

SUSTAINABLE, AND AFFORDABLE, AND HISTORIC? OH MY! A TYPOLOGY STUDY
OF AFFORDABLE AND SUSTAINABLE HOUSING IN PORTLAND, OR

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A THESIS

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THESIS ABSTRACT

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Master of Science in Historic Preservation

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Title: Sustainable, and Affordable, and Historic? Oh My! A Typology Study of Affordable and Sustainable Houses in Portland, OR.

In the 1920's, the outskirts of Portland was considered rural homesteading land, given to eastern newcomers. Throughout Multnomah county, a series of "small homes" were built in the 1920's. They are recognizable for their small size and for their placement on their lot. These homes were considered the era's affordable housing solution. Today they offer a potential re-evaluation of how preservation, affordability, and sustainability intersect.

These fields are sometimes pitted against each other but truly, at their core, they promote similar ideas of accessibility to safe and obtainable shelter. Considering the events of the last 100 years since these small homes were built, the greater Portland community can reevaluate how they want to move forward in terms of sustainability and affordable housing. The focus of this paper will be to provide a typology study that explores a specific example of how those three fields engage with each other beneficially.

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CHAPTER 1

THESIS INTRODUCTION

Thesis Narrative

There is a misconception that historic preservation is anti-affordable housing. It might stem from the preciousness that we associate with historic sites and the perceived constraints on changing a historic building. At first glance, it is easy to make this assumption. There are many rules, laws, and regulations that come with traditional preservation, some of which make it difficult to practice on a modest budget. This is due to many issues, such as lack of craftspeople, lack of information, or lack of appropriate materials. It might stem from what people choose to preserve.

The history of grassroots preservation is often taken back to the ladies of Mount Vernon, who were upset by the state of George Washington's home, many of whom consider this the establishment of formal preservation in the United States.. To consider oneself at the same level as George Washington seems out of place, maybe even a little egotistical, so it is reasonable to think people might not think of their homes as preservation "worthy." This perspective is changing, however, as more preservationists are demanding to preserve sites like the Georgia B. Williams Nursing Home, or the Threatt Filling Station and Family Farm; be treated to the same level of attention and care as Mount Vernon. The two sites mentioned above are on the National Trust for Historic Preservation's 2022 America's Most Endangered Historic Site list.¹ The list sheds light on historic sites that reflect a forgotten history from one of the many minority groups within the United States.

¹ "Discover America's 11 Most Endangered Historic Places for 2021," National Trust for Historic Preservation, June 3rd, 2021, accessed May 2022, <https://savingplaces.org/stories/11-most-endangered-historic-places-2021#.YgFoturMKUk>

Preservationists today usually try to use the act of preservation as a tool, using the surroundings as context and a guide for moving forward. By using preservation as a tool for affordable housing, one is subverting the mainstream history that is typically told, sharing the little told history of the poor, the oppressed, and the overshadowed. Similar to ideas that Dolores Hayden proposed, in conveying the power of people and their relation to places, what might seem to have little significance to the majority still has significance to at least one.

When taken as an abstract concept, loosely defined simply by what “preserve” means, it seems like preservation would be the best solution for affordable housing.

To preserve as much material as possible. This would save a lot of money on materials.

To preserve as much craft as possible. This would save a lot of money on labor.

To preserve as much of the history as possible. This would save a lot of emotional and social value.

The diagram below is meant to establish a summarization of the goal of this research, including the context for this research. This research does not exist in a void, so it is important to acknowledge this. The literature review gives full context to research conducted by other preservationists on their relation to sustainability and affordability.

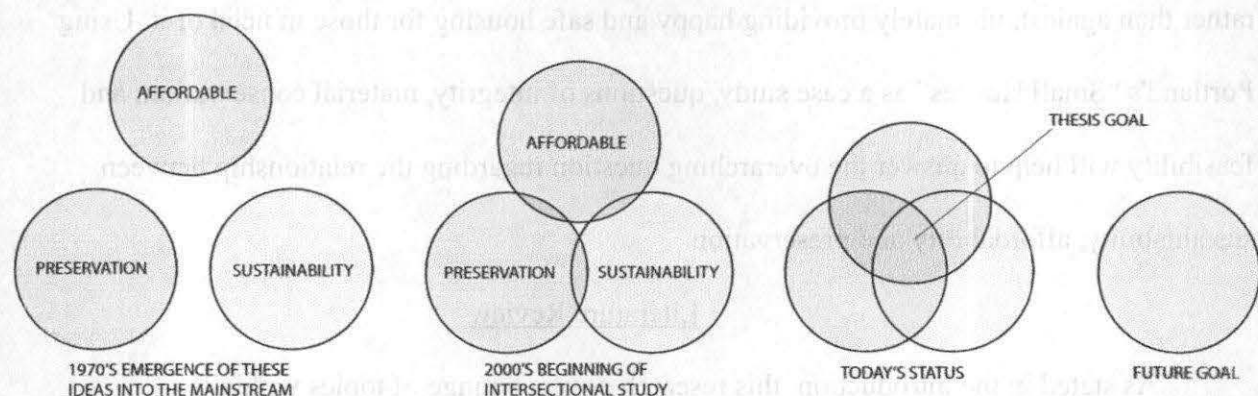


Figure 1.1. Diagram created by author to demonstrate the core concept and perspective that is used to guide the research for this thesis.

This is where the distinction between formal and informal preservation should be introduced. For the sake of this paper's discussion, these terms are devised to explain the difference between preservation that applies to the National Register and the Secretary of Interior's standards and the looser, more layperson's version of preservation, do-it-yourself maintenance. The formal kind of preservation requires a higher level of information, is stricter in terms of what can and cannot occur to the property and requires time on the part of the government and property owner. The informal kind of preservation requires the desire to "preserve" in the simplest form possible. It makes exceptions where they are needed. It allows for more flexibility. It is not the pure *tabula rasa* that new construction can be, but informal preservation has its benefits, just as formal preservation does. Considering these two forms of preservation, how can existing housing use both to become sustainable? What effects do preservation have on the average homeowner's budget? How does this type of sustainable preservation relate to the overall conversation on sustainability and climate change?

With so many complex questions, one complex answer arises; when preservation, affordability and sustainability are all taken into consideration, they tend to work with each other, rather than against, ultimately providing happy and safe housing for those in need of it. Using Portland's "Small Houses" as a case study, questions of integrity, material conservation, and feasibility will help to answer the overarching question regarding the relationship between sustainability, affordability and preservation.

Literature Review

As stated in the introduction, this research covers a range of topics within the preservation, sustainability and affordability fields. This has affected the level and type of

research conducted for this thesis, as subjects range from embodied carbon to affordable housing in historic neighborhoods to the theory of integrity. Each subject fits nicely within the three topics (preservation, sustainability, and affordability) and follows a similar structure as this thesis. The important subjects within the preservation scope were vernacular theory, integrity theory, neighborhood development and general East Portland History. The important subjects within the sustainability scope were embodied carbon theory, sustainable building science methods, Tally computer software, the Intergovernmental Panel on Climate Change, and sustainable urban planning theories. The important subjects within affordability were Missing Middle Housing theory, Carbon Tax policy, affordable and DIY building science methods, and Transit Oriented Design theory.

Starting with understanding the history and environment of the area of study, it was important to gather a brief history of east Portland. Using the *East Portland Historical Overview and Historic Preservation Study* from 2009 proved incredibly helpful despite the lack of direct connection to the Portland Small Houses that were identified. This study provided a general history of the development of east portland, tying the development of the region to transportation. After digesting this overview, a deeper understanding of the area of study was necessary to understand how and why tiny homes might have been built in the 1920's. Susan Nelson is a local historian for the Cully neighborhood and provided a context for the more northern regions of the area. She had a lack of knowledge specifically for the blocks in question but was able to share maps, images and resources that led to a more solid understanding of the neighborhood, as well as general contextual information.

A field survey was conducted to gather photos of the existing buildings and after the survey, intensive level research was conducted on each home, using historic water permits to

gather an understanding of how the buildings might've changed over the 100 year period. Historic photos would have been a better tool for this aspect but they were distinctly lacking from newspapers and the city archive due to these blocks being outside of the city jurisdiction until the 1930's. Newspapers were used rather to gather context on the urban planning development of Portland, specifically the city's history of zoning which relates to research conducted on sustainability and affordability.

The research on sustainability was specifically targeted on embodied carbon theory. One book in particular emerged as the leading book on embodied carbon calculation and place within the building industry. *Embodied Carbon in Buildings: Measurement, Management, and Mitigation* by Francesco Pomponi and Catherine De Wolf has the lens of calculating embodied carbon from the architect's perspective and not the preservationist's perspective. The book makes accurate suggestions on how to consider embodied carbon within a construction project, assuming the reader is working on a new construction project. Due to this, it was hard to apply it to preservation techniques as it lacked considerations to integrity but Pomponi and De Wolf outline the best way to reduce the embodied carbon footprint of a building in general, regardless of the building's historic status. Francesco Pomponi has become a proponent of embodied carbon theory, writing numerous articles that ultimately suggest that a lower embodied carbon is better within a building and reusing materials can achieve this, specifically within the built environment.

LEED provided an excellent framework for exploring sustainability within architecture, similar to the work of Pomponi, but in relation to new construction. Researching the LEED certification process was useful in terms of understanding the acceptance of embodied carbon in a mainstream sustainability ideology, but what it lacks is mainly its connection to preservation

and adaptive reuse. This research mainly references LEED version 3 and version 4. Currently the United States Green Building Council uses version 4 for contemporary certifications but version 3 was helpful in understanding the stages of development and integration of preservation ideas as being sustainable.

The research on affordability was focused on more urban planning methods that could help reduce the cost of housing and provide more housing in general through densification planning. Daniel Parolek's *Missing Middle Housing: Thinking Big and Building Small to Respond to Today's Housing Crisis* was written in 2020 and has only become more accurate in terms of housing needs. Parolek relates his urban theory to historic dense neighborhoods and the multitude of housing typologies that have become lost over time. This lost of rentable, walkable, and affordable housing to a housing market that is either single family housing or multifamily apartments showcases the need for a typology study of Portland's housing, starting with the Portland Small Houses to understand how housing can be affordable, accessible and made sustainability, while fitting in a historic neighborhood.

Parolek's work relates strongly to John Renne and David Listokin's work in Transit Oriented Design (TOD). Renne and Listokin research the integration of preservation and urban planning that encourages more density and public transportation. Their research was instrumental in formulating a suggestion that works within a historic context, rather than a *tabula rasa*.

Several books that were referenced for vernacular architecture theory, *The Power of Place* by Dolores Hayden, *Houses without Names* by Thomas C. Hubka, and *Building a Market* by Richard G. Harris. Hayden, Hubka, and Harris all contribute to the vernacular architecture discussion in varying capacities. Hayden's work leans more towards preservation as an act of power, particularly in terms of minority groups who have historically been systematically

oppressed. Her book, *The Power of Place*, pits preservation theory from Ada Louise Huxtable and Herbert J. Gans against each other, leaning more towards Gans' school of thought. In terms of integrity, Hayden and Hubka did not offer very much concrete advice towards the topic of integrity and preservation of common spaces. Allison Hoagland, however, had a specific case study that proved critical to understanding how to use Multiple Property Documentation to allow informal preservation in formal preservation practice.

Problem Statement

Currently in the United States, the demand for housing is at an all time high. Rental stock is at an all time low and new homes are not being built fast enough to match the rate at which they are being demanded². This was a trend in the US before the 2020 pandemic, which has only exasperated the problem.³ Without any more supply to supplement the market, housing prices soared. As difficult as it is to believe, however, building more houses is not the best solution.

While it resolves the need for more housing, the amount of carbon and energy required would be detrimental to the climate. One study suggests that the US needs approximately 5 million homes to help stabilize the current housing crisis.⁴ The carbon emission of constructing just one home is on average 55.1 tons of carbon.⁵ If the US were to build the 5 million homes needed, the endeavor would release 275 million tons of carbon into the atmosphere. This does not even begin to incorporate the embodied carbon of the 5 million homes. Embodied Carbon, the hidden environmental tax that is associated with every aspect of doing anything, includes the

²"The State of the Nation's Housing - 2019," Joint Center for Housing Studies of Harvard University, The President and Fellows of Harvard College: Boston, 2019.

³Ibid

⁴Diana Olick, "American is short more than 5 million homes, and builders can't make up the difference. September 2021, Accessed January 2022.

<https://www.cnn.com/2021/09/14/america-is-short-more-than-5-million-homes-study-says.html>

⁵Lloyd Alter, "The Carbon Footprint of a Renovation Vs. New Construction," Treehugger, October 2018, Accessed January 2022.

<https://www.treehugger.com/the-carbon-footprint-of-a-renovation-vs-new-construction-4857500#:~:text=According%20to%20the%20Guardian%2C%20the,house%20emitted%20only%2015%20tonnes.>

carbon emissions of transportation, material production, labor, operation, and demolition. It is the whole life cycle of a building and every ounce of carbon it could release from when the architect first turns on their computer to start drawings, until the building is torn down and ultimately replaced.

Some estimate that even a sustainably built home could still release carbon for up to 50 years after construction, releasing up to 5x the original amount of carbon.⁶ Adjusting for embodied carbon, building 5 million homes in the US would release 1.4 billion tons of carbon over the course of 50 years. Considering the world needs to be carbon neutral by 2050 to avoid the most devastating effects of climate change, it seems like climate change and providing housing are at odds. The environmental costs and actual costs would be astonishing.

This is where preservation can provide a source of sustainable, *and* affordable housing. Using a specific example in Portland, OR, the case study will demonstrate the impacts of incorporating embodied carbon studies in preservation, weighing the pros and cons of preservation and affordability.

Methods

A large portion of this study includes the examination of the “Small Houses” and uses contemporary building sciences to determine the extent of change that might occur in order for the building to be considered sustainable. Sustainable can be defined as a variety of things, usually with a strong connotation to environmentalism. Sustainable can be more than simply being good for the environment, it can relate to the longevity of something. A vast majority of the discussion will be the determination of whether some of these sustainable alterations are viable options in the intersection of affordability and preservation. Ideally the sustainable option

⁶ Tobias Roberts. “Embodied Energy in the Home,” Build with Rise, April 2020, Accessed January 2022.
<https://www.buildwithrise.com/stories/embodied-energy-in-the-home>

is also the best option for preservation due to its consideration to expanding the lifecycle of a building.

This is where the importance of a good context statement shows its importance, as it will help determine what the neighborhood could evolve into, based on what it used to be. Similar to determining what are character defining features of a building for the National Register, the historic context statement will determine what are the character defining features of the neighborhood.

The field survey was conducted to determine where the Small Houses are located and their current condition. Notes were made on the survey, such as “very clear example of SH [Small Houses] characteristics”, “difficult to see, refer to Sanborn Maps”, in order to make future data collection easier. A qualitative survey was intended but due to the scope of this research, it was determined unnecessary. The survey would have gathered community data about the neighborhood, but this would guide the study towards a more generalized discussion. By grounding the research in a historic context, paired with building science data, this study can be used alongside studies that look at urban planning, architecture and preservation in academic settings. The field survey relates this study to a specific location, bringing nuance to academic discourse, especially instances using embodied carbon as a lens.

The field survey is mostly valuable in determining the current conditions of the Small Houses. Building sciences then helped understand how the current conditions can be and should be altered. To understand building sciences and the relationship to climate change, quantitative data is important to give values to these topics. The projected r-values of insulation, and potential electrical power gain of solar panels can only really be understood with numbers, which will ultimately be tied to an economic figure. This is primarily how the topic of affordability can be

quantified; a cheaper cost means greater sense of affordability. To consider the economics of a preservation and sustainability project without considering the financial implications is lacking in morals, as it's creating assumptions that are no longer accurate due to the increased rate of inequality in the United States.

Quantitative data allows three diverse topics to come together, have a common ground, and to speak the same language. It also makes it easier as a researcher to tie the topics together for the reader to understand. The meaning for the quantitative data, however, comes from qualitative data which will come from studies regarding the health, happiness, and social aims of similar case studies.

Data Analysis

The data used in this research is a mixture of qualitative and quantitative data. This is due to the nature of this research, using both contemporary sources and calculations for embodied carbon, and historic information that can only be interpreted with qualitative means. The nature of the research that is cited in this paper is also a mixture as sources were a mixture of primary historic documents which as water permits which would need interpretation, and more scientific carbon emission calculations conducted using software.

The analysis uses a range of lenses and is overshadowed by the researcher's experience as an architect. Most of the building science data stems from the researcher's past experience in the architecture and construction industries, but then uses historic building science data to understand how the Portland Small Houses have possibly changed over their 100 year history. This is done to try and be as accurate as possible, without being able to view the houses in person.

There was a significant lack of data that would have proven immensely helpful. The lack of data meant looking at other sources that could provide answers, i.e. referring to historic building science practices. The lack of data can be related to the historic context and stems from the lack of history related to lower income housing in Portland. The lack of information and data is telling, and while challenging, offers so much potential, it becomes exciting. To supplement missing data, historic water permits and 1930's census data was explored and proved to be rewarding in the information they provided, specifically in regards to the lives of the people who lived in these homes during the Great Depression.

CHAPTER 2

HISTORIC CONTEXT STATEMENT

Introduction

The Portland Small Houses are located in the south west part of the Cully Neighborhood and the eastern edge of the Beaumont Wilshire Neighborhood. The area is between NE 42nd st and NE 63rd st, and between NE Fremont St. and NE Prescott St. This area was not incorporated into the City of Portland until at the earliest 1931 and as late as the 1980's according to Portlandmaps (Figure 2.25). Until the 1980's, this area was a mixture of agricultural, industrial, and residential; urban, suburban, and rural; modern, traditional, and a mixture of both. Settlement in this area was driven by the foreign-born immigrant population, the desire for a dense and zoned city, and the introduction of the streetcar to the east edge of the area of study, creating a streetcar neighborhood.⁷

Many of the homes in the area of study today were built between the 1910-1960's. Most of the activity occurred in the 1920's when there was a housing boom in Portland, due to increasing population. This is when the Portland Small Houses were constructed. This makes the Small Houses unique, as these homes would not have undergone planning review under the City of Portland Jurisdiction. As seen in the "Annexation by Decades" map, provided by the City of Portland, the area of study was partially annexed in 1931 and later in 1980, prior to when many of the Small Houses were built. This is important to note because it will impact the access to primary sources and has added additional places that could hold important information. Instead

⁷ Carl Abbott, "Settlement Patterns in the Portland Region: A Historical Overview," *Portland Regional Planning History*, (1994).

https://pdxscholar.library.pdx.edu/oscdl_planning/10/?utm_source=pdxscholar.library.pdx.edu%2Foscdl_planning%2F10&utm_medium=PDF&utm_campaign=PDFCoverPages

of just consulting the City of Portland archives, the Multnomah county archives was also explored.

The Portland Small Houses are noted for their distinct form and location on their lot. Most of the houses surrounding the Small Houses are centered on the lot, with a very standard and regular front setback of 20 ft and the minimum side setbacks of 7 ft. The Small Houses are built to the side of the lot, towards the rear, and have a more boxy form as they are squat and only have one story. They are technically craftsmen in style but they are decorated very simply and show very little ornamentation regardless of specific “style”. Compared to their surroundings, they seem very out of place.

One reason for the houses’ location on their lot is that the Small House owners built these homes as a placeholder, with the intention of building a better house once there was more money. Small Houses would then get converted into garages or work sheds. This is evident on Sanborn maps. Properties that showed what appears to be a Small House in 1928, showed the same footprint in the same place, with the addition of a larger building in front of the original structure. This is based on the 1950 Sanborn Maps, and is still the case based on contemporary mapping. Permitting would then show records of this home as being built in the 1930’s or 1940’s, dates that are out of the period of time when most Small Homes were built.

One such example is 5740 NE Prescott St, formorally 1534 Prescott St. The 1928 Sanborn map shows a Small House-like structure on the lot and the 1950 Sanborn Map (Figure 2.24) shows the same lot with a new structure, reportedly built in 1947⁸. This follows the idea that people in this area intended to replace their Small Houses. The ones that remain today might really be symbolic of unfulfilled potential and hopes.

⁸ “5740”, PortlandMaps, The City of Portland, Accessed May 2022.
https://www.portlandmaps.com/detail/property/5740-NE-PRESCOTT-ST/R237918_did/#

Due to the seemingly temporary nature of the Small Houses, it is remarkable that these structures are around 100 years old. These Small houses are around 600-800 square feet. This is, on average, smaller than most of the surrounding structures which have bigger footprints and more than one stories. It would seem reasonable to demolish these homes and replace them with something larger and more in demand.

The Small Houses are wooden framed with originally wooden siding that has either been maintained or replaced with vinyl siding. They are all originally one story, with the exception of small houses that have undergone renovations (5136 NE Mason St. & 4129 NE 49th Ave). In Chapter 3, the historic building sciences are considered when exploring environmental adaptations to the Small Houses. This is using qualitative data to understand how it might impact the quantitative data gathered to compare different sustainability options.

Context and Themes

Due to the uniqueness of the Portland Small Homes; unique due to their form, location, and purpose; it was difficult to find specific information on this typology. This is because of a lack of permitting information with the county, a lack of photos of the properties as it was a typical residential neighborhood, and first person testimonies were not collected as a part of this research. The combination of a growing population and expanding wealth gap, expanding transportation methods, and introduction of zoning code contributed to the typological development of the Portland Small Houses.

The homes were primarily built in the 1920's, which is odd since this is considered a time of great prosperity and wealth in the US. The construction of these Small Houses somewhat contradict this perception and could express the underlying wealth inequality that was pervasive

in the 1920's in Portland, OR (Figure 2.1).⁹ From 1920-1929, "The West" represented most of America's economic wealth, stemming from gold, oil and agriculture; drawing in thousands of people to migrate westward from the Mississippi.¹⁰ Portland, OR, in particular became home to many immigrants and white settlers from the East Coast. It is important to note that there was a proportionally small, but notable African American population in Portland at this time, but due to institutionalized, legislative racism, only 2,000 Black people lived in the whole state by 1920¹¹. Based on the 1930 census data for this area, no African Americans lived in this area. Research conducted by Hannah Mellor in their terminal project, *Demolition and Preservation in the Albina District of Portland, Oregon*, shows that the African American population of Portland primarily resided in the Albina district, located to the west of this research area of study, and in southeast Portland. This information allows us to view the area of study as primarily white, likely newcomers to Portland who either lived on the east coast for a few generations or were white immigrants from Europe and Canada. Using 1930's census data to confirm this, all of the inhabitants of the Portland Small Houses were first generation Portlanders, with many of their children representing the first generation born in born.

The area of study was greatly influenced by the Portland City and Suburban Railway, a network of streetcars that connected neighborhoods east of the Willamette river to Downtown Portland west of the river¹². Based on Carl Abbott's map of Portland streetcar ridership map of

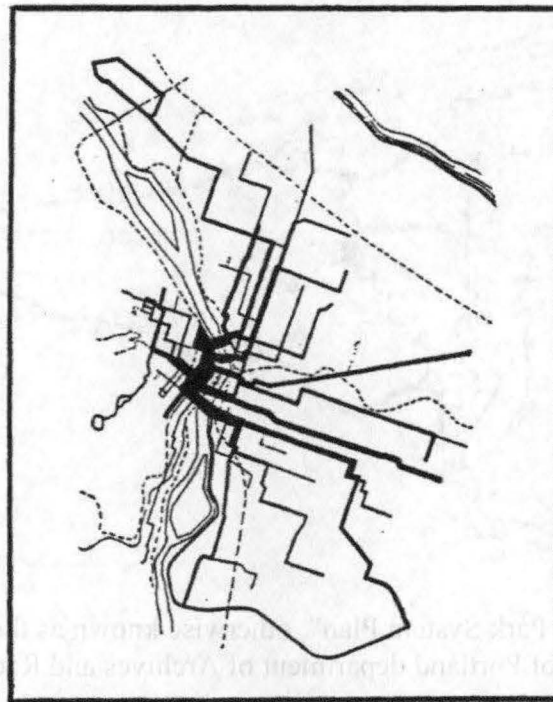
⁹ Estelle Sommeiller and Mark Price, "The New Gilded Age," *The Economic Institute*, July, 2018, <https://www.epi.org/publication/the-new-gilded-age-income-inequality-in-the-u-s-by-state-metropolitan-area-and-county/#epi-toc-6>

¹⁰ Carl Abbott, "Settlement Patterns in the Portland Region: A Historical Overview," *Portland Regional Planning History*, (1994). https://pdxscholar.library.pdx.edu/oscdl_planning/10/?utm_source=pdxscholar.library.pdx.edu%2Foscdl_planning%2F10&utm_medium=PDF&utm_campaign=PDFCoverPages

¹¹ Alana Semuels, "The Racist History of Portland, the Whitest City in America," *The Atlantic*, July 22nd, 2016, Accessed May 2022. <https://www.theatlantic.com/business/archive/2016/07/racist-history-portland/492035/>

¹² Richard Thompson, "Portland Streetcar System," *Oregon Encyclopedia*, March 17th, 2018, accessed May 2022. https://www.oregonencyclopedia.org/articles/portland_streetcar_system/#.YnBrY9rMKUI

the 1920's (Figure 2.1), 1920's suburban developments moved eastward because of its relative flatness compared to the hills of west Portland. In the evaluation of census data gathered, many of the residents in the Portland Small Houses worked at the waterfront or in downtown industrial areas, thus likely used the streetcar to commute to work. The lack of driveways in the yards of the area of scope confirms this. Virginia Savage McAlester identified this as a characteristic of "Streetcar Suburban Streetscape."¹³ Based on the Sanborn maps, the driveways that are seen today were likely added after the 1950's when cars would have been more accessible, coinciding with the decline of the Portland interurban rail in the mid 1940's.¹⁴



Streetcar Ridership in 1920

Figure 2.1 Streetcar Ridership in 1920 in Portland. Map is from Carl Abbott's research on the history of settlement in the Portland Region

¹³ Virginia Savage McAlester, *A Field Guide to American Houses (Revised)* (New York: Knopf, 2015) p/69

¹⁴ "Portland's Interurban Years," TriMet, accessed June 2022, <https://trimet.org/history/newinterurban.htm>.

This development of Portland, sprawling outwards from the Willamette River west and eastwards led to development of the first planning Commission formed by seven volunteers in 1918, later to become the Bureau of Planning.¹⁵ Portland was undergoing its *City Beautiful* movement, characterized by the Bennett Plan in 1914, followed by the Cheney Plan in 1921; a plan of major traffic streets, boulevards and park systems to address growing traffic and congestion problems (Figure 2.2).^{16 17}

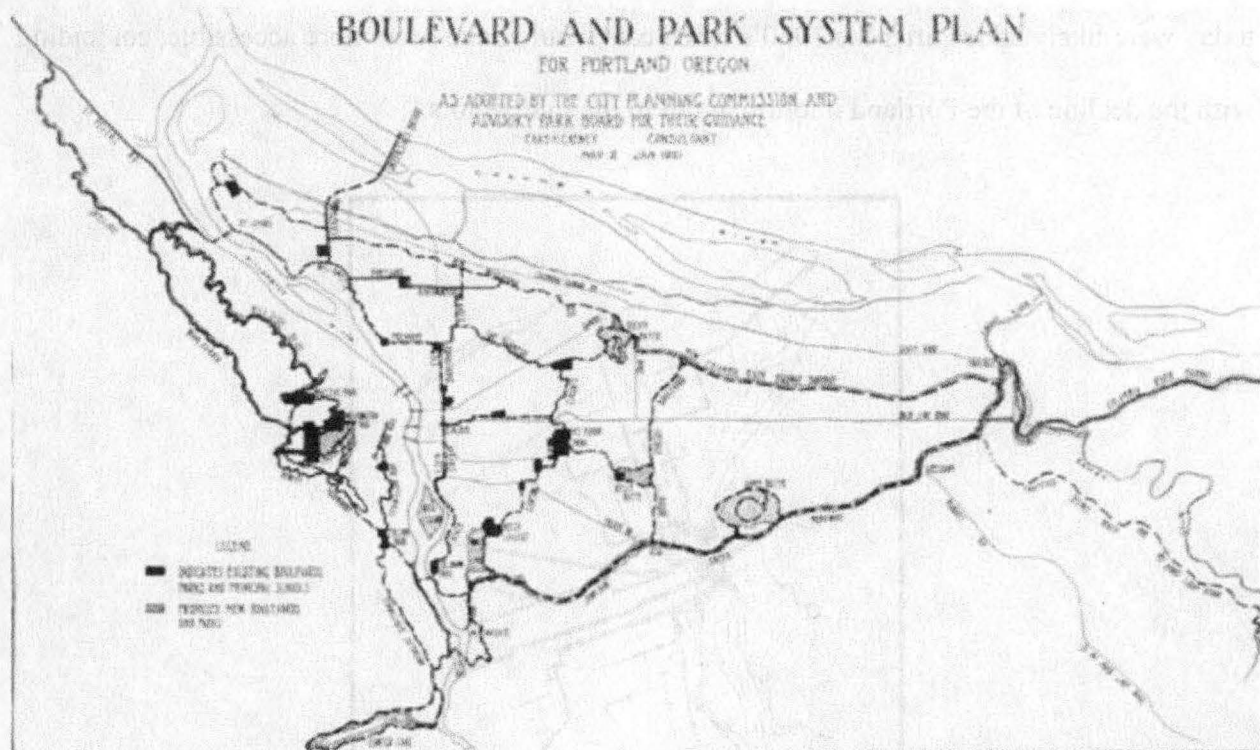


Figure 2.2 “Boulevard and Park System Plan”, otherwise known as the Cheney Plan, 1921. Accessed through the City of Portland department of Archives and Record Management.

“Portland is the most idealistic city in the world, I believe; let’s keep it so” - Mr. Flegel, 1920 on Portland Zoning laws

¹⁵ “1902 to 1952 Archives & Record Management,” The City of Portland Archives, Accessed May 2022, <https://www.portlandoregon.gov/archives/article/284517>

¹⁶Ibid

¹⁷ The Bureau of Planning, the City of Portland, “East Portland Community Plan Project Summary Report,” August 25th, 1997, page 54.

A new tool in urban planning theory was emerging at this point: *Zoning*. Previously, zoning had only been used experimentally in places like New York, Chicago, and St. Louis.¹⁸ As early as 1916, Portland was pushing for zoning laws that would separate the town into three distinct types of building uses, separating residential, business, and industrial zones.¹⁹ Within these zones, there were sub zones that allowed for multifamily apartments, mixed use buildings, and light industrial manufacturing (figure 2.3).²⁰ Many arguments were used to support a zoning system, mostly relating to moral uprightness, protection of realty values, and for no other reason than why not. Some of the reasonings were likely coded. “Business Houses close to residence sections [are] declared to have [a] bad effect on children, as have dance halls and movies,” according to Professor Hastings in his original call for zoning in 1916.²¹ Using zoning as a way to separate different classes would explain why proponents of zoning believed that dance halls and movies would morally corrupt the youth. In a time of great social upheaval, control was key. “No city that has once tried zoning regulations has ever abandoned them, so far as we can find,” cried the Portland City Planning Commission in the newspaper in 1920.²² The Planning Commission went so far as to place ads in the newspaper, declaring that if you care for your home, you would “Save your Homes! Vote 500 X Yes,” claiming that zoning will protect the homeowner’s property value.²³ In light of the housing boom that was occurring at this time, many people would have been motivated to protect their costly investment. Newspaper ads at this time advertised homes for \$3,300; roughly \$47,000 today,²⁴ a steal by today’s standards but a weighty investment to newcomers in Portland.

¹⁸ Hudson B Hastings, “Building Control by Zones Favored,” *The Sunday Oregonian*, (Portland, OR), Dec. 17th, 1916.

¹⁹ Ibid

²⁰ Ibid

²¹ Ibid

²² “Building Act Urged on Homeowners,” *The Sunday Oregonian*, (Portland, OR), October 31st, 1920

²³ “Save Your Home,” *The Sunday Oregonian*, (Portland, OR), October 31st, 1920.

²⁴ “Four Room Bungalow at Popular Price,” *The Oregon Journal*. October 2nd, 1921.

Opposition to these zoning laws felt that zoning would give the City of Portland too much oversight, which would be impossible to adequately oversee. It was also considered speculative that “the zoning system [was] declare[d] that it will prove a stabilizer of property values and insure investors against loss.”²⁵ Supporters of zoning were considered “idealists and dreamers”, considering zoning something that would be unachievable.²⁶ The City of Portland Planning Commission had already proposed a zoning ordinance in 1919. The ordinance was defeated 30,631 to 30,085 (546 votes) and branded a “long-haired attempt to invade private enterprise”.²⁷ It was not until 1924 that the first zoning code was passed. Written by the planning commission and the Portland realty board it contains four zones 1) single family residential, 2) single family or multi-family residential, 3) general business/light manufacturing, 4) unrestricted. No height restrictions are proposed. The collaboration between the government entity and business interest group proved to be the coalition that was needed to get the legislation passed.²⁸ This will forever link planning and business entities in Portland, manifesting into Security Maps and Redlining in the 1940’s and 1950’s.²⁹

²⁵ “Chamber Factions Debate on Zoning,” *The Sunday Oregonian*, (Portland, OR), Feb. 1920.

²⁶ Ibid.

²⁷ <https://www.portlandoregon.gov/archives/article/284517>

²⁸ <https://www.portlandoregon.gov/archives/article/284517>

²⁹ Richard Rothstein, *The Color of Law*, (New York: Liveright Publishing Company, 2017) p. 45

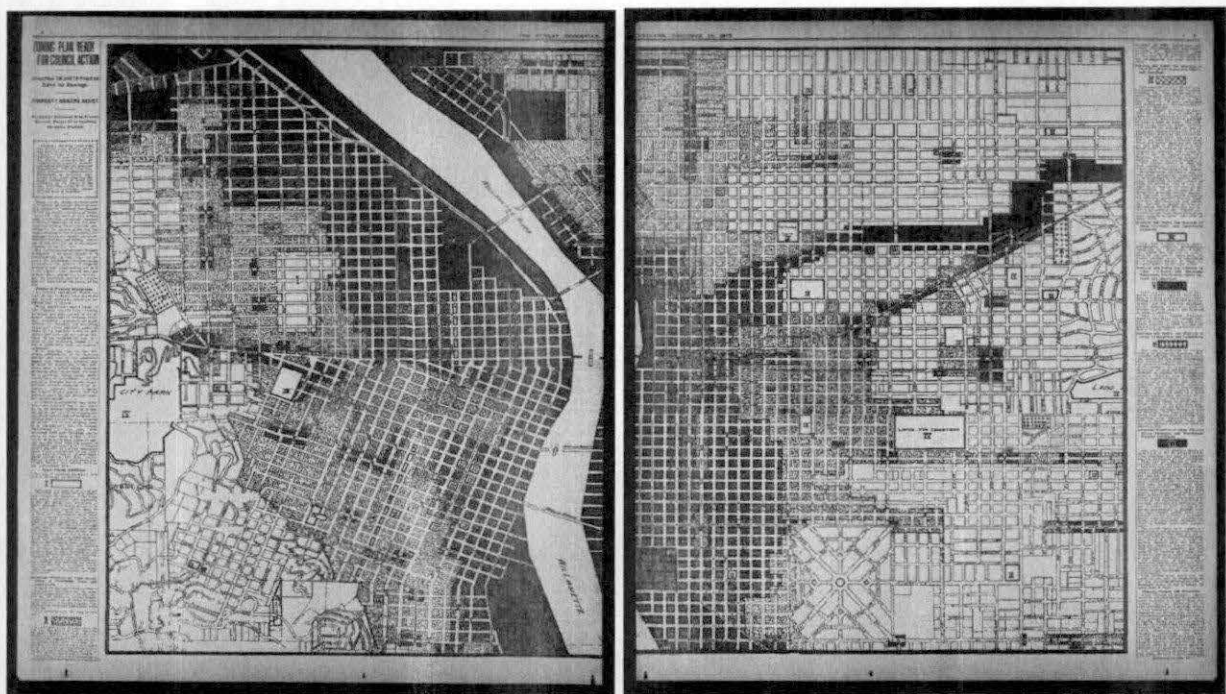


Figure 2.3 Double page spread of the proposed zoning boundaries, zones, and subzones in Portland. Published in *The Sunday Oregonian*, December 14th, 1919.

The impact of this on the Portland Small Houses is slightly speculative. The region of Portland that this type of home is found was not incorporated into the City of Portland until the 1930's, or as late as the 1980's (figure 2.23). The lots were developed circa 1922, but inhabited prior to this, as understood by the area of study map developed by the author (figure 2.21). Under the county jurisdiction, oversight would have been minimal and cheap development could have been achieved. The Portland Small Houses don't necessarily break code as there was no equivalent "code" in the way that is understood today for that area of Portland. According to some sources, after this area was incorporated under the jurisdiction of Portland, the homeowners were sued for their homes not aligning with the "look" of the neighborhood. This has yet to be substantiated, ideally with future research. One reasonable explanation for electing to build here meant less competition with in-demand lots and existing homes. Lots outside of the

city jurisdiction would be cheaper but being in this specific location would mean proximity to work in the city via the Portland Interurban.

Boundary

The boundary area is mostly based on where the most properties could be found in close proximity to each other. Photos were collected on a field survey, conducted on the 31st of October, 2021. photos of homes that were identified using Google maps and the 1929 and 1950 Sanborn Map helped solidify the area of study. This specific area is of interest as it was unincorporated but developed land prior to the establishment of zoning, while also maintaining a strong connection via transportation.

Several of these properties in this survey reside within the Calman subdivision, such as 4621 NE Beech St. and 4605 NE Failing St. It should be noted that the plat map is assigned and approved by the county commissioners in Multnomah county rather than under the jurisdiction of the City of Portland. This is due to the fact that this area was unincorporated by Portland. This was one of the clues that help give context to the area. Stemming from the intense housing boom, the need for developed land meant moving to more rural settings. This is a trait in American cities that is fairly common in the early 20th century.³⁰

³⁰ Virginia Savage McAlester, *A Field Guide to American Houses (Revised)* (New York: Knopf, 2015).

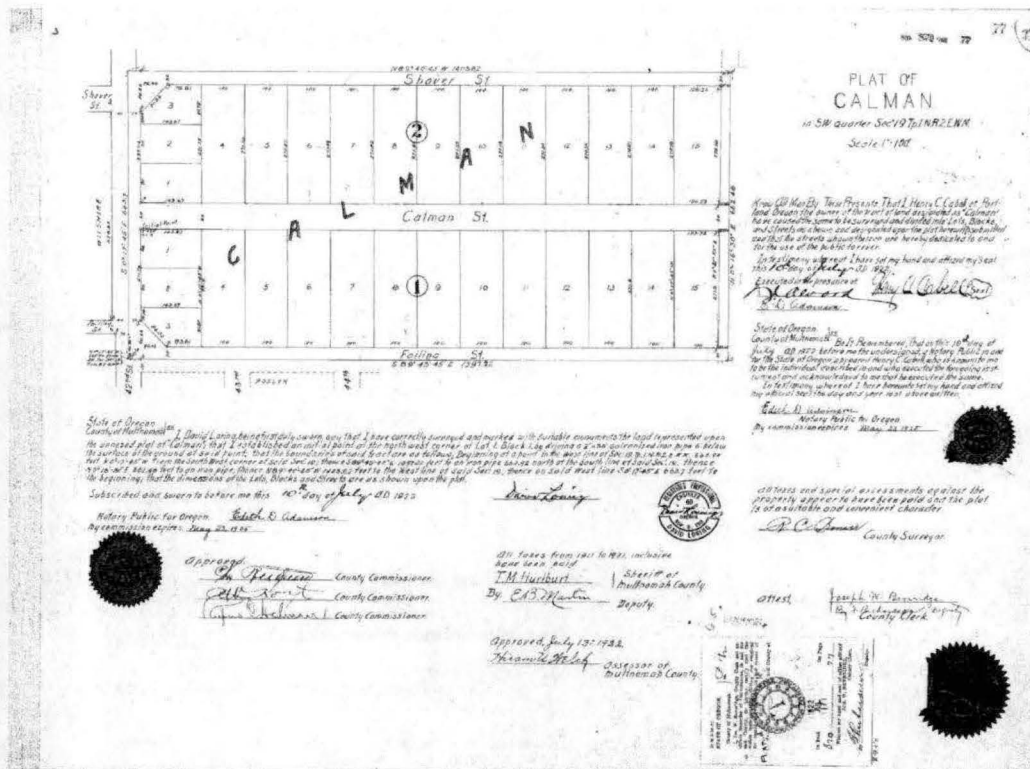


Figure 2.4. Plat Map of the Calman Subdivision, approved July 10th, 1922 by the county of Multnomah. Accessed through the Multnomah County Survey and Assessor Image Locator.

A street map from 1931 shows the widening of NE Prescott to NE Shaver St., noting that the street plans were approved by the Council of the City of Portland, thereby establishing “that Prescott Street, within the city limits, from East 42nd St to the easterly city boundary.”³¹ It was common for roads in the City of Portland to be widened, due to the increasing demands by automobile usage. Transportation will prove to always be a demand on city infrastructure,³² later with the creation of highways and light rails in the 1960’s and 1970’s. The establishment of this area of Portland heavily relates to the incorporation of transportation in the development of the built environment. The Opening, Laying-out and Establishing map (figure 2.5) shows the streets that were widened and established under city jurisdiction. This moves the easternmost boundary of the city of Portland to the western edge of what is today NE 52nd Ave. This would partially

³¹ The Bureau of Planning, the City of Portland, “East Portland Community Plan Project Summary Report,” August 25th, 1997, p.245

³² Ibid

explain the road configuration that causes a disconnect between NE Skidmore St and NE Mason St.; as well as the abrupt cut off to NE Campaign St. The grid east of the NE 52nd Ave boundary does not completely match the grid west of this line. It would not be until the 1980's that this area was wholly under Portland jurisdiction.

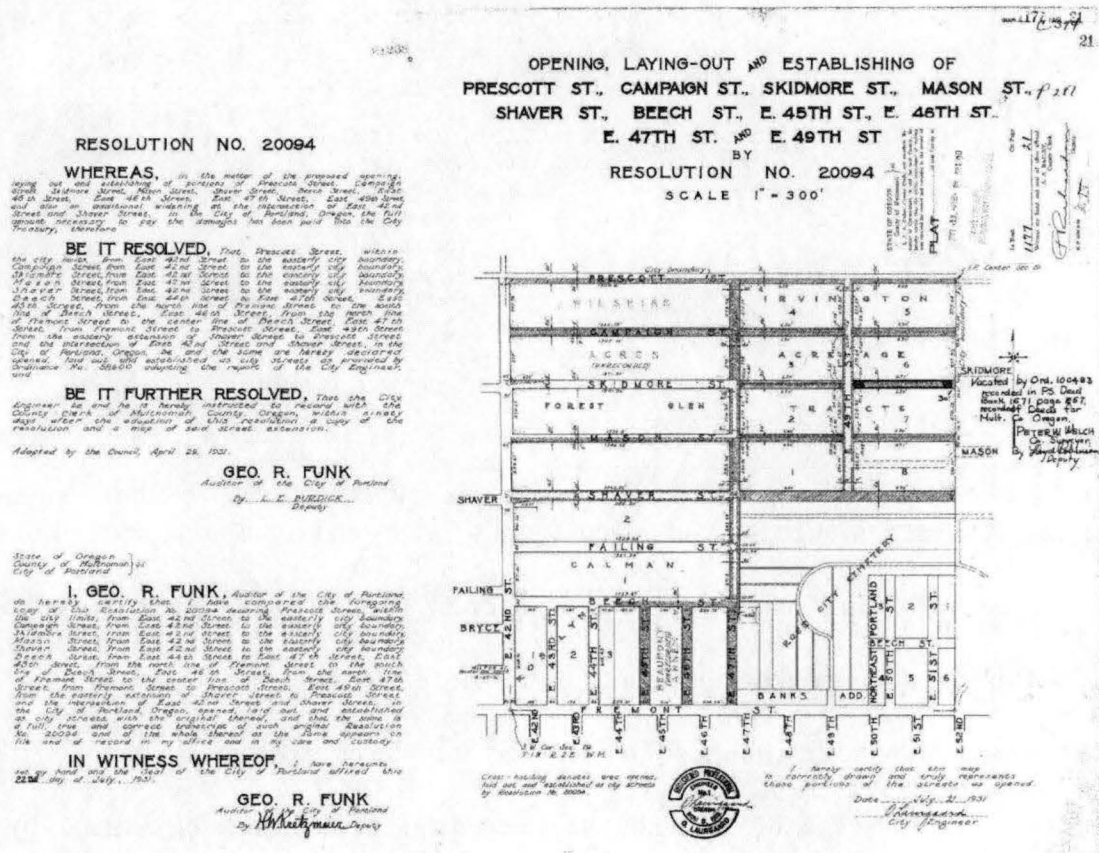


Figure 2.5. “Opening, Laying-Out and Establishing of Prescott St, etc.” plat map. Approved by the Council of the City of Portland on April 10th, 1931. Accessed through the Multnomah County Survey and Assessor Image Locator.

It is important to note the city boundary of 1931 would not be an effective boundary line as the Portland Small Houses could be found east of NE 52th Ave. Since most of the homes in question were built between 1922-1929, it would seem that the typology of this housing, in its small size and unregulated nature would thrive in unincorporated, but planned, land. This land

would be cheap and accessible, and have very limited regulations, making it easier to build homes that would otherwise not meet neighborhood standards.

Associated Property Types

The following properties were selected for this study due to their form, location, and overall contemporary identification as so named “Portland Small Houses.” Using vernacular theory laid out by Thomas Hubka in *Houses without Names*, it became clear that the identification process was more about the form and relationship the house has with the surrounding neighborhood. Hubka would consider these homes as “common”, despite how much they might seem *uncommon*. A “common house” is defined as a small to medium size house that were not designed or constructed by architects and builders for individual owners.³³ Based on this definition of a common house, the Portland Small House is indeed common, requiring a vernacular architecture lens to be brought to the identification process. The form, shape, materiality, and neighborhood development play more of a role in the identification process rather than the style or general level of integrity. The following structures exemplify the Portland Small Houses based on the historic context and the qualifications set out by vernacular architecture identification.

³³ Thomas Hubka, *Houses without Names* (Knoxville: The University of Tennessee Press, 2013), 7

4527 NE Beech St

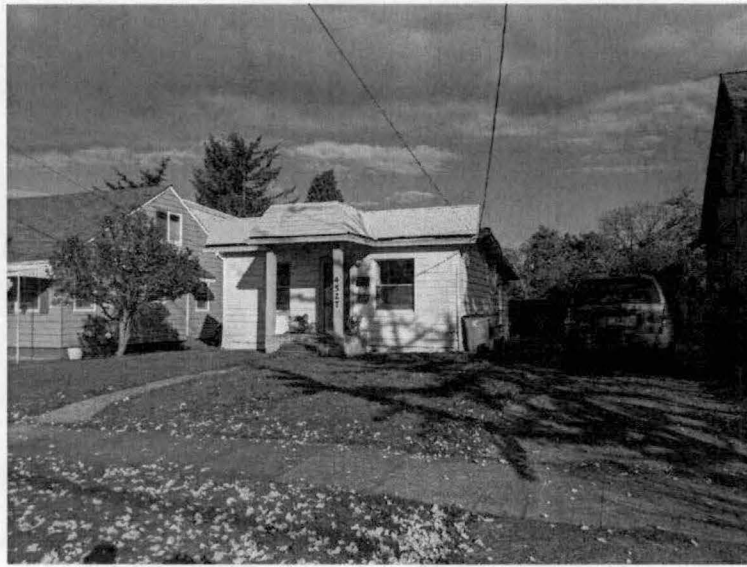


Figure 2.6. 4527 NE Beech St. Photograph by Author

4527 NE Beech st is located between NE Beech St. and NE Failing St., facing south towards NE Beech St. The house is slightly more than half way on the block between NE 42nd Ave. and NE 47th Ave. 4527 NE Beech St. sits on a standard lot that is 50 ft wide, but is slightly longer than most lots on its block. The lot is 8,200 sq ft and is a part of the Calman subdivision, platted in 1922 (figure 2.4).

The house was built in 1925 and had the historic address of 1273 Beech St. according to the Directory of Street and House Changes from 1933.³⁴ The house was constructed on a concrete foundation but contains no basement. Permit data shows that the house was connected to the city's central water system in 1944 (figure 2.7). Based on the plan shown below, the footprint of the building has not changed at least since 1944.

³⁴ *Directory, Street and House Changes, Portland, Oregon. [Part 1 and 2],* (Crane Direct-Mail Service: Portland, OR, 1933)

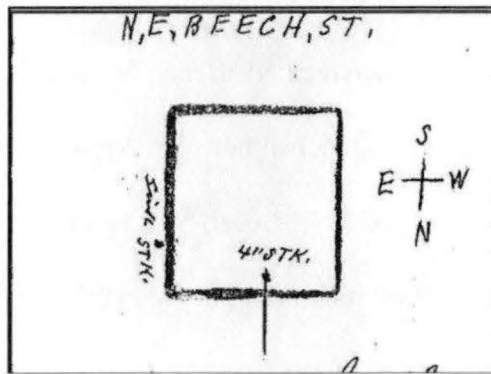


Figure 2.7. A hand drawn sketch of the building plan included with the water permit from 1944. Accessed from PortlandMaps.com

The owner of the home according to the 1930 Census was Berl Penny, a grain handler who worked on the waterfront. The proximity to the waterfront and downtown via streetcar would have made living so far east an affordable option for many families moving to Portland in the 1920's. Today, there is a garage and driveway while originally there was not, relating to how this neighborhood was primarily a streetcar neighborhood rather than a auto-oriented neighborhood.

4621 NE Beech St



Figure 2.8. 4621 NE Beech St. Photograph by Author.

4621 NE Beech St. is located between NE Beech St. and NE Failing St., facing south towards NE Beech St. The house is sandwiched between NE 42nd Ave. and NE 47th Ave, but significantly closer to NE 47th Ave. 4621 NE Beech St. sits on a standard lot that is 50 ft wide, but is slightly shorter than most lots on its block. The lot is 6,800 sq ft. This property is also a part of the Calman subdivision, created in 1922.

The house was built in 1927 and had the historic address of 1281 Beech St.³⁵ The house was constructed on a concrete foundation but contains no basement. Permit data shows that the house was connected to the city's central water system in 1929. Based on the plan shown below, the footprint of the building has changed significantly between 1929 and 1994 (figures 2.9). It is clear that the house was expanded to the west as the porch that is seen today is seen on the eastern corner of the drawn plans from 1929. This is confirmed by Sanborn maps from 1928.

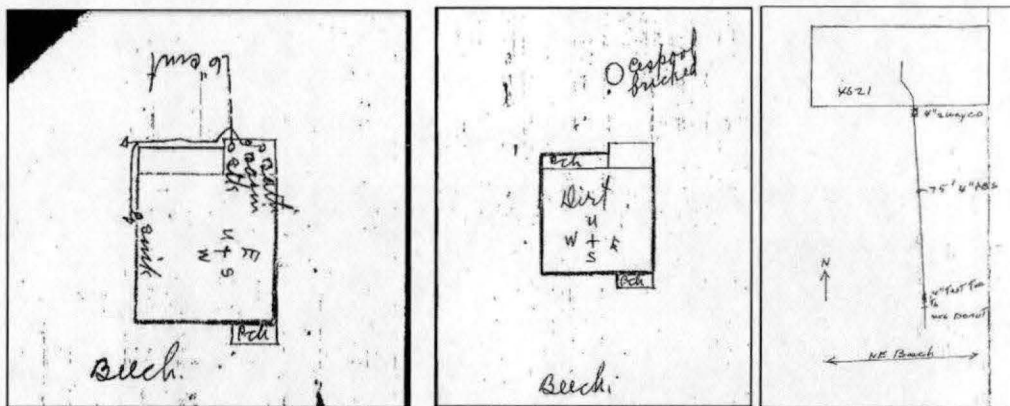


Figure 2.9. Leftmost image, a hand drawn sketch of the building plan included with the water permit from 1929. Accessed from PortlandMaps.com
Center image, a hand drawn sketch of the building plan included with the water permit from 1929. Accessed from PortlandMaps.com
Rightmost image, a hand drawn sketch of the building plan included with the water permit from 1994. Accessed from PortlandMaps.com

³⁵ Ibib

The owners of the home according to the 1930 Census was Frederick and Evelyn Hardt. Frederick was a first generation German immigrant who worked at a bakery. At the time, Portland had a sizable first generation German population.³⁶

4605 NE Failing St



Figure 2.10. 4605 NE Failing St. Photograph by Author.

4605 NE Failing St. is located between NE Failing St. and NE Shaver St., facing south towards NE Failing St. The house is sandwiched between NE 42nd Ave. and NE 47th Ave, but significantly closer to NE 47th Ave. 4621 NE Beech St. sits on a standard lot that is 50 ft wide, but the rear of the lot turns towards the west, forming an upside down “L” shape in plan . The lot is 8,825 sq ft.

The house was built in 1925 and had the historic address of 1279 NE Failing St. It should be noted that NE Failing St. was originally referred to as “Calman St.” as seen on the 1928

³⁶ Steven Schreiber, Heather Viets, “Volga Germans in Oregon,” *Oregon Encyclopedia*, April 2022, Accessed May 2022, <https://www.oregonencyclopedia.org/articles/volga-germans-in-oregon/#.YnMxN9rMKUk>

Sanborn Maps. The house was constructed on a concrete foundation but contains no basement. Water permit data shows that the house was connected to the city's central water system in 1965 (figure 2.11). This is quite late compared to other homes in the area. Based on the plan shown below, the footprint of the building has not changed since at least 1965.

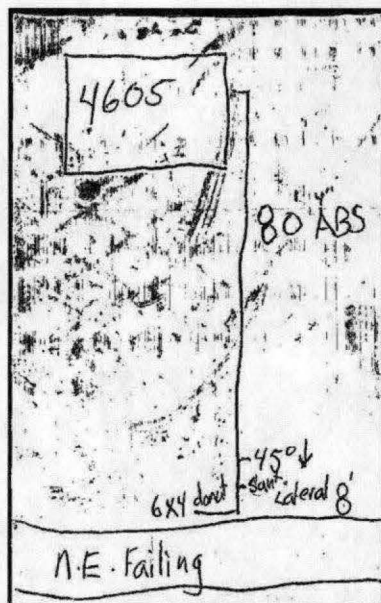


Figure 2.11. A hand drawn sketch of the building plan included with the water permit from 1965. Accessed from PortlandMaps.com

The owner of the home according to the 1930 Census was Mary Robinson of Missouri who stayed at home while her son Fred Robinson worked as a truck driver for the same bakery as their neighbor in 4621 NE Beech St. (previous property).

5117 NE Mason St



Figure 2.12. 5117 NE Mason St. Photograph by Author.

5117 NE Mason St. is located between NE Mason St. and NE Mason Ct., facing south towards NE Mason St. The house is sandwiched between NE 49th Ave. and NE 52th Ave, but significantly closer to NE 52nd Ave. 5117 NE Mason St. sits on a slightly narrower lot that is 35 ft wide. The rear of the lot is backed by an existing alley which is not common for most of the blocks studied in this survey. The lot is 4, 680 sq ft, which is on the smaller side in comparison to other lots in this area.

The house was built in 1924 and had the historic address of 1415 NE Mason St. The house was constructed on a concrete foundation but contains no basement. There are no historic permits that are available so when it was connected to the central city sewage system is unknown. Due to the overall form that is visible today, it should be noted that any alterations to the building footprint is unlikely.

The owner of the home according to the 1930 Census was Charles and Erma Parker. Charles was a workman at a milling company. Their household had a total of six people, making the 732 sq ft house very tight.

4541 NE Failing St.

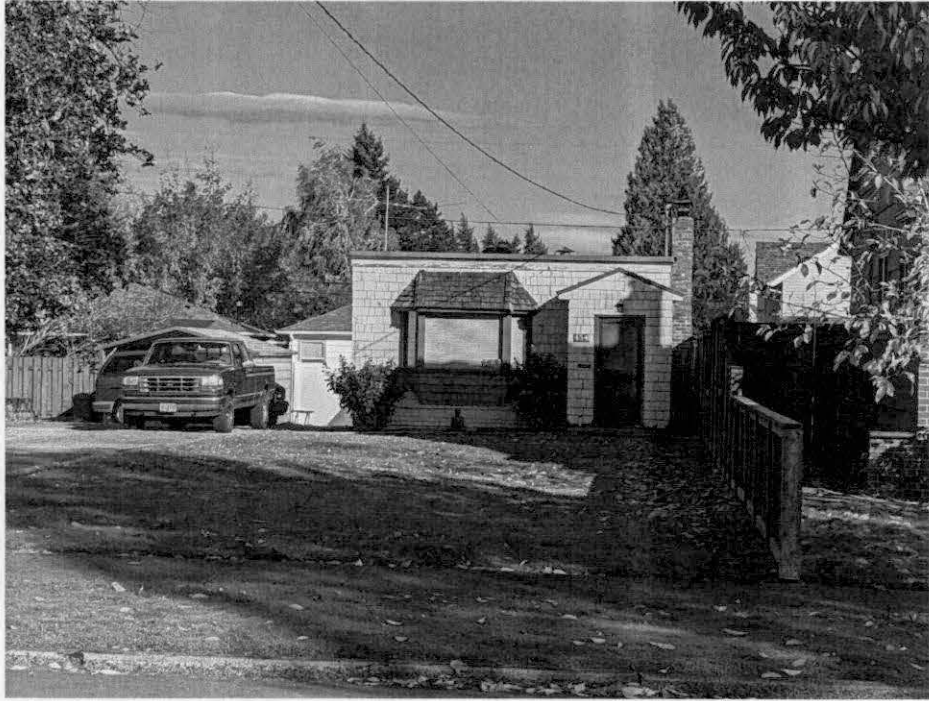


Figure 2.13. 4541 NE Failing St. Photograph by Author.

4541 NE Failing St. is located between NE Failing St. and NE Shaver St., facing south towards NE Failing St. The house is sandwiched between NE 42nd Ave. and NE 47th Ave, but significantly closer to NE 47th Ave. 4621 NE Beech St. sits on a standard lot that is 50 ft wide, but is significantly shorter than most lots on its block. The lot is 8, 825 sq ft.

The house was built in 1925 and had the historic address of 1277 NE Failing St. The house was constructed on a concrete foundation but contains no basement. Permit data shows that the house was connected to the city's central water system in 1955 (figure 2.14). Based on the plan shown below, the footprint of the building has not changed since at least 1955.

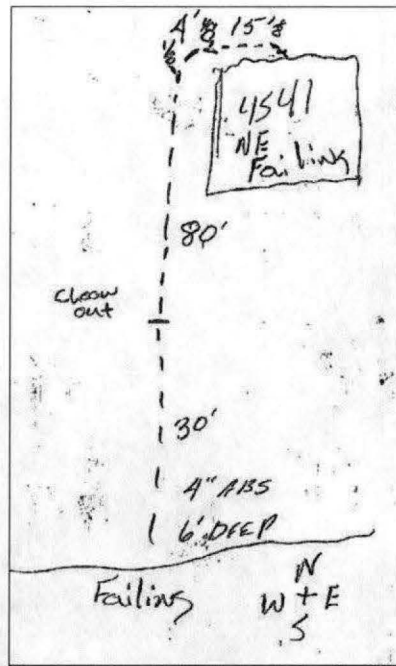


Figure 2.14. A hand drawn sketch of the building plan included with the water permit from 1955. Accessed from PortlandMaps.com

The owner of the home according to the 1930 Census was Ernest and Maude Desrochers, both first generation French-Canadians. Ernest Desrocher was a laborer at the waterfront docks. According to the water permit, the Desrochers lived in 4541 Failing St. until at least 1955. This is a good thing as it can lead to improved levels of historic integrity on the property.

5127 NE Mason St.



Figure 2.15. 5127 NE Mason St. Photograph by Author.

5127 NE Mason St. is located between NE Mason St. and NE Mason Ct., facing south towards NE Mason St. The house is sandwiched between NE 49th Ave. and NE 52th Ave, but significantly closer to NE 52nd Ave. 5127 NE Mason St. sits on a slightly narrower lot that is 35 ft wide. The rear of the lot is backed by an alley which is not common for most of the blocks studied in this survey. The lot is 4,680 sq ft, which is on the smaller side in comparison to other lots in this area.

The house was built in 1926 and had the historic address of 1422 NE Mason St. The house was constructed on a concrete foundation but contains no basement. Unlike many of the other Small Houses in this study, this property has an accessible attic, making it a 1.5 story building instead of 1 story like the other properties.

Permit data shows that the house was connected to the city's central water system in 1955 (figure 2.16). Based on the plan shown below, the footprint of the building has not changed since at least 1955. Due to this distinction, it's possible that this small house was not intended to be temporary housing, but rather emulate other small houses in the area and was simply viewed as an affordable housing option.

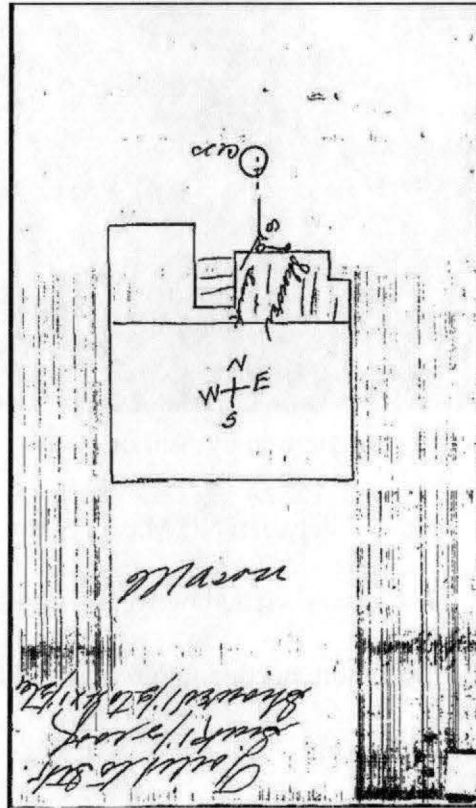


Figure 2.16. A hand drawn sketch of the building plan included with the water permit from 1940. Accessed from PortlandMaps.com

Census data from 1930 was unavailable for this property.

5211 NE Mason St.



Figure 2.17. 5211 NE Mason St. Photograph by Author.

5211 NE Mason St. is located between NE Mason St. and NE Skidmore St., facing south towards NE Mason St. The house is sandwiched between NE 49nd Ave. and NE 54th Ave, located roughly in equidistant from both north-south roads. 5211 NE Mason St. sits on a standard lot that is 50 ft wide, but is slightly longer than most lots on its block. The lot is 8, 825 sq ft.

The house was built in 1928 and its historic address was unavailable. This is likely due to the fact that this property is west of the NE 52nd Ave boundary that was established in 1931. This land was incorporated into the City of Portland prior to address changes. Sanborn Maps from 1928 and 1951 are unreliable sources of address for areas unincorporated into the city. The house was constructed on a concrete foundation but contains no basement. Permit information was also unavailable for this property, again, likely due to the house being in unincorporated land until the 1980's.

Census data from 1930 was unavailable for this property. Despite a lack of information about this property it needs to be noted that this property still displays key features of being a Portland Small House. It's one of the few examples from the area of Portland that was incorporated after 1980. It's an example of how little information there really is out there about these buildings.

4129 NE 49th Ave

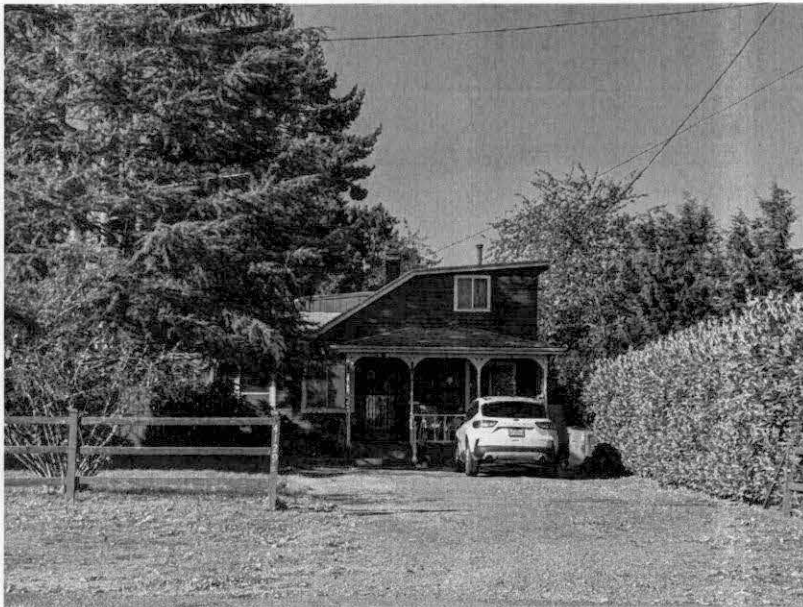


Figure 2.18. 4129 NE 49th Ave. Photograph by Author.

4129 NE 49th Ave. is located between NE Mason St. and NE Skidmore St., facing east towards NE 49th Ave. 4129 NE 49th Ave.. sits on a lot that is 54 ft wide, which is slightly larger but this is due to the property's orientation on the block, which is east-west rather than north-south like all the other properties. The lot is 6,210 sq ft.

The house was built in 1926 and had the historic address of 891 E 49th St. The house was constructed on a concrete foundation but contains no basement. Permit data shows that the house was connected to the city's central water system in 1948 (figure 2.19 & 2.20). Based on

the plan shown below, the footprint of the building has changed significantly and multiple times since 1948.

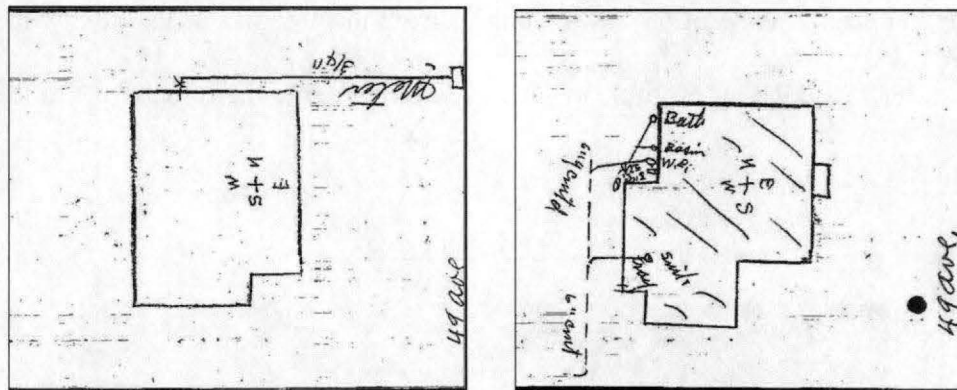


Figure 2.19. Leftmost image, A hand drawn sketch of the building plan included with the water permit from 1948. Accessed from PortlandMaps.com
 Leftmost image, A hand drawn sketch of the building plan included with the water permit from 1949. Accessed from PortlandMaps.com

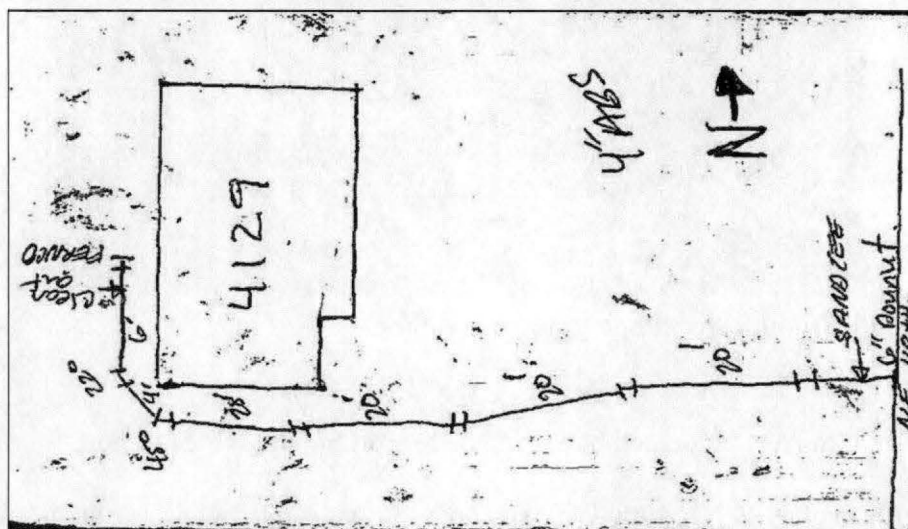


Figure 2.20. Leftmost image, A hand drawn sketch of the building plan included with the water permit from 1993. Accessed from PortlandMaps.com

The water permit from 1948 reflects the addition of metered water to the home, whereas the water permit in 1949 reflects a change in the footprint of the home, likely due to an addition of a bathroom, as noted by the word “bath” written on the plan. There is a third permit from

1967, but does not note any change to the building footprint. It does show that the owner for the property has remained the same 1948 until 1967, an Emily Davenport.³⁷

The owner of the home according to the 1930 Census was Charles and Mary Reynolds, first generation immigrants from Northern Ireland and Scotland. Charles Reynolds was a carpenter and Mary Reynolds was a factory worker.

Chart 2.1: Charted Integrity of Portland Small Houses

Current Address	Historic Address	Year Built	Size (SF)	Aspects of Integrity						
				Location	Setting	Design	Materials	Workmanship	Feeling	Association
4527 NE Beech St.	1273 Beech St	1925	720	High	High	Mid	Low	Low	Mid	Mid
4621 NE Beech St.	1281 Beech St	1927	812	High	High	Mid-High	Mid-low	Low	Mid	High
4605 NE Failing St.	1279 Failing St.	1925	270	High	High	High	Mid-low	Mid	Mid	High
5117 NE Mason St.	1415 Mason St	1924	732	High	Mid	High	Mid	Mid	High	Mid
4541 NE Failing St.	1277 Failing St	1925	612	High	High	Low	Low	Low	Low	High
5127 NE Mason St.	1422 Mason St	1925	912	High	High	High	Mid	High	Low	Mid
5211 NE Mason St.	n/a	1928	891	High	High	Mid	Mid	Mid	Low	Low
4129 NE 49th Ave	891 E 49th St	1926	793	High	High	793	Mid	Mid	Mid	Mid

This chart is helpful in understanding the levels of integrity of each Portland Small House. This is important in regards to formal preservation. The most common features that have the highest levels of integrity are in relation to location, setting, feeling, and association. Regardless of material and craftsmanship integrity, the Portland Small House is still recognizable. The importance of this is discussed in chapter 3.

³⁷ Water permit, for 4129 NE 49th Ave. for 1967

Significance

The significance of this historic context is hopefully helpful in exploring future research in this topic. Despite the lack of information, likely due to the fact that the Portland Small Houses was housing for low-income occupants. That makes this research and future significant as it is shedding light onto a topic that is not commonly discussed.

This research could lay the groundwork for a future multiple property document that then could provide formal preservation paths for homeowners wanting to preserve their historic homes. It can also change perspectives on what can and should be preserved, hopefully allowing for more nuanced formal preservation practices. Considering the changes on the building scale will be discussed in the next chapter, but the overall general history of each home is important to note as it impacts the sustainable adaptations that can be done.

On a larger scale, understanding the neighborhood context means that any future development can ideally be done with sensitivity and consideration to the history. This will be discussed to a greater extent in chapter 4, but the significance of this history is important to note in relation to the individual homes. It gives reasons for the Portland Small Houses locations and their location on their respective lots.

Appendix 1



Figure 2.21 Map of Area of Scope showing homes based on the decade they were built. Map developed by the author using data from Portland Maps

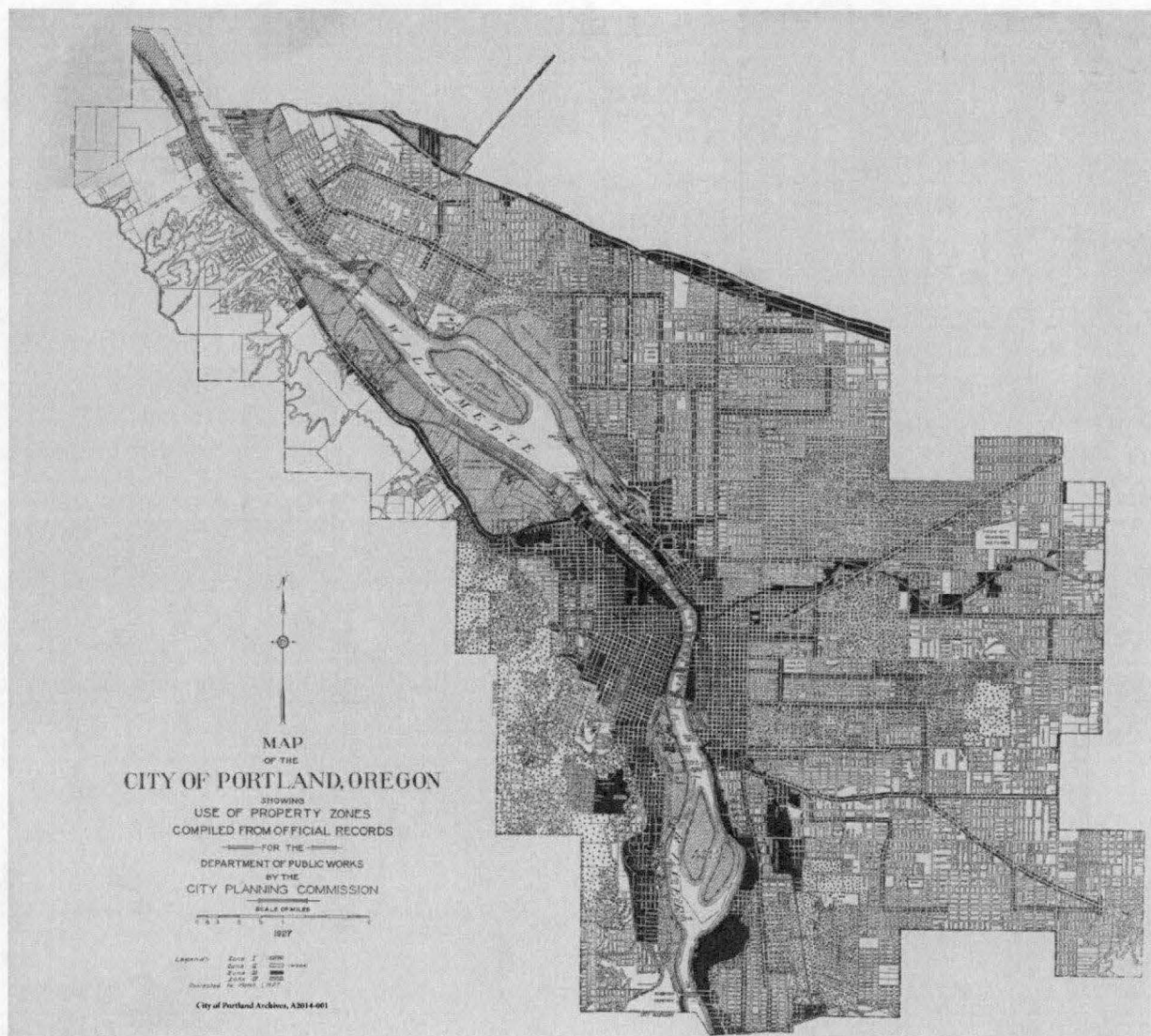


Figure 2.22. Zoning Map of the City of Portland, 1927. Map provided by Susan Nelson, local historian for the Cully Neighborhood.

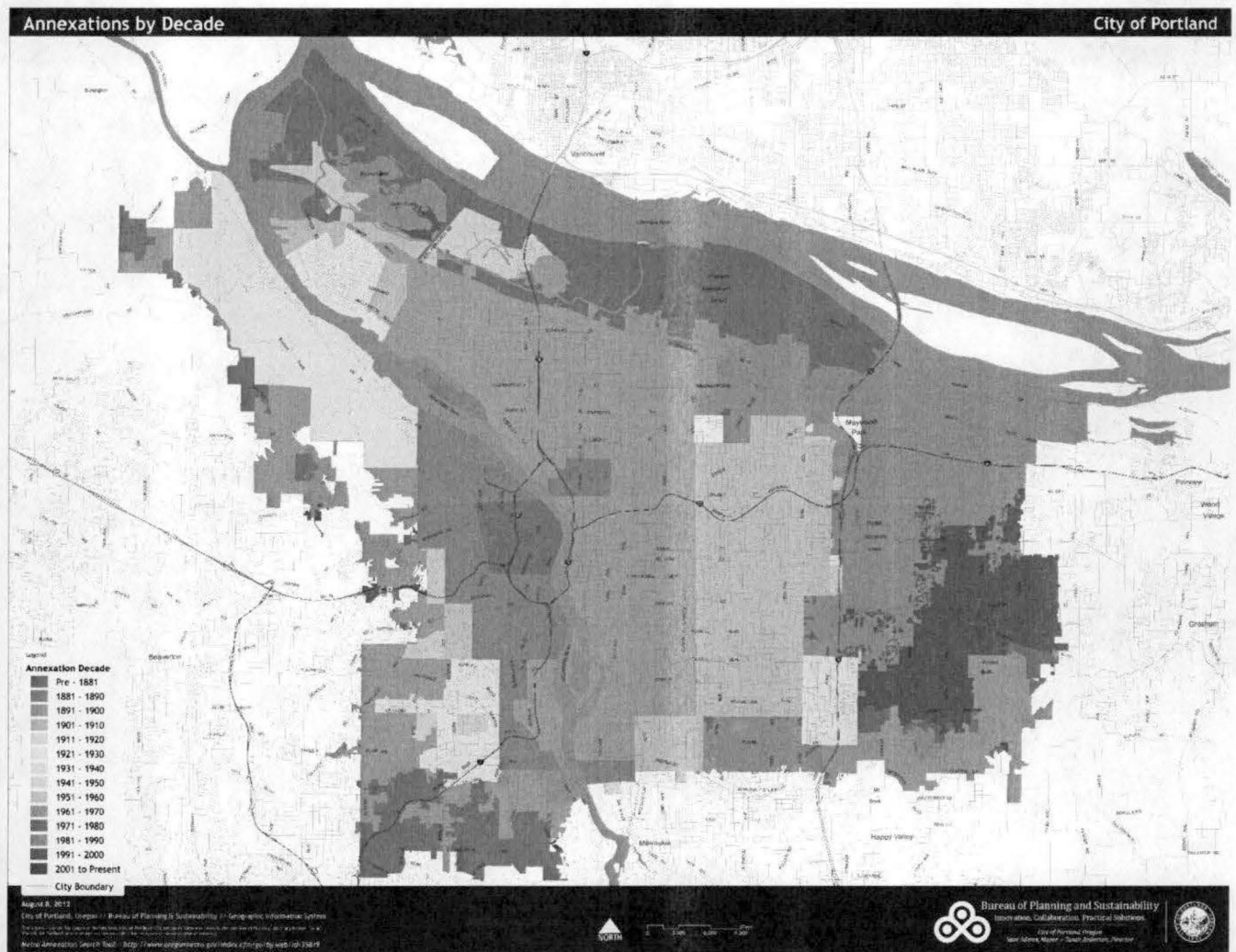


Figure 2.23 - Annexation map of Portland, provided by Susan Nelson, a local historian for the Cully neighborhood.

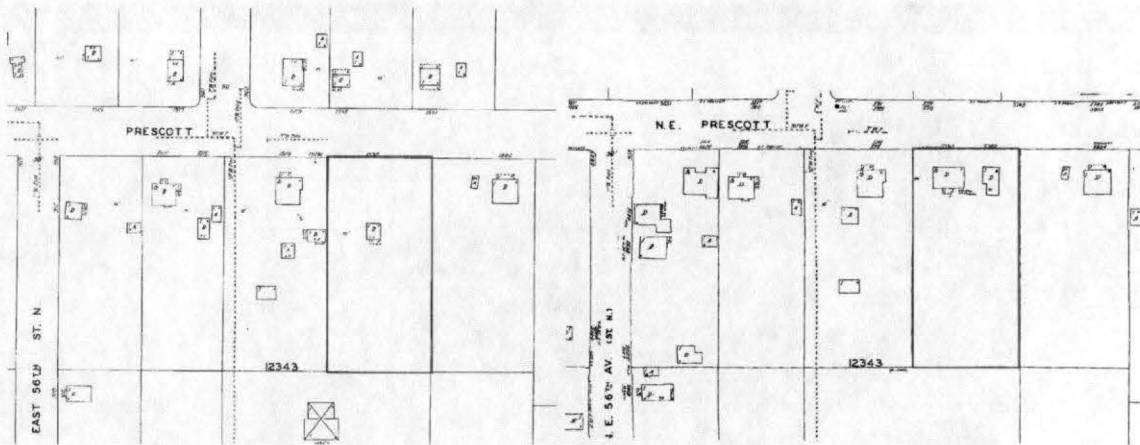


Figure 2.24 - 1928 Sanborn Map (Left) and 1951 Sanborn Map (Right) of a property within area of scope, property is outlined in red



Figure 2.25 - PortlandMaps image of a property within area of scope, property is outlined in blue.

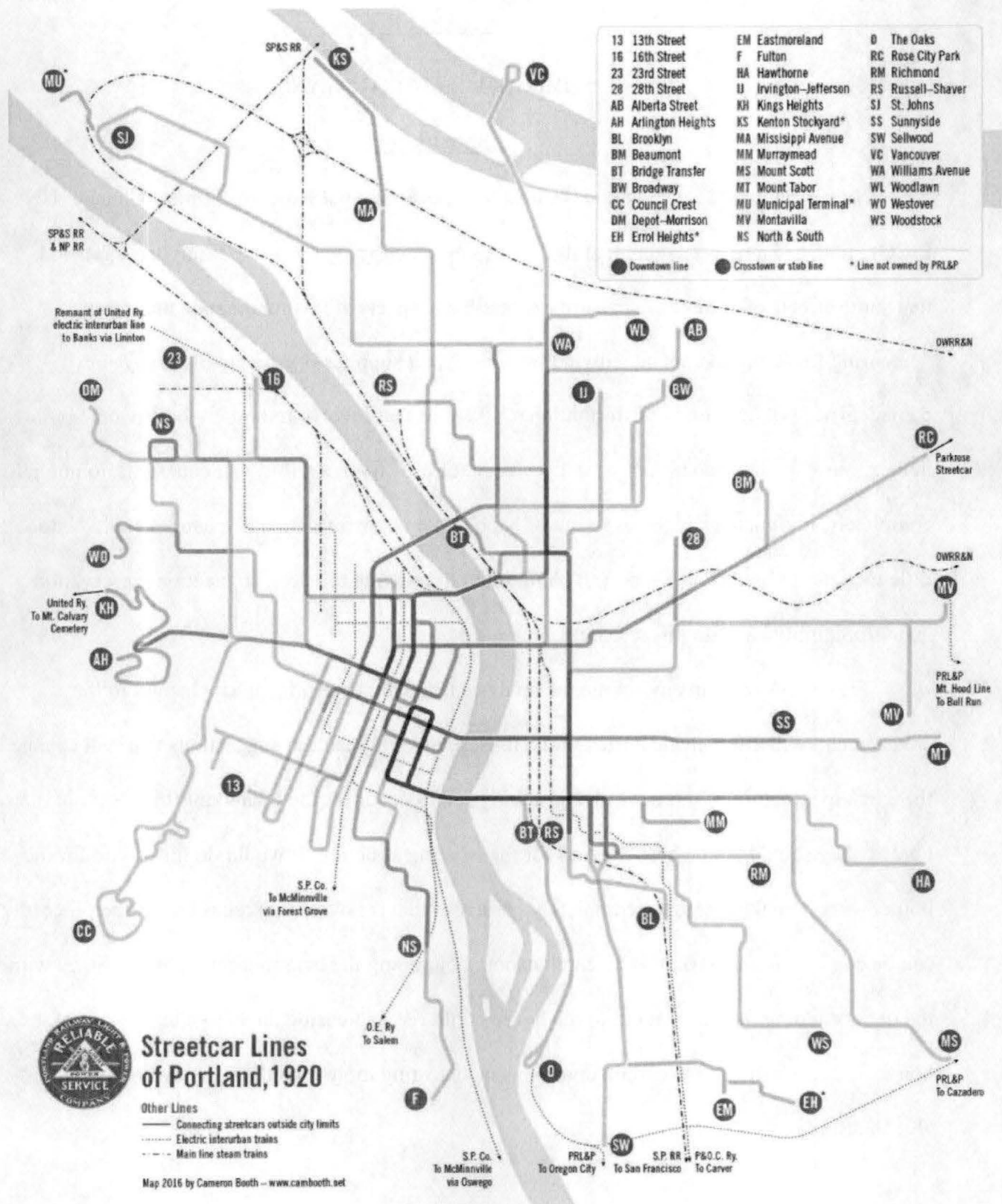


Figure 2.26. Map of the Portland Streetcar Network - 1904

CHAPTER 3

ENVIRONMENTAL ANALYSIS

Introduction

In February 2022, the United Nations Intergovernmental Panel on Climate Change (UN IPCC) published a report saying that the world's climate is outpacing our ability to adapt, and that some effects of climate change are irreversible. Aspects of this report state that when "preparing for future threats, like dwindling freshwater supplies or irreversible ecosystem damage, [we] will require "transformational" changes that involve rethinking how people build homes, grow food, produce energy and protect nature."³⁸ Even so, if global emissions do not halt completely, if climate change ran so out of hand, even "transformational" changes could be too little too late. In light of this report, it's important to reiterate the deep connection preservation and affordability have on this research.

The purpose of an environmental analysis is to help determine what changes to the environment will affect the historic Small Houses, and will result in suggestions that will change the existing structure. If there are changes that need to occur for the inhabitants to be safe in their homes, they should be the best changes for the existing structure. It would do little good for the homeowner to make the house completely passive if that is not what is required. As the process can be costly and intensive, this research is not about doing the bare minimum, but it comes with the understanding that to do more to the house could risk increasing the embodied carbon of the home, impacting the global carbon emissions, and costing more than the homeowner might be able to afford.

³⁸ Brad Plumer and Raymond Zhong, "Climate Change is Harming the Planet Faster Than We Can Adapt, U.N. Warns," *The New York Times*, Feb 28th, 2022, Accessed March 2022.
<https://www.nytimes.com/2022/02/28/climate/climate-change-ipcc-report.html>

The intention is to selectively add positive carbon that will net a negative carbon reaction in the shortest long term plan. An example of this might be to add insulation so that the mechanical loads of the building are lessened and less electricity is needed. Since so much electricity is still produced from non-renewable sources, less electricity means less carbon. The carbon needed to produce and install the insulation will emit more carbon initially but over the long term, the insulation will result in the home using less carbon, creating a net negative carbon footprint depending on the life cycle of the insulation.

Importance of Embodied Carbon

An important aspect of considering embodied carbon is determining how long it will take to offset that initial carbon emission, the cost of this process, and how it impacts the existing condition. The existing condition is important to note, as it relates to the topic of Embodied Carbon. Embodied Carbon is the holistic approach to viewing a product, which when applied to the global supply chain, links each and every aspect of carbon emission to a single product.³⁹ It's best to explain using an example. Drywall is produced using gypsum, which is a soft, chalk-like mineral. It is compressed between two layers of sturdy paper, and mounted to studs in large sheets using small metal screws. A layer of "mud", which is composed of gypsum dust and water, is spread over the joints of the boards so that the finish result is a cohesive, smooth surface.⁴⁰ It is the typical finish for most interiors. A holistic embodied carbon view of installing drywall would consider each material needed (gypsum, paper, water, metal, etc.) and consider the emissions needed to manufacture every element. Consider the energy needed to mine or produce gypsum and metal for the screws. The paper is made from trees which are chopped

³⁹ Francesco Pomponi and Alice Moncaster, "Embodied Carbon and reduction in the building environment - What does the evidence say?" *Journal of Environmental Management*, 181 (2016) 688

⁴⁰ "How Drywall is Made," *How Products Are Made*, Accessed May 2022, <http://www.madehow.com/Volume-2/Drywall.html>

down, and the water is used in creating the drywall mud. Each element requires carbon to create, to manufacture, and to transport all across the world, in order for a building to have a finished drywall interior.

Ideally the materials are mined and made locally, and transported a short distance. But wouldn't it make more sense to keep what is already there? The beauty of embodied carbon is that instead of doing the same job twice (ie. installing an interior finish), it encourages the reuse of the existing, reusing the materials that have already emitted carbon.

Some studies suggest that when considering embodied carbon, a building will need to be occupied for up to 70 years before its embodied carbon can be neutralized. The study compared the reuse of an existing building, to a newly constructed "net zero" building, and found that while the new building would emit less occupational carbon, the materials and labor of the building would release carbon for the next 35-70 years, making the building not *truly* "net zero". The existing building, after its renovation, would be neutralized within the next 5-10 years. At best, it would take roughly 35 years for the existing building to have released more carbon than the newly high performing constructed building.⁴¹

It is important to consider this in terms of years as many climate scientists insist that we as a planet need to stop emitting carbon by 2050.⁴² To build a new building, following the highest standard of sustainability, would still be detrimental to the climate. To renovate an existing building, however, could reduce our global carbon footprint.⁴³

⁴¹ Michael Adlerstein, "Assessing the Carbon-Saving Value of Retrofitting versus Demolition and New Construction at the United Nations Headquarters," (*The United Nations Capital Master Plan*, New York, December 2016)

⁴² Antonio Guterres, "Carbon Neutrality by 2050; The World's Most Urgent Mission," *The United Nations*, December 11th, 2020, Accessed May 2022, <https://www.un.org/sg/en/content/sg/articles/2020-12-11/carbon-neutrality-2050-the-world%E2%80%99s-most-urgent-mission>

⁴³ John Cole and Sattar Sattary, "Reducing Embodied Energy Through Retrofit," *Sustainable Retrofitting of Commercial Buildings - Warm Climates*, edited by Richard Hyde, Nathan Groenhout, Francis Barram, and Ken Yeang, 258. New York: Taylor & Francis Group, 2013.

Using the drywall example, once again, it makes sense to keep the existing interior surface once the holistic carbon emissions are considered. This aligns with preservation practice, which would ideally keep as much existing material as possible, and it can be beneficial to the homeowner's wallet as it becomes one less thing for the contractor to purchase and install.^{44 45} It gives a stronger meaning to the phrase, "Reduce, Reuse, Recycle."

Application of Embodied Carbon Calculations

There are many software plug-ins that consider the carbon emissions of a product being added to a building.⁴⁶ Some softwares can even compare the carbon emissions between keeping the existing drywall, for instance, or replacing it.⁴⁷ It requires a deep understanding of building sciences and project management, as the software calculates the carbon emissions of a project down to the exact screw necessary to keep the project together. In order to determine how much carbon you save by keeping the existing drywall, you first have to understand how much carbon it would take to replace it, determining where the drywall is from, and selecting the exact manufacturer for the screws. Fortunately softwares will calculate this.

This process can be intensive and makes calculating the embodied carbon of a project difficult, but fortunately, not impossible. Many sustainability certification processes are recognizing the impact of embodied carbon and are adjusting the certification process for adaptive reuse projects. In 1998, the United States Green Building Council piloted LEED, the certification process that has been widely accepted within the US as a guideline for building

⁴⁴ W. Brown Morton, Anne E. Grimmer, and Kay D. Weeks, *The Secretary of the Interior's standards for rehabilitation & illustrated guidelines for rehabilitating historic buildings*, Washington, D.C.: U.S. Department of the Interior, National Park Service, Cultural Resources, Preservation Assistance Division, 1992.

⁴⁵ Francis Barram, "The Economic Case for Retrofitting Using Bioclimatic Principles," *Sustainable Retrofitting of Commercial Buildings - Warm Climates*, edited by Richard Hyde, Nathan Groenhout, Francis Barram, and Ken Yeang, 135. New York: Taylor & Francis Group, 2013.

⁴⁶ One such software is called Tally, designed to be used with Revit and started in 2008, <https://choosetally.com/overview/>

⁴⁷ This software is called PlanIT Impact, designed by Dominique Davison, <https://www.planitimpact.com/about/>

sustainable buildings. Originally, LEED certification was primarily focused on new construction, and eventually considered existing structures for LEED Certification.⁴⁸ The combination of preservation and sustainability seemed challenging and at odds with each other until LEED v.3, when points were given for “maintain[ing] existing walls, floors, and roof”, as well as material reuse.⁴⁹ This minimal reference to the existing structure hints at the well known phrase, “the greenest building is the one already built”.⁵⁰ This small reference, however, does not consider how a preservationist should be integrated into the design process, nor does this reference speak to the significance of reusing walls, floors, or roofs; roughly ¾ of a building and a significant carbon load on the construction process. To achieve LEED Platinum Standards, the project needs 90 points minimum, and reusing materials grants only 5 points at most, only 6% of the points needed to achieve certification.

LEED v.4.1 places a focus on building performance over a period of time, making allowances for existing buildings due to the profound reuse of materials involved.⁵¹ Existing buildings are a large part of the Building Life-Cycle Impact reduction, as recognized by v.4 but none of the earlier versions of LEED. While not necessarily encouraging the reuse of existing buildings, LEED is at least discouraging the demolition of existing buildings.⁵² The percentage of the existing building that is being reused is calculated, and the greater the amount, the more points the LEED project can receive, increasing its certification level. Points are also given to

⁴⁸ Melissa Baker, “LEED: Past, Present and Future,” *United States Green Building Council*, Dec 11th, 2018, Accessed March 2022, <https://www.usgbc.org/articles/leed-past-present-and-future>

⁴⁹ Michelle Cottrell, *Guidebook to the LEED Certification Process V.3*, (Hoboken: John Wiley & Sons, 2011) 157.

⁵⁰ Robert Adam, “The Greenest Building is the one that already exists,” *The Architects Journal*, September 24th, 2019, accessed June 2022, <https://www.architectsjournal.co.uk/news/opinion/the-greenest-building-is-the-one-that-already-exists#:~:text=Carl%20Elefante%2C%20former%20president%20of,the%20one%20that%20already%20exists'>.

⁵¹ Jeff Gavin, “The Evolution of LEED,” *Electrical Contractor*, Accessed March 2022, <https://www.ecmag.com/section/green-building/evolution-leed>.

⁵² “LEED v4.1 Building Design and Construction,” (United States Green Building Council, Washington D.C., October 2021.)

projects built within a historic context, but they are specified as “limiting conditions” that “may consequentially impact buildings and infrastructure within the associated jurisdiction.”⁵³ It is not considering the historic context as a benefit but as a challenge that must be overcome.

Adjustments to the Existing Conditions

As previously stated, LEED v.4 makes for some allowances in building performances for projects using an existing building. This concession gives the perception that older buildings are inherently worse than newer buildings, which has been proven untrue.⁵⁴ Old buildings and new buildings are simply different, and require the understanding that some features in old buildings are bugs in old buildings and vice versa.

Summary of this section: Calculating embodied carbon can get too big. How far must an architect consider and what are actual adaptations that can help curb the embodied carbon of a building? Besides letting time resolve the EC, how can we guarantee that the footprint will start lower?⁵⁵ (figure 3.3)

Case Study: Adaptive Reuse & Embodied Carbon Considerations

In the early 2000’s, the UN commissioned a new building to replace their building from the 1950’s.⁵⁶ The existing building was deemed uninhabitable and detrimental to the wellbeing of the inhabitants. A new project was proposed, but due to budgeting, the idea of reusing the building was considered heavily. The winning argument for reusing the building was an embodied carbon analysis that compared a renovation project meant to aid with the wellbeing of

⁵³Ibid

⁵⁴ Melissa Baker, “Agility and Evolution: How LEED is Moving in the Market,” *United States Green Building Council*, November 2017, Accessed March 2022, <https://www.usgbc.org/articles/agility-and-evolution-how-leed-moving-market>.

⁵⁵ “Carbon Impact of Gypsum Board,” *Carbon Smart Materials Palette*, Accessed May 2022, <https://materialspalette.org/gypsum-board/>.

⁵⁶ Ibid

the inhabitants and the desired design of a newly constructed building of a comparable size and scope.

The researchers found that the renovated building, while not as efficient as the new building, had a carbon footprint so reduced, it would take 70 years before the new building could neutralize the carbon footprint established by the new building.. This calculation considered the embodied carbon of the materials and labor, used this as a starting point, and then calculated the building operation carbon load for the following 100 years. It wasn't until 2080 that the new building would "become" more efficient (Chart 3.3). Again, it must be reiterated that the world must be carbon neutral by 2050. This goal set out by the UN does not mean carbon emissions cannot be emitted at all. Ideally less carbon will be emitted and features in the built environment can neutralize more than is emitted.

IPCC 2022 Climate Report Considerations

The IPCC (Intergovernmental Panel on Climate Change) of the United Nations was created to gather research conducted by climate scientists from around the world to help the world overcome the impending climate considerations. Their reports include considerations and adaptations that would best mitigate the most severe effects of climate change. This research would be remiss to exclude these suggestions and will instead consider what the IPCC suggests as a lens for the adaptations of the Portland Small Houses.

Some adjustments that should be considered for the Portland Small Houses that would also consider the preservation of the structure include the following; adding insulation, changing HVAC systems, adding air barriers, and changing windows. These alterations to the Portland Small House typology will consider a range of costs and general effectiveness, taking into consideration the future changes to the climate based on the 2022 IPCC report for North America

and the 2015 City of Portland Climate Change Preparedness Plan. The changes will be applied to Tally, a carbon calculation software that can then be used to compare and contrast new construction that might be sustainable with any reused materials. This calculation will only be done with wall cavities as more specific information is needed to understand the embodied carbon of mechanical systems and window replacements. Generally there is already enough academic scholarship available to apply to this situation to make educated recommendations.

Due to the urban location of the Portland Small Houses, it is important to note that the

“climate impacts are felt disproportionately in urban communities with the most economically and socially marginalized, most affected... Robust adaptation plans are those developed in inclusive ways. However, few adaptation plans for urban areas and infrastructure are being developed through consultation and co-production with diverse and marginalized urban communities. The concerns and capacities of marginalized communities are rarely considered in planning.”⁵⁷

This only reinforces the need for a study that considers historically excluded neighborhoods and structures, common homes, regardless of how little information there is about the structures. Their adaptations need to be accessible and functional, as well as efficient. This brings in the following sections which break down the individual adaptations into parts that can be done step by step, or all at once.

Adding Insulation

Insulation is what is to a building to insure that cold air cannot enter a warm building in winter, or a cooled building cannot get heated by the summer air. There are many types of insulation, which add up to a specific R-Value, the amount of which is specified by code.

⁵⁷ Dodman, D., B. Hayward, M. Pelling, V. Castan Broto, W. Chow, E. Chu, R. Dawson, L. Khirfan, T. McPhearson, A. Prakash, Y. Zheng, and G. Ziervogel, 2022: Cities, Settlements and Key Infrastructure. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

R-value is the resistance factor that energy experiences when moving from one material to another. A higher R-value will result in more resistance to thermal exchange. In Portland, walls typically should have an R-Value of 21⁵⁸. Portland, OR is in climate zone 4⁵⁹, which expresses a wide range of temperatures from very hot and dry in the summer, to very wet and cold in the winter. This affects how the building can be constructed, ideally to the optimal standards necessary to let the building perform best with the climate.

To study how insulation will affect the Portland Small House typology specifically, four wall types have been developed. This wall system will exclude a vapor barrier for the sake of consistency with the existing fabric, and vapor barriers will be heavily discussed at a later point. There will be three types of wall systems that will reflect the different levels of intervention. There is only so much that can be done with historic material, and each case is highly nuanced, so it should be considered that this is merely using the rough sizes and general layout of the Portland Small House Typology.

Figures 3.1 through Figures 3.4 show the wall cavities as sections. They also include information about the location of the vapor barriers which will be discussed in the next section.

⁵⁸ “Chapter 11 - Energy Efficiency,” *2021 Oregon Residential Specialty Code*, July 2021, Accessed May 2022, <https://codes.iccsafe.org/content/ORRSC2021P1/chapter-11-energy-efficiency>

⁵⁹ Climate zones help architects estimate approximately how much insulation should go where, and then the project can get more nuanced as more information is collected.

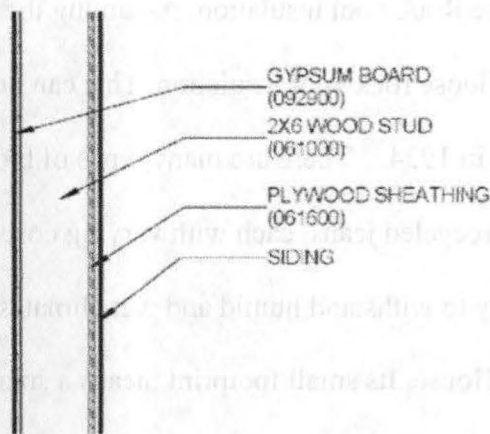


Figure 3.1. The Existing Method

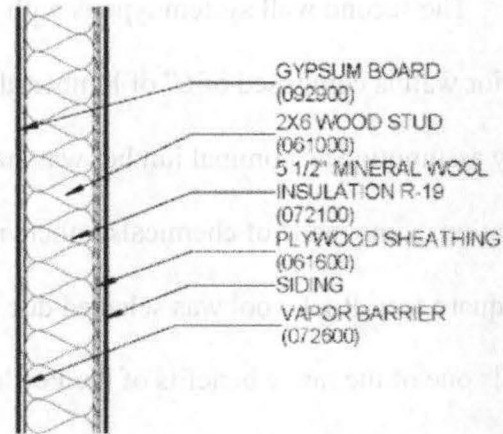


Figure 3.2. The Rochwool Method

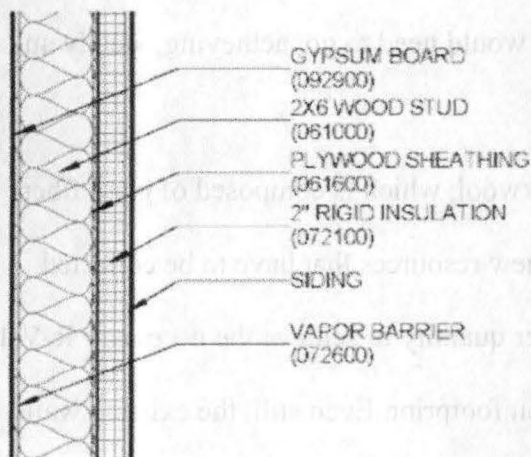


Figure 3.3. The Hybrid Method

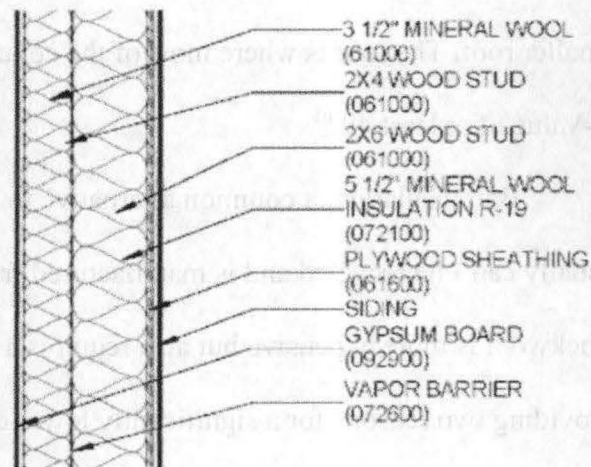


Figure 3.4. The Furred-Out Method

The first wall system type is the existing fabric. This will be used as a control and is set to have the embodied carbon of 0. The Tally report shows the existing wall as a slightly higher than zero embodied carbon, mainly because it's considering the age of the structure and its need to be replaced or maintained as pieces get damaged. This will help consider how much more carbon will be emitted in relation to the amount of insulation exclusively. Since it is assumed that the structures do not have any insulation, or were not built with insulation, any that is added will add to the carbon emissions of the property. This can be offset with solar panels and more efficient HVAC systems, but it is important to first determine how much will need to be offset.

The second wall system type is with blown loose Rockwool insulation. Assuming the exterior wall is composed of 6" of lumber, this is 6" of loose rockwool insulation. This can be a tricky assumption as nominal lumber was standardized in 1924.⁶⁰ There are many types of blown insulation, some made of chemicals, others made with recycled jeans, each with varying costs per square feet. Rockwool was selected due to its ability to withstand humid and wet climates. This is one of the many benefits of the Portland Small House. Its small footprint means a small perimeter, which would mean a smaller amount of insulation needed to protect the interior. It is also a 1 story structure which means fewer exterior walls. The small footprint also means a smaller roof. The roof is where most of the cellulose would need to go, achieving, ideally an R-Value of at least 49.⁶¹

Batt insulation, a common alternative to Rockwool, which is composed of glass fibers usually can't be recycled and is manufactured from new resources that have to be collected. Rockwool is more expensive but also requires a lower quantity to achieve the necessary R-Value, providing two reasons for a significantly lower carbon footprint. Even still, the existing walls might not be thick enough to provide an R-value high enough to achieve the necessary R-21. A higher quality Rockwool would be necessary to meet code requirements⁶².

The third wall system type is a hybrid method that uses blown loose cellulose and continuous exterior closed cell insulation. This is known to be the best method in new construction for efficiency in terms of building performance and is financially efficient, achieving a higher R-value per square foot per dollar in new construction. The Hybrid method does require more labor, materials and time which does not make it the most cost effective

⁶⁰ L. W. Smith and L. W. Wood, *History of Yard Lumber Size Standards*, Forest Products Laboratory, Forest Service, US Department of Agriculture, Madison, WI, 1964.

⁶¹ Ibid

⁶² Ibid

system to use on a historic property. This method does slightly alter the historic footprint of the structure and would involve the removal of the existing exterior cladding. This can “ruin” some sense of integrity for some preservationists, however it should be noted that the concept of integrity will be discussed and reevaluated in relation to the Portland Small Houses, due to its apparent lack of integrity.

The Hybrid method will build off the information provided by the Rockwool method, but will include 2 inches of exterior insulation that is composed of closed cell insulation. There are many types of closed cell insulation. They are typically rigid in nature, one can imagine the pink foam that is seen in Home Depot. For this method, however, rockwool will be used. Rockwool was traditionally more like fiberglass batt insulation. It is now available in rigid slabs much like XPS and rigid insulation due to it being a great insulator for exterior purposes. Since rockwool is made of basalt and recycled slag, it is a material that has a lower carbon footprint than most other exterior insulations.

The fourth method is adding furring strips to the interior of the structure, thickening the wall to provide more space for more Rockwool insulation. This relates closely to the second method but requires more consideration as it might mean relocation of outlets and electrical wiring. It would also reduce the interior square footage, removing any historical interior perimeter wall coverings. This does protect the exterior material.

The Fur-Out method does have its benefits, especially in areas that cannot be pushed outwards. In cases where a property might be close to the property line, due to a historic lack of building regulations in regards to these properties, using exterior insulation is out of the question. To achieve the desired insulation would mean taking space from the interior space and devoting it to insulation. How much space it takes up varies but it would be roughly 4”-6” off of the walls

in certain situations (2x4 or 2x6 plus half an inch for drywall). This would also be based on how thick the walls already are.

Chart 3.1: Comparative Table with all Insulation Methods

Methods	Expected R-Value	Added Footprint	Estimated cost per SF (\$/SF)	Estimated Cost for whole house	Estimated Carbon Emissions
Existing Method	R-2.5	none	none	none	none
Rockwool Method	R-22.9	none	\$1.2-2.8	\$1,152-\$2,688	600 CO ₂ eq
Hybrid Method	R-30.7	+2" in all directions	\$2.93-4.53	\$2,812-\$4,348	1,800 CO ₂ eq
Furring Method	R-35.9	-4" to 6" on all exterior walls from the interior footprint	\$7.2-\$18.8	\$6,912-\$18,048	1,100 CO ₂ eq

The costs of the methods are based on average cost per square footage. The size that is used to determine the overall cost is based on a 600 sq ft Portland Small House with 10 ft high walls. The generated a 24 ft x 24 ft footprint, a 96ft perimeter; which is then multiplied by the height of the wall to determine the overall area of the exterior walls that the Rockwool insulation will be covering. This does not include labor costs, which will increase significantly when there is more of a demolition process, such as in the Hybrid Method and the Furring Method.

To determine the embodied carbon for each wall type, the wall cavities were modeled in an architectural software, Revit, and Tally, a carbon footprint calculator software was used to compare the different wall types. For the sake of comparisons, two new wall construction types were added. New Construction - Ideal Method is a wall type that achieves R-53, designed by Scott Edwards Architects and Hammer & Hand Construction.⁶³ New Construction - Typical is a wall type that achieves R-X, the minimum R-value required for the City of Portland new

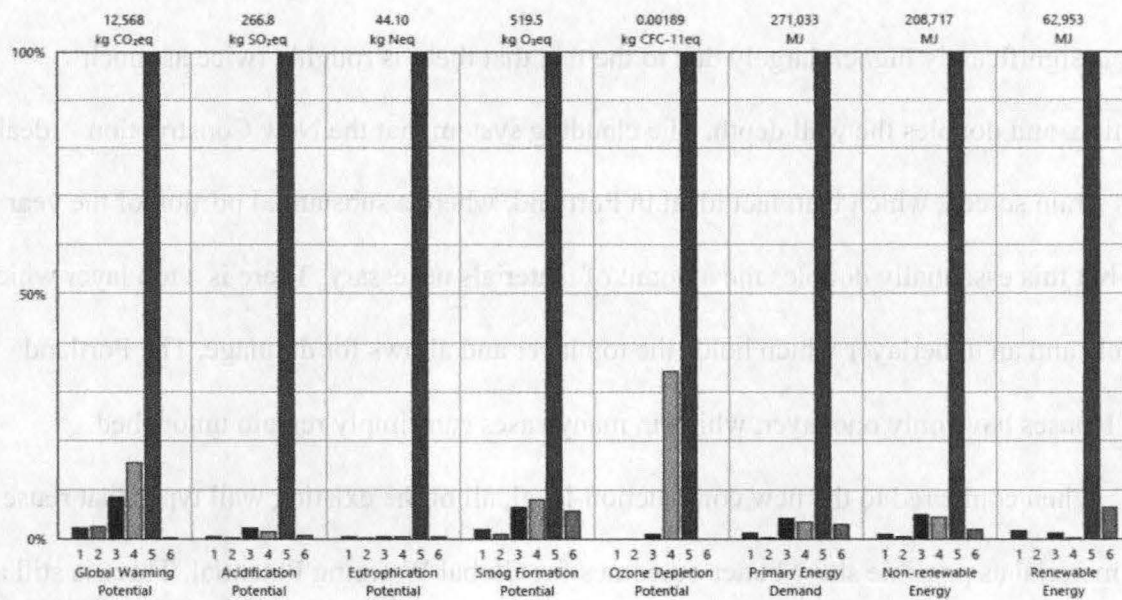
⁶³ "Pumpkin Ridge Passive House," *Hammer & Hand Construction*, Accessed April 2022, <https://hammerandhand.com/portfolio/pumpkin-ridge-passive-house/>

structure code. Chart 3.1 shows levels of a variety of emission types, ranging from the embodied carbon of the materials, the amount of ozone depleting gasses, and amount of energy required to process and transport the materials to the construction site (embodied energy). The embodied energy of the materials takes into consideration the general location of this study (Portland, OR) and calculates the closest sources for the materials required to complete the project.

Based on the results it is very clear that reusing the existing structure drastically reduces the embodied carbon of the Portland Small Houses. The New Construction - Ideal, shown in green, is significantly higher, largely due to the fact that there is roughly twice as much insulation, and doubles the wall depth. The cladding system that the New Construction - Ideal uses is a rain screen, which is in fact ideal in Portland, where a substantial portion of the year is rainy; but this essentially doubles the amount of materials necessary. There is a top layer which is visible and an underlayer which holds the top layer and allows for drainage. The Portland Small Houses have only one layer, which in many cases can simply remain untouched.

When compared to the new construction-ideal, all of the existing wall types that reuse as much material as possible show better outcomes for Global Warming Potential. There is still an embodied carbon that needs to be offset but it is relatively smaller. The building performance of the Portland Small House would be better if it used the new construction - ideal method but it would be too cost ineffective to actually be something obtainable for these houses. With the addition of a vapor barrier to either the Rockwool method or Hybrid method, the operational carbon emissions of the building would decrease significantly due to a more efficient building envelope.

Chart 3.2: Embodied Carbon (EC) Results from Tally, comparing the EC of Different Wall Cavities



Legend

Design Options

- Cellulose Method
- Existing Method (primary)
- Furring Method
- Hybrid Method
- New Construction - Ideal
- New Construction - Typical

Adding Vapor Barriers

Vapor barriers are used to limit the flow of air and moisture from the outside to the inside or vice versa. High air flow from one to the other is linked with heat loss or gain, and inefficient energy usage. When the air flow is minimized and highly controlled, it allows for more efficient

heating and cooling machines, using less energy for a shorter amount of time. One of the complications with vapor barriers is how it affects moisture control. If a building isn't allowed to breathe, it can lead to a humid wall cavity that will let the insulation rot and the wood structure decay. Adding too much insulation or placing the air barrier in the wrong location can ultimately be more damaging than helpful to the building.

Historically, vapor barriers; or rather “exterior wall vapor retarders”, were used in the late 1930's and 1940's as a part of “set of moisture management practices”.⁶⁴ With the housing boom of the late 1940's and 1950's, building technologies rapidly evolved, resulting in buildings that were designed for thermal comfort. Terminology such as “dewpoint”, “moisture”, and “condensation” were applied to building performance, explaining why a home might feel cold and damp or hot and humid. Standards were set in place to control the amount of fresh air that could enter a building, either through air leakage or from heating and cooling systems.

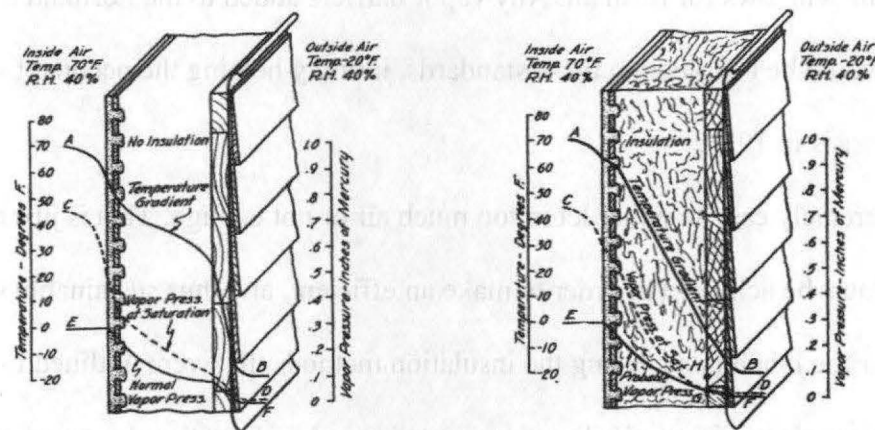


Figure 3.5. A diagram produced in 1938 by Frank Rowley, explaining Diffusion Theory.⁶⁵ Rowley used this theory to carry out many experiments and went on to found the US Mineral Wool Association.

⁶⁴Allison A. Bailes, “The History of Peeling Paint, Insulation, and Vapor Barriers,” *Green Building Advisor*, November 2013, Accessed April 2022,

<https://www.greenbuildingadvisor.com/article/the-history-of-peeling-paint-insulation-and-vapor-barriers>

⁶⁵ William B. Rose, *Water in Buildings*, (Hoboken: John Wiley & Sons, 2005)

Considering that the Portland Small Houses were all built in the 1920's, it is safe to say that the structures do not have vapor barriers unless they were added when the exterior cladding was changed. In some instances this was done, with a few homes showing vinyl siding from sometime between 1950-1970. This would certainly call into question the quality of the vapor barrier. As much as building technologies evolved from the 1930's to 1970's, vapor barriers have radically changed between the 1970's until now. It is likely that Portland Small Houses that show newer cladding circa 1970 have vapor barriers that should be changed.

In the 1970's, air flow standards were reduced from 15 cfm (cubic feet per minute) to 5 cfm to maximize building efficiency. Buildings were packaged so tightly that people suffered from Sick Building Syndrome (SBS) due to a lack of fresh oxygen and toxic building materials that released Volatile Organic Compounds (VOCs, think "fresh car smell").⁶⁶ Imagine that fresh-car smell constantly for a whole work day, for a whole work week, with no chance of rolling down the windows for fresh air. Any vapor barriers added to the Portland Small Houses in the 1970's would be beholden to these standards, initially helping the occupant save energy during the oil crisis in 1973.

It is extremely easy to either let in too much air or not enough. This is just one of the fine balances that must be achieved in order to make an efficient, and thus sustainable structure that is also healthy for the inhabitants. Using the insulation methods that were outlined in the Adding Insulation section, air barrier methods are suggested based on how they best perform with the appropriate insulation method.

The first method is the Interior Method, which functions best with the Rockwool insulation method. This is due to the location of the dew point. The dew point is where

⁶⁶ Stephanie Buck, "The Mysterious Illness Affecting 1970's Females Office Workers Become 'Sick Building Syndrome'," *Timeline*, May 2017, Accessed April 2022. <https://timeline.com/sick-building-syndrome-cc82f76a07e9>

condensation will occur within a wall cavity. This is where water will form once cold vapor hits a warm surface. In the city of Portland, it is written in the city code that the vapor barrier shall reside on the interior side of the framed wall, as that is where the condensation will occur in the Portland climate.⁶⁷ This method works best with the Rockwool Method because installing insulation from the interior does require a barrier of some kind that can keep the insulation in place until drywall can be installed. This helps with the overall costs of Rockwool installation as it will increase overall building performance while serving another necessary purpose. This does require removing all drywall or plaster from the interior walls on the exterior perimeter. This would be an added cost and carbon footprint load. One could entertain keeping the existing interior finish and blowing in insulation from holes at the top of each wall cavity, but the lack of the vapor barrier would still mean air and moisture can pass between the outside and inside.

The second method is named the Sandwich Method, as this method would require a vapor barrier between the two types of insulation used in the Hybrid insulation method. The vapor barrier would be installed on the exterior of the framed structure but it would be on the inside of the insulation that would cause significant amounts of condensation. This method would pair best with a mechanical system that controls humidity as well as air temperature. The types of mechanical systems will be discussed in a future section.

The installation of the vapor barrier between the cellulose and rigid insulation layer would need to occur prior to installing the rigid insulation layer. This vapor barrier method is thus best with an insulation method that would require removing the exterior cladding. It makes

⁶⁷ "Section R806 Roof Ventilation Appeal Summary," *The City of Portland Developmental Services*, June 2018, Accessed April 2022.
https://www.portlandoregon.gov/bds/appeals/index.cfm?action=entry&appeal_id=18033#:~:text=Class%20I%20or%20II%20vapor,1405.3.

financial sense to benefit the building performance as much as possible while one is capable of doing so.

The fourth method is a modified Interior method that would be paired with the Furred Method. This vapor barrier method is similar to the Sandwich method and considers how moisture can become a serious issue with extremely thick and dense insulation.⁶⁸ Due to the fact that the Furred method tackles insulation installation from the interior, the vapor barrier would simply be placed between the existing framed structure and the additional frame structure. This would mean cellulose would be used in the historic wall cavity and more cellulose could be added to the additional wall cavity and held in place by simple paper. Figure 3.3 and 3.4. shows in more detail where the vapor barrier lies in relation to the insulation, the historic framing and the new framing.

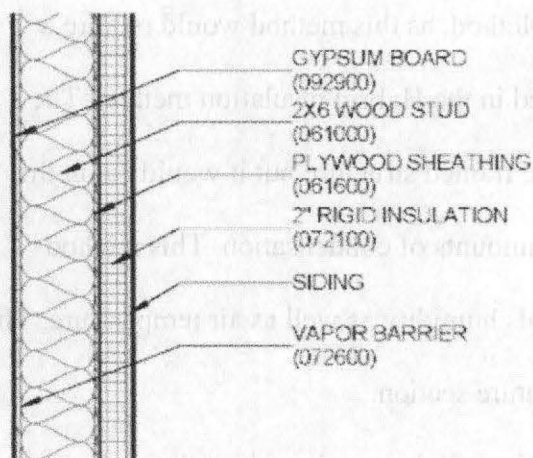


Figure 3.3. The Hybrid Method

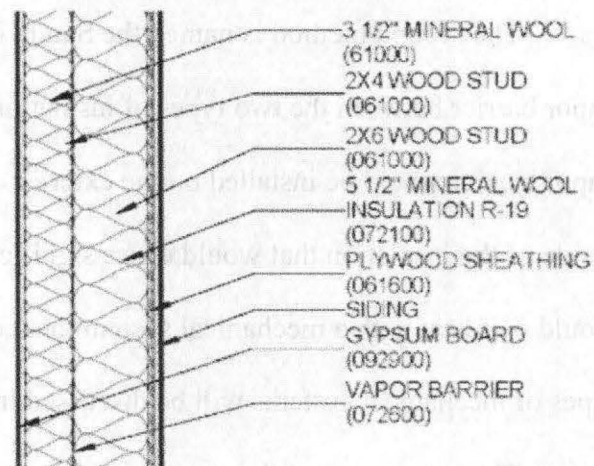


Figure 3.4. The Furred Method

This method would not take away from any interior footprint as vapor barriers are extremely thin. This method could also be adapted to the possibility that there is insulation within the historic wall cavity that could be reused. Rather than assuming that the cavities are

⁶⁸ Colin Craven and Robbin Garber-Slaught, "Cellulose Insulation Moisture Performance in Cold Climate Construction," *Cold Climate Housing Research Center*, 2014.

empty, a method should be developed to adapt to the best case scenarios. This would save considerable costs to the homeowner and would lower the embodied carbon of the home as the only additions to the home would come from the added 4"-6" of insulation.

The relationship between insulation and vapor barriers really determine the course of action. This is merely one small relationship that building sciences need to consider when altering a home. Fortunately, these adaptations can be made more straightforward with accurate mechanical selection which controls not only the heating and cooling but the movement of air from the interior to the exterior and vice versa.

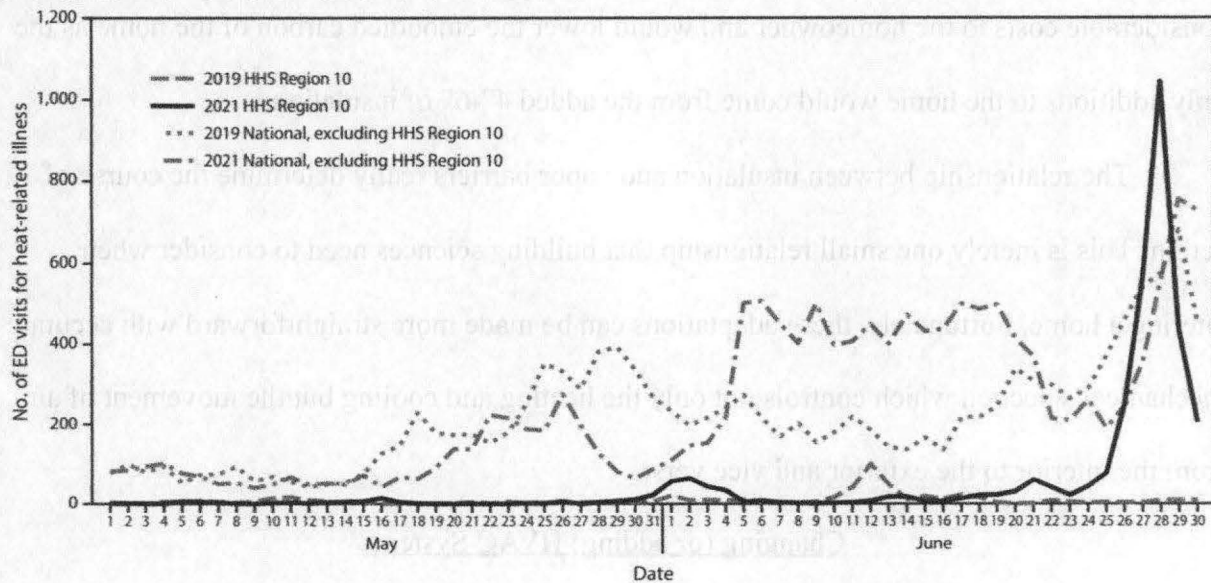
Changing (or adding) HVAC Systems

In June 2021, there was a major heat bubble that focused on the Pacific Northwest in a way that has never been seen before. Temperatures skyrocketed up to 116F (46.7C) between June 25th until July 14th.⁶⁹ The US Department of Health and Human Services (HHS) tracked emergency department (ED) visits between May 2021 and July 2021. The Pacific Northwest region had 3,504 heat related ED visits, 79% of which occurred between June 25th-30th, 2021. On June 28th alone, 1,038 heat related ED visits occurred. Only 9 heat related ED visits occurred only a year before on the same day. During the June 25th to 30th period, the Pacific Northwest accounted for 15% of all heat related ED visits, while only accounting for 4% of the nationwide population.

Chart 3.3 below shows the drastic change in ED visits between 2021 and 2019, as compared between nationwide statistics and region 10 (Pacific Northwest) statistics.

⁶⁹ Paul J. Schramm, Ambarish Vaidyanathan, Lakshmi Radhakrishnan, Abigail Gates, Kathleen Hartnett, Patrick Breyse, "Heat-Related Emergency Department Visits During the Northwestern Heat Wave — United States, June 2021," *Morbidity and Mortality Weekly Report*, 29 (July 2021) 1020-1021.

Chart 3.3. Number of ED Visits for Heat Related Illness in 2021 & 2019. Chart provided by the US Department of Health and Human Services.



The drastic change in temperature, which was 47F hotter than usual, left many in dire situations. It is estimated that 600 people across Oregon, Washington and Western Canada died due to the heat wave.⁷⁰ The cause for these deaths can directly be attributed to climate change, but is compounded by the fact that roughly only 79% of the homes in the Portland area have air conditioning. This is significantly more than Portland’s neighbor, Seattle, which is only 44% air conditioned.⁷¹ Due to the anticipation of a rainy and chillier (by comparison) summer, many residents were caught off guard. Once it was clear that an air conditioning unit would be necessary, many people were unable to purchase a unit. It was joked that “trying to buy an AC unit in Seattle right now (June 28th) feels like trying to find a Nintendo switch in April 2020.”⁷²

⁷⁰ Gillian Flaccus, “Record-Breaking heat wave in 2021 is an example of climate change’s impact in North America,” *PBS NewsHour*, March 1st, 2022. Accessed April 2022, <https://www.pbs.org/newshour/science/record-breaking-heat-wave-in-2021-is-an-example-of-climate-changes-impact-in-north-america>.

⁷¹ Yana Pashaeva, “The Desperate Hunt for Air Conditioners in Oregon and Washington,” *Slate*, July 2021, Accessed April 2022, <https://slate.com/technology/2021/07/oregon-washington-heat-conditioner.html>.

⁷² Ibid

In newer residences, heating and cooling air conditioners are typical. They are required by the City of Portland Ordinance Nos. 187432.⁷³ They offer a high level of comfort when the climate becomes more unpredictable, which based on current trends is only likely to continue. For the City of Portland region, the changes that will occur due to climate change will severely affect the historic housing conditions. Summers will be hotter and drier, winters will be colder and snowier.⁷⁴ There will be longer stretches of time that will be drought conditions, increasing the chances of wildfires.⁷⁵ When it does rain, it will lead to greater levels of flooding.⁷⁶ This is compounded by the fact that wildfires would damage the trees which help protect against flooding, moving more of the rain runoff towards the rivers and Portland metropolitan area.⁷⁷

Using the Portland Small Houses as a case study and guideline for a typical un-airconditioned home in Portland, this section will make recommendations on how the existing condition should be mediated and what the best method should be. This section will be more straightforward than the previous sections as there is little comparison necessary. The section will be divided between ventilation; of which there is natural and artificial, and heating and cooling air conditioning; which is completely artificial but can be provided by a variety of options.

The case for ventilation is very compelling. As explained briefly before, if there is not enough fresh air in a building, it can physically make people sick. There is a minimum requirement for fresh air, as guaranteed by ASHRAE 90.1-2019, as adopted by the state of

⁷³ "Chapter 27.05 Equipment -General," The City of Portland, Portland, OR, 2015.
<https://www.portland.gov/code/27/05>

⁷⁴ Andy McEvoy, Max Nielsen-Pincus, Andres Holz, Arielle J. Catalano and Kelly E. Gleason, "Projected Impact of Mid-21st Century Climate Change on Wildfire Hazard in a Major Urban Watershed outside Portland, Oregon, USA," *Fire*, 3, 70, (2020)

⁷⁵ Ibid

⁷⁶ Ibid

⁷⁷ Jon Franczyk and Heejun Chang, "The effects of climate change and urbanization on the runoff of the Rock Creek basin in the Portland metropolitan area, Oregon, USA," *Hydrological Processes*, 23 (2009).

Oregon in October 2021, which requires 100 cfm in kitchens, and 50 cfm in bathrooms.^{78 79} This is a big difference from the 15 cfm required in the 1970's. The exhaust is primarily needed, not to remove foul smells, but for removing the humidity in the air. If the air of the interior of the structure is too damp, it will lower the dewpoint of the air and cause condensation to form on the incorrect side of the vapor barrier, causing issues down the road like mold, rot and eventual decay of structure.⁸⁰ This can prove negative on the inhabitant's health, the building's condition, and the longevity of the built environment.

If an airtight vapor barrier is used around the building, a supply machine will be required alongside an exhaust machine. The supply machine allows for the building to have a controlled entry point for air to flow into the building when air is exhausted from the building. If there was only an exhaust, working by itself, it would be like a person sucking on a straw with a finger blocking the otherside. A vacuum would form, causing absolutely no air movement, despite the machine's best efforts. Having both machines can be expensive, especially if both are necessary for each bathroom and kitchen. It is, however, the most cost effective of the systems, mainly because they can be spot placed. They only require one hole to the exterior, and one in the interior. Other systems, like ERVs can require whole house ductwork and remodeling.

"ERV" stands for energy recovery ventilation. It is similar to HRVs (heat recovery ventilation) but transfers heat and moisture. ERVs are ideal for newly constructed homes as they require a network of ducts, granting access to each room of the house to the ERV. Once this is established, fresh air from the outside can be exchanged for "used" air from the inside and when

⁷⁸ "Oregon Energy Efficiency Specialty Code," State of Oregon BCD Codes and Standards, Accessed May 2022, <https://www.oregon.gov/bcd/codes-stand/Pages/oeesc-adoption.aspx>

⁷⁹ "4.6 Indoor Air Quality and Mechanical Ventilation," *2019 Building Energy Efficiency Standards*, International Building Code, 4.6.9.C.

⁸⁰ Sharon C. Parks, "Holding the Line: Controlling Unwanted Moisture in Historic Buildings," *Preservation Brief 39* National Parks, Washington D.C. October, 1996, Accessed May 2022, <https://www.nps.gov/tps/how-to-preserve/briefs/39-control-unwanted-moisture.htm>

the air passes through the machine, the heat and moisture of the interior air is passed to the exterior air. This makes sure that cold dry air from the outside (in this example, it's winter) does not make the heating and cooling system work extra hard to warm the air. The diagram below lays out a simplified version of how this system works.

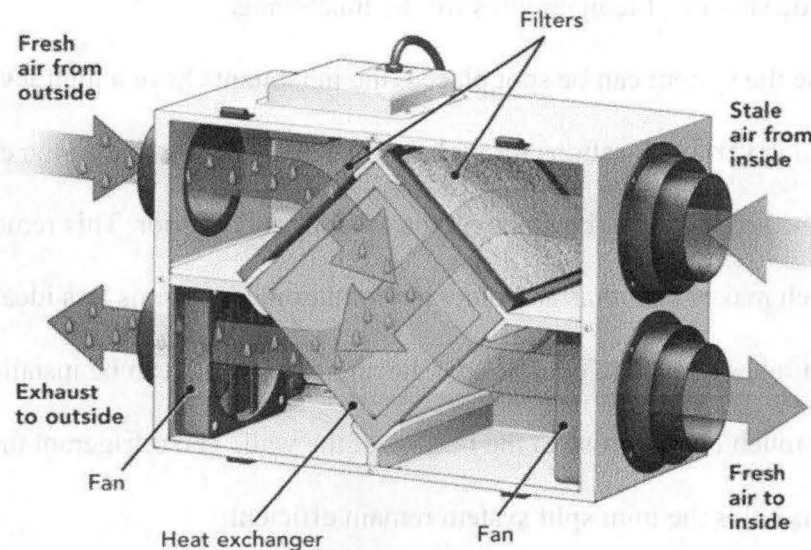


Figure 3.6. Diagram is from an article by David Ponshok. It explains the air exchange process that occurs within an ERV.⁸¹

Due to the historic nature of the Portland Small Houses, this is not an ideal choice for ventilating the space. Only in one instance is there potential for an ERV as the Small House had an attic (5127 NE Mason St.). If the intention is to retain as much historic material as possible, due to historic preservation or to lower the embodied carbon, then retaining as much drywall and interior finishes as possible is necessary. This encourages the use of a two part exhaust-supply system.

⁸¹ David Ponshok, "Heat Recovery Ventilator(HRV) vs Energy Recovery Ventilator(ERV): What's the Right Unit for Your Home?" EP Sales Incorporated, April 21st, 2017, Accessed June 2022.
<https://www.epsalesinc.com/heat-recovery-ventilator-hrv-vs-energy-recovery-ventilator-erv-whats-right-unit-home/>

The system that pairs well with the exhaust-supply ventilation system is the mini-split. This system functions by recycling the interior air through a series of refrigerant tubes that transfer energy to the air and uses a fan to circulate the air. This system does not change the moisture content of the air, only the temperature. Fortunately, it can function in the cold and heat, providing a wide change of temperatures for the inhabitants.

Because the system can be spot placed, the inhabitants have a high level of control over the temperature in various locations throughout the residence. Similar to the exhaust-supply system, only one hole needs to be made on the exterior and interior. This removes the need for ductwork, which makes heat fans and older air conditioning systems less ideal than a mini split. The refrigerant tubes needed to cool or heat the air are thin, and can be installed into the wall cavity without much compromise to the r-value of the wall. The refrigerant tubes are also insulated as this helps the mini split system remain efficient.

As summers grow hotter and winters grow colder, mini splits can provide instant relief to historic homes. They limit the amount of material alterations and can easily be reversed if and when systems become more efficient. Because the mini split comes in two parts (the condenser and the mini split), they can be upgraded separately, without future alterations to the building after the initial installation.

Changing The Windows

This is one of the highest hills a historic preservationist will die on. The National Parks Service outlines extensive guidelines around window alterations, warning against vinyl windows and going as far as denying historic tax credits for the purchase and installation of vinyl windows.⁸² In the case of the Portland Small Houses, however, many of the homes have already

⁸²John H. Myers, "The Repair of Historic Wooden Windows," *Preservation Brief 9*, National Parks Service, Washington D.C. 1918, Accessed May 2022.
<https://www.nps.gov/tps/how-to-preserve/briefs/9-wooden-windows.htm>.

had their windows replaced, sadly with vinyl windows. This makes sense in terms of affordability. Repairing historic wood windows can cost more and require more intensive craftsmanship that can be harder to find. There is also a misconception that vinyl windows are more efficient than wood windows

In the 1970's, vinyl windows were incredibly popular, largely due to the oil crisis and pushy sales people. Ever since then, they have only taken over the market, pushing out wood and metal windows farther out of the market, creating a vicious cycle. With their cheaper prices, more demand for vinyl windows decreases demand for wood windows, drives craftspeople out of the industry, driving the cost up for wood windows, and thus increasing demand for vinyl windows. In reality, wood windows can provide roughly the same U-value as vinyl windows, as it is not really the frame that transfers the heat but the glass.⁸³ Rather than replacing the whole window, it is better to seal around the window, reseal the glazing around the glass, replace the hardware of the window, or replace the glass in the window frame.⁸⁴ This, unfortunately, can be costly. And again, most of the windows have been replaced on Portland Small Houses. Only the openings in the walls hold a small aspect of integrity, in terms of general craftsmanship.

To mediate the existing vinyl windows is now the goal, and can open new paths of discussion relating to the topic of integrity. Oftentimes, in survey work, when windows have been changed, this decreases the overall integrity of the home. It should, however, simply alter the story of the building. Why was the window replaced with vinyl? If the window was replaced in the 1970's, this can be because of the nationwide oil crisis and an attempt to make the house

⁸³ Kęstutis Miškinis, Raimondas Bliūdžius, Vidmantas Dikavičius, Arunas Burlingis, "Assessment of Acoustic and Thermal Properties of Airtight Wooden Windows Used in Baltic and Scandinavian Countries," *Journal of Environmental Engineering and Landscape Management*, 27 (2019) p142

⁸⁴ Cezary Misiópecki, Robert Hart, Arild Gustavsen, and Bjorn Petter Jelle, "Operating hardware impact on the heat transfer properties of windows," *Energies* 14 (2021).

more energy efficient, hopefully to bring down the monthly energy bill. The vinyl windows are now a part of the building's story and should be considered in the overall makeup of the building.

If the windows have been replaced in the 1970's, the windows should be improved upon, especially because windows have drastically changed in the last 50 years. It would be beneficial for the Portland Small Houses to have double glazed windows, ideally with films and coatings that reflect UV rays. The seals around the windows should be updated from the interior and the exterior of the windows as it is likely that builders in the 1970's used a material that does not have a 50 year lifespan.

If the homeowner is pursuing the Rockwool Method for insulation, with an added vapor barrier on the interior, sealants can be added around the window and door openings to make them tighter. The figure below shows how air can leak out of the home around the edges where the window frame meets the wall and how the glass of the old windows can let energy radiate out. The mullions and wooden parts of the window do not actually show much energy loss, which supports a more accurate understanding of how wood windows function compared to vinyl windows. A beneficial future study that preservationists would benefit from is a thermographic inspection of old wood windows compared to newly sealed wood windows, both of which should be compared to vinyl windows to accurately determine the actual benefits of replacing windows.

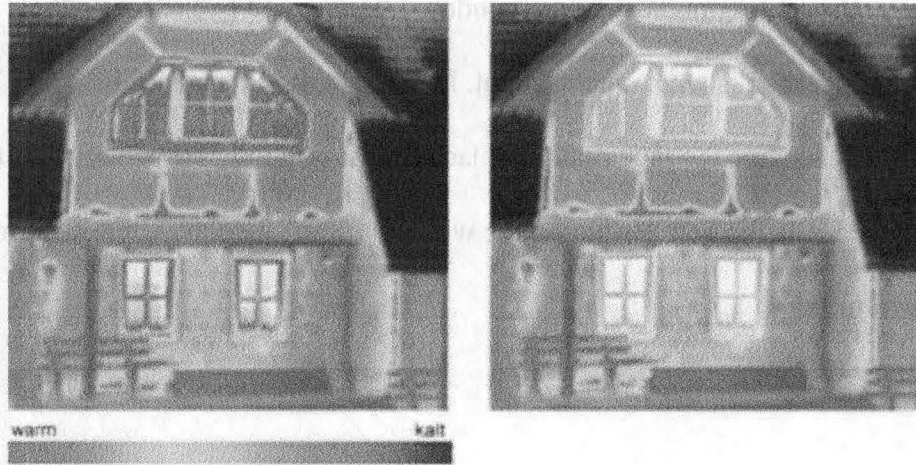


Figure 3.7. A thermographic study conducted by Weru, a window supply company. The left image shows a high level of air leakage while the right image shows a significantly lower level of air leakage after replacing the old windows with newer windows.⁸⁵

Replacing all of the windows on a Portland Small House would be beneficial, and relatively cost effective due to the low number of windows the houses typically have to begin with. It also does not need to happen all at once and there are quick fixes that can happen in the meantime. Storm windows can add an extra layer of glazing and protect slightly damaged windows while the homeowner replaces the window. Sealants can be added around the edges that open to the outside, blocking any air flow that might be making its way through the window components.

Condensation is a big issue on the interior side of the glazing. It can make the sealant more likely to fail, making the window more inefficient.⁸⁶ In homes that have well sized mechanical systems, paired with the right vapor barrier and insulation requirements, condensation becomes less of an issue on windows. If condensation does still occur, a multi-paned glass window is the best way to resolve this issue.

⁸⁵ "Energy Efficient Windows - A Guide," *Starglaze*, November 2019, Accessed April 2022, <https://www.starglaze-windows.com/blog/energy-efficient-windows-a-guide/>.

⁸⁶ Wahid Maref, Nathan Van Den Bosssche, Marianne Margaret Armstrong, Michael Lacasse, Hakim Elmahdy, Rock Glazer, "Laboratory Tests of Window-Wall Interface Details to Evaluate the Risk of Condensation on Windows," *Journal of Testing and Evaluation*, 39 (2011).

Replacing the glazing in the existing window frame would be the best option, especially when the embodied carbon is taken into account. Insulated Glazed Units (IGUs) and Vacuum Insulated Glass (VIGs) have the potential to replace the glazing in older windows. If the repairperson then reseals the new glazing to the window frame, then the window frame can be reused, as shown in figure 3.8.

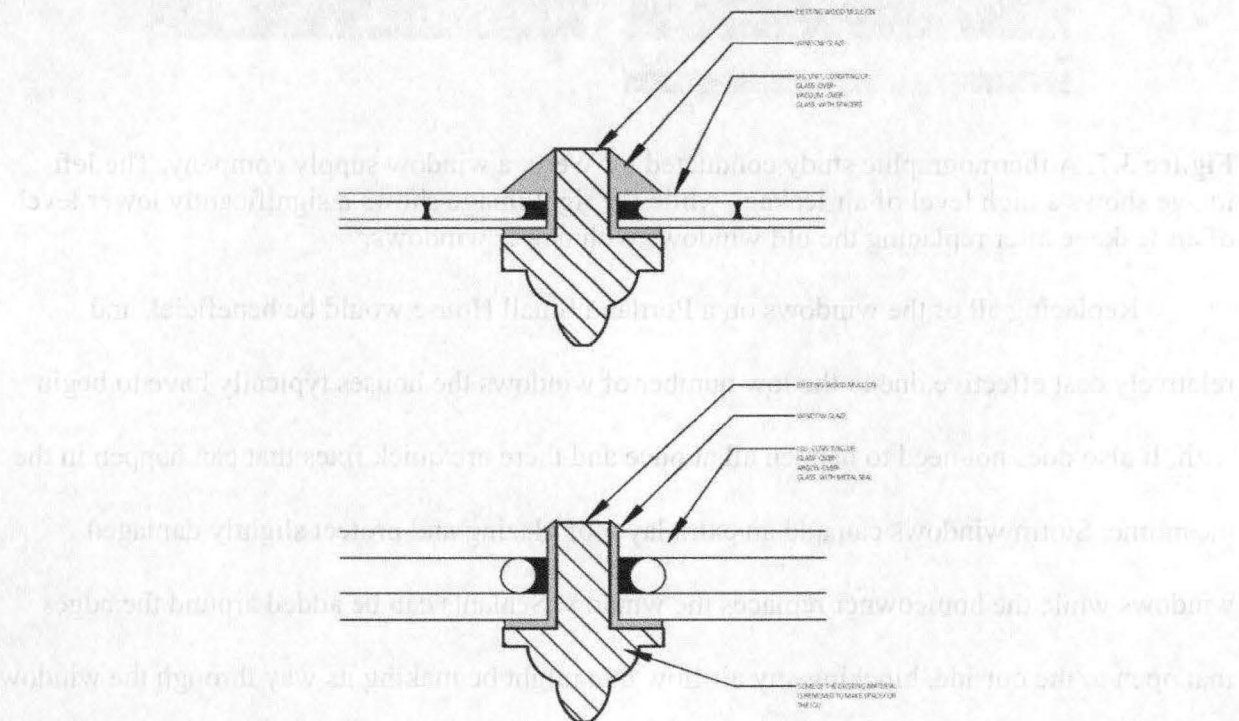


Figure 3.8. A diagram showing how replacement IGUs or VIGs would fit in the existing wood window structure. The top diagram shows a wood mullion glazed with a VIG, the bottom diagram shows a wood mullion glazed with an IGU. Detail created by author.

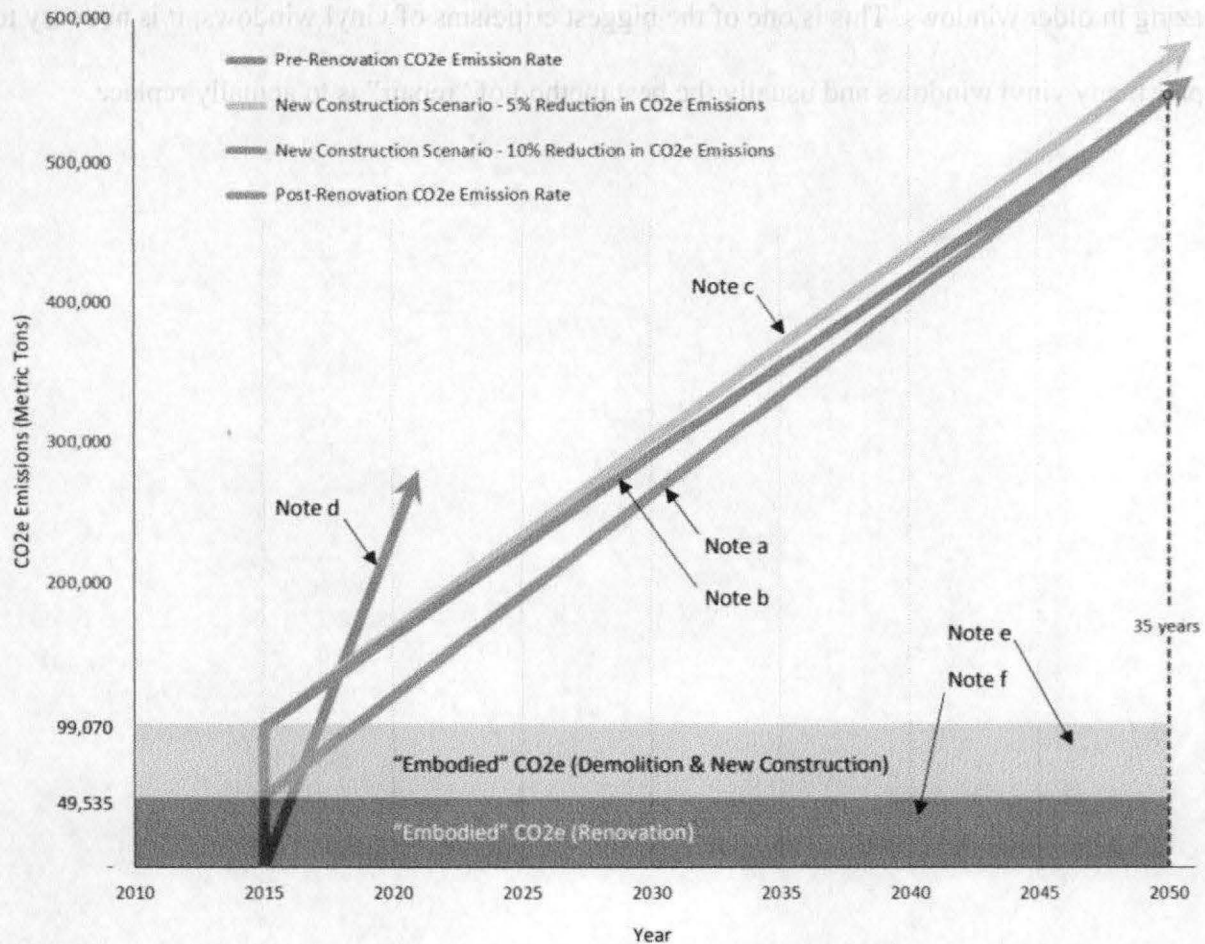
IGUs have been around and have been used for both residential and commercial projects. For restoration projects, they are not the most practical glazing substitution unless a new wooden sash is created for the window frame. This is due to the depth of the mullion, which usually has to be narrowed in order to fit the IGU, as shown in the figure above. A newer product, VIGs are

thinner in profile and still achieve the same U-value as IGUs.⁸⁷ They gain their efficiency from the vacuum between the glass, held a part with a minimal spacer. The vacuum is enough to stop heat transfer. The thin profile of the VIG makes it an ideal candidate for the replacement of glazing in older windows. This is one of the biggest criticisms of vinyl windows, it is not easy to repair many vinyl windows and usually the best method of “repair” is to actually replace.

⁸⁷ The inverse of the R-Value. It is accepted that glass will transfer high levels of heat, mostly gaining solar heat energy. The U-value is the factor needed to estimate the amount of heat energy glass transfer. The lower the U-Value, the better.

Appendix 2

Chart 3.6: Projected CO₂e Emissions (Embodied and Operational) for Renovation vs. New Construction at the United Nation Campus, from Michael Adlerstein's study of "Assessing the Carbon-Saving Value of Retrofitting vs. Demolition and New Construction at the United Nation Headquarters." (2016)



CHAPTER 4

AFFORDABILITY ANALYSIS

Introduction

Today, there is a lot of concern and fear about housing. Due to low inventory stock of homes and an increased demand, prices are increasing. It is estimated that 5 million homes will be needed to relieve some of the pressures on the housing industry. This is assuming you can afford a home in the first place, which oftentimes, can be inaccessible to many people who want homes. This is where the terms “affordability” and “obtainability” need to be defined and those definitions will be used to guide the direction of this conversation.

“Affordability” is typically viewed as 30% of one’s monthly income before taxes. If someone makes \$3,000 a month, roughly \$1,000 of that income can be dedicated housing. This bracket typically holds true for people in the median income bracket. People who are in lower income brackets typically need a lower “affordability” rate as 30% can no longer be considered feasible. This term is useful in determining if a housing option is not a financial burden on an individual’s life, but is mostly used in more generalized and governmental circumstances.⁸⁸

“Obtainability” refers to the potential home owner’s ability to move from “potential” to “actual” homeowner. The process of buying a home or getting approved for an apartment can be difficult and exclusionary to many people, especially those who have been oppressed financially. The generational wealth gap needs to be acknowledged here, and while this research might not be a solution, it can be one of many solutions. Attainable housing can typically be provided with mindfully designed or renovated homes that have a target price that is not asking for a wide profit margin, and considers how the wealth gap can be mediated by providing housing. Many

⁸⁸ “Glossary of Terms to Affordable Housing,” U.S. Department of Housing & Urban Development, August 2011, Accessed June 2022. <https://archives.hud.gov/local/nv/goodstories/2006-04-06glos.cfm>

characteristics of Attainable Housing are shared by Middle Housing. Both have mindful design processes that effectively and efficiently provide for the inhabitant's needs. The construction methods are simple, but strong, usually using sustainable practices like more insulation.

Attainable Housing and Middle Housing are both typically in existing neighborhoods.

The makeup of a neighborhood will greatly impact the home value of a property. Both attainable housing and middle housing work well in existing neighborhoods with a historic context.⁸⁹

Feasibility of Preservation

This section will require an analysis of the integrity of the buildings. Overall most of the Portland Small Houses have generally poor integrity. This is noted through present day materials, replacement of windows, and lack of craftsmanship. In the field of preservation, there are 7 aspects of integrity which all connect to each other. Using each of the seven aspects, the Portland Small Houses can be analyzed in a more traditional way.

The location of the Small Homes is easy enough, as most of these houses have not moved since they were incorporated in the City of Portland in the 1920's. It is possible that some of the houses were constructed earlier and moved to their current location as there are documented cases of this happening in the Cully neighborhood but for the purposes of this research, where they are currently located is most important.⁹⁰

The setting of the neighborhood has drastically changed since the 1920's. This can be noted in the map used to understand the development of the neighborhood (Figure 4.1). Many of the homes that are seen in the neighborhood today were built in the 1950's and 1960's. These more mid century homes typically replaced homes built in the 1920's or were being built on

⁸⁹ Daniel G.Parolek, *Missing Middle Housing: Thinking Big and Building Small*. (Washington DC: Island Press, 2020).

⁹⁰ Susan Nelson, interviewed by author, Portland, OR, March 15th, 2022.

empty lots. This is evident in the Sanborn maps from 1928 and 1950, which will consistently show houses on many lots in this area. The overall setting however, remains thoroughly residential. This is, in part, thanks to the zoning ordinances that were passed in 1920 in the city of Portland, which would then get applied to any lots later incorporated into the city jurisdiction.

The overall design of the Small Houses show the highest sense of integrity, as they are very easily recognizable today. The overall form, style, placement on the lot, and general compositions (i.e. location of doors and windows) have remained the same. Generally, a good way to consider overall design is, “would the original inhabitants of the house recognize the home as theirs?” If the answer is yes, then it retained strong design integrity.

The materials of the building have significantly changed and this is noticeable through the types of materials that replace the original. Most of the Small Houses in this study have vinyl siding and vinyl windows which would have replaced wooden siding and wooden windows. Vinyl building products were not available until the 1950’s and 1960’s, when the building industry really could take advantage of technological advances. That’s to say, while the Small Houses might have terrible integrity in regards to their original 1920’s material, some have incredible integrity in the 1950’s home improvement era.

The 1950’s and 1960’s was a time when the American homeowner wanted the classic American dream and homeownership was an aspect of that. People who might not have been able to afford a new house in the 1950’s could have settled for a home built in the 1920’s and improved it themselves to fit the homogeneous idealization of suburban america. This was a common trend seen nationwide, which saw a sharp growth in construction and population in both the 1910’s-1920’s and 1950’s-1960’s, and reinforced by the growth of home improvement stores and companies in the City of Portland in both eras⁹¹.

⁹¹ Richard Harris, *Building A Market*, (Chicago: The University of Chicago Press: 2012) 161

The integrity of the workmanship is tied heavily to the materials and feeling of the building. In the case of the Portland Small Houses, there are elements of original craftsmanship, such as porches and doors. However, the overall craftsmanship has low levels of integrity, with a few elements here and there that show some original craftsmanship. This aspect of integrity would be stronger if the interior of the Small Houses could be studied, but since that was unachievable during the research process, understanding overall integrity will be an exterior process only. One house, 4541 NE Failing St., seems to have retained its original brick chimney, which looks to be in excellent condition. This is, unfortunately, the only element of the exterior that has retained its original craftsmanship on this specific house.

The general feeling of the Small Houses is very high in terms of integrity. They are incredibly recognizable as small and the relationship of building to street has been retained. A few homes have been expanded, for example 4129 NE 49th Ave. The set back of the house and the original footprint are still visible, giving the house a *feeling* of being a Portland Small House.

The association of the houses has overall, remained the same. They are still homes, and they are still in a residential neighborhood. Overall, they seem to have the qualities necessary to be protected and formally preserved. At the very least, demolition should not be an option for these homes.

Questions of Integrity

The question of integrity is mostly a question of preservation and the concept of formal and informal preservation. Formal preservation is more official, more documented. Formal preservation is preservation under the watchful eye of trained preservationists, versed in theory and experience; the watchful eye of the National Parks Service, full of professionals and experts in types of plywood and masonry. Informal preservation is the preservation of the everyday

DIY-minded individual who may or may not have theory, research or experience; and definitely does not have any oversight by anyone other than their local jurisdiction. Looking at the Portland Small Houses, one can see a lot of informal preservation. Most of the windows were replaced with vinyl windows, probably from the 1990's or 2000's. Most of the homes have vinyl siding, probably from the 1960's or 1970's. Some homes are completely unrecognizable as they have evolved and grown away from their original Small House form.

The informal preservation done to the Small Houses have kept the homes from being torn down and replaced, of which there are many examples that can be tracked through the use of Sanborn maps and aerial images. The informal preservation has sustained the homes sufficiently throughout the home's 100 year life span, a feat that *has* to be considered in the preservation determination process, especially when the informal preservation speaks to the history of the building. Specifically considering the vinyl siding, if the siding was originally replaced in the 1960's and 1970's, then this element of the home might speak to the era in building material history when predatory siding salesmen sold subpar materials to low-income homeowners.⁹² This should merely expand the story of the building. Allison Hoagland identified a similar case study where a company town from 1899-1900 in Colver, Pennsylvania showed low levels of material integrity due to "homeowners replac[ing] windows and add[ing] new siding - usually in a different material than the original or replacement siding" (informal preservation).⁹³ Hoagland notes that changing the siding poses problems from preservationists and listing property on the National Register of Historic Places (formal preservation). Fortunately, there was a multiple property document (MPD) that stipulated that if the overall form and shape of the building was intact, then the replacement of the original siding with something out of period would not

⁹² Alison Hoagland, "Industrial Housing and Vinyl Siding: Historical Significance Flexibility Applied," *Session III: Who Defines Significance?*, 1999.

⁹³ Ibid

disqualify the building from the nomination process.⁹⁴ A similar MPD could serve to protect and formally preserve the Portland Small Houses.

The Secretary of Interior's Standards states that "distinctive materials, features, finishes, and construction techniques...that characterize a property shall be preserved."⁹⁵ This would imply that alternative siding, whether it's vinyl, aluminum, or cement board, should be preserved as long as the material is of the period of significance. Due to the context of the Portland Small Houses, a conservative period of significance would be from 1920-1929, refer to chapter 2. This time frame does not fully tell the story of the Portland Small House and limits the preservationist's capacity for formal preservation. A more liberal, and obtainable period of significance would be several, starting with 1920-1929, a post war period of 1945-1960, an environmentally minded period of 1970-1980, and an economic driven period of 2008-present. These periods encapsulate general trends that relate to nationwide building and social trends, as well as trends that relate to Portland's urban and social development.

Selecting multiple period of significance, some of which are more in the recent past⁹⁶, can be helpful in the initial act of preserving the Portland Small Homes, especially if the low level of integrity is considered good in telling the story of the building. This however can make it challenging to move forward with alterations that can improve the building's sustainable response to changing environmental conditions.

Sustainable Practice

Many of the changes done to the Portland Small Houses have been environmental responses. Vinyl windows were marketed as more efficient and helpful for lowering electricity

⁹⁴ Ibid

⁹⁵ "Standards for Preservation," National Parks Service, Accessed May 2022.
<https://www.nps.gov/tps/standards/four-treatments/treatment-preservation.htm>.

⁹⁶ "Recent Past" refers to history within the past 50 years. The 50 year mark is oftentimes considered the defining factor in whether a building can/should be preserved according to NPS standards. If a period of significance is within the 50 year mark, then it needs to have a special nomination criteria, G, in order to get nominated.

bills, thus more sustainable and economical. Vinyl siding was seen as more durable and long lasting, as well as more air tight. The main alterations to the homes within this study are geared towards lowering occupancy costs, and this practice tends to be good towards general environmental causes. Therefore, it should not be unimaginable to consider that any future alterations to the building that are geared towards lowering occupancy costs, and thus carbon footprint, should be within the preservation scope.

Due to the impending climate crisis, one should consider good preservation practice sustainable practice. If the preservation of a building should keep the building inhabitable for another 100 years, it needs to keep the environment inhabitable for the next 100 years and consider an environment that might be less inhabitable for the next 100 years.

As an example, consider a building that used to have gas heating. Literal preservation practice would dictate the preservation of gas fixtures and the use of gas within the structure for heating. This is impractical, however, as gas can fail more often than electrical sources of heating.⁹⁷ It would be poor practice to restore a source of destruction within a historic structure. The same should be said of preserving the Portland Small Homes. Relying on informal preservation procedures for a more formal preservation practice would mean the continued use of structure as is, a more efficient and low cost occupancy footprint, and attainable housing for low income residents; while maintaining the historic context for the area of study. Maintaining the historic context of the area does not mean creating a barrier to more dense housing.

Impacts of Increased Density

Since 1920, the Portland population has more than tripled while the size of the city has not gotten too much bigger. The metropolitan area of Portland can still increase but compared to

⁹⁷ "Gas vs Electric Furnace," *Fixr*, Accessed May 2022, <https://www.fixr.com/comparisons/gas-vs-electric-furnace>.

other cities, it is relatively small.⁹⁸ The density of Portland will only grow higher as the population increases (Chart 4.1 & 4.2). This is not necessarily a bad thing. A higher density can lead to decreased tax spending on expansive and sprawling infrastructure, and an increase in local consumerism mainly due to the larger number of consumers per square foot.⁹⁹

In relation to the Portland Small Houses, there is ample opportunity to increase the density of the community they're located in. Because of their location on their lots, there is a lot of room for another Small House in front of the existing structure. This was even the intention as noted in chapter 2, and it is besides the point that Portland Small Houses have typically been demolished in these cases. They were sometimes converted into garages and sheds. Having another home in front of the existing structure would instantly double the occupancy of the lot without completely overwhelming the neighborhood, especially if the new structure is a copy of the existing structure. Using the Portland Small House as a typology for new construction would mean a smaller embodied carbon, while increasing the density and ideally decreasing the demand for housing in the community. The question of integrity does come up again, unfortunately, and might be seen initially as a deterrent to either preservation or densification. Looking at the notorious Eastmoreland Historic District, it is easy to tie single family housing and preservation together.¹⁰⁰ This is by a MPD would be preferable to preserving a typology, rather than a Historic District.

John Renne and David Listokin explore how combining historic preservation and transit oriented development (TOD) can be an opportunity for rectifying past mistakes and encouraging

⁹⁸ "Portland, Oregon Population 2022," World Population Review, Accessed May 2022.
<https://worldpopulationreview.com/us-cities/portland-or-population>

⁹⁹ Andrew M. Coutts, Jason Beringer, and Nigel J. Tapper, "Impact of Increasing Urban Density on Local Climate: Spatial and Temporal Variations in the Surface Energy Balance in Melbourne, Australia," *American Meteorological Society*, (2007).

¹⁰⁰ Joelle Jones, "Historic Districts: Preserving culture or perpetuating segregation?" *KOIN Portland*, November 3rd, 2021, accessed June 2022.
<https://www.koin.com/local/multnomah-county/historic-districts-preserving-culture-or-perpetuating-segregation/>

organic place making, giving the community the opportunity to develop their built environment.¹⁰¹ Tied closely to the 15-Minute City urban planning theory, TOD focuses on developing transit within 10 minutes of any given location in the urban landscape.¹⁰² Transit hubs are strategically placed in denser areas, to serve more people, which places pressure on less dense areas of cities to demolish their historic housing that could be replaced with denser housing. Missing Middle Housing (MMH), which will be explored as a case study in the next section, also helps to avoid the demolition of housing viewed as “less dense”.

Renne and Listokin identify a gap in research around TOD and preservation, stating that “the preservation of historic properties in TOD locations has much to offer in terms of amenity, place-making and linkage to the past.”¹⁰³ The benefits of maintaining historic less dense housing outweigh the benefits of replacing the historic housing with more dense housing. In the case of the Portland Small Houses, this is very true. The average DU¹⁰⁴ in this area of study is 7.2. This is fairly average in this area of Portland. A lot with an existing Portland Small House and a copy would have a DU of nearly 14.2 which is on par with the Buckman neighborhood’s density.¹⁰⁵

Case Study: Missing Middle Housing

Missing Middle Housing (MMH) is a topic that is emerging in the field of architecture and urban planning related to densifying areas of a city in a way that is meaningful and sustainable. A tool designated to help with making a city more sustainable, MMH is a healthy, and affordable option for housing for a greater group of people. MMH provides a diverse range

¹⁰¹ John L. Renne and David Listokin, “The opportunities and tensions of historic preservation and transit oriented development (TOD),” *Cities* 90 (2019) 249.

¹⁰² Ibid

¹⁰³ Ibid

¹⁰⁴ Dwelling units per acre

¹⁰⁵ Aarian Marshall, “How to Save Portland From Becoming the Next San Francisco,” *Bloomberg*, May 4th, 2015, Accessed May 2022,

<https://www.bloomberg.com/news/articles/2015-05-04/how-to-build-a-denser-portland-without-a-housing-squeeze>.

of housing types that typically range from 2 to 19 units, and provide well designed, compact, and walkable additions to an existing neighborhood.¹⁰⁶

Based on historic typologies, newly constructed MMH projects provide more housing options in places people generally want to live in, but might not be able to afford. There is typically less parking, more green space, and a greater sense of community due to the arrangement of the houses and their location within an existing neighborhood. MMH is an ideal option as infill housing as the scale fits in with existing neighborhoods and it provides an affordable option in an area that might otherwise be unobtainable. The Portland Small Houses should be considered as a typology that should be replicated in MMH projects. Traditionally the Portland Small Houses were a type of housing meant to be obtainable and have square footages that are comparable to units in a MMH project, while also being located in a neighborhood that is walkable.

Based on lots that are roughly 6,000 square feet, and a building footprint that is on average 600 square feet (1/10th of the lot), there could be an opportunity to densify the lot by replicating the typology of the Portland Small House. This could be a money making opportunity for the Small Houses Owner and could also provide starter homes for people wanting to live in the Beaumont-Wilshire/Cully Neighborhoods.

These homes could sell for roughly \$70-100,000 less than other homes in the area. Alternatively, these units could rent for around \$1,000; \$600 less than the average rental price in Portland, OR.^{107 108}

¹⁰⁶ Ibid

¹⁰⁷ "Portland, OR Rental Market Trends," *RentCafe*, Accessed March 2022.
<https://www.rentcafe.com/average-rent-market-trends/us/or/portland/>.

¹⁰⁸ Daniel G. Parolek, *Missing Middle Housing: Thinking Big and Building Small*, (Washington DC: Island Press, 2020).

Considering the history of the area and how zoning plays a role in the development of the area, it is clear that modifications to the zoning ordinances to the area are necessary. The debates that were present in many of the articles from the 1920's in Portland parallel many of the conversations that architects, planners, and preservationists are having today. The current zoning for this area is R-5, which dictates one unit per 5,000 square feet lot. Changing the zoning to R-2.5 would double the unit density for this area, but if form-based zoning was used, as suggested by Parolek, it could triple the density of the area, if not quadruple. This will be explored slightly more in the next section.

Appendix 3

Chart 4.1. Portland Population through time. From World Population review.

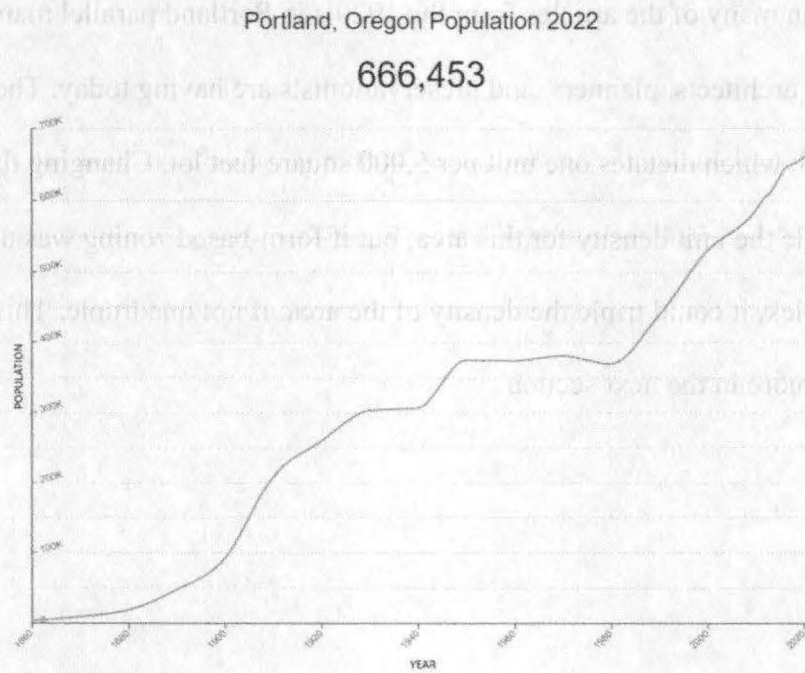
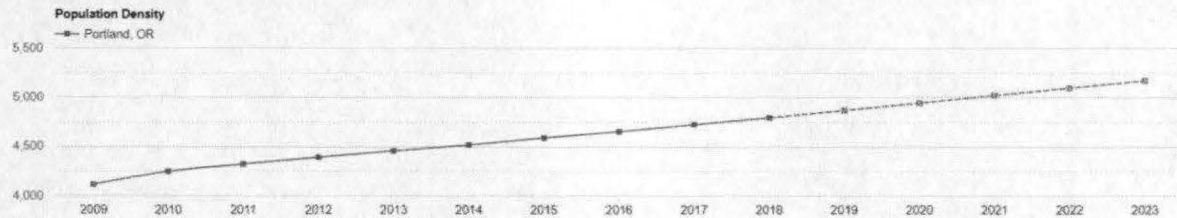


Chart 4.2. Portland Density through time. From World Population review.

Population Density API



CHAPTER 5

COURSE OF ACTION

Introduction

Understanding the problem is critical to solving the problem, as obtaining the solution is usually the goal for many problem solvers. Rather than outlining specific solutions, the Portland Small Houses lends itself towards providing suggestions rather than hardline action points that Portland should take. The discourse that arose around this research, however, will lead to some hardline points of action. The solutions are so multi-disciplinary, it would be a challenge for one person to direct the solutions to the many. Considering the weight of climate change and housing equality, it is necessary to call for changes to the preservation, architecture, construction, planning and policy industries.

The research presented in this thesis is merely based on just that; research. The next chapter outlines a few points of action which would be natural next steps, that are grounded in extensive research. It is now up to the community to determine what to do with this information, ideally in a way that best suits them. Some of the solutions are policy driven, either on a local level, state level, national level, and maybe ultimately on a global level. Other solutions are more ideological and require a change in neighborhood attitudes. Other solutions are for institutions and call for change within industries that have the power to implement them.

Carbon Tax

Ideally set at a national level, but could also be set at a statewide or city wide level, a carbon tax is a tax on the amount of carbon that is emitted to create the product or how much carbon cannot be recovered by creating the product. For example, cutting down trees, even with an ax could result in a carbon tax because it reduces nature's ability to remove carbon from the

atmosphere. If the lumberjack were to plant X number of trees needed to mediate the original tree's capacity to remove carbon, then the process is a carbon neutral process, resulting in 0% tax on the lumberjack's business. This simple example does not convey the complexities of carbon tax within our globalized capitalist society, but it is an example that conveys the basics of the principle idea.

Carbon taxes are not a new idea. In *A Case Study for a Carbon Tax*, the Shi-ling Hsu works to move policy forward in a way that can monetize carbon use for those who suffer under the burden of environmental injustice, while the use of carbon. Due to our economic systems being driven by profits, a carbon tax would drive prices up for the producer and for the consumer.¹⁰⁹ Hsu outlines ten arguments for a carbon tax, based on US government policy in 2011. Since this is 10 years ago, it is easy to consider this information slightly outdated, but there are nuggets of useful information such as a context for the concept of a carbon tax.

Economists have argued for and against carbon taxes for reasons ranging from the easiest solution to climate change, to the misfortune of having a government that is ineffective enough to implement such policy.¹¹⁰ Several alternatives are mentioned, of which carbon tax incentives are mentioned and will be discussed in the next section. They would work best in tandem with a carbon tax, using a stick and carrot persuasion method. The carbon tax would charge you for the carbon you use and the carbon incentive would pay you for the carbon you save. The incentives would be paid for using the taxes.

There is a fear that the implementation of a stick without a carrot would drive companies and developments away, especially if there are not any other carrots to keep them around. This is

¹⁰⁹ Shi-Ling Hsu, *The Case for a Carbon Tax: Getting Past Our Hang-Ups to Effective Climate Policy*, (Washington D.C.: Island Press, 2011).

¹¹⁰ Shi-Ling Hsu, *The Case for a Carbon Tax: Getting Past Our Hang-Ups to Effective Climate Policy*, (Washington D.C.: Island Press, 2011)⁷

why a tax carbon policy would need to be applied at least at the state level, or national level, and ideally at a global level. Due to the effects of climate change affecting everyone, it would make sense for a global effort to reduce carbon, in a way that is tied to money. Countries like Sweden, Norway, Denmark, Finland, and the UK have instituted a carbon tax to some success, financially and politically, but this has not swade larger countries. Sweden has shown an increase in GDP (Chart 5.1) and uses a strategy of creating multiple types of carbon taxes, allowing for a wide range of carbon ownership and responsibility, guaranteeing that “polluters pay”.¹¹¹ This kind of effort becomes incredibly political and requires some understanding that Hsu’s book was published in 2011, five years prior to Donald Trump’s rejection of the 2016 Paris Climate Agreement.

The fear of developers retreating to another city, state or country is more than enough to kill certain policies.¹¹² There are moral grounds for why punishment should occur to those who pollute and harm the planet in a way that is unsustainable, but this is not grounds enough for the creation of certain policies, such as carbon taxes.

Carbon Incentives

As mentioned before, carbon tax incentives work best in tandem with a carbon tax but if one must be established over the other, it is reasonable to consider the carbon tax incentive as a more politically successful policy. Policies that put money in the hands of taxpayers tend to gather a greater response and have connotations with being a reward, rather than a punishment.¹¹³

¹¹¹ “Sweden’s Carbon Tax,” *The Government Offices of Sweden*, Accessed April 2022, <https://www.government.se/government-policy/swedens-carbon-tax/swedens-carbon-tax/>.

¹¹² Shi-Ling Hsu, *The Case for a Carbon Tax: Getting Past OUR Hang-Ups to Effective Climate Policy*, (Washington D.C.: Island Press, 2011). 63

¹¹³ Lourdes German and Joseph Parilla, “How Tax Incentives can power more equitable, inclusive growth.” *Bookings*, May 2021, Accessed April 2022.

<https://www.brookings.edu/blog/the-avenue/2021/05/05/how-tax-incentives-can-power-more-equitable-inclusive-growth/>

A carbon tax incentive would be a reward for proving that you either removed carbon from the atmosphere or reduced the amount of carbon you would've emitted. In the case of embodied carbon in the built environment, this would require the documentation of what was retained, what was replaced and how it was replaced. Knowing where the replacement material comes from and how it was manufactured would be key to calculating the overall embodied carbon of the process. Documentation at every stage would require extensive photography and notes of the existing condition. This might sound like a lot, but it is already required for receiving historic tax credits for historic buildings, another incentive that encourages the reuse and adaptation of old material. Using the historic tax credit model for a carbon tax incentive would be the best way to encourage the reuse of existing buildings that might not be able to be considered historic but could still serve the community well as a building, i.e. buildings from within the last 50 years.

LEED as a program requires much of the same documentation, making it a program that is inline to successfully use embodied carbon as an incentive in their certification process. This would be one of the first steps towards implementing a Carbon Tax Incentive (CTI). A CTI could be used on historic renovation projects, as well as adaptive reuse projects, making the CTI program beneficial for architects, preservationists, and developers; three groups who are sometimes pitted against each other. The Association for Preservation Technology would be an excellent place to start implementing change. Their sustainability mission statement does not include any mention of embodied carbon, but would be an excellent resource in regards to sharing research geared towards the preservation of materials for sustainable purposes that architects and developers can reference.¹¹⁴ This is useful for parts of the US that might not have policies that encourage carbon taxes or incentives.

¹¹⁴ "Sustainable Preservation Technical Committee," Association for Preservation Technology International, Accessed June 2022. <https://www.apti.org/sustainable-preservation>

Adaptive Reuses

Is retrofitting the future of architecture? Based on research in this thesis, yes. The reuse of materials and retaining as low of an embodied carbon footprint as possible is necessary for the building industry to reduce their overall carbon footprint. Architects and builders are no strangers to adaptive reuse theory, as the practice goes as far back in time as the practice of construction itself.¹¹⁵ Now, in retrospect, there is theory applied to adaptive reuse projects, tied with the architect's perspective of the building's typology. During the 1960's and 1970's, when the preservation and sustainability fields emerged in the mainstream, adaptive reuse was used for conservation, "education, freedom of expression and sustainability."¹¹⁶

Bringing back the phrase "the greenest building is the one that is already built", a phrase that rings ever so much more true when considering embodied carbon. The expression was used to summarize sustainability theory in relation to adaptive reuse projects. It seems intrinsically obvious that reusing a material, or a building, would be better in terms of sustainability. The performance of the building might affect the sustainability argument, but this is where adaptive reuse could be best used. The adaptive reuse process makes sure that the building is up to code, has an increased level of safety and meets contemporary ASHRAE¹¹⁷ and IBC¹¹⁸ standards.¹¹⁹ This increase in standards lets the building get more use and increased occupancy, prolonging the lifespan of the building, and therefore saves the building from being demolished. Adaptive reuse is appealing to not only architects but preservationists in terms of retaining historic material.

The Secretary of the Interior's Standards for the Treatment of Historic Properties calls for the preservation of material, details, shape and use, but is not completely opposed to the

¹¹⁵ Liliane Wong, *Adaptive Reuse: Extending the Lives of Buildings* (Basel: Birkhauser Verlag, 2016) 8.

¹¹⁶ Liliane Wong, *Adaptive Reuse: Extending the Lives of Buildings* (Basel: Birkhauser Verlag, 2016) p.96

¹¹⁷ American Society of Heating, Refrigerating and Air-Conditioning Engineers.

¹¹⁸ International Building Code.

¹¹⁹ Liliane Wong, *Adaptive Reuse: Extending the Lives of Buildings* (Basel: Birkhauser Verlag, 2016) p.21

“introduction of a new use as long as it wields minimal change to the monument’s distinctive character.”¹²⁰ This is helpful for architects and preservationists alike. Using the Washington High School on SE Stark St. as an example, architects and preservationists were able to retain much of the existing character (to the advantage of the architect and preservationist) and use historic tax credits to reuse the building as retail, office, and bar space; providing new uses for the community while maintaining much of the original historic material.¹²¹ This project was not marketed as a sustainability project but had the Washington High building been demolished and a new structure of the same size been built on the same lot, it would have increased the embodied carbon significantly. Now the school acts as an anchor in the Buckman neighborhood, providing economic income to the area and amenities to the increased multifamily housing developments in the neighborhood. To help mainstream adaptive reuse, programs in architecture and historic preservation schools need to encourage adaptive reuse projects in the classroom. A certification process that can help guide students towards these types of projects would mean a career that is geared towards adaptive reuse projects, which should be the future of architecture, and must include the input of preservationists.

Increased Density

In the 2022 ICPP of the UN released a report that higher urban density is all but guaranteed in the future and the effects of climate change will disproportionately affect city dwellers over the rural population.¹²² ¹²³ The IPCC has identified gaps in urban planning that lead to inaction on the part of jurisdictions, a lack of financial support to follow through with city sustainability plans, and the lack of investment in outdated infrastructure.¹²⁴ These gaps,

¹²⁰ Liliane Wong, *Adaptive Reuse: Extending the Lives of Buildings* (Basel: Birkhauser Verlag, 2016) p.172

¹²¹ “Washington High School - History,” *Washington High School PDX*, Accessed May 2022.

<https://washingtonhighschoolpdx.com/history/>

¹²² Ibid

¹²³ Ibid

¹²⁴ Ibid

however, if they could be filled, could benefit the greatest number of people all across the world. This is where the argument for the benefits of increased density within a city. Portland, OR specifically has a relatively low urban density compared to other cities in the US. Compared to other cities globally, the density in Portland could be called suburban rather than urban.

The desire to make Portland, OR, more dense might not be desirable to many but could impact the most in terms of lowering the city's footprint. In terms of urban planning and designing a city that is geared towards transit oriented design (TOD), pockets of extremely high density mixed in with areas of low density and middle density allows for a more efficient transit system that is used by more people.¹²⁵ A more public transit heavy city that is also walkable tends to have a lower carbon footprint.¹²⁶ A more efficient city transit allows for more institutionalized equity and a de-stigmatization of public transportation.¹²⁷ The more people there are in a city, the cheaper it becomes to run a public transportation system per square mile.¹²⁸

Not only is a denser city good for moving around the city, but it will also provide financial benefits. There is a greater pool for tax revenues as there will be more people, with not too much of an increase in infrastructure if the city is planned as a transit orientation design. Hubs of great density can be located in transportation hubs (or vice versa), allowing for more effective use of transportation hubs, bringing down the cost of construction per person. On average bus occupancy will be higher per bus but would bring down overall road traffic, meaning that maintenance on infrastructure could be more sustainability managed.¹²⁹

Density within the built environment is relatively simple as well, and mainly faces conflict from NIMBY opposition.¹³⁰ In terms of construction, since most planning codes rely on

¹²⁵ Ibid

¹²⁶ Ibid

¹²⁷ Ibid

¹²⁸ Ibid

¹²⁹ Ibid

¹³⁰ NIMBY stands for "Not in My Back Yard".

a density based set of codes, many buildings try to meet the max density of their zone and in the case of Portland, should achieve a greater density.¹³¹ For Portland Small Houses, the lot location lends itself well to increasing the density of the lot and thus neighborhood, but might face opposition from the city as being “too dense”. This language leads to NIMBY discourse. Figures 5.1 and 5.2 show in diagrammatic form how the existing condition looks compared to a significantly more dense condition. The additional units are based on the same form and size as the Portland Small Houses. The intuition is to show that increasing the density does not need to be a terrifying endeavor.

Not only would homeowners have to deal with potential neighborhood challenges, but banks might find these projects hard to fund. This either means developers need to come in and see if they can make a profit off of attainable housing, or another solution needs to be devised. Community Land Trusts are a good way to fund, build and sell homes that work based on cyclical trust processes. The community comes together and pools their resources towards a specific goal. It might be building a house or repairing one that already exists. They then have the power to choose who they sell that house to, typically looking to break even with the cost of construction or renovation. This is an opportunity for communities to take back the idea of profit driven housing and provide housing for people at a reasonable cost. This process also means that people are brought to the community who can in return support the land trust and perpetuate the cycle.¹³²

¹³¹ Ibid

¹³² “Community Land Trusts (CLTs),” *Common-Wealth.Org*, Accessed June 2022.
<https://community-wealth.org/strategies/panel/clts/index.html>

Appendix 4

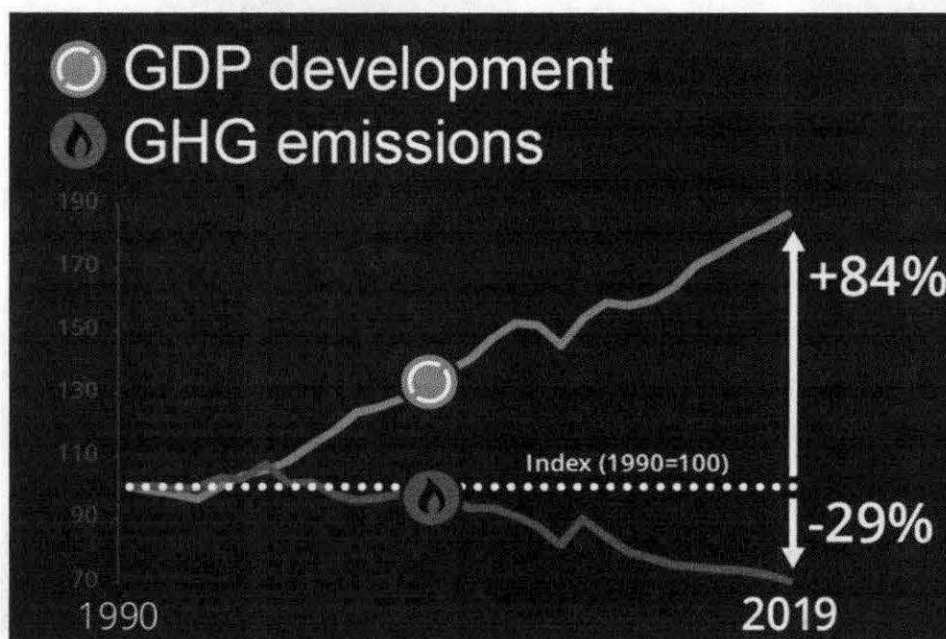


Chart 5.1. Chart shows the increase in Swedish GDP as Greenhouse gasses decrease. Chart is from the Government of Sweden.

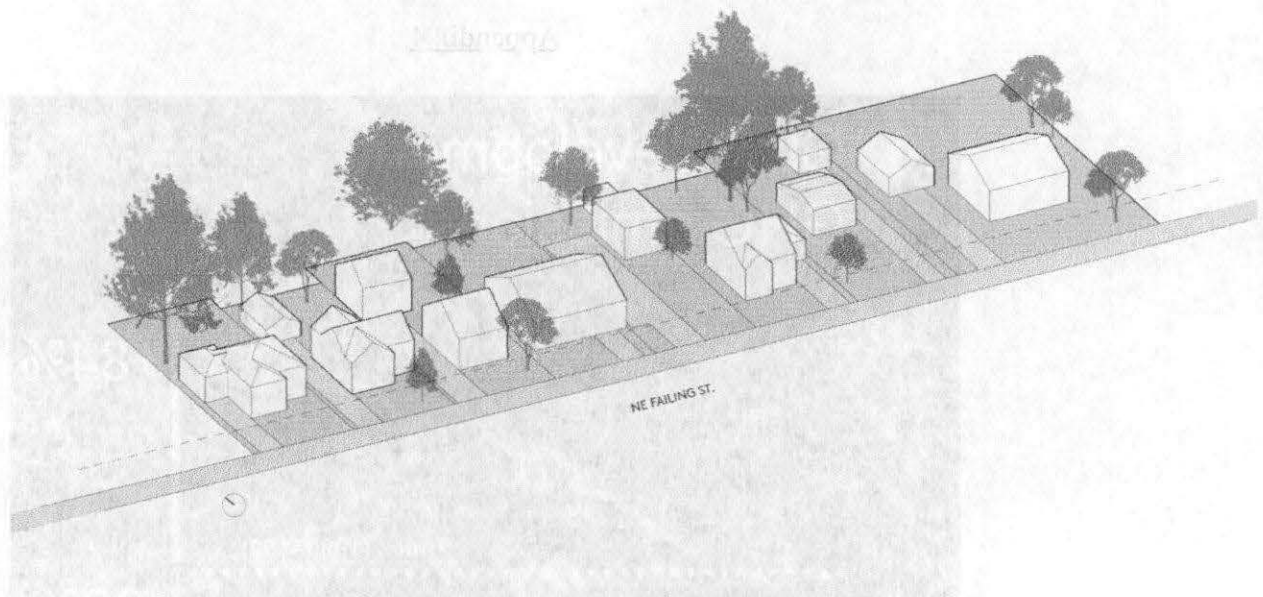


Figure 5.1 Diagram created by author. Based on actual data from PortlandMaps, this diagram shows the neighborhood as it is with two existing Portland Small Houses. Their size, shape and distance from the road really show how unique they are from the rest of the neighborhood.

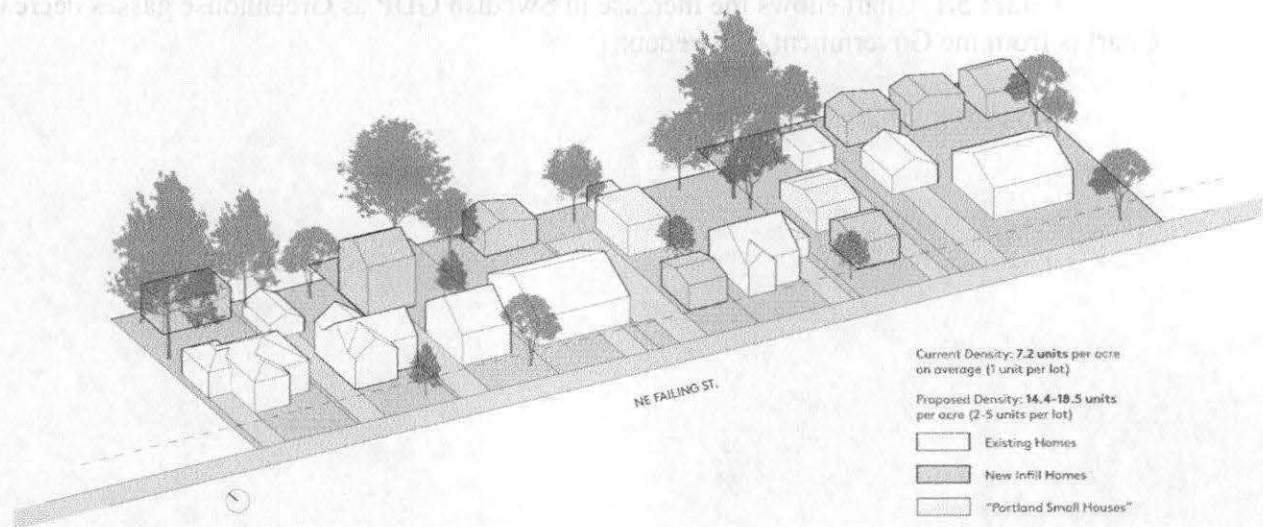


Figure 5.2 Diagram created by author. Based on the previous diagram, this plan shows what potential infill could look fairly approachable and would benefit the community by increasing the density. The added dwellings are based on the proportions of the existing Portland Small Houses.

CHAPTER 6

CONCLUSION

Future Research

Future research on this topic could be expanded into three topics which were covered in this paper. The first would be on the general topic of Portland Small Houses. An intensive survey of Portland could uncover all the locations of still existing homes, influencing the context of the homes and understanding their development more accurately and acutely. Secondly, the impacts of embodied carbon on greater scales. As more material is saved and reused, less carbon is emitted. Thirdly, how preservation can be rebranded and marketed as affordable housing solutions.

There is some evidence of Portland Small Houses existing outside of the area of study that was identified in chapter 1. The reasons the Portland Small Houses exist in this area are also evident in other parts of Portland, meaning that there is a chance that other Small Houses exist. Methods of future study include extensive study of Sanborn maps from 1929, and 1951. A field survey should then be conducted in order to establish what is still existing. Eventually, a study of the interior of the homes would be necessary to further understand the homes in greater depth. The importance of this study would be to learn about an element of Portland history within a group of people that are typically excluded from history. The Portland Small Houses could be considered a housing typology that developed around transportation hubs, on cheap land that was just outside of the city limits, adding texture to the story of housing in the 1920's in Portland.

An example of a typical Portland Small House was identified by the author in Kansas City, MO (Figure 6.1 & figure 6.2). It shows similar characteristics in its construction as the Small Houses in Portland, only the house was constructed 10 years prior to most of the Portland

Small Houses. The neighborhood development around this area shows similar characteristics (unincorporated land until the late 1970's, connected to the financial center via an interurban trolley, and surrounded by later 1940's and 1950's development). This shows that maybe the Portland Small Houses should actually be considered the American Small Houses? Perhaps Interurban Small Houses? Their development is distinct to early 20th century development in an environment with extensive access to lumber and land, so it would be easy to continue finding these Small Houses throughout the rest of the United States and even North America. This would push forward the preservation of these homes radically.



Figure 6.1 A Kansas City Small House, photograph by author. June 2022

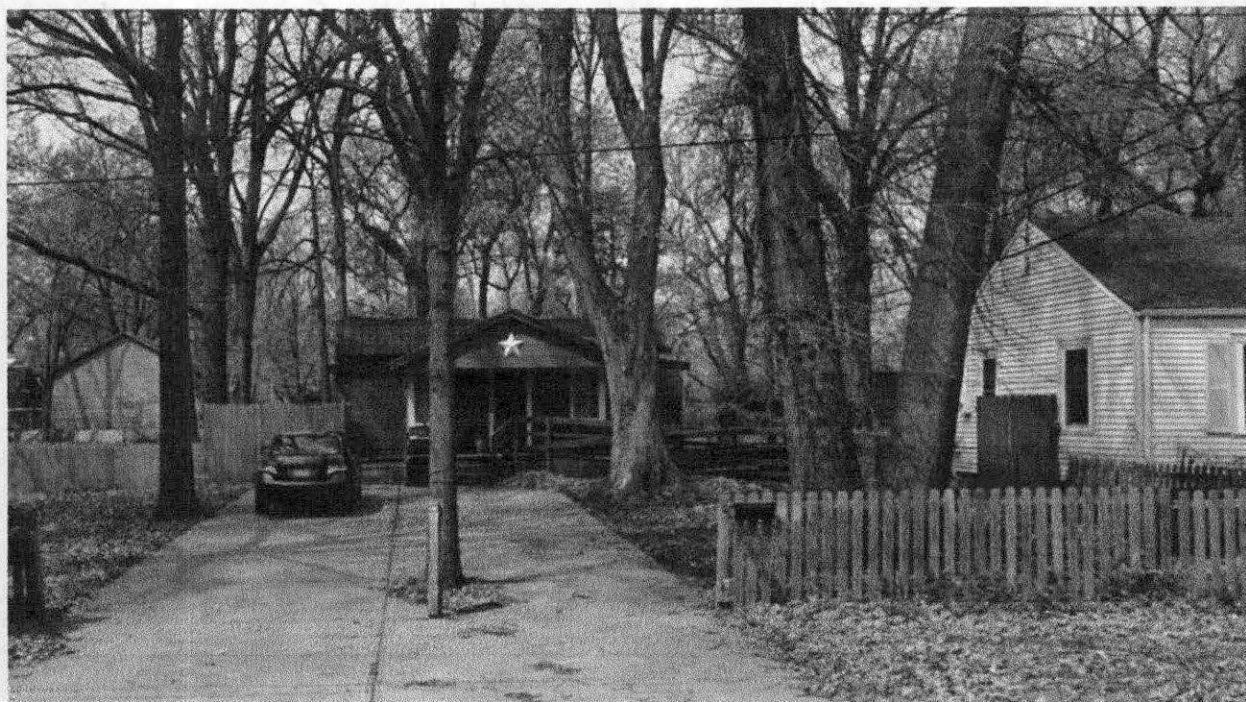


Figure 6.2 A Kansas City Small House, photograph by author. June 2022

The impacts of embodied carbon should be better appreciated, especially as there is software that does take this into consideration. This form of study would be impactful in both the preservation and architectural industry and influential in climate policy regarding the built environment. A study that includes a variety of scales would be beneficial, as small homes are not the only type of buildings being constructed in the US. Considering the costs at such scales would be beneficial for developers to buy in on the benefits of utilizing embodied carbon. LEED and the US Green Building Council could use the study to make changes in their certification process, giving historic structures the credit towards sustainability that they are due. Architecture programs might consider adaptive reuse studios, in order to meet the demand for knowledge of altering existing structures. Future study of embodied carbon would help the subject become mainstream and widely accepted.

Another concept that should become widely accepted, the idea of preservation and affordability. Based on numerous studies, essays, and anecdotes, preservation and affordability go hand in hand under the right circumstances.¹³³ Making this common practice would in turn help the preservation community as much as the community needing affordable housing. Houses that are well maintained for example cost less for the homeowner than building a new house to replace the old house. Home maintenance programs cost less than issuing demolition permits and maintaining a landbank of empty lots. Home values tend to go up when the homeowner maintains an old building, and go down when the home is next to an empty lot or abandoned home. Providing this assistance also means that preservationists have fewer larger projects. This is one way that generational wealth can also be sustained and built up. The maintenance of old homes is beneficial to the whole community as a sustainable method of keeping people in their homes for longer periods of time; as an environmentally and affordable, sustainable answer to the housing crisis.

There is a lot of work to be done, based on the future research that should be done. It is mainly a response to the gaps found in the literature review, the general trends in sustainability and preservation that were incorporated into this study, and an intense idealism of what the author wished this study could cover in the limited scope of a thesis. The future research is not intended to be out of reach aspirations but a checklist of intended studies that would push this research further.

¹³³ As a personal antidote, a recent project that I am working on quotes \$150 per square foot in renovations of a 100 year old church to become affordable housing. To demolish and build the same number of units would cost about \$500 per square foot. The units can only be rented as affordable units if they are in an old renovated church. The newly constructed project would be unobtainable to the local community.

Limitations

Limitations to this study are based on a few factors. The most significant factor is the lack of information on this specific typology, however, due to this factor, there was a call to action¹³⁴. There was a need to document and study that which had very little information and access to information meant it needed to be studied. Based on the information that was gathered, the Portland Small Houses were certainly geared towards lower income families in need of affordable housing, usually having just moved to Portland from another state or country. These are the groups of people that historians are trying to document, despite the lack of documentation. As a preservationist, the Portland Small Houses allows this limited story to be told through the built environment and interpreted through maps and newspaper articles.

A limitation that did not hinder the story but failed to manifest throughout the research was a lack of photographs. This makes the section about integrity merely a highly educated guesswork of a section, which is based on a lot of similar examples and research on the theory of integrity in preservation. Having photos would mean a more accurate idea of what was changed and when, as well as possible interpretations as to why. This would either make the arguments about integrity and preservation stronger or weaker, changing some overall elements of this thesis. This is an element that could come to light with future study of the interior of the homes.

Not being able to enter a Portland Small House proved challenging and limiting. Thomas Hubka's book, *Houses without Names*, has a section about interpreting a rough floor plan based on window locations and exterior footprint, which proved helpful. It does not, however, give any clue as to how the interior might've changed or what the interior finishes are like. It is also possible that the projected floor plan is completely inaccurate, making the Portland Small Houses

¹³⁴ Rather, a call to study

incredibly unique in their programming. Until future study has been conducted, information about the Portland Small Houses only relate to the exterior of the homes.

Summary

It is difficult to summarize this research as it bridges several topics, decades, and industries. Originally starting with a core concept about exploring the intersection of preservation, sustainability and affordability, the research was using a case study that was a historic example of affordable housing, using embodied carbon as a focus on environmentalism. The three fields (preservation, sustainability, and affordability) all have their ties to activism and grassroots movements in American history. They are also grounded heavily in the built environment and housing.¹³⁵ Their relationship with each other allowed for a study of the Portland Small Houses to have a focus on the sustainable adaptation of the homes to make the houses themselves more affordable and become a template for future newly constructed affordable and sustainable housing.

The preservation of the Portland Small Houses became key to making the homes sustainable. Using a Tally, a modeling software, different wall types were compared to existing methods, altered methods, and newly constructed methods, calculating the embodied carbon of each. The newly constructed method showed a significantly higher embodied carbon, making anything new instantly have a larger carbon footprint. The preservation of as much original material as possible is essential to lowering the emissions of carbon on our planet and it is proven.

The sustainable alteration of the home without too much cost or too much alteration to the historic fabric is also possible but is granted more flexibility with the Portland Small Houses due to their history of constant informal alterations. Changing the building to adapt the home is

¹³⁵ In general but not the rule.

what makes the house affordable and habitable, and was necessary for the continual existence of the home. The acts of informal preservation should not deter formal preservation and should be considered in the formal preservation process, with a suggested reevaluation of the concept of integrity within the preservation toolbox.

The affordability of preservation and sustainable adaptation is ingrained into the history of the building. Their origin as an affordable housing option in the 1920's was emphasized by their location near the boundary of Portland permitting oversight¹³⁶, proximity to public transportation¹³⁷, and location on the lot.¹³⁸ The preservation of the homes is a cheaper method of obtaining housing than building a new structure, especially in the long term as the homeowners maintain the home and make improvements to the building.¹³⁹

Ultimately, the summary of this research is best encapsulated as a call to action. The knowledge is there and available, there are homes out there and resources for them, whether it is people, financing, or information. With the impending doom that is climate change, let this research show that neither preservation, affordability or sustainability stand in each other's way, and cannot be the excuse to not execute one, or the other, or the other. They are a cohesive network that builds off of each other.

¹³⁶ Less permitting oversight meant that the home could be constructed using cheaper or subpar methods on land that was cheap to access because of its distance from downtown Portland.

¹³⁷ This granted the inhabitants accessible transportation to work in downtown Portland.

¹³⁸ This granted the inhabitants the ability to improve or build a better house in the future while giving them the option to keep the smaller house as a garage or shed.

¹³⁹ Ibid

Appendix A

Wall Cavity Comparison

Portland Small House Wall Cavities

4/14/2022



tally.

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Wall Cavity Comparison

Portland Small House Wall Cavities

4/14/2022

Report Summary

Created with Tally
Commercial Version 2020.06.09.01

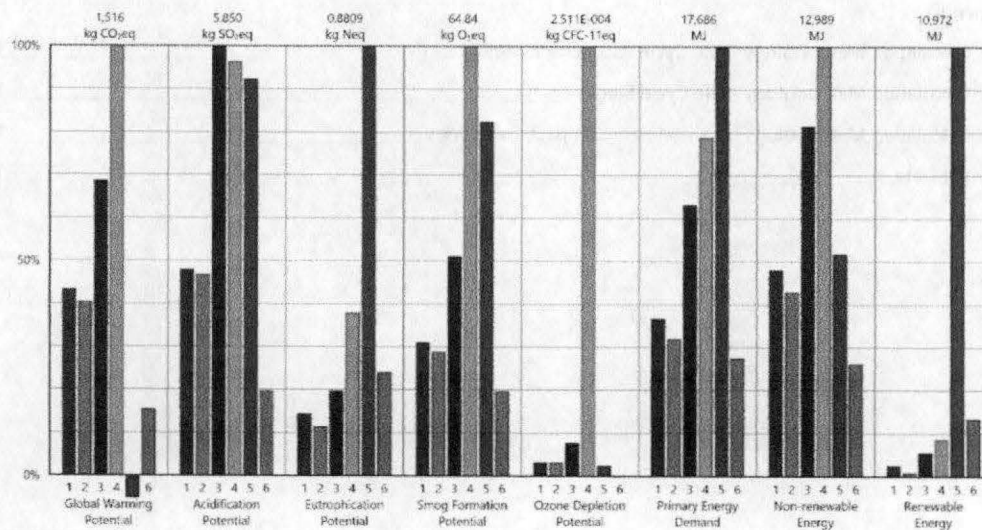
Goal and Scope of Assessment

This report is intended to compare different wall types in order to better understand the building performance and carbon load in relation to the Portland Small Houses

Author Maddy Irwin
Company University of Oregon
Date 4/14/2022

Project Wall Cavity Comparison
Location Portland, OR
Gross Area 600 ft²
Building Life 60 years

Boundaries Cradle to grave, inclusive of biogenic carbon; see appendix for a full list of materials and processes

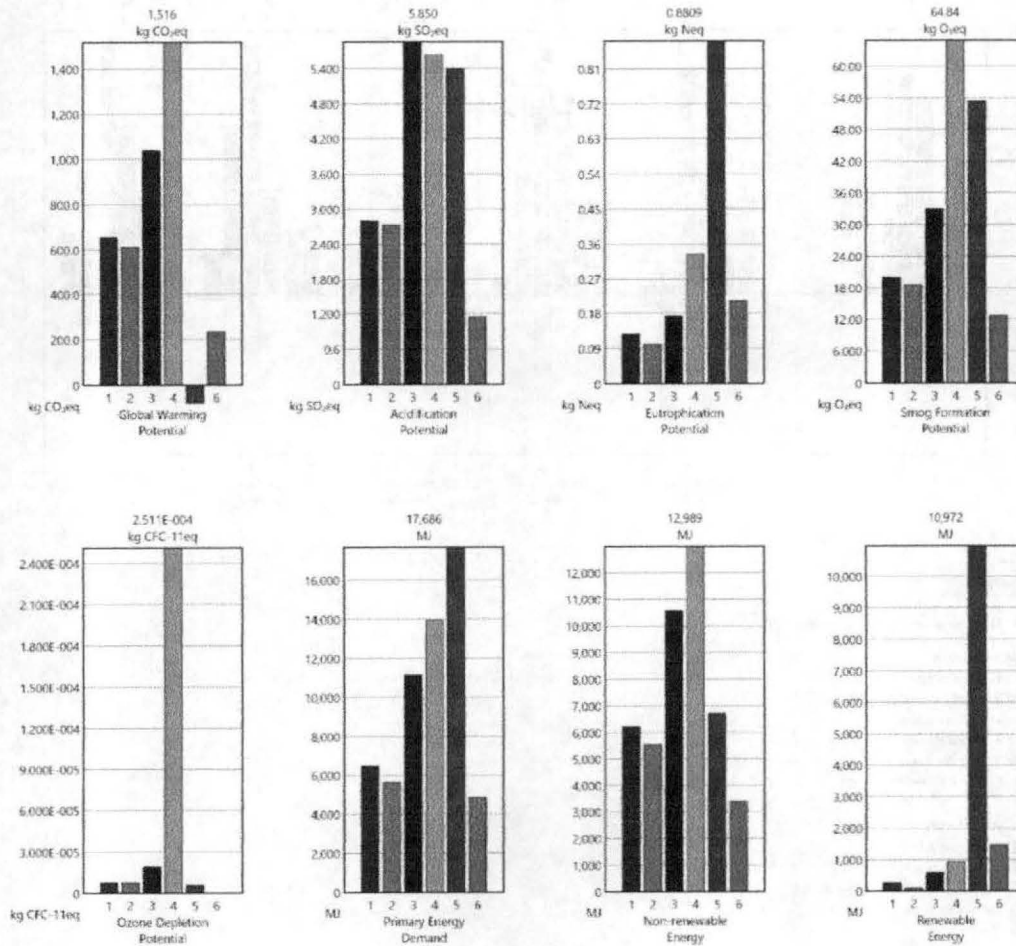


Legend

Design Options

- Cellulose Method
- Existing Method (primary)
- Furring Method
- Hybrid Method
- New Construction - Ideal
- New Construction - Typical

Report Summary (continued)



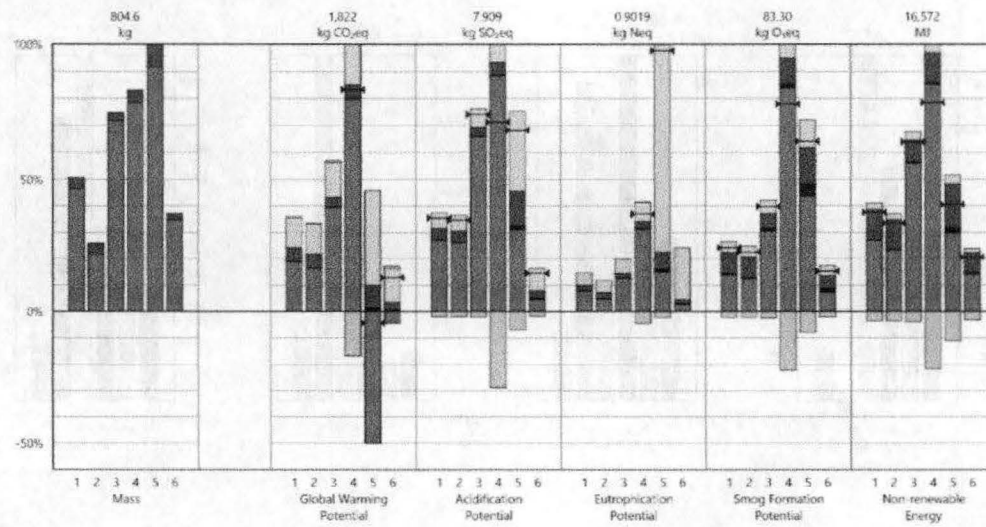
Legend

- Design Options
- Cellulose Method
 - Existing Method (primary)
 - Furring Method
 - Hybrid Method
 - New Construction - Ideal
 - New Construction - Typical

Wall Cavity Comparison Portland Small House Wall Cavities

4/14/2022

Results per Life Cycle Stage



Legend

Net value (impacts + credits)

Design Options

- Option 1 - Cellulose Method
- Option 2 - Existing Method (primary)
- Option 3 - Furring Method
- Option 4 - Hybrid Method
- Option 5 - New Construction - Ideal
- Option 6 - New Construction - Typical

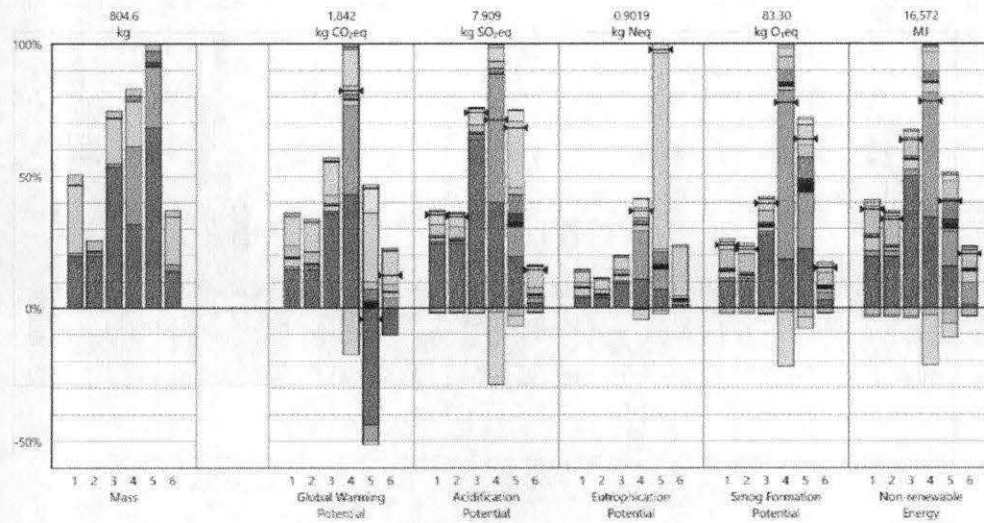
Life Cycle Stages

- Product [A1-A3]
- Transportation [A4]
- Maintenance and Replacement [B2-B5]
- End of Life [C2-C4]
- Module D [D]

Wall Cavity Comparison Portland Small House Wall Cavities

4/14/2022

Results per Life Cycle Stage, itemized by Division



Legend

Net value (impacts + credits)

Design Options

- Option 1 - Cellulose Method
- Option 2 - Existing Method (primary)
- Option 3 - Furring Method
- Option 4 - Hybrid Method
- Option 5 - New Construction - Ideal
- Option 6 - New Construction - Typical

Product [A1-A3]

- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 09 - Finishes

Transportation [A4]

- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 09 - Finishes

Maintenance and Replacement [B2-B5]

- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 09 - Finishes

End of Life [C2-C4]

- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 09 - Finishes

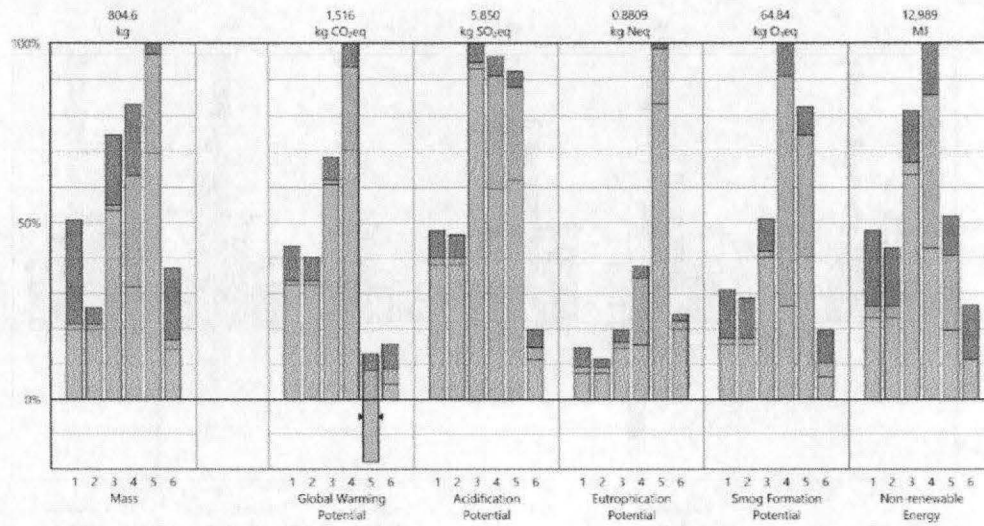
Module D [D]

- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 09 - Finishes

Wall Cavity Comparison Portland Small House Wall Cavities

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Results per Division



Legend

Net value (impacts + credits)

Design Options

- Option 1 - Cellulose Method
- Option 2 - Existing Method (primary)
- Option 3 - Furring Method
- Option 4 - Hybrid Method
- Option 5 - New Construction - Ideal
- Option 6 - New Construction - Typical

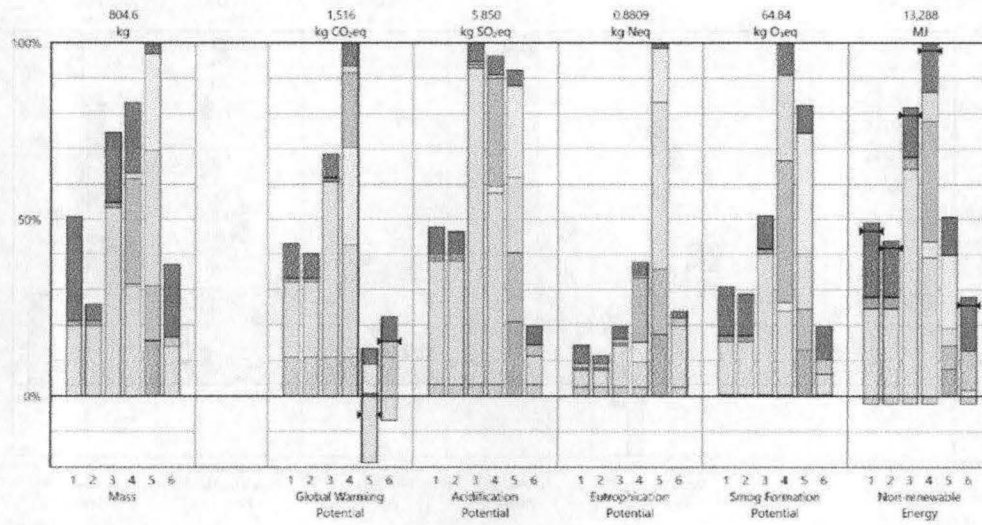
Divisions

- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 09 - Finishes

Wall Cavity Comparison Portland Small House Wall Cavities

4/14/2022

Results per Division, itemized by Tally Entry



Legend

Net value (impacts + credits)

Design Options

- Option 1 - Cellulose Method
- Option 2 - Existing Method (primary)
- Option 3 - Furring Method
- Option 4 - Hybrid Method
- Option 5 - New Construction - Ideal
- Option 6 - New Construction - Typical

06 - Wood/Plastics/Composites

- Oriented strandboard (OSB)
- Particle board
- Plywood, exterior grade
- Wood framing with insulation
- XPS (polystyrene) insulating sheathing

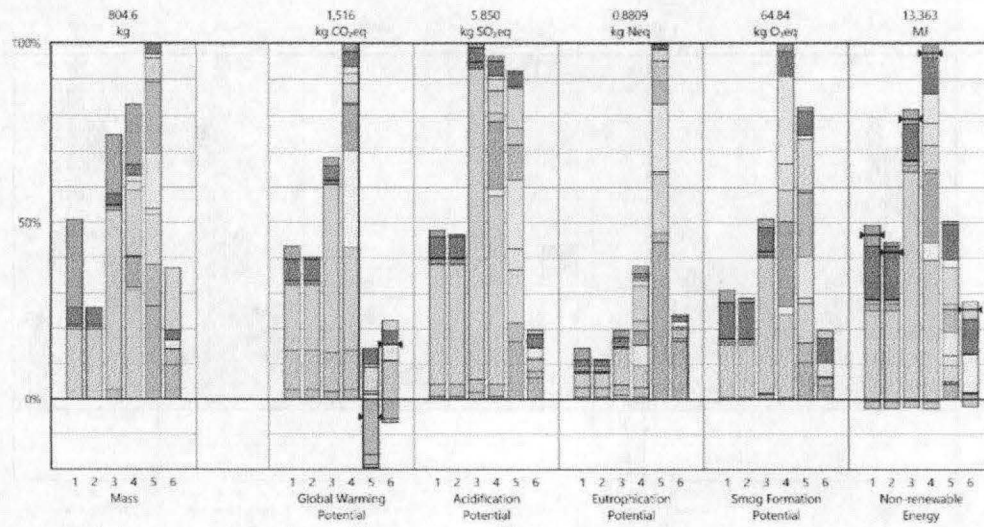
07 - Thermal and Moisture Protection

- Asphalt felt sheet
- Fiber cement panel
- Plastic siding, vinyl
- Self-adhering membrane
- Wood rainscreen, hardwood

09 - Finishes

- Wall board, gypsum

Results per Division, itemized by Material



Legend

Net value (impacts + credits)

Design Options

- Option 1 - Cellulose Method
- Option 2 - Existing Method (primary)
- Option 3 - Furring Method
- Option 4 - Hybrid Method
- Option 5 - New Construction - Ideal
- Option 6 - New Construction - Typical

06 - Wood/Plastics/Composites

- Cellulose insulation, blown
- Domestic softwood, US, AWC - EPD
- Exterior grade plywood, US
- Mineral wool, high density, NAIMA - EPD
- Oriented strandboard (OSB), AWC - EPD
- Paint, Brillux, Silicone facade paint - EPD
- Particleboard, AWC - EPD
- XPS insulating sheathing, Foamular (R-4, 15 psi), Owens Corning - EPD

07 - Thermal and Moisture Protection

- Aluminum extrusion, AEC - EPD
- Asphalt felt sheet, roofing underlayment, ARMA - EPD
- Elm lumber, 1 inch
- Fasteners, galvanized steel
- Fasteners, stainless steel
- Fiber cement board
- Galvanized steel support
- Paint, exterior acrylic latex
- Self-adhering flashing membrane, 40 mil
- Vinyl siding
- Wood stain, water based

09 - Finishes

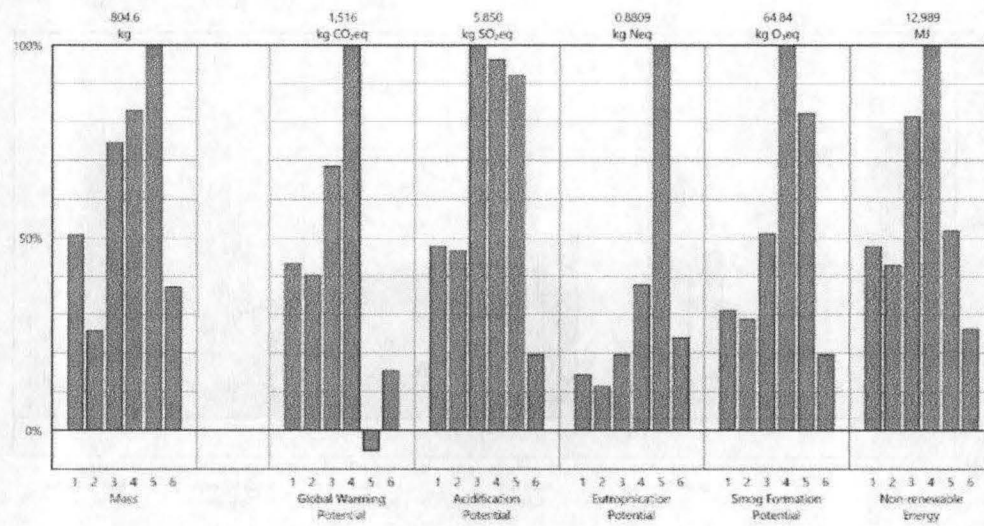
- Paint, interior acrylic latex

- Wall board, gypsum, moisture- and mold-resistant
- Wall board, gypsum, natural

Wall Cavity Comparison Portland Small House Wall Cavities

4/14/2022

Results per Revit Category



Legend

Net value (impacts + credits)

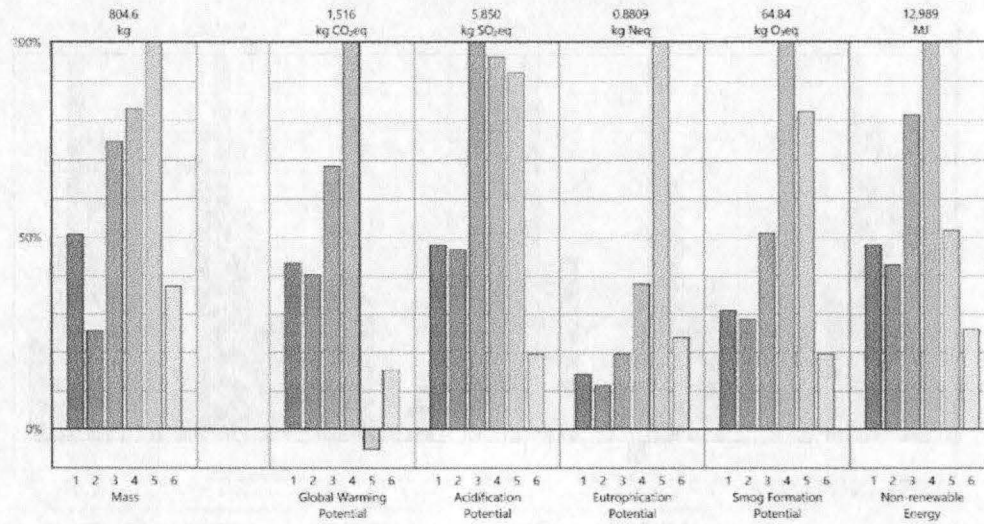
Design Options

- Option 1 - Cellulose Method
- Option 2 - Existing Method (primary)
- Option 3 - Furring Method
- Option 4 - Hybrid Method
- Option 5 - New Construction - Ideal
- Option 6 - New Construction - Typical

Revit Categories

Walls

Results per Revit Category, itemized by Family



Legend

Net value (impacts + credits)

Design Options

- Option 1 - Cellulose Method
- Option 2 - Existing Method (primary)
- Option 3 - Furring Method
- Option 4 - Hybrid Method
- Option 5 - New Construction - Ideal
- Option 6 - New Construction - Typical

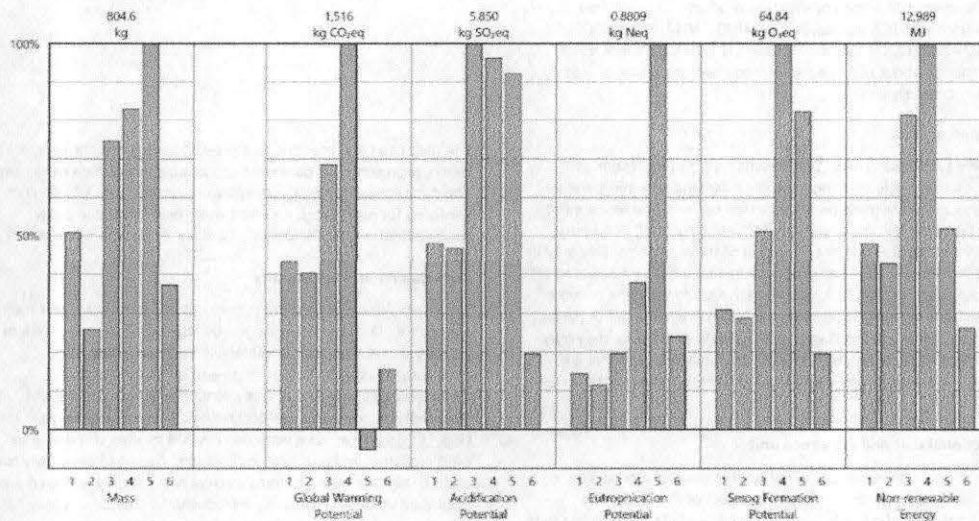
Walls

- Cellulose Method
- Existing Method
- Furring Method
- Hybrid Method
- New Construction - Ideal
- New Construction - Typical

Wall Cavity Comparison Portland Small House Wall Cavities

4/14/2022

Results per Building Element



Legend

Net value (impacts + credits)

Design Options

- Option 1 - Cellulose Method
- Option 2 - Existing Method (primary)
- Option 3 - Furring Method
- Option 4 - Hybrid Method
- Option 5 - New Construction - Ideal
- Option 6 - New Construction - Typical

Building Elements

Enclosure

Calculation Methodology

LIFE CYCLE ASSESSMENT METHODS

The following provides a description of terms and methods associated with the use of Tally to conduct life cycle assessment for construction works and construction products. Tally methodology is consistent with LCA standards ISO 14040: 14044, ISO 21930:2017, ISO 21931:2010, EN 15804:2012, and EN 15978:2011. For more information about LCA, please refer to these standards or visit www.choosetally.com.

Studied objects

The life cycle assessment (LCA) results reported represent an analysis of a single building, multiple buildings, or a comparative analysis of two or more building design options. The assessment may represent the complete architectural, structural, and finish systems of the building(s) or a subset of those systems. This may be used to compare the relative environmental impacts associated with building components or for comparative study with one or more reference buildings. Design options may represent a full or partial building across various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference unit

A functional unit is the quantified performance of a product, building, or system that defines the object of the study. The functional unit of a single building should include the building type (e.g. office, factory), relevant technical and functional requirements (e.g. regulatory requirements, energy performance), pattern of use (e.g. occupancy, usable floor area), and the required service life. For a design option comparison of a partial building, the functional unit is the complete set of building systems or products that perform a given function. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the modeler.

The reference unit is the full collection of processes and materials required to produce a building or portion thereof and is quantified according to the given goal and scope of the assessment over the full life of the building. If construction impacts are included in the assessment, the reference unit also includes the energy, water, and fuel consumed on the building site during construction. If operational energy is included in the assessment, the reference unit includes the electrical and thermal energy consumed on site over the life of the building.

Data source

Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and thinkstep. LCA modeling was conducted in GaBi 8.5 using GaBi 2018 databases and in accordance with [GaBi databases and modeling principles](#).

The data used are intended to represent the US and the year 2017. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Data quality and uncertainty

Uncertainty in results can stem from both the data used and their application. Data quality is judged by: its measured, calculated, or estimated precision; its completeness, such as unreported emissions; its consistency, or degree of uniformity of the methodology applied on a study serving as a data source; and geographical, temporal, and technological representativeness. The [GaBi LCI databases](#) have been used in LCA models worldwide in both industrial and scientific applications. These LCI databases have additionally been used both as internal and critically reviewed and published studies. Uncertainty introduced by the use of proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to appropriately apply the predefined material entries to the building under study.

System boundaries and delimitations

The analysis accounts for the full cradle to grave life cycle of the design options studied across all life cycle stages, including material manufacturing, maintenance and replacement, and eventual end of life. Optionally, the construction impacts and operational energy of the building can be included within the scope. Product stage impacts are excluded for materials and components indicated as existing or salvaged by the modeler. The modeler defines whether the boundary includes or excludes the flow of biogenic carbon, which is the carbon absorbed and generated by biological sources (e.g. trees, algae) rather than from fossil resources.

Architectural materials and assemblies include all materials required for the product's manufacturing and use including hardware, sealants, adhesives, coatings, and finishing. The materials are included up to a 1% cut-off factor by mass except for known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Calculation Methodology

LIFE CYCLE STAGES

The following describes the scope and system boundaries used to define each stage of the life cycle of a building or building product, from raw material acquisition to final disposal. For products listed in Tally as Environmental Product Declarations (EPD), the full life cycle impacts are included, even if the published EPD only includes the Product stage [A1-A3].

Product [EN 15978 A1 - A3]

This encompasses the full manufacturing stage, including raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. The product stage scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle to gate scope. Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials are not included and are considered outside the scope of assessment.

Transportation [EN 15978 A4]

This counts transportation from the manufacturer to the building site during the construction stage and can be modified by the modeler.

Construction Installation [EN 15978 A5] (Optional)

This includes the anticipated or measured energy and water consumed on-site during the construction installation process, as specified by the modeler.

Maintenance and Replacement [EN 15978 B2-B5]

This encompasses the replacement of materials in accordance with their expected service life. This includes the end of life treatment of the existing products as well as the cradle to gate manufacturing and transportation to site of the replacement products. The service life is specified separately for each product. Refurbishment of materials marked as existing or salvaged by the modeler is also included.

Operational Energy [EN 15978 B6] (Optional)

This is based on the anticipated or measured energy and natural gas consumed at the building site over the lifetime of the building, as indicated by the modeler.

End of Life [EN 15978 C2-C4]

This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Stage C2 encompasses the transport from the construction site to end-of-life treatment based on national averages. Stages C3-C4 account for waste processing and disposal, i.e., impacts associated with landfilling or incineration.

Module D [EN 15978 D]

This accounts for reuse potentials that fall beyond the system boundary, such as energy recovery and recycling of materials. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates.

PRODUCT	CONSTRUCTION	USE	END-OF-LIFE	MODULE D
A1. Extraction A2. Transport (to factory) A3. Manufacturing	A4. Transport (to site) A5. Construction Installation	B1. Use B2. Maintenance B3. Repair B4. Replacement B5. Refurbishment B6. Operational energy B7. Operational water	C1. Demolition C2. Transport (to disposal) C3. Waste processing C4. Disposal	D. Benefits and loads beyond the system boundary from: 1. Reuse 2. Recycling 3. Energy recovery

Life-Cycle Stages as defined by EN 15978. Processes included in Tally modeling scope are shown in bold. Italics indicate optional processes.

Calculation Methodology

ENVIRONMENTAL IMPACT CATEGORIES

A characterization scheme translates all emissions and fuel use associated with the reference flow into quantities of categorized environmental impact. As the degree that the emissions will result in environmental harm depends on regional ecosystem conditions and the location in which they occur, the results are reported as impact potential. Potential impacts are reported in kilograms of equivalent relative contribution (eq) of an emission commonly associated with that form of environmental impact (e.g. kg CO₂eq).

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme, the environmental impact model developed by the US EPA to quantify environmental impact risk associated with emissions to the environment in the United States. TRACI is the standard environmental impact reporting format for LCA in North America. Impacts associated with land use change and fresh water depletion are not included in TRACI 2.1. For more information on TRACI 2.1, reference Bare 2010, EPA 2012, and Guinée 2001. For further description of measurement of environmental impacts in LCA, see Simonen 2014.

Acidification Potential (AP) kg SO₂eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H⁺) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) kg Neq

A measure of the impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems, increased biomass production may lead to depressed oxygen levels caused by the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) kg CO₂eq

A measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may, in turn, have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) kg CFC-11eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants. As these impacts tend to be very small, ODP impacts can be difficult to calculate and are prone to a larger margin of error than the other impact categories.

Smog Formation Potential (SFP) kg O₃eq

A measure of ground level ozone, caused by various chemical reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues, including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage.

Primary Energy Demand (PED) MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED tracks energy resource use, not the environmental impacts associated with the resource use. PED is expressed in energy demand from non-renewable resources and from renewable resources. Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account when calculating this result.

Non-Renewable Energy Demand MJ (lower heating value)

A measure of the energy extracted from non-renewable resources (e.g. petroleum, natural gas, etc.) contributing to the PED. Non-renewable resources are those that cannot be regenerated within a human time scale. Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account when calculating this result.

Renewable Energy Demand MJ (lower heating value)

A measure of the energy extracted from renewable resources (e.g. hydropower, wind energy, solar power, etc.) contributing to the PED. Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account when calculating this result.

LCI Data

END-OF-LIFE [C2-C4]

A Life Cycle Inventory (LCI) is a compilation and quantification of inputs and outputs for the reference unit. The following LCI provides a summary of all energy, construction, transportation, and material inputs present in the study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur, along with any notes and system boundaries accompanying their database entries. Each entry lists the detailed scope for the LCI data sources used from the GaBi LCI database and identifies the LCI data source.

For LCI data sourced from an Environmental Product Declaration (EPD), the product manufacturer, EPD identification number, and Program Operator are listed. Where the LCI source does not provide data for all life cycle stages, default North American average values are used. This is of particular importance for European EPD sources, as EPD data are generally only provided for the product stage, and North American average values are used for the remaining life cycle stages.

Where specific quantities are associated with a data entry, such as user inputs, energy values, or material mass, the quantity is listed on the same line as the title of the entry.

TRANSPORTATION [A4]

Default transportation values are based on the three-digit material commodity code in the 2012 Commodity Flow Survey by the US Department of Transportation Bureau of Transportation Statistics and the US Department of Commerce where more specific industry-level transportation is not available.

Transportation by Barge

Scope:

The data set represents the transportation of 1 kg of material from the manufacturer location to the building site by barge.

LCI Source:

GLO: Average ship, 1500t payload capacity/ canal ts (2017)

US: Diesel mix at filling station ts (2014)

Transportation by Container Ship

Scope:

The data set represents the transportation of 1 kg of material from the manufacturer location to the building site by container ship.

LCI Source:

GLO: Container ship, 27500 dwt payload capacity, ocean going ts (2017)

US: Heavy fuel oil at refinery (0.3wt.% S) ts (2014)

Transportation by Rail

Scope:

The data set represents the transportation of 1 kg of material from the manufacturer location to the building site by cargo rail.

LCI Source:

GLO: Rail transport cargo - Diesel, average train, gross tonne weight 1000t / 726t

payload capacity ts (2017)

US: Diesel mix at filling station ts (2014)

Transportation by Truck

Scope:

The data set represents the transportation of 1 kg of material from the manufacturer location to the building site by diesel truck.

LCI Source:

US: Truck - Trailer, basic enclosed / 45,000 lb payload - 8b ts (2017)

US: Diesel mix at filling station ts (2014)

LCI Data (continued)

END-OF-LIFE [C2-C4]

Specific end-of-life scenarios are detailed for each entry based on the US construction and demolition waste treatment methods and rates in the 2016 WARM Model by the US Environmental Protection Agency except where otherwise specified. Heterogeneous assemblies are modeled using the appropriate methodologies for the component materials.

End-of-Life Landfill

Scope:

Materials for which no recycling or incineration rates are known, no recycling occurs within the US at a commercial scale, or which are unable to be recycled are landfilled. This includes glass, drywall, insulation, and plastics. The solids contents of coatings, sealants, and paints are assumed to go to landfill, while the solvents or water evaporate during installation. Where the landfill contains biodegradable material, the energy recovered from landfill gas utilization is reflected as a credit in Module D.

LCI Source:

US: Glass/inert on landfill ts (2017)
US: Biodegradable waste on landfill, post-consumer ts (2017)
US: Plastic waste on landfill, post-consumer ts (2017)

Concrete End-of-Life

Scope:

Concrete (or other masonry products) are recycled into aggregate or general fill material or they are landfilled. It is assumed that 55% of the concrete is recycled. Module D accounts for both the credit associated with off-setting the production aggregate and the burden of the grinding energy required for processing.

LCI Source:

US: Diesel mix at refinery ts (2014)
GLO: Fork lifter (diesel consumption) ts (2016)
EU - 28 Gravel 2/32 ts (2017)
US: Glass/inert on landfill ts (2017)

Metals End-of-Life

Scope:

Metal products are modeled using the avoided burden approach. The recycling rate at end of life is used to determine how much secondary metal can be recovered after having subtracted any scrap input into manufacturing (net scrap). Net scrap results in an environmental credit in Module D for the corresponding share of the primary burden that can be allocated to the subsequent product system using secondary material as an input. If the value in Module D reflects an environmental burden, then the original product (A1-A3) contains more secondary material than is recovered.

LCI Source:

Aluminum - RNA: Primary Aluminum Ingot AA/ts (2010)
Aluminum - RNA: Secondary Aluminum Ingot AA/ts (2010)
Brass - GLO: Zinc mix ts (2012)
Brass - GLO: Copper (99.99% cathode) CA (2013)
Brass - EU-28: Brass (CuZn20) ts (2017)
Copper - DE: Recycling potential copper sheet ts (2016)
Steel - GLO: Value of scrap worldsteel (2014)
Zinc - GLO: Special high grade zinc IZA (2012)

Wood End-of-Life

Scope:

End of Life waste treatment methods and rates for wood are based on the 2014 Municipal Solid Waste and Construction Demolition Wood Waste Generation and Recovery in the United States report by Dovetail Partners, Inc. It is assumed that 65.5% of wood is sent to landfill, 17.5% to incineration, and 17.5% to recovery.

LCI Source:

US: Untreated wood in waste incineration plant ts (2017)
US: Wood product (OSB, particle board) waste in waste incineration plant ts (2017)
US: Wood products (OSB, particle board) on landfill, post-consumer ts (2017)
US: Untreated wood on landfill, post-consumer ts (2017)
RNA: Softwood lumber CORRIM (2011)

Wall Cavity Comparison

Portland Small House Wall Cavities

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LCI Data

PRODUCT [A1-A3]

Materials and components are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur. The masses given here refer to the quantity of each material used over the building's life cycle, which includes both Product [A1-A3] and Use [B2-B5] stages.

Additional provided data describing scope boundaries for each life cycle stage may be useful for interpretation of the impacts associated with the specific material or component. Each material or component is listed with its service life, or period of time after installation it is expected to meet the service requirements prior to replacement or repair. This value is indicated in parentheses next to the mass of the material associated with the listed Revit family. Values for transportation distance or service life shown with an asterisk (*) indicate user defined changes to default values. Values for service life shown with a dagger (†) indicate materials identified by the modeler as existing or salvaged.

Aluminum extrusion, AEC - EPD **68.0 kg**

Used in the following Revit families:
Hybrid Method 68.0 kg (60 yrs)

Used in the following Tally entries:
Fiber cement panel

Description:
Extruded aluminum part. Industry-wide EPD from the Aluminum Extruders Council.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 663 km

End-of-Life Scope:
95% Recovered
5% Landfilled (inert material)

Module D Scope:
Product has 36.4% scrap input while remainder is processed and credited as avoided burden

LCI Source:
RNA: Aluminum extrusion, mill finish - AEC (A1-A3) ts-EPD (2015)
RNA: Primary Aluminum Ingot AA/As (2010)
RNA: Secondary Aluminum Ingot AA/As (2010)

EPD Source:
11240237.101.1

EPD Designation Holder:
Aluminum Extruders Council (AEC)

EPD Program Operator:
UL Environment

EPD Expiration:
10/4/2021

Asphalt felt sheet, roofing underlayment, ARMA - EPD **23.4 kg**

Used in the following Revit families:
Cellulose Method 7.8 kg (60 yrs*)
Existing Method 7.8 kg (60 yrs*)
Furring Method 7.8 kg (60 yrs*)

Used in the following Tally entries:
Asphalt felt sheet

Description:
Asphalt felt sheet, exclusive of spray adhesive for roofing and wall application. Type II felt, also called No. 30 asphalt felt, is the minimum accepted by the IRC and IRC for underlayment and interlayment. Data based on industry-wide EPD from the Asphalt Roofing Manufacturers Association.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 172 km

End-of-Life Scope:
5% Recycled into bitumen
95% Landfilled (inert waste)

Module D Scope:
Avoided burden credit for recycling into bitumen, includes grinding energy

LCI Source:
RNA: Underlayment, asphalt shingle roofing system component - ARMA (A1-A3) ts (2012)

EPD Source:
4787168709.101.1

EPD Designation Holder:
Asphalt Roofing Manufacturers Association (ARMA)

EPD Program Operator:
UL Environment

EPD Expiration:
10/28/2021

Cellulose insulation, blown **290.2 kg**

Used in the following Revit families:
New Construction - Ideal 212.4 kg (60 yrs)
New Construction - Typical 77.9 kg (60 yrs*)

Used in the following Tally entries:
Wood framing with insulation

Description:
Blown-in cellulose insulation

Life Cycle Inventory:
Waste paper fibers
Boric acid
Boraxpentahydrate

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 1020 km

End-of-Life Scope:
100% Landfilled (biodegradable waste)

LCI Source:
DE: Cellulose fibre blowing insulation material (EN15804 A1-A3) ts (2017)

Domestic softwood, US, AWC - EPD **153.5 kg**

Used in the following Revit families:
Cellulose Method 0.0 kg (60 yrs*)
Existing Method 0.0 kg (60 yrs*)
Furring Method 22.4 kg (60 yrs*)
Hybrid Method 0.0 kg (60 yrs*)
New Construction - Ideal 95.9 kg (60 yrs*)
New Construction - Typical 35.2 kg (60 yrs*)

Used in the following Tally entries:
Wood framing with insulation

Description:
Kiln-dried and planed softwood dimensional lumber for standard framing or planking. Industry-wide EPD from the American Wood Council.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 383 km

End-of-Life Scope:
14.5% Recovered

Wall Cavity Comparison

Portland Small House Wall Cavities

4/14/2022

LCI Data (continued)

22% Incinerated with energy recovery 63.5% Landfilled (wood product waste)		End-of-Life Scope: 14.5% Recovered 22% Incinerated with energy recovery 63.5% Landfilled (wood product waste)	
Module D Scope: Recovered wood products credited as avoided burden.		Module D Scope: Recovered wood products credited as avoided burden.	
LCI Source: RNA: Softwood lumber CORRIM (2011)		LCI Source: RNA: Softwood plywood CORRIM (2011)	
EPD Source: 13CA24184.102.1			
EPD Designation Holder: American Wood Council and Canadian Wood Council			
EPD Program Operator: UL Environment			
EPD Expiration: 4/16/2019			
Elm lumber, 1 inch	157.4 kg	Fasteners, galvanized steel	12.8 kg
Used in the following Revit families: New Construction - Ideal	157.4 kg (60 yrs*)	Used in the following Revit families: Cellulose Method Existing Method Furring Method	4.3 kg (40 yrs) 4.3 kg (40 yrs) 4.3 kg (40 yrs)
Used in the following Tally entries: Wood rainscreen, hardwood		Used in the following Tally entries: Asphalt felt sheet	
Description: Kiln-dried American Elm (slippery, brown, or grey elm) hardwood lumber of 1" nominal thickness as produced in the eastern and central United States, focusing on the main production technologies and region-specific characteristics. Elm is frequently used for flooring, furniture, paneling, and millwork. Link for interactive LCA data tool is provided at the link listed as "EPD Information" full LCA report is available at http://naturepackaging.org/wp-content/uploads/2016/02/LifeCycleAssessment-Lumber.pdf .		Description: Galvanized steel part, appropriate for use as fasteners and specialized hardware (bolts, nails, clips, etc.).	
Life Cycle Inventory: 100% Elm		Life Cycle Inventory: 100% Galvanized steel	
Product Scope: Cradle to gate, uncoated		Product Scope: Cradle to gate	
Transportation Distance: By truck: 383 km		Transportation Distance: By truck: 1001 km	
End-of-Life Scope: 14.5% Recovered 22% Incinerated with energy recovery 63.5% Landfilled (wood product waste)		End-of-Life Scope: 70% Recovered 30% Landfilled (inert material)	
Module D Scope: Recovered wood products credited as avoided burden.		Module D Scope: Product has 16% scrap input while remainder is processed and credited as avoided burden.	
LCI Source: US: Elm lumber, 1 inch (593 kg/m ³), kiln-dried to AHRC (2017)		LCI Source: GLO: Steel wire rod worldsteel (2014) GLO: Steel turning ts (2017) GLO: Electrolytic galvanisation (1 m ² steel sheet part, electrolytic) ts (2017) GLO: Value of scrap worldsteel (2014)	
EPD Source: Information			
EPD Designation Holder: American Hardwood Export Council (AHEC)			
Exterior grade plywood, US	0.0 kg	Fasteners, stainless steel	12.0 kg
Used in the following Revit families: Cellulose Method Existing Method Furring Method Hybrid Method New Construction - Typical	0.0 kg (60 yrs*) 0.0 kg (60 yrs*) 0.0 kg (60 yrs*) 0.0 kg (60 yrs*) 0.0 kg (60 yrs*)	Used in the following Revit families: Cellulose Method Existing Method Furring Method Hybrid Method New Construction - Ideal New Construction - Typical	0.7 kg (30 yrs*) 0.7 kg (30 yrs*) 0.7 kg (50 yrs) 3.1 kg (60 yrs) 6.1 kg (50 yrs) 0.7 kg (50 yrs)
Used in the following Tally entries: Plywood, exter or grade		Used in the following Tally entries: Fiber cement panel Plastic siding, vinyl Wood rainscreen, hardwood	
Description: Plywood, unfinished		Description: Stainless steel part, appropriate for use as fasteners and specialized hardware (bolts, nails, clips, etc.). Data based on industry-wide EPDs for primary and secondary metal from the World Steel Association.	
Life Cycle Inventory: Proxied by interior grade plywood		Life Cycle Inventory: 100% Stainless steel	
Product Scope: Cradle to gate, uncoated		Product Scope: Cradle to gate	
Transportation Distance: By truck: 468 km		Transportation Distance: By truck: 1001 km	
		End-of-Life Scope: 98% Recovered 2% Landfilled (inert material)	
		Module D Scope: Product has 58% scrap input while remainder is processed and credited as avoided burden.	
		LCI Source: RER: Stainless steel Quarto plate (304) Eurofer (2010)	

Wall Cavity Comparison

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LCI Data (continued)

GLO: Steel turning ts (2017)
US: Electricity grid mix ts (2014)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2010)

Fiber cement board **149.3 kg**
Used in the following Revit families:
Hybrid Method 149.3 kg (60 yrs*)

Used in the following Tally entries:
Fiber cement panel

Description:
Medium density fiber cement board, for interior and exterior, as cladding material for curtain-type ventilated facades, roofing, for decorative interior finishing, drywall, foundation base, or permanent formwork. Default thickness 5/16".

Life Cycle Inventory:
40% Cement
10% Cellulose
25% Sand
25% Fly ash

Product Scope:
Cradle to gate, excluding any coatings

Transportation Distance:
By truck: 172 km

End-of-Life Scope:
100% landfilled (10% biodegradable waste, 90% inert waste)

Module D Scope:
Credit associated with energy recovered from landfill gas utilization

LCI Source:
DE: Fly ash (EN15804 A1-A3) ts (2017)
US: Portland cement PCA/ts (2014)
DE: Cellulose fibre boards (EN 15804 A1-A3) ts (2017)
US: Silica sand (Excavation and processing) ts (2017)

Galvanized steel support **47.6 kg**
Used in the following Revit families:
New Construction - Ideal 47.6 kg (50 yrs)

Used in the following Tally entries:
Wood rainscreen, hardwood

Description:
Hot dipped galvanized steel profile, for use with cladding systems.

Life Cycle Inventory:
100% Steel, hot dip galvanized

Product Scope:
Cradle to gate for deck only.

Transportation Distance:
By truck: 431 km

End-of-Life Scope:
98% Recovered
2% Landfilled (inert material)

Module D Scope:
Product has 44% scrap input while remainder is processed and credited as avoided burden.

LCI Source:
RNA: Steel hot dip galvanized worldsteel (2007)
GLO: Steel sheet stamping and bending (5% loss) ts (2014)
US: Electricity grid mix ts (2014)
US: Lubricants at refinery ts (2014)
GLO: Compressed air 7 bar (medium power consumption) ts (2014)
US: Metal roll forming MCA (2010)
GLO: Value of scrap worldsteel (2014)

Mineral wool, high density, NAIMA - EPD **974.1 kg**
Used in the following Revit families:
Cellulose Method 158.6 kg (60 yrs)
Existing Method 158.6 kg (60 yrs)
Furring Method 407.8 kg (60 yrs)
Hybrid Method 249.2 kg (60 yrs)

Used in the following Tally entries:
Wood framing with insulation

Description:
Rock board, heavy density, industry-wide EPD from the North America Insulation Manufacturers Association. EPD representative of conditions in North America.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate

Transportation Distance:
By truck: 172 km

End-of-Life Scope:
100% Landfilled (inert waste)

LCI Source:
US: Rock board insulation (heavy density) NAIMA (2007)

EPD Source:
4786060412.102.1

EPD Designation Holder:
North American Insulation Manufacturer's Association (NAIMA)

EPD Program Operator:
UL Environment

EPD Expiration:
11/8/2018

Oriented strandboard (OSB), AWC - EPD **112.2 kg**
Used in the following Revit families:
New Construction - Ideal 112.2 kg (60 yrs*)

Used in the following Tally entries:
Oriented strandboard (OSB)

Description:
Generic Oriented Strand Board (OSB or Flakeboard), engineered wood sheet product using wood strands bonded together with resin, pressed into sheets. Industry-wide EPD from the American Wood Council.

Life Cycle Inventory:
For information and quantities, see EPD

Product Scope:
Cradle to gate, uncoated

Transportation Distance:
By truck: 468 km

End-of-Life Scope:
14.5% Recovered
22% Incinerated with energy recovery
63.5% Landfilled (wood product waste)

Module D Scope:
Recovered wood products credited as avoided burden.

LCI Source:
RNA: Oriented strand board (OSB) CORRIM (2011)

EPD Source:
33CA24184.101.1

EPD Designation Holder:
American Wood Council and Canadian Wood Council

EPD Program Operator:
UL Environment

EPD Expiration:
4/16/2019

LCI Data (continued)

Paint, Brillux, Silicone facade paint - EPD

13.6 kg

Used in the following Revit families:

New Construction - Ideal

13.6 kg (15 yrs)

Used in the following Tally entries:

Oriented strandboard (OSB)

Description:

Silicone facade paints by Brillux GmbH & Co. KG. Appropriate for use as coating and bonding agent for mineral and organic substrates as well as on wood and metal surfaces for outdoor use. EPD representative of German (DE) conditions.

Life Cycle Inventory:

For information and quantities, see EPD.

Product Scope:

Cradle to gate

Transportation Distance:

By truck: 642 km

End-of-Life Scope:

Includes disposal to landfill

LCI Source:

DE: Primers and facade paints, Silicon-Fassadenfarbe - Brillux (A1-A3) ts: EPD (2010)

EPD Source:

EPD-BRX-2012411-D

EPD Designation Holder:

Brillux GmbH & Co. KG

EPD Program Operator:

Institut Bauen und Umwelt (IBU)

EPD Expiration:

11/17/2017

Paint, exterior acrylic latex

20.4 kg

Used in the following Revit families:

Hybrid Method

20.4 kg (10 yrs)

Used in the following Tally entries:

Fiber cement panel

Description:

Acrylic-based latex paint for exterior applications. Associated reference table includes primer.

Life Cycle Inventory:

20.5% Binding agent
35% Pigments and fillers
40% Water
4.5% Organic solvents

Product Scope:

Cradle to gate, including emissions during application

Transportation Distance:

By truck: 642 km

End-of-Life Scope:

100% to landfill (plastic waste)

LCI Source:

DE: Application paint emulsion (building, exterior, white) ts (2017)

Paint, interior acrylic latex

171.5 kg

Used in the following Revit families:

Cellulose Method

36.7 kg (7 yrs)

Existing Method

36.7 kg (7 yrs)

Furring Method

24.5 kg (7 yrs)

Hybrid Method

24.5 kg (7 yrs)

New Construction - Ideal

24.5 kg (7 yrs)

New Construction - Typical

24.5 kg (7 yrs)

Used in the following Tally entries:

Wall board, gypsum

Description:

Acrylic-based paint for interior applications

Life Cycle Inventory:

21% Binding agent
35% Pigments and fillers

42% Water

2% Organic solvents

Product Scope:

Cradle to gate, including emissions during application

Transportation Distance:

By truck: 642 km

End-of-Life Scope:

100% to landfill (plastic waste)

LCI Source:

DE: Application paint emulsion (building, interior, white, wear resistant) ts (2017)

Particleboard, AWC - EPD

125.6 kg

Used in the following Revit families:

New Construction - Ideal

125.6 kg (60 yrs*)

Used in the following Tally entries:

Particle board

Description:

Generic particleboard. Industry-wide EPD from the American Wood Council. EPD representative of conditions in the US.

Life Cycle Inventory:

For information and quantities, see EPD.

Product Scope:

Cradle to gate

Transportation Distance:

By truck: 468 km

End-of-Life Scope:

14.5% Recovered
22% Incinerated with energy recovery
63.5% Landfilled (wood product waste)

Module D Scope:

Recovered wood products credited as avoided burden.

LCI Source:

RNA: Particleboard CORRIM (2011)

EPD Source:

13CA26184.108.1

EPD Designation Holder:

American Wood Council and Canadian Wood Council

EPD Program Operator:

UL Environment

Self adhering flashing membrane, 40 mil

14.2 kg

Used in the following Revit families:

Hybrid Method

14.2 kg (60 yrs*)

Used in the following Tally entries:

Self adhering membrane

Description:

40 mil (1 mm) Asphalt rubber sheet inclusive of polyethylene backing

Life Cycle Inventory:

82% Rubberized asphalt (25% SBS)
18% Polyethylene HD

Product Scope:

Cradle to gate for materials only, neglects manufacturing requirements

Transportation Distance:

By truck: 172 km

End-of-Life Scope:

100% Landfilled (plastic waste)

LCI Source:

US: Styrene-butadiene rubber (SBR) ts (2017)
DE: Bitumen cold adhesive (EN15804 A1-A3) ts (2017)
US: Polyethylene High Density Granulate (PE-HD) ts (2017)
GLO: Plastic Film (PE, PP, PVC) ts (2017)
US: Electricity grid mix ts (2014)
US: Thermal energy from natural gas ts (2014)
US: Lubricants at refinery ts (2014)

Wall Cavity Comparison

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LCI Data (continued)

Vinyl siding 19.8 kg Used in the following Revit families: - Cellulose Method 0.0 kg (60 yrs*) - Existing Method 0.0 kg (60 yrs*) - Furring Method 0.0 kg (60 yrs*) - New Construction - Typical 19.8 kg (60 yrs*) Used in the following Tally entries: - Plastic siding, vinyl Description: - Rigid vinyl siding (0.04" thickness) factory formed and cut. Entry exclusive of wood stud, separate weather barrier, or other support material. Life Cycle Inventory: 100% PVC Product Scope: - Cradle to gate, excluding any coatings Transportation Distance: - By truck: 1299 km End-of-Life Scope: 100% landfilled (pestic waste) LCI Source: - US: Polyvinylchloride granulate (E-PVC) ts (2017) - GLD: Plastic Extrusion ts (2017) - US: Electricity grid mix ts (2014) - US: Thermal energy from natural gas ts (2014) - US: Lubricants at refinery ts (2014)	LCI Source: - DE: Gypsum wallboard (EN15804 A1-A3) ts (2017) Wood stain, water based 9.2 kg Used in the following Revit families: - New Construction - Ideal 9.2 kg (10 yrs) Used in the following Tally entries: - Wood rainscreen, hardwood Description: - Semi-transparent stain for interior and exterior wood surfaces Life Cycle Inventory: 60% Water 28% Acrylate resin 7% Acrylate emulsion 5% Dipropylene glycol 1.3% NMVOC emissions Product Scope: - Cradle to gate, including emissions during application Transportation Distance: - By truck: 642 km End-of-Life Scope: 38.7% solids to landfill (plastic waste) LCI Source: - US: Tap water from groundwater ts (2017) - US: Acrylate resin (solvent systems) ts (2017) - DE: Acrylate (emulsion) ts (2017) - US: Dipropylene glycol by product propylene glycol via PO hydrogenation ts (2017)
Wall board, gypsum, moisture- and mold-resistant 468.3 kg Used in the following Revit families: - Cellulose Method 200.7 kg (60 yrs*) - Existing Method 0.0 kg (60 yrs*) - Furring Method 133.8 kg (60 yrs*) - Hybrid Method 133.8 kg (60 yrs*) Used in the following Tally entries: - Wall board, gypsum Description: - Moisture- and mold-resistant gypsum board Life Cycle Inventory: 100% Moisture-resistant gypsum wallboard (Gypsum, Boric acid, Cement, Sodium lignin sulfonate, Glass fibres, Silane, Polyglucose, Perlite, Paper, Casein glue) Product Scope: - Cradle to gate Transportation Distance: - By truck: 172 km End-of-Life Scope: 100% Landfilled (inert waste) LCI Source: - DE: Gypsum plaster board (Moisture resistant) (EN15804 A1-A3) ts (2017)	XPS insulating sheathing, Foamular (R-4, 15 psi), Owens Corning - EPD 6.0 kg Used in the following Revit families: - Hybrid Method 6.0 kg (60 yrs*) Used in the following Tally entries: - XPS (polystyrene) insulating sheathing Description: - FOAMULAR XPS (polystyrene) insulating sheathing board. HFC foaming agent. EPD representative of US manufacturing condition. FOAMULAR insulated sheathing board is available with a variety of R-values / thicknesses, ranging from R3-R5. This entry is based on an R4 board with a total thickness of 0.75 inch and a compressive strength of 15 psi. Note: This temporary entry is sourced directly from third-party verified EPD data and replaces a Tally entry that is undergoing a quality assurance review. This entry Life Cycle Inventory: - For information and quantities, see EPD. Product Scope: - Cradle to gate. Note: Product stage expanded to include blowing agent emissions during distribution and installation, and diffusion from product over service life (B1). As these impacts make a significant contribution to GWP they have been included in the product stage. Transportation Distance: - By truck: 1190 km End-of-Life Scope: 100% Landfilled (plastic waste); includes blowing agent emissions released during disposal LCI Source: - US: Extruded polystyrene (XPS) insulation sheathing board, FOAMULAR - Owens Corning EPD (2018), modeled with Simapro 8, source for secondary data isecoinvent 3.4 EPD Source: 4788721162.101.1 EPD Designation Holder: - Owens Corning EPD Program Operator: - UL Environment EPD Expiration: 1/1/2024
Wall board, gypsum, natural 141.6 kg Used in the following Revit families: - New Construction - Ideal 0.0 kg (60 yrs*) - New Construction - Typical 141.6 kg (60 yrs*) Used in the following Tally entries: - Wall board, gypsum Description: - Natural gypsum board Life Cycle Inventory: 100% Gypsum wallboard (Gypsum, Boric acid, Cement, Glass fibres, Ferrochrome-lignine sulfonate, Silane, Polyglucose, Perlite, Paper, Casein glue) Product Scope: - Cradle to gate Transportation Distance: - By truck: 172 km End-of-Life Scope: 100% Landfilled (inert waste)	

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