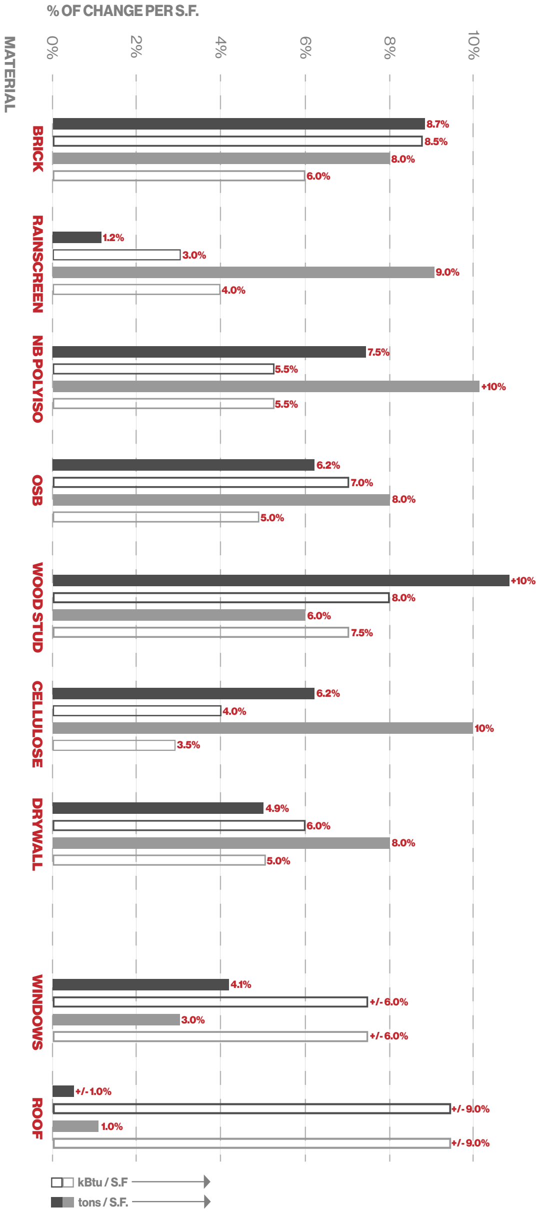
While many of these numbers within the graphics are not positive impacts, there is a corelation of initial carbon increase from transportation and construction to the decrease in carbon after the house is standing and lived in.

Looking at the insulation additions again, these materials had the greatest positive impact through not only energy, but carbon as well. This is due to the fact that they are a very light material as well as they have an extremely long lifespan that can continue on after through a recycling process.

In the end, the positive and negative affects of the existing materials and the proposed operational carbon impacts equalled out to be around the same as the existing. Creating no more or no less, proving that renovation of what is existing is better for the environment than the new construction of a single-family house.

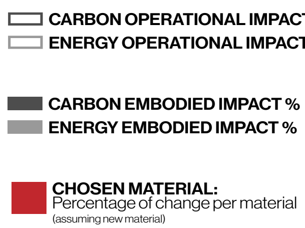
ANALYSIS:

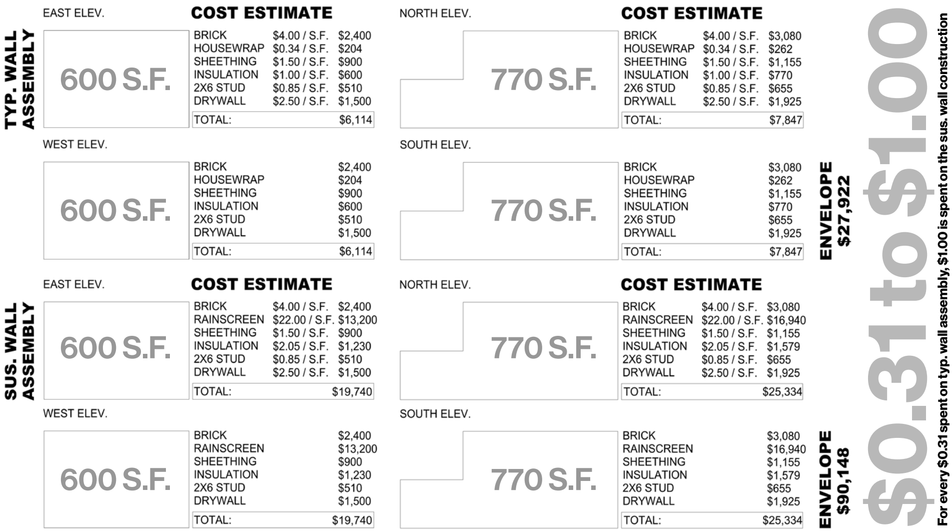
CONNECTION



Following the individual studies of energy and carbon through material, a graph was created to find any cooralation between the changes of the two topics as well as the operational and embodied impacts. Shown in the graph above is the percentage of change per S.F. of the house through each material. Looking at energy and carbon through embodied and operational impacts. In addition to this, the information shown is neither positive or negative. Each material has a different outcome. Majority of the carbon is negaive, yet energy mainly has a positive change.

Through this study, it quickly became apparent that there is no real connection between the impacts. With that being said, there is a significance to the fact that when the carbon percentages become a large negative impact, the energy positive impact counters with a close or equivalent percentage.





TYP. WALL ASSEMBLY

EAST ELEV. (600 S.F.) — COST ESTIMATE

BRICK	$4.00 / S.F.	$2,400
HOUSEWRAP	$0.34 / S.F.	$204
SHEETHING	$1.50 / S.F.	$900
INSULATION	$1.00 / S.F.	$600
2X6 STUD	$0.85 / S.F.	$510
DRYWALL	$2.50 / S.F.	$1,500
TOTAL:		$6,114

NORTH ELEV. (770 S.F.) — COST ESTIMATE

BRICK	$4.00 / S.F.	$3,080
HOUSEWRAP	$0.34 / S.F.	$262
SHEETHING	$1.50 / S.F.	$1,155
INSULATION	$1.00 / S.F.	$770
2X6 STUD	$0.85 / S.F.	$655
DRYWALL	$2.50 / S.F.	$1,925
TOTAL:		$7,847

WEST ELEV. (600 S.F.)

BRICK	$2,400
HOUSEWRAP	$204
SHEETHING	$900
INSULATION	$600
2X6 STUD	$510
DRYWALL	$1,500
TOTAL:	$6,114

SOUTH ELEV. (770 S.F.)

BRICK	$3,080
HOUSEWRAP	$262
SHEETHING	$1,155
INSULATION	$770
2X6 STUD	$655
DRYWALL	$1,925
TOTAL:	$7,847

ENVELOPE $27,922

SUS. WALL ASSEMBLY

EAST ELEV. (600 S.F.) — COST ESTIMATE

BRICK	$4.00 / S.F.	$2,400
RAINSCREEN	$22.00 / S.F.	$13,200
SHEETHING	$1.50 / S.F.	$900
INSULATION	$2.05 / S.F.	$1,230
2X6 STUD	$0.85 / S.F.	$510
DRYWALL	$2.50 / S.F.	$1,500
TOTAL:		$19,740

NORTH ELEV. (770 S.F.) — COST ESTIMATE

BRICK	$4.00 / S.F.	$3,080
RAINSCREEN	$22.00 / S.F.	$16,940
SHEETHING	$1.50 / S.F.	$1,155
INSULATION	$2.05 / S.F.	$1,579
2X6 STUD	$0.85 / S.F.	$655
DRYWALL	$2.50 / S.F.	$1,925
TOTAL:		$25,334

WEST ELEV. (600 S.F.)

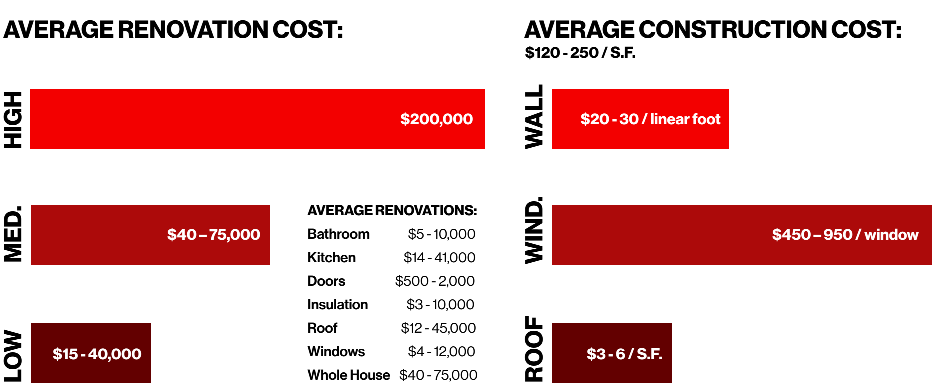
BRICK	$2,400
RAINSCREEN	$13,200
SHEETHING	$900
INSULATION	$1,230
2X6 STUD	$510
DRYWALL	$1,500
TOTAL:	$19,740

SOUTH ELEV. (770 S.F.)

BRICK	$3,080
RAINSCREEN	$16,940
SHEETHING	$1,155
INSULATION	$1,579
2X6 STUD	$655
DRYWALL	$1,925
TOTAL:	$25,334

ENVELOPE $90,148

Before finalizing the conversation of connection of material, carbon and energy, there is an additional factor that plays a huge role in the determination of this research. This is the factor of cost. Previously, this thesis mentioned the lack of change in the industry of single-family housing construction. The main reason is the increase in cost of materials and lack of knowledge on savings after construction. The graphic above shows the cost of construction of an existing and sustainable house and the findings in cost per material. Below, the graphs show the average renovation and construction costs of the proposed changes. In the following pages, keep these images in mind when analyzing the overhead cost versus future savings.



AVERAGE RENOVATIONS:

Bathroom	$5 - 10,000
Kitchen	$14 - 41,000
Doors	$500 - 2,000
Insulation	$3 - 10,000
Roof	$12 - 45,000
Windows	$4 - 12,000
Whole House	$40 - 75,000

HOMEOWNER MATRIX

Based on data of the material's life span, carbon impact, and energy usage.

CHOSEN MATERIAL: Based on previous research for ex. matrix

MATERIAL — **ENVIRONMENTAL IMPACT + PRICE**

WALL

	MATERIAL	LOW	MED.	HIGH	(+) carbon	(+) energy	(+) r-value	(+) cost
choose one (1)	BRICK			125.9 TONS, 20.6 EUI, R=0.20, $4.00 / S.F.	125.9	20.6	0.20	4.00
	VINYL		112.1 TONS, 18.5 EUI, R=0.61, $8.00 / S.F.					
choose one (1)	CEL. INSUL.			120.4 TONS, 21.7 EUI, R=3.50/inch, $1.50 / S.F.	120.4	21.7	3.50	1.50
	FIB. INSUL.		147.8 TONS, 18.7 EUI, R=3.10/inch, $1.00 / S.F.					
optional	POLY. INSUL.			123.1 TONS, 24.4 EUI, R=6.50/inch, $0.55 / S.F.	123.1	24.4	6.50	0.55
choose one (1)	RAINSCREEN			109.4 TONS, 20.9 EUI, R=0.50, $22.00 / S.F.	109.4	20.9	0.50	22.00
	HOUSEWRAP	109.4 TONS, 17.4 EUI, R=4.17, $0.34 / S.F.						
given materials	WOOD STUDS		238.2 TONS, 19.4 EUI, R=12.70, $0.85 / S.F.		238.2	19.4	12.7	0.85
	OSB	120.4 TONS, 20.3 EUI, R=0.62, $1.50 / S.F.			120.4	20.3	0.62	1.50
	DRYWALL		117.7 TONS, 20.4 EUI, R=0.45, $2.50 / S.F.		117.7	20.4	0.45	2.50
+ box A	Wall Totals				box A1: 955.1	box A2: 147.7	box A3: 24.47	box A4: 32.9/S.F.

WINDOW

	MATERIAL	LOW	MED.	HIGH	(+) carbon	(+) energy	u-value	(+) cost
choose one (1)	SINGLE PANE	112.18 TONS, 16.6 EUI, U=1.00, $450 / window						
	DOUBLE PANE		114.9 TONS, 16.9 EUI, U=0.50, $634 / window					
	TRIPLE PANE			117.7 TONS, 17.2 EUI, U=0.23, $950 / window	117.7	17.2	0.23	950/W (x6W)
+ box B	Window Totals				box B1: 117.7	box B2: 17.2	box B3: 0.23	box B4: 5700

ROOF [C]

	MATERIAL	LOW	MED.	HIGH	(+) carbon	(+) energy	(+) r-value	(+) cost
given materials	ASPHALT		110.8 TONS, 16.1 EUI, R=0.44, $6.00 / S.F.		110.8	16.1	0.44	6.00
	RAFTERS		238.2 TONS, 19.4 EUI, R=12.70, $0.90 / S.F.		238.2	19.4	12.7	0.90
choose one (1)	CEL. INSUL.			120.4 TONS, 21.7 EUI, R=3.50/inch, $1.50 / S.F.	120.4	21.7	3.50	1.50
	FIB. INSUL.		147.8 TONS, 18.7 EUI, R=3.10/inch, $1.00 / S.F.					
+ box C	Roof Totals				box C1: 469.4	box C2: 57.2	box C3: 16.6	box C4: 8.4

SAVINGS:

Average Energy Usage / year + Cost

The utility cost per square foot in Metro Detroit is $2.32, electric is an average of $1.85. A 2,000 S.F. home caculates out to $3,700 / year.

Existing buildings:

reducing consumption by 20% to 30% can produce savings from 6%-9% of total annual costs.

energy efficiency investments can increase asset value by $2.00-$3.00 for each $1.00 spent.

SOURCE: Rules of Thumb for Energy Efficiency in Buildings I U.S. Environmental Protection Agency

Years after Construction + Savings / year **3 - 6%**

5 YEARS	10 YEARS	15 YEARS	20 YEARS
-$16,791.15 / $102,070.85 / 14%	-$31,210.29 / $87,651.71 / 26%	-$43,592.49 / $75,269.52 / 37%	-$54,225.51 / $64,636.50 / 46%
-$33,582.30 / $85,279.70 / 28%	-$62,420.58 / $73,232.57 / 38%	-$87,184.98 / $62,887.32 / 47%	-$108,451.02 / $54,003.48 / 55%

	(-) carbon	(-) energy
Existing Totals	1552	237
Total Change	box D1: 1542.1	box D2: 222.1
− Improved Total	9.9 TONS	14.9

	(+) carbon	(+) energy	(+) r-value	(+) cost
Wall Totals	box A1: 955.1	box A2: 147.7	box A3: 24.5	box A4: 32.9
Window Totals	box B1: 117.7	box B2: 17.2	box B3	box B4
Roof Totals	box C1: 469.4	box C2: 57.2	box C3: 16.6	box C4: 8.4
+ Total Change	box D1: 1542.1	box D2: 222.1	41.1	box D4: 41.3

x House S.F.: 113,162 + box B4: 5700 = 118,862

to create 20% change box D1 = 300+ total change

to create 20% change box D2 = 45+ total change

Homeowner Matrix

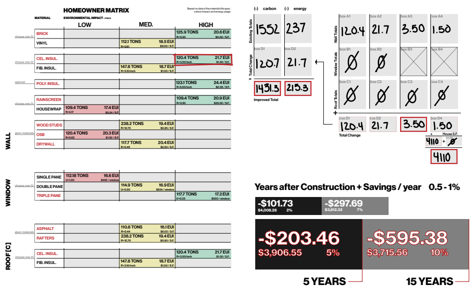
To conclude this thesis' study, a home owner matrix was created. The intentions of this chart is for the homeowner to be able to pick and choose which materials or parts of their house they would like to renovate. From there, they are able to add their carbon, energy, and cost together to see what type of impact it will have on the environment as well as what type of cost savings they can have in the end.

Shown in the matrices is an example of how it could potentially be filled out if one were to want to make all of the proposed sustainable changes as well as three other options of only improving the insulation, windows, or roof.

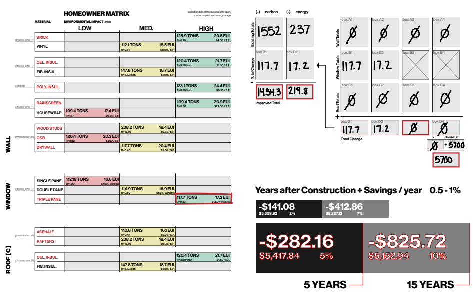
One of the greatest pieces of information found through the creation of this matrix is that there is plenty of research already found for cost and energy savings in the end. In terms of consumption reduction within the house, for every 20-30% of impact created through this matrix, the homeowner can save 6-9% on energy costs within their house. Along with this benefit, for every $2-3 spent on renovations the home gains $1 in assets. Which means that once the renovation is completed, not only will the home owner save on operational costs, but they will also be able to make a profit if they choose to sell in the future. At the bottom of the matrix near the total impacts, there is a section for the homeowner to estimate their energy cost savings throughout 5-20 years after the renovation as well.

It is important to note that this matrix can be extended through future studies that can include the previous studies of energy generation, occupancy, daylighting, etc.

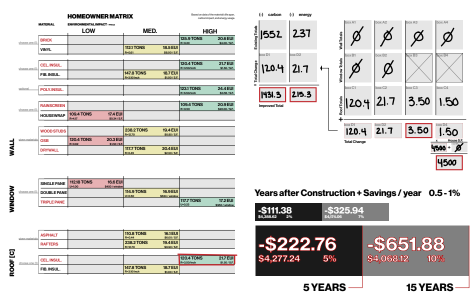
INSULATION



WINDOWS



ROOF



Isabella Hartsig

HOMEOWNER MATRIX

Based on data of the material's life span, carbon impact, and energy usage.

CHOSEN MATERIAL: Based on previous research for ex. matrix

ENVIRONMENTAL IMPACT + PRICE

		MATERIAL	LOW	MED.	HIGH
WALL	choose one (1)	BRICK			125.9 TONS 20.6 EUI R=0.20 $4.00 / S.F.
		VINYL		112.1 TONS 18.5 EUI R=0.61 $8.00 / S.F.	
	choose one (1)	CEL. INSUL.			120.4 TONS 21.7 EUI R=3.50/inch $1.50 / S.F.
		FIB. INSUL.		147.8 TONS 18.7 EUI R=3.10/inch $1.00 / S.F.	
	optional	POLY. INSUL.			123.1 TONS 24.4 EUI R=6.50/inch $0.55 / S.F.
	choose one (1)	RAINSCREEN			109.4 TONS 20.9 EUI R=0.50 $22.00 / S.F.
		HOUSEWRAP	109.4 TONS 17.4 EUI R=4.17 $0.34 / S.F.		
	given materials	WOOD STUDS		238.2 TONS 19.4 EUI R=12.70 $0.85 / S.F.	
		OSB	120.4 TONS 20.3 EUI R=0.62 $1.50 / S.F.		
		DRYWALL		117.7 TONS 20.4 EUI R=0.45 $2.50 / S.F.	
WINDOW	choose one (1)	SINGLE PANE	112.18 TONS 16.6 EUI U=1.00 $450 / window		
		DOUBLE PANE		114.9 TONS 16.9 EUI U=0.50 $634 / window	
		TRIPLE PANE			117.7 TONS 17.2 EUI U=0.23 $950 / window
ROOF [C]	given materials	ASPHALT		110.8 TONS 16.1 EUI R=0.44 $6.00 / S.F.	
		RAFTERS		238.2 TONS 19.4 EUI R=12.70 $0.90 / S.F.	
	choose one (1)	CEL. INSUL.			120.4 TONS 21.7 EUI R=3.50/inch $1.50 / S.F.
		FIB. INSUL.		147.8 TONS 18.7 EUI R=3.10/inch $1.00 / S.F.	

(+) carbon (+) energy (+) r-value (+) cost

\+ box A: box A1 box A2 box A3 box A4 — Wall Totals

(+) carbon (+) energy u-value (+) cost

\+ box B: box B1 box B2 box B3 box B4 — Window Totals

(+) carbon (+) energy (+) r-value (+) cost

\+ box C: box C1 box C2 box C3 box C4 — Roof Totals

(-) carbon (-) energy

Existing Totals

Total Change: box D1 box D2

\- Improved Total

(+) carbon (+) energy (+) r-value (+) cost

Wall Totals: box A1 box A2 box A3 box A4

Window Totals: box B1 box B2 box B3 box B4

Roof Totals: box C1 box C2 box C3 box C4

\+ Total Change: box D1 box D2 box D4

x House S.F.

box B4

\+

Whole House Renovation

Years after Construction + Savings / year 3 - 6%

-$16,791.15 $102,070.85 14%	-$31,210.29 $87,651.71 26%	-$43,592.49 $75,269.52 37%	-$54,225.51 $64,636.50 46%

5 YEARS	10 YEARS	15 YEARS	20 YEARS
-$33,582.30 $85,279.70 28%	-$62,420.58 $73,232.57 38%	-$87,184.98 $62,887.32 47%	-$108,451.02 $54,003.48 55%

Insulation Renovation

Years after Construction + Savings / year 0.5 - 1%

-$101.73 $4,008.28 2%	-$297.69 $3,812.32 7%

5 YEARS	15 YEARS
-$203.46 $3,906.55 5%	-$595.38 $3,715.56 10%

Window Renovation

Years after Construction + Savings / year 0.5 - 1%

-$141.08 $5,558.92 2%	-$412.86 $5,287.13 7%

5 YEARS	15 YEARS
-$282.16 $5,417.84 5%	-$825.72 $5,152.94 10%

Roof Renovation

Years after Construction + Savings / year 0.5 - 1%

-$111.38 $4,388.62 2%	-$325.94 $4,174.06 7%

5 YEARS	15 YEARS
-$222.76 $4,277.24 5%	-$651.88 $4,068.12 10%

SAVINGS:

Average Energy Usage / year + Cost

The utility cost per square foot in Metro Detroit is $2.32, electric is an average of $1.85. A 2,000 S.F. home caculates out to $3,700 / year.

Existing buildings: reducing consumption by 20% to 30% can produce savings from 6%-9% of total annual costs.

energy efficiency investments can increase asset value by $2.00-$3.00 for each $1.00 spent.

to create 20% change box D1 = 300+ total change

to create 20% change box D2 = 45+ total change


05

DISCUSSION

Throughout this thesis, the discussion has revolved around the concept of sustainability through material, energy, and carbon. However, there are other definitions of sustainability that are practiced in the current housing developments and design which need to be addressed and considered for the future of this study.
The following chapter will analyze three different definitions of sustainability from interviews of contractors, architects, builders, students, and institutions.

How Houses are Built Today

Interview

This interview process consisted of 17 questions about the interviewee's experience in the field of residential building.

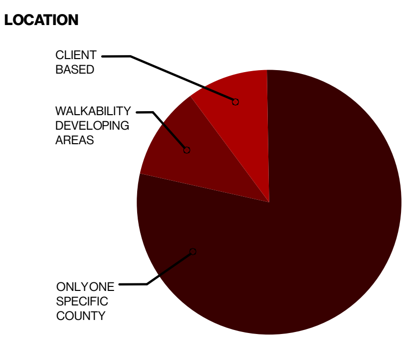
The beginning 9 questions start with personal questions such as job title, how they started out, how many houses they have built, what their priorities are, and their definition of sustainability. The answers to these questions helped understand the interviewees answers to the next set of questions as each definition of sustainability differed.

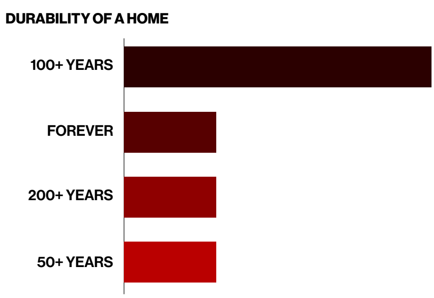
Many of the interviewees have been in the field for more than 10 years making them experienced in the realm of residential construction. Yet, many of them prioritized sustainable building methods as a last thought if thought of at all (The graphic is). As well as the definitions of sustainability ranging far and wide from this thesis (The graphic is).

In the next set of 8 questions, the interviewees were asked to describe their building process'. Asking questions that relate to how the location and design is chosen, what type of clients, lifespan of the houses, the future of housing, and intensives to build more sustainably.

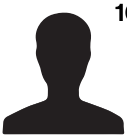
Similarly to the responses to the definitions of sustainability, the responses to these questions were vastly different. When asked the durability of the houses built, the responses ranged from 50 years to forever. This was an interesting response in regard to this thesis as through the material study research, it was found that most building materials used do not last 50 to 100 years confirms the assumptions that the builders and architects are not aware of how their houses are actually preforming.

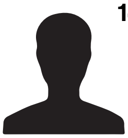
Then when questioned about the future of housing, many responded with the shrinking of





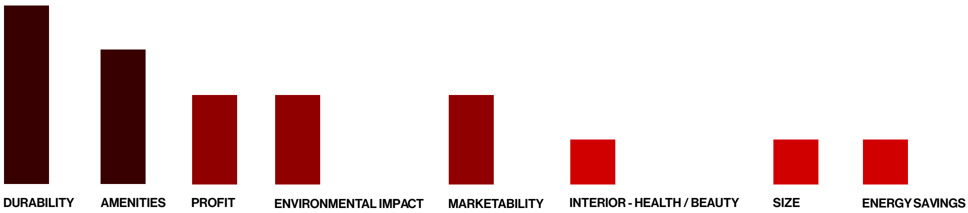
CONTRACTOR	DEVELOPER	BUILDER
10 YEARS 10 HOUSES 1K S.F. RESIDENTIAL	34 YEARS 1K HOUSES 2-4K S.F. RESIDENTIAL	25 YEARS 14 HOUSES 2-5K S.F. RESIDENTIAL



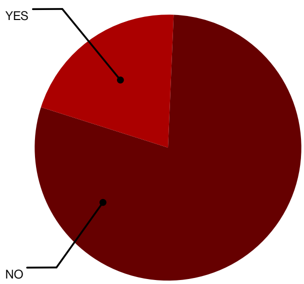


square footage, but one answer significantly stuck out from the rest. It was a response by an architect and it read as follows, “We don’t want any of the globalism. We don’t agree with ‘Leed Certified Homes’ we don’t agree with ‘15 minute cities’. We want individuals to have the ability to build the home they want, not the home they’re told they can have. No Tax incentives, and corporate / lobbyist interests. Back to basics. Government interference in building practices outside of safety is unnecessary. Utility restrictions for gas and other energy usage should not exist”. Interestingly enough no matter what profession, sustainability is not a knowledgeable topic in the field of residential construction.

PRIORITIES



SUSTAINABLE DESIGN



DEFINITION OF SUSTAINABILITY

Indefinitely repeatable in concept.

My design instincts lead me to seek efficient layouts and use of space, craft homes that weathers well, and use materials that require minimal maintenance.

Being able to continue doing something the same way and still remaining feasible regarding budget and supply.

Using natural products and earth friendly construction.

Being able to self sustain.

How you preform with the house.

Other Definitions of Sustainability

Looking at a more common definition of sustainability, LEED. An interview was conducted with a student from Kansas University, Liz Franka. For her thesis, she works closely with Studio804 to conduct an analysis of a house through the construction.
When asked directly, “What is your definition of sustainability?”, their response was a measurement through performance of the LEED point system.
LEED is a leadership in Energy and Environmental Design is a green building certification program that allows designers to follow a list of sustainable methods in which they could potentially get certification for.
While this is a very valid way of defining a sustainable home from the typical one, it is not as in depth of a study as a whole energy and carbon analysis. This is because the architects and contractors who follow the lists are not extending their knowledge as well as not looking at the energy or carbon savings in the end.
There are a plethora of other precedents that follow this same view point of sustainability. Many projects are praised for their LEED accreditations.
When comparing LEED to this thesis, it was found that when only following the proposed wall section and material selection as previously mentioned, a house can meet about 50% or more of the 40 points needed for a silver certification.

PRECEDENTS

Grand Traverse Bay in Northern Michigan
M-22 House by Michael Fitzhugh Architect

Omena in Sothern Michigan
OMENA Lake House by Danny Forster & Architecture

Ann Arbor, Michigan
Veridian at County Farm, County Farm Community

INTERVIEW PROCESS

LIZ FRANKA

KU
School of Architecture & Design
studio 804

Liz has contributed to 2 houses with Studio 804 as a non-profit organization similar to a Lab-Spec. research outlook on production. The goal of these houses are to be built as Net Zero houses and LEED Platnum Certified.

The question was proposed of how sustainability is meaured in their "sustainable homes" and the response was, "We tend to measure that sort of thing through **performance**, similar to the way we follow the LEED point system".

PRECEDENTS

Studio804- First LEED Certified project in the state, all LEED projects follow

LEED RESIDENTIAL BD+C: SINGLE-FAMILY

Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).

INTEGRATIVE PROCESS	2PT
FLOODPLAIN AVOIDANCE	REQ.
LEED FOR NEIGHBORHOOD DEVELOPMENT	10PT
SITE SELECTION	6PT
COMPACT DEVELOPMENT	1PT
COMMUNITY RESOURCES	1PT
ACCESS TO TRANSIT	1PT
CONSTRUCTION ACTIVITY POLLUTION PREVENTION	REQ.
HEAT ISLAND REDUCTION	1PT
RAINWATER MANAGEMENT	2PT
NONTOXIC PEST CONTROL	2PT
WATER USE	REQ.
WATER METERING	REQ.
TOTAL WATER USE	15PT
INDOOR WATER USE	11PT
OUTDOOR WATER USE	4PT
MINIMUM ENERGY PERFORMANCE	REQ.
ENERGY METERING	REQ.
EDUCATION OF HOMEOWNER, TENANT, OR BUILDING MANAGER	REQ.
ANNUAL ENERGY USE	36PT
EFFICIENT HOT WATER DISTRIPUTION SYSTEM	2PT
HVAC START-UP CREDENTIALING	1PT
REFRIGERANT MANAGEMENT	1PT
CERTIFIED TROPICAL WOOD	REQ.
DURABILITY MANAGEMENT	REQ.
DURABILITY MANAGEMENT VERIFICATION	1PT
ENVIRONMENTALLY PREFERABLE PRODUCTS	5PT
CONSTRUCTION WASTE MANAGEMENT	1PT
MATERIAL-EFFICIENT FRAMING	2PT
VENTILATION	REQ.
COMBUSTION VENTING	REQ.
GARAGE POLLUTANT PROTECTION	REQ.
RADON-RESISTANT CONSTRUCTION	REQ.
AIR FILTERING	REQ.
COMPARTMENTALIZATION	REQ.
ENHANCED VENTILATION	3PT
CONTAMINANT CONTROL	3PT
BALANCING OF HEATING AND COOLING DISTRIBUTION SYSTEMS	6PT
LOW-EMITTING PRODUCTS	1PT
PRELIMINARY RATING	REQ.
INNOVATION	5PT
LEED ACCREDITED PROFESSIONAL	1PT
REGIONAL PRIORITY	4PT
MUST BE IN PERMANENT LOCATION ON EXISTING LAND	REQ.
MUST USE REASONABLE LEED BOUNDARIES	REQ.
MUST COMPLY WITH PROJECT SIZE REQUIREMENTS	REQ.
CIRCULAR PRODUCTS	1PT
HEAT ISLAND MITIGATION WITH COOL WALLS	1PT
WATER LEAK DETECTION AND MONITORING	1PT
TOTAL POTENTIAL CREDITS EARNED	**27PT**

LEED O+M: EXISTING BUILDINGS

Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).

TRANSPORTATION PERFORMANCE	REQ.
RAINWATER MANAGEMENT	1PT
HEAT ISLAND REDUCTION	1PT
LIGHT POLLUTION REDUCTION	1PT
SITE MANAGEMENT	1PT
WATER PERFORMANCE	REQ.
ENERGY EFFICIENCY BEST MANAGEMENT PRACTICES	REQ.
FUNDAMENTAL REFRIDGERANT MANAGMENT	REQ.
ENERGY PERFORMANCE	REQ.
ENGANCED REFRIGERANT MANAGMENT	1PT
GRID HARMONIZATION	1PT
PURCHASING POLICY	REQ.
FACILITY MAINTENANCE AND RENOVATIONS POLICY	REQ.
WASTE PERFORMANCE	REQ.
PURCHASING	1PT
MINIMUM INDOOR AIR QUALITY	REQ.
ENVIRONMENTAL TOBACCO SMOKE CONTROL	REQ.
GREEN CLEANING POLICY	REQ.
INDOOR ENVIRONMENTAL QUALITY PERFORMANCE	REQ.
GREEN CLEANING	1PT
INTEGRATED PEST MANAGEMENT	1PT
INNOVATION	1PT
PROJECT INFORMATION FORM	1PT
MUST BE IN A PERMANENT LOCATION ON EXISTING LAND	REQ.
MUST USE REASONABLE LEED BOUNDARIES	REQ.
MUST COMPLY WITH PROJECT SIZE REQUIREMENTS	REQ.
INDOOR AIR QUALITY PROCEDURE	REQ.
ERGONOMICS APPROACH FOR COMPUTER USERS	1PT
BIRD COLLISION DETERRENCE	1PT
ENHANCED ACOUSTICAL PERFORMANCE - EXTERIOR NOISE CONTROL	1PT
COMMUNITY CONTAMINANT PREVENTION - AIRBORNE RELEASES	1PT
GREEN TRAINING FOR WORKERS	1PT
LOCAL FOOD PRODUCTION	1PT
VERIFIED CONSTRUCTION & DEMOLITION RECYCLING RATES	1PT
SOCIAL EQUITY WITHIN THE COMMUNITY	1PT
SOCIAL EQUITY WITHIN THE OPERATIONS AND MAINTENANCE STAFF	1PT
ETS CONTROL FOR PROJECTS IN JAPAN	0PT
INTEGRATIVE PROCESS	1PT
LEGAL WOOD	1PT
LEAD RISK REDUCTION	1PT
ISO 50002 ENERGY AUDIT	1PT
WATER RESTORATION CERTIFICATES	1PT
INFORMING DESIGN USING TRIPLE BOTTOM LINE ANALYSIS	1PT
RESIDENTIAL ENERGY SUBMETERING AND REAL-TIME USAGE DATA	1PT
INFORMING DESIGN BY MAJOR CREDIT CATEGORY USING TRIPLE BOTTOM LINE	1PT
INFORMING DESIGN BY MAJOR CREDIT CATEGORY USING TRIPLE BOTTOM LINE	1PT
INCLUSIVE DESIGN	1PT
COMPREHENSIVE COMPOSTING	1PT
TOTAL POTENTIAL CREDITS EARNED	**22PT**

Other Definitions of Sustainability

When looking for a precedent that follows a closer definition of sustainability, the Passive House Institute was found.

Passive House – EnerPHit – PHI Low Energy Building
“The ‘Passive House’ and ‘EnerPHit’ energy standards for buildings as defined by the Passive House Institute in this document have the objective of ensuring the following building characteristics in particular: year-round comfortable and healthy indoor conditions,
an extremely high level of energy efficiency (as a prerequisite for cost-effective operation and climate protection), a high level of user satisfaction.
These criteria describe requirements that are precisely defined for achieving these objectives.
The ‘PHI Low Energy Building’ standard is an alternative standard for buildings which do not completely meet the energy-efficiency and comfort objectives.”

This definition has been the closest research and accreditation process to this thesis.

Precedents









06

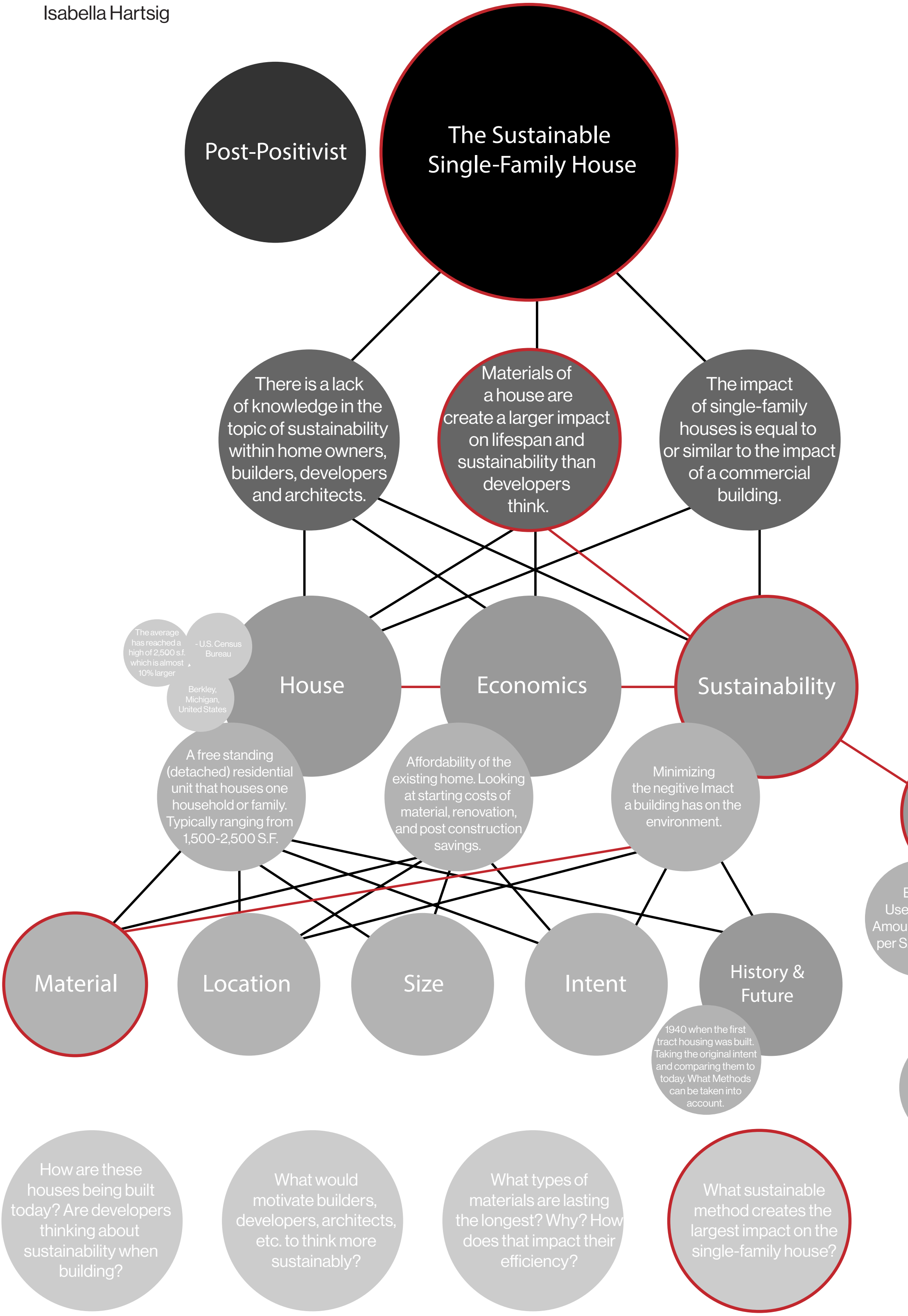
METHODS

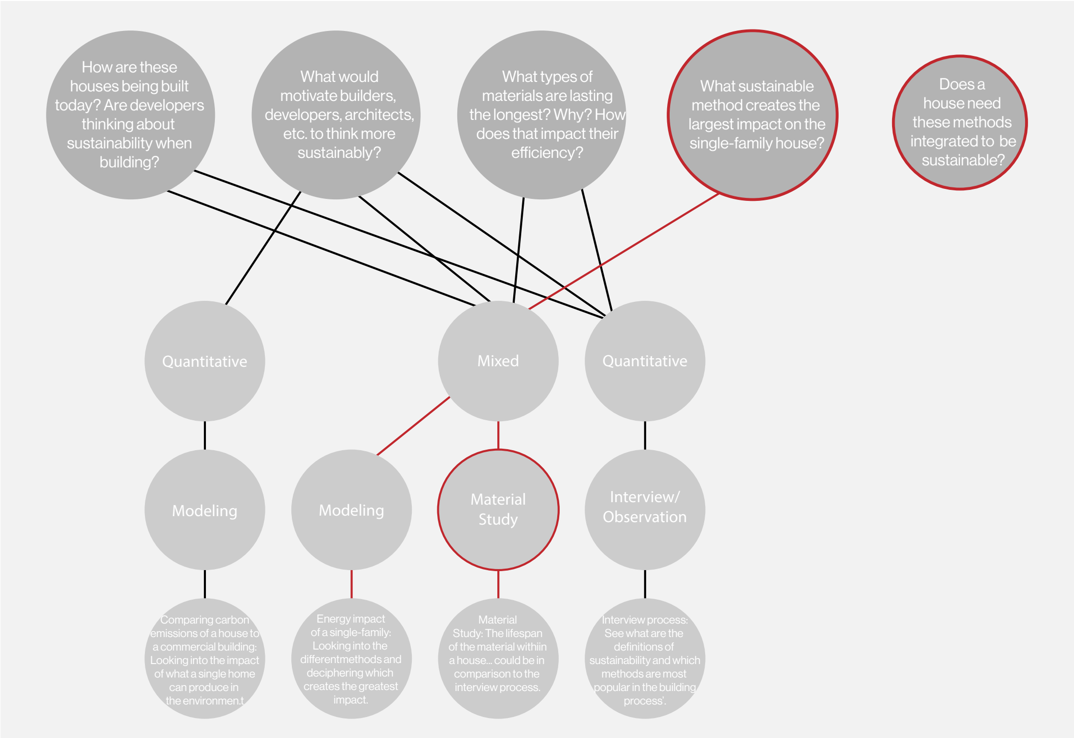
Post-Positivist

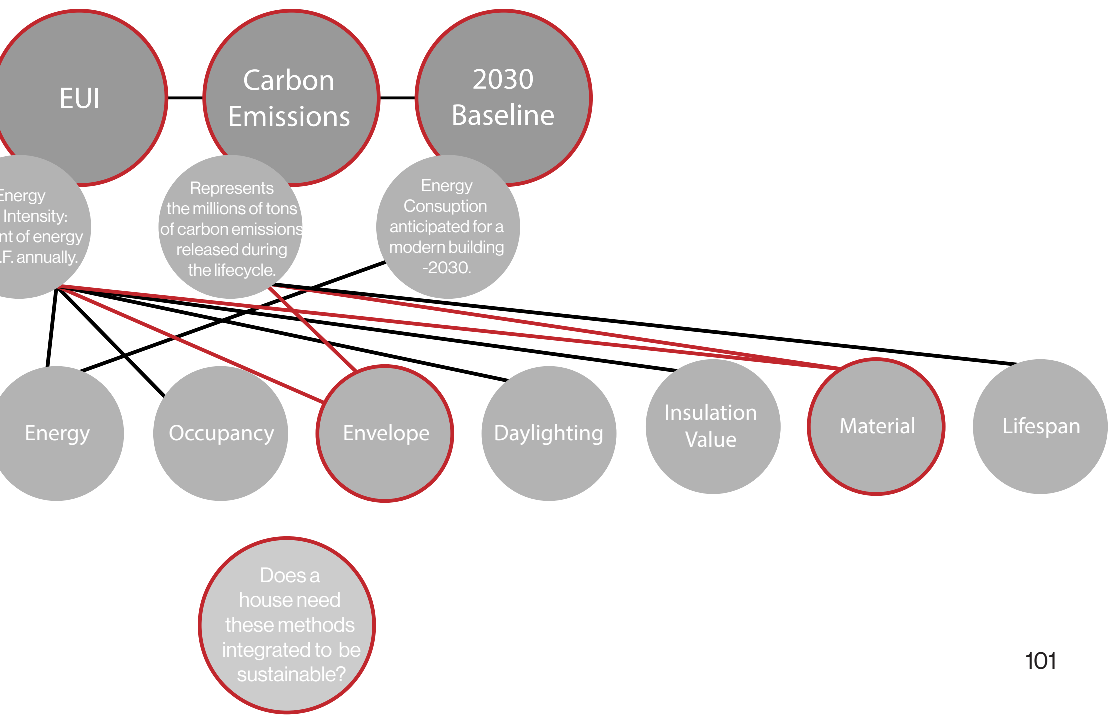
Mixed Methods

This thesis is based on a Post-Positivist research method. Meaning that the reader is expected to have a general understanding of the concept and the results of the information found and explained is structured and realistic. Within this research, the ways of finding are mixed through qualitative and quantitative research. Using methods such as interviews, observations, modeling, and material studies.

Isabella Hartsig




How are these houses being built today? Are developers thinking about sustainability when building?
What would motivate builders, developers, architects, etc. to think more sustainably?
What types of materials are lasting the longest? Why? How does that impact their efficiency?
What sustainable method creates the largest impact on the single-family house?
Does a house need these methods integrated to be sustainable?
Quantitative
Mixed
Quantitative
Modeling
Modeling
Material Study
Interview/ Observation
Comparing carbon emissions of a house to a commercial building: Looking into the impact of what a single home can produce in the environment.
Energy impact of a single-family: Looking into the differentmethods and deciphering which creates the greatest impact.
Material Study: The lifespan of the material withiin a house... could be in comparison to the interview process.
Interview process: See what are the definitions of sustainability and which methods are most popular in the building process'.


EUI
Carbon Emissions
2030 Baseline
Energy Intensity: nt of energy .F. annually.
Represents the millions of tons of carbon emissions released during the lifecycle.
Energy Consuption anticipated for a modern building -2030.
Energy
Occupancy
Envelope
Daylighting
Insulation Value
Material
Lifespan
Does a house need these methods integrated to be sustainable?

Ethnographic Study

The intent of this Ethnographic research is to observe how others view different types of 'typical' single-family houses. Utilizing the Photo Elicitation method for this research, the viewers will answer research questions in response to the photos provided. Each one of the questions uses a different framework as they each are based on different responses from the viewer. The intent is to see if others have the same idea of the house as anticipated from the thesis' assumptions. Each of the images will allow the viewer to understand the space through an exterior point of view and the second set of images correspond to the second question which will begin to compare this thesis' perspective to the answers given. The validity of these responses are based on the answers from the viewer and how closely they align with the expected, prerecorded responses.

Questions:
What type of house is the image showing?
What is one word to describe the experience on the interior of this house?

Responses from Viewers:
Image 1 -
Starter Home, Single-Family
Small, Cluttered, Cozy, Comfortable, Dark
Image 2 -
Family, Single-Family, Subdivision
Loud, Comfortable, Cookie-Cutter, Dynamic
Image 3 -
Modern, Contemporary
Abstract, Bright, Empty, Cold
Image 4 -
New, Mansion, Castle
Cold, Open, Bright, Grand








Artistic Comparison

With the intention of driving the thesis focus to look outside of the practical aspects, this project was to find art that corresponded to the topic of The Sustainable Single-Family House.

As previously mentioned, this thesis is primarily focused on the idea of being very practical and usable in real-world circumstanses, however, if looked at from a broader point of view, there are artistic aspects that are within. The three topics that fit well with the artistic ideology are material, sustainability, and the house itself. Many artist took it apon themself to creat art that spoke about their views of the house and what a house could mean to a person. Others took into account the lack of knowledge of sustainability and created installations that showcased the ability to reach a sustainable goal vs. how far the world is from achieving it.

House 365

Clinton Snider

What are you learning from this work?

I thought the idea of HAVING to reuse materials from abandoned houses in detroit was a very interesting idea for a piece of art. It is also in a constant state of change as it is passed around to different owners to add to the piece. It is very similar to the idea for my thesis of reimagining the single family house to meet the new sustainability standards. I say this because it is ever changing and will always need to be improved over time.

How has the maker placed the viewer in direct engagement with the topic, question, or problem?

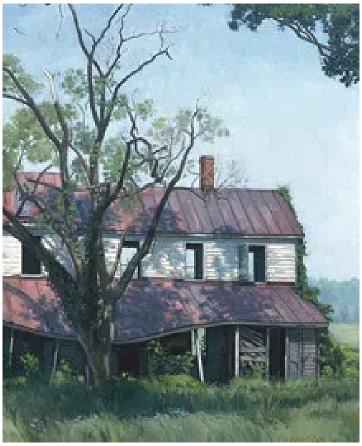
There is a direct engagement with the piece of art when the viewers and 'owners' are asked to add to the 'tiny house'. The questions would be; what needs to be fixed, what more is there to add, and how can we make it better.

How does that direct egagnement force you to confront new information in order to learn?

It forces the viewers and owners to learn by adapting to what they have around them. With the idea of only being able to use materials from abandoned homes the viewers must look at their surroundings to find what is best suited for the project.

3/10

https://www.nbcnews.com/id/wbna34426807



The Tone of Abandoned House
Ephraim Rubenstein

What are you learning from this work?

I think it is an important piece that shows what happens when people stop interviening with nature. It shows how we as people need to start noticing the habits of nature and follow with it rather than against it.

How has the maker placed the viewer in direct engagement with the topic, question, or problem?

The viewer is in direct engagement by giving them a view of the house in question and with contrast of showing the nature that has taken over the abandoned house.

How does that direct egagnement force you to confront new information in order to learn?

It forces the viewer to notice how this house is in natures way - when the house was not abandoned one can imagine how much the plants were cut back vs. how they truely could grow.

3/10

https://www.artistsnetwork.com/magazine/

Photosynthesis
Akihisa Hirata

What are you learning from this work?

The importance of storing solar energy. This installation was to show the solar panels of different companies and embrace the importance of sustainable workplaces.

How has the maker placed the viewer in direct engagement with the topic, question, or problem?

The viewer is in direct engagement as the solar panels are 'floating' above their head, almost frozen in space for the viewer to walk through.

How does that direct egagnement force you to confront new information in order to learn?

It forces the viewer to confront the idea of solar energy and how it can be stored and used for future use.

1/10

https://www.designboom.com/design/mi-

The Tripple Bottom Line
Marc Handelman
Aggregates

What are you learning from this work?

The interpretation of the tripple bottom line of sustainability and the earth by an artist. This helps with my thesis research as it takes what I am researching and taking out the housing aspect to see the bigger picture.

How has the maker placed the viewer in direct engagement with the topic, question, or problem?

The viewer is placed in direct engagement by interacting with the pieces of art and books as shown in the picture. There is a series of images that address different topics called 'aggregates'.

How does that direct egagnement force you to confront new information in order to learn?

It forces you to confront new information by very clearly throwing the harsh facts of the unballanced tripple bottom line of the environment in your face through the art.

4/10

https://www.sikkemajenkinsco.com/aggregates

07

CONCLUSION

As a result of this thesis reaserch, it can be said that the typical single-family house, as of today, is not up to the new standard of sustainability.
With the information proposed to the homeowner, these types of existing houses can easily be brought up to standard simply thorugh the renovation of the envelope, windows, or roof.
This book is just the begining for the study of sustainability within the single-family house. This study is meant to be continued for further reasearch of energy and carbon not only through the envelope, but through every method of sustainable design.
Nevertheless, this thesis proves that there is a significan problem with the development of single-family houses and the first step to rehabilitation for the environment is to begin sustainable renovations to the existing houses. Soon after these changes are made to the existing houses, the same or similar process can be applied to new build homes.

Make the change now for the future of the environment and health within the home.

Isabella Hartsig

WORK CITED

"18 Inexpensive Sustainable Homes Almost Anyone Can Afford." Elemental Green | Dream Discover Design, 4 Apr. 2024, elemental.green/18-inexpensive-sustainable-homes-almost-anyone-can-afford/.
"The 2030 Calculator: A Product Carbon Footprint Calculator." 2030calculator.Com, www.2030calculator.com/. Accessed 17 Apr. 2024.

"40 Attainable, Sustainable Homes That Are Still Affordable." Attainable Home, 26 Nov. 2022, www.attainable-home.com/40-attainable-sustainable-homes/.

"About the Commercial Buildings Integration Program." Energy.Gov, www.energy.gov/eere/buildings/about-commercial-buildings-integration-program#:~:text=Commercial%20Building%20Basics&text=Commercial%20buildings%20consume%2013.6%20quads,all%20U.S.%20carbon%20dioxide%20emissions). Accessed 21 Sept. 2023.

Assumptions and References for Household Carbon Footprint Calculator ..., www.epa.gov/ghgemissions/assumptions-and-references-household-carbon-footprint-calculator. Accessed 21 Sept. 2023.

Author links open overlay panelMichael Grauer, et al. "Ventilated Rainscreen Cladding System Subframe Contribution to Annual Source Energy Use in Mid-Size Office Buildings." Energy and Buildings, Elsevier, 22 Jan. 2019, www.sciencedirect.com/science/article/abs/pii/S0378778818314312.

Badger, Emily, and Quoctrung Bui. "Cities Start to Question an American Ideal: A House with a Yard on Every Lot." The New York Times, The New York Times, 18 June 2019, www.nytimes.com/interactive/2019/06/18/upshot/cities-across-america-question-single-family-zoning.html?mtrref=undefined&gwh=A3FB94A2E-049849015C3EEB61906451B&gwt=pay&assetType=PAYWALL.

Brooker, Jena. "In Michigan, a New Housing Project Shows That Sustainable Development Isn't Only for the Rich." Grist, 21 Dec. 2021, grist.org/buildings/in-michigan-a-new-housing-project-shows-that-sustainable-development-isnt-only-for-the-rich/.

"Buy Direct." Build on Your Own Lot, ecocraft-homes.com/buy-direct-new-home-construction.php?what=plan. Accessed 21 Sept. 2023.

"Calculating Energy Savings." EPA, Environmental Protection Agency, 8 Sept. 2016, 19january2017snapshot.epa.gov/statelocalclimate/calculating-energy-savings_.html.

CHATGPT: Get Instant Answers, Find Inspiration, Learn Something New, chat.openai.com/. Accessed 18 Apr. 2024.

CLF_NJA_Admin. "1 - Embodied Carbon 101." Carbon Leadership Forum, 2 Apr. 2023, carbonleadershipforum.org/embodied-carbon-101/#:~:text=In%20the%20building%20industry%2C%20embodied,due%20to%20building%20energy%20consumption.

"Commercial Buildings Have Gotten Larger in the United States, with Implications for Energy." Homepage - U.S. Energy Information Administration (EIA), www.eia.gov/todayinenergy/detail.php?id=46118#:~:text=C-BECS%20estimates%20that%205.9%20million,was%20last%20conducted%20in%202012. Accessed 21 Sept. 2023. Accessed 21 Sept. 2023.

Criteria for Buildings, passiv.de/downloads/03_building_criteria_en.pdf. Accessed 18 Apr. 2024.
"Custom Floor Plans: Modern Prefab Homes: Round Homes." Deltec Homes, 20 Mar. 2023, www.deltechomes.com/our-homes/#renew-collection.

Engineering, www.solardecathlon.gov/2023/assets/pdfs/Kansas_Engineering.pdf. Accessed 18 Apr. 2024.
"Euroshield." Recycled Indestructible Roofing in Calgary Alberta, www.euroshieldroofing.com/#:~:text=All%20Euroshield%C2%AE%20rubber%20roofs,stands%20the%20test%20of%20time. Accessed 17 Apr. 2024.

"Haven Studio." Designbuild, designbuild.ku.edu/haven-studio. Accessed 17 Apr. 2024.
"Housing Inventory Estimate: Total Housing Units in the United States." FRED, 2 Aug. 2023, fred.stlouisfed.org/series/ETOTALUSQ176N.

Housing Supply Chartbook December 2021 - Urban Institute, www.urban.org/sites/default/files/publication/105262/housing-supply-chartbook-december-2021_0.pdf. Accessed 21 Sept. 2023.

"How Housewrap Can Help Keep Your Home Cool - Low-e Insulation." LOW, 19 Aug. 2022, low-e.com/how-housewrap-can-help-keep-your-home-cool/#:~:text=Low%2DE%20Housewrap%C2%AE%20works,is%20exterior%20sheathing%20(OSB).

"How Much CO2 Is Emitted by Building a New House?" MIT Climate Portal, climate.mit.edu/ask-mit/how-much-co2-emitted-building-new-house#:~:text=Depending%20on%20size%2C%20materials%2C%20and,might%20emit%20over%20its%20lifetime. Accessed 21 Sept. 2023.

"How Much Does It Cost to Build a Single-Family Home?" Fixr.Com | The Cost to Build a Single-Family Home in Your Area, www.fixr.com/costs/build-single-family-house. Accessed 21 Sept. 2023.

"How Much Does It Cost to Remodel a House? (2024)." HomeGuide, homeguide.com/costs/house-remodeling-cost. Accessed 17 Apr. 2024.

Hu, Ming. "Beyond Operational Energy Efficiency: A Balanced Sustainability Index from a Life Cycle Consideration." MDPI, Multidisciplinary Digital Publishing Institute, 13 Oct. 2021, www.mdpi.com/2071-1050/13/20/11263.

Hubble, Andrew. "OSB vs. Fiberboard Sheathing: Choosing the Best Option." Barricade Building Products, 25 Mar. 2020, barricadebp.com/news/osb-vs-fiberboard-structural-sheathing-choosing-the-best-option#:~:text=OSB%20(%C2%BD%2Dinch)%20has,resistant%20to%20expansion%20and%20contraction.

Jankovic, Ljubomir, and John Christophers. "Cumulative Embodied and Operational Emissions of Retrofit in Birmingham Zero Carbon House." Frontiers, Frontiers, 16 May 2022, www.frontiersin.org/articles/10.3389/fbuil.2022.826265/full.

"Ladybug Tools." Ladybug, www.ladybug.tools/ladybug.html. Accessed 17 Apr. 2024.

maletix973. "How to Make Windows Parametrically in Grasshopper." McNeel Forum, 20 Feb. 2021, discourse.mcneel.com/t/how-to-make-windows-parametrically-in-grasshopper/118906/2.

Mathers, Jason. "Green Freight Math: How to Calculate Emissions for a Truck Move." EDF+Business, 6 Apr. 2021, business.edf.org/insights/green-freight-math-how-to-calculate-emissions-for-a-truck-move/.
Monthly Residential Construction, July 2023 - Census.Gov, www.census.gov/construction/nrc/pdf/newresconst.pdf. Accessed 21 Sept. 2023.

MrBrBanks. "Life Expectancy Chart & Building Materials: Comparables." BHHOMEINSPECTIONS.COM, 13 Oct. 2023, www.bhhomeinspections.com/building-materials-life-expectancy-chart/.

"Plan 28123J: Under 2500 Square Foot Craftsman House Plan with 4 Beds and 3-Car Tandem Garage." Architectural Designs, www.architecturaldesigns.com/house-plans/under-2500-square-foot-craftsman-house-plan-with-4-beds-and-3-car-tandem-garage-28123j. Accessed 21 Sept. 2023.

"Population Density by State 2023." Wisevoter, 9 June 2023, wisevoter.com/state-rankings/population-density-by-state/.

"R-Value of Drywall: Will Drywall Help Insulate?" Residential Construction Management Software, www.hyphensolutions.com/info/blog/r-value-of-drywall-will-drywall-help-insulate/#:~:text=Drywall%20has%20a%20relatively%20low,are%20commonly%20used%20for%20insulation. Accessed 17 Apr. 2024.

R-Values for Nominal 2x4 in. Wood-Frame Walls | Download Table, www.researchgate.net/figure/R-values-for-Nominal-2x4-in-Wood-Frame-Walls_tbl1_26901053. Accessed 18 Apr. 2024.

Rainscreen - System Protection, niccates.com/wp-content/uploads/2021/07/RainscreenSystemBrochure_2021-WEB.pdf. Accessed 18 Apr. 2024.

"Recommended Home Insulation R–Values." ENERGY STAR, www.energystar.gov/saveathome/seal_insulate/identify-problems-you-want-fix/diy-checks-inspections/insulation-r-values. Accessed 17 Apr. 2024.
Reducing Energy Use in Existing Homes by 30%, www.nrel.gov/docs/fy15osti/62328.pdf. Accessed 18 Apr. 2024.

Required, Prerequisite |. "LEED Credit Library: U.S. Green Building Council." LEED Credit Library | U.S. Green Building Council, www.usgbc.org/credits/. Accessed 17 Apr. 2024.

Rules of Thumb for Energy Efficiency in Buildings, www.epa.gov/sites/default/files/2016-03/documents/table_rules_of_thumb.pdf. Accessed 18 Apr. 2024.

"Slicker® 10 Classic Rainscreen 10mm - 39.37" x 38.5' Roll (125 Square Feet per Roll)." Warehoos, warehoos.com/products/slicker%C2%AE-classic-rainscreen-10mm-39-37-x-46-5-roll-125-square-feet-per-roll. Accessed 17 Apr. 2024.

Solaripedia, www.solaripedia.com/files/344.pdf. Accessed 18 Apr. 2024.
Someka. "Michigan County Map and Population List in Excel." Someka, 17 Oct. 2023, www.someka.net/blog/michigan-county-map/.

"Studio 804." No Title –, 5 Aug. 2022, studio804.com/.

"THERM Export Workflow." Hydra Viewer, hydrashare.github.io/hydra/viewer?owner=chriswmackey&fork=hydra_2&id=THERM_Export_Workflow&slide=0&scale=8&offset=-2186.250411255113%2C-2082.1128201579745. Accessed 17 Apr. 2024.

U.S. Census Bureau Quickfacts: United States, www.census.gov/quickfacts/fact/table/US/VET605221. Accessed 21 Sept. 2023.

www.thirdwavedigital.com, Third Wave Digital -. "Energy Efficiency." Brick Industry Association, www.gobrick.com/learn-about-brick/energy-efficiency#:~:text=Clay%20brick%20improves%20energy%20efficiency,and%20EIFS%20(synthetic%20stucco). Accessed 17 Apr. 2024.

Housing trends in the United States have been influenced by societal needs of the time. As the climate crisis continues, how can building standards reflect this need for sustainability? This thesis investigation sought to develop a strategy for re-imagining the single-family house to achieve increased sustainability. The research begins with the definition of sustainability as the impact on the environment through material, carbon, and energy, and the recognition that no one component overtakes the other, as all components are working together in a system of sustainable balance. Currently, the environmental impact is double what it should be according to the 2030 baseline and the carbon emissions are over by a minimum of half a million kg. Through interview data and an observation process of current and future residential construction, it is shown that there is an extreme interest in profit over any other aspect of efficiency, affordability, and sustainability. This now raises the question of: Can sustainability be affordable?

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