

GMRHP

Systems of a House

GREATER MINNESOTA RESILIENT
HOUSING PROJECT

DRAFT

THE SYSTEMS OF A HOUSE

What is a house fundamentally; can we view the house as a collection of systems and analyse how those systems have changed over time?

Author: Tom Negaard

Everyone will have a different answer to the question of what a house is. Culture, history, time, place, among other factors, contribute to and influence what a house has been and what they have evolved to be. The question itself, though, does pose a secondary inquiry: is there a collection of universal attributes which homes uniquely give to those who live in them? Identifying this group could help us re-frame our personal definition of a home while providing a baseline with which we can evaluate the evolution of the single family home in the United States. It is easy to forget that Minnesota was once solely inhabited by humans who survived and thrived in temporary structures built from poles and stretched skin. The home has evolved and with it came expectations and systems which, though effective, have, in part, contributed to the large, isolated, and expensive homes of the modern day. Since the average US home has grown to that of excess - both of size and cost - a return to the fundamentals is necessary to spark change.

Figure 1 breaks down some of the fundamental elements of what a home provides to those who live in it. This diagram is meant to identify commonalities that are essential to the idea of a home and devoid of cultural, spatial, or time-specific attributes. With each category, there are associated systems which bring the abstract idea into physicality. How essential are each one of these systems? How present is each category in the modern day home; should they all be present?

What does a house provide?

A house provides physical protection from the outside world - including weather, animals, and other humans. How the home responds to these environments is site specific though the essence of protection is essential.

The house is also a place for gathering and living. By bringing people together to live in proximity and also providing hospitality to others. The home is a place to store, prepare, and share meals and a collection of



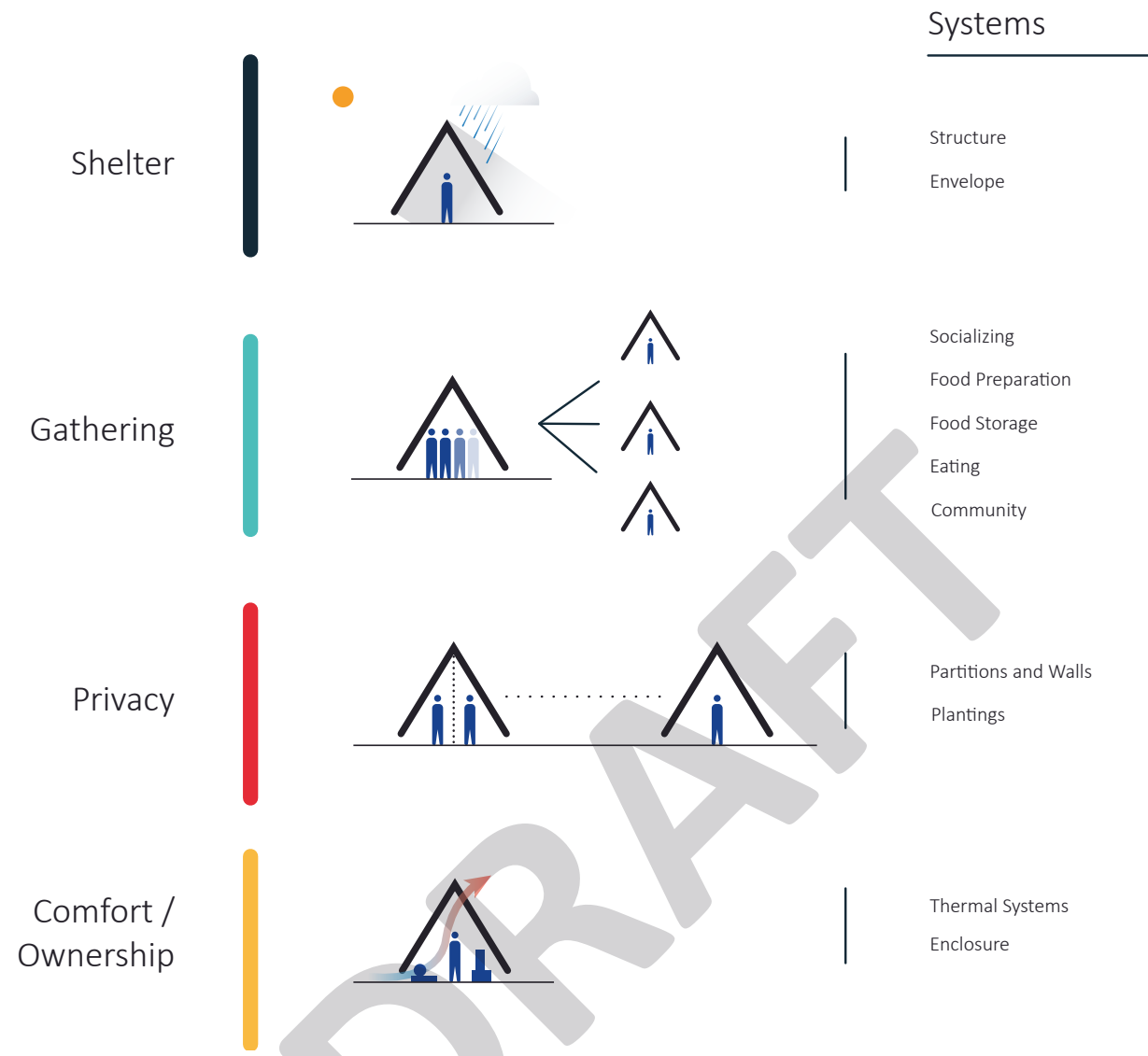
Blackfoot Tipis, 1913
source: United States Library of Congress

systems are responsible for making that possible. It is also responsible for connecting other homes in proximity, creating, in essence, a community. The home promotes gathering and connection both within and outside of its walls.

The adverse of gathering is the benefit of privacy that the home affords. Separating and subdividing spaces within gives individuals or groups private (or semi-private) spaces inside of the home. The enclosure of the house externally privatizes its spaces and contents from the outside world. Other systems, such as plantings and sheer distance,

isolate a home from other signs of humanity. Internally, it is mostly walls and openings which provide privacy to those who live-in and use a home.

Lastly, homes provide a level of comfort and ownership to its inhabitants. Ownership can come from the contents of the house - filling it with things that are your own, an inward / outward expression of uniqueness through customization, and /or the association of memories which give the home the sense of being "yours." The ways in which we "claim" a home as our own contribute to the



What does a home provide?

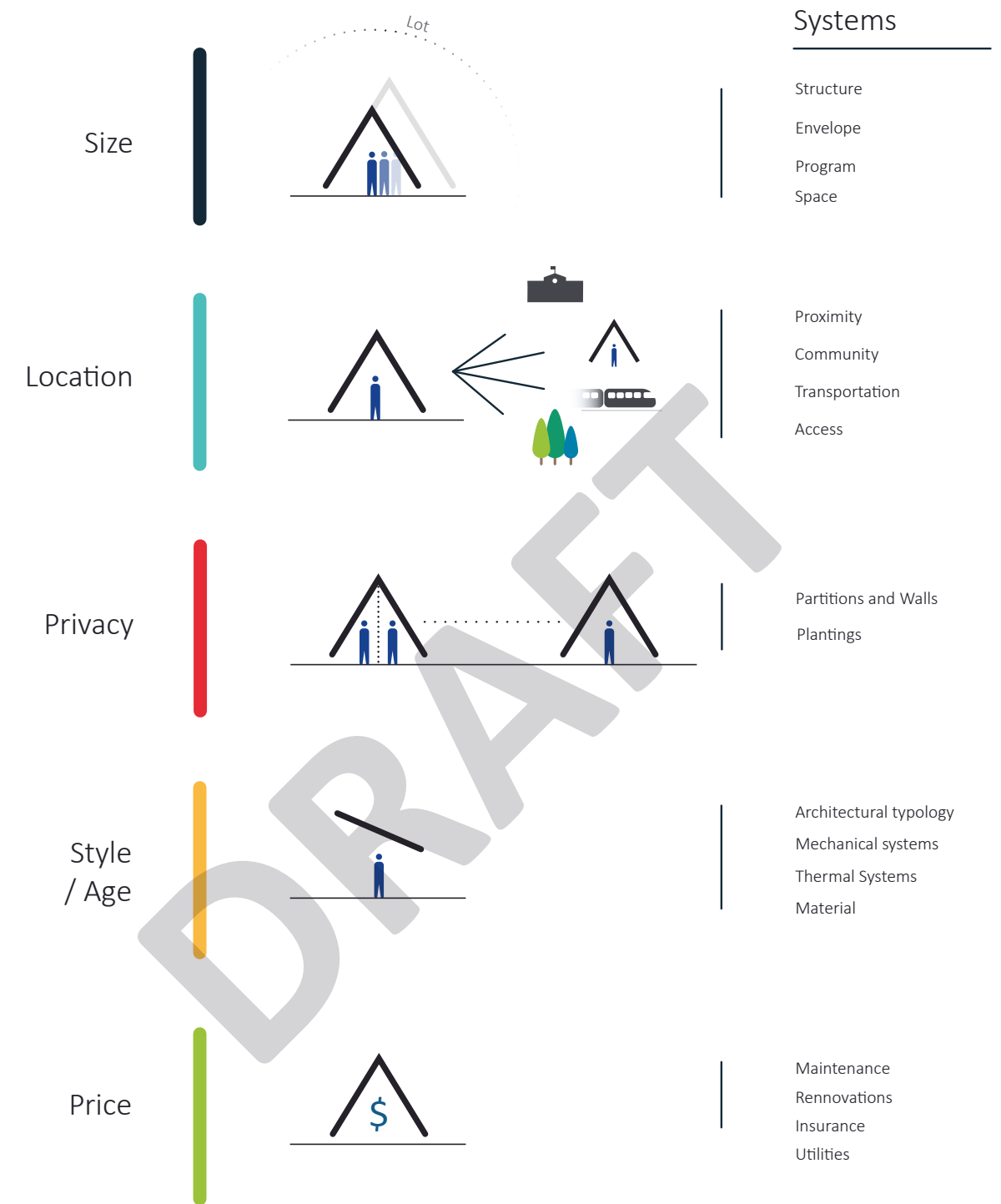
Figure 1

comfort of being in one's home. Additionally, systems such as enclosure and thermal control create more habitable spaces and further protection of one's self and property from external stressors.

As these are categories which the home provides to its inhabitants, it is important to note that these differ from that which we look for in a home - if by nothing else than nomenclature. The most common categories of importance for those shopping for (or designing) a new or existing home are size, location, privacy, style/age, and cost (Figure 2).

These terms are much more tangible though connections can be drawn with our more abstract list.

After re-examining and categorizing what makes our homes what they are, we must look at the evolution of the American detached single family home (DSFH) - as it is the affordability of this house type that this research is concerned. The DSFH was reinterpreted in the 20th century most famously by Sears, Roebuck, and Co., who sold simple and affordable kit homes to populate and iconize the expanding American suburb. Affordable single



What do we look for in a home?

Figure 2

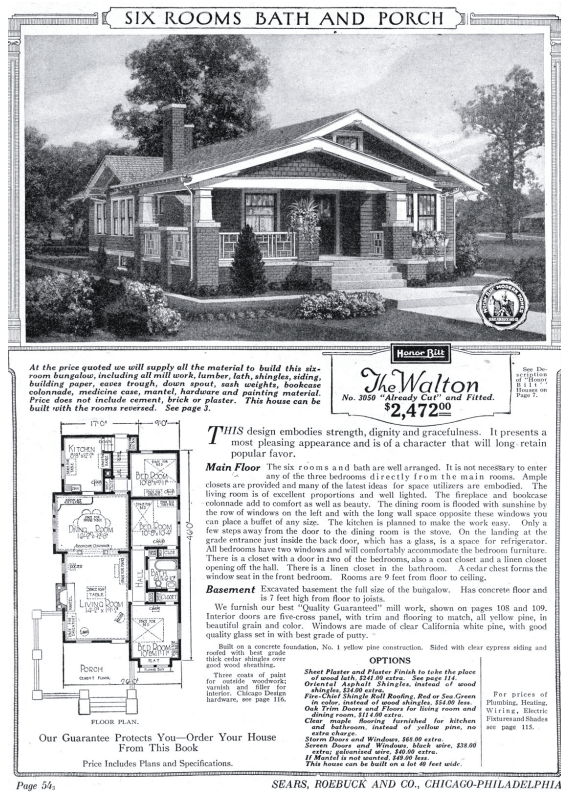


Figure 3: Sears Modern Home | 1930 | 1,196 sq ft
source: searsarchives.com



Figure 4: Levittown Homes | 1950s | 1,200 sq ft
source: levittowners.com



Figure 5: Cliff May Homes | 1950s | 1,232 sq ft
source: dwell.com

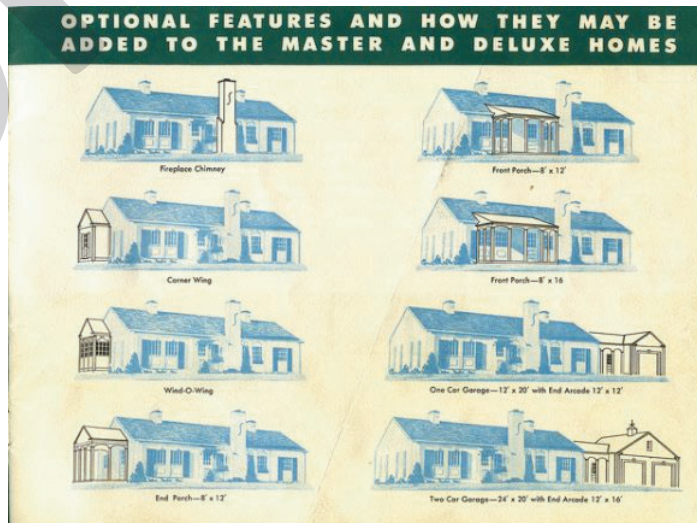


Figure 6: Gunnison Home Catalog | 1950
source: 99percentinvisible.com

Average New Home Size (2019)¹:

2,301 sq ft

Average Home Cost (MN)²:

\$263,708

\$183 / sq ft

USA - 2314 sq ft

Australia - 2217

Denmark - 1475

France - 1432

Spain - 1044

Ireland - 947

UK - 818

Averages for single family homes

Figure 7
sources: 1) US Census; 2) Zillow

Average floor space of newly built homes

Figure 8
sources: policyexchange, CABE, US Census Bureau, BBC

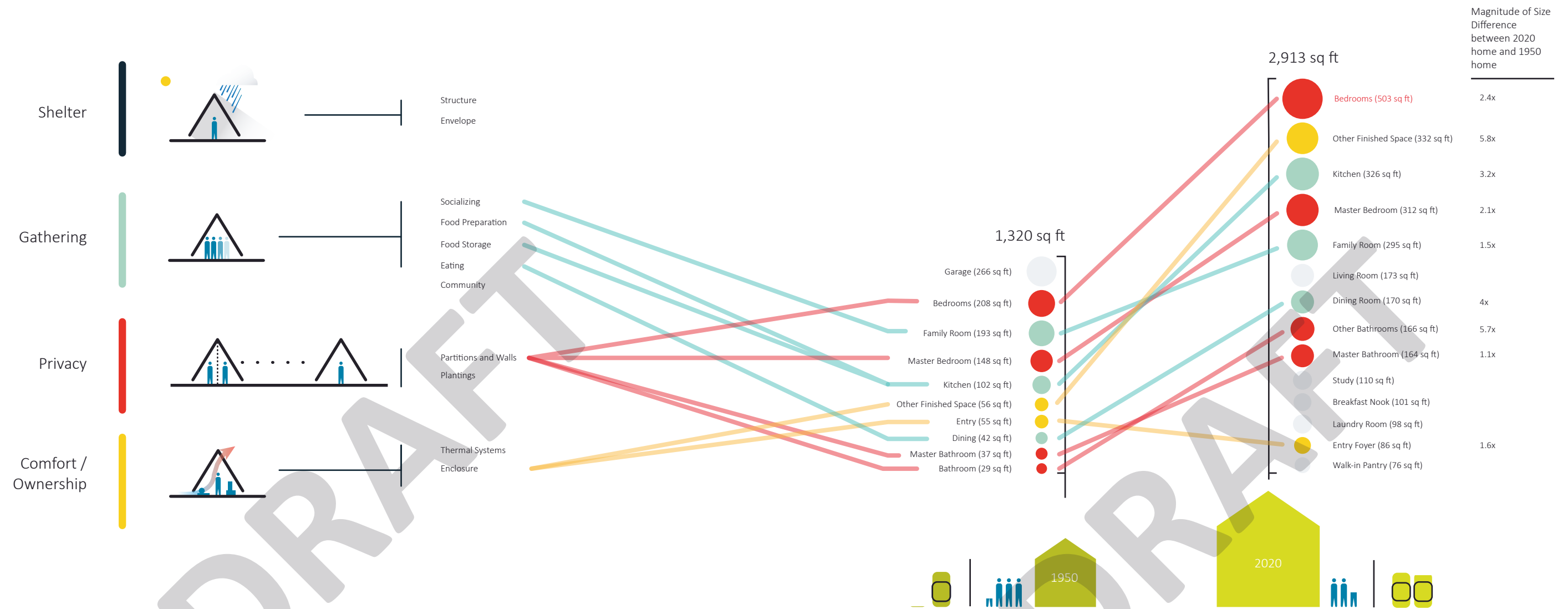
family homes were available to the masses. They were attainable, quick, and varied (though part of a limited catalog). The homes featured in Sears catalogs ranged in size from 600 - 1,500+ sq ft - with prices as low as \$1.2 / sq ft - not adjusted for inflation (searsarchive.com).

Sears set the standard for affordable single family housing by using the kit home method to lower costs and increase efficiency. As the century progressed, there were continuous examples of designers, builders, and manufacturers who used kit or prefabricated home processes to design and build affordable houses for the masses. These homes often had an associated architectural language - be they part of a

How has the single family home changed; how can it continue to change?

notable development effort (Sears or Levittown) or designed with an aesthetic signature (Cliff May Homes). This type of home design and construction, although successful, has fallen out of favor with US home builders and buyers; in 2017, modular homes represented only 1% of new single-family houses completed (US Census). While the construction industry is slow to adopt new construction methods, the size and price of homes has changed dramatically over the last century.

While it is out of the scope of this research to examine and evaluate why US homes have ballooned to their current average size and cost., it is undeniable that American homes are huge - a comparison of average home sizes across Western



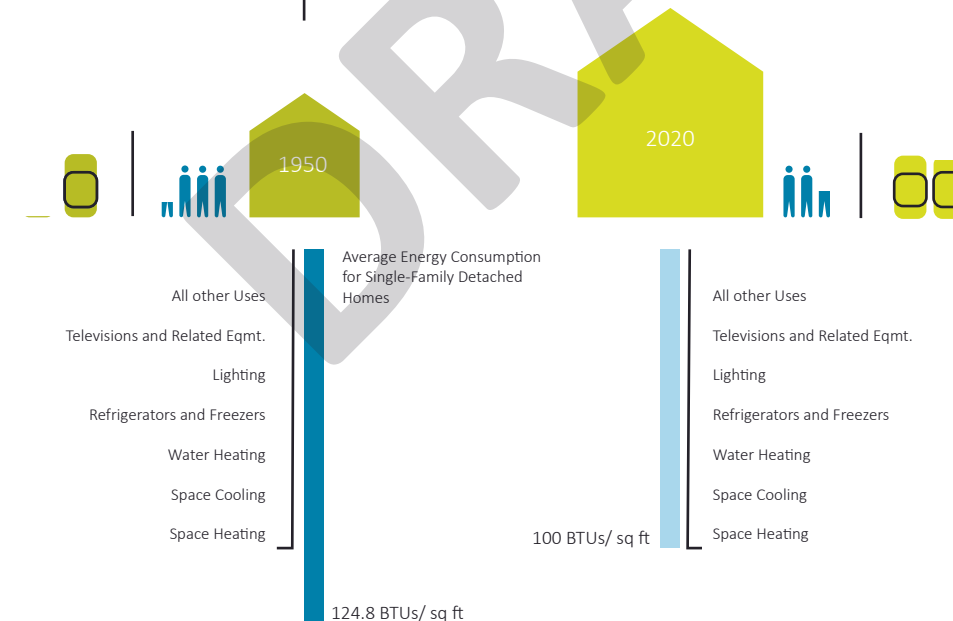
countries shows as much (Figure 8). The average size of 2,265 sq ft for the Midwest (2,314 for the US as a whole) is a 71% increase in area from the 1950s national average and a 62% increase from the national average in 1910 (propertyshark).

Figure 9 pulls apart two homes from two different times and shows, room-by-room, how spaces in homes have grown, or been added, to sum up to such a large house.

One way to make homes more affordable is to make them smaller - less floor area means less material and labor costs among others. Only 70 years ago, the average US family was larger yet lived in homes over half the size as the average 2020 home (statista.com). The amenities and size

of spaces that Americans have come to expect in a home are only decades old. Go back further and you will find that humans can tolerate much less in this climate.

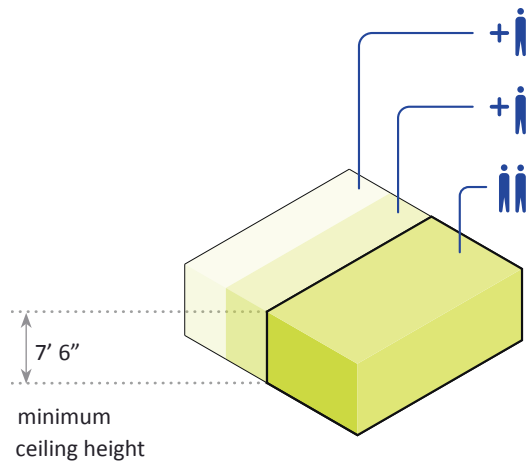
Another factor which dictates the size of homes is building code. The Minnesota Building Code establishes minimum program and size requirements for both habitable spaces and dwelling units. Figure 10 lays out the required spaces and how small those spaces are allowed to be for an “efficiency dwelling unit”. Living rooms and bedrooms are considered “habitable spaces” - requiring a minimum dimension of 7’ in any plan dimension. They each have their own respective minimum areas. The smallest a living room can be is 220 ft² - with 100 ft² added for each additional person (beyond two) living in the dwelling. Kitchens are not bound by



What is a modern home?

Figure 9

sources: homeadvisor.com, propertyshark.com, levittowner.com, nahb.com



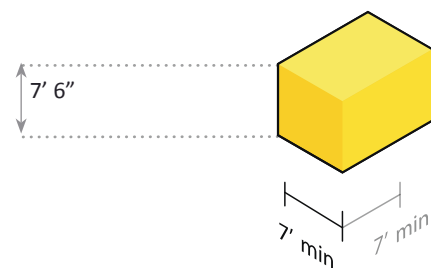
Living Room

Minimum Area:

220 ft² | Two people
+ 100 ft² for every additional resident

Habitable Spaces

7' minimum dimension in any direction



Bedrooms

Minimum Area:

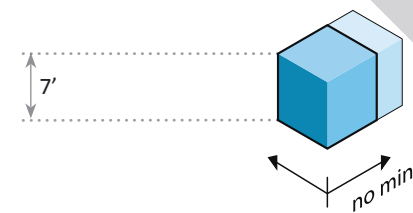
70 ft²



Kitchen

Must include:

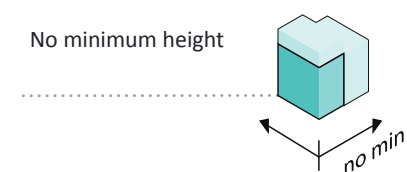
- Sink
- Cooking Appliances
- Refrigerator



Bathroom

Must include:

- lavatory
- bathtub
- shower
- water closet



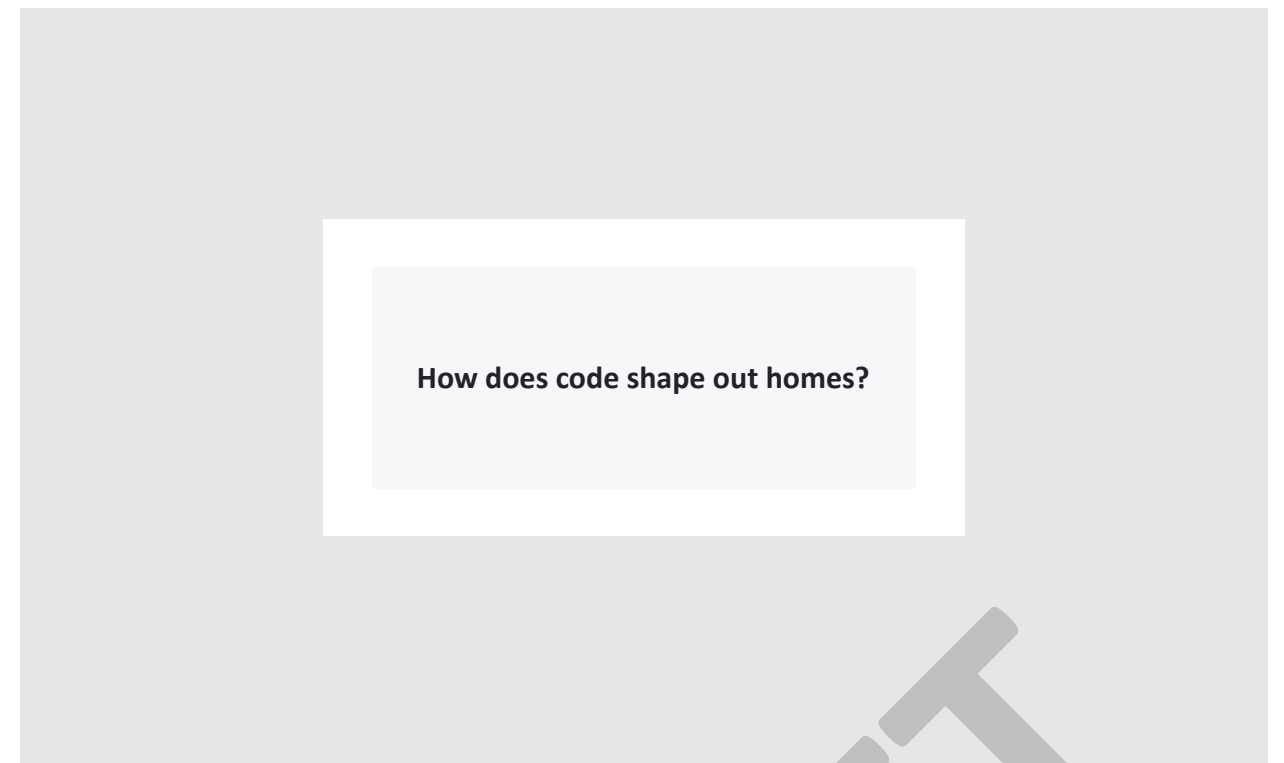
Separate Closet

No minimum area

Minnesota Building Code - Interior Spaces

Figure 10

source: Minnesota Building Code 2020



the 7' dimensional constraint though they must maintain 3' of clear space between counter fronts, appliances, and / or walls. The code does spell out what kinds of appliances (vaguely) are necessary in a kitchen - specifying each appliance have a minimum of 30" of clear working space. A similar list of requirements is included for bathrooms. Kitchens and bathrooms, though, do have restrictions on their ceiling height along with habitable spaces.

Habitable spaces have a minimum allowable ceiling height of 7'-6" while kitchens and bathrooms have a 7' minimum. Closets have no restriction on dimensions. It is these five spaces which are required for an "efficiency dwelling unit" to meet code standards on program. There are additional code requirements for lighting, ventilation, and finishes. These requirements have all impact on the cost of a home and who / what is being constructed. Most homes in Minnesota are built to code both for safety considerations and fiscal security. Homes that are built to code are safer investments for lenders. For more information on building code, please refer to [chapter AA](#).

Home-builders, home-buyers, and home-designers, need to think critically about what their definition of home is, and how much home they need, in a time of nationwide affordable housing shortages. Would young homebuyers be willing to purchase a \$800 sq ft home with fewer of the commonplace luxuries (laundry rooms, air conditioning, etc.)? Would homebuyers be willing to off-load half of their shared living space to the exterior - creating a smaller home footprint in the winter and a much larger space for the other three seasons? Homeowners may be willing to accept less if the supply (and the price of said supply) reflected their needs. There is a serious demand for less expensive housing in the US and Minnesota, specifically. By continuing to critique our own definitions of "house", we can question our assumptions and expectations - possibly arriving at a home that better fits an individual's lifestyle and budget.

HOW DO WE MAKE HOUSES?

Who is designing our homes?

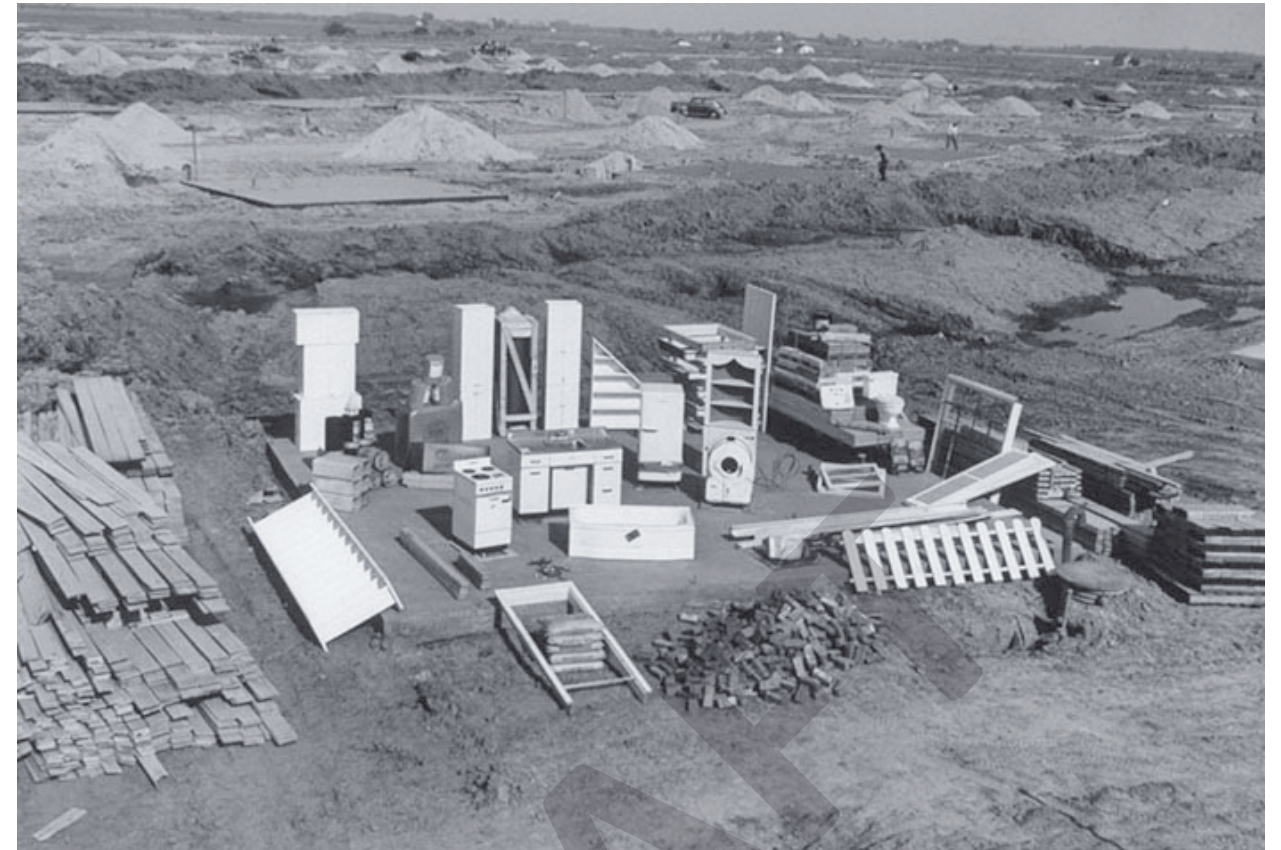
Author: Tom Negaard

Most homes in the United States are not designed by residential architects. Some estimate only 1-2% of new homes built in the US pass through a residential firm. The architect's process is a luxury - reserved for those who can afford it. A completely custom home takes time, money and involvement for both the home buyer and the architect. If working with an architect gives home buyers the largest voice in the design of their home, then who is designing most of the homes built in the US?

The question might seem trivial; but if we start asking homeowners if they are willing to sacrifice space and amenities to achieve a more affordable home, then the question of who has a say in what is built becomes important. Someone (plural, and not the homeowner or architect working with the future homeowner) is making the bulk of the design decisions of the US housing supply. These decisions directly contribute to the size, efficiency, and cost of homes. Some

processes involve the home buyers to varying degrees while others exclude them completely.

Figure 11 unpacks six of the most common ways that we make and acquire homes. These processes vary in duration, cost, efficiency, and homeowner input - though they all end in the same place. The lengthiest, and most involved, process is working with a residential architect to design one's home. By looking at the relative involvement and timescale, it is not surprising that this option comes at a premium. Architects work off of a percentage of the cost of construction and are invested and involved in each project. This codependency on cost and time has driven the architectural experience to those who can afford it. While homes built by architects are usually above average in cost, they are built to suit. Since the homeowner has been involved, they are receiving a home which has the size, amenities, and features they desire. As we move to other options, the new houses become more a function of what is available - leaving the



Levittown kit home construction in process
source: cargocollective.com

home buyer at the mercy of the supply instead of customizing to their needs.

Spec and tract homes are similar in that developers / builders are constructing homes with the assumption that a demand will exist. Home buyers can insert themselves into the process at any point though most enter towards the end of the cycle. At this point, the buyers are still able to exercise some influence over their new home - sometimes allowed to choose finishing details or appliances - though the bulk of the home was designed and built without them.

Modular / prefab and kit homes are more customizable though they are still edited from a selected catalog of home designs. They differ in by whom and where construction takes place. Kit homes are assembled on site with pre-cut pieces while modular homes are built in a factory and attached on site.

Finally, buyers can buy an already built and lived-in home. The house could have been built using any of the previous methods but that has no impact on the timeline of the new owner's purchase. The fastest (relatively) way to acquire a home, the buyer has to choose from what is available but forgoes many of the hidden costs and extended timelines associated with building a new home.

There is a disconnect between who is designing the majority of US homes and the needs / wants of those looking to build or buy. There cannot be meaningful change to the design (and, by extension, cost) of homes if home buyers continue to vote with only their dollar. If the barriers to entry were lower, designs were opensourced, and architects / designers were destigmatized as too expensive, there could be a clearer dialogue between demand and supply of US homes.

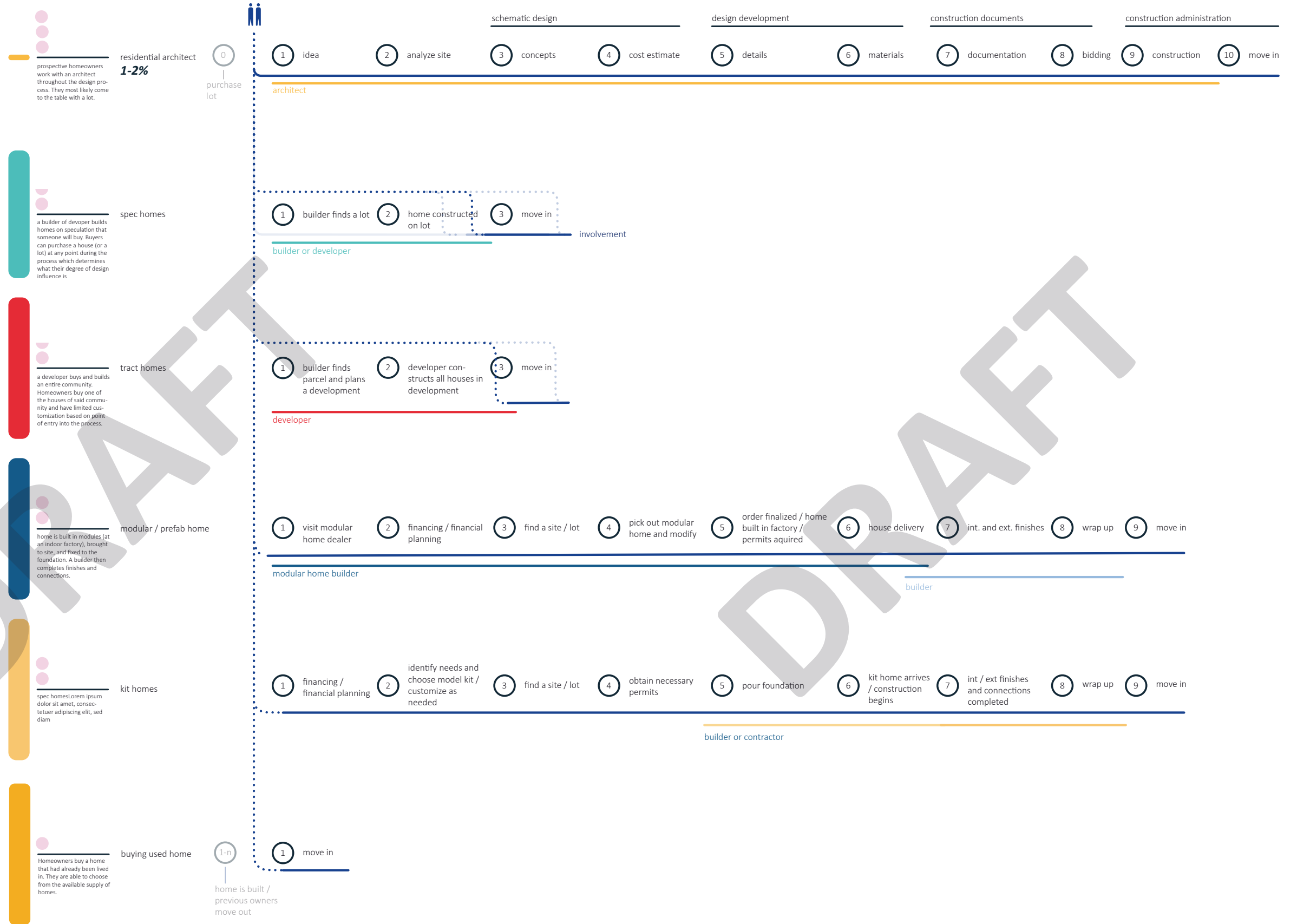
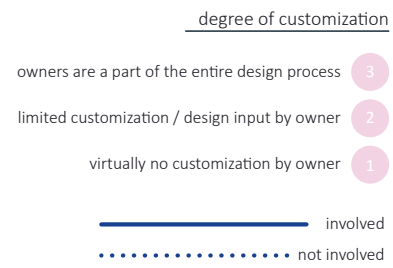
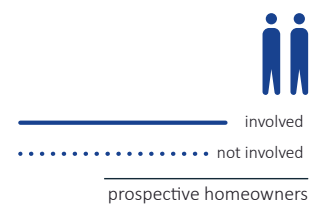


Figure 11: There are many ways we, in the United States, design, build, and buy houses. These processes vary in length, homeowner involvement, and relative costs. This diagram compares six of the most common ways we make homes

THE COST OF A HOUSE

Author: Tom Negaard

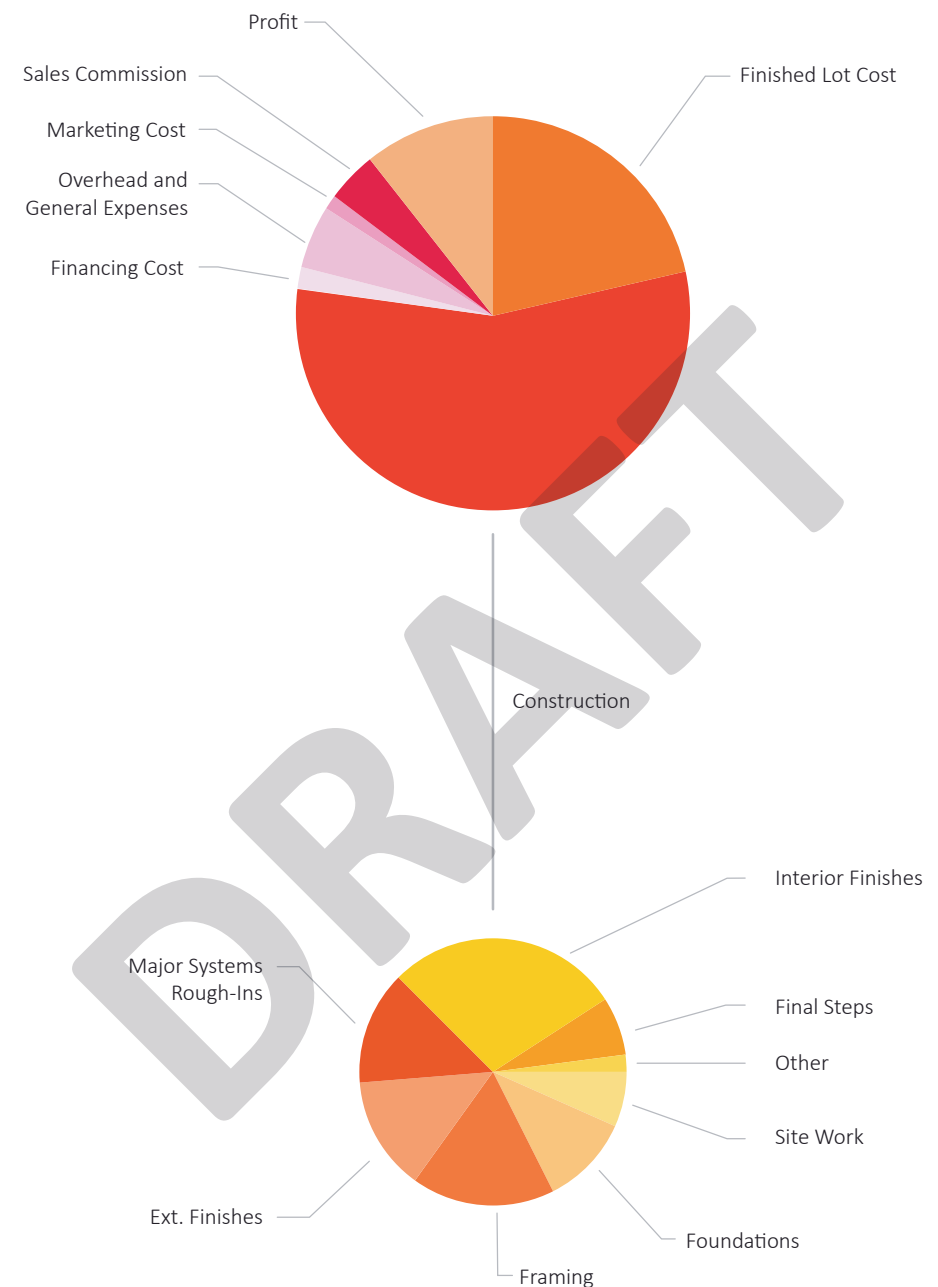
Arguably the most significant factor in the consideration of buying or building a home is money. The average cost of a US home has gone from \$3,200 (\$81,000 adjusted for inflation) in 1915 to over \$260,000 in 2020 (US News, US Census). In Minnesota, the average home price has grown to over 4x the median household income (MinnPost). Some contributors to these increased costs are materials, labor, regulations and land.

Tariffs and demands on lumber have stressed the wood industry and contributed to increased materials costs. (MinnPost) Additionally, costly high-tech extras are being added to more homes. There is a workforce shortage in the home construction industry. Contractors are forced to pay higher wages to keep and retain workers (MinnPost). Regulations also impose cost burden on new and existing homes - for more information, see [chapter XX](#). Lastly, the price of land has steadily increased, and with it, the cost of ownership. As rising costs make homes less attainable, cultural decisions are also affecting the supply of homes.

Following the 2008 financial crisis, home buyers are consistently “buying down” and opting to move less affordable homes away from the income bracket most appropriate for them. A resistance to move also limits the supply of available housing. The relationships of these interconnected factors beg the question, how is the cost of a home broken down?

The National Association of Home Builders collected and categorized the different variables which create the total cost of a home (Figure 12). Of the total, construction (55.6%) and finished lot cost (21.5%) have the largest shares. The construction piece was further broken down into sub-categories which contribute to its 56% stake. Interior finishes are the single largest contributor to the construction cost, though there is not a significant drop off between subsequent categories.

Now that the costs are laid out, can we visualize what decisions, or lack there of, are contributing to the rising cost of home ownership?



Single Family Home Cost Breakdown

Figure 12

sources: National Association of Home Builders

HOUSE COST INTERACTIVE MODEL

As helpful as it is to see the cost of a home subdivided into percentages of a circle, a more helpful tool would be an interactive one - where designers, builders, or buyers could make decisions and see those choices reflected in the (estimated) cost of their home. Our interactive model can afford more transparency in the costly design - build process and potentially encourage conversations around what is and is not necessary in a buyer's new home.

The interactive cost model, diagramed in Figure 14, begins with user input on size / number of rooms in their desired house. The categories are derived from the most common spaces in US homes. When the user changes an input (adjusts the number of bedrooms from two to three, for example) a new total square footage is calculated for the house. This is then multiplied and summed with a series of other costs which are directly connected to the square footage of the home (materials, framing, finishes, foundations, etc.) The user can then input the cost of their lot and adjust the cost per unit area to landscape. Further costs, such as permitting, financing, and profit, can be linked to the home's footprint or total cost to provide a more accurate cost profile of the home. With the tool, a user's decisions will, in real time, generate an estimated cost and size of their prospective home.

Furthermore, the decisions on size and number of rooms also have an effect on the energy use of the home. These connections have been made in the model and provide an annual energy use and cost to the homeowner. One could weigh the addition of solar panels as increasing their construction cost but lowering their energy bills. Additional connections and conditional costs are being added to make this experience as accurate as possible.

This model is speculative and currently based off of national averages - many on a per-sq ft basis. Area evaluation are not appropriate for all systems in a house. We are working to continue to add data and make it possible for firms / contractors / builders to input their own numbers based on their region. It is important to note how dependent a home's cost will be on its location. By giving users the ability to most accurately reflect their location-specific costs, we hope the model will generate a clearer picture of a home's cost.

Community assets can also be leveraged in the building of homes. Not only can this lower costs but it can foster a sense of ownership by the community and its members. The cost model can be linked with a similar model that measures the assets of a particular community and weighs the impact of their involvement on the construction cost of a house (Figure 13). This type of integration is the next step for this project's interactive model.

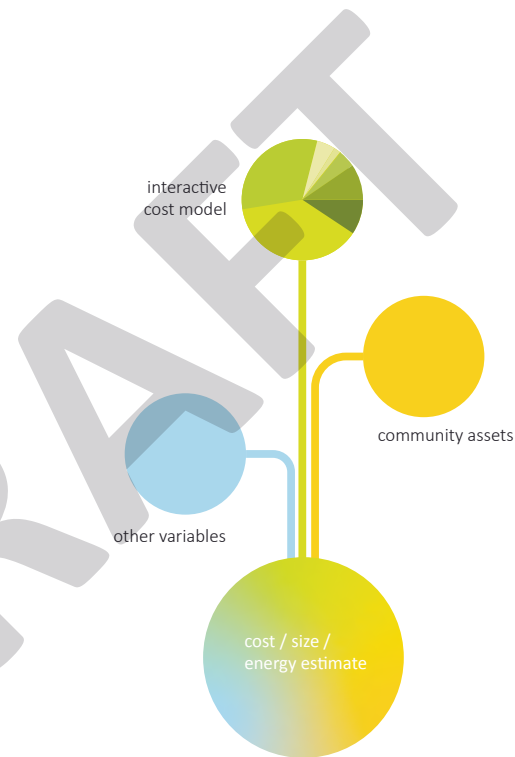


Figure 13 (above): How the interactive cost model is only one piece of the puzzle. Additional factors can and should be added to create a clearer picture of a future home's cost, size, and energy demands.

Figure 14 (left): Diagram of the interactive cost model

