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Olen, Michael E. Deconstruction: Reducing the Costs of Deconstructing Blighted Buildings

Abstract

Demolition produces 90% of all Construction and Demolition (C&D) debris in the United States (EPA, 2018i). Milwaukee has been using mechanical demolition to remove blighted buildings and are simultaneously embracing deconstruction as an alternative to mechanical demolition.

"In theory," Yogi Berra once said, "there is no difference between theory and practice. In practice there is." This is more than just a famous quote repurposed as a bumper sticker you can buy on Amazon for $3.95 plus $4.99 shipping (Amazon, 2018), the quote captures the difficulty of a seemingly straightforward task of deconstructing a house. Deconstruction is defined as taking a structure apart in order to maximize the amount of material that can be reused. This simplistic definition however, does not consider the layers of regulated steps required to get the building materials to a retail market.

A philosophical meaning of the word deconstruction can help us to understand how separating the building into its individual parts can educate us on the interdependencies of the parts. Ideally, decision makers can learn how structure, and its removal, impacts the surrounding community. This research looks at reducing the cost of deconstruction and increasing the benefit to the community at the same time.

Acknowledgments

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Chapter I: Introduction

Deconstruction is the act of razing, or demolishing, a building using measures that maximize the reuse of salvageable building materials and recycling the remaining waste. Demolition is the act of razing a structure using mechanical methods, with a focus on removing the building cost efficiently and quickly. Prior to 2018, mechanical demolition had been the preferred method for the City of Milwaukee to use when removing blighted and vacant buildings. Deconstruction, on the other hand, was beginning to be seen as an environmentally friendly way to remove a building but cost prohibitive on a large scale. Milwaukee, along with other cities across the country, began to use deconstruction as a method to raze buildings and re-use the building materials that would normally be placed in a land fill or recycled.

The cost of deconstruction increased dramatically from 2015 to 2018 as an increased focus was placed on environmental and safety regulations. After the implementation of the deconstruction ordinance that required every property built in 1929 or earlier to de deconstructed as opposed to undergoing mechanical demolition (City of Milwaukee, 2017b). The increased costs of deconstruction caused a backlog of vacant and blighted buildings waiting to be razed. Many of those buildings were owned by the City of Milwaukee. From 2010 to 2017, the Department of Neighborhood Services (DNS) would average150 demolitions a year. The number of demolitions and deconstruction initiated over the first six months of 2018 was less than twenty. The 2018 demolitions included buildings that were either built after 1929 or the buildings were exempted from the deconstruction ordinance due to extensive damage to salvageable building materials.

Over the last several years, Milwaukee has also been experiencing a crisis in the lead levels of children in the city. The publicity that surrounded lead water service lines as a potential source of lead poisoning in children also shined a light on the possibility that lead-based paint (LBP) could have a role in high blood level tests (Bence, 2016). Research has indicated that lead paint dust in demolition has been a problem nationally and one of the specifications in the deconstruction ordinance was the incorporation of the Environmental Protection Agency's (EPA) Renovation, Repair, and Painting (RRP) rule. The implementation of the ordinance meant that deconstruction contractors would be regulated by the State of Wisconsin and the Milwaukee Department of Health Services.

Milwaukee is the largest city in the state of Wisconsin and the 31st largest city in the United States with a population of 595,047 (U.S. Census Bureau, 2018). It was once known as the machine shop to the world, a moniker that is still applicable in many ways for this industrial manufacturing city. One and two-family dwellings that helped make Milwaukee a city with a high population density also allowed workers to walk to the shops and factories. Many of these structures are well over a century old and contain vintage millwork, Douglas fir structural components, lead paint, and asbestos. These houses were built with the same strength and tenacity that built the manufacturing and beer sectors that made the city famous, but even the best built buildings need maintenance, and the rising poverty level across some areas of the city came with deferred maintenance on needed repairs such as roofs and foundations. A multitude of factors including, but not limited to the loss of manufacturing jobs and prevalent poverty, played into the City of Milwaukee owning over 500 blighted and vacant buildings by the end of 2018.

The rising poverty rate and loss of jobs also played a role in the increased rate of tax-foreclosures the city completed. Homes that were taken over by the city were marketed with the intent of returning the property to the tax rolls. Properties that could not sell, for whatever reason, or had deteriorated past the point of habitability were set to be razed. Historically, the city maintained a pipeline averaging 200 properties on the list to be demolished, or razed.

Figure 1. Exterior of typical City of Milwaukee duplex

Six months after the City of Milwaukee (2018) adopted the deconstruction ordinance in January of 2018, the backlog was nearing 500 blighted and vacant properties. These often blighted properties place costs onto the citizens of the community in the form of added code enforcement, fire and police calls, court costs, crime, and lower property tax revenue (Kellum, 2017). Having such a large number of properties in the backlog to be demolished or deconstructed comes at a substantial cost to the city financially.

Prior to the deconstruction ordinance going into effect in 2018, the city would prepare packages of buildings that would need to be demolished. These packages that contained a small number of properties, averaging around six to eight, were put out to bid to qualified demolition contractors. The city and the DNS began to introduce packages of buildings that would need to be deconstructed around 2010. These were pilot programs and tests to see how deconstruction would work out in the field and allowed for the city's Residents Preference Program (RPP), to be included into the demolition and deconstruction budget (City of Milwaukee, 2018). Before the deconstruction ordinance went into effect, contracts that were let out to bid for deconstruction of city owned houses began coming at a higher cost due to the increased RPP labor demands that were place in the contract by the city. Hiring of unemployed or under-employed individuals from the qualifying areas of the city was a prominent requirement on city contracts (City of Milwaukee, 2018). Developers could be required to have RPP workers complete 40% of the labor hours on a project. Later in 2017, as the implementation of the deconstruction ordinance neared, the requirements to meet LBP environmental regulations of the EPA, the Occupational Health and Safety Administration (OSHA), and both the State of Wisconsin and the Milwaukee Departments of Health were blamed for the increased bid being received by the deconstruction contractors.

Costs to deconstruct houses in Milwaukee increased 200% to 300% over the from 2010 to 2018. Bids received from the typical contractor for the mechanical demolition of a house remained steady at $15,000 to $20,000 while bids to deconstruct that same house might come in at $45,000 to $60,000. Milwaukee budgets a specific amount of money each year to remove structures that have either deteriorated or have experienced a fire and the owner is not able to raze the property. The increased costs for deconstruction caused the number of houses that could be razed via demolition and deconstruction to decrease dramatically.

Several peer cities around the country adopted similar ordinances to Milwaukee's deconstruction ordinance. The deconstruction program in Portland, Oregon, for instance, was used as the model that Milwaukee used during the development of the Milwaukee ordinance. During this same time, the city was managing an issue in the Milwaukee Health Department related to the testing and notification of children that might have been exposed to lead. It was thought that many children were being exposed to lead from the lead water service lines that went into the residences and by the deteriorated LBP that was used interior and exterior of many of the homes in Milwaukee. A bid package of properties to be deconstructed was put together and walk-throughs conducted. Bids from contractors came back at such a prohibitive cost, that management tabled the project and let out the project to bid two more times after subsequent revisions and received comparable results. No new city owned deconstructions were started in 2018 and there was a only a couple private deconstructions.

Statement of the Problem

Rising costs of deconstruction caused an increasing backlog of vacant and blighted buildings to remain in place across the City of Milwaukee. Milwaukee needs to bring down the cost of deconstruction to be similar with the price of mechanical demolition in order to sustain the removal of 150 blighted structures in a typical year.

Purpose of the Study

The purpose of this study was to analyze the costs associated with the deconstruction of structures in the Milwaukee area and to find areas of cost efficiencies. Jurisdictions and contractors can use the research provided as best practice path to follow to deconstruct houses and salvage the value from them at a cost closer to mechanical demolition. It is expected that this study will be utilized as a tool for cities and towns that are establishing or looking to improve their deconstruction ordinances.

Objectives

Milwaukee’s deconstruction ordinance specifies that house built prior in 1929 or earlier need to be deconstructed. The ordinance also includes historic houses and those that are in historic districts regardless of the date the structure was built. Removing blighted structures is a safety and quality of life issue. The costs to deconstruct structures to meet the requirements of Milwaukee's deconstruction ordinance has increased significantly. This study addresses these five functions related to the costs of deconstruction:

1. Define the labor and process costs required to deconstruct a structure defined as worker hours per square foot.
2. Identify the environmental regulations and constraints that effect the costs of deconstruction.
3. Classify the economic landscape that benefits deconstruction such as rising housing costs, economic development, increase in new permits, and population growth.
4. Define the marketplace for material salvaged from deconstructions.
5. Define the best practices for deconstructing houses.

Significance of the Study

Contractors that specialize in deconstruction can benefit this research by creating a lean deconstruction process. Traditional demolition companies that focus on mechanical demolitions can use this research to expand business opportunities into deconstruction work and find the value in material that has historically been landfilled. Municipalities will be able to control the contract bidding process by understanding the economics of deconstruction and the end market of salvaged materials. The impact that deconstruction has on the construction sector as part of the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) building rating system which can provide guidance to contractors to a more sustainable and lean business model. Removing the blighted structures from neighborhoods has been documented to reduce crime and improve quality of life (Branas et al., 2016).

Assumptions of the Study

The City of Milwaukee requires structures built in 1929 or earlier, located in a historic district, or designated historic to be deconstructed and the material to be reused, savaged, or recycled, depending on the specific commodity. The assumptions of this study are:

1. The deconstruction ordinance remains in place at the discretion of the Common Council for the City of Milwaukee, and could be changed, replaced, or suspended.
2. The local, state, and federal regulations governing contractors disturbing LBP, asbestos, and other environmental hazards will remain at current levels or become more restrictive.
3. The deconstruction ordinance will continue to include language that requires contractors to follow all applicable regulations.
4. The market for reclaimed lumber will remain stable or increase with the continued demand for sustainable and green properties that fall under designations such as the USGBC's LEED certification.

Definition of Terms

This section lists the definitions that are commonly used in the demolition and deconstruction process in the City of Milwaukee.

Abate. To put an end to (Merriam-Webster, 2018). Remove lead, asbestos, or other hazardous material from a site prior to demolition or deconstruction.

Asbestos. A naturally occurring fiber that is found in rock and soil (Environmental protection Agency [EPA], 2018c).

Blight. **"**A building that shows signs of deterioration sufficient to constitute a threat to human health, safety, and public welfare" (Housing and Urban Development [HUD], 2009).

Board foot. A piece of lumber equal to 12 inches x 12 inches x 1 inch thick or an equivalent amount of wood equaling 144 square inches (Merriam-Webster, 2018b).

Cross laminated timber (CLT). CLT is a large panel or engineered wood system that is made up of smaller pieces glued together in perpendicular layers.

Construction and demolition debris (C&D). C&D is the debris generated at construction and demolition sites.

Construction consolidation center (CCC). "A distribution facility through which material deliveries are channeled to construction sites" (Lundesjo, 2011). Using a CCC can help streamline jobsite deliveries and provide a safer working environment.

Contractor value. Price expected to be paid for material on job site of storage facility with minimal processing from contractor.

Deconstruction. "Deconstruction is the disassembly of a building in order to recover maximum amount of material for reuse and recycle" (Zahir, 2015).

Deconstruction consolidation center (DCC). The DCC is the same logistics concept as the CCC but in reverse. Using a DCC or a processing facility, contractors can remove the material from a site and process it at a central location that has staff capable of sorting, de-nailing, and preparing material to ship to end users (MSU, 2017, p. 2).

Deconstruction contractor. The Deconstruction Administrative Rules for the City of Milwaukee (2017a) defines a deconstruction contractor as:

> An Individual or business capable of obtaining permits to raze and remove buildings in the City of Milwaukee who has successfully completed a deconstruction contractor certification program either hosted by the Department of Neighborhood Services or

approved by the Commissioner. A business shall be considered certified if at least one person regularly employed by the company is certified. (p. 1).

Deconstruction consultant. The Deconstruction Administrative Rules for the City of Milwaukee (2018, p. 2) defines Deconstruction consultant as "an individual who has carefully completed a deconstruction Consultant certification program either hosted by the Department of Neighborhood Services or approved by the commissioner."

The consultant is allowed to sub-contract out the raze of the building to contractors capable of obtaining the raze permit for the deconstruction.

Diversion rate. The amount of construction and demolition, C&D, material diverted from going to a landfill. The rate is measured as a percentage of the total C&D debris form a project.

Dust lead hazard standards, DLHS. The EPA (2018e) defines dust lead hazard standards as:

> Exceeding 40 micrograms of lead in dust per square foot on floors, 250 micrograms of lead in dust per square foot on window sills, and 400 parts per million (ppm) of lead in bare soil in children's play areas or 1200 ppm average for bare soil in the rest of the yard.

Excavator. "A power operated shovel" (Merriam-Webster, 2018a).

Exterior wall envelope. The International Code Council (2009) defines an exterior wall envelope as: "a system or assembly of exterior wall components, including exterior wall finish materials, that provide protection of the building structural members, including framing and sheathing materials, and conditioned interior space, from the detrimental effects of the exterior environment." (p.277).

Grade. Also known as grade plane, the point at which a structure meets ground level. Typically measured at a point six feet away from the foundation on sloped sites.

Lead. A toxic element that is found within the Earth and used within many products including paint (EPA, 2018g).

LEED. A building rating system for green and construction and operation of buildings (USGBC, 2018).

Mechanically laminated timber (MLT). "Timbers of smaller cross section are (which come from smaller, more readily available trees) are used to generate a larger composite cross section" (Miller, 2009, p. 2).

Neighborhood fabric. The relationships between houses to houses, blocks, streets, and the people that use them. "The arrangement of physical components in relation to each other" (Merriam-Webster, 2018).

Opportunity fund. "Private investment vehicle, certified by the Treasury, to aggregate and deploy capital in Opportunity Zones for eligible uses defined as Opportunity Zone Property" (Carroll, 2018).

Opportunity zones. "An opportunity zone is an economically distressed community where new investments, under certain conditions, may be eligible for preferential tax treatment" (IRS, 2018)

Qualified person. Someone "who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project (OSHA, 2018)."

Raze. The demolition of a building or structure.

Residents Preference Program (RPP). A City of Milwaukee workforce development program aimed at getting job opportunities for unemployed and underemployed individuals in the construction trades (City of Milwaukee, 2018). An RPP requirement can be placed on a project that receives city funding.

Retail value. Price expected to be paid for material at retail establishment after processing.

Landfill. The Deconstruction Administrative Rules for the City of Milwaukee (December 20, 2018, p. 2) defines landfill as: "To dispose of refuse and other waste materials not suitable for reuse, repurpose, or recycling through an approved facility in accordance with local, state, and federal laws."

Recycle. The Deconstruction Administrative Rules for the City of Milwaukee (December 20, 2018, p. 2) defines recycle as converting "the salvaged material into new materials and objects."

Repurpose. The Deconstruction Administrative Rules for the City of Milwaukee (December 20, 2018, p. 2) defines repurpose as "to use salvaged material in a manner differing from their use prior to being salvaged but not altering the state of the materials."

Reuse. The Deconstruction Administrative Rules for the City of Milwaukee (December 20, 2018, p. 2) defines reuse as "to use salvaged materials in a manner most similar to its use prior to being salvaged."

Toxic Substance Control Act (TSCA). Enacted in 1976, The TSCA gives the EPA (2018g) the power to "require reporting, record-keeping, and testing requirements, and restrictions related to chemical substances and/or mixtures." (p. 1)

Limitations of the Study

This study, and the results from it, are limited to the City of Milwaukee. Limitations of this study include:

1. Information and data were limited to the Milwaukee region, or a region anchored by a peer city.
2. Interview responses are assumed to be truthful.
3. All participation in the study was voluntary.

Methodology

Data was collected from contractors and contract information regarding the prices, worker hours, and diversion rates from previous deconstructions. The goal was to get data benchmarks that were in place prior to the ordinance implementation. Information was then gathered from peer cities to determine the costs associated with deconstructions and demolitions to find out where the City of Milwaukee is in relation to the national average and as compared to labor cost in the construction industry in general.

Chapter II: Literature Review

The number of vacant and blighted buildings owned by the City of Milwaukee increased dramatically over the first six months of 2018. Deconstruction contractors were stating that the increased costs were associated with the higher regulatory costs of deconstruction as opposed to mechanical demolition and the workforce requirements the city put into the contract specifications. Milwaukee needs to bring down the costs of deconstruction to a point where an average of 150 structures can be deconstructed in a year.

The purpose of this study was to examine the six key factors of deconstructing structures in a high-density urban city and how these factors affect the costs associated with deconstruction of structures within the City of Milwaukee. Six main factors of deconstruction include: material reuse, economic, environmental, deconstruction process, employment, and social capital. This literature review will bring research on the factors of deconstruction together and provide an understanding how these six elements affect the whole of deconstruction and how they work together as a system. With this information, the construction industry can understand how the upfront costs of deconstruction but can also help create opportunities to reduce ancillary costs.

Material Reuse

Material reuse is the goal. It is the reason deconstruction is taking place in the City of Milwaukee as evidenced by being listed in the administrative rules at the top of the hierarchy of deconstruction materials (City of Milwaukee, 2017). Berghorn (2018) suggests that lowering deconstruction costs and increasing markets for salvaged material could help feed the pipeline to a highly skilled construction workforce. There is a consistent demand for a skilled work force as construction unemployment keeps decreasing and there is a demand for training for people looking to work (BLS, 2018). The plan for Milwaukee was to get the material out of a blighted structure using deconstruction and fuel the pipeline for young men and women to get higher wage construction jobs (City of Milwaukee, 2018).

Deconstruction ordinance, like the one adopted by the cities of Milwaukee (2017b) and Portland, have assumed that the value of the salvaged material would help offset the costs of deconstruction. A study put out by the Michigan State University (MSU) Center for Community and Economic Development (2017) focused on getting most yield from the bulk of framing material that makes up the structure of a building. The deconstruction industry in the Midwest is not as advanced as other areas and this is not a positive, but there is a built-in industrial infrastructure in places like Muskegon, Michigan and Milwaukee that could make shipping to processors of salvaged material easier (MSU, 2017).

The typical 2,400 square foot house in Milwaukee will average 7,000 board feet (bd ft) of lumber (Olen, 2018a). This includes framing, finish flooring, subfloors, and sheathing. George Berghorn, (as cited in Schroeder, 2017) states that average Michigan home can has 6,000 bd ft of lumber. A bd ft is a volume of lumber equal to 12 inches x 12 inches x 1 inch. By using a board foot calculator (University of Missouri, 2000) we can get standard number than equates to a volume of wood and allow us to calculate a weight. Framing material used to construct houses in Milwaukee prior to 1930 was predominately Douglas fir. Calculations used in this research to determine Douglas fir bd ft weight is 3.25 pounds per bd ft (Olen, 2018) (see Deconstruction material count spreadsheet in Appendix c).

The Environmental Protection Agency (EPA) (2010) stated that in 2004 an estimated 65 million tons debris resulted from the demolition of 300,000 buildings. The EPA went on to estimate that a range of 20% to 30% of the material was reused or recycled while the remainder was sent to landfills (EPA, 2010). Languell, Guy, & Kibert, (2000) stated that waste from

Construction and Demolition, (C&D) represented 33% of the non-industrial waste nationally and the EPA (2018h) stated that 534 million tons of C&D debris was produced in 2014. Concrete represented 375.3 million tons of the C&D debris. Concrete recycling is a standard best practice in the waste management industry and is the process utilized by private demolition and deconstruction contractors. The remaining 158.7 million tons from the EPA's 2014 numbers should be the focus of recycling and reuse research.

A typical demolition project for the City of Milwaukee can reach a 40% to 50% diversion rate by recycling material including, but not limited to, concrete, asphalt shingles, and the larger framing material (C. Kraco, personal communication, July 15, 2018). Typically, a third-party recycling facility will take the C&D debris from the demolition contractor and separate the recyclable material and dispose of the remainder (Waste Management, 2018). The Federal Emergency Management Agency (FEMA) (2010) estimates that the typical 2000 square foot house will generate 400 cubic yards of debris. The EPA (2016) volume to weight conversion table states that a cubic yard of for bulk C&D waste = an estimated 484 pounds. The following equation from FEMA (2018) allows for the simple estimating of debris expected from a demolition.

$$[\text{Length (ft)} \times \text{width (ft)} \times \text{height (ft)} \times 0.33]/27 = \text{Cubic Yards}$$

The typical 2,000 square foot house will produce an estimated 193,600 pounds of C&D debris. In this example, the hypothetical house will be 25 feet wide by 40 feet deep and have two stories.

Concrete. The concrete used in the foundation will be recycled and the weight using the EPA (2016) conversion rate will be 860 Pounds per cubic yard.

Slab weight = (1,000 x 0.5) / 27 = 18.52 cubic yards

18.52 x 860 lbs. = 15,927 lbs

Wall weight = 25 + 40 + 25 + 40 = 130

130 x 8 ft high x 8 inches wide = 130 x 8 x (8 / 12) = 693.33

693.33 / 27= 25.68 cubic yards = 22,085 lbs.

Footing weight = (130 x 2)/27 = 9.63 cubic yards = 8,273 lbs

15,927 + 22,085 + 8,273 = 46,285 lbs of concrete

The typical two-story house on a 1,000 square foot footprint would weigh 193,600 lbs., including 46,285 lbs. of concrete foundations, slabs and footings. The concrete debris cannot be reused in its existing state after a deconstruction or demolition. The concrete and masonry block is recycled as a best practice in the demolition and deconstruction industry. Brick and stone foundations that have not been painted can be salvaged.

Wood framing material. The U.S. Green Building Council (USGBC) (2018) points to the integrated process as "getting everyone who will be involved in the project, from the design phase to construction to the actual day-to-day operations, together right from the start to collaborate." This type of design mentality will help introduce contractors to the needs of the design community and on the flip side help designers understand what kind of material is available for the material reuse credits for LEED credits. Schroeder (2017) states that the wood material that cannot be reused or repurposed can be recycled into wood pellets that are used for heating. Recycling the un-useable material is the third choice on the hierarchy of salvaged material after reuse and repurpose, but recycling the material into pellets, mulch, or for use in a bio-refinery does divert it from the landfill.

Regrading. Berghorn (2018, p. 14) asked the question "do the mechanical properties of salvaged lumber meet existing standards for inclusion in the manufacturing of cross laminated timber?" Using reclaimed lumber in structural application will require the material to be regraded prior to use. Robert Falk (personal communication, July 09, 2018) deemed Regrading of reclaimed lumber cost prohibitive currently, but there is room for further research on regarding reclaimed lumber. Michelle Kam-Biron (personal communication, July 05, 2018), Joe Miller (personal communication, July 09, 2018) and Robert Falk (personal communication, July 09, 2018) all concluded that the variations in reclaimed lumber including nail holes and other defects would make the use of reclaimed material in cross laminated timbers cost prohibitive. Falk (2018) added that inconsistent and unreliable sourcing of the material could be difficult, and the greater concern may be quality control. From the research by Miller (2009), the strength and purpose of mechanically laminated timber (MLT), demonstrated that there is a gap for similar research focusing on using reclaimed lumber in a structural system like MLT or CLT.

The EPA (2010), Berghorn (2018), and the City of Milwaukee (2018c) put a high value on material reuse for the economic benefit of bringing down the cost of deconstruction by partially offsetting the higher labor cost compared to mechanical demolition. The more material that deconstruction can yield from a building should mean a lower net cost for deconstruction after the material is sold at retail. An ancillary effect of this type of retail market would be the warehousing and retail workforce development components. Berghorn (2018, p. 13) states that a focus on "high volume, low value materials" is pivotal to driving down the costs of deconstructions, especially considering the volume of material idle in vacant buildings.

A Michigan State University (MSU) study (2017) found that Milwaukee was the only one of ten cities on the study where shipping the salvaged material by barge was feasible. This is an interesting option compared to standard trucking and shipping containers. Contractors have learned that buyers of salvaged materials like bulk quantities, and shipping containers would still be the best option for sending material across the country or across the region (B. Spencer, personal communication, June 22, 2018). Shipping containers can be staged on the job site to store material during deconstruction and then transported to a local salvage warehouse that accepts donations like the Rebuilding Exchange (2018) in Chicago, Illinois or across the country by rail or ship. Chicago, Illinois and Madison, Wisconsin have C&D recycling ordinances in place to help reduce construction waste. Chicago's ordinance requires that 50% of the debris from any construction site be recycled while Madison's requires contractors to have an approved recycling plan (MSU, 2017).

Economic Factors

Zahir (2015) states that economic development often requires demolition and unfortunately, although it is efficient, it creates a great deal of waste. In a deconstruction pilot fact sheet, the EPA (2010), stated that the high labor costs associated with deconstruction was a barrier to a City of Philadelphia neighborhood transformation initiative. In this instance, the EPA awarded an innovation grant to a Philadelphia non-profit with the goal of harvesting the framing lumber from the buildings. The EPA (2010), study found the typical row house demolition in Philadelphia required an even greater amount of hand demolition and less use of heavy machinery. A row house will often have shared walls and the use of large machinery risked causing damage to the neighboring structures (EPA, 2010). The project was to incorporate a mechanized deconstruction to reduce labor cost from standard deconstruction and increase the amount of material salvaged over mechanical demolition (EPA, 2010).

The EPA (2010) results from the Philadelphia mechanized deconstruction pilot reported net costs of $8.94 per square foot, which were on the higher end of the reported $7.75 to $9.30 range for a traditional mechanical demolition project but higher that the reported typical hand demolition cost of $7.50 to $7.75 per square foot. The Institute for Local Self Reliance (ILSR) (2007) reported net costs of $10.08 per square foot for the same project at 3224 Susquehanna in Philadelphia. Berghorn (2018) mentioned in a presentation on May 7, 2018, that one square foot of deconstruction cost is from $1.02 in San Francisco in 1996 to a cost of $22.61 in Lansing Michigan in 2016. A wide range of costs per square foot would indicate that additional research is needed to get a baseline cost for deconstruction that considers all of the regulatory concerns. One major regulation that is the EPA's (2018d) RRP rule that treats mechanical demolitions differently than deconstructions. The EPA (2010) and the ILSR (2007) do not mention whether the contractor doing the mechanized deconstruction as part of the Philadelphia pilot performed the work using recommended lead safe practices as a demolition or whether he was required to do so as a deconstruction.

Environmental Factors

Research exists on the environmental factors associated with deconstruction and demolition including information on sustainability, asbestos, and LBP. Sustainability and the infrastructure of green construction are still in a bit of infancy in many parts of the construction sector. Many large contractors and architects of all size firms are working with USGBC and finding ways to improve performance of new buildings. There is even a movement to design specifically for deconstruction, so the structure could be more efficiently taken apart at the end of the building's lifecycle (EPA, 2008). Greenhouse gas emissions and embodied energy can be reduced with the implementation of a comprehensive deconstruction plan (Zahir, 2015). But the key point is not just the comprehensive implementation, it is getting the reclaimed materials put into an end use. Without the end market, the effects will be negligible.

Lead-based paint. The EPA (2018h) is charged with regulating LBP under the Toxic Substances Control Act, (TSCA). The EPA (2018a) has submitted proposed rule changes to the Dust-lead Hazard Standards (DLHS) and for a proposed change to the definition of LBP. The proposal calls for no changes to the definition of LBP and to change the DLHS to 10 micrograms per square foot on floors and 100 micrograms per square foot on window sills from the current 40 micrograms and 250 micrograms respectively. This change could affect the contractors and workers performing deconstruction and may require additional training to the new requirements.

Rabito et al. (2006) found that when several demolitions occur within a census block there can be an increase in children's blood lead levels. The research conducted by Rabito et al (2006) combined data from a blood level database and from the St. Louis Demolition Permit Database. Rabito et al (2006) found that:

> After controlling for other risk factors, being exposed to a single demolition was not related to an increase in blood lead level. However, being exposed to multiple demolitions on a residential block was associated with a significant increase in children's blood lead levels. (p. 349)

A Study from The Annie E. Casey Foundation (2011), supports that LBP presents a hazard for the community during demolition as dust fall from a job site can travel greater distance. Dust fall spread is not as significant during deconstruction because the building is contained during the stripping of paint covered materials and there is less dust produced during the removal of exterior building envelope. The Annie E. Casey Foundation states that "Despite clear-cut evidence that poorly supervised demolition can exacerbate lead contamination and other environmental health hazards in affected neighborhoods, few meaningful safety requirements are imposed on demolition practices employed nationwide" (2011, p. 2).

Studies found that demolition activities, including debris removal, were associated with a significant increase in lead dust in an area up to 10 meters of a demolition site (Farfel et al., 2003) (The Annie E. Casey Foundation, 2011). Debris removal occurs at the end of demolition after the house has been reduced to rubble and is inside the foundation or in a pile on the ground. The Farfel et al. study found that the process of removing debris produce significantly less lead dust fall than did the process of bringing the building down with a machine. There does not appear to be any studies done to compare lead dust fall in demolition versus deconstruction. One study attempted to quantify the lead in the air at five deconstruction and demolition sites, but Ayodele's (2014) results from the five houses in the Springwell area of Detroit were too limited and additional studies were recommended. Demolition and deconstruction will both include debris removal and foundation removal, but should be greater during the machine demolition phase, while deconstruction removes the LBP material and stores it in the foundation area, if available, while the exterior envelope of the structure is still in place. The Annie E. Casey Foundation (2011) study found that children in St. Louis experienced higher levels of lead from nearby demolitions than did similar children in other neighborhoods and the study supported the finding that children that lived within a close proximate to multiple demolitions had a greater chance of having high blood lead levels.

The EPA considers deconstruction on the same level as mechanical demolition (S. Mooney, personal communication, August 3, 2018) and recommends contractors use lead safe best practices when deconstruction a building. Deconstruction does fall outside of the scope of the EPA's RRP rule. Mechanical demolition of a building also falls outside the scope of the RRP rule, but in the case of mechanical demolition, contractors do not have to meet lead training requirements.

Deconstruction Process Factors

In 1993, the Center for Disease Control (CDC) published a seminal article in the Morbidity and Mortality Weekly Report (MMWR) discussing the case of for workers who had immigrated from Mexico and were hired to cut apart metal beams from a bridge demolition. The workers experienced symptoms related to lead dust exposure and were subsequently tested at a local health clinic (CDC, 1993). The workers were terminated after the company received the test results on the workers. OSHA did inspect the property at the request of the workers. Noted in this article was that at the time there was a practice in the construction industry of subcontracting hazardous work to “workers with limited access training, personal protective equipment, and other safety and health measures” (CDC, 1993, p. 390). There are studies done on LBP dust and mechanical demolition, but there is a need for studies to be conducted on deconstruction and LBP. Future studies could address how the cost of LBP safety best practices and lead training affect the prices of deconstruction.

OSHA (2018) requires an engineering plan regardless of whether a structure is to be demolished mechanically or deconstructed. Where demolition may have three people on a site but not directly in a building, deconstruction could have anywhere from 3 to 30 people in and around a house as it is being demolished. An engineering plan for the safe deconstruction of the building is critical to establish a safe process (OSHA, 2018). Additional research needs to be done to determine how the EPA requirements to meet the RRP rule add on to the costs of deconstruction. The Philadelphia pilot that EPA (2010) sponsored would seem to indicate that meeting the regulatory requirements of the RRP rule were negligible. The pilot was conducted in 2004 and it is unclear from the documentation whether RRP requirements were met or what level of best practices were used by the contractor. It is important to note that regardless of whether federal, state, or local regulations require meeting the RRP rule requirements, contractors should use lead-safe best practices during deconstructions (S. Mooney, Personal communication, August 3, 2018).

Designing for Deconstruction (DFD) is a concept that the industry is pushing and should therefore be a part of deconstruction plans especially as the industry attempts to find outlets for the old growth material (Pulaski, Hewitt, Horman, & Guy, 2003). Knowing how the material will be used could direct how the building is deconstructed. Pulaski, et al. (2003, p. 2) stated that "to understand the challenges of DfD, it is important to understand the deconstruction process." Unfortunately, many demolition contractors of residential buildings are fairly removed from the design process.

The shift towards LEED and an integrative design process (USGBC, 2018a) by the architectural community could be the impetus demolition and deconstruction contractors need to begin thinking about how the material they salvage will be used and the best way to maximize the yield for given use. The Material Resources (MR) category of LEED is where deconstruction can have an impact for developers. Credits are available for construction and demolition waste management as well as building lifecycle impact reduction (USGBC, 2018b). LEED credits could also be available for developer using a deconstruction site if it has a priority designation such as a Federal Empowerment Zone site, or a site in a U.S. Department of Housing and Urban Development qualified Census Tract (USGBC, 2018d). The land may not be normally thought of as a material, but the LEED credits do have value to developers and property owners, and if the intent is to get the value out of a property to help defray the cost of future deconstructions, LEED need to be in the conversation.

Several studies support the use of Building Information Modeling (BIM) and other technologies to create efficiencies in the deconstruction processes (Berghorn, 2018; Ge et al., 2017). This technology would also help establish the OSHA required engineering plans for the structure, while a model done of the surrounding area could help define areas that need protection from potential lead dust fall.

Employment

The ILSR (2008) and others have referenced that municipalities including, but not limited to Philadelphia and Milwaukee, have used the prospect of increase employment to adopt deconstruction initiatives and ordinances. The EPA (2010) that the high labor costs can also be a constraint to deconstruction, especially if the use of prevailing wages are required (ISLR, 2008). In 2003, according to the ISLR (2008) the prevailing wage for a West Philadelphia deconstruction project ranged from $29.84 to 33.45 per hour. Although that is a strong wage, it may not be sustainable for the workforce development objectives that make up many of the deconstruction initiatives. The mean annual wage for construction laborers in the state of Pennsylvania was $39,180 with an hourly mean wage of $18.84 (BLS, 2017). The workforce development component of the Philadelphia pilot, therefore, was paying laborers 58% more than the mean construction labor was making in 2017. Deconstruction should be a training ground and help pave the way to a construction career but would be difficult to pay prevailing wage of a traditional construction laborer and train them at the same time while keeping deconstruction lean and efficient. It would be appropriate and beneficial to transition the semi-skilled workers from the deconstruction industry to the generally higher skilled work required in the construction industry. This would require the public sector working with the private construction industry to pull employees through the pipeline until they are ready for the private sector construction laborer positions.

Deconstruction is more labor intensive in theory and could have the effect of creating jobs and even creating a “new industry of skilled jobs” Zahir (2015). Berghorn (2018) stated that a deconstruction operation in a moderate-size market could support 12 full time jobs to per 100 homes. Berghorn (2018) predicts that due to efficiencies and automation in the deconstruction sector, lumber recycling in California will support 62.5 jobs per 10,000 tons of material where it currently uses 100 jobs. Considering the ever-increasing labor shortage in construction and the skilled trades, deconstruction should be considered a pipeline to construction work in the existing construction industry and not an end goal. Where Berghorn (2018) focuses on the number of jobs created in the deconstruction industry, additional research could be done on how to use deconstruction jobs, that are being subsidized by the public sector for blight removal, as a transitional to the lager construction industry where demand for skilled labor is high. Skill is required to operate machinery and drive the heavy equipment used in deconstruction and demolition. According to the Bureau of Labor Statistics (BLS) (2018), total compensation for in the construction sector has risen 3% over the last twelve months with a median salary for laborers and equipment operators in the second quarter of 2018 of $34,950 and $49,150 respectively. It may be unnecessarily duplicative to create an entirely new industry to serve deconstruction, perhaps a leaner and smarter set of young demolition companies, that can work with more flexibility, is needed to disrupt the traditional demolition market.

The Philadelphia pilot that the EPA (2010) participated in utilized a mechanized method of deconstruction specifically to reduce labor costs. Although not found in any research on deconstruction, it could be expected that the increased number of deconstruction occurring in a region would cause the number of deconstruction contractors to increase. A contractor may increase the number of crews working on different structures while decreasing the number on each site. The literature related to the Philadelphia pilot does not reference whether the EPA treated the project as deconstruction, in which case the employees would need to be certified and use lead safe best practices, or if the EPA treated the pilot project as demolition, where it would have been exempt from the EPA's RRP program (EPA, 2018d; Institute for Local Self-Reliance, 2008).

Social Capital

Aldrich (2018) defines social capital as the social ties and networks that communities rely on to function and recover from disruptions. The process of removing blighted properties from urban areas leaves a vacant lot that will mostly sit vacant for a period of time. Vacant lots in Detroit and Milwaukee can be bought for a much lower price than vacant lots in Portland and San Francisco. The effect of vacant lots on a neighborhood can begin to separate the social fabric of the community as neighbors are spaced further apart. When neighbors lose the social capital, the ability to rely on that network to recovery after a disruption becomes more difficult (Aldrich, 2018). Where Aldrich's research has a focus on resilience and how communities overcome disasters like the Fukushima earthquake (2018). A 9.0 magnitude earthquake hit Fukushima, Japan on March 1, 2011 and was followed by a tsunami (Gulati, Casto, & Krontiris, 2014). The two nuclear power plants in Fukishima, the Daiichi plant, experienced a melt down after the earthquake knocked out power and the workers could not cool the system; and the Daini plant which is a short distance away was able to maintain power to the cooling systems and avoid a meltdown (Gulati et al., 2014). The Fukushima earthquake and the damage to the two reactors and the town is emblematic of how communities, whether a city, a neighborhood, or even coworkers in a business, work through disruptions. Social capital used during and after disasters (Aldrich, 2028) can work for other types of community disruptions. Lead poisoning in water pipes, blighted buildings, and the underlying economics of low-income areas can be the stressors or disruptions that the community struggles to overcome.

Ted Reiff, of the Reuse People of America, stated during a conference on reusing deconstruction materials, that removing blighted buildings helps to reduce fire and police calls to the site (Pohl, 2018). This theory is backed up by an article form the American Journal of Public Health that concluded "urban blight remediation programs can be cost-beneficial strategies that significantly and sustainably reduce firearm violence (Branas et al., 2016). Vacant lots tend to blend into the background, as citizens become use to the ever-increasing removal of blighted properties. The costs to maintain these properties both vacant lots and blighted structures on the municipalities needs further research. It is urban renewal without the forward development.

Rabito et al (2006) concluded that prior to urban renewal initiative that include multiple demolitions in a neighborhood, the impact on children's blood lead levels should be taken into consideration. The study also suggests that dust suppression and containment activities should be included with neighborhood notification of the increased risk. The article also suggests that the concentration of deteriorated housing stock in urban centers is often concentrated in low income areas and exasperates the effects of lead dust in concentrated areas.

The Annie E. Casey Foundation (2011) studied the health hazards faced by the community during demolition activities. The study involved the transformation of the East Baltimore area around John's Hopkins University and Hospital into a mixed-income and mixed-use area. Increasing the social capital of the community requires the ongoing engagement of the community about urban renewal and the demolition and deconstructions involved in the process.

The existing research indicates that the strengths and challenges of the deconstruction industry, as it relates to residential structures, is affected by six factors; material reuse, economic, environmental, deconstruction process, employment, and social capital factors.

Material reuse is the reason that deconstruction takes place. The quality of framing material, trim, and built in cabinetry that exists in houses is a testament to a different time. Many people will often hear others say, “they don’t build them like they used to.” That sentiment is the reason we need to get not only the valuable material out of the building, but also the lower value higher yield product that often gets overlooked.

The industry needs to understand that economic factors are different in different areas of the country and deconstruction plays a different role in some situations. For instance, a deconstruction in Portland to salvage material to be used on a development that is quickly following on the site is entirely different than removing an aging duplex that the City of Milwaukee took over in a tax foreclosure. Deconstruction can work in both economic situations, but it needs to be tailored and specific. Research can be conducted along these lines to determine the best variant of deconstruction in given economic situations.

Environmental factors are a concern for the people doing work on the buildings, for the neighborhood, and for future development. Research should be done on whether mechanized deconstruction falls under the EPA’s RRP rule as does demolition. The pilot deconstruction programs conducted with the EPA did not mention the LBP best practices, which suggests that they were exempted from the EPA’s RRP rule.

The process of deconstruction may require the most research going forward. From smaller and leaner crews and companies to high tech tools such as building information modeling, deconstruction can go on a continuous improvement overhaul to help streamline costs.

Employment factors in deconstruction have not been fully studied. Much of the available research is geared towards using deconstruction as a workforce development program, but there is a disconnect between these predominately city supported deconstruction programs and the construction industry. The goal should be to train and transit employees into the construction sector. Research needs be conducted to determine the most efficient and cost-effective use of a labor force on deconstructions. There is a need for workforce development programs in many urban cities and deconstruction has been chosen as a vehicle for those programs. The issue is that a larger untrained labor force on a single job can become inefficient and cumbersome. Studies like the EPA pilot (2010) with a work force with a much smaller span of control can deconstruct properties faster and with reduced costs. Four deconstruction crews working on four houses should in theory be more efficient and allow for greater training opportunities, this should be addressed in future studies.

Social Capital has become increasingly important as cities such as flint Michigan, Baltimore, and Milwaukee struggle with a lead poisoning crisis the demolition of blighted houses predominately occurs in lower income where new development is slow to follow. Further research should be conducted to determine the effects of removing houses from the community landscape has on the quality of life in the community.

Material reuse, economic factors, environmental factors, deconstruction process, employment, and social capital all play a significant role in the deconstruction industry. All of these gears have to be in place and working together to get the system to function properly. The literature review has shown gaps in the existing research that needs to be filled and further research will have the effect of moving the gears just a little bit closer, enough to start the other wheels turning. When research plugs the gaps in the data, when designers begin using reclaimed lumber more, when engineers find a way to re-grade vintage timbers, when contractors move to lean deconstruction, or when a labor force is in such demand that general contractors buy in to a public-sector training concept, that is when deconstruction will get in the mainstream construction sector.

Chapter III: Methodology

Deconstruction is the process of taking a building apart in a manner that maximizes the reuse, repurpose or recycling of the building material. The City of Milwaukee began doing deconstruction in the early part of 2008. Some of the early incarnations of deconstruction were done for the Milwaukee Metropolitan Sewerage District (MMSD) and included the removal of houses along the Kinnickinnic River in Milwaukee. Under one contract for the deconstruction of 16 houses along river, Ray Hintz Inc. was the low bidder with a bid of $833,960, or an average of $52,122 per house (Behm, 2011). The average costs were roughly 100% higher than the low estimates to mechanically demolish the buildings.

The purpose of this case study was to analyze the costs associated with the deconstruction of structures in the City of Milwaukee. Deconstruction projects for MMSD set a price level for deconstruction that is unsustainable. 500 properties owned by the City of Milwaukee were in a queue to be demolished or deconstructed as of July 31, 2018. The current research on deconstruction details the environmental impact and the workforce development benefit, but there is little available research on the process of deconstruction, whether mechanized or hand deconstruction. This research brought in data from Milwaukee's past mechanical demolitions and deconstructions. The research also gathered some of the exceptional research that has already been done on deconstruction and demolition. A measure of the success of this study will be how the data can go from an information/data stage to an implementation stage when an industry can act on the continuous improvement inputs we receive.

Data Selection and Description

The Department of Neighborhood Services (DNS) for the City of Milwaukee inspects and monitors all the demolitions and deconstructions in the city. In cases where the Department of

City Development (DCD) decided to raze a city owned structure in the past, the department acted as the general contractor for the demolition or deconstruction. DNS contracted out the demolition or deconstruction of the work to qualified contractors who submit bids for the projects. Each project had specifications that the contractors must meet to complete the specific project. This research will gather the data from the previous deconstructions and mechanical demolitions done in the City of Milwaukee to get a representation of the costs associated with both and costs that are specific to each. Data will also be gathers on deconstructions performed as part of projects done by peer cities across the country to compare with the data from Milwaukee.

Instrumentation

The City of Milwaukee as contracted out the deconstruction of more than thirty residential structures since 2015. This data related to these deconstructions including, but not limited to, the costs, square feet, and worker hours required to complete, have been put into a spread sheet for analysis along with deconstructions at Fort Campbell, Riverdale, the Presidio, and Fort Ord.

Five U.S. Army buildings were deconstructed at Fort Campbell in Kentucky. The deconstruction of the former barracks and warehouse buildings were done with the assistance of the University of Florida's Powell Center for Construction and Environment encompassed 19,320 square feet (Guy, Williams, & Courson, 2002).

A project in Riverdale, Maryland was done with the National Association of Homebuilders (NAHB) and the EPA. In 1997, the EPA released a report written by the NAHB Research Center about the deconstruction of a 2,000-square-feet building at the Riverdale Village housing development in Riverdale, Maryland. Built in the 1940’s, and originally designed to house aircraft workers. The Department of Housing and Urban Development (HUD) took over the property in 1995 after the previous owner defaulted on a loan and let the property become deteriorated (HUD, 1998). Removing the brick exterior walls of these four-unit structures were a difficult part of the deconstruction project and required 245 worker hours to remove according to the NAHB case study (1998). 245 worker hours represents 21.5% of the overall hours deconstructing the building.

Presidio is part of a 1,480-acre property in San Francisco that the Army transferred to the National Park Service in 1995 (CalRecycle, 2018). Building 901 was a 8100 square foot structure built in 1942 and was deconstructed by a local deconstruction contractor (CalRecycle, 2018). Fort Ord deconstructed several buildings and we have analyzed five buildings totaling more than and include the data as part of this research (Cook, 1997).

Data Collection Procedures

There has been some research done on the costs of deconstruction, but initial research on the topic shows a wide range of costs per square foot that vary across the country.
Interviews were also conducted with experts from various fields ranging from building officials, academics, trade group representative, to designers and architects. Data on the deconstruction process was collected during job site inspections from 2015-2018. Permission to collect information was granted from City of Milwaukee Department of Neighborhood Services (DNS).

This study required data on the costs of deconstructions as well as the worker hours needed to complete the projects. The data was obtained from records kept by the organizations sponsoring the deconstruction projects as well as data from deconstructions done in the City of Milwaukee. Permission was obtained from the City of Milwaukee and informed consent received from survey participants. Contract and cost breakdown data was gathered from records on deconstructions in the city of Milwaukee from 2010 to 2018. Records contain information on costs and material reuse, repurpose, recycle, or landfill. Data on deconstruction include information from the no-profit and for-profit contractors. Work hours were tracked under the Residents Preference Program (RPP) for deconstruction packages that included that component.

Data was also analyzed from the City of Detroit's (2018) Demolition Data Lens that tracks the costs and locations of the over 16,000 demolitions done in the city of from 2014 to December of 2018.

Data Analysis

The data from the City of Milwaukee records on deconstruction was analyzed and compiled to develop a database that was easily searchable. This information provided a benchmark cost per square foot that could be compared to deconstruction practices in peer cities and to case studies that are included in prior research.

Limitations

This analysis of past deconstructions focused on publicly owned buildings with the understanding that the tax benefits of donating salvaged material would not be available to the City of Milwaukee or other similar public entity. The City of Milwaukee owns quite a few buildings that have been taken over by tax foreclosure. Over 500 of these buildings are scheduled to be razed, and most fall under the requirement of the deconstruction ordinance of being built in 1929 or earlier. These building get marketed for resale by the Department of Community Development (DCD) for several years in some cases. In cases where the building cannot be for sale due to whatever reason(s), DCD will refer the structure to DNS for demolition or deconstruction.

At this point of a building’s lifecycle, the condition of the building is from partially to severely deteriorated. The structures could then stay on the list of properties for an additional few years before a raze might be finalized. Metal that made up the mechanical systems would have been removed by the salvage operators who are not affiliated with the city. The windows and doors could be broken; and the house could be left open to the surrounding elements. The framing lumber, sub-floor and sheathing might be the only valuable material left to salvage from the structure.

LBP generally was used on most surfaces including the wood siding, walls, masonry, and even the hardwood floors. Building elements containing any hazardous material are to be disposed properly according to the City of Milwaukee deconstruction contract specifications. These items do not need to be removed and prepared for sale and can instead be placed directly into the proper dumpster.

Records created by the City of Milwaukee or submitted as part of the bidding process are considered open records and are available to the general public under an open records request.

Summary

Existing research has been completed on the costs of deconstruction which included the net costs, or the cost of the work minus the value of the material that was sold from the property. The measurement was on a cost per square foot basis. This is a pretty consistent benchmark used in current research although it is important to understand that there are base costs which go into deconstruction and it may make the price per square foot to deconstruct an 800 square foot cottage more than a 3,000 square foot duplex on the similar sized lots. Base costs may include, but are not limited to, temporary bathroom facilities, utility disconnects, and fencing. This research attempted to understand what the driving costs of deconstruction process are?

Assuming the process to deconstruct a house is similar in different markets, but the market for reclaimed materials could be vastly different and, could solely focus on the costs related to the deconstruction process. There is a noticeable gap in the research on the costs associated with meeting the EPA's renovation, repair, and painting program that exempts mechanical demolition.

Chapter IV: Results

Understanding the value of a structure is critical prior to starting a deconstruction. The structure however is just one piece of the puzzle, and the research clarified how the structure can drive other benefits including, but not limited to, workforce development and blight mitigation.

Material Assessment

Understanding the building that is to be deconstructed and how the material can be removed to obtain the highest yield. Vacant buildings were inspected as a part of this research and Milwaukee's assessment tool, that quantifies the value of the material inside the building, was updated to include material such as the wood lathe which was not harvested from buildings in a significant number prior to 2018. Table 1 and 2 provide a look at the type of materials that is the focus of the deconstruction efforts in Milwaukee. Table 1 lists the materials at a retail value, or what the private owner might be able to write off in tax deduction if the materials were to be donated to a non-profit. Table 2 calculates the value of materials at the contractor value, or what the contactor can expect the materials to sell for on-site with minimal preparation work. The workup consisted of seven houses on a private development that the owner wanted to raze or deconstruct. Some house may have better millwork and flooring, like the house in Figure 2, while others may be filled with leftover debris from previous tenants.

This assessment can be used on a variety of building types by plugging in square footage and wall heights into the assessment spreadsheet. Historically a percentage of material is expected to be damaged during deconstruction, and those percentages were factored into the spreadsheet. Hardwood flooring for example can be difficult to remove cleanly and up to 25% of a floor can be damaged during deconstruction. Additionally, hardwood flooring under kitchen tile or laminate is not expected to be harvested.

Table 1

Framing Material Assessment, Retail Value

Material	Description	Value per unit	Total value
2 x 4 Studs	9,384 bd ft	$2.50 bd ft	$23,460
2 x 6 Rafters	4,658 bd ft	$2.50 bd ft	$11,645
2 x 8 Floor joists	12,468 bd ft	$2.50 bd ft	$31,170
2 x 6 Attic floor joists	4,938 bd ft	$2.50 bd ft	$12,345
1 x 6 Sub floor	10,717 sq ft	$2.50 bd ft	$35,723
¾" x 2 ¼" Hardwood	3,689 sq ft	$2.50 bd ft	$12,298
1 x 6 Sheathing	9,416 sq ft	$2.50 bd ft	$31,388
Beams	1,419 bd ft	$3.50 bd ft	$4,965
Lathe	22,027 sq ft	$2.00 bd ft	$58,738
		Total estimated value =	$221,731
		Estimated value per house =	$31,676
		Estimated value per sq ft =	$17.56

Note. In this table bd ft = board foot and sq ft = square foot. Reclaimed lumber values in Table 1 are based on prices after processing and in a retail environment for a proposed seven house private deconstruction project.

The estimated value of the materials for the proposed project in Tables 1 and 2 illustrates two important factors in the deconstruction infrastructure. Contractors willing to hold on to the material in a storage facility can get a higher price but at risk of the added costs to store the material until it is sold. Selling the material prior to starting the deconstruction removes the storage and transportation costs from the equation and could allow for increased volume of materials.

Table 2

Framing Material Assessment, Contractor Value

Material	Description	Value per unit	Total value
2 x 4 Studs	9,384 bd ft	$0.50 bd ft	$4,692
2 x 6 Rafters	4,658 bd ft	$0.75 bd ft	$3,494
2 x 8 Floor joists	12,468 bd ft	$1.00 bd ft	$12,468
2 x 6 Attic floor joists	4,938 bd ft	$0.75 bd ft	$3,704
1 x 6 Sub floor	10,717 sq ft	$1.50 sq. ft	$21,434
¾" x 2 ¼"Hardwood	3.689 sq ft	$2.50 sq. ft	$9,838
1 x 6 Sheathing	9.416 sq ft	$1.50 bd ft	$18,833
Beams	1,419 bd ft	$2.00 bd ft	$2,387
Lathe	22,027 sq ft	$0.25 sq. ft	$7.342
		Total estimated value =	$84,641
		Estimated value per house =	$12,092
		Estimated value per sq ft. =	$6.07

Note. In this table bd ft = board foot/feet and sq ft = square foot/feet. Lumber values are representative of 2018 prices being paid to a Milwaukee contractor for sales on-site or in contractor's storage for a proposed seven house private deconstruction project.

The estimated total value of materials which is of $84,641 for the seven houses described in Table 2 is a number for the jurisdiction to show potential contractors the value anticipated in the bidding process. Retail value of the materials, estimated at $221,731 and shown in Table 1, is equal to the donated value a private owner could expect from an assessment. These values represent the investment of a jurisdiction like the City of Milwaukee is making from the cost of hiring the contractors, in the workforce and in the adjacent property values within the neighborhoods affected by deconstructions. The amount of materials listed in the description column can help a jurisdiction to gauge a contractor's efficiency in harvesting the materials. DNS and the City of Milwaukee would benefit from the material assessments through measuring how the amount of materials harvested compared to the estimated amount. Maintaining records of contractor performance will drive continuous improvement, but would require contractors to submit material reports that can be verified by field observations from city inspectors.

Figure 2. Interior of vacant duplex in Milwaukee.

Figure 2 shows the interior of a vacant Milwaukee duplex. Typically, the first and second floors had similar trim and built-in cabinetry although years of use and painting can vary the quality of the material. In many cases, the units were either painted or vandalized like the missing column in Figure 3. Additionally, damage and theft may occur in the intervening months between an assessment and the beginning of deconstruction. For those reasons, although the value exists for the unpainted built-in cabinetry, the estimated values were left off the assessments of building material and are instead included in the deconstruction matrix, where it can be included as part of the historical context of the structure.

Figure 3 shows the interior picture of typical attic framing in Milwaukee with 2 x 4 or 2 x 6 rafters 24" on center and 1 x 8 and 1 x 10 roof decking. The majority of the houses built in 1929 or earlier that fall under the deconstruction ordinance have a roof pitch of 12/12 with an open unfinished attic space, while the remaining bungalow and craftsman style houses will have lower pitches and finished, or habitable, spaces in the second floor/attic areas. Unfinished attic spaces make deconstruction cleaner, more efficient, and more cost effective.

Roof decking, as seen in figure 3, is difficult to salvage in large numbers due to the age, use, and multiple layers of roofing material installed on top of it. Any salvageable roof decking material is a bonus, but the material is not included in value assessment calculations. Most of the decking is best suited for recycling although reusable materials can be harvested in smaller sizes of 2-3 feet and less.

Figure 3. Attic framing.

Regression Analysis of Square Feet, Worker Hours, and Costs

Regression analysis was performed on the deconstructions conducted in the City of Milwaukee from 2015 through 2018. Five separate contractors were under contract to deconstruct the thirty-four structures. The results from the regression analysis indicate that inputs like square feet and worker hours do not result in costs falling in the predicted range.

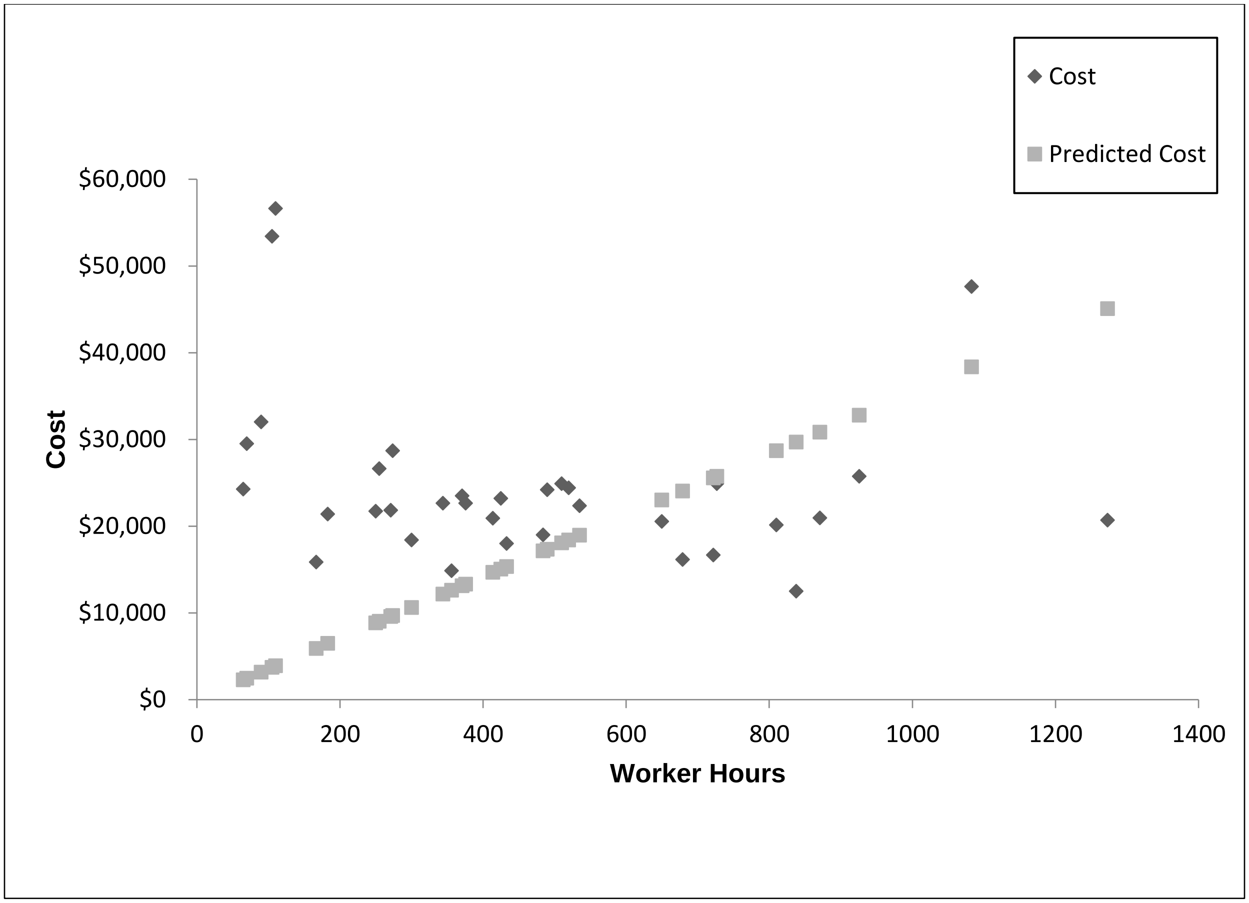

Figure 4. Regression, worker hours to cost.

Figure 4 contains data rerecorded for thirty-four observations on deconstructions in the City of Milwaukee and the costs of those deconstruction. An R square number of 0.555 for the data in Figure 4 shows that just over 55% of the worker hour inputs for jobs fit the model. The correlation coefficient for this model was 0.745, showing a positive relationship, but not nearly as strong as we would expect.

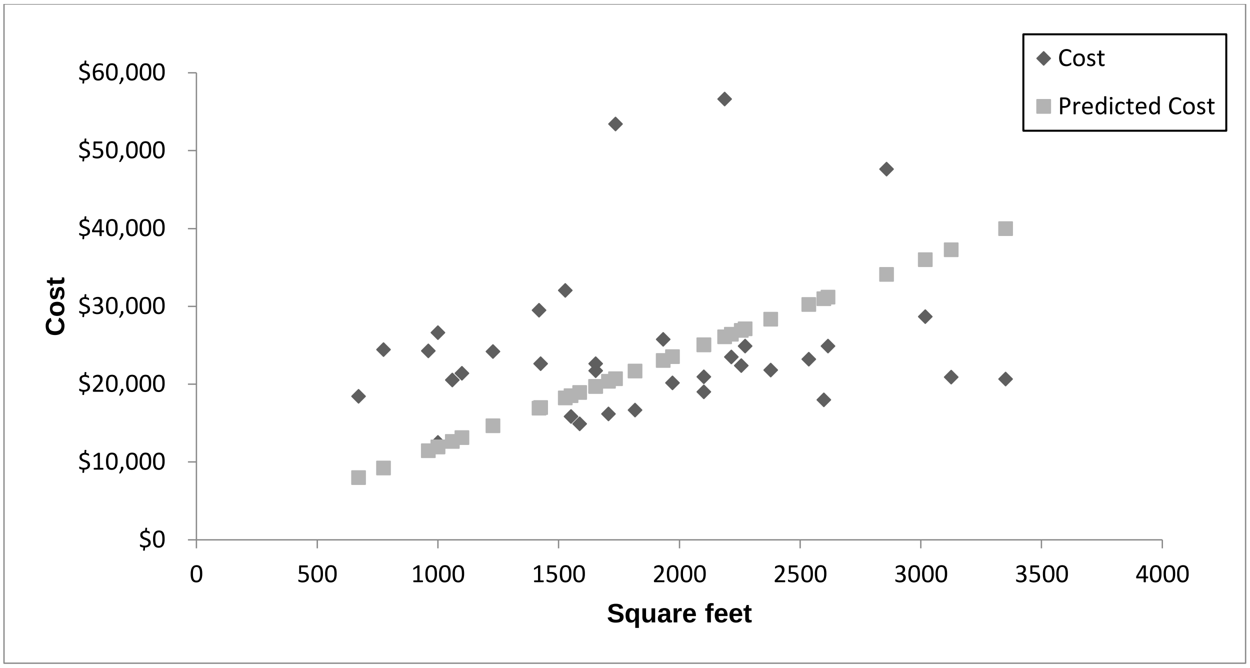

Figure 5. Regression analysis of square feet to cost.

Figure 5 shows data from the same deconstructions used in Figure 4 but shows a tighter relationship of the square feet to the costs. The R square number for this analysis was 0.803 and the correlation coefficient was a much closer to perfect 0.896.

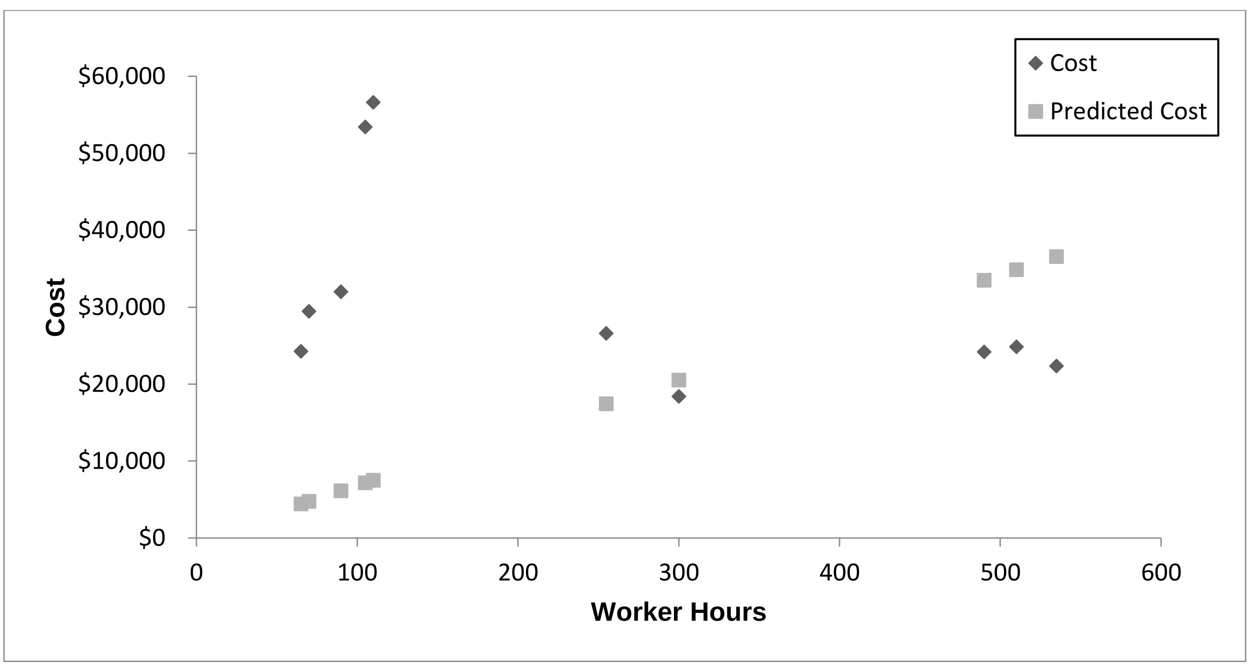

Figure 6. 2017 and 2018 Deconstructions worker hours to cost.

Figure 6 illustrates the wide spread of a worker hours to costs regression analysis of the most recent ten deconstructions performed in the City of Milwaukee. This information suggests that the smaller houses that are being deconstructed take fewer hours to complete, but the costs are not reflective of the fewer worker hours.

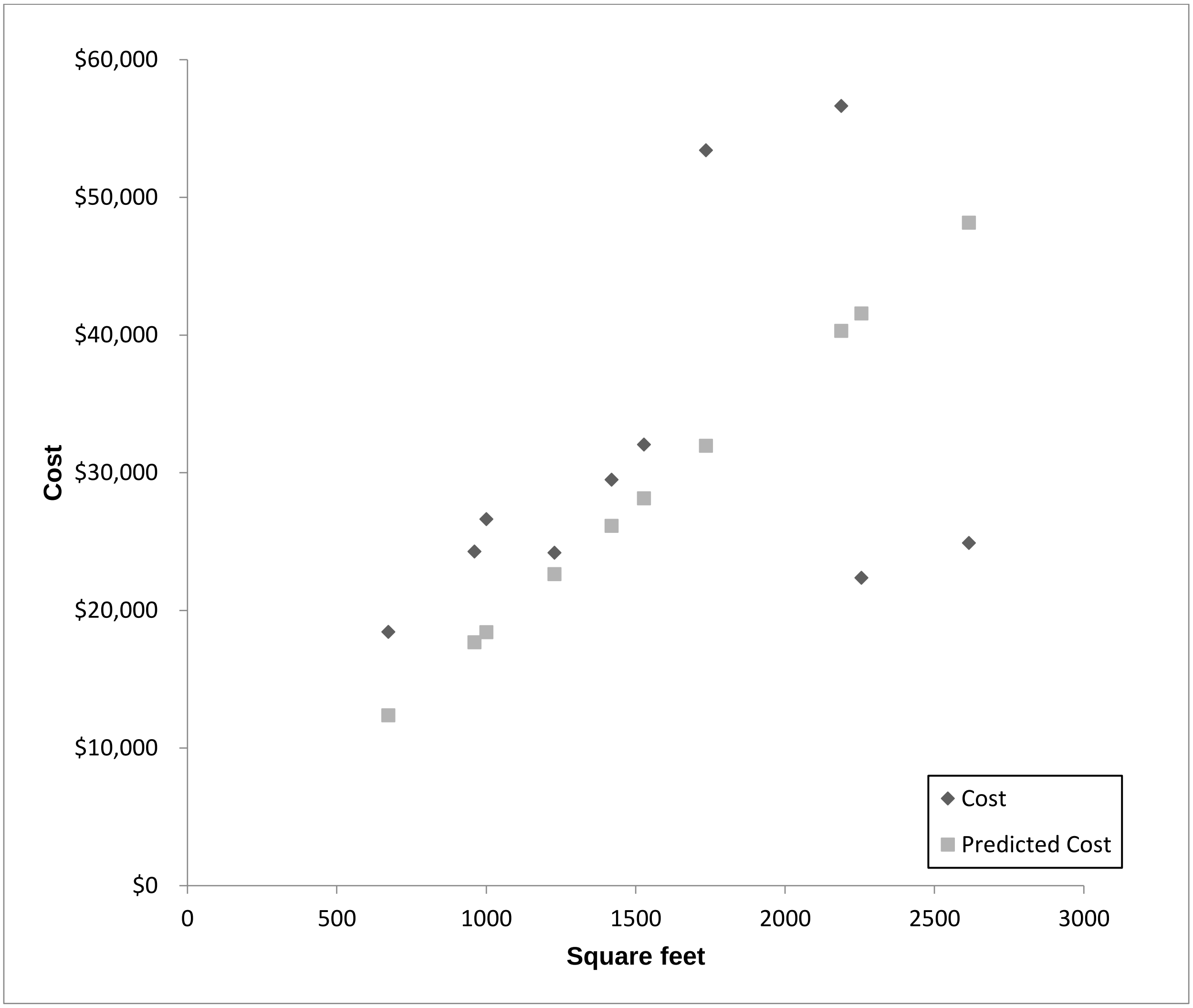

Figure 7. 2017 and 2018 Deconstructions square feet to cost.

The cost to square feet regression analysis of the most recent ten deconstructions performed in the City of Milwaukee, shows a much tighter relationship than the 34 deconstructions performed since 2015 that are shown in Figure 5.

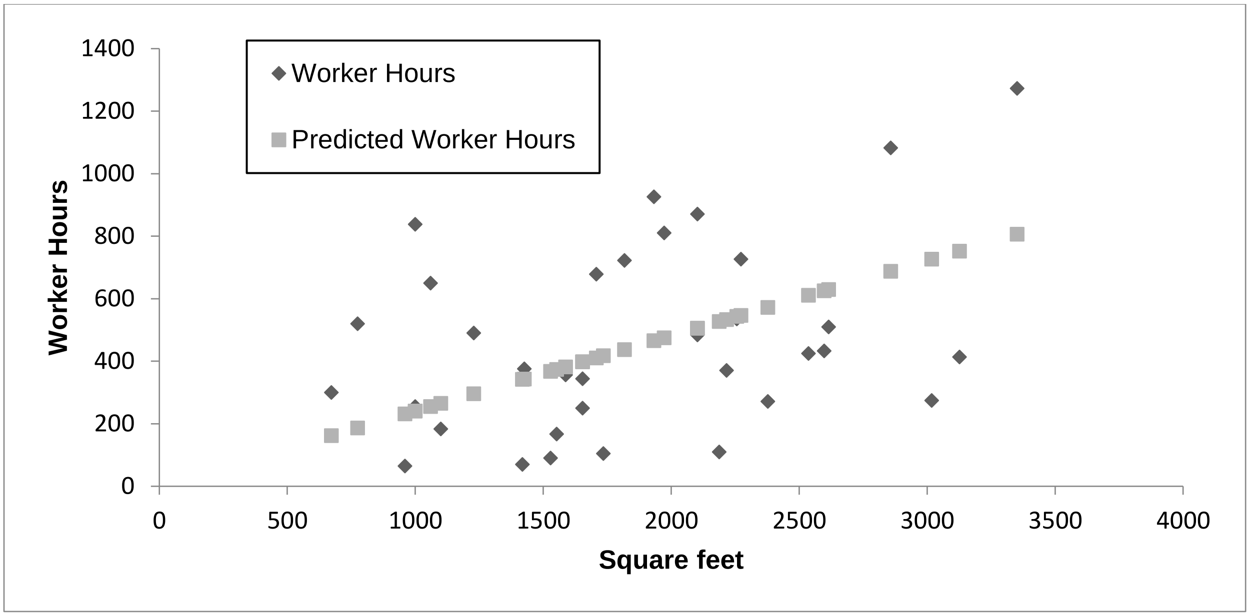

Figure 8. Worker hours to square feet.

Figure 8 illustrates the regression analysis of worker hours to square feet for thirty-four deconstructions since 2015. The R square is 0.739 and the correlation coefficient is 0.86. In this graph we have a much wider spread of actual worker hours compared to what the predicted worker hours would be.

Table 3

Worker Hours Per Square Foot

Locations	Worker hours per square foot
Fort Ord, Marina, CA	0.31
Fort Campbell (Kentucky)	0.38
Presidio (San Francisco)	0.12
Riverdale	0.51
Milwaukee, WI	0.25
Average of analyzed deconstructions	0.314

Note. Regression statistics put the coefficient at 0.29

Table 3 illustrates the worker hours required to deconstruct buildings on several military bases, a HUD property in Maryland, and the deconstructions done in the City of Milwaukee. The average worker hours per square foot for the properties was 0.314. Using this number, the City of Milwaukee can get an estimate of the time required to deconstruct properties by simply plugging in the square feet of the property.

To put these workforce and assessment numbers into context, a large project to deconstruct 100 properties with an average of 1,800 square feet, would be estimated to take 56,520 worker hours and result in a framing material yield of $1,092,600 at $6.07 per square foot. The average cost per square foot of a recent deconstruction bid in the City of Milwaukee was $21.15. This would result in cost to the City of Milwaukee to deconstruct 100 buildings at $3,807,000 with an estimated value of materials of $1,092,600 for the deconstruction contractor.

Chapter V: Discussion, Conclusion and Recommendation

This chapter will present: an overview of the study, conclusions that were drawn from the results of the study, and recommendations based on the conclusions.

Discussion

There is a gap in research on the use of deconstruction to remove blight and develop a strong labor force for a growing construction industry. The City of Milwaukee maintained 400-500 vacant and blighted properties throughout 2018. Many issues plagued the properties including deteriorating exterior LBP, crime, and illegal dumping of garbage.

Restatement of the problem. The cost to deconstruct a building in the City of Milwaukee increased dramatically over the course of several years as regulatory requirements became clear and a deconstruction ordinance was enacted by the Milwaukee Common Council. Historically, the City of Milwaukee has razed 150 blighted properties per year and maintained a backlog of roughly two hundred blighted and vacant properties that were slated for demolition. The deconstruction ordinance enacted in January of 2018 required that structures built in 1929 or earlier be deconstructed as opposed to mechanically demolished.

Purpose of the study. The purpose of the study was to analyze the costs associated with deconstructing publicly owned structures to find cost efficiencies in the process and to understand the inherent value of the building materials used in the structure.

Objectives. The objectives of the study were as follows:

1. Define the labor and process costs required to deconstruct a structure.
2. Identify the environmental regulations and labor constraints that effect the deconstruction costs.

3. Develop assessment process used in evaluating amount of building material contained in a structure.
4. Define the best practices used for deconstructing houses.

Methodology. The methodology of this study included analyzing historic data on deconstructions conducted by the City of Milwaukee Department of Neighborhood Services as well as several deconstructions conducted by public entities across the United States. A total of 42 deconstructions of City of Milwaukee owned properties were analyzed as well as 13 buildings deconstructed by HUD and the U.S. Military.

Conclusions

When deconstruction is used by the private sector, there can be positive outcomes for both the municipality that owns the structures and the contractors performing the work. The results of this research allow for the use of three key metrics that can help model a cities portfolio of blighted properties, so the decision makers can make judgments on what buildings to deconstruct and when. Key metrics, as shown in Table 3, for the City of Milwaukee's deconstruction effort include: the worker hours per square foot, the on-site value of material per square foot, and the cost to deconstruct per square foot.

Workforce development is a critical component of deconstruction and drives many decisions on projects. Using worker hours per square foot allows communities to see this component as part of the economic equation and have a benchmark to set for contractors. This number includes all the components of a project including office time, set up, and processing material as well as the hours needed to physically take down the building. Continually developing a workforce is an economic decision that can determine where business decide locate to or move from.

Table 4 below, shows the important metrics of the deconstructions that were analyzed as part of this research. This information can serve as bullet points when informing decision makers about benchmarks to use when discussing or planning future deconstruction projects.

Table 4

Putting Results to Work

Metric	
Average square feet per deconstruction	1610 sq ft
Average cost per deconstruction	$29,644
Average cost of deconstruction per square foot	$21.15 sq ft
Average worker hours per square foot	0.314 wh/sq ft
Average worker hours per deconstruction	505.54
Average cost per worker hour	15.75 hr
Average labor costs per deconstruction	$7,962
Estimated reclaimed lumber on-site value per house	$12,092
Estimated on-site value of reclaimed lumber per square foot	$6.70 sq ft
Average board feet of reclaimed lumber per house	9,147 bd ft
Average weight of reclaimed lumber per house	28,145 lbs.
Estimated board feet of reclaimed lumber in 500 houses	4,624,174 bd ft
Estimated weight of reclaimed lumber in 500 houses (lbs.)	13,872,523 lbs
Estimated weight of reclaimed lumber in 500 houses (tons.)	6,936 tons
Projected costs to deconstruct 500 houses containing 813,919 square feet	$14,986,228
Projected labor costs to deconstruct 500 houses	$3,981,128
Projected on-site value of reclaimed lumber from 500 houses	$6,046,000
Projected retail value of reclaimed lumber from 500 houses	$15,115,000

Note. Average square foot (sq ft) of 1610 represents seven houses in 2018 deconstruction bid package with average cost of $29,644. In this table bd ft = board foot/feet, sq ft = square foot/feet, and wh = worker hours.

Recommendations

Recommendations for the City of Milwaukee include further improvements in funding, building and material assessment, improving the processes used to deconstruct, and finding efficiencies in material handling.

Funding. Exploring additional funding streams specific to deconstructions and construction workforce development is recommended to assist in the rapid deconstruction of the large volume of properties that have built up in the city's backlog of blight structures. This expanded funding could serve as a stepping stone until a private deconstruction infrastructure has been sufficiently established. There has been grant funding available for workforce development in the City of Milwaukee including from federal, state, and local philanthropic organizations. The majority of the federal funding channels through Employ Milwaukee, which is the workforce development board under the Workforce Innovation and Opportunity Act (WIOA) (Employ Milwaukee, 2018a).

Employ Milwaukee had a revenue of $17,703,049 in 2017 and program expense minus Management and General expenses of $16,442,170 (Employ Milwaukee, 2018b). The City of Milwaukee has been able to use some of these funds to hire and train workers on deconstructions as well as other training opportunities inside DNS. Not everyone who is trained in the construction industry needs or wants to be out at a job site. Critical roles exist in design, logistical support, and even the inspection and enforcement. Employ Milwaukee offers an opportunity to bring in young adults, from areas where deconstructions and demolitions are taking place, to experience training on various functions of the construction industry.

This research suggests that engaging the philanthropic offices of some of the larger general contractors working in Milwaukee could lead to an innovative partnership to develop future workers in the trades. Contractors are currently working with local high schools to help address the labor shortage in the industry. There may be some willing to not only address the labor shortage, but also spur economic development in areas of high unemployment and underemployment by taking high school apprenticeship programs to those recently out of high school struggling to find work (Findorff, 2018).

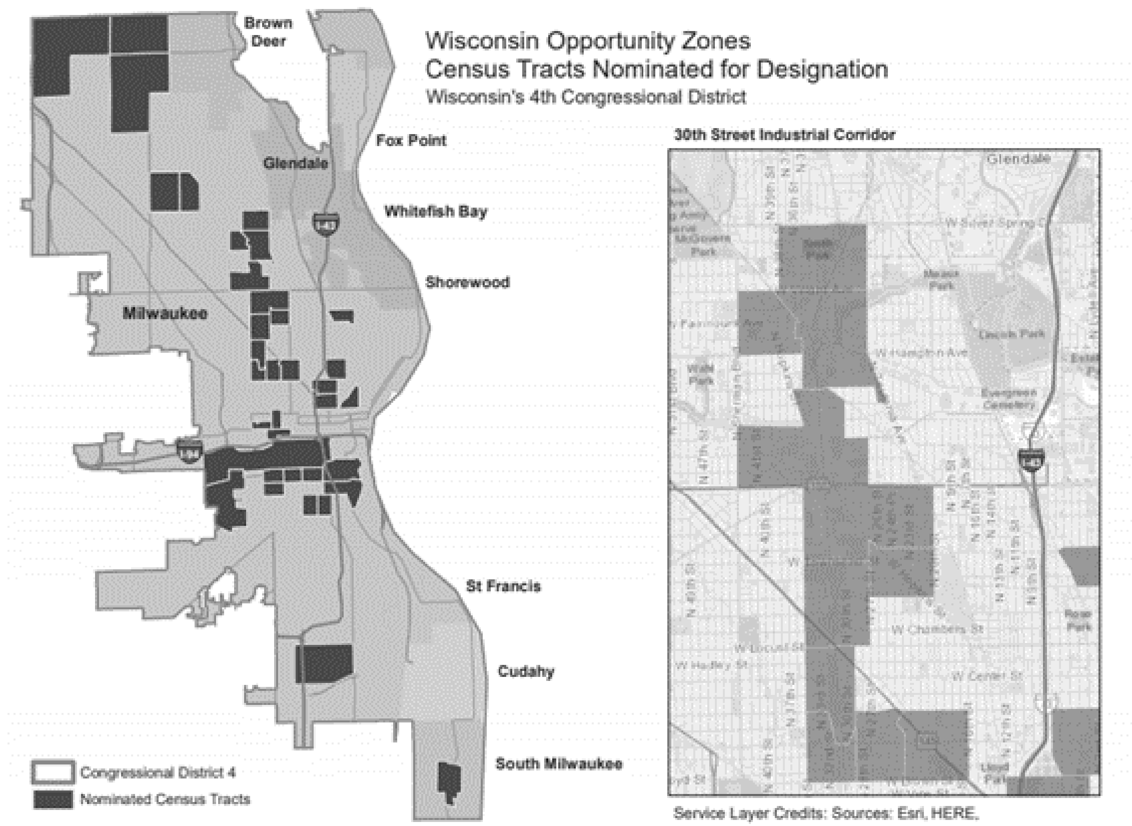

Figure 9. Opportunity zones in Wisconsin’s 4th congressional district (WHEDA, 2018a).

Opportunity zones, that were developed as part of the 2017 Tax Cut and Jobs Act enacted by congress in 2017, created 34 opportunity zones inside the City of Milwaukee (WHEDA, 2018b). The map on the right side of Figure 9 are the opportunity zones in the 30th Street corridor of Milwaukee. Opportunity zones are meant to help direct investment into economically distressed areas, and these are areas where many deconstructions take place. Combining the opportunity zones with the LEED credits and tax benefits, might convince developers to invest in deconstructions in Milwaukee. The encouragement and education about the potential benefits is a job the City of Milwaukee can take on without much additional recourses.

Although Wisconsin did not participate in the U.S. Treasury's Hardest Hit Fund (HHF) program, there are lessons that can be learned from states that are using HHF funds through Blight Elimination Programs. Michigan established the Hardest Hit Fund Blight Elimination Program in 2013 to help communities remove blight by demolition using HHF and U.S. Treasury's Troubled Asset Relief Program (TARP) funds (Quinn, 2013). The goal of the program was to reduce future foreclosures and strengthen neighboring property values by demolition of blighted properties. Further research might help Milwaukee understand how money spent on blight elimination has helped to stabilize and possibly improve surrounding property values. Understanding the benefits on blight elimination through research similar to Dynamo Metrics work on the HHF funds used in Detroit (2015), that found a positive 4.2% impact on surrounding property values from each demolition in an area using HHF money. This type of research may help deliver additional funding for the City of Milwaukee's blight elimination and deconstruction efforts.

Assessment. It is recommended that the City of Milwaukee design and implement a standardized assessment process that can identify building materials within a building. This assessment can serve several functions including, but not limited to, advising decision makers on the value of material that is embodied in the vacant and blighted structures that are scheduled for demolition. Although the city could not benefit from the potential tax deduction of a charitable donation, this benchmark assessment could be used as a reference for private developers that may be interested in purchasing the blighted structure and taking advantage of the tax implications and LEED credits associated with deconstruction.

Once the decision has been made to deconstruct a structure, each structure needs an individual plan for deconstruction. An engineering assessment can be done at the same time as the material assessment. BIM can be used and an engineering exam can be done of this information as well as an on-site engineering inspection. The workforce development component that is a part of the City of Milwaukee's deconstruction ordinance makes the engineering plan for deconstruction a critical component of the deconstruction process. There is a possibility of having a majority of the job site labor force in training. This training environment can begin with crews walking through the computer simulation of the building and becoming familiar with the components and possible structural issues such as deteriorated beams or faulty connections.

Assessments can also be used to market the material that is inside the structure. The 500 buildings in pipeline that the City of Milwaukee maintains contains an estimated framing material value $12,092 each for a total of over $6 million dollars. This value is what a contractor can expect from sales with minimal processing at the job site. A one foot long 2 x 6 rafter equal to one board foot has a contractor value of $0.75 under the City of Milwaukee's assessment.

Lumber pricing can vary across the country based on economic condition in areas across the country. Areas where deconstruction is used for blight removal and workforce development and sustainability may have lower prices than areas where deconstruction is used primarily for sustainability. The price list below was included in an email from Ted Reiff, President of the ReUse People of America, and reflects the September 2018 prices in their Oakland, California retail store. Reiff mentioned that the prices, including $1.00 for a vintage 2 x 6, compared to a Milwaukee assessment value of $0.75, are a "liquidation value" that reflects the store's dependency on the volume of material (T. Reiff, personal communication, November 29, 2018). Reiff goes on to state that if the ReUse People "were to hold out for the highest and best use and were located on main street we would be getting 5 to 6 times more" (T. Reiff, personal communication, November 29, 2018).

The city can help to facilitate deconstructions by marketing that material to area developers and providing documentation on the structures online as well as in print at the permit desk. This "marketing" effort is something that can become a function of the Deconstruction Advisory Group that the commissioner of the Department of Neighborhood Services put together in 2018.

Part of this research developed a deconstruction matrix, this tool can be used as a quick assessment done at the initial inspection of the property. Considerations in the matrix include the potential material to be harvested, but also assessment information like site logistics, neighborhood issues, and nuisance factors. Figure 10 shows a deconstruction matrix performed on a City of Milwaukee house located at 2655 N 20th St. The house is down the street from a vacant Milwaukee Public School and is also within walking distance to a community garden. An alley to the West provides access to the lot for contractors and heavy machinery.

Address		2655 N 20th St		**Date**		7/25/2018	
Census tract				**Inspector**		Olen	
Aldermanic District							
Deconstruction Matrix							
Material		Deconstructability		Logistics		Context	
Score 0-6		Score 0-6		Score 0-6		Score 0-2	
Flooring	6	Debris	6	Tall Chimney	3	Vandalism/graffiti	1
Trim	6	Insulation	3	Building Height	3	ASR's and Complaints	2
Siding	3	Unfinished attic	6	Stripped Mech.	3	# of recent demolitions in area	0
Bricks	3	Neighboring lot	6	Nuisance Vehicle	3	Community Garden nearby	2
Foundation	3	Basement	5	Space between buildings	6	Nuisance Property	1
Windows	2	Gutted	2	Square feet	3	Near another Decon	2
Built-ins	6	Fire Damage	6	Site constraints	3	Illegal Dumping	1
Staircases	6	Major street	5	Alley access	6	Historic District	0
Framing	6	Roofing material	3	Garage	4	% of vacant lots on block	0
Trees	2	Age of building	5	Hazards	3	Schools nearby	2
Total	43	Total	47	Total	37	Total	11
Maximum points	60	Maximum points	60	Maximum points	60	Maximum points	20
						Total Deconstruction Points	138
Properties will be ranked on a score of 0-200, with 200 being the best possible deconstruction candidate.							
Inspector can set input scores based of a 0-6 scale for Material, Deconstructability and Logistics. Context inputs will be ranked on a scale of 0-2.							
Does not set up well for Deconstruction	0	No Community benefit from deconstruction	0				
Well below average	1	Average community benefit from deconstruction of structure	1				
Below average	2	Above average community benefit from deconstruction	2				
Average	3	**Notes:**					
Above average	4						
Well above average	5						
Sets up perfect for Deconstruction	6						

Figure 10. Deconstruction matrix.

Predicting or modeling the social impact of a demolition or deconstruction on a surrounding area will also benefit decision makers when deciding where to invest funds for blight removal. A report was commission to develop analytics based on data available from the City of Detroit and other partners to determine just how blight removal affected neighboring properties. The report found that houses located within 500 feet of a demolition funded by HHF experienced an increase of 4.2% in the property’s value (Dynamo Metrics, LLC., 2015). The City of Detroit has been awarded over $100 million in HHF to aid in blight removal in the city (Dynamo Metrics, LLC., 2015, p. 4).

Figure 11. 2655 N 20th St, Milwaukee, Wisconsin.

This research could be duplicated in Milwaukee and it would benefit the City of Milwaukee to start incorporating an analytical approach to deconstruction and demolition decisions. As an example, the average cost of demolitions in Detroit using HHF was $14,855 (Dynamo Metrics LLC., 2015, p. 9) and it is a number that is comparable to the City of Milwaukee's demolitions. The estimated value of the building material in the average City of Milwaukee deconstruction is $12,902, while the average deconstruction bid in the city of Milwaukee for 2018 was $29,644. It leaves an estimated net cost to deconstruct of $16,742. The $12,902 value of the building materials is an investment in the workforce and an even greater investment in the neighborhood. If each property within 500 feet of a deconstruction had a 4.2% increase in a $58,600 property value (Zillow, 2018), could see 40 houses in the immediate area with an aggregate property value increase of $98,448.

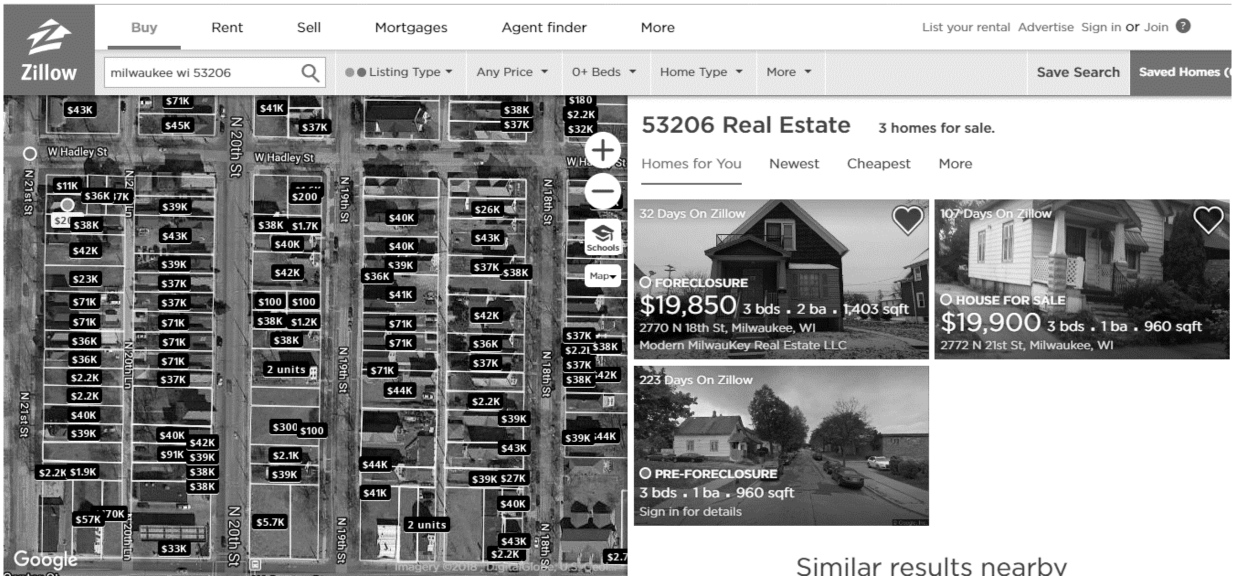

Figure 12. Zillow screenshot of housing values on satellite image of 53206 zip code.

Zillow used a Google map of an area in the 53206 zip code and overlaid values of the properties. If each lot is roughly 30 feet wide and 100 feet deep, the reader gets an understanding of how many houses could be affected by an 4.2% increase in property value in a 500 foot area of a blighted property.

Process. Deconstruction is essentially construction of the building in reverse and because of that there are risks involved with deconstruction. The International Fire Code (IFC) by International Code Council (ICC) covers fire hazards during construction and demolition in Chapter 33 of the 2018 edition. Therefore, contractors must be cognizant the adopted building codes of the jurisdiction which the deconstruction is taking place (ICC, 2018). A recent fire that occurred in Superior, Wisconsin illustrates that crews were salvaging timbers from an historic grain elevator when a fire erupted causing an estimated $2.5 million in damages, including a reported $450,000 in vintage timber that had already been sold (WDIO, 2018). One of the first steps of any deconstruction should be the engineering exam that is required by OSHA on all demolition sites (OSHA, 2018b).

Deconstruction begins after the abatement of hazardous materials and the proper permitting, paperwork, and site safety features have been obtained, made, and are in place. The soft strip of unpainted cabinetry, hardwood flooring and millwork is the first step. Once the valuable material that can be easily damaged is removed, the set up for the removal of LBP containing material can begin. The set up and take down of protective equipment and material can add valuable time to each daily schedule. Therefore it is recommended that all the LBP material is removed prior to moving on to the next stage of deconstruction.

The method of deconstruction from here is dependent on the equipment and capabilities of the contractor. Milwaukee can require time frames and other benchmarks be met by establishing them in the bid specification language. An example of this may be a neighbored organization that is training a larger group of unskilled workers and needs more time at the earlier stages to get the crew comfortably working in an inherently unsafe environment. This type of arrangement should be clearly spelled out in the contract and overseen by qualified contractors on-site. Penalization and hybrid deconstruction have been proven successful on many job-sites and should be embraced by municipalities considering deconstruction. The focus should be on the amount of material reused, repurposed, or recycled, and not necessarily how that work was completed. Different structures and site conditions may dictate proper deconstruction techniques, and again can be easily agreed upon prior to starting a project.

Material handling. A large-scale deconstruction project of several houses would benefit from a Deconstruction Consolidation Center (DCC) that can act as a central facility to process material. Many construction companies working on large projects in urban areas use Construction Consolidation Centers (CCCs) to streamline the logistics process and reduce costs and emissions. A large facility can be supported by the municipality as place where crews can de-nail, sort, and prepare material for shipment.

The use of an offsite facility will also help to reduce the time contractors who are on-site disturbing neighbors and mitigate any possible hazards like kids playing near jobsites. Contractors using a DCC would benefit from a panelized form of deconstruction, where wall sections are removed and transported directly to a staging area at the DCC for disassembly in a controlled environment. A DCC will also allow for a safer environment for buyers to inspect and handle material.

The objective of the DCC is sustainability. The purpose of the proposed of the DCC is to set up a facility that can accept materials from public and private demolitions and deconstructions. Ideally, the responsibility should be taken care of by the private sector as the market in the city and around the region becomes established. Over this transitional period the warehousing and marketing function can be directed by a local non-profit group willing to train employees in the handling, retail, and repurpose of reclaimed building materials.

The recent implementation of the deconstruction ordinance presents challenges and opportunities. There is a design trend taking place to use reclaimed lumber in commercial and residential application as a design feature. Vintage windows and doors are being repurposed and incorporated into new construction and remodeling projects. The success of Habitat for Humanity's Restore facilities in the Milwaukee area and around the country has proven the viability of the market for building materials and salvage.

Workforce development was an integral part of the adoption of the deconstruction ordinance in the City of Milwaukee. Currently there is a gap between the deconstruction of a building and the eventual reuse of the salvaged material that needs to be filled. The City of

Milwaukee can help to close this gap by providing the facility to warehouse the material and create a space where a non-profit organization can train apprentices on the warehousing, storage and retail of the building material.

Many construction firms are using CCCs to reduce waste and carbon emissions that would normally occur at heavily trafficked urban sites (Lundesjo, 2011). The CCC is used as an offsite staging area where materials can be stored until they are needed at the jobsite. The DCC would function as a CCC where materials could be stored until the shipment to the end user or pick up at the secured facility. Partnering with a group like Near West Side partners could put some ownership in the project where the salvage yard is located and gets some buy in from the local community. Ideally, the salvaged materials from City of Milwaukee owned deconstructions would be reused and repurposed in the city, fostering that local connection, sense of ownership, and honoring the architectural sensitivity of the materials.

A system to safely remove LBP from the exterior siding material that wraps many of Milwaukee’s residential buildings would open up an untapped amount of material. It is recommended that the City of Milwaukee works with federal partners like the EPA and HUD to explore funding opportunities for removing deteriorated LBP from the city owned structures as soon as reasonably possible. It may make economic sense to bring in a specialized third-party contractor separated from the deconstruction to mitigate the lead hazard, so it does not put the public at risk while the structure works its way through the deconstruction pipeline. A mobile trailer mounted system, which is similar to the one designed by John Stephens and Stan Cook for the Fort Ord deconstruction project (EPA, 2015, p. 17), could be used by the crews to remove the exterior source of lead from Milwaukee’s neighborhoods.

Regression statistics suggest that bringing the worker hours more in line with what can be expected for a deconstruction which is based on the square foot. The City of Milwaukee should implement a monitoring policy to better document the work hours of each project and the tasks that were completed. This will help the continuous improvement of the deconstruction contractors and also the improvement of the City of Milwaukee estimating time and labor required for the jobs. The documentation provided by the contractor may be helpful from an accounting perspective, but more detailed documentation is required to streamline the deconstruction process. The focus on workforce development suggests that a closer working relationship with the larger general contractors in the area could help direct deconstruction process improvements. The City of Milwaukee is making efforts to train crews for the construction industry and bring in the general contractors to the deconstruction advisory committee as being an excellent first step.

When Yogi Berra said that "in theory there is no difference between theory and practice" but "in practice there is," (Amazon, 2018,) he might have been trying to send a message to his team that thinking about being successful is good but it won't work unless you put in the practice. Learning from mistakes is a part of growth. An organization can iron out mistakes I the field and try new theories in practice, where failure can be a benefit. Continuous improvement relies on finding the small thing that may cause the big problems. This idea brings our research back to the philosophical or literary definition of the word deconstruction which describes it "as the act of breaking something down into its separate parts in order to understand its meaning, especially when this is different from how it was previously understood" (Oxford Dictionary, 2018).

Deconstructing a house involves breaking the structure down into its individual pieces and then finding the best use for those pieces. In the City of Milwaukee, deconstruction also involves how the community previously understood that building as a part of the neighborhood fabric and how the process of deconstruction, and a resulting vacant lot. The will affect the community going forward through workforce development, property taxes, lead and asbestos abatement, and crime reduction. Deconstruction benefits like these can be monetized through changes in property values over time. These are the benefits that decision makers need to understand and incorporate when planning local deconstruction ordinances and determining which houses to deconstruct, mechanically raze, or rehabilitate.

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Appendix A: Reclaimed lumber price list: ReUse People of America, Oakland warehouse

ALL PRICES BY LINEAL FOOT						
		REDWOOD, SIDING, OLD	**CLEAR REDWOOI**	**PRESSURE**		
LUMBEI	**DOUG. FIR**	**GROWTH, ROUGH, VG FI**	**AND OTHER FINE**	**TREATED**	***PLYWOOD***	***PLYWOOD***
SIZES	**PRICES**	**AND 1X T&G**	**WOODS**		***THICKNESS***	***PRICES***
1x2	**0.10**	**0.15**	**0.25**	**N/A**	1/4	$8.00
1x3	*0.15*	*0.25*	*0.40*	*N/A*	3/8	$10.00
1x4	**0.20**	**0.30**	**0.50**	**N/A**	1/2	$12.00
1x6	*0.25*	*0.50*	*0.75*	*N/A*	5/8	$15.00
1x8	**0.35**	**0.60**	**1.00**	**N/A**	3/4	$17.00
1x10	*0.50*	*0.75*	*1.25*	*N/A*	3/4 T&G	$19.00
1x12	**0.75**	**1.00**	**1.50**	**N/A**	11/4T&G	$23.00
1x14	*1.00*	*1.25*	*1.75*	*N/A*	T1-11 1/2	$18.00
1x16	**1.25**	**1.5**	**2.00**		T1-11 5/8	$21.00
1x18	*1.50*	*1.75*	*2.50*		T1-11 3/4	$23.00
						OSB
2x2	**0.15**	**0.20**	**0.35**	**0.20**	1/4	$5.00
2x3	*0.20*	*0.35*	*0.60*	*0.30*	3/8	$6.00
2x4	**0.25**	**0.50**	**0.75**	**0.40**	1/2	$8.00
2x6	*0.40*	*1.00*	*1.25*	*0.75*	5/8	$10.00
2x8	**0.50**	**1.25**	**1.50**	**1.00**	3/4	$12.00
2x10	*0.75*	*1.50*	*2.00*	*1.25*	3/4 T&G	$13.00
2x12	**1.00**	**2.00**	**2.50**	**1.50**	11/4 T&G	$18.00
2x14	*1.50*	*2.50*	*3.00*	*2.00*	T1-11 1/2	$15.00
					T1-11 5/8	$17.00
3x3	**0.25**	**0.35**	**0.50**	**N/A**	T1-11 3/4	$20.00
3x4	*0.40*	*0.75*	*1.00*	*N/A*		
3x6	**0.60**	**1.25**	**1.50**	**N/A**		
3x8	*0.75*	*1.75*	*2.00*	*N/A*		
3x10	**1.00**	**2.00**	**3.00**	**N/A**		
3x12	*1.50*	*3.00*	*3.50*	*N/A*		
3x14	**2.00**	**4.00**	**4.50**	**N/A**		
3x16	*3.00*	*4.50*	*6.00*	*N/A*		
4x4	**0.80**	**1.00**	**1.25**	**1.00**		
4x6	*1.10*	*1.50*	*2.00*	*1.50*		
4x8	**1.50**	**2.50**	**3.00**	**1.75**		
4x10	*1.75*	*3.50*	*4.00*	*2.25*		
4x12	**2.00**	**4.00**	**5.00**	**2.75**		
4x14	*2.50*	*4.50*	*6.00*	*3.25*		
4x16	**3.00**	**5.00**	**7.00**	**3.75**		
4x18	*3.50*	*5.50*	*8.00*	*5.00*		
4x20	**4.00**	**6.00**	**10.00**	**5.50**		
6x6	**2.00**	**3.00**	**4.00**	**2.50**		
6x8	*2.50*	*4.00*	*5.00*	*3.00*		
6x10	**3.00**	**5.00**	**7.00**	**3.50**		
6x12	*3.50*	*6.00*	*8.00*	*4.00*		
6x14	**4.00**	**7.00**	**9.00**	**4.50**		
6x16	*4.50*	*8.00*	*10.00*	*5.00*		
6x18	**5.00**	**9.00**	**12.00**	**6.25**		
6x20	*6.00*	*10.00*	*15.00*	*7.50*		
Note			**NO HOLD TAGS ON LUMBER**		Beams 8x8 or bigger	
Fir 2x4 thru 2x12 t&g Regular fir prices.			**NO EXCEPTIONS**		**$10 and up**	

Price list courtesy of Ted Reiff, Reuse People of America (T. Reiff, personal communication, November 29, 2018)

Appendix B: Milwaukee deconstructability index

Material		Deconstructability		Logistics		Context	
Score	0-5	Score	0-5	Score	0-5	Score	0-2
Flooring		Amount of debris		Tall Chimney		Vandalism	
Trim		Insulation		Height of building		ASR's and Complaints	
Siding		Unfinished attic		Stripped Mechanicals		Busy street	
Bricks		Neighboring lot		Nuisance Vehicle/animals		Community Grade Nearby	
Foundation		Unfinished basement		Space between existing buildings		Nuisance Property	
Windows		Gutted		Square feet of building		Near another Decon	
Built-ins		Fire Damage/ Deterioration		Overall site constraints. Trees, power lines, poles, etc.		Illegal Dumping	
Staircases		Major street		Alley access		Historic Neighborhood.	
Framing		Roofing material and layers		Garage on site		Windows/doors transferable	
Trees		Age: Rank 1-10		Hazards		Schools nearby	
Total		Total		Total		Total	
						Total points	20
Properties will be ranked on a score of 0-200, with 200 being the best possible deconstruction candidate.							
Inspector can set input scores based of a 0-6 scale for Material, Deconstructability and Logistics. Context inputs will be ranked on a scale of 0-2. deconstruction.							

The City of Milwaukee deconstructability index is functions as a rapid assessment tool for inspectors to use when making a firs assessment of a structure. The structure is ranked in four categories including material, deconstructability, logistics, and context. This tool is based on the EPA's Deconstruction Rapid Assessment Tool, but is designed for Milwaukee's structure, neighborhoods, and context (EPA, 2015b).