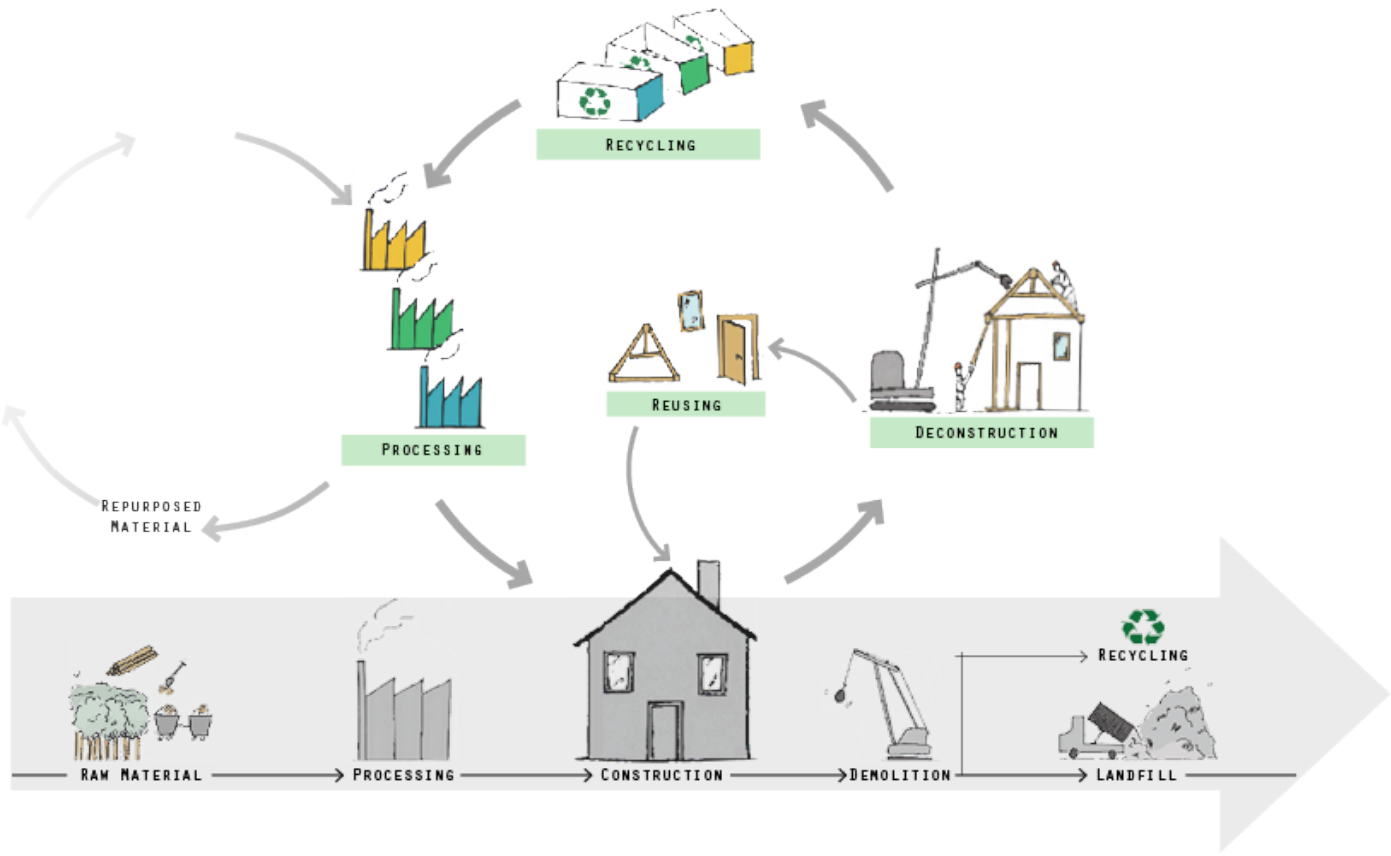

MUSKEGON, MICHIGAN DECONSTRUCTION ECONOMIC CLUSTER FEASIBILITY STUDY

Michigan State University Center for Community and Economic Development
West Michigan Shoreline Regional Development Commission
2017

Executive Summary

Purpose:

Funded in part by the U.S. Department of Commerce Economic Development Administration, the Muskegon Deconstruction Feasibility study was designed to examine the feasibility of deconstruction as an alternative solution to the economic, social, and environmental problem of structural abandonment. Focusing on Midwest legacy cities with high concentrations of structural abandonment, this study tests the economic feasibility of using deconstruction practices rather than demolition as a way to reduce blight. Additionally, the study explores the feasibility of establishing a deconstruction based, repurposing sector economy in Muskegon, Michigan. Taking advantage of the under-utilized Port of Muskegon, a cluster economy would receive salvaged building materials from deconstruction activities in surrounding Great Lakes port cities, then process and sell those materials through repurposing centers. This cluster economy would require a skilled labor force, supplied by job training programs in an area that has suffered from high unemployment rates.

Process:

With the advice and guidance of a local and regional advisory committee, the MSU team gathered secondary and primary data. The catchment area of cities targeted by this study was selected with specific criteria, including cities with high concentrations of structural abandonment, an active port to transport deconstructed materials to Muskegon, and a land bank to facilitate the acquisition of abandoned houses eligible for deconstruction. All cities in the catchment area for this study are in close proximity to a deep water port.

Several data collection methods were necessary, including communication with land banks in the catchment area in order to gather data on the amount of abandoned properties held by individual land banks, current practices for eliminating blighted structures, number of properties sold or demolished annually, the types and volume of material generated in structural demolition, possible reuses of this material, the identification of industries that may reuse this material and transportation costs associated with shipping this material to the Port of Muskegon, and primary sources of funding for blight removal. Research was gathered through phone and in person interviews, as well as through online questionnaires.

Findings:

At the conclusion of this study, several findings are presented that can influence the feasibility of increased deconstruction practices in the Midwest. Additionally, a strategic economic development plan outlines the steps necessary to establish a deconstruction based economic sector in Muskegon. Relevant to both deconstruction practices and the deconstruction cluster economy, the study concluded that there is a sustainable supply of salvaged materials available in the designated catchment area that can be sourced from abandoned vacant properties, renovations, or new construction. With respect to the feasibility of increased deconstruction practices as an alternative to demolition, the study found that while a deconstruction enterprise can probably earn a small net profit, wood and brick materials were shown to have the most immediate promise for repurposing values.

While shipping was examined, the findings of this study concluded that truck transport was the favored mode of transportation in 9 out of 10 designated cities, with the exception of Milwaukee where barge

transportation was feasible. This is partially a result of the inability to utilize container shipping for transporting salvaged building materials, as well as a primitive Great Lakes deconstruction industry supply chain. More developed supply chains in Europe, California, and the East Coast allow deconstruction practices to be more competitive against demolition and disposal. A successful supply chain is defined by the ease with which deconstruction firms can acquire abandoned homes from land banks, access a skilled deconstruction labor force, and use low cost modes of transportation to move salvaged materials to processing facilities.

This study found that - considering the existing supply of salvageable building materials in the catchment area, the presence of existing domestic and international firms involved in repurposing salvaged building materials, and the sufficient capacity and infrastructure of the Port of Muskegon - a deconstruction based economic cluster in Muskegon is feasible. In order to develop an economic sector beyond this feasibility study, steps would need to be taken by both public and private partnerships in West Michigan to develop a supply chain for salvaged building materials in the Great Lakes. To promote the development of this new economic sector, West Michigan leaders would need to market Muskegon to industries with the capacity to repurpose salvaged building materials. In addition to soliciting business ventures, financing from private and public ventures is necessary to assist business formation and expansion, as well as developing an extensive workforce training support.

Recommendations:

Based on the findings presented in the study, several recommendations have been developed in order to increase the feasibility of deconstruction practices and establishing a deconstruction based economy in Muskegon. Demolition is favored by land banks as the primary solution to eliminating blight because it is both inexpensive and can be done quickly. The additional cost of deconstruction when compared to demolition can be reduced if: net cost is considered, firms prioritize salvaged materials that have high resale value when compared to time spent salvaging, and firms purchase groups of abandoned structures that are in close proximity.

With respect to policy, federal funds used for blight elimination including Hardest Hit Funds and CDBG grants often require funding be used within a short time frame. Loosening time restrictions would allow land banks to contract deconstruction firms to remove abandoned structures at a more reasonable pace. Additionally, state legislation to increase tipping fees for dumping C&D materials in landfills would increase the cost of demolition, and allow deconstruction firms to compete more competitively. Local ordinances mandating all demolition activities must repurpose or reuse at least a portion of C&D materials directly would also increase the demand for deconstruction practices.

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Acknowledgements

Principal Authors

This feasibility study was coordinated by Adrianna Jordan, AICP, and Dr. Rex LaMore, and is the result of the hard work of such talented individuals as Jacob Hite, Hafsa Khan, Lauren Ross, and Noah Strayer, as well as the guidance and expertise provided by the Muskegon Advisory Committee (see Appendix A). Also contributing to this report were Arya Anuranjita, Sahil Bakshi, George Berghorn, Ph.D., LEED AP BD+C, and M.G. Matt Syal, Ph.D., LEED AP from the Michigan State University School of Planning, Design & Construction.

Introduction to the MSU Center for Community and Economic Development

Michigan State University is the nation's premier land-grant university, and in that tradition, the MSU Center for Community and Economic Development (CCED) is committed to developing and applying knowledge to address the needs of contemporary society.

Our mission is to advance MSU's land-grant mission by creating, applying, and disseminating valued knowledge through responsive engagement, strategic partnerships, and collaborative learning. We are dedicated to empowering communities to create sustainable prosperity and an equitable global knowledge economy.

Since its establishment in downtown Lansing, Michigan in 1969, CCED, in partnership with public and private organizations, has developed and conducted numerous innovative programs that address local concerns while building the capacity of students, scholars and communities to address future challenges. Student, faculty, and community involvement is a crucial element of the CCED's mission. The CCED focuses its resources on the unique challenges of distressed communities throughout the state of Michigan.

In carrying out the mission of the CCED we:

- Create and support an innovative learning environment for collaborative learning in community and economic development
- Provide training and direct assistance designed to increase the capabilities of community-based organizations, private enterprises and public institutions
- Conduct research that assists in the development and implementation of effective problem-solving strategies
- Provide a multidisciplinary capacity to respond to the complex, interrelated issues of distressed communities
- Promote and expand MSU's capacity to provide needed training, direct assistance, and research to address the issues of communities.

Introduction to the West Michigan Shoreline Regional Development Commission

The West Michigan Shoreline Regional Development Commission is a federal and state designated regional planning and development agency serving 120 local governments in Lake, Mason, Muskegon, Newaygo, and Oceana Counties.

WMSRDC is also responsible for the management and administration of the homeland security program for the counties of Clare, Ionia, Isabella, Kent, Lake, Mason, Mecosta, Montcalm, Muskegon, Newaygo, Oceana, Osceola, and Ottawa.

WMSRDC is also the planning agency for the metropolitan transportation planning (MPO) program for Muskegon and Northern Ottawa Counties.

The mission of the Commission is to promote and foster regional development in West Michigan through cooperation amongst local governments and other regional partners. WMSRDC provides services and manages and administers programs in homeland security, transportation planning, economic development, environmental planning, community development, local government services, and other special projects.

Erasmus University

We would like to recognize the contributions provided by our two Erasmus University masters students, Sjoerd Raijmans, and Chris Jan Weijzen, and extend our gratitude to the Dutch Consulate in Chicago and T. Arnold Boezaart for organizing the students' research experience.

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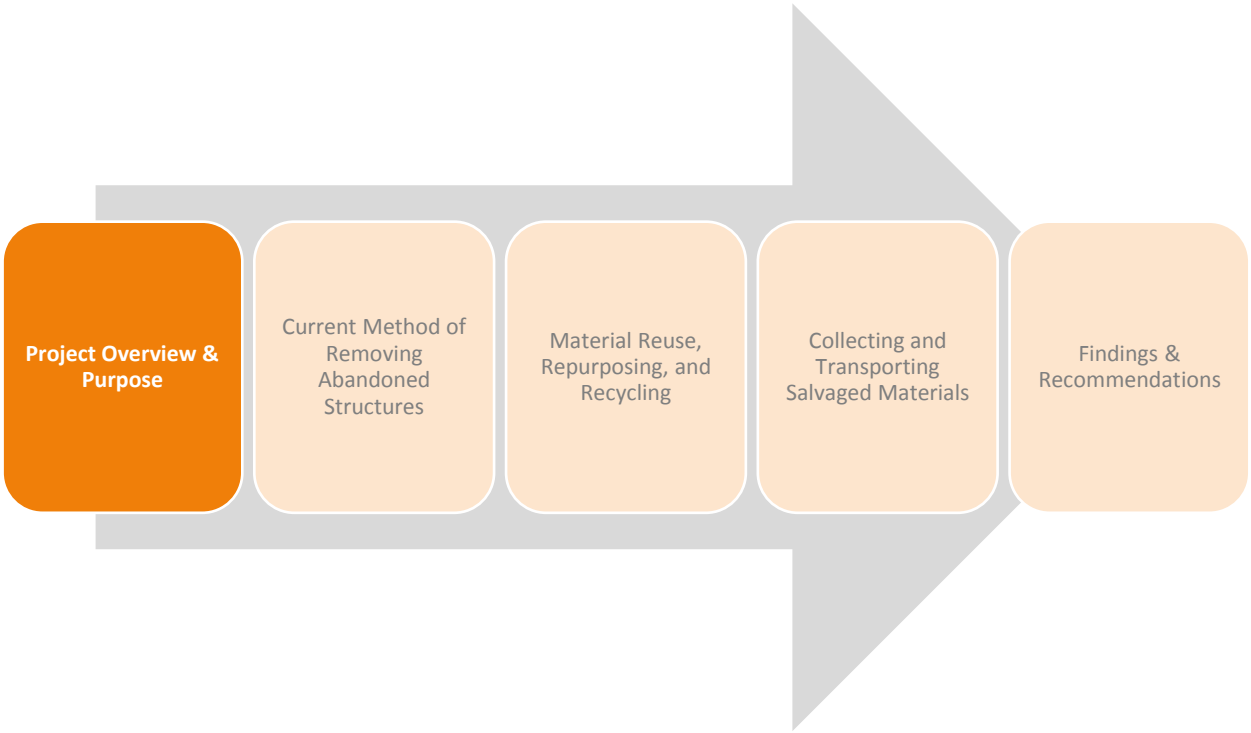
CHAPTER 1: PROJECT OVERVIEW & PURPOSE



CHAPTER 1: Scale of Abandonment

This study explores the feasibility of establishing a deconstruction economic sector in Muskegon, Michigan. Deconstruction is an alternative solution to the problem of structural abandonment that repurposes and recycles deconstructed building materials in contrast to the practice of demolition and landfilling blighted housing. This study designates Muskegon, Michigan as the economic hub for repurposing construction materials. Muskegon was chosen for this study because of its deep water port, considered to be underutilized, and community leadership interest in this sector.

The high concentration of abandoned structures in Midwest cities offers an opportunity to utilize the Great Lakes marine transportation system to transport deconstructed building materials to Muskegon to be repurposed, recycled, and reused. Therefore, the catchment area used to collect construction materials was designed to include metropolitan areas that:

- Are located near a Great Lakes port
- Have a high concentration of vacant/abandoned housing
- Have a land bank in operation, or other organization fulfilling similar functions

What is Structural Abandonment in the United States?

Increasingly high levels of residential, commercial, and industrial structural abandonment can be attributed in part to the outsourcing of blue-collar jobs, and the foreclosure crisis following the housing market decline, which led to chronic urban decline, depopulation, and disinvestment (LaMore, 2013). These factors of economic hardship and depopulation are particularly relevant in Midwest and Rust Belt cities. Nearly 40 percent of the nation's vacant homes are concentrated in just 10 percent of all census tracts; Wayne County, Michigan and Cook County, Illinois each have more than 200 high-vacancy neighborhoods (HUD, 2014). According to the U.S. Department of Housing and Urban Development's Neighborhood Stabilization Program (NSP), abandoned properties are defined as those that had been foreclosed upon and vacant for at least 90 days and no mortgage or tax payment has been made by the property owner in that period or a code enforcement inspection has determined that the property is not habitable and the owner has not taken corrective actions within 90 days of the deficiencies notification (HUD, 2008).

What are the Causes of Abandonment?

Abandonment is a visual expression of hardship. Structural abandonment occurs for a number of reasons and to all types of properties; for cities that have experienced depopulation and disinvestment from events such as the Great Recession, and the decades-long decline of industry, the aftermath is dismal. When industry begins to decline, jobs are lost and residents' sources of income disappear. Although strongly felt in rust belt cities in the Midwest, the mortgage crisis was a detriment to communities across the nation. Residents were given mortgages despite poor credit that hinted at the high probability of default. The easier accessibility of mortgages led to a higher demand for homes, which drove up their prices. Once homeowners began defaulting on their homes in unsustainable volumes the housing bubble generated by these practices burst and left a landscape of abandonment. The 2010 United States foreclosure crisis resulted in increased vacant housing and blighted neighborhoods throughout the country, and particularly impacted low income neighborhoods; the worst concentration of abandoned

housing was estimated to be in Wayne County, Detroit [89,000 units] and Cook County, Illinois [65,000 units] (Joint Center for Housing Studies of Harvard University, 2013).

What are the Impacts of Abandonment?

Structural abandonment causes negative social, economic, and environmental effects. Increased numbers of abandoned buildings in U.S. legacy cities contributes to lower property values in the surrounding community, and are associated with higher rates of crime and unemployment. Local governments are often unable to allocate enough public resources to demolish and remove large numbers of blighted structures. Additionally, the U.S. Environmental Protection Agency (EPA) estimated that in 2003 the United States generated 325 million tons of construction and demolition (C&D) debris (EPA, 2004) which is approximately 25-40% of the U.S. solid waste stream. With an average of 28 years remaining on many of Michigan's landfills, it is expected that with time, landfill space will become quite limited.

Environmental Impacts

Landfills

C&D materials consist of debris generated during the construction, renovation, and demolition of buildings, roads, and bridges. Cement concrete comprises the majority of C&D waste by weight, 67% in 2013, followed by asphalt concrete (18%) and wood products (8%). Drywall and plaster, steel, asphalt shingles, and brick and clay tile also contribute to C&D waste generation. In 2013, an estimated 530 million tons of C&D debris was generated in the United States, more than double the amount of other municipal solid waste. Demolition represents over 90% of C&D debris generation, while construction contributes less than 10%. The reduction of C&D waste production through increased recycle and reuse rates could conserve landfill space and reduce the environmental impact associated with the extraction and consumption of new resources and production of new materials (EPA, 2016).

In the U.S. today, the majority of solid waste is landfilled. The Great Lakes region is no exception to this solid-waste disposal challenge; there are rising concerns about environmental and health effects of landfills. Many municipalities do not have recycling regulations in place, and as waste is continuously generated and dumped, landfills in the region are reaching their maximum holding capacity, increasing concerns about the quantity of waste dumped in landfills, wastewater and runoff into the Great Lakes, and nuclear waste dumping.

The 600,000 residents in Kent County, Michigan generate about 1.8 million cubic yards of trash annually, and the local landfills are quickly running out of space. A recent study conducted in the county estimated that 75 percent of recyclable waste, such as glass and plastics, are being dumped into landfills. Waste management officials have advised residents to increase their recycling. In order to make this happen, Kent County's "Imagine Trash" campaign sought to reduce landfill waste 20 percent by 2020 and 90 percent by 2030. But so far, even Governor Rick Snyder's statewide recycling initiative increasing the state's waste diversion rate from 15 percent to 30 percent minimum, has been difficult to reach (Rosengren, 2016).

Landfills in the Great Lakes region are filling up. In recent years, imported Canadian trash has been a contested issue in Michigan; because Michigan has comparatively low landfill costs, about $46 per ton of waste, companies prefer transporting trash to the state's landfills as opposed to dumping in their own

state or country. According to a report by the Michigan Department of Environmental Quality, in the September 2013 fiscal year, Michigan accepted 44.9 million cubic yards of waste from Canada, a 1.4 percent increase from the previous year. Michigan also imports trash from Ohio, Indiana, Wisconsin, and Florida. In 2014, the DEQ estimated that Michigan's current landfills have approximately 28 years of disposal capacity remaining (Anders, 2014).

As more trash is landfilled, pollution and greenhouse gases have become a rising concern. Landfills produce and leach harmful gases, such as carbon dioxide, methane, hazardous air pollutants, odorous compounds, and volatile organic compounds into the air. These air pollutants create smog and contribute to global climate change. Stoney Hollow Landfill in Dayton, Ohio has been cited for violating U.S. EPA guidelines for landfill wells. Residents in Jefferson Township and the City of Moraine, Ohio started filing complaints about odors emanating from the landfill site in April 2016. According to Ohio EPA spokeswoman Dina Pierce, increasing temperatures in the area contributed to rising gas levels causing a noticeable odor. Stoney Hollow management addressed the problem by lowering temperatures within the landfill (Blizzard, 2016).

Economics of Landfills

Managing residential and municipal trash is costly to both taxpayers and waste management companies. Costs include everything from trash pickup to infrastructure improvements in landfill sites to meeting environmental regulations. Over the past several years, the cost of basic waste collection and recycling services have dramatically increased. The greatest costs incurred throughout the waste management process are associated with the process of discarding waste into landfills (O'Connor, 2010).

The direct costs of waste management and disposal, such as collection, landfilling, open dumping, composting, waste-to-energy incineration, and anaerobic digestion, are some of the main expenses associated with waste management, and are illustrated in Table 1, below. In a global context, waste collection and disposal costs in high income countries, such as the United States and European nations, are some of the highest.

Table 1: Estimated Solid Waste Management Costs by Disposal Method

Estimated Solid Waste Management Costs by Disposal Method [1]

	Low Income Countries	Lower Mid Inc Countries	Upper Mid Inc Countries	High Income Countries
Income (GNI/capita)	<$876	$876-3,465	$3,466-10,725	>$10,725
Waste Generation (tonnes/capita/yr)	0.22	0.29	0.42	0.78
Collection Efficiency (percent collected)	43%	68%	85%	98%
Cost of Collection and Disposal (US$/tonne)				
Collection[2]	20-50	30-75	40-90	85-250
Sanitary Landfill	10-30	15-40	25-65	40-100
Open Dumping	2-8	3-10	NA	NA
Composting[3]	5-30	10-40	20-75	35-90
Waste -to-Energy Incineration[4]	NA	40-100	60-150	70-200
Anaerobic Digestion[5]	NA	20-80	50-100	65-150

NOTE: This is a compilation table from several World Bank documents, discussions with the World Bank's Thematic Group on Solid Waste, Carl Bartone and other industry and organizational colleagues. Costs associated with uncollected waste—more than half of all waste generated in low-income countries—are not included.

Source: (World Bank, n.d.)

However on a national scale, tipping fees in the Midwest are on the low-side. Tipping fees for each of the states in this study's catchment area are shown in Figure 1, as well as rates for Maine (the highest in the U.S.) and Nevada (the lowest in the U.S.). As the graphic shows, all of the states in the catchment area, with the exception of Wisconsin, have tipping fees below the national average of $49.78 (Green Power, Inc., 2014). Because of this, some states ship their refuse to Midwest states, to take advantage of the lower rates.

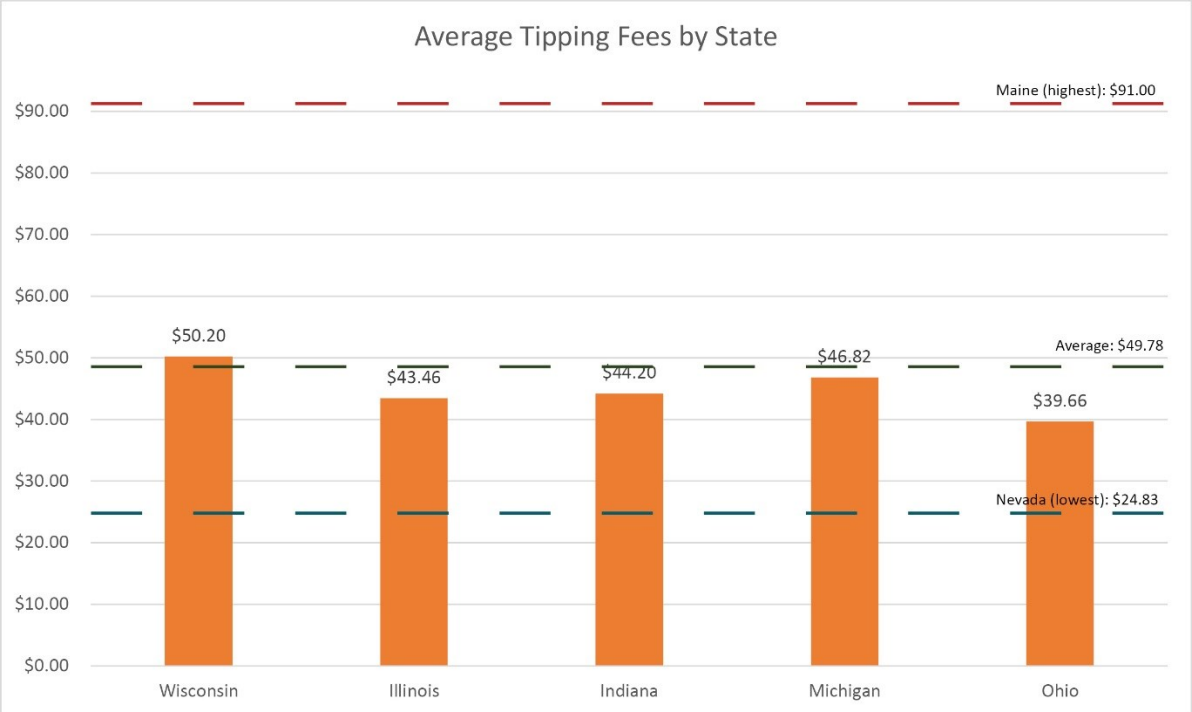
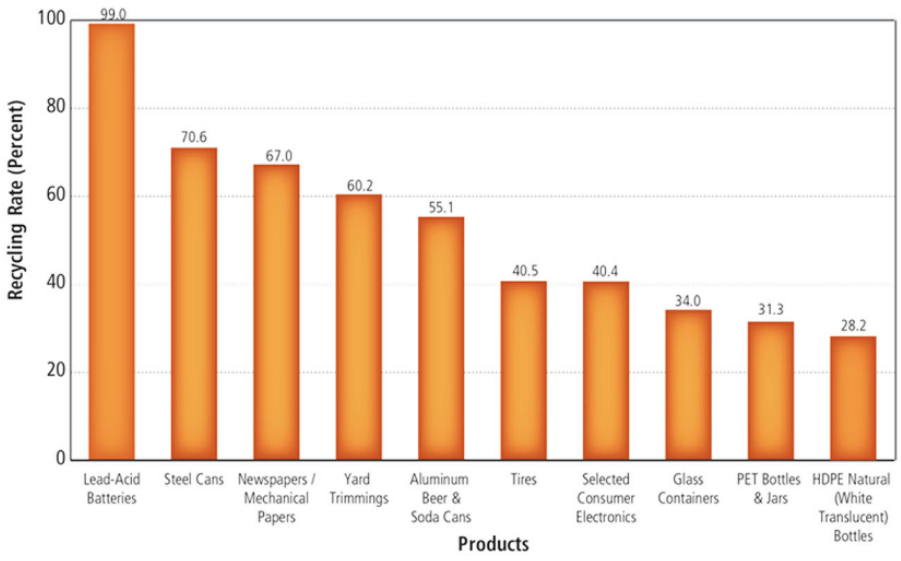


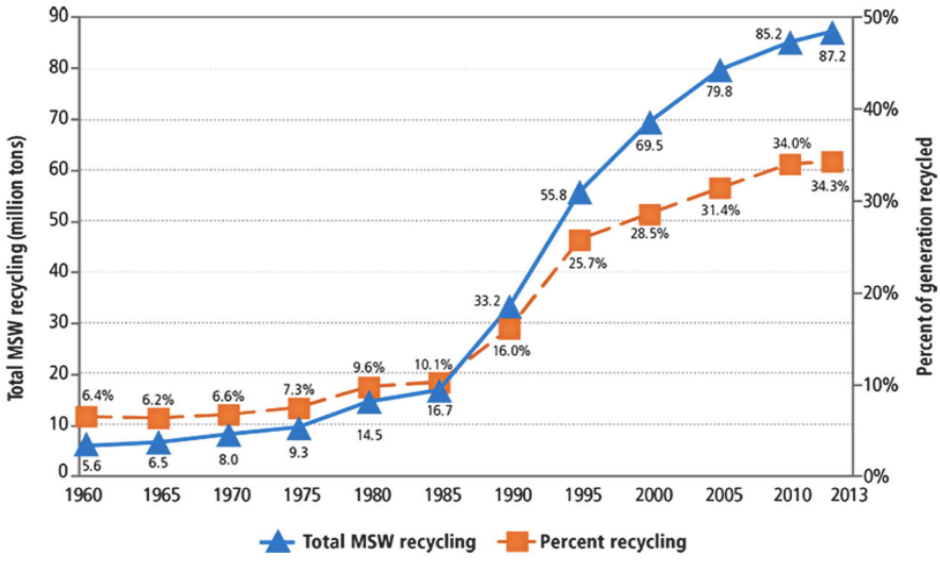
Figure 1: Average Tipping Fees by State per ton
Source: (Green Power, Inc., 2014)

According to the EPA, companies in the United States generate and dispose of 7.6 billion tons of nonhazardous industrial solid waste annually. Of the total waste produced in all sectors, only 34.3 percent is recycled and the rest is landfilled. Various types of subsidies such as grants, loans, payments, and tax incentives have been used in consumer waste management to mitigate the cost of disposal. Advance Disposal Fees (ADFs) on consumer products generate revenue and help subsidize the cost of the otherwise unprofitable activity of disposal. Other subsides in the Great Lakes region include bottle handling fees paid by the distributors, fees on "hard-to-dispose material" such as motor oil, tires, antifreeze, and solvents, and grants or loan programs to promote recycling (EPA). As a result, recycling rates have increased for most products. Figures 2 and 3, below, show this increase by material and as a percent comparison across several decades.



Recycling Rates of Selected Products, 2013.
Does not include combustion with energy recovery.
Mechanical papers include directories, newspaper inserts, and some advertisement and direct mail printing.

Figure 2: Recycling rates of selected products in 2013
Source: (EPA, 2015)



MSW Recycling Rates, 1960-2013

Figure 3: Municipal Solid Waste (MSW) Recycling Rates, 1960-2013
Source: (EPA, 2015)

Water pollution

Water may be impacted at nearly every step of construction material's life cycle. Water pollution can be caused when runoff from construction and demolition sites or landfills contaminates surrounding water sources via groundwater. Raw material extraction can alter aquatic habitats through increased runoff, which adds sediment and pollutants to bodies of water. The processing and manufacturing of materials additionally contributes to wastewater production and the depletion of water sources (Calkins, 2009, p. 39).

Deforestation

The causes of deforestation vary and can be driven by poverty, economic growth, governmental policy, technological change, and cultural factors. Large scale removal of forested land is common to facilitate agriculture, livestock farming and ranching, logging for timber, and degradation and general forest loss due to climate change (World Wildlife Fund, n.d.). For the purposes of construction, forests are harvested for lumber and cleared to accommodate mining of metal ore, minerals, stone, and gravel (Calkins, 2009, p. 19).

Forests play a critical role in mitigating climate change, processing carbon dioxide and other greenhouse gas emissions, housing wildlife and preserving biodiversity, and preventing soil erosion. About forty-six to fifty-eight thousand square miles of forest are lost on average each year. In the Amazon, 17 percent of the forest has been lost in the last fifty years. Tropical forests hold more than 210 gigatons of carbon, and deforestation represents around fifteen percent of greenhouse gas emissions. Once released, greenhouse gas emissions contribute to rising global temperatures, changes in weather patterns, disruption of water cycles, and increased frequency of extreme weather (World Wildlife Fund, n.d.).

Trees play an important role in regional water cycles by maintaining the balance between precipitation rate and river flows. On a global scale, deforestation can affect albedo, surface temperatures, water evaporation, and rainfall patterns. Deforestation also causes soil erosion; without trees to anchor the land, fertile soil can erode into rivers and other bodies of water. An estimated one third of the world's arable land has been lost to soil erosion and other types of degradation since 1960 (World Wildlife Fund, n.d.).

Air pollution

Air pollution can be mainly associated with material extraction, transport, manufacture, and construction activity (Calkins, 2009, p. 17). Air pollution caused by construction activity is usually the result of "fossil fuel combustion for energy, non-energy uses for fossil fuels, chemical conversion of materials, dust in processing operations, fumes, and other sources" (Calkins, 2009, p. 35). In *Quantifying Greenhouse Gas Emissions in Key Industrial Sectors*, the EPA reported that the construction sector alone released 100 million metric tons of carbon dioxide in 2002 (EPA, 2009, p. 5). Figure 4, below, shows emissions from various sectors in the construction industry. It should be noted that among the specified subsectors, residential constructions are the top emission generators. As more materials are repurposed and reused, this rate will be significantly altered.

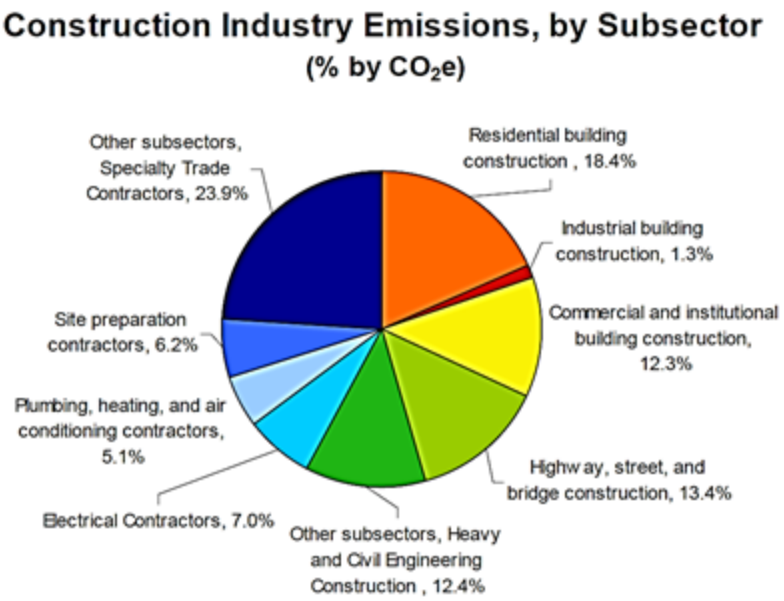


Figure 4: Construction Industry Emissions
Source: (EPA, 2009, p. 6)

A 2010 report by the USDA Forest Products Laboratory and the U.S. Army Corps of Engineers showed that the cumulative energy consumed in producing virgin lumber compared to reclaimed framing lumber and wood flooring resulted in 3-5 times greater global warming potential (Bergman, Gu, Falk, & Napier, 2010).

Social Impacts

Structural abandonment and its social impacts tend to go hand-in-hand; increased poverty levels are often associated with concentrations of structural abandonment, which can in turn be linked to limited economic and social opportunities, creating a complicated cycle of community blight. Vacant and abandoned housing is an indicator of neighborhood distress, as abandoned housing is associated with crime, increased risk to neighborhood health and welfare, lower property values, and high municipal costs. All of which contribute to neighborhood decline and disinvestment. “Concentrated poverty multiplies the severity of problems faced by communities and poor individuals. As neighborhoods become dominated by joblessness, racial segregation, and single parentage, they become isolated from middle-class society and the private economy” (Orfield, 1997, p. 18).

Health Impacts

Lead is a common and highly dangerous health and safety hazard that can be associated with deconstruction and demolition activities. Lead can cause lifelong learning and behavioral problems in children if they are exposed at a young age. Dust from lead can be ingested or inhaled, and it only takes about the equivalency of three granules of lead dust to cause significant and irreversible brain damage in young children (Thompson, 2014). In terms of structures, lead is commonly found in paint, water pipes, and some fixtures. Homes built before 1978 have an increased chance of lead-based paint. Demolition can produce large amounts of ambient lead dust. A study conducted in Maryland found that dust fall during demolition is six times the allowed EPA standard. In addition, lead dust can remain present after

work activities have been completed, and can then be blown into homes or picked up on shoes (Thompson, 2014). Demolition done using a "wetting" process can reduce this hazard, but does not eliminate lead dust completely (Matheny, 2015).

Economic Impacts

Because land-banks and related entities are ultimately responsible for demolition of abandoned properties, the costs discussed in this section are those that are borne by the taxpayers, often of the municipality in which the demolition takes place. For a community already struggling with depressed economic opportunity, the additional burden of demolition can mean the difference between economic recovery and decline.

The cost of residential demolition varies and is dependent on such factors as costs of disposal of hazardous materials, demolition permits, structure removal, backfill with clean soil, and final grade materials like seeding and mulching. In Detroit, the average cost of demolition by the Detroit Land bank has risen as high as $16,400 per-home in 2015. Current per-home demolition costs have fallen to an average of $12,619 in 2016 (City of Detroit, 2016). Nationally, the U.S. Government Accountability Office estimated that residential demolition typically costs between $4,800 and $7,000 per property (HUD, 2014)[1]. Demolition is vital for certain areas such as those with a high concentration of structural abandonment, especially given that public entities lose tax revenues from stagnant abandoned properties; however, tax revenues are just a small portion of the problem. The presence of blighted or contaminated properties has a significant impact on property values. The cleanup of a contaminated property with a hazardous substance, pollutant, or contaminant through the EPA's brownfield program can increase residential property values between 5.1-12.8% (EPA, 2016).

According to a study published by University of Florida's Center for Construction and Environment, the cost of deconstruction can be calculated using this expression:

(Deconstruction + Disposal + Processing) – (Contract Price + Salvage Value) = Net Deconstruction Costs.

The net cost for demolition can be calculated using this expression: (Demolition + Disposal) – (Contract Price) = Net Demolition Costs (Guy & McLendon, 2003).

[1] Note: Our analysis did not find a community with demolition costs this low.

In order for deconstruction to be profitable, cost-effective, and competitive with traditional demolition practices, the savings from disposal costs and revenue from resale of salvaged materials must be greater than the labor cost. According to a study conducted by Northwestern University which analyzed comparative cost data from six wood-frame residential deconstruction sites and data from demolition sites in Massachusetts, labor costs are most expensive line item when it comes to deconstruction. In Table 2, below, are comparative cost breakdowns showing the total costs for each method.

Table 2: Average deconstruction and demolition costs for Massachusetts

Average deconstruction and demolition costs for Massachusetts (based on CCE study)	
Deconstruction	
(1) Disposal ($/SF) = disposal (#/SF)/2000 × disposal cost ($/ton)	0.94
Disposal (#/SF)	19.05
Disposal cost ($/ton)	99.20 (transport and tipping–sorted waste)
(2) Deconstruction labor ($/SF) = productivity (h/SF) × labor rate ($/h)	9.11
Productivity (h/SF)	0.29
Labor rate ($/h)	31.30
(3) Other costs (tests, permits, general conditions)	1.86
Other costs ($/SF)	1.86
(4) Gross deconstruction cost ($/SF) = (1) + (2) + (3)	11.91
(5) Salvage ($/SF)	
Salvage ($/SF)	3.4
(6) Net deconstruction cost assuming 50% salvage, $/SF = (4) − 0.5 × (5)	10.21
Demolition	
(1) Disposal ($/SF) = disposal (#/SF)/2000 × disposal cost ($/ton)	3.56
Disposal (#/SF)	52.33
Disposal cost ($/ton)	136.20 (transport and tipping–unsorted)
(2) Demolition cost (for MA) ($/SF)	3.14
(3) Other costs (tests, permits, general conditions)	1.45
Other costs ($/SF)	1.45
(4) Total demolition cost ($/SF) = (1) + (2) + (3)	8.15
Demolition—gross deconstruction ($/SF) = 8.15 − 11.91	−3.76
Demolition—net deconstruction assuming 50% salvage = 8.15 − 10.21	−2.06

Source: Dantata, N., Touran, A., & Wang, J. (2005). An analysis of cost and duration for deconstruction and demolition of residential buildings in Massachusetts. Resources, Conservation and Recycling, 44(1), 1-15.

Many of the materials salvaged during deconstruction cannot be reused without breaking the materials down and recombining them with others to create new products. These types of material transformations require skilled workers that have valuable knowledge of the chemical properties of salvaged materials such as gypsum, PVC/linoleum, and asphalt shingles.

The University of Florida study also included a cost breakdown comparison of all the activities involved in both deconstructing and demolishing a building. These costs include labor, disposal, permits, tests, and general conditions. It should be noted that the average square footage of the deconstructed and demolished structures was on average 1,476 square feet. The labor costs were calculated using the average rate for a building laborer in the Boston area, which is $31.30/hr.

Reuse and Repurposing Options

The value of salvaged materials is highly variable depending on their end use. This is because the end value of the materials is contingent on how it was recycled – upcycled to create value-added products, recycled to create products with the same or equivalent use, or downcycled to create a lower value product. In general, reused materials have the highest return on value relative to the labor cost to extract them because they can be used for a similar purpose with little or no processing. Recycled materials have the next highest return on value, based on their need for additional shipping and processing. Repurposed materials have the lowest return on value of the three options presented, due to the processing required and lower resale value (Chini & Kibert, 2000).

Reclaimed products such as wood that require minimal transformation create additional jobs towards the end of the supply chain. Reclaimed wood can be used in both large volumes on new construction projects, and in small volumes for artisanal purposes. Large volumes of materials require workers to manage reclaimed warehouses and sell the materials. With small volumes, skilled artists are needed to craft materials into items such as tables, chairs, bedframes, cutting boards, and other household objects.

Methodology

How was data collected? Surveys used, major data points

Data was collected for this study from four main sources:

1. ***Online survey of Great Lakes land banks and associated organizations (Appendix B).*** A draft of the survey, along with introductory language, and a subject consent form were created by the MSU Center for Community and Economic Development and the School of Planning, Design, and Construction in June 2016. Critical feedback on the draft survey questions was provided courtesy of the Detroit Land Bank Authority, and the survey was then revised and formatted for online distribution using Qualtrics. Next, the final version of the nine-question survey was distributed via e-mail to all land banks located within the designated catchment area on July 19, 2016. The survey was closed and the results were analyzed in October, 2016.

2. ***Phone and in-person interviews with land banks and associated organizations.*** Various stakeholder interviews were conducted with land banks and associated organizations. The purpose of these interviews was to understand issues related to the creation of a reliable supply chain, transportation of materials, materials processing, port facilities, financing, et cetera.

3. ***In-field analysis of vacant residential structures and the materials they yield during a deconstruction operation.*** The MSU School of Planning, Design, and Construction performed in-field observations and analyses of 10 randomly selected vacant residential structures owned by the Ingham County Land Bank on September 19th and 30th, 2016. This work consisted of measuring the square footage of roofs, walls, and floors to gather data on the potential of salvaging various materials found in the homes. Most of the homes surveyed were pre-World War II wood-framed homes located in Lansing.

4. ***Existing studies and reports.*** A literature review was undertaken at the beginning of the study to identify existing data, case studies, models, and best practices. Key studies and reports reviewed by the project team include:

- *Approaches and Associated Costs of Building Demolition and Deconstruction,* Shershah Zahir (2015)
- *Comprehensive Economic Development Strategy (CEDS),* WMSRDC (2016)
- *Cost Prediction Model for Deconstruction and Impact of Design for Deconstruction,* Amol Tatiya (2016)
- *Deconstruction and Reuse*, Delta Institute (2012)
- *Design for Reuse*, Public Architecture (2010)
- *Greenwood's Guide to Great Lakes Shipping*, Harbor House (2016)
- *Port of Muskegon Economic Impact Study*, Development Research Partners (2015)
- *Port of Muskegon Port Study,* Martin Associates (2016)
- *Quantifying the Environmental Impact of Reclaimed Building Materials in New Construction*, Sarah Buffaloe (2014)
- *Reverse Logistics in the Construction Industry,* Hosseini, Rameezdeen, Chileshe, Lehmann (2015)

How was data analyzed?

Various methods of data analysis were used depending on whether data was qualitative or quantitative in nature.

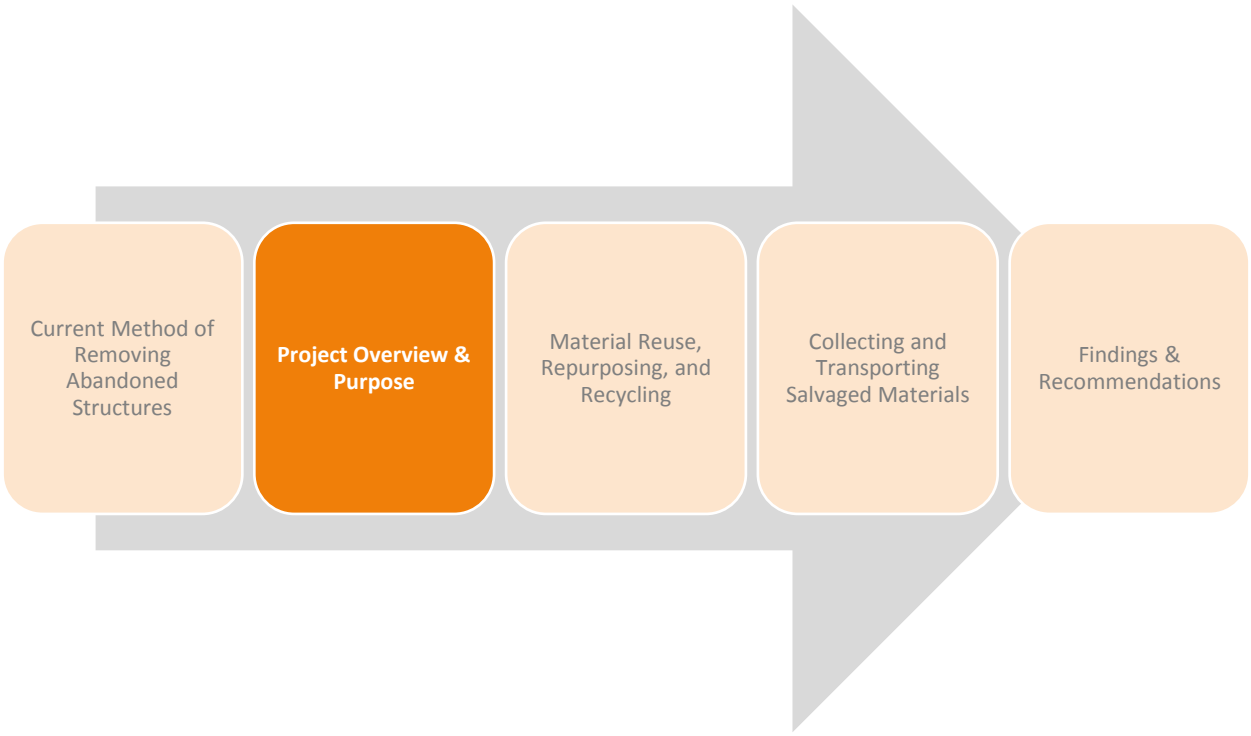
1. ***Online survey of Great Lakes land banks and associated organizations (Appendix B).*** A total of 11 responses were received from land banks. Given the small sample size, descriptive statistics were used when appropriate.

2. ***Phone and in-person interviews with land banks and associated organizations.*** The qualitative data gathered through phone and in-person interviews was treated as reference and case study material for best practices in deconstruction. No formal analysis was done on this data source.

3. ***In-field analysis of vacant residential structures and the materials they yield during a deconstruction operation.*** Data gathered in the field from vacant homes was used to calculate the average square footage of an asphalt-shingle roof on a pre-World War II wood-framed house, and to approximate the percentage of homes that contained lathe and plaster versus drywall.

4. ***Existing studies and reports.*** Data and results from existing studies and reports were compared with our study's findings, mined for new resources, and leveraged to reduce duplicative data-gathering efforts.

CHAPTER 2: CURRENT METHOD OF REMOVING ABANDONED STRUCTURES



CHAPTER 2: Current Method of Removing Abandoned Structures

Scale and Scope of Abandonment in U.S. and the Midwest

Structural abandonment has plagued the Midwest for over 40 years. The urban decline, depopulation, and disinvestment during that time period resulted in high numbers of vacant residential, commercial, and industrial structures. While the factors that contribute to structural abandonment affect cities nationwide, they disproportionately affect the designated catchment area for this study.

As defined by the three parameters described in Chapter 1 (municipalities located near a Great Lakes port; have a high concentration of vacant/abandoned housing; and have a land bank in operation, or other organization fulfilling similar functions), the catchment area, shown in Figure 5 below, includes Ashtabula County, the City of Buffalo, the City of Chicago, the City of Cleveland, the City of Detroit, the City of Milwaukee, Muskegon County, and the City of Toledo as well as two amalgamated areas: the cities of Portage and Gary, and Bay County and the cities of Saginaw and Midland.

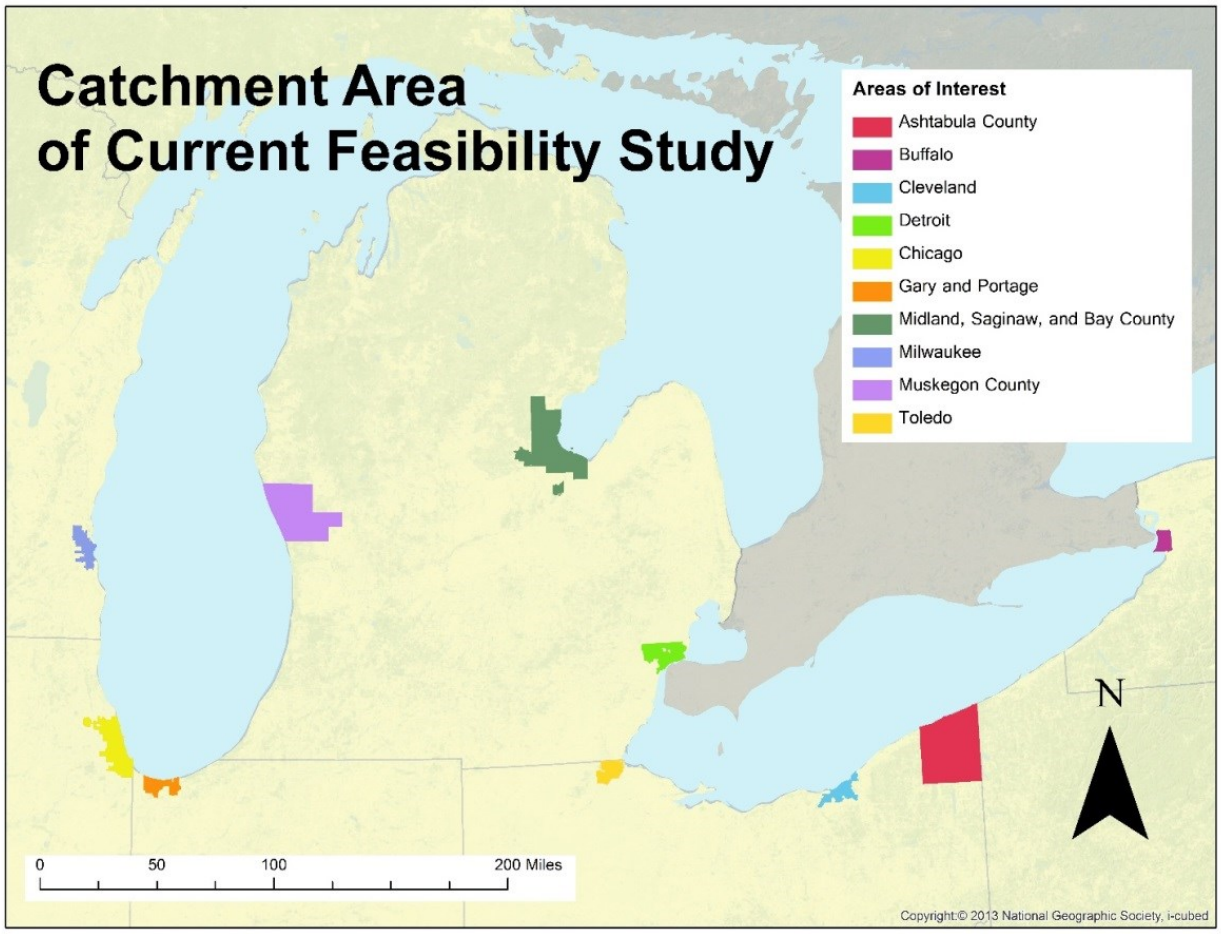


Figure 5: Feasibility Study Catchment Area

Number of Abandoned Structures

Both in terms of total number of vacant units and vacancy rates, the Midwest bears a disproportionate share of structural abandonment within the United States. As a region, the Midwest is estimated to have 3,481,986 vacant housing units, large portions of which are concentrated in the Chicago [341,014], Cleveland [155,403], and Detroit [221,533] metropolitan areas (U.S. Census, 2015).

Statistical aggregation of nationwide residential, commercial, and industrial abandonment is not commonly available data. Commercial and industrial abandonment is defined and measured differently than residential vacancies, and is therefore difficult to measure in an aggregate statistic. This makes cost/benefit analysis of deconstruction in large Midwestern cities with high concentrations of residential, commercial, and industrial abandonment difficult. However, the research team has made several estimates based on available data. The team gave particular focus to residential abandonment. A future study should expand on commercial and industrial materials. The creation of nationwide statistical aggregates, inclusive of all abandoned structures, would be helpful to expanding deconstruction opportunities.

Scale and Causes of Abandonment by Land Use

Industrial Abandonment

With respect to industrial vacancies in the Midwest, the most common forms of structural abandonment are automaker and supplier plants. In 1979, 447 auto plants were in operation across the country. Of those, 267 such plants (nearly 60%) have closed and only 180 remain in operation at present. Nearly 65% of all closed automotive plant facilities are located in Michigan, Ohio, and Indiana. Abandoned industrial properties are often environmentally contaminated, making repurposing or even demolishing these structures difficult. There are approximately 500,000 brownfield industrial properties in the United States (HUD, 2014).

Commercial Abandonment

Minimal consolidated data exists about the amount of commercial abandonment at the state or national level. The U.S. Energy Information Administration, in its Commercial Buildings Energy Consumption Survey (EIA, 2012) does recognize a "Vacant" category, which is defined as:

"Buildings in which more floorspace was vacant than was used for any single commercial activity at the time of interview. Therefore, a vacant building may have some occupied floorspace."

Based on most recent data, 296,000 vacant commercial buildings accounted for nearly 3.26 billion square feet of floor space nationwide in 2012. The East North Central census division (Michigan, Wisconsin, Ohio, Indiana, and Illinois) accounted for 24,000 vacant commercial buildings and 345 million square feet.

Large scale commercial abandonment is often the result of trends in commercial retail development. Recently, commercial structures have taken the form of "power centers", and open-air shopping centers with an average leasable area of 438,626 square feet (ICSC, 2017). "Power centers" are characterized by the presence of three or more discount "big-box" retail anchors, along with a number of smaller retailers.

The development of big-box retail often outstrips consumer demand, resulting in structural abandonment. Between 1990 and 2005, the amount of retail space per capita in the U.S. doubled, while per capita income grew by only 28% (Institute for Local Self-Reliance, 2007). Often, large scale commercial structures are abandoned in favor of even larger ones. For instance, the most common reason cited for closing a Wal-Mart Discount Store is to open a Wal-Mart Superstore. Repurposing or filling these abandoned structures is complicated by the fact that retailers will often take steps to prevent competitors from occupying the abandoned sites, to prevent future competition. Much like abandoned industrial structures, commercial structures are also costly and difficult to repurpose or demolish. Abandoned commercial structures can pose public health and safety hazards, and the size and design of commercial big-box stores makes them nearly as difficult to repurpose as abandoned industrial sites. Windowless, single-story buildings have limited use beyond big-box retail. A 2005 analysis in Texas found that the state's 30 empty Wal-Mart stores have been idle for an average of three years. Many have been abandoned for over a decade (Institute for Local Self-Reliance, 2007).

Residential Abandonment

The U.S. Census Bureau's Housing Vacancies and Homeownership data provides some information on rental and homeowner vacancy rates, as measured by the Housing Vacancy Survey (HVS) and the Current Population Survey (CPS). For the purpose of measuring residential structural abandonment, the definition of "Other Vacant Housing Units" is used. A housing unit is classified as "other vacant" when it does not fit into any year-round vacant category. Housing units are commonly labeled "other vacant" when no one lives in the unit due to:

- owners' preference or personal situation;
- needed repairs or renovations;
- foreclosure;
- and abandonment/condemnation (Kresin, 2013)

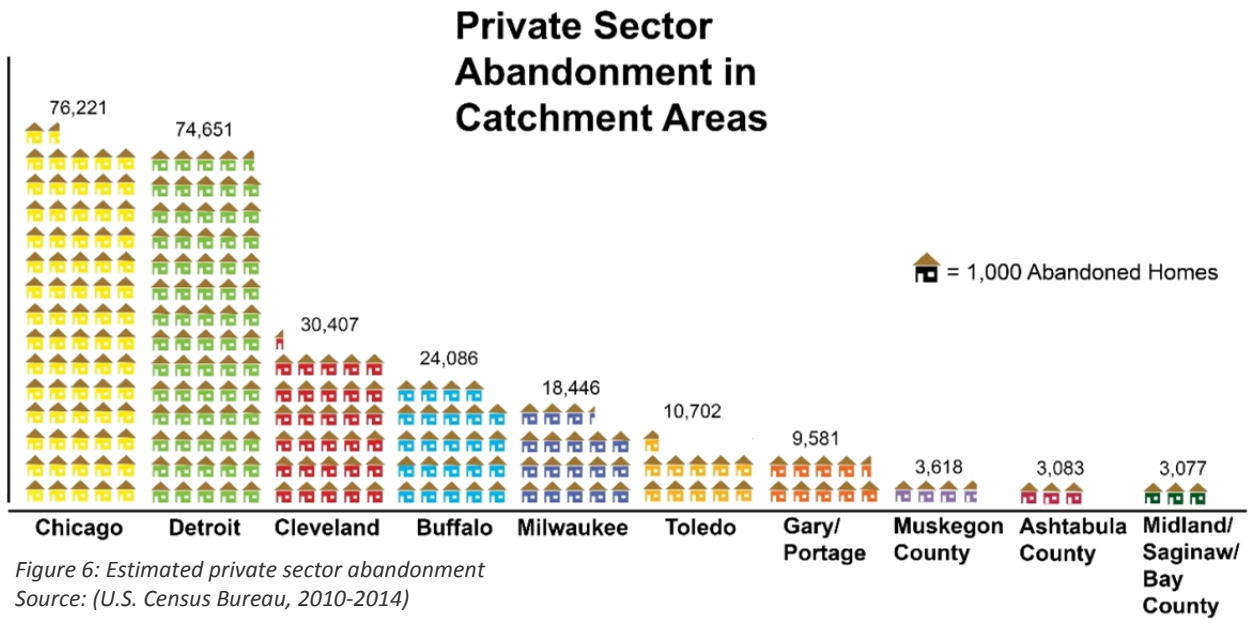


Figure 6: Estimated private sector abandonment
Source: (U.S. Census Bureau, 2010-2014)

The following table provides these estimates for 2014 for the purpose of estimating the volume of material debris available in the catchment area; the team used "other vacant" as the base of analysis. It should be noted that this estimated vacancy does not necessarily represent the units that will be demolished or deconstructed ultimately.

Table 3: Vacant Residential Units in Catchment Cities

	Total Housing Units	Total Vacant Units	Other Vacant Units	Other Vacant % of Total Housing Units
Ashtabula County, OH	45,964	7,031	3,083	6.7%
Buffalo, NY	133,538	22,094	24,086	18%
Chicago, IL	1,190,998	162,169	76,221	6.4%
Cleveland, OH	212,269	45,619	30,407	14.3%
Detroit, MI	363, 280	109,083	74,651	20.5%
Gary/Portage, IN	41,910	11,164	9,581	22.8%
Milwaukee, WI	257,965	27,784	18,446	7.2%
Muskegon County, MI	73,368	8,479	3,618	4.9%
Saginaw/ Midland/Bay County, MI	58,639	7,526	3,077	5.2%
Toledo, OH	138,538	20,573	10,702	7.7%

Source: (U.S. Census Bureau, 2010-2014)

Compared to year-round vacant units, "other vacant" units are more likely to have a long duration of vacancy (more than one year), to be older units (1969 or earlier), and to be single-family homes (mobile homes, manufactured homes, and one-unit structures) (Kresin, 2013). As a result, housing units classified as "other vacant" are appropriately used to measure structural residential abandonment for this study. Within the designated catchment area selected for this study there are significant levels of vacant housing

units. Both the cities of Chicago and Detroit have approximately 75,000 “other vacant” housing units each. Additionally, Cleveland has over 30,000 “other vacant” housing units, and Gary, Indiana, and Toledo, Ohio each have approximately 10,000 “other vacant” housing units. Even outside of Detroit there is significant structural abandonment across Michigan. The Saginaw/Midland/Bay City area has just over 3,000 “other vacant” units, and Muskegon County has roughly 3,500 (U.S. Census Bureau, 2010-2014).

Material Recovery Process: The “Three Skim Paradigm”

The “three skim paradigm” is a term used to explain the unpermitted (illegal) and permitted deconstruction activities that occur once a house is abandoned, and usually, no longer habitable.

First Skim: Removal of metal items

The first phase of the skim is typically illegal activity that takes place within days, if not weeks, of a property becoming abandoned. Opportunists known as “scrappers” break into a house and extract all of the easily salvaged copper wiring and other metal items of value such as stainless steel fixtures and cast-iron pipes. Other items, such as pre-World War II lead piping are so low value that they are usually not worth skimming. Due to the high value of the materials in question, and their relatively easy accessibility, this activity can occur regardless of whether a building is slated for demolition or deconstruction.

Once the scrappers have finished harvesting an abandoned home, they sell the skimmed metal to scrap metal dealers. In 2014 the passage of Public Act 99 limited maximum cash transactions for scrap metal to $25 within Michigan. This law, along with decreasing scrap-metal prices, appears to have slowed down the scrap-metal black market.

Second Skim: Items of architectural value

In the second skim, items of architectural value are removed from the residence for reuse. Items extracted in the second skim typically include fireplace mantels, wood molding, carved bannisters, kitchen and bathroom cabinets and fixtures, lighting, and architecturally valuable windows and doors. Finished hardwood flooring may also be removed during the second skim.

Fixtures go to resale facilities

Facilities such as Habitat for Humanity Restore, Architectural Salvage Warehouse of Detroit, and the Rebuilding Exchange in Chicago are all retail outlets that are open to the public for the sale of second skim materials. Reclaim Detroit also had a warehouse of salvaged materials until a February 3rd, 2016 fire completely destroyed their inventory (Bethencourt & Stafford, 2016). Nonetheless, during the summer of 2016, Reclaim Detroit signed a contract with the City of Detroit to operate a Detroit-based deconstruction hub that is scheduled to open in the summer of 2017. At the same facility “Reclaim Detroit will also establish a retail center for entrepreneurs to sell their products made from reclaimed materials. At least 75 percent of the 25 to 30 employees hired for [the hub] must be city residents” (Benedetti, 2016). Throughout the catchment area there is evidence that these type of facilities exist though no complete list was formed for this analysis.

Third skim: Everything that's left

The third skim encompasses all remaining materials such as dimensional lumber, antique timber framing, brick, stone, lath and plaster, asphalt shingle roofing, PVC or vinyl flooring, and ceramic tiles. These materials are usually too dangerous and time-consuming to salvage without professional training.

Safety of materials remaining (lead/asbestos)

Asbestos and lead are common hazardous substances found in homes built during the mid-20th century. Asbestos is typically found in mid-century insulation and flooring products, and lead was added to paint to make it more durable and easy to maintain. Following a 1989 EPA issue, and subsequent appeal, several asbestos-containing products are now banned from use in the U.S. (EPA, 2016). Unlike asbestos-containing products, lead paint in consumer products was completely banned by the federal government in 1978. Deconstruction contractors should assume that all homes built prior to 1989 contain asbestos, that all homes built prior to 1978 contain lead paint, and that any home targeted for deconstruction must go through a hazardous material abatement process before crews can begin their work. In repurposing/recycling this material similar consideration must be given.

What's left: High-volume/low-value materials

The materials salvaged in the third skim are typically high-volume/low-value materials that need to be taken to a central facility for further sorting and processing. Unlike the second skim materials which hold value due to their unique attributes, the value of the third skim materials lies in their product consistency and volume since these types of materials are typically used in bulk on new construction projects. The Forest Stewardship Council offers a certification program for reclaimed lumber that provides a national level of quality control for these third skim materials (Forest Stewardship Council, n.d.).

Currently when a structure is demolished, most of the material ends up in a landfill or in the case of aggregate, it may be repurposed on site. This feasibility study gives particular attention to the debris that remains after the first and second skim. Materials removed in the first and second skim are most efficiently recycled or repurposed at the local level.

Volume of each material in the Great Lakes Region

A thorough review of the nature of salvageable materials found in the third skim of abandoned structures was conducted. In order to develop a list of materials that could be salvaged from the abandoned houses in the region, the nature of the abandoned homes was assessed. Three factors of analysis were identified including (a) the structure's age, (b) number of rooms present, and (c) the type of residential structure. The typical square footage and architectural characteristics that could be expected in a house were also established, and some of the common problems found in abandoned buildings were studied from literature and case studies.

Typology of abandoned houses

Through a review of U.S. Census Data 5-year estimates, we determined that a typical house in the catchment area had the following characteristics as outlined in Table 4.

Table 4: Typology of Abandoned Houses in the Catchment Area

Abandoned Housing Types in Catchment Area							
State	**City**	**Total Housing Units**	**Vacant Total / Other**		**Year Most Units Built***	**Type***	**Rooms***
INDIANA	Gary	41,910	11,164	9,581	1979 and earlier/1950-1959	Detached- single unit	4 - 8
ILLINOIS	Chicago	1,190,998	162,169	76,221	1939 and earlier	Detached, 20 or more units, 3 to 4 units	3 - 6
MICHIGAN	Detroit	363,280	109,083	74,651	1959 and earlier/ 1939 and earlier	Detached- single	5 - 6
	Saginaw/ Midland/ Bay City	58,639	7,526	3,077	1939 and earlier/1950-1979; Midland – 1990-1999	Detached – single	5 - 7
	Muskegon County	73,368	8,479	3,618	1940-1959	Detached - single	4 - 5
OHIO	Ashtabula County	45,964	7,031	3,083	1939 and earlier	Detached - single	6 – 7
	Cleveland	212,269	45,619	30,407	1939 and earlier	Detached - single	5 – 6
	Toledo	138,538	20,573	10,702	1939 and earlier	Detached - single	5 – 6
WISCONSIN	Milwaukee	257,965	27,784	18,446	1939 and earlier/ 1950-1959	Detached – single, 2 units, 20 or more units	3 – 6
NEW YORK	Buffalo	133,538	22,094	24,086	1939 and earlier	Detached – single, 2 units	4 – 6
Totals and Average Type				**253,872**	**1950 and earlier**	**Detached, single-unit; not manufactured;**	**4 - 6**

Source: U.S. Census ACS (2010-2014 5-Year Estimates)
**Note: Data for these sections includes occupied as well as vacant structures*

The detached, open-planned houses built prior to 1950 made use of the expansive flat land that characterized early suburban architecture. The most popular home style was Colonial Revival, although other styles including the Cape-Cod, the American Foursquare, and the Crasftsman were also common. Typical characteristics of these architectural styles include:

- One to one-and-a-half stories (two stories are occasionally found)
- Low or moderately pitched roof, with end gables
- Dominant front porch
- Simple façade, clean lines, little ornamentation
- Chimneys, fireplaces with brick facing
- Concrete slabs (sometimes found in basements)
- Shingled roofs, vinyl siding
- Wood framing
- Wood flooring, vinyl tiles
- Drywall

Condition of abandoned houses

A study of the current condition of abandoned buildings in metropolitan areas by the American Housing Survey has identified some of the moderate to severe problems that abandoned homes generally display, including moisture damage and deterioration of the structural quality of building materials. Considering the architectural styles and characteristics mentioned above, the volume of recoverable salvageable materials after three skims may be low. Visual inspection of a sample of land bank-controlled abandoned houses in Lansing that had been marked for demolition supported this finding. The majority of structures observed were in a dilapidated condition, with few materials recoverable from the interior including some drywall, vinyl flooring, and carpeting. However, structural lumber and roofing shingles were typically in salvageable condition.

Images source: https://weather.com/travel/news/ruins-rust-belt-abandoned-buildings-photos

Types of material in abandoned houses

The most ubiquitous material found in abandoned houses is wood. This exists in structural (i.e., framing members, roof trusses, floor joists) and non-structural (i.e., roof and wall sheathing, fireplace mantles, flooring, siding, trim/architectural material) forms. Concerns related to this material often stem from the physical condition of the material, typically owing to damage from insects, water and fire, as well as the potential for interior and exterior surfaces to be coated with lead-based paint. Windows and doors are also commonly encountered in abandoned homes, often with the same concerns with paint coatings.

Interior walls are typically some combination of gypsum board or plaster and lathe (although one house assessed by the research team had corrugated cardboard covering the interior face of the studs). In abandoned houses inspected by the research group, plaster and lathe were encountered frequently; however, many homes also had gypsum board walls, sometimes installed as a retrofit directly over existing plaster.

Roofing materials are typically asphalt shingles. Multiple-layer roofs were commonly encountered, so the actual number of shingles present on homes may be 2-3 times the roof area. Asphaltic and asbestos-based siding products were also encountered; however, wood, vinyl, and aluminum siding were most commonly seen.

Brick is typically found in chimneys, whether exposed or otherwise hidden. None of the abandoned houses observed in Lansing were made of brick; however, a visual review of Muskegon Land Bank-controlled properties revealed a small number of brick structures. Owing to the age of abandoned structures, concrete block and stone are typically encountered as the foundation material.

Table 5: Types of Salvageable Material Available After Three Skims

Table 5: Types of Salvageable Material Available After Three Skims	
Material Category and Subcategory [a]	**Specific Materials**
1.0 Concrete (CSI Division 3)	Concrete walkways
	Poured concrete foundations
	Patios and poured stoops/steps
2.0 Masonry (CSI Division 4)	Clay bricks (exterior, chimney)
	Concrete masonry units (foundation)
	Stone (exterior, chimney, foundation)
3.0 Wood Products (CSI Division 6)	
3.1 Framing Lumber	2"x4" (typically softwood species)
	2"x8" (typically softwood species)
	2"x10" (typically softwood species)
	2"x12" (typically softwood species)
3.2 Roof and Wall Sheathing	Plywood
	Oriented Strand Board (OSB)
3.3 Flooring	Plywood (subfloor)
	OSB (subfloor)
	Wood flooring (softwood and hardwood species)
4.0 Roofing (CSI Division 7)	Asphaltic roof shingles
5.0 Interior Finishes (CSI Division 9)	
5.1 Wall Finishes	Gypsum board
	Plaster and lathe
	Wood panels
5.2 Floor Finishes	Vinyl Flooring
	Linoleum Flooring
	Ceramic Tile Flooring
	Carpet
Notes: a\ CSI = Construction Specifications Institute Master Format 50 Division System; CSI is a standard for organizing specifications and other written information for commercial and institutional building projects in the U.S. and Canada.	

Volume of material in abandoned houses

Based on the number of "other vacant" structures in the catchment area, calculated in Table 4, and an estimate of the amount of material per structure, the following table estimates the total potentially available material.

Table 6: Estimated Salvageable Material Quantities from Residential Structures

Table 6: Estimated Salvageable Material Quantities from Residential Structures		
Material Name	**Estimated Quantity** [a]	**Total Potential Volume in Catchment Area**
Framing Lumber	4,000 board feet (BF) [b]	1,015,488,000 BF
Standard Brick [c]	5,000 bricks	269,867,744 bricks
Asphalt Shingles	650 square feet ($ft^{2)}$)	165,016,800 ft^2
Flooring	1,125 ft^2	285,606,000 ft^2
Concrete	37 cubic yards (yd^3)	9,393,264 yd^3
Drywall	1,445 ft^2	366,845,040 ft^2
Siding [d]	1,620 ft^2	411,272,640 ft^2

Notes:
a\ Estimated material quantities are for a prototypical 1,500 square foot house
b\ One board foot is equivalent to a piece of wood 12" x 12" x 1"
c\ Standard brick measures 3-5/8" x 2-1/4" x 8"
d\ Based on field observations, primary siding material was vinyl; based on these observations, the total potential volume in catchment can be assumed as 80% vinyl, 15% aluminum, and 5% asphaltic siding materials

Table 6 provides an overview of the typical amount of salvageable materials that are found in the abandoned houses and is derived from a combination of source literature and visual inspections. The different volumes of each material can potentially be recovered from a single-family detached house averaging 1,500 to 2,000 square feet. A total volume of the amount of salvageable material present in the catchment area (approximately 253,872 houses) is also calculated.

Note: The actual amount of salvage will depend upon the current condition and quality of the materials in the abandoned houses.

Current Practice of Demolition of Residential Structures – Public Funding

The United States Department of Housing and Urban Development (HUD) and the United States Department of the Treasury have consistently funded the prevention and elimination of blighted neighborhoods, particularly during times of economic recession, typically through Community Development Block Grants (CDBG). Funding is primarily allocated for the demolition of abandoned structures, but is also used for deconstruction, mortgage assistance, and community revitalization.

Community Development Block Grant Program – HUD

The CDBG program is federally funded by HUD and is one of its longest running programs. The program's purpose is to provide funds to states and cities to provide for a variety of community development needs, including blight elimination and structural rehabilitation. The funds appropriation level for CDBG varies; the level was $3.1 billion for the 2014 fiscal year. Since its authorization in 1974, CDBG has invested $144 billion in communities across the United States and more than 1.3 million homes were rehabilitated between 2004 and 2013 (HUD, n.d.). HUD allocates CDBGs to the State of Michigan through the Michigan Strategic Fund, with assistance from the Michigan Economic Development Corporation (MEDC) (MEDC, n.d.).

Neighborhood Stabilization Program (NSP) – HUD

The Neighborhood Stabilization Program (NSP) provides assistance to state and local governments, and certain local communities to acquire, rehabilitate, resell, or redevelop foreclosed properties that might otherwise become sources of abandonment and blight within their communities. Specifically, funds are designated to assist households whose annual incomes are up to 120% of the area median income.

NSP funds may be used by grantees for activities that include, but are not limited to:

- establishing financing mechanisms for the purchase and redevelopment of foreclosed homes and residential properties;
- the purchase of abandoned residential properties;
- establishing land banks for foreclosed homes;
- demolishing blighted structures;
- or redeveloping demolished or vacant properties.

In addition, NSP funds must be aligned with at least one CDBG national objective:

- Housing Activities: Providing or improving permanent residential structures that will be occupied by a household whose income is at or below 120% of area median income.
- Area Benefits Activities: Benefiting all the residents of a primarily residential area in which at least 51% of the residents have incomes at or below 120% of area median income.
- Limited Clientele Activities: Serving a limited clientele whose incomes are at or below 120% of area median income.

NSP grantees develop their own programs and funding priorities. Grantees must use at least 25% of the funds appropriated to house individuals or families whose incomes do not exceed 50% of the area median income. All activities funded by NSP must benefit low- and moderate-income persons whose income does not exceed 120% of the area median income (HUD, 2016).

Hardest Hit Fund – U.S. Dept. of Treasury

Established in February 2010 by the United States Treasury in response to the economic recession, the Hardest Hit Fund (HHF) was designed to aid families in states hardest hit by the housing market crash. The funds are administered by each state's Housing Finance Agency (HFA) with the purpose of assisting struggling or unemployed homeowners in paying their mortgage, helping homeowners that owe more on

their mortgage than their home is worth, and facilitating transitions out of homes into more affordable places of residence. States can use the funds to develop locally-tailored foreclosure prevention solutions and blight elimination (U.S. Department of the Treasury, n.d.).

Michigan's Hardest Hit Fund program has received over $761 million to operate its HHF programs since its creation in 2010. The Michigan Homeowner Assistance Nonprofit Housing Corporation (MHA), created by the Michigan State Housing Development Authority (MSHDA), designs programs and oversees the distribution of Hardest Hit Funds in Michigan. With specific respect to blight elimination, the MHA established the Hardest Hit Fund Blight Elimination Program to address communities with high vacancy rates. In September 2016, an additional $11.7 million in blight elimination grants was allocated to 10 cities and counties across Michigan. The funding originates from $188.1 million the state received in April of the same year from the Hardest Hit Fund to address continuing problems from the foreclosure crisis (MSHDA, n.d.).

Economic Impacts of Deconstruction vs. Demolition

This feasibility study examines the use of deconstruction as a possible solution to the practice of private sector abandonment. Deconstruction is the process of systematically dismantling a structure, aiming to maximize the recovery of materials for reuse and recycling. While the demolition industry does participate in some recycling of C&D waste, opportunities for the reuse and repurposing of building materials are typically minimal. Conversely, deconstruction prioritizes the recovery of building materials, with the primary objective being to maximize their value in a secondary market (Delta Institute, 2012).

The following diagram from the Delta Institute, shows an example of the materials one can expect to recover in each "skim" of deconstruction, versus those that are lost in demolition. The diagram is for illustration purposes only, and are not necessarily reflective of actual practice.

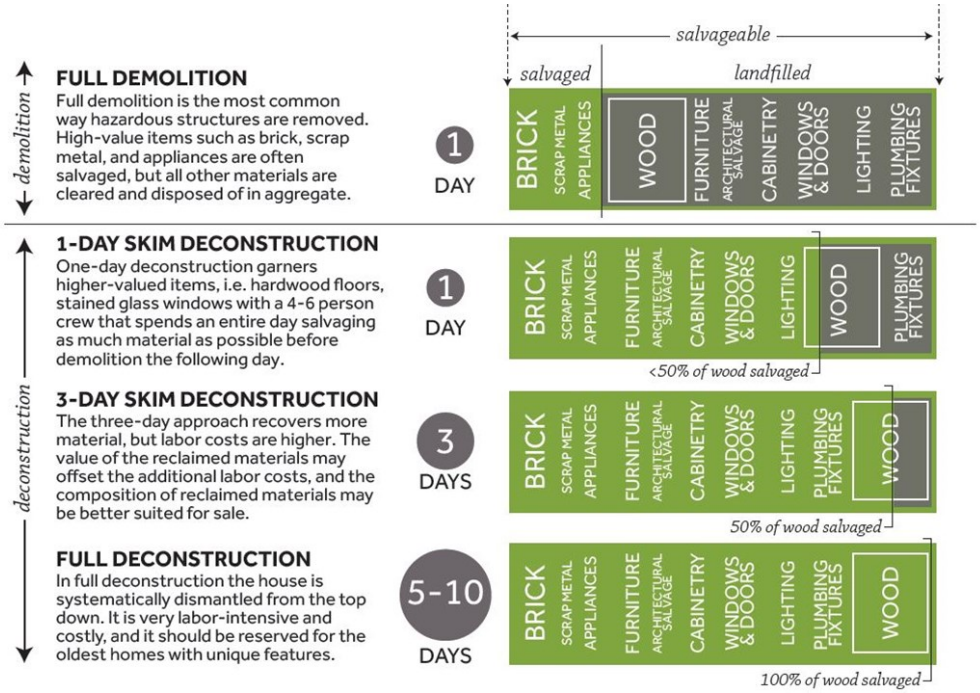


Figure 7: Three Skim Paradigm
Source: (Delta Institute, 2015)

The demolition of blighted structures associated with private sector abandonment strains limited public resources due to the cost of mass demolition, and contributes high volumes of construction demolition waste to landfills. In addition, the demolition of abandoned structures has limited economic value and clear environmental ramifications. While inexpensive and fast when compared to deconstruction, structural demolition misses out on the value of reclaimed C&D materials. Conversely, the practice of dismantling, removing, and restoring abandoned structures has value in the reuse and repurposing of C&D materials. One study concluded that when materials are salvaged at a rate of 50% the average cost of a residential deconstruction is $4.83/sf, whereas the average cost of a residential demolition is $5.36/sf (Dantat, Touran, & Wang, 2005).

While land banks in the Great Lakes area have invested at least some time and resources into deconstruction projects, a relatively small proportion of funding is allocated to deconstruction practices as compared to demolition. This is can be at least partially attributed to pressure coming from federal funding sources and community members on local governments to remove blighted structures in the fastest way possible (HUD, 2014). While demolition does not benefit from the value of recycled C&D materials and contributes to landfill growth, it is often the preferred method of blight elimination due to the initial labor, resources investment, and time consuming practices necessary for deconstruction. (LaMore, 2013).

Limited Use of Deconstruction

With specific respect to the federal funding of deconstructing abandoned structures, the Neighborhood Stabilization Program has previously allocated funds for deconstruction and worker training programs. Often, these projects are done in conjunction with larger demolition projects, with a smaller number of homes being deconstructed while a majority are demolished. HUD has provided guidelines for how land bank authorities can use NSP funds to incorporate deconstruction into blight removal practices by:

- assessing the market potential for salvaged building materials;
- assessing the potential for workforce training;
- discussing the relationship between conventional demolition and deconstruction;
- and describing scenarios for job creation and business opportunities (HUD, 2008).

In 2011, the Cuyahoga Land Bank partnered with the City of East Cleveland to demolish 24 apartment buildings and 31 abandoned homes, while an additional five apartment buildings were deconstructed (Cuyahoga Land Bank, 2011). In 2012, the Neighborhood Stabilization 3 Program designated a deconstruction project with Wayne County that focused on workforce development. The program allocated approximately $950,000 to SER-Metro Detroit, an employment and economic development firm, to contract with demolition companies and employ workers directly to deconstruct approximately 10 units (HUD, 2013).

National and Global trends that may affect the economic feasibility of this sector

Oil Costs

This study relies on the established port and shipping networks along the Great Lakes for both collecting structural debris from cities with high volumes of abandonment, and distributing repurposed and recycled materials using the shipping industry already present in the region. Specifically, this study explores the feasibility of using articulated tug barges (ATBs) to ship raw and post-processed salvaged construction materials. ATBs have greater operating efficiency and lower costs when compared to towed barges and self-propelled barges (Crowley Maritime Corporation, 2016). Tug boats consume approximately 85 gallons, or about two barrels of oil per hour (Puget Sound Clean Air Agency, n.d.).

The following graphic shows a comparison of fuel consumption across several modes of transportation.

Energy Efficiency of Shipping Methods

Number of miles one ton can be carried per gallon of fuel
(Adapted from U.S. DOT Maritime Administration)

Mode of Transportation	Number of Miles/Gallon Carrying One Ton of Cargo
	514 miles/gallon
	202 miles/gallon
	59 miles/gallon

Figure 8: Energy Efficiency of Shipping Methods
Source: (Tennessee-Tombigbee Waterway, n.d.)

Due to our reliance on fossil fuels for industry operation, including all modes of shipping, fluctuating global oil prices are a critical consideration for the long-term viability of the proposed deconstruction industry. Currently, the U.S. is one of the world's top oil producers at 13.7 million barrels per day (CNN Money, 2016). According to data published by the U.S. Energy Information Administration (EIA), Brent crude oil prices, which are a major benchmark for oil prices worldwide, averaged $52 per barrel in 2015 - the lowest in five years (EIA, 2016).

Future projections for crude oil show a steady rise in oil prices per gallon (EIA, 2015). On the whole, global oil costs are highly volatile and react to a variety of geopolitical and economic events, as well as oil consumption rates, and supply disruptions (EIA, 2016). Therefore, long-term oil forecasts are considered to be somewhat unreliable and subject to change.

Construction Industry and Materials Demand

Over the past 20 years, the U.S. construction industry has been moving toward ever-increasing sustainability goals. Green building standards have become more common in the construction landscape, and while some are part of the code-setting process (i.e., the National Green Building Standard, ICC-700), the vast majority are intended for voluntary compliance. Leadership in Energy and Environmental Design (LEED) has held the dominant market share among U.S. green building certification programs. This market impact has been felt throughout the U.S. construction industry; currently, the green building sector is outpacing overall construction growth in the U.S. (Shutters, 2015). A significant focus of LEED projects is the minimization of construction waste and the inclusion of reused or repurposed construction materials, finishes, and even entire buildings in a certified project. Out of 100 possible points in the LEED v4 Building Design and Construction certification program, eight points (8%) can be attained through a combination of building/material reuse and waste minimization during construction.

LEED credits also reflect growing consumer demand for repurposed and bio-based materials. Retail outlets like the Construction Junction in Pittsburgh, PA, Ballard Reuse in Seattle, WA, the ReBuilding Exchange in Chicago, IL, and the Architectural Salvage Warehouse of Detroit, MI reflect the demand for salvaged and recycled or otherwise repurposed building materials.

Bio-based materials, typically plastics and plastic-like compounds (i.e., foams) are also growing in the marketplace. The province of Ontario, Canada is seeing significant growth in the biorefining sector with either proposed or operational facilities in Sarnia and Thunder Bay. These facilities, and others like them, use wood and agricultural product feedstocks to make synthetic chemicals without the need for petroleum-based products. As wood sourcing becomes a central issue to the continued operation and growth of biorefining plants, additional feedstocks of the needed raw materials will need to be identified and managed sustainably. This may provide an entry point for lower-quality salvaged wood from deconstruction operations into a high value-added supply chain.

In Michigan, the Michigan Forest Biomaterials Institute (MiFBI) is attempting to support sector growth for innovative biomaterials, recycled wood opportunities, and mass timber construction. Headquartered at Michigan Technological University and consisting of a statewide consortium of academic and industry partners, MiFBI seeks to advance the conversation around economic opportunities for biomaterials, and attempts to connect supply sources with end users and researchers.

Also impacting the U.S. (and global) construction industry is the growing use of mechanization. This has taken many forms, from “flying forms” used in reinforced concrete construction of tall buildings to 3D concrete “whole building” printers and robotic bricklaying assistants. Robotics may have a place in the deconstruction industry as well. The Ero concrete recycling robot, designed in 2013 by a student at Sweden’s Umeå Institute of Design, is a robot that can recycle concrete and separates rebar and other debris from the concrete matrix in the field. Such technologies when applied to a broader set of building material salvage challenges have the potential to advance deconstruction by making tedious, manual labor-intensive tasks more cost and time efficient, thereby incentivizing additional deconstruction activity.

Coincident with the increased use of technology and mechanization in construction are shifts in workforce needs. More jobs within the construction trades require either some post-high school preparation or require the completion of an apprenticeship program (often completed in partnership with a local community college). This means that additional demands will be placed on workforce development

efforts, as construction labor is still significantly below where it was 10 years ago, and now requires greater amounts of education and training in order to gain entry.

International Trade Laws and Regulations

The ability to sell salvaged materials in the international marketplace is affected by international trade laws and regulations. Many countries have varying requirements and standards pertaining to construction materials in regards to functionality, safety, and sustainability. When considering international markets, one must also take into account the various costs, such as import and export taxes, in addition to the cost of transportation. The cost of shipping materials to different markets affects the profitability of salvaging materials, and also affects accessibility to different buyer markets.

Since the implementation of the North American Free Trade Agreement (NAFTA), U.S. manufacturing exports have increased 258%, and the United States maintains a growing manufacturing trade surplus with Canada and Mexico. American exports of computer and electronic products, furniture, paper, and fabricated metals have all more than tripled since NAFTA implementation.

The United States has free trade agreements (FTA) with twenty countries around the world. While these countries may not necessarily find it feasible to import construction materials from the U.S. currently, the FTAs allow the U.S. to access markets for various products in many economic sectors more easily, and export goods at a lower rate than compared to countries without existing FTAs. The United States also has a series of Bilateral Investment Treaties (BITs) to help protect private investment, develop market-oriented policies in partner countries, and promote U.S. exports.

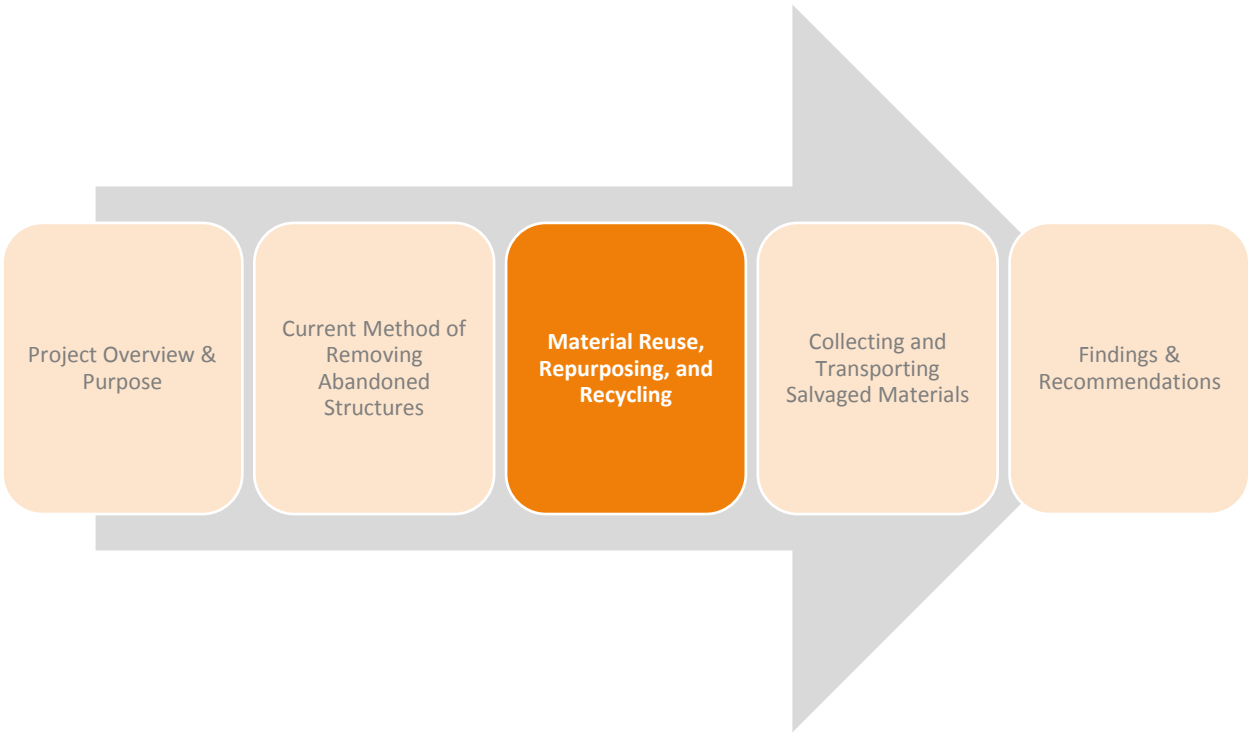
The United States is also a member of the World Trade Organization (WTO). The WTO sets out rules governing trade among the 154 countries. Since 2001, the United States and other WTO members have engaged in the Doha Development Round of world trade talks to address the global economic crisis and help to restore trade's role in leading economic growth and development.

Like the U.S., many countries have different standards and regulations for building materials. There are also some organizations (such as the Forest Stewardship Council) that have formed global standards for the creation of sustainable materials. Because different cities, counties, states, and nations choose to adopt different construction criteria, the way materials are recycled and reused will play a significant role in determining the markets they can be sold in.

The National Green Building Standard (NGBS) was developed in 2008 by the National Association of Homebuilders Home Innovation Labs through a multi-party, consensus-driven process. The standard focuses on the certification of single family homes, multifamily homes, remodeling projects, and land development projects. As of 2016, 91,571 homes had been NGBS-certified (Home Innovation Research Labs, 2016).

The NGBS, also known as ICC/ASHRAE 700-2015, became the first residential green building standard to undergo the code adoption process. The standards-based code has also received full approval from the American National Standards Institute, a third-party organization that accredits standards. The International Green Construction Code (IgCC) also permits compliance with ICC 700 NGBS as an alternate compliance path for residential buildings more than four stories in height.

CHAPTER 3: MATERIAL REUSE, REPURPOSING, AND RECYCLING



CHAPTER 3: MATERIAL REUSE, REPURPOSING, AND RECYCLING

Salvaged Material Reuse

Reuse is a broad term that within this context relates to salvaged building materials. Reuse is defined by the Leadership in Energy and Environmental Design (LEED) version 4 standard as, "the reemployment of materials in the same or a related capacity as their original application, thus extending the lifetime of materials that would otherwise be discarded. Reuse includes the recovery and reemployment of materials recovered from existing building or construction sites" (U.S. Green Building Council, n.d.). This points to a dichotomy within the definition. For the purposes of this report, reuse indicates that a product is being reused in its extant form, for its intended purpose. Reused building materials typically originate during the first skim, and include windows, doors, cabinets, furnishing, light fixtures, and plumbing fixtures. A review of inventory at several reused material warehouses (ReUse Stores and Construction Junction, Pittsburgh, PA - http://www.cjreuse.org/) supports this finding.

Salvaged Material Repurposing

Within the context of building materials, repurposing typically means that a product is being reused in its existing or modified form, but for a use other than what it was designed for. Some salvaged building material is repurposed locally. This is often the result of some combination of low value intrinsic to the material or high transportation costs, due to material weight. This repurposing activity is typically in response to local markets and demand. Example materials that are typically repurposed locally include concrete, structural lumber, and doors.

Concrete is typically crushed to provide aggregate material. This aggregate may be reused as "crusher run" (also known as quarry process, dense grade aggregate, or road stone) which has a variety of uses. Crusher run can be used for loose-fill driveways and roads, as sub-base below concrete or asphalt paving, as backfill around utility lines, and as a base for masonry.

Non-construction use of salvaged building materials is also a potential repurposing strategy. Structural lumber and doors are often reused for purposes other than that for which they were originally intended. This is described in the next section. As we will discuss in this section, some materials can be repurposed by reconfiguring the material, such as asphalt shingles.

Non-Construction Reuse of Salvaged Materials

Many household items such as fireplace mantles, structural beams and flooring, cast iron radiators, porcelain baths and sinks, terracotta tiles, antique bricks and stone, lighting fixtures, siding and molding etc. can be reused - extending the life of the product, and thereby saving resources that would be utilized in the manufacture of new products. However, the major limitation to repurposing these salvaged items from pre-demolition and deconstructed sites for their original intended use is that they may be coated with lead-based paint, or may not meet sustainability, safety and energy-efficient guidelines prevalent today (Gromicko, n.d.).

Thus, salvaged materials from abandoned homes often find new life as design elements and retail products for their aesthetic, cultural, and vintage value. Contemporary restaurants, offices and homes like to present an eclectic 'feel' by incorporating a variety of furniture and decor in their spaces that preserve a part of history, as do adaptive reuse practices. They can also be an economically feasible and environmentally-friendly option for home remodeling projects - coffee tables made out of salvaged floorboards are an example of such popular reuse, as evidenced by AltruWood, and the appearance of these items in popular retail outlets.

Recycling Possibilities for Raw Materials

From a life-cycle analysis perspective, building materials made with recycled elements can be more desirable - environmentally, economically, as well as socially. However, in order to reuse the material salvaged from deconstruction, strategic planning is often required to determine what options would be most feasible in the long run. For example, while considering the manufacturing process of new ceiling tiles, virgin gypsum would not need to be mined if recycled tile content was used in its place. On the other hand, manual labor and transportation costs, and grinding processes used in the recovery of spent ceiling tiles do not have to be accounted for while mining gypsum. Most abandoned houses in the Midwest, having been constructed between 1920 and 1950, bear salvageable material that might have had a rich history as determined in Chapter 2.

The growing interest in using recycled or repurposed materials in new construction and renovation projects has created a concern related to validating recycled/repurposed content claims. The Recycling Certification Institute (RCI) has emerged as a third-party evaluator and certifier of recycling facilities and recycling lines within non-certified facilities (Recycling Certification Institute, n.d.).

Based on the research and analysis done in the previous sections, the final list of salvageable materials found in abandoned houses is given below. This section identifies and exemplifies different options for reuse and potential markets for the materials.

Table 7: Types of Salvageable Material Available

Table 7: Types of Salvageable Material Available After Three Skims			
Material Category and Subcategory [a]	**Specific Materials**		
1.0 Concrete (CSI Division 3)	Concrete walkways	Poured concrete foundations	Patios and poured stoops/steps
2.0 Masonry (CSI Division 4)	Clay bricks (exterior, chimney)	Concrete masonry units (foundation)	Stone (exterior, chimney, foundation)
3.0 Wood Products (CSI Division 6)			
3.1 Framing Lumber	2"x4" / 2"x8" / 2"x10" / 2"x12" (typically softwood species)		
3.2 Roof and Wall Sheathing	Plywood	Oriented Strand Board (OSB)	
3.3 Flooring	Plywood (subfloor)	OSB (subfloor)	Wood flooring (softwood and hardwood species)
4.0 Roofing (CSI Division 7)	Asphaltic roof shingles		
5.0 Interior Finishes (CSI Division 9)			
5.1 Wall Finishes	Gypsum board	Plaster and lathe	Wood panels
5.2 Floor Finishes	Vinyl	Ceramic Tile	
	Linoleum	Carpet	

Notes:

a) CSI = Construction Specifications Institute Master Format 50 Division System; CSI is a standard for organizing specifications and other written information for commercial and institutional building projects in the U.S. and Canada.

Drywall and Gypsum

Gypsum is most commonly found sandwiched between sheets of paper-facing and paperboard backing in the form of drywall panels, primarily used to make interior walls and ceilings in the U.S. It also happens to be one of the largest contributors in the residential C&D waste category - 14% of which comes only from demolition. Sulfate present in gypsum (calcium sulfate dihydrate) poses a disposal problem in many landfill sites, often leaking into and contaminating nearby watersheds (Construction & Demolition Recycling Association, 2016). Hydrogen sulfide gas may also be formed due to anaerobic reaction with wet, organic matter found in landfill sites, producing odor and concentrated gas issues. However, owing to its high recycling value and with the help of mechanical processes such as sieving and grinding, there are several ways in which gypsum can be reused after deconstruction.

- Manufacture of new drywall: gypsum can be recycled back to its original state, also known as 'closed-loop' recycling, if most of the paper can be removed. Presence of paper in the recycled content affects the fire rating of gypsum.
- Construction site reuse: drywall scraps can be used to fill wall cavities in new construction, eliminating hauling and tipping costs.
- Production of Portland cement: requires virgin gypsum, with less than 1% paper content.
- Soil amendment - Gypsum can promote plant growth and improve drainage in soils in agricultural fields. It can also help in composting.
- Grease absorption in industrial shop floors; or as an athletic field marker.

Siding and Vinyl

Vinyl, most commonly used as exterior siding, became popular in the 1950s when it was introduced as an alternative to wood or aluminum siding. However, being relatively cheap, it was prone to sagging, cracking, buckling etc. The crucial limitation of recycling vinyl from the flooring or siding of abandoned houses today is the presence of other contaminants in the building material, such as original adhesive, dirt, nails, pieces of aluminum flashing and the like. Siding is thus put through rigorous shredding and cleaning processes that use magnets, and even washing - before it can be recycled and used in the manufacture of new siding (Smith, 2012). Another use vinyl is frequently subject to is in the manufacture of resilient flooring, which is made up of almost 40% of recycled content, including vinyl composite tiles and used carpet scraps (vinyl backing).

Framing wood/exterior painting wood

Wood has a whole host of criteria that comes into play in its reuse and recycling. The basis of this is that lumber is usually available in multiple forms and sizes. A typical 1,500 to 2,000 square foot house might contain anywhere between 6,000 to 13,000 board feet (BF) of lumber, where 1 BF is equal to a piece of wood that is 12 inches by 12 inches, with a thickness of 1 inch. Such wood is typically found in the form of framing lumber, flooring, cabinets, and facade work. Extensive literature reviews have also established that depending upon dimensions used, such as 2"x4", 2"x8", and 2"x10", the lumber used in framing houses is typically 8 feet long. Depending upon the quality of lumber and the type of construction, some houses use 10 to 14 foot framing lumber as well. Other forms of salvageable wood in houses are plywood, oriented strand board (OSB), wood siding, and wooden panels (McKeever & Phelps, 1994).

The restriction with salvaged wood is that it needs to be treated properly before it can be reused. Nails must be removed, the wood must be planed, paints and finishes may need to be removed, and the wood

may need to be kiln-dried to remove any insect infestation and to prevent further warping and bending. After proper treatment, high-quality flooring in older structures can be reclaimed and reused in new floors. Recycled exterior siding and interior beams also help in adding character and uniqueness to newly constructed homes. The Forest Stewardship Council (FSC) can certify lumber that has been reclaimed and saved from being sent to landfill sites in the form of certified flooring, siding and other wood products. By assimilating these in surface and structural components in new building designs and construction projects, Leadership in Energy and Environmental Design (LEED) rating system points can also be scored. The conventional uses of reclaimed and recycled wood are listed below.

- Architectural, landscaping elements
- Furniture, wall art, and paneling
- Formwork boards and wooden ties
- Fuel for energy generation

Asphalt Shingles

Asphalt, found in pavements, roads, roofing shingles etc., is one of the most recycled products in the U.S. According to a report published by the National Asphalt Pavement Association (NAPA), the use of Recycled Asphalt Shingles (RAS) increased from 702,000 tons in the year 2009 to 1.10 million tons in 2010 (NAPA, n.d.). Shingle recycling is often done after roof tear-offs, when asphalt shingles have reached the end of their twenty to fifty-year life, as an inexpensive, resourceful and valuable alternative to being landfilled (ShingleRecycling.org). The potential presence of asbestos in the shingles is considered to be the biggest problem in the context of recycling, with federal regulations prohibiting the recycling of asbestos-containing shingles. Nonetheless, there are many potential uses and markets that are economically viable for recycled shingles, such as:

- Hot-Mix Asphalt (HMA): reduced demand on virgin asphalt cement and reduced processing of raw materials for aggregates required in paving. Shingles added to HMA have also been shown to improve its resistance to cracking and rutting by reinforcing the fiber matrix.
- Cold patch for potholes: fiberglass or felt from the shingles tend to behave more efficiently in patches, possibly lasting longer than other patch materials.
- Production of new roofing shingles: U.S. Dept. of Energy established that up to 20% of recycled shingles could be added to new shingle production content, while accounting for significant energy savings without affecting its quality.
- Supplemental fuel source: air pollution is a pertinent concern.
- Landscaping element: tiling for patios, garden paths, and as winter walkway aide.

Recent research has shown some concern with the use of RAS in HMA paving, particularly in cold climates. Exposure to cold climates during use is believed to degrade the quality of the asphalt binder in the shingles such that when this RAS is incorporated into HMA, the resultant asphalt displays less flexibility, particularly at cold temperatures, than pavement using RAS originating from more temperate areas (Hassan, Lodge, Mohammed, & King Jr., 2016). A proposed solution to this is the addition of waste rubber (from scrap tires) to the RAS/HMA, which could solve an additional urban waste management challenge.

Concrete

After being recovered from demolition sites, rebar metals need to be separated by magnets from the concrete, and it has to be devoid of scraps of paper, wood, etc. before recycling. Then the concrete can be crushed into uncontaminated aggregates of different sizes. The various uses of recycled concrete depend upon this size and quality control at the crushing facilities, and some examples include:

- Dry aggregate for new concrete –
    - If the recycled concrete has no contaminants and the size of the aggregates are very small, it can be used in the manufacture of new concrete (ready-mix). This also reduces the need for obtaining new gravel by mining.
- Road base –
    - Concrete (such as in pavement-form) can be broken down into gravel and placed beneath asphalt roadways as a base layer in new construction or in the placement of construction access or other temporary road surfaces. Called "crusher run," this material is typically cheaper than similarly-sized gravel for such application. Additionally, this helps in reusing the concrete already present onsite, or at nearby sites, thereby saving hauling and transportation costs (and attendant carbon emissions) for recycling and disposal.
- Revetments and soil stabilization –
    - Larger pieces of concrete can be used as retaining walls in order to control erosion and drainage along water bodies, and in terraced gardens as landscape features.
- Pipe bedding –
    - Concrete often serves as a solid and unyielding foundation for laying out underground utilities. Due to the weight of concrete and corresponding costs of transport the research team recommends that this material be re-used locally.

Workforce opportunities in deconstruction/material reuse

Job creation opportunity

Because deconstruction requires more labor hours and manpower than demolition, it is a powerful tool for economic development and job creation. According to Jeff Carroll, Director of Details, a social enterprise of the Humanim non-profit in Baltimore, a deconstruction site will require between 12 and 24 skilled workers, whereas a demolition site only requires two to three workers. Labor is needed for every aspect, including supervising and coordinating team efforts, mechanically removing building materials, and processing and sorting materials for reuse or disposal. In the process, workers gain both construction and deconstruction skills for maintaining, renovating, and restoring buildings, and hazardous substance handling. These learned skills and in-field knowledge can be taken with the worker.

In considering the establishment of a deconstruction sector in Muskegon, a skilled workforce will be necessary to support this emerging sector. Employment opportunities that might be needed are described here.

The U.S. Department of Labor categorizes recycling-related jobs into two categories: 1) recycling coordinators, and 2) recycling and reclamation workers (O*NET, n.d.). Other job categories appear as being related to recycling operations, such as refuse and recyclable material collectors, supply chain

managers, and green marketers; however, these occupations are not included in this section as they describe workers in sectors that are much broader than the salvaged materials recycling industry.

Recycling coordinators are described as individuals who "supervise curbside and drop-off recycling programs for municipal governments and private firms" (O*NET, n.d.). Reported job titles include Recycling Coordinator, Recycling Director, Recycling Manager, Recycling Program Manager, Recycling Specialist, and Waste Reduction Coordinator. Nationally, 47% of people in this classification held a high school diploma, 23% held an associate's degree, and 30% held a bachelor's degree. Selected knowledge, skills, and abilities include:

- Knowledge
    - Customer and Personal Service
    - Administration and Management
    - Clerical
    - Education and Training
    - Production and Processing
- Skills
    - Speaking
    - Management of Personnel Resources
    - Active Listening
    - Coordination
    - Critical Thinking
- Abilities
    - Oral Comprehension
    - Oral Expression
    - Speech Clarity
    - Speech Recognition
    - Deductive Reasoning

Michigan wages for these workers are consistent with national averages, with wages ranging from $26,860 to $76,370 and a median of $45,670. While the national outlook for these positions shows slower than average growth, at an annual rate of 2% between 2014 and 2024, Michigan expects to see 7% annual growth over that same time period, resulting in 180 annual openings.

Recycling and reclamation workers are engaged in "prepar[ing] and sort[ing] materials or products for recycling. Identify[ing] and remov[ing] hazardous substances. Dismantl[ing] components of products such as appliances" (O*NET, n.d.). Typical reported job titles for this classification include Laborer, Box Sorter, Convenience Recycle Center Tech, Deconstruction and Decontamination Waste Operations Specialist, Non-Ferrous Material Handler, and Sort Line Worker. Nationally, 74% of workers in this classification had a high school diploma or equivalent and 15% had an associate's degree. Selected knowledge, skills, and abilities include:

- Knowledge
    - Production and Processing
    - Mechanical
    - Administration and Management
    - Public Safety and Security
    - Education and Training
- Skills
    - Operation and Control
    - Active Listening
    - Monitoring
    - Operation Monitoring
- Abilities
    - Manual Dexterity
    - Control Precision
    - Arm-Hand Steadiness
    - Multi-limb Coordination
    - Near Vision

Michigan wages for these positions are somewhat consistent with national averages. Salaries range from $19,410 to $46,090 with a median of $32,290. While the national job outlook for these positions is slower than average at 3% annual growth, Michigan expects to increase the workforce by 12% each year between 2014 and 2024. This results in 330 anticipated openings each year during that time period.

In a 2014 survey of 47 construction and demolition debris recycling firms, reporting material generation capacities of 10,000 tons to 149 million tons, with an average of 3.31 million tons - 46 respondents reported a range of employees between 2 and 248, with an average facility employing 32 workers (Townsend, Wilson, & Beck, 2014). Based on analysis of these results, the authors of the report concluded that 233 jobs are created per million tons of recycled C&D debris in mixed C&D recycling facilities and 45 jobs are created per million tons in bulk aggregate recycling facilities.

Necessary Industrial Infrastructure

Construction and demolition debris recycling facilities come in a variety of forms, from highly-mechanized bulk C&D recycling facilities to transfer stations and specialized, highly-manual facilities. In an early 2000s report prepared by the University of Florida and the Florida Department of Transportation, three prototypes of C&D recycling facilities were identified: 1) manual separation only (i.e., "dump and pick"), 2) combination manual and mechanical separation, and 3) heavy mechanical processing and separation (Ellis, Agdas, & Frost, 2014). These facilities were cited as having reject volumes (volume of materials sent to landfills due to incompatibility with facility and/or reuse) of >50%, 25-50%, and <25%, respectively. Process diagrams for these three facility types are shown in Figure 9.

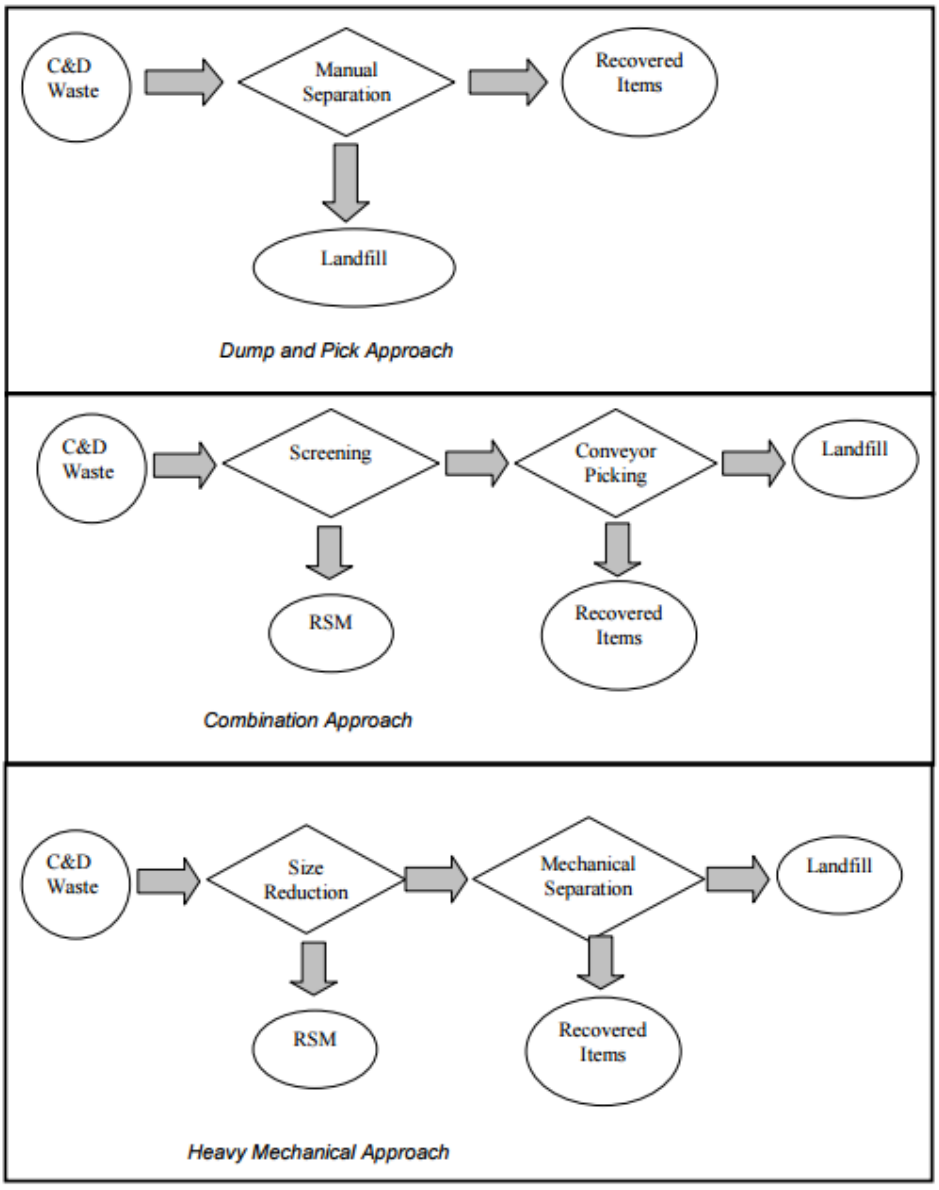


Figure 9: Approaches to Construction and Demolition Debris Recycling
Source: (Ellis, Agdas, & Frost, 2014)

Table 8: Construction and Demolition Recycling Equipment

Table 8: C&D Facility Recycling Equipment				
Equipment Type	**Minimum**	**Mean**	**Maximum**	**N**
Mechanized Sorting Lines	1	1.1	2	21
Manual Sorting Lines	1	1.3	4	31
Front End Loaders	1	3.4	22	44
Transfer Trailers	1	6.4	38	22
Crushers	1	2.1	7	23
Screeners	1	2.3	14	37
Roll-Offs	1	40	370	38

Source: (Townsend, Wilson, & Beck, 2014)

In addition to equipment costs, C&D recycling facilities are significant consumers of energy. On average, annual facility consumption was found to be 303,000 kilowatt hours (electricity), 63,500 gallons of diesel fuel, and 12,500 therms of natural gas (where 1 therm is equal to approximately 100,000 British Thermal Units) (Townsend, Wilson, & Beck, 2014).

Disaggregated actual startup costs for developing new C&D recycling facilities are difficult to obtain, as much of that information is considered proprietary data; however, a business plan for a proposed Burlington, VT facility from 2005 was reviewed as part of this project (Green Seal Environmental, Inc., 2005). The facility was proposed to handle 50 tons/day (15,000 tons per year) of mixed C&D debris with inbound deliveries via roll-off, dump bodies, pick-up, and residential and outbound shipping via roll-off, dump bodies, and live-floor trailers. The facility was expected to employ eight individuals (five production, one operations, and two administration). Equipment purchases were estimated at $600,000 with mobile equipment and scales accounting for another $350,000; this resulted in a total recycling infrastructure cost of $63.33 per ton in the first year, assuming the facility reached full operating capacity of 15,000 tons. Materials were expected to be recycled as follows:

- C&D fines – landfill cover
- Otherwise unusable wastes – boiler fuel
- Clean wood – compost and fuel
- Aggregate – local crushing plants
- Metals – local recyclers
- Gypsum – regional gypsum manufacturer/recycler
- Asphalt shingles – no known local markets at the time of the business plan development
- Cardboard – local cardboard recycler.

Status of Markets for Materials

In this section, the research team, led by colleagues from Erasmus University in the Netherlands, gave considerable attention to the existing supply chain in Europe that supports structural material. Consideration was also given to the relatively underdeveloped Michigan supply chain in this sector.

Business models in the recycling industry heavily depend on the recycling fees that are charged to the demolition companies or contractors (personal communication, May 24, 2016). It happens often that the demolition company is the same company as the recycler, and when this is the case an internal fee will be charged or the customer will be charged directly from both entities.

The scrap value of recycled materials is market-driven and therefore can fluctuate heavily. There are also materials that cost money to recycle or properly dispose of in a landfill instead of generating income. Examples include processed wood, linoleum with traces of glue, and insulation.

The research team noted that the European Union has a much more advanced market economy in this sector, so information on the uses and companies engaged in this sector are discussed in some detail. By understanding the existing practices in the EU, the potential for replicating or attracting these industries to West Michigan can be considered.

To advance this sector in the region, a targeted industry strategy will be necessary.

International

Research was conducted to investigate whether it is economically feasible to ship raw salvaged materials from Muskegon to Europe. First the team researched whether there were existing business models handling the shipment of certain (waste) commodities, and then the team looked for specific Dutch or other European firms that might be interested in buying the raw materials. Additionally, the team conducted key informant interviews referenced in this section.

In 2012, 710,405 tons of CDW were imported into The Netherlands. Around 70% of this was hazardous CDW, and asbestos accounts for the majority of this percentage. The high volume of hazardous CDW materials is due to the fact that the Netherlands is home to highly reliable and developed recycling facilities (Inspectie Leefomgeving en Transport, n.d.). This indicates that the hazardous materials processing industry, and in particular those that process asbestos, may be interested in processing overseas materials for a fee. Therefore, any U.S. exporters of asbestos would pay twice – first for the overseas shipping costs, and second to process the material. However, one interviewee was unsure about waste movements between the U.S. and Europe. That being said, they felt this possibility might be feasible in the future since sustainability is becoming a more important topic and commodity prices are rising. One company in particular, Beelen, may also be interested in international expansion. A drawback is the fact that shipping waste materials is strictly regulated.

The statement that no intercontinental C&D waste streams exist is also confirmed by the Dutch association for CDW firms (personal communication, June 15, 2016). They acknowledge that markets for CDW have a local orientation, and in Europe usually only neighboring countries trade in CDW. The two main drivers to stimulate international CDW trade are commodity prices and local dumping fees, and these initiated the C&D wood waste stream from the UK to the Netherlands and Germany.

Although no European or Dutch CDW recycling firms are active in the U.S., there are some industry-related companies, such as manufacturers of CDW machines and equipment, from the Netherlands who are active in the U.S. or other parts of the world.

Gypsum

Gypsum products are among the few construction materials where closed-loop recycling is possible. Therefore, gypsum is 100% recyclable and can always be reused since the chemical composition of the raw materials in plasterboard stays the same (Gypsum Recycling International, n.d.).

There are three types of gypsum :

- Natural gypsum which is processed gypsum from quarries or mines, formed geologically. China, Iran, and Spain cover almost 50% of the natural gypsum production.
- Synthetic gypsum. The main source of synthetic gypsum is FGD (Flue-Gas- Desulphurization) gypsum, a by-product of industrial process (desulphurization of gases in coal fired power stations). This is produced in most Western European countries that lack natural gypsum deposits.
- Recycled gypsum from the processing of gypsum waste. At the European level Belgium, the Netherlands, and Denmark are on the frontline when it comes to recycling gypsum.

In Europe there is a strong multinational orientation and there is not a common European market for CDW. This makes the forecasting of CDW developments more difficult. However, all over Europe efforts are being made to increase the recycling rate of gypsum. The development of the Life+ Gypsum to Gypsum (GtoG) project, which began in January 2013, promotes the transformation of the gypsum waste market with a focus on achieving higher gypsum recycling rates in Europe (EuroGypsum, n.d.).

In Europe, only Belgium, Denmark, France, the Netherlands, and the UK currently have a market for recycled gypsum. In addition, Belgium, France, the Netherlands, and the UK have voluntary agreements in place to increase the recyclability of gypsum based waste (EuroGypsum, n.d.).

The two main gypsum recyclers worldwide are GRI and NWGR (both operating in the U.S.). Nantet Locabennes and Ritleng Revalorizations have recently started operations in France. In the UK, three gypsum recyclers are identified as suppliers: Roy Hatfield Ltd, Arrow Gypsum Recycling, and Countrystyl.

Stakeholders for operating a European supply chain listed by the GtoG (EuroGypsum, n.d.) include:

Coordinators

Eurogypsum, the European association of plasterboard manufacturers, Belgium Universities

The National Technical University of Athens, Greece and Universidad Politécnica de Madrid, Spain

Laboratories

Fundación Gomez Pardo (LOEMCO), Spain

Consulting agencies

Recovering SARL, France

Demolition companies

Occamat, France
Cantillon Ltd, UK
Recycling assistance BVBA, Belgium
Pinault & Gapaix, France
KS Engineering, Germany

Recycling companies

New West Gypsum Recycling Benelux BVBA, Belgium
Gips Recycling Dan mark A/S, Denmark

Gypsum manufacturing companies

Placoplâtre SA (Saint Gobain group), France Siniat SA, France
Siniat Ltd, United Kingdom
Knauf Gips KG, Germany
NV Saint Gobain Construction Products Belgium SA (Gyproc), Belgium

In general the business model of Construction and Demolition (C&D) plasterboard waste consists of processing the gypsum by recyclers who sell the recycled gypsum to the manufacturers.

Siding and Vinyl

PVC is the most used polymer in the building and construction sector and over 60% of Western Europe's annual PVC production is used in this sector (PVC, n.d.). The European Council of Vinyl Manufacturers (ECVM) groups the materials for CDW into pipes & fittings, profiles, cables and flooring. VinylPlus, the sustainability program of the European PVC industry, distinguishes coated fabrics, flexible PVC and rigid PVC. Linoleum flooring has largely been replaced by PVC flooring which is sometimes still colloquially (and erroneously) referred to as "linoleum".

The collection and separation of PVC materials from CDW is required in order to treat the materials for reuse or recycling. Materials are picked up at demolition sites or they can be left at drop-off locations. Some manufacturing companies enable take-back guarantee systems (VinylPlus, 2016).

In The Netherlands the company Vereniging Kunststof Gevelelementenindustrie (VKG) facilitates a trade association for plastic façade elements and PVC pipe tubes. They take care of the collection, transport and processing. The components of PVC, rubber, and steel will be separated before the PVC is cleaned and processed into PVC pallets. These pallets are used as raw material for new plastic frames. This process can be repeated at least ten times without loss of quality. VKG is open for members of VKG which are 120 companies that make up about 75% of the Dutch market. In 2014 more than 4,000 tons of plastic frames were processed.

Roofcollect organizes the collection of end-of-life roofing membranes in most of the European countries. The initiator of Roofcollect is the European Single Ply Waterproofing Association (ESWA).

Recofloor have a take-back scheme for vinyl flooring to recycle it into new flooring. Recofloor operates 60 drop-off sites in the UK. Recofloor is initiated by two leading flooring manufacturers in the UK; Altro and

Polyflor. Fitters, contractors, and customers can return their vinyl flooring waste to Recofloor. The waste is either used for the manufacturing of new flooring or used to make traffic cones and road signs. Since 2009 more than 2,500 tons of vinyl waste has been collected.

Recofloor is part of Vinylplus initiative through EPFLOOR (European PVC Flooring Manufacturing Sector Group). EPFLOOR's mission is to recycle increasing quantities of Post-Consumer PVC flooring waste in Western Europe. They represent 90% of the flooring manufacturing market.

Recovinyl is an initiative of the European PVC industry and was created as part of VinylPlus program. Recovinyl works in partnership with consumers, businesses, municipalities, waste management companies, recyclers and converters, as well as the European Commission and national and local governments.

A selected example for recycling PVC waste is Vinyloop Ferrara SpA, which has a partnership with leading PVC manufacturers Solvay and Serge Ferrari. Vinyloop uses recycling technology for difficult-to-treat PVC waste that produces a virgin-like recycled PVC compound.

Table 9 gives an overview of the amount of recycled PVC type per association affiliated with VinylPlus.

Table 9: Amount of Recycled PVC Type per Association

PROJECT	TYPE OF PVC	TONNAGE RECYCLED IN 2014	TONNAGE RECYCLED IN 2015
IVK/EPCoat (incl. Recovinyl)	Coated fabrics	8,941*	10,853*
EPFLOOR	Flooring	3,314*	3,938*
EPPA (incl. Recovinyl)	Window profiles & profile related PVC	203,962**	232,757**
ESWA – ROOFCOLLECT and Recovinyl	Flexible PVC	96,536 tons which consist of:	87,537 tons which consist of:
ESWA – ROOFCOLLECT	Flexible PVC	4,045*	3,249*
Recovinyl	Flexible PVC applications	92,491**	84,289**
TEPPFA (incl. Recovinyl)	Pipes & fittings	55,225	49,412**
ERPA via Recovinyl (incl. CIFRA and Pack-Upgrade Project)	Rigid PVC film	20,214**	24,371**
Recovinyl (incl. Vinyloop Ferrara)	Cables	92,826	106,044
TOTAL		481,018	514,913

* Tonnage including Norway and Switzerland
** Tonnage including Switzerland

Source: (VinylPlus, 2016)

High-Value Wood

The most efficient wood for selling on the market is minimally treated/processed, or untreated/unprocessed CDW wood which is also known as 'high value' wood. In contrast to the large market for wood as biomass input, the market for other CDW wood applications seems to be very small. That being said, we identified three supply chain models in the Netherlands that use recycled CDW wood.

First, there is the wholesale company that sells wooden planks to both consumers and business clients on a limited basis. These planks can be bought in small amounts and can serve multiple purposes.

There are also companies that specialize in processing CDW wood into vintage furniture and interior purposes. As in the wholesale case this CDW wood has to be recovered in whole wooden planks and cannot be fragmented or shredded.

Another option for wood to be recycled or even reused is by processing it into chipboard. Only the highest quality of CDW wood can be used for this process. The small amount of wood that qualifies for this purpose would be crushed into small pieces and may be mixed with other sorts of recycled wood before being processed into chipboard. The chipboard is then sold for multiple purposes but cannot be reused in construction because of the weak characteristics obtained during processing.

Overall the business models of recycled high value CDW wood are limited and have a very strong local orientation.

There is however, the possibility that minimally or untreated wood derived from demolished buildings may have value in Europe or locally. On a local basis this unprocessed wood may be used for manufacturing (vintage) furniture or other specific uses. If we consider the international recycled wood market we notice that there is already a lively trade in wood pellets, also from the U.S. to the EU and especially shipments to the U.K. and the Netherlands. The U.S. is the largest supplier of wood pellets to the U.K. – providing 82% of the 4.5 million short tons of fuel to the Drax plant in 2014 (U.S. Energy Information Administration, 2015). The demand for wood pellets is mostly fostered by legislation in EU countries which demands more sustainable energy sources such as energy plants that use wood pellets (biomass) as input.

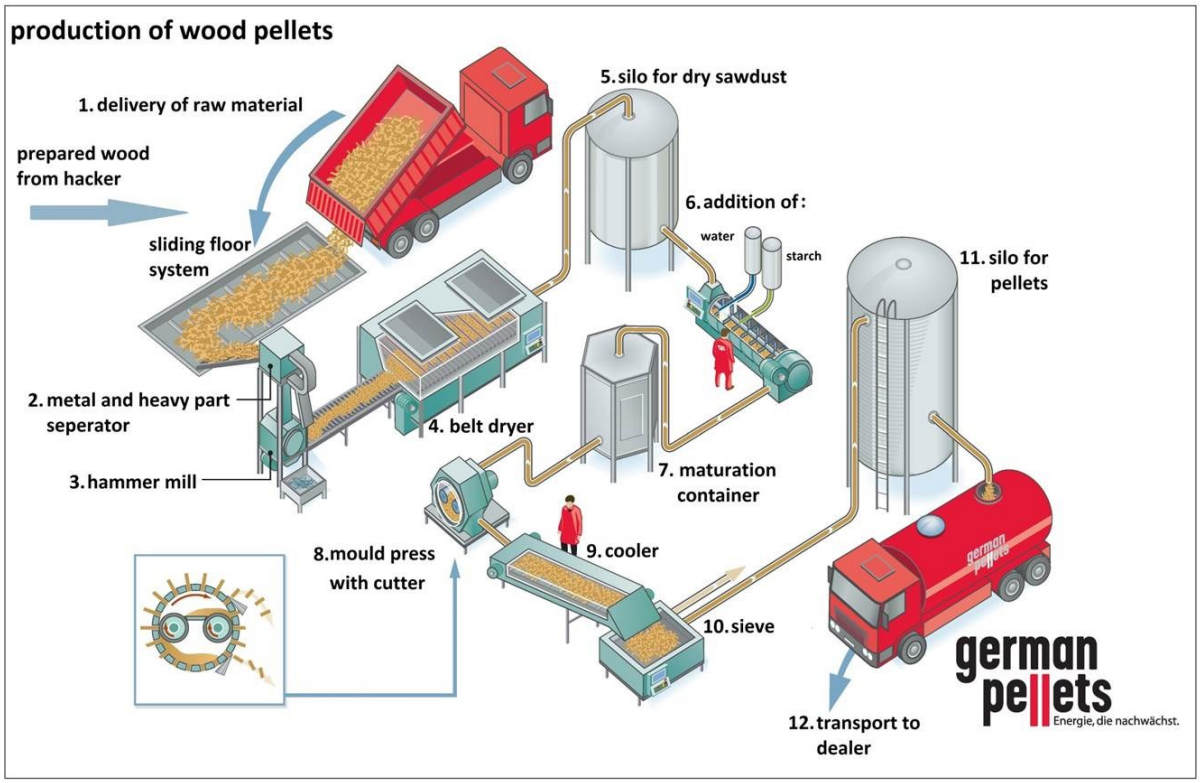


Figure 11: the process of turning raw wood into pellets ready for shipping
Source: www.german-pellets.de

In regards as to whether unprocessed CDW wood is also applicable in the wood pellet process, we contacted both U.S. based and Dutch companies. In general, CDW wood does not burn well enough to be processed into wood pellets, therefore most of the raw materials used for wood pellet production are tree trunks which generally come from the Southern U.S. states (personal communication, June 13, 2016).

There is another option for high-value CDW wood to be used in biomass energy plants, namely shredding and light processing before going into the energy plant. An international biomass trader at one of the largest Dutch energy companies confirms this and states that this is done on a large scale. The price per ton at the gate of the energy plant varies from $0 to $11.00/ton in the Netherlands and in other parts of Europe.

When processing, transportation, and handling costs are also taken into account the shipment of one ton of high-value CDW wood from the U.S. to Europe would cost approximately $27.50 (personal communication, June 13, 2016). Although the international biomass trader does find this case very interesting he states that without high dumping fees in the U.S. or significantly higher prices of wood in Europe, industries in The Netherlands and Europe will not be interested to buy high value CDW wood. He also notes that there are no international long distance shipping movements of CDW wood anywhere in the world at this moment.

Low-Value Wood

Another type of waste that is already best shipped in the EU is **low-value wood**. This is mostly done from the United Kingdom (UK) to both The Netherlands and Germany. The reason for this transshipment lies in the fact that tariffs to deposit inflammable waste and refuse derived fuel (RDF) as input for energy plants have risen dramatically in the UK. Therefore it is economically attractive to ship and deposit the low-value wood to Europe's mainland. Again, the team was not able to identify a feasible supply chain that could generate income for U.S. originated raw materials. The recent Brexit will not have any impact in the short or medium run. However, uncertainty within Britain is likely to appear for many businesses both British-owned and global companies whether to make capital investments or hire people. For the future, British and European leaders will have to decide what option to choose. They can maintain free trade and ignore the impulses that led voters to choose for a Brexit. Or they can become a more isolated economy which would honors its voters' wishes (Irwin, 2016).

Asphalt shingles

When researching the use and markets of asphalt shingles in Europe and the U.S., two notable differences occur. First, asphalt shingles are less common in Europe than in the U.S. In Europe the brick tiles are still very popular. Secondly, the term asphalt shingles is not very appropriate in Europe since the asphalt is mostly installed on flat roofs in large strips or squares. Therefore bitumen roofing is a more appropriate designation in Europe. The difference between the use of asphalt roofing in the U.S. and Europe is depicted in Figures 12 and 13, below.

Figure 12: The use of asphalt shingles in the U.S.
Source: http://www.remodelingcalculator.org/wp-content/uploads/2014/02/Asphalt-Roof-Shingles.jpg

Figure 13: The use of bitumen roofing in Europe
Source: http://www.bielso.nl/

In Europe bitumen roofing is widely recycled and used to produce new products. An international leading company in the field of bitumen (recycling) is the Danish Icopal. They both produce and recycle bitumen and have one plant located in Groningen, Netherlands that recycles bitumen up to 100% (www.bieslo.nl). This plant is unique since it is the only one in the world that recycles bitumen cradle to cradle to the full extent. The recycling process starts at the dismantling of the roofing felts which are then shredded and recycled into a resource for new roofing felts. This input is then mixed with virgin bitumen and used in the regular production process. Hereafter the output is sold for multiple purposes such as bitumen roofing.

The collecting of the waste bitumen in Europe is done in two ways:

- Individuals can get free big bags at designated collection point and return them full with bitumen waste. There is no charge in this process and individuals may qualify for discounts on future Icopal purchases.
- Contractors or demolition firms have to send a sample of the bitumen roof to Icopal to see if it qualifies for recycling. If this is the case a partnering recycling firm will dismantle and collect the

bitumen construction and demolition waste and transport it to Icopal. This service requires a fee and Icopal or similar firms do not pay for construction and demolition bitumen roof waste.

Glass

The process of recycling sheet glass or windows is relatively new and it was only in 2002 when the world's first sheet glass processing plant was opened in Belgium, by a firm called Maltha. All of the recycled construction and demolition glass in both Belgium and the Netherlands is reproduced at this facility. When the glass is qualified as clean enough to be recycled it will be processed into new small glass particles that are sold for multiple purposes to manufacturers. Depending on the purpose, the recycling process will be slightly modified. The main uses of the recycled flat glass are: sheet glass, insulation products, and the packaging glass industry, at 15%, 13%, and 71.5%, respectively (maltha-glassrecycling.com).

The business model starts at Dutch national legislation. Every producer or importer of sheet glass must pay a fee of $0.56 per 10.76 square feet of sheet glass that it produces or imports. This waste disposal fee is paid to an organization called Vlakglas Recycling Nederland who provides free of charge collecting points throughout the Netherlands for sheet glass. Larger amounts of construction and demolition waste sheet glass can be collected at location, however a fee has to be paid for this.

As mentioned earlier, all this sheet glass is transported to the Maltha recycling plant in Belgium where it will be processed in order to be sold on a secondary market.

Concrete

Concrete is a mixture of stone, gravel and sand (aggregate), water and cement. There are several types of concrete, depending on the used production method and whether or not additives are included in the concrete. Some examples are: reinforced concrete, concrete stones, and autoclaved cellular concrete (ACC). The following discussion provides an overview of potential concrete reuses.

End-of-life concrete accounts for about 80% of construction and demolition waste in the EU. Currently most of the concrete waste is used for road construction. The C2CA project is a European project that studies the recycling technologies for concrete and the economic feasibility of recycled concrete.

The C2CA project is a European project with partnerships between leading experts from universities, demolishing companies and cement industries. While present technologies available to recycle concrete are energy intensive and polluting, the C2CA technology aims to reduce CO2 emissions and standardize quality control. The technology allows for local re-use of up to 80% of the waste at the building site which will highly reduce transportation of concrete.

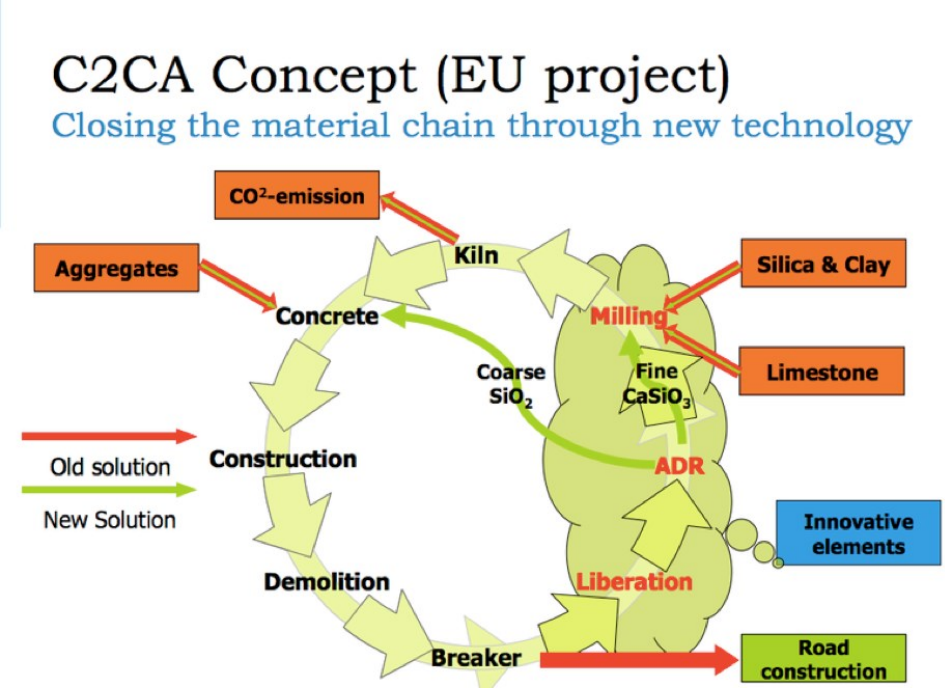


Figure 14:C2CA Concept
Source: http://www.c2ca.eu/activities/the-recycling-process/

Advanced Dry Recovery (ADR) is a new technology that is being developed by this project. ADR is operated mechanically and without prior drying or wet screening. This reduces process complexity and avoids problems with dust or sludge. ADR is applied to remove the fines and light contaminants.

It uses kinetic energy to break the bonds that are formed by moisture and fine particles and can classify materials almost independent of their moisture content. After breaking up the material into a jet, the fine particles are separated from the coarse particles. ADR separation has the effect that the aggregate is concentrated into a coarse aggregate product and a fine fraction which includes the cement paste and contaminants such as wood, plastics and foams.

Figure 15: ADR Separation
Source: http://www.c2ca.eu/gallery/

The C2CA project partners are:

Universities and research centers

- Delft University of Technology (NL)
- La Sapienza University of Rome (IT)
- AGH University of Science and Technology (PL)
- Institute of Chemical Engineering and High Temperature Chemical Processes (GR)
- Barcelona Supercomputing Centre (ES)
- Leiden University (NL)
- Technical University Denmark (DK)

Companies and industrial partners

- Strukton (NL)
- Theo Pouw (NL)
- Heidelberg Cement (DE)
- Holcim (CH)
- DV srl (IT)
- Laser2000 (NL)
- Inashco R&D (NL)

Bricks

On a smaller and local scale in Europe, bricks are sold for re-use after the deconstruction of a building. Bricks are very durable and have a long lifetime. Depending on the type of cement or mortar used with the bricks, removing them from a building can be destructive. In order to prepare a brick for re-use the

mortar can be removed manually or with temperature treatment. Van Dijk (2001) proved that bricks covered with cement require a temperature of 1000°F for separating the brick from the cement. Higher temperatures will result in more cracks in the bricks. For the recycling of bricks some practices include the crushing of bricks to be used as aggregate, as well as aggregate being used to make new bricks. Because of their mineral structure bricks can be used after demolition as: filling and stabilizing material for infrastructure works, aggregates precast and prefabricated concrete and mortar, aggregates for calcium silicate bricks, and red “crushed brick" as clay tennis courts. The company StoneCycle is developing different sorts of brick that are 100% made out of different sorts of construction and demolition waste. The company was founded in 2013 and although progress has been made there does not yet exist a large scale production of these construction waste recycled bricks (stonecycling.com).

Granulates

Stony granulates that are derived from crushing concrete, asphalt, and other debris are normally of very low value and are commonly used for roadway foundations, backfill operations, and drainage. When granulates are processed for the concrete industry it is of much higher value. However, the quality standards are so high that only a small amount of high quality granulate can be used to make new concrete. In conclusion, it is hardly economical feasible to ship granulates from the U.S. to industries in Europe because of the overall low values and high spatial volumes.

Metals

Except for the instance of unprocessed wood, all of the above mentioned materials and industries are unlikely to be shipped from the U.S. to Europe because the value is too low or fees must be paid by the U.S. party instead of the other way around. However, metals may be a game changer in this matter.

Metals, especially structural steel, are some of the most valuable materials in a building and usually easy to sort and recycle after demolition. Because of their relatively high value, a global market for trading scrap metal already exists. The main question is if the sum of the price minus the transportation costs in Europe is more attractive than selling U.S. scrap metal on the U.S. scrap metal market.

Something to take into consideration is that metals prices are subject to global markets. They change every day and are quoted by several firms and exchanges. One of them is the London Metal Exchange which also provides quotes for both scrap and re-bar metal. The fact that metal prices are quoted globally may not foster the economic feasibility of transporting scrap metals from the U.S. to Europe.

An industry insight from the second largest metal producer of the Netherlands reveals that the market for recycled metals is lively but consists of large networks. This means that steel producers do not purchase the scrap steel directly from the source (i.e. the demolition firm) but several firms who act as middlemen are situated between the source and the final user (personal communication, June 17, 2016). There are very few companies who operate on a global scale in this sector, and one of them is EMR Group. EMR has facilities located all over the world including the Netherlands and the U.S. It is because of this global presence that the recycled metals are likely to be traded and processed domestically. Therefore the intercontinental trade in C&D metal waste is of no significance.

Wood Products

Due to significant focus given to deconstruction of wood-framed buildings by the U.S. Forest Service since the early 2000s (Falk, 2005; Falk and Guy, 2005; Falk et al., 2008), relatively robust salvaged lumber markets exist in the Midwest and information about them is readily available. Additionally, Reclaim Detroit and the Architectural Salvage Warehouse of Detroit both provide regional outlets for salvaged lumber and wood products resulting from deconstruction operations largely in the Detroit metropolitan area.

Within the Midwest, many options exist for the processing and value-added use of salvaged lumber, to include board lumber, engineered flooring, millwork, oriented strand board (OSB), sawdust, wood doors, and wood chips. Table 10 on the following page is based on a review of the Reusewood.org North American Wood Reuse and Recycling Directory (reusewood.org, 2016). A query was run for companies located within a 150 mile radius of Muskegon, MI (straight line radius) that accept salvaged wood products for re-sale or other value-added reuse. This represents a starting point to identify local and regional markets which might accept salvaged building materials, without looking so far out from Muskegon that shipping costs my become a deterrent. In cases where the database listed potential outlets for these materials beyond the 150 mile radius, a total count has been provided of these facilities in each section.

Board lumber is typically reused for non-structural applications. According to a national industry survey conducted by the U.S. Forest Service (Falk and Guy, 2005), 2x4 lumber is typically the smallest nominal board size salvaged (33% of respondents). Thirteen percent reported salvaging only 2x6 and larger, while a combined 22% of respondents reported the ability to salvage 1x4 or 1x6 lumber. Six foot lengths were reported as typically the shortest lengths salvaged for dimensional lumber, nearly twice as often as four foot lengths.

Oak, pine, and Douglas fir were the most desired materials for salvage and resale; these also align with the most common species of wood species in residential construction. The most prevalent value-added material from these materials was flooring, accounting for 50% of the responses about value-added reuse.

While it is technically feasible to reuse this material for structural purposes, the cost to regrade and recertify the lumber often makes this process impractical. Poor quality materials, such as those damaged by fire, smoke, rot, and insects, may become feedstock for the manufacture of wood pellets. Eleven companies were identified within a 150-mile radius of Muskegon that accept salvaged board lumber; an additional 161 companies were identified between 160 miles and 1,953 miles from Muskegon. Typical value-added products from this material include interior trim and millwork, engineered lumber, hardwood flooring, and treated wood.

Table 10: Companies Accepting Salvaged Wood Products within 150 Miles of Muskegon, MI
Source: (reusewood.org, 2016)

Table 10: Companies Accepting Salvaged Wood Products Within 150 Miles of Muskegon, MI								
Company Name and City	**Distance (miles)**	**Board Lumber**	**Engineered Flooring**	**Millwork**	**OSB**	**Sawdust**	**Wood Chips**	**Wood Doors**
Pragmatic Construction Milwaukee, WI	86	X		X				X
IM Salvage Co. Milwaukee, WI	87	X		X				X
TKG Environmental Services Group Waukegan, IL	100		X	X	X	X	X	X
Odom Reuse Traverse City, MI	103	X		X				X
Soil Solutions Elkhart, IN	108						X	
Architectural Artifacts Chicago, IL	114	X		X				X
The Rebuilding Exchange Chicago, IL	115	X						X
Habitat for Humanity of Saginaw Saginaw, MI	116	X		X				X
Soil Solutions Goshen, IN	116						X	
Castle Ridge Keep Crystal Lake, IL	124					X		
Habitat for Humanity Restore Appleton, WI	126	X		X				X
Habitat for Humanity Northern Fox Valley Restore Elgin, IL	133	X		X				X
North American Dismantling Corp. Lapeer, MI	148	X		X			X	X
21st Century Salvage Ypsilanti, MI	150	X		X				

Engineered flooring uses a solid wood veneer glued onto a wood substrate. The flooring is typically between ½" and ¾" thick and can be manufactured up to 12" wide. Due to its newness, engineered flooring may not be encountered frequently in building deconstruction operations; however, one company was located within 150 miles of Muskegon that accepts salvaged engineered flooring in the production of wood chips. While chipping may not provide a strong return on investment for the intrinsic value of this material, it may provide an option in the case of salvaging damaged flooring. Six additional facilities that accept salvaged engineered flooring were identified between 190 and 1,900 miles from Muskegon, in Indiana, Ohio, Arkansas, Connecticut, California, and Washington.

Millwork is a broad category generally consisting of wood trim materials, to include moldings, window and door casings, window and door frames, door slabs, and staircase components. Ten companies within 150 miles of Muskegon were located that will accept salvaged millwork; an additional 130 companies were identified between 160 and 1,953 miles of Muskegon. Due to the high intrinsic value of these materials, most of these firms resell the millwork in its existing condition; however, one solution provider lists their material production services as shavings and woodchips, again providing an opportunity to salvage damaged, lower-value materials.

Oriented Strand Board (OSB) is a structural panel product made up of wood strands that have been bonded together in a phenolic resin matrix through a process using heat and pressure to form boards. Challenges to the reuse of OSB include the material's low durability (i.e., leads to damage during the deconstruction process), propensity toward water damage when exposed to the elements, and the lack of a "clean" waste product due to the presence of resins and binders. One company located within the 150 mile radius of Muskegon accepts OSB in the manufacture of shavings and wood chips. Three additional firms were located between 190 and 1,906 miles of Muskegon, located in Indiana, California, and Washington. These plants manufacture a combination of one or more of pallets, woodchips, wood shavings and/or mulch.

Sawdust and wood chips, while typically not found in a building during the deconstruction process, could be generated relatively easily by contractors from low-value wood salvaged from these buildings. Sawdust is generally a by-product of other manufacturing processes, such as sanding or planning, and wood chips are larger pieces of wood, generally made through a chipping or flailing process. Two companies within a 150 mile radius of Muskegon accept sawdust; an additional two firms accept wood chips. One company produces shavings and chips, two produce mulch and compost, and one produces animal bedding, woodchips, and mulch. Ten wood pellet manufacturing plants are located within Michigan; however, they did not appear in the Reusewood.org database. These plants all accept some combination of sawdust and/or wood pellets. An additional 96 comparable firms were located between 190 and 1,906 miles of Muskegon. Like the ones located nearer to Muskegon, the majority manufacture a combination of shavings, chips, mulch, compost, and animal bedding.

Wood door slabs are typically found in one of three forms: 1) panel doors, 2) hollow core doors, and 3) solid core doors. Panel doors are typically a full thickness slab, ranging from 1.5 to 2.5 inches thick. Thinner inset panels may be used to provide decorative styles. Hollow core doors use thin wood veneers (approximately 1/8 inch thick) attached one either side of 1 inch spacers; these spacers are the only solid fill inside the door. Solid core doors are constructed similarly to hollow core doors, except the two veneers surround a solid core of engineered wood (hardboard or particleboard). Doors are commonly salvaged and reused as-is, or used in many up-cycling modes, to include wall paneling, headboards, tabletops, and

other consumer goods. Eleven companies were located within a 150 mile radius of Muskegon that accept salvaged wood doors; an additional 134 companies were found from 160 to 1,953 miles from Muskegon.

The Michigan Context

Michigan has several existing industries that may be in a position to accept salvaged building materials from deconstruction operations, and remanufacture them into other commodities. These industries include hot mix asphalt, wood pellets, and composite/engineered lumber products.

Wood Pellet Manufacturing

Michigan has a well-developed wood pellet manufacturing industry. A review of pellet plants conducted by Biomass Magazine identified eleven manufacturing facilities in Michigan, which are distributed across the state, though the largest concentrations are in the northern lower and upper peninsulas (Biomass Magazine, n.d.). These plants have a combined capacity of 255,650 short tons of pellets (by volume) per year, which represents 14% of the national industry.

While pellets may be manufactured by first chipping logs, the majority of manufacturers utilize chips or sawdust, which originate as waste materials from sawmills and other local wood products processors. Some facilities, such as Maeder Brothers Quality Wood Pellets in Weidman, Michigan, collocate pellet production facilities with an existing sawmill, in order to capitalize on the opportunity for sawmill waste materials as a feedstock for pellet manufacturing.

While export markets for U.S.-manufactured pellets seem to be slowing down, the domestic market is expected to experience 67% growth between 2013 and 2020 (Strauss, 2014). This is a result of increasing residential demand, as well as the potential to use pellets as either a primary fuel source or as a co-fired fuel in older coal power plants. Additionally, Michigan has significant potential to increase growth in rural residential markets, as over 800,000 rural residences that are not currently connected to natural gas could be converted to wood pellet heating fuel, just through use of the in-state resource (Strauss, 2014). This represents significant potential opportunity to use low-quality salvaged wood as a feedstock for pellet manufacturing. Six of the ten pellet plants in the state are located within 125 road miles of Muskegon, representing an annual pellet capacity of 199,000 short tons (77.8% of total statewide pellet capacity).

Composite/Engineered Wood Products

Compared to other Upper Great Lakes states and provinces, Michigan does not have a very large or diverse composite and engineered wood products market. Oriented strand board (OSB) has been a mainstay of this industry sector in the state, as a result of manufacturing facilities located in Grayling and Sagola, Michigan. Weyerhaeuser's OSB mill in Grayling produces OSB for flooring panels and sheathing products. The Louisiana Pacific mill in Sagola produces OSB for use in composite siding, manufactured in Newberry, Michigan. Both mills receive logs and use flakers to create the strands that are needed for OSB from various species of wood. At this time, pre-flaked wood or chips are not used in the production of OSB at either facility; however, this could represent an opportunity for the use of clean, pre-flaked wood from deconstruction/salvage operations.

Auraco North America announced during the summer of 2016 that they would open a particleboard mill in Grayling, MI with a production capacity of 424 million square foot per year. This mill utilizes a different

wood species mix than does the neighboring Weyerhaeuser facility, thereby minimizing competition for the same resource. The new mill is also said to complement the company's medium density fiberboard (MDF) plant located in Sault Ste. Marie, Ontario. Both the Grayling and Sault facilities could be consumers of pre-processed (i.e., clean dimensional lumber processed into wood flour, sawdust, and/or chips) salvaged lumber from deconstruction operations, which is then transported to these facilities for use as a feedstock in the manufacturing process.

Torrefied Wood

Torrefaction is a process whereby biomass is subjected to high temperatures (200-300°C), which produces a better fuel for combustion and gasification applications. Torrefied wood is a very stable, dry product, without concerns related to rot or biological growth on the biomass. Value added through torrefaction includes higher energy density, water-repellant behavior, elimination of biological activity, and improved grindability. These properties make torrefied wood a potential replacement for coal in traditional combustion boiler-based power plants. Additionally, torrefied wood has significantly lower mineral content compared to coal; ash content is 10-25% lower than that of coal and sulfur content is 95% lower than that of coal (Hopkins, 2008).

Torrefied wood has an energy value that is nearly that of coal (12,000 BTU/lb. for coal; 11,000 BTU/lb. for torrefied wood), with the same fuel generation efficiency (35% fuel to energy). The North Carolina analysis shows that torrefied wood breaks even with coal at a coal cost of $80/ton, making this technology more feasible than ever. Similarly to wood pellets, torrefaction can utilize low quality salvaged wood that has been pre-processed into chips. While not at the top end of the value chain, this may represent a significant market opportunity for the movement of large quantities of waste wood, as exists within this study's catchment area.

Transmaterial

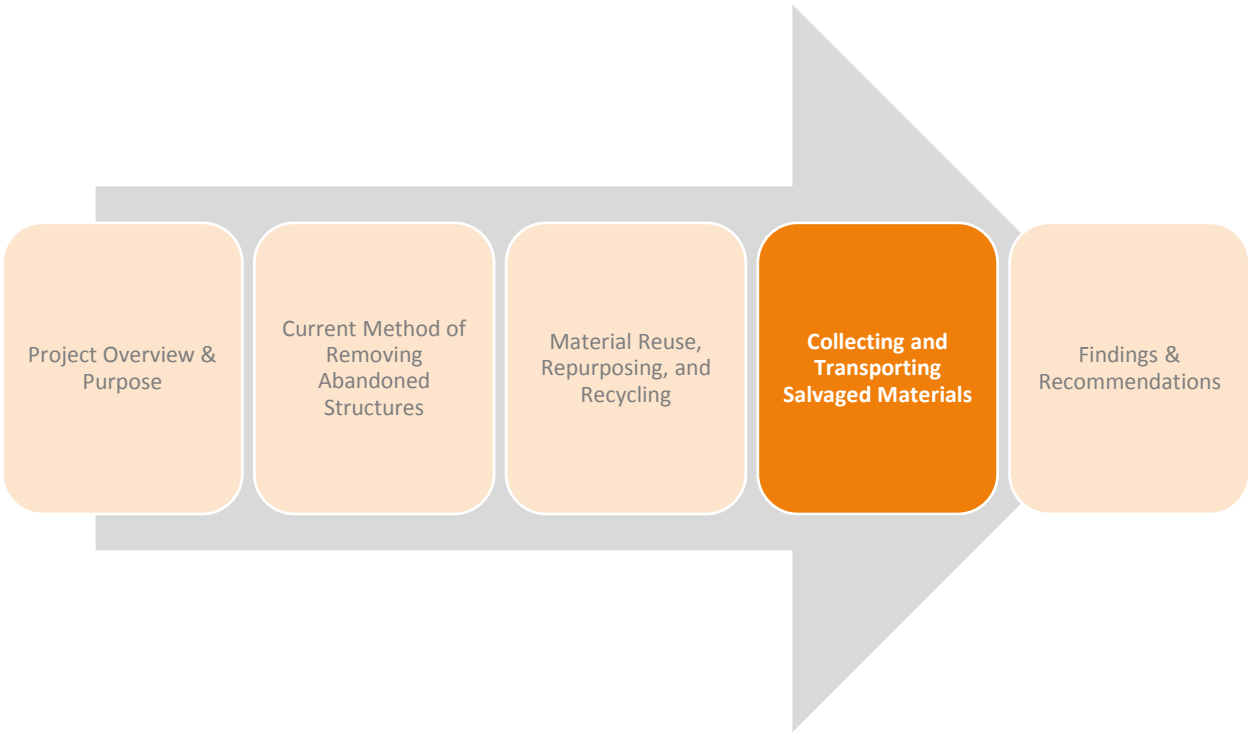
'Transmaterial' was identified as one of the possible outlets of salvaged materials. These are emergent products that are technologically advanced and environmentally friendly, and inspire designers to create transformational spaces. A major portion of these products, which are used to create hybrid structural, spatial and surface systems, is biochemically manufactured from 'second-life' materials derived from repurposed waste. Even though the performance of the repurposed material is not the same as the product it replaces, new and unexpected benefits arise from its reuse. Blaine Brownell, the author of the 'Transmaterial' book series and editor of the 'Transstudio' online material forum, has curated several catalogs of these innovative products that seamlessly combine material technology and waste management. Examples of Transmaterial that can be generated from the salvageable materials that have been identified in the catchment area of this study are given in Table 11.

Table 11: Transmaterial Applications from Commonly Salvaged Material

Category	Name	Item No.	Description	Content	Applications	Contact
TRANSMATERIAL, TRANSMATERIAL 2 AND TRANSMATERIAL 3						
Concrete						
	Faswall	031119-001	Recycled Insulating Concrete Forms	Recycled Waste Wood Chips, Portland Cement	Cast-in-place Concrete Construction	K-X Faswall International Corp. Montmorenci, SC
	Intaglio Composites	034000-002	Photographic Imaging in Concrete	Concrete	Vertical, Horizontal	Intaglio Composites Arlington, TX
	Sensitile Terrazo	034800-001	Light-reactive Concrete	Concrete, Polymethyl Methacrylate (PMMA)	Decorative surfacing, flooring	SensiTile Systems Detroit, MI
	Erwin Hauer Continua	121400-004	Digitally Fabricated Multidimensional Surfaces	Concrete, Gypsum Cement, Stone	Wall Panels, Space Dividers	EHR Design Associates LLC New Haven, CT
Metal						
	Tri-Chord Steel	054100-001	Thermally Efficient Steel Framing System	Postconsumer Recycled Steel	Structural and Non-structural Framing	Tri-Chord Steel Systems, Inc. Phoenix, AZ
	City Servings	124616-001	Vessels made from Repurposed Metals	Reclaimed Metal Washers, Connections	Containers, Art Objects	Realm Dekor Columbus, OH
	Leaf	265113-003	Adjustable Bicolor LED Light	Steel, Aluminum, Plastic	Tablelamp, Wall Lighting	Herman Miller Inc. Zeeland, MI
	Live Within Skin	129200-001	Vertical Garden Wall System	Steel, Stone, Cladding, Coir-Growing Medium	Architectural Facades, Fencing and Landscape, Interior Accent Walls	Greenememe Los Angeles, CA
	My Studio	125916-001	Recyleable Office-Furniture System	Steel, Wood, Aluminum, Glass, Laminate	Workplace Furniture	Herman Miller Inc. Zeeland, MI
	APEX Mesh	055000-003	Expanded metal mesh	Carbon steel, Stainless steel, Copper, Brass, Aluminum	Facades, Sunscreens, Balustrades	Amico Burlington, ON Canada
Wood						
	Body Index	125200-003	Biomorphically Derived Chair	Leather-clad Plywood Core, Steel Base	Furniture	Proces2 San Francisco, CA
	Moveable Walls	102219-001	Pre-assembled, Moveable, Full-height Partitions	Recycled Wall Covering, Wood Pulp, Gypsum, Recycled Glass, Recycled Cotton Insulation	Office Interiors	Haworth Calgary, Alberta - Canada
	Ecotextures	064200-002	Panels Crafted from OSB	OSB	Wall Panels, Flooring	Architectural Systems, Inc. New York, NY
	Agriboard	061200-002	Bio-based Structural Insulated Panel	Engineered lumber, Oriented Strand Board	Commercial, Residential buildings - upto 3 stories	Agriboard Industries Electra, TX
	Structural Tambour	068000-012	Wood-fabric Hybrid Tambour	Wood, Fabric, Staples	Furniture, Installations, Flooring	University of Wisconsin, Madison
	Clamp-A-Leg	125000-006	Set of Legs to make an Instant Table	Wood, Cast Metal	Tables, Desks, Counters	Jorre van Ast London, UK
Glass						
	Stones	088113-002	Recycled Construction-Waste Glass	Recycled Cast Glass	Feature Walls, Sculptures, Door Panels, Skylights	Joel Berman Glass Studios Ltd. Vancouver, BC - Canada
	Ombrae System	413000-001	Sculptural Imaging with Optical Tile	Material Substrates - Glass, Plastics, Stone, Concrete, Metal and Wood	Product Design, Architecture and Interior Design Elements, Packaging, Signage, Advertising	QMAAS Vancouver, BC - Canada
	Crystalized Glass Stone	093000-003	Glass-Stone Tiles and Slabs	Glass	Flooring, Surfacing applications	Architectural Systems, Inc New York NY
	G Series	099413-001	Recycled Glass Architectural Coating	100% Postconsumer Recycled Glass	Wall, Ceiling applications, Customized Canvas	EverGreene Architectural Arts, Inc. New York NY
	IceStone	123613-001	Durable Surface Material	Recycled Glass, Cement	Kitchen Countertops, Bathroom Vanities, Flooring, Wall Cladding, Outdoor Furniture	IceStone LLC Brooklyn, NY
Mineral						
	Photo-cast Tiles	093013-001	Photographic Bas-Relief Ceramic Tiles	Clay, Gypsum Polymer, Metal Powder	Wall Tiles, Accents	Photo-Form LLC Scottsdale, AZ
	Fusionstone	096340-001	Fused Stone and Glass Composite	Stone, Glass	Counter Surfaces, Flooring	Architectural Systems, Inc. New York, NY
Plastic						
	Flexisurf	096516-002	Reclycled PVC Flooring	Recycled PVC, Polyester	Resilient Flooring, Tabletop Surfaces, Ladder Treads, Mousepads	Yemm & Hart Ltd. New York, NY

The variety of reuses noted in the analysis and Table 11 above can be helpful in attracting selected users or suppliers of these products in the target region of West Michigan.

CHAPTER 4: COLLECTING AND TRANSPORTING SALVAGED MATERIALS



CHAPTER 4: COLLECTING AND TRANSPORTING SALVAGED MATERIALS

In this section we examine the collection and transportation of material to the Muskegon region. Critical to the advancement of this sector will be the capacity to collect and efficiently transport structural materials in sufficient volume to sustain this sector within the catchment area. The research team expended considerable effort to determine the optimal method of transporting salvaged materials to Muskegon. With support from students from Erasmus University in the Netherlands, an in-depth analysis of shipping versus trucking was conducted.

Analysis of On-Site and Off-Site Treatment & Processing

Based on informal interviews with deconstruction contractors, land banks, and salvaged material warehouses, the current process of building deconstruction involves contractors mobilizing to each building location, and focusing efforts on a single building at a time. The deconstruction techniques typically employed are manual in nature, whereas mechanized efforts are typical in demolition processes (Zahir & Syal, 2015). Any salvaged building materials must then be collected onsite and transported to either an intermediate or final processing/resale location.

This commonly-used approach limits technical and economic efficiencies that are available through concepts of mechanization, bulk processing, on-site material staging and sorting, and pre-processing close to the point of origin.

The Potential for Local Separation of Materials

Various environmental and economic factors determine whether it makes sense to separate salvaged materials locally at the point of demolition/deconstruction. From an environmental perspective, on-site separation of materials may increase asbestos and lead contamination of the soil and air. Financially, if federal funding is being used in part to pay the wages of on-site deconstruction crews then the Davis-Bacon regulation may apply (see https://www.dol.gov/whd/contracts/dbra.htm for details); however, this may not apply if workers move off-site to a processing facility, or the number of units falls below the minimum. Another important factor is whether the local community has any facilities in place to sort and process materials. Chicago already has an established deconstruction hub called the Rebuilding Exchange, and Detroit planned to set up a deconstruction hub in 2017. Where such reuse hubs may exist, site separation may be unnecessary.

The most efficient method of material collection in local communities considered for this feasibility study is gathering what materials are left after the first and second skims to be sent in bulk to a collection site. At this collection site the high-volume/low-value material can be sorted, processed, and then loaded into an appropriate container for transport. This method increases the speed at which abandoned structures are removed but results in salvaged material that will need special consideration in handling and shipping to the final site for repurposing or reuse.

Great Lakes Shipping Potential

Potential of Transporting Salvaged Material to a Central Processing Facility

In order to transform the Port of Muskegon into a regional collection point for CDW, an economic assessment of the transportation possibilities must be conducted. The targeted catchment area consists of six Midwest states and is depicted in the figure below. Including Muskegon itself, 10 cities and counties have been investigated in regards to the possibilities of CDW shipments.

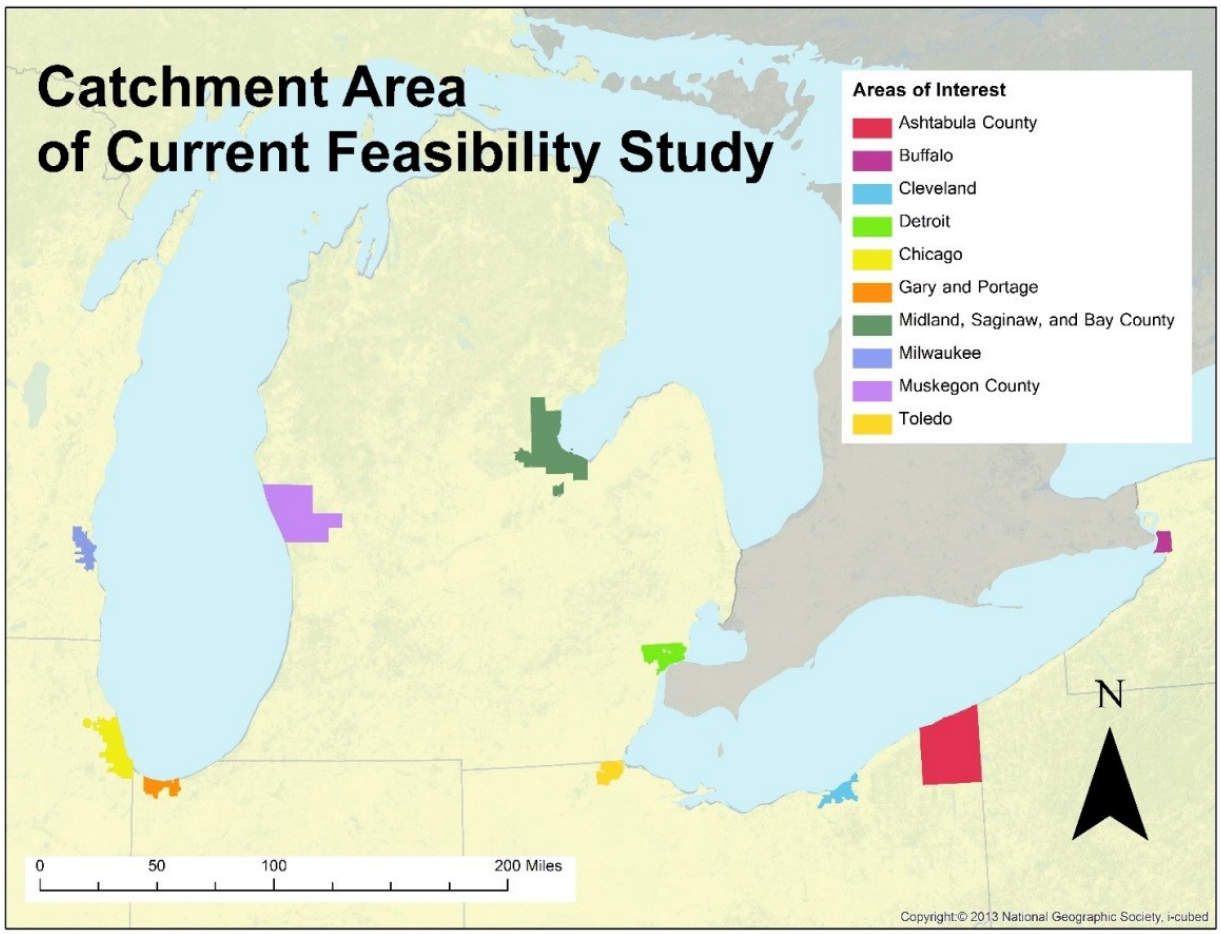


Figure 16: Feasibility Study Catchment Area

Considering the Port of Muskegon as the base point in this study, as it is the only naturally deep draft port on the west side of Michigan, waterborne transportation is included in the assessment of possible transportation options. In addition, this method is compared to road transportation by truck which is currently the most common form of CDW transportation. Rail transportation is excluded from the analysis based on confidential Waybill samples showing that Michigan has on average the highest freight rail rates in the United States (Prater, O'Neil Jr., & Sparger, 2013). This was re-confirmed with CN, one of the largest railroad operators in both the U.S. and Canada. Moreover, not all the railroads in the counties of interest

are operated by the same railroad company. For example, the Muskegon railroads are operated by a small local firm. This makes integration of all the destinations by rail costly. Additionally, retrieving relevant rates and information is difficult.

Overall, shipping CDW from the Great Lakes to Europe by water transport is uncommon; shipping firms indicate concerns about handling this type of material because of the low frequency, uncertain supply, and possible ship damage from hazardous materials. Waterborne shipping of CDW could utilize either containers, break-bulk ships, or barges. Container shipping is rarely seen on the Great Lakes. Break-bulk shipping is done in moderate frequency from the Great Lakes to Europe. Both dry bulk and liquid bulk represent the majority of shipping in the Great Lakes area. As demonstrated by concerns about hazardous materials, unprocessed CDW does not appear to be suited to either of these forms of transportation.

The main advantage of barge transportation is that it generally uses less energy on average than rail or truck transportation, although factors such as water currents and weather conditions can impact energy use. In addition, barges can carry much larger loads than other modes of transportation. An average Seawaymax barge can carry up to 2,500 TEU (twenty-foot equivalent), compared with one or two TEU for the average semi-truck. There are however limits, if salvaged materials aren't available to ship in extremely large quantities. Another weakness of barge transportation is that at some point in the process a truck must still be involved to move salvaged materials from the deconstruction site to a barge, and moving the materials from a site to a truck to a barge introduces a second cycle of loading and unloading which can lengthen the transport time and add cost. Loading from the site and then keeping materials on a truck until they arrive at the processing facility requires only one loading and unloading cycle.

Current Volume and Capacity of Great Lakes shipping

According to Martin Associates, "from 2006 through 2014, the total Great Lakes tonnage exhibited a 23.5% decline in total tonnage from 173 million tons in 2006 to 132 million tons [in] 2014" (Martin Associates, 2016). Notably, Great Lakes ports were badly impacted by the recession, and have never fully recovered. Foreign tonnage moving through the St. Lawrence Seaway was similarly impacted and hovers below pre-recession levels. From 2006 to 2015 international cargo declined from 47 million tons to 36 million – representing a decline of 23%.

Given the sharp decline in tonnage moving through the Great Lakes since the recession, and the loss of coal tonnage coming into the Port of Muskegon due to the closure of the BC Cobb power plant, the shipping industry might be well-poised to handle any increase in shipping volume related to the development of a deconstruction industry.

Domestic shipping companies

Two locally-based shipping companies were explored for the purposes of shipping salvaged building materials to the Port of Muskegon. These two companies are Pere Marquette Shipping and Andrie. Pere Marquette, based in Ludington, uses a U.S. flagged, self-loading, 494 foot articulated barge that has a 5,000 net ton capacity. It ships a variety of cargo including previous experience shipping scrap metal and lumber, and is equipped with a hydraulic crane that can be used as a clamshell, grapple, or magnet. Pere Marquette specializes in smaller quantities and cargos that are not suited for traditional self-unloading barges, and can often maneuver into smaller ports better than the larger "Lakers". Andrie is based out of the Verplank Docks at the Port of Muskegon, and operates multiple U.S. flagged barges and tugboats

capable of handling a wide variety of cargo. Available barge lengths range from 270 feet to 460 feet, and include articulated, towed, and self-propelled barges. A self-loading hydraulic crane is available on at least one of the barges. Although it may be possible to ship containers on these barges, it is much more likely that materials would be shipped as bulk or break bulk cargo.

International shipping companies

The team applauded Spliethoff, an international shipping company that is based in the Netherlands and already has bi-monthly shipping service with a general cargo ship from Antwerp (Belgium) to the Great Lakes. At the time of this study, they were not able to provide any guidance on their willingness to participate.

Another Dutch shipping company that is active in the Great Lakes is Wagenborg. They do not have any pre-determined shipping schedules from Europe to the United States. However they ship an average of two to three times a month from Europe (mostly Rotterdam) to the Great Lakes region. From Europe to the Great Lakes they usually ship large amounts of high quality steel and some other break bulk (i.e. paper and concentrates) to the ports of Cleveland, Detroit, and Chicago. Once they are completely unloaded they ship to the ports of Duluth and Thunder Bay (Canada) fully loaded with agricultural commodities such as grain.

Besides the fact that there is no room for extra cargo on the backhaul, Wagenborg is not very enthusiastic about shipping construction and demolition waste. This is due to the fact that their ships are on average only 6.5 years old and unprocessed CDW may damage the interior of the ships. They also acknowledge that other shipping firms may have the same objections, and apart from some inter-Europe household waste flows, they are not aware of intercontinental movements of CDW.

Wagenborg complies with the Jones Act, as they do not load and unload the same cargo within the United States. Therefore the Jones Act should not be problematical since, for example, a foreign operated ship could load some CDW waste in Milwaukee, then Muskegon, and finally Detroit before potentially exporting it to Europe.

Other shipping companies that ship internationally from the Great Lakes are mentioned in the Greenwood's Guide to Great Lakes Shipping, 2013 edition. Most of them are not suited to ship CDW from Lake Michigan. The shipping companies include:

- BBC Chartering Canada
    - Specializes in heavy lifting
- Fednav Limited
    - Have a substantial fleet including break-bulk ships and have bi-monthly lines from the Great Lakes to Europe. Unfortunately, they do not have experience with CDW and are not very interested in this project. When and if there is more interest they will get in touch.
- Hapag-Lloyd Canada
    - Ships only from Montreal
- Jebsens International
    - Ships only to the end of the St. Lawrence Seaway
- Laurin Maritime Inc.
    - Ships only liquid bulk, mostly petroleum

- Lithuanian Shipping Co.
    - Operates only three ships, two of them have drafts that exceed the maximum of the Port of Muskegon
- Navigation Maritime Bulgare
    - Operates only bulk ships
- Polsteam USA Inc.
    - Operates only bulk ships
- Stolt-Nielsen USA Inc.
    - Ships only liquid bulk

Container shipping via the Great Lakes

Since its introduction in the 1960s, the container has evolved to become one of the most important technical improvements contributing to the process of globalization. Containerization has led to several changes in shipping economics and logistics, and how distribution and production relate to each other. After the introduction of the container, new distribution practices developed, such as a shift from push logistics to pull logistics (Notteboom & Rodrigue, 2009). Containerization of bulk cargo has gradually increased over the past decades. One of the main factors of this increase has been the imbalance in global trade relationships and container cargo movements (Kawasaki & Matsuda, 2015).

Due to the nature of transporting bulk material there are several challenges that occur when moving bulk material in or out of a container. First of all, the availability of containers can be problematic. When using containers for widely dispersed activities, like building and deconstruction material transportation, containers must be available within a close proximity. Additionally, sufficient quantities must be present and the containers have to be suitable to load the materials that must be moved. This is an issue since the majority of the containers are owned by maritime shipping companies that prefer these containers to remain within their system so that they generate income for the maritime shippers instead of generating income for truck, rail, or barge companies (Rodrigue & Notteboom, 2014).

Another issue involves container handling. Containers are well suited to handle packaged cargo that moves into the container either directly or on pallets. When handling bulk material such as deconstruction materials, the cargo is likely to impact the state of the container because of dust or damage. This raises the possibility of damaging other goods after CDW transportation within a container. Dedicated containers that only handle bulk material like CDW are another option and would reduce the cost of container preparation (Rodrigue & Notteboom, 2014). However, this probably results in empty container movements and high costs of repositioning the container to the region needed. Ultimately this process may contradict the goal of using a container: a universal load and transportation unit. The next issue involves the loading and unloading of containers. Regular freight loads for containers are dominantly being loaded horizontally, either with forklifts or manually. Loading bulk cargo such as demolition material is a complex operation. Alternative techniques are possible by loading the freight vertically by lifting the container, enabling loading and unloading the container. This requires specialized equipment, at both loading and unloading sites, that are able to flip the container vertically. This could be an attractive option when there is a constant flow of materials (Rodrigue & Notteboom, 2014).

The weight issue is also a challenge when moving bulk materials in containers. Conventional freight being moved in containers such as retail products tend to be much lighter than bulk material. The shipping industry prefers using larger containers (40 footers) because they offer economies of scale. Containerships are designed for a specific weight load distribution. When adjustments have to be made in the distribution of this load, shipping lines might start to increase their loading fees.

Considering the ports that are located within the containment area, the research team noted that only Cleveland (26,619), Detroit (211), and Milwaukee (2) are listed as having inbound and/or outbound container traffic in the year 2015 (Saint Lawrence Seaway Management Corporation, 2015)[2]. Although other ports do have some infrastructure available to handle containers, the fact that there are no containers currently being moved could make the initiation of a container transportation system harder.

On the other hand, shipping CDW with containers has some advantages. Some materials such as gypsum/drywall must be protected from rainy conditions, necessitating constant covered shipping. Another advantage is that a storage facility for containers only requires an open piece of land whereas most bulk materials must be stored covered. Nevertheless, these advantages probably do not outweigh the shortcomings of CDW container shipments in the Great Lakes region.

Summarizing the above findings, it is currently not practical to ship CDW in containers. The main reasons include the lack of container supplies in the Great Lakes region, the need for specialized loading and unloading equipment at the origin and destination, the corresponding cost, and the absence of a container infrastructure in most of the ports of interest.

Transportation of CDW to Muskegon: Shipping versus Trucks

Road Transportation Cost Analysis

Doing an economic analysis on specific trucking routes requires a number of assumptions to be made in order to obtain verifiable results. The first and arguably most important assumption involves the cost factor of truck transportation itself. The cost rate per mile is retrieved from DAT data which monitors more than $28 billion in freight bills in over 65,000 lanes. Moreover, the rates are updated weekly to market conditions and Midwest specific rates are also provided. The rates used in this analysis were for the week of August 7th -13th, 2016 and averaged $1.92 per mile (DAT Trendlines, n.d.). This rate is for closed vans which are suited to transport general cargo, including CDW. The fact that these rates involve closed vans is favorable for this specific study since gypsum/drywall is a material of interest.

The per-mile-rate is assumed to include fuel costs, driver costs, material costs, depreciation costs and a number of other relevant costs; however, route specific toll costs are not included. Therefore, the desktop application of Tollsmart is used in order to obtain these costs.

As for the car load, a closed semi-large truck with five axles is taken as a reference point. These trucks are assumed to be able to carry 26 metric tons (Tennessee-Tombigbee Waterway, n.d.). This number is

[2] These figures are limited because only container shipments that moved through the St. Lawrence Seaway are taken into account. Nevertheless they provide a good estimation of total hauls.

important in order to calculate the truck rate per ton-mile. This makes the comparison with waterborne transportation possible.

The last assumptions necessary for the economic analysis are the start and end points of the route. The Mart Dock in Muskegon was used for the end point since it is accessible by road and water and offers both handling and storage services of cargo. For the nine target counties their local ports were used as the starting point of the route. The only exception is the City of Gary which uses the Port of Burns Harbor, located 10 miles away, as its starting point. All the route distances to Muskegon are calculated using Google Maps and measured in miles.

The table below provides an overview of the cost components for each route with the cost per ton mile as the most important indicator. This is set at $0.07 based on a truckload capacity of 26 tons and a $1.92 per mile rate. Since the legislation on recycling in Canada is more sophisticated than in the U.S., which also results in a large inflow of Canadian CDW into Michigan, the Port of Hamilton, Ontario is also included in the analysis, although it is not part of the catchment area for this study.

Table 12: Route Costs to Port of Muskegon

Port of origination	Distance to Muskegon	Toll cost in in USD	Total cost per MT
Milwaukee	285	27.75	$22.11
Chicago	180	9.20	$13.65
Gary	157	0.00	$11.59
Detroit	197	0.00	$14.55
Toledo	225	0.00	$16.62
Bay City	148	0.00	$10.93
Cleveland	339	32.25	$26.27
Ashtabula	399	32.25	$30.71
Buffalo	425	49.75	$33.30
Hamilton, Ontario	361	18.75	$27.38

A major advantage of shipping by truck is that the trucks can be loaded at the deconstruction site itself, and would then move directly to the recycling facility in Muskegon since a truckload of 26 metric tons can be filled at once. As previously mentioned, moving CDW to Muskegon via water requires two loading cycles, and a barge has several thousand tons of capacity which can be both an advantage and disadvantage. Due to the large quantity needed before shipment the CDW also has to be stored at the ports of origin before shipment to Muskegon.

Waterborne Transportation Cost Analysis

Transportation by water usually involves more activities and entities than road transportation, and requires a substantial amount of additional service investments. The necessity of a well-dredged and built port, including all services for handling cargo, is the largest differential factor. Moreover, ships and tug-barge combinations are more expensive than trucks.

These higher investment costs give preference to truck transportation for short to medium distance haulages. Both train and waterborne transportation become more plausible as the distance between two destinations increases. The break-even points of the transportation distances regarding these three modes of transportation are a widely discussed phenomenon in academic literature. A recent study by Rodrigue (2013) sets general break-even points for the three most used freight transportation modes: truck, rail, and maritime shipping. In the figure below two break-even points are depicted, point D1 is generally located between 350 and 500 miles, while D2 is located around 1,000 miles.

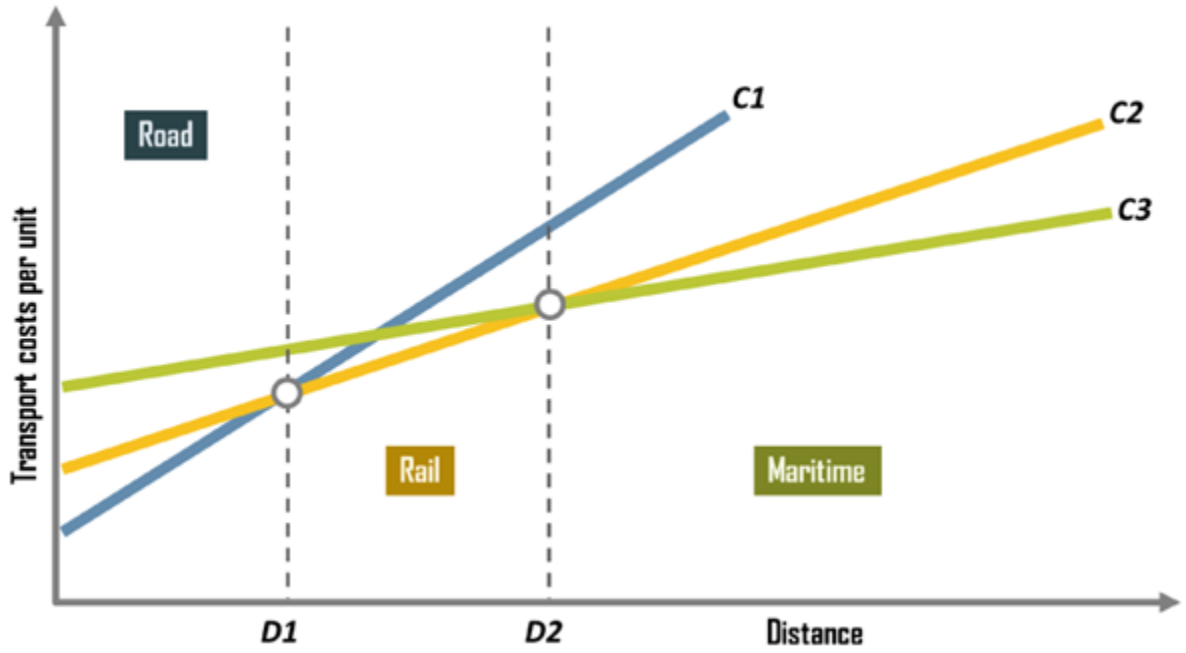


Figure 17: Transportation Costs Over Distance by Unit
Source: The geography of transportation systems (Rodrigue, 2013)

These distances are useful for the economic analysis of different transportation modes. Nevertheless, one should always take route-specific characteristics into account, and the figure above merely provides reference points.

Due to the infrastructure needed for waterborne transportation, no per mile rate is available or applicable. A rate for every route has to be obtained. Several shipping firms who operate in the Great Lakes area were contacted for information on this topic. The response rate was very limited but one of the larger firms operating within the region was able to provide helpful information. They provided two specific rates for a tug-barge vessel with a maximum capacity of 7,800 metric tons and bin walls on the side. Loading and unloading time are also taken into account. The rates are as follows:

- Hamilton, Ontario – Muskegon $230,000.00
- Detroit – Muskegon $115,000.00

No specific data was available for the other nine ports; however, the above data was used in conjunction with trip distance to create a specific rate for every route. As stated earlier, a drawback of waterborne shipping is drayage, or the transport of goods over a short distance as part of a longer overall journey. CDW first has to be shipped from the deconstruction site to the port by truck before it is trans-loaded onto a ship. Due to the large vessel capacity, it is also very likely that the CDW first has to be stored at the port before shipment to Muskegon. This implies three extra cost components compared to truck transportation: drayage, storage and trans-loading costs.

Based on consultation with experts in the field, the following costs per metric ton were assigned for each handling:

- Drayage: $6.00
- Storage: $2.00
- Transshipment: $5.00

Taking all the cost components into account provides the total cost rate per metric ton for each waterborne route, and these are presented in Table 13. Distances are provided in nautical miles and calculated using the online port distance tool at www.searates.com. The cost per metric ton is established assuming a fully loaded barge with a 7,800 metric ton capacity.

Table 13: Total Cost Rate per Metric Ton for Each Waterborne Route

Port of origination	Estimated Distance to Muskegon	Ship fee in USD	Ship fee	Drayage + storage	Trans-shipment	Total
Milwaukee	76	$45,000	5.77	8.00	5.00	$18.77
Chicago	101	$50,000	6.41	8.00	5.00	$19.41
Gary	99	$50,000	6.41	8.00	5.00	$19.41
Detroit	488	$115,000	14.74	8.00	5.00	$27.74
Toledo	537	$130,000	16.67	8.00	5.00	$29.67
Bay City	407	$105,000	13.46	8.00	5.00	$26.46
Cleveland	591	$150,000	19.23	8.00	5.00	$32.23
Ashtabula	615	$170,000	21.79	8.00	5.00	$34.79
Buffalo	712	$200,000	33.30	8.00	5.00	$38.64
Hamilton	778	$230,000	27.38	8.00	5.00	$42.49

**All rates are given in U.S. dollars and the last four columns are rate per metric ton (MT).*

Analysis Conclusions

Table 14 provides an overview of both the truck and barge rates per metric ton of CDW shipped to Muskegon from every port of interest. The transportation mode with the lowest rate is highlighted in green.

Table 14: Truck and Barge Rates per Metric Ton of CDW

Port of origination	Truck rate per MT	Barge rate per MT
Milwaukee	$22.11	$18.77
Chicago	$13.65	$19.41
Gary	$11.59	$19.41
Detroit	$14.55	$27.74
Toledo	$16.62	$29.67
Bay City	$10.93	$26.46
Cleveland	$26.27	$32.23
Ashtabula	$30.71	$34.79
Buffalo	$33.30	$38.64
Hamilton, Ontario	$27.38	$42.49

**the lower rate is highlighted in green*

Table 14, above, illustrates that truck transportation is preferred in nine out of 10 routes. Waterborne transportation is only economically favorable between Milwaukee and Muskegon. This is due to their geographic locations and the fact that water transport is both faster and a shorter distance than truck transport. For all other routes of interest, shipping CDW by truck is the best economic option. As previously mentioned, this is primarily due to the extra costs that come with waterborne shipments of CDW from a construction site including drayage, storage, and trans-shipment.

From a practical perspective truck transportation is also favorable over barge transportation. While the amount of CDW needed to fill up a barge and get the lowest transportation rates is very large, truck transportation is more flexible and does not require a large amount of CDW. In addition, no investment has to be made and no fees have to be paid for storage and trans-shipment infrastructure in ports of

origin. This makes truck transportation the preferred CDW transport option from both a practical and economical perspective.

Port Capacity of the Great Lakes

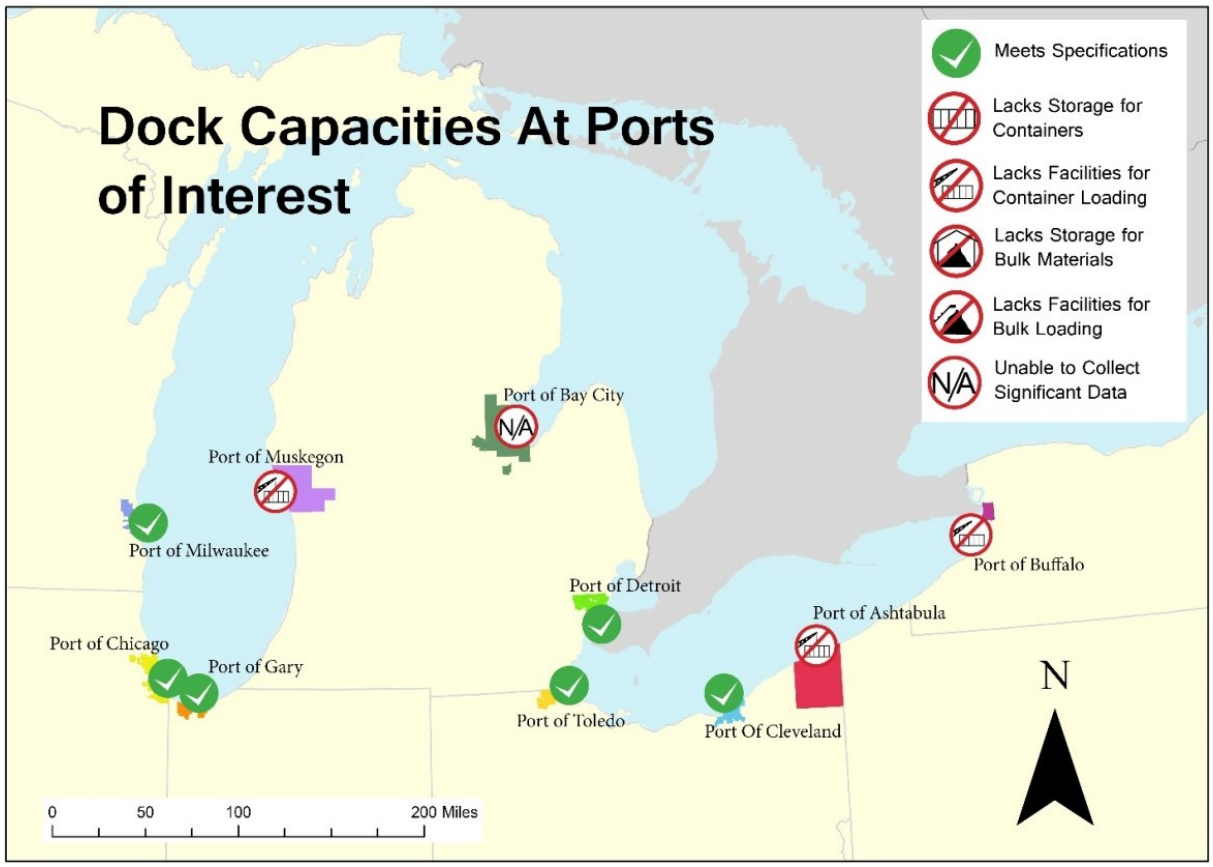


Figure 18: Dock Capacities at Ports of Interest

Port Authority Data

All the dock capacities at the ports of interest were assessed and are summarized in Figure 18. Several major ports such as Cleveland and Detroit have multiple quays (structures that are used for loading and unloading boats) which are privately operated. Therefore, the provided dock capacities of these ports refer to a private quay that has a large capacity available for other parties to utilize.

An interesting finding regarding the Port of Muskegon is that the available crane at the Mart Dock has the capacity to load and unload containers. However, an interview with the operating management of the dock revealed that it is not possible to load and unload containers at the moment because the right permits are not in place. It is expected that in the near future this hurdle will be overcome and containers will be able to enter and leave the Port of Muskegon. Table 15 provides more detail of the dock capacities of all the ports of interest.

Table 15: Dock Capacities at Ports of Interest

Port	Facility to load bulk material	Storage for bulk materials (covered)	Facility to load/unload container	Storage for container	Terminal size	Quay measurements (feet)
Muskegon (Mart Dock)	Yes	Yes	No	Yes	20 acres outdoor, 200,000 ft^2 indoor	2,500
Milwaukee	Yes	Yes	Yes	Yes	5 acres direct, more in port	1,300
Chicago	Yes	Yes	Yes	Yes	400,000 ft^2	3,000
Gary (Burns Harbor)	Yes	Yes	Yes	Yes	90,000 ft^2 covered, 330,000 ft^2 open	1,000
Detroit	Yes	Yes	Yes	Yes	200,000 ft^2 covered, 80 acres open	5,500
Toledo	Yes	Yes	Yes	Yes	600,000 ft^2 covered, 125 acres outdoor	4,100
Bay City	N/A	N/A	N/A	N/A	N/A	500
Cleveland	Yes	Yes	Yes	Yes	300,000 ft^2 inside storage	1,000
Ashtabula	Yes	Yes	No	Yes	400,000 ft^2 inside storage, 200 acres open storage	2,000
Buffalo	Yes	Yes	No	Yes	40,000 ft^2, 200 acres outside	3,900
Hamilton (Canada)	Yes	Yes	Yes	Yes	90,000 ft^2, 50 acres	1,500

Storage and Handling Capacity at Ports

The table below analyzes the capacity of the ports within the catchment area to accommodate the barge transport of materials salvaged from deconstructed homes. Consideration was given to whether the docks can handle storage of the materials, length of the docks, available equipment, and availability of a longshoremen workforce.

It is important to note that the minimum dock length needed to handle a Seawaymax cargo ship (the largest ship that can fit through the canal locks of the St. Lawrence Seaway) is 740 feet; whereas a first generation converted cargo vessel is typically 440 feet in length.

Table 16: Storage and Handling Capacity of Catchment Area Ports

Port Location	Warehouse /Wharf	Max. Dock Length	Lift/Crane Capacity	Longshoremen
Muskegon (Mart Dock)	Yes	2,500	2 45-ton gantry cranes	Available
Milwaukee	Yes	1,300	Crawler, mobile, and locomotive cranes	N/A
Chicago	Yes	3,000	Multiple cranes that can lift up to 250 tons	Available
Gary (Burns Harbor)	Yes	1,000	9 crawler cranes up to 240 tons	Available
Detroit	Yes	5,500	Multiple cranes that can lift up to 200 tons	Available
Toledo	Yes	4,100	Multiple cranes that can lift up to 225 tons	Available
Bay City	N/A	500	Cargo handled by ships gear only	N/A
Cleveland	Yes	1,000	Multiple cranes that can lift up to 300 tons	Available
Ashtabula	Yes	2,000	2 45-ton gantry cranes	Available
Buffalo	Yes	3,900	Mobile cranes available upon request	Available
Hamilton (Canada)	Yes	1,500	Cranes rented as required	Available

Outlier Ports

The Port of Hamilton, Ontario is not included in this study's original catchment area, and its data therefore cannot be used to influence the findings of this study. However the Port of Hamilton has significant data regarding its shipping capacity on the Great Lakes, and can be used to estimate the capacity of other Great Lake Ports in the designated catchment area. Gary, Indiana has a high number of abandoned structures, but no port within the city. However the nearby Port of Indiana – Burns Harbor, located in Portage, Indiana, allows for Gary's structural abandonment data to be included in the study.

Potential Upstream Obstacles

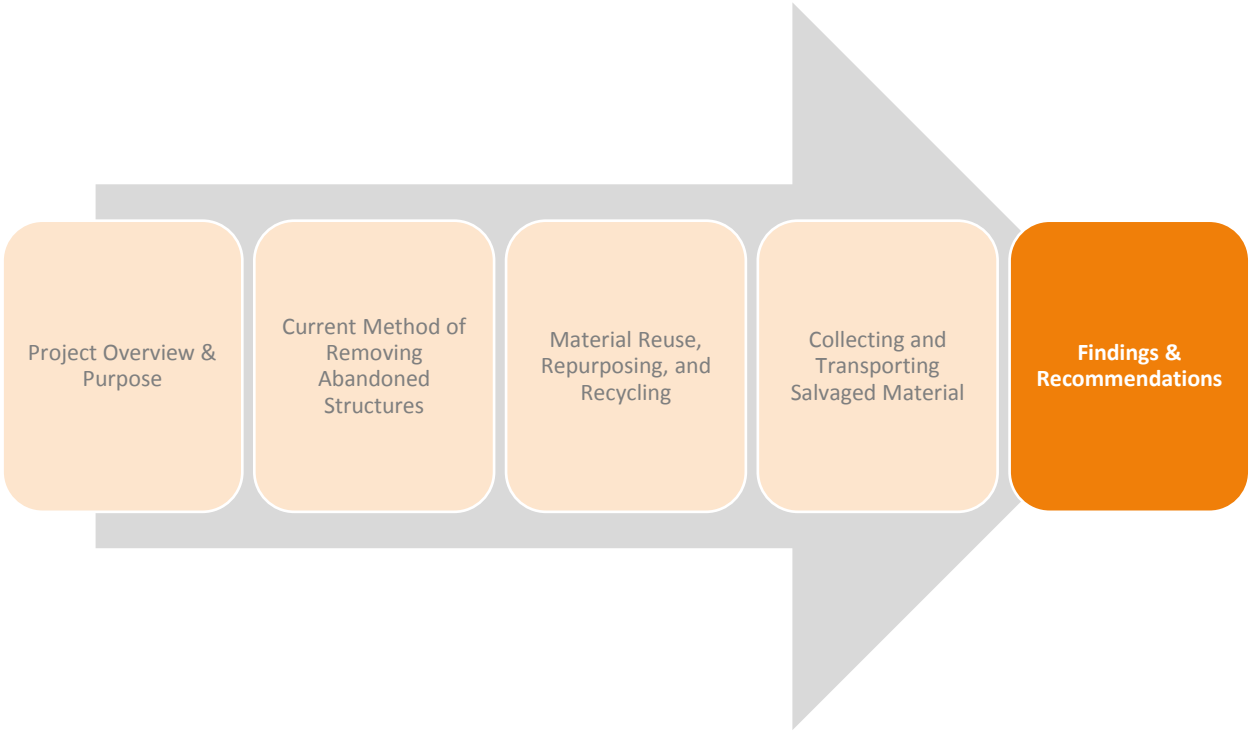
Cleveland's recent expansion into international shipping on the St. Lawrence Seaway is one of the few examples of regularly scheduled container shipping on the Great Lakes. While expansion into international and container-freight shipping offers regional economic growth to Great Lake port cities, certain obstacles make container shipping more difficult on the Great Lakes as compared to ocean-going container ships. Container freight shipping is significantly larger than typical ships moving bulk cargo around the Great Lakes. This presents logistical complications for Great Lake ports, and in particular for the locks on the Great Lakes-Saint Lawrence Seaway system, which are too small for large container ships. In addition, while container shipping consumes far less fuel compared to typical lakers, they move very slowly. Slow shipping speeds of containers complicate logistics due to the seasonality of the Great Lakes seaway (O'Reilly, 2008), and additional legislative problems compound international and container shipping logistics. The Merchant Marine Act regulates maritime commerce between U.S. ports. Specifically, the federal statute requires that all goods transported between U.S. ports must be carried by ships constructed in the United States, and that these ships must be owned and crewed by U.S. citizens.

Customs Process

In general, shipping and therefore customs clearance of CDW is not common in the Great Lakes area, and only a moderate level of information was available.

Kuehne & Nagle Inc. is a German freight forwarder with over 1,200 offices in 100 countries. Kuehne & Nagle pointed out that they do not forward any scrap material because of the low value of the cargo. Past experiences shipping these materials showed that customs delays during the shipment will often result in more problems with scrap material compared to other cargo. Because of the delays, the cargo has to be stored for a longer period than anticipated. This comes at an extra cost and often led the owner to abandon the goods because the costs would exceed the value of the material and would leave the forwarder with extra costs. Kuehne & Nagle Inc. also emphasized that in order to export these materials a licensed freight forwarder is needed.

CHAPTER 5: FINDINGS & RECOMMENDATIONS



CHAPTER 5: FINDINGS AND RECOMMENDATIONS

The following summary of findings and recommendations are derived from the assessment conducted in the report and in consideration of the overall practices currently employed in removing abandoned structures. These findings and recommendations can serve as a guide for possible future actions to advance the deconstruction sector in the catchment area.

Scale of Abandonment

- Based on available information gathered from the catchment area, there appears to be sufficient high-volume/low-value materials to sustain a deconstruction sector.

Transportation

- Limited shipping capacity for structural debris exists due in part to the shipping capacity of the Great Lakes and the availability of containers.
- Truck transport of materials is feasible in most cases and may be more appropriate in gathering the material from dispersed sites.

Current Methods of Removing Abandoned Structures

- The current practice of removing abandoned structures is heavily weighted toward demolition, which limits the capacity to extract materials.
- Low tipping fees in the region also lead to low rates of separation, recycling, and repurposing of structural materials, particularly the third skim (high-volume/low-value) materials.

Material Available/Reuse

- The Midwest has, with some exception (where first and second skim materials are collected and repurposed), a weak materials reuse/repurposing supply chain.
- Wood and brick show the most immediate promise.
- There are industries globally that have developed markets and methods for recycled/repurposed material. These industries might be interested to locate in Muskegon.
- The job potential for the deconstruction sector is promising.

Policy recommendations

Local

Ordinances can be effectively used by local governments to increase the use of recycled C&D materials and deconstruction practices over demolition. Mandatory reuse and recycling rates are useful for necessitating specific levels of deconstruction during C&D projects.

The City of Chicago's C&D Debris Recycling Ordinance requires contractors to track the amount of C&D debris generated on project sites, and recycle at least 50% of the debris which is regulated by the Chicago Department of Environment. Beginning in 2010, the City of Madison, Wisconsin mandates the recycling of C&D materials from construction, roofing, and removing projects. Parties seeking a demolition permit in the City of Madison must have a recycling and reuse plan approved by the recycling coordinator prior

to the insurance of the demolition permit. In July of 2016, Portland, Oregon banned the demolitions of homes built on or before 1916. The law requires homes to instead be deconstructed, saving an estimated 4,000 tons of C&D material waste annually (Environmental Leader, 2016). In addition to C&D recycling ordinances, many municipalities enact green building ordinances to ensure that the construction of new public facilities utilize sustainable building practices. The City of Evanston, Illinois' Green Building Ordinance states that new construction or building renovation projects greater than 10,000 square feet that are city-owned or city-financed must obtain a LEED silver sustainability rating (City of Evanston, 2016). The Materials and Resources (MR) credit category of LEED certification focuses on minimizing the impact associated with the "extraction, processing, transport, maintenance, and disposal of building materials." The MR credit category seeks to support a life-cycle approach that promotes resource efficiency. Both ordinances can potentially increase demand for recycled construction materials during new construction, and make future deconstruction practices more cost effective by incentivizing sustainable building practices (Delta Institute, 2012)

State

State legislation encouraging the creation of land banks would allow individual cities, municipalities, and counties to more efficiently manage and redevelop abandoned, blighted, and vacant structures. By advocating for deconstruction rather than demolition, land banks with large property portfolios can create economies of scale, and therefore profit from the resale of high-volume/low-value recycled construction materials.

Michigan legislation regarding the creation of land banks is widely considered to be exemplary state policy, after which New York and Maryland's land bank legislation is modeled. Michigan state law allows land banks in the state to recapture 50% of the property tax revenues for the first five years after transfer of property to a private party, which provides an ongoing income stream.

Additionally, Michigan state law reduced the time necessary for foreclosing on vacant, tax-delinquent properties, allowing Michigan land banks to quickly acquire tax-delinquent properties (Alexander, 2011). State legislation supporting the creation of land bank authorities allows deconstruction projects easy access to acquiring large numbers of abandoned structures in concentrated areas, which is crucial to the success of a deconstruction economy that relies on high-volume/low-value C&D materials.

An increase in the tipping fees across the Great Lakes should also be considered at the state level. States could raise the tipping fees themselves or leverage a tax on them.

Further, a significant focus of U.S. Green Building Council LEED projects is the inclusion of reused or repurposed construction materials and finishes in a certified project. Out of 100 possible points in the LEED v4 Building Design and Construction certification program, eight points (8%) can be attained by using recycled materials and finishes. This policy of using recycled materials salvaged from vacant buildings could also be implemented as a mandatory policy at the individual state level across the Great Lakes region.

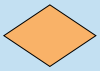
National

The following summary of findings and recommendations are derived for the assessment in the report and in consideration of the overall state of affairs as it relates to current practices and policies in structural

abandonment. They should serve as a guide in considering possible next steps in moving forward in this field.

Summary table

Table 17: Summary of feasibility study findings

Finding	Supports feasibility?	Recommendation
A sustainable supply of salvaged materials exists.		Salvaged building materials can be sourced from abandoned vacant properties, renovations, or new construction.
Low tipping fees reduce the incentive to recycle/reuse.		Consider incentives that advance reuse/recycling and revisit tipping fees to account for long-term impacts of disposal.
Great Lakes has a weak deconstruction industry supply chain.		Although the Great Lakes region has abundant sources of salvaged building materials, the supply chain is primitive. Deconstruction contractors must be able to bid competitively against demolition firms, processing facilities must be developed, and wholesale and retail warehouses must be established.
Wood and brick show the most promise.		Deconstruction efforts that focus on wood and brick rather than asphalt shingles, lath and plaster, or PVC are likely to yield better returns at this time.
Deconstruction employs more workers than demolition jobs.		A typical residential demolition may employ 2-3 people, but a typical deconstruction job employs 10-15 people at average wages of $11-15 an hour (except when Davis Bacon prevailing wages apply).
The Port of Muskegon has sufficient capacity and facilities to handle deconstruction sector logistics.		The Port of Muskegon can feasibly be used as a processing base for deconstruction materials gathered from around the Great Lakes.
Truck transport is favored in 9 out of 10 routes.		Truck transportation is favored between Muskegon and all Great Lakes catchment area cities with exception to Milwaukee. It is more feasible to transport salvaged materials from Milwaukee to Muskegon via barge.

Feasibility of Deconstruction Cluster

The development of a new economic sector requires a comprehensive strategy that secures material supply, material transport, business agreements to utilize the supply, firm location assistance, and worker training assistance and support.

This feasibility study has provided evidential information that has determined that a sufficient supply of building material can be found, that the material can be transported (trucking is the preferred initial method), and that there are reuse potentials for the products and markets for these repurposed materials. This study has also determined that there are existing industries in the United States and around the world that have the technical capacity to reuse elements of structural materials, and that Muskegon has the physical infrastructure in place and workforce capacity to support these industries if the materials are collected.

To move beyond the initial feasibility study, both public and private sector leaders will need to advance a strategic economic development plan that undertakes the following actions:

Table 18: Steps for strategic economic development plan

Steps	Actions
Step 1	Identify a lead agency/champion to advocate for the development of this sector. The lead agency/agent should establish a consortium that could be called the West Michigan Material Resource Consortium WMMRC of critical collaborators in the region who have the financial, technical, and resource capacity to solicit entrepreneurial interest in the community.
Step 2	Develop a target marketing strategy of industries that have the capacity to reuse/repurpose the structural materials. As a startup strategy we recommend that the region focus on wood products as the principal target. Other salvaged materials (roofing/linoleum) can be added as secondary markets (the key here is industry interest).
Step 3	Aggressively solicit the interest of these industries to consider locating and expanding in Muskegon. In this step, the region can begin to identify itself as "a unique place to do green business!"
Step 4	Create a financing capacity (private and public) to assist with business formation and expansion. Examples can include targeted capital support including revolving loan funds, private equity investments, product research support and public incentives that result in vacant structure utilization and employment opportunities for local unemployed persons.
Step 5	Assist interested industries in site acquisition and securing workforce training support. Based on our analysis, while the Port of Muskegon was the initial target for the feasibility study, the reliance on Great Lakes shipping as the principal form of transporting the salvaged materials is not currently developed at this time to the level of efficiency to support this sectoral start up. In later stages of development as the supply chain for material transport matures and the markets for repurposed materials expand the utilization of the port can be considered; however, in the initial stages of sectoral development early industry adopters can use trucking as their principal source of transport and can locate accordingly in the region in those areas where the transportation infrastructure is adequate for this start up stage (loading/shipping/unloading).

Summary

Having a robust supply chain is critical for the successful collection, processing, and re-distribution of salvaged materials back into the market economy. As previously mentioned, places such as Europe have mature supply chains that make deconstruction and salvage economically competitive against demolition and disposal. The success of the supply chain is dependent primarily on the ease of collecting materials from land banks and other entities, access to skilled and efficient deconstruction crews, and low-cost reliable means of transporting the salvaged materials to facilities for processing and resale.

Haste to demolish

One of the largest impediments to deconstruction is the pressure to remove blighted structures in short timeframes in order to fulfill federal Hardest Hit and CDBG requirements. This time pressure discourages deconstruction out of the concern that deconstruction will double the time required to complete blight removal work. Partial, rather than full deconstructions can improve the speed of deconstruction jobs, as can over scheduling work crews, and bidding on and completing packages of deconstruction jobs located in close proximity to one another.

Transportation

This study found that truck transportation was the most economically efficient transportation mode for transporting materials to the Port of Muskegon from nine of the communities in the catchment area including Ashtabula County, Bay County, Cook County, Cuyahoga County, Erie County, Lucas County, Wayne County, and the City of Gary. Bulk transport of salvaged materials via barge was only economically warranted for transport of materials from the City of Milwaukee.

Potential for reuse/repurposing and impediments

In addition to some of the challenges mentioned earlier in this study, the deconstruction sector also faces additional impediments such as training construction workers in deconstruction techniques, relocating European companies that use salvaged materials as feedstocks to their manufacturing processes to the U.S.(and facilitating the formation of similar domestic companies focused on the reuse of salvaged building materials), and finally, developing a supply chain for deconstructed materials once they are removed.

The National Association of Regional Councils (NARC) in partnership with the U.S. Department of Labor's *Pathways out of Poverty* program has instituted deconstruction training programs. The program curriculum includes OSHA 10-30 hour safety training program, lead and asbestos safety training, and basic deconstruction certification training. In addition, participants can also get a course in green rehabilitation training. In addition to this training, a general laborer must have a basic understanding of math, reading, writing, and clear diction. The training program has a cost and requires over 30 hours of time.

Approximately 12 similar programs were discovered during a review of deconstruction education and training programs available in the United States. Of the programs that were discovered, all have originated within the past five to seven years, and the majority were funded through either the U.S. Department of Labor's Pathways out of Poverty program or the Green Jobs Innovation Fund.

The national review uncovered just one example where deconstruction training has moved beyond the workforce training level and moved to an academic program. Illinois Central College offers an undergraduate certificate in deconstruction. The program began in 2014 with funding from the Illinois

Green Economy Network (http://www.igencc.org/) and consists of a seven credit, one semester experience. In addition to academic courses, the program features EPA Repair, Renovation, and Painting (RRP) certification (lead safety).

The small number of available training programs and lack of academic programs is problematic in two ways. First, it is difficult to create nationwide capacity within a deconstruction labor force with a small number of extant training programs. Secondly, workforce training programs alone, without any higher-level education, can potentially create an unsustainable condition within the workforce. This concern was communicated to the research team by a federal government manager, who was previously involved with deconstruction research. This individual's assertion was that most of the existing training programs only prepare workers for lower-wage jobs, without an established pathway to move people into longer-term, higher skill and wage employment. As a result, their agency abandoned further deconstruction research until such time that a sustainable model for workforce development is created.

The second impediment is creating a business environment for European companies to invest in domestic deconstruction activity, CDW recycling, and CDW manufacturing, and relocate to the U.S. Currently, many companies that ship internationally are not shipping to the Great Lakes region for various reasons, including shipping and trade laws such as the Jones Act. European shipping companies that might ship to the U.S. include BBC Chartering Canada, Fednav Limited, Hapag-Lloyd Canada, Jebsens International, Laurin Maritime Inc., Lithuanian Shipping Co., Navigating Maritime Bulgare, Polsteam USA Inc., and Stolt-Nielsen USA Inc.

Finally, a regional and domestic supply chain will need to be established for construction and demolition waste. This includes the handling of reuse materials from salvage to manufacturing to sale. Currently, there are markets established in some urban areas such as Detroit, however, not all regions have this organization. Additionally, the majority of markets that have been established focus on either the retail reuse of materials or non-structural materials (i.e., plumbing and electric fixtures, architectural features, non-structural reuse of lumber, etc.). This is an impediment due to the sheer volume of potentially salvageable materials available through expanded deconstruction activity, as presented in Chapter 7. In order to adequately address the potential quantity of low-value-high-volume materials, commercialized, industrial reuses should be encouraged and developed.

APPENDIX A: RESOURCES AND OUTREACH EFFORTS

Advisory committee

The Muskegon County Deconstruction Economic Cluster Advisory Committee was formed in 2015. It is made up of experts and stakeholders from the Muskegon area and other areas significantly affected by blight around Michigan. During the course of this study, the Advisory Committee met at least bi-monthly in order to receive updates from the researchers and provide valuable insight and guidance on next steps. MSU CCED and WMSRDC would like to extend our sincerest appreciation for the services provided by the Advisory Committee members, without whom, this report would not be possible.

Mohamed "Moe" Ayoub, Senior Planner, City of Dearborn
T. Arnold Boezaart, Grand Valley State University, Michigan Alternative and Renewable Energy Center
Leslie G. Brand III, Chief Executive Officer, Supply Chain Solutions Inc.
Tim Burgess, Land Bank Coordinator, Muskegon County Land Bank Authority
Stephen Carlson, Program Manager, Economic Development, WMSRDC
Sara Damm, Sustainability Coordinator, Muskegon County Sustainability Office
Christopher Dean, Fire Chief, Muskegon Heights Fire Department
Cris Doby, Program Officer, Fred A. and Barbara M. Erb Family
Matt Flechter, Recycling and Marketing Development Specialist, Michigan Department of Environmental Quality
Ashley Fleser, Executive Director, Muskegon County Habitat for Humanity
Brad Garmon, Director of Conservation and Emerging Issues, Michigan Environmental Council
Ed Garner, President & CEO, Muskegon Area First
Jeremy Haines, Sales and Marketing Manager, Reclaim Detroit
John Higgs, Padnos Scrap Management and Recycling
Kristopher Jolley, Marketing and Sales Manager, MSU Surplus and Recycling Center
Erin Kelly, City of Detroit
Jack Kennedy, Commissioner, Muskegon County Road Commission
Erin Kuhn, Executive Director, WMSRDC
Cindi Langlois, M.Ed., Workforce Training and Account Manager, Office of Academic Affairs, Muskegon Community College
Adam Lawver, Administrative Associate I/S, MSU IPF Landscape Services
Connie Maxim-Sparrow, Grants Coordinator, Muskegon County
Lynn Mulder, Padnos Scrap Management and Recycling
Kerrin O'Brien, Michigan Recycling Coalition
Daniel Pratt, Construction Director, Architectural Salvage Warehouse Detroit
Eve Pytel, Director of Strategic Priorities, Delta Institute
Andrea J. Riegler, Architect
Lisa Sabourin, President/CEO, Employers Association of West Michigan
Byron Turnquist, Commissioner, City of Muskegon
Jonathan Wilson, Economic Development Coordinator, Muskegon County

Great Lakes Land Banks and Related Entities

The purpose of a land bank is to work in the public interest to acquire, manage, and re-market abandoned and foreclosed properties in order to prevent or limit the spread of blight within a community. Often, this means that land banks are in the business of demolishing and/or deconstructing structures that are beyond the point of rehabilitation. Due to the large volume of demolition and/or deconstruction handled by land banks, they are poised to be a key supplier of salvaged materials for the Port of Muskegon's proposed deconstruction cluster. The following land banks were included in our study area, and were contacted as study stakeholders:

Ashtabula County Land Reutilization Corporation (Land Bank)

Website: http://www.co.ashtabula.oh.us/672/Ashtabula-County-Land-Bank

Bay County Land Bank

Website: http://www.baycounty-mi.gov/Treasurer/Land-Bank.aspx

Detroit Land Bank Authority

Website: http://www.buildingdetroit.org/

Buffalo-Erie-Niagara Land Improvement Corporation

Website: http://www.benlic.org/

Cook County Land Bank

Website: http://www.cookcountylandbank.org/

City of Milwaukee Neighborhood Services

Website: http://city.milwaukee.gov/DNS#.WF1QSbIrLIU

Cuyahoga County Land Bank

Website: http://www.cuyahogalandbank.org/

Gary Department of Planning, Redevelopment, and Zoning

Website: http://www.gary.in.us/redevelopment/

Ingham County Land Bank

Website: http://www.inghamlandbank.org/

Lucas County Land Reutilization Corporation (Land Bank)

Website: http://co.lucas.oh.us/index.aspx?nid=2063

Muskegon County Land Bank

Website: http://www.muskegonlandbank.org/

State of Michigan Land Bank

Website: http://www.michigan.gov/landbank/

State or National Level Organizations

During the course of our research, the project team reached out to various state-level entities in the Great Lakes region in order to gather information about deconstruction activities, as well as programs to salvage C&D materials. These entities included:

Center for Community Progress. The Center for Community Progress is the only national nonprofit specifically dedicated to building a future in which vacant and abandoned properties no longer exist.

Website: http://www.communityprogress.net/

Michigan Association of Land Banks. The Michigan Association of Land Banks strives to ensure that Michigan Land Banks have the statewide policies, support, and capacity to effectively operate and share information about local land bank programs.

Website: http://milandbank.org/membership/current-members/

Michigan Recycling Coalition. The Michigan Recycling Coalition (MRC) represents recycling and composting interests statewide. The Coalition is a recognized authority on waste reduction, beneficial utilization, recycling, and composting through the experience of its Staff and Committees.

Website: http://www.michiganrecycles.org/

Michigan State Housing Development Authority (MSHDA). MSHDA's mission is to enhance Michigan's economic and social health through housing and community development activities.

Website: http://www.michigan.gov/mshda/

Michigan Economic Development Corporation (MEDC). The mission of MEDC is to market Michigan and provide the tools and environment to drive job creation and investment.

Website: http://www.michiganbusiness.org/#home-intro

Contractors, Salvagers, and Recyclers

Contractors, salvage operations, and recyclers were contacted during the study in an effort to understand the existing supply chain for salvaged C&D materials, and to find ways to improve the supply chain so that it is reliable and predictable. The following organizations were consulted during this study:

Architectural Salvage Warehouse of Detroit. The Architectural Salvage Warehouse of Detroit deconstructs buildings in Southeast Michigan to keep environmental resources out of the waste stream, and to make decent, affordable housing materials available to low- and moderate-income families.

Website: http://www.aswdetroit.org/

Delta Institute. Delta Institute is a nonprofit organization with program work across its three strategic priority areas: energy, ecosystems and waste. To help demonstrate the market potential of sustainable businesses, Delta creates and manages innovative social enterprises, including the P2E2 Center, a for-

profit carbon credit trading platform, the Revere LLC, a for-profit energy efficiency lender, and it launched the Rebuilding Exchange, a nonprofit materials reuse store.

Website: http://delta-institute.org/

Details. Details is part of Humanim, a 501(c)3 nonprofit located in Baltimore. Every Details project diverts salvageable materials from overflowing landfills, and creates jobs for skilled crew members who have faced barriers to employment.

Website: http://www.details.org/

Habitat for Humanity - Restore. Habitat for Humanity ReStores are nonprofit home improvement stores and donation centers that sell new and gently used furniture, appliances, home accessories, building materials and more to the public at a fraction of the retail price.

Website: http://www.habitat.org/restores

MSU Surplus Store and Recycling Center. The MSU Surplus Store and Recycling Center collects used items from the MSU community and makes them available for resale at low prices. It is also involved in salvaging, processing, and re-marketing reclaimed construction materials from deconstructed buildings on the MSU campus.

Website: http://msusurplusstore.com/

Padnos. Padnos is a full-service recycling company handling paper, plastics, metals and more. They tailor recycling programs for industrial and commercial clients throughout the United States.

Website: http://www.padnos.com/

Reclaim Detroit. Reclaim Detroit's mission is to institutionalize deconstruction as part of mainstream building removal practices in order to maximize the social, environmental, and economic benefits for the local community. They are particularly focused on helping solve Detroit's blight problem and committed to creating jobs and a vibrant reuse industry, and are also invested in deconstruction-related job training programs.

Website: https://reclaimingdetroit.org/

Rockford Construction. From capital, planning, and preconstruction to construction and property management, Rockford provides an extensive array of services to meet their clients' ever changing needs. Rockford has regional offices in Michigan and Florida and has built projects in over 800 cities.

Website: http://rockfordconstruction.com/

Outreach Efforts

Stakeholder Interviews

Numerous stakeholder interviews were conducted with organizations involved in the salvaging, processing, transportation, or financing of deconstruction materials between March and September 2016. Most interviews were conducted via phone, although others were conducted over e-mail or in-person. A list of the individuals interviewed for this project can be found below:

Jeff Carroll, Details Director at Humanim. On September 28, 2016 MSU spoke in person with Jeff Carroll about how to sustainably run a deconstruction organization to create skilled jobs for local residents, and competitively compete with demolition firms.

Ashley Fleser, Muskegon County Habitat for Humanity Executive Director. On May 10, 2016 MSU spoke via telephone with Ashley Fleser about salvaged materials data available from Habitat for Humanity ReStore.

Bradley Guy, Assistant Professor of Architecture at the Catholic University of America. On September 28, 2016 MSU spoke in person with Professor Guy about the economics of transporting reclaimed materials.

Jeremy Haines, Sales Manager at Reclaim Detroit. MSU co-presented a session on deconstruction with Jeremy Haines at the annual Michigan Recycling Conference on May 4, 2016. Following the session, MSU met with Jeremy to discuss Reclaim Detroit's deconstruction efforts.

Larry Karnes, MDOT Freight Policy Specialist. On March 10, 2016 MSU had a telephone call with Larry Karnes regarding the logistics of using barges to ship salvaged materials to the Port of Muskegon. Larry also provided contact information for local regional barge operators that have the capacity to potentially ship materials.

Erin Kelly, formerly of Detroit Future City, now Lead Landscape Architect at the City of Detroit. On April 14, 2016 MSU spoke with Erin Kelly regarding the 2013 Partial Project, a pilot project in the Springwells neighborhood of Southwest Detroit to deconstruct seven homes using different experimental timeframes for each home.

Kris Jolley and Adam Lawver, MSU Surplus Store Reuse and Recycling Manager, and MSU Landscape Construction Manager. The project team met in-person with Kris Jolley and Adam Lawver on March 24, 2016 to discuss on-campus deconstruction initiatives, and processing, supply chain creation, and retailing for salvaged materials.

Danielle Lewinski, Vice President and Director of Michigan Initiatives for the Center for Community Progress. MSU spoke by phone with Danielle Lewinski on March 29, 2016 regarding current deconstruction efforts by land banks in the Great Lakes region.

Chris Shaw, graduate student working with Fresh Coast Capital. MSU was contacted by Chris Shaw to discuss potential overlaps between the service areas of Fresh Coast Capital and the proposed deconstruction hub at the Port of Muskegon.

Rochelle Sibbio, President & CEO of Habitat for Humanity, Summit County, OH. Rochelle participated in the survey distributed to land banks, and provided MSU with resources to reach out to other organizations conducting similar research.

Gregory White, Ports America Chief Commercial Officer. MSU spoke with Gregory White at the Muskegon Port Day event and in subsequent e-mails about the feasibility of using barges to ship salvaged materials. Mr. White specialized for over 20 years in container shipping.

Outreach Events

Dutch Consul Meeting. Through efforts coordinated by Advisory Committee member Arnold Boezaart, a meeting was arranged at MSU with representatives from the Dutch Consulate office in Chicago on June 2,

2016. Dutch representatives at this meeting included Deputy Consul General Stephan van de Wall, Marjolein Overbosch, Marketing and Communications Manager at DMT Clear Gas Solutions, and Herman Huisman, Senior Advisor for the International Corporation at Rijkswaterstaat, an agency of the Ministry of Infrastructure and the Environment. Topics covered during the meeting included European companies involved in the wholesale or retail uses of materials salvaged from deconstruction, companies involved with abatement of toxic building materials, information about the Netherlands waste-to-fuel incineration businesses, and municipal bench-marking systems for quality of life and the environment.

Detroit Field Trip. The project team traveled to the City of Detroit the morning of June 17, 2016 to meet with Pura Bascos, Director of Acquisition and Land Reuse, and her colleagues at the Detroit Land Bank Authority to discuss the land bank's plans for deconstructing 10 homes, as well as efforts to gather and track GIS data on each property owned by the lank bank. Later that day, the project team met for lunch with Jeremy Haines, Sales Manager at Reclaim Detroit, to discuss the plans for a deconstruction hub to process and re-market salvaged materials in the City of Detroit.

Muskegon Port Day. The MSU research team participated in the Muskegon Port Day event on July 26, 2016. This event enabled our outreach efforts with organizations such as Martin Associates and Ports America. The purpose of Muskegon's Port Day was to highlight the Port of Muskegon's economic opportunities and regional benefits.

APPENDIX B: SURVEY OF TARGET CITIES (CASE STUDY DATA)

Surveys were sent to land banks and salvaged building material operations facilities within the catchment area for this study. Ten responses were received; however, this includes respondents from within the Great Lakes states, but from outside of the study's catchment area.

Due to low response rates of the land banks in the target cities, data was collected for the year 2015 from municipal websites in the catchment area, including reporting data on federal Hardest Hit funding. This collected online data was compiled and used to calculate the average number of abandoned houses in the catchment area, the average number of houses being demolished by the municipal entities, and the average percentage of houses being demolished. These numbers have been used in Table 19 below to estimate the total value of recoverable materials potentially available in the catchment area from these abandoned houses.

In estimating the total number of materials available, the quantity of abandoned houses in the City of Chicago has been included, but excluded from the number and percentage of houses demolished, because municipal reporting for that activity was inconclusive.

Number of Abandoned Buildings in Target Areas

Table 19: Number of Abandoned Buildings Reported by Survey Respondents

Table 19: Number of Abandoned Buildings Reported by Survey Respondents		
	Number of Abandoned Buildings	
Jurisdiction	**Survey Data[a]**	**U.S. Census Data[b]**
Charlevoix County, MI	0	244
Anonymous County	10	991
Delta County, MI	14	1,169
Muskegon County, MI	100	3,618
Monroe County, MI	5	1,370
Ingham County, MI	1,300	4,901
Summit County, OH	6,000	13,787
Anonymous County	273	3,852

Notes:

a) Respondents were asked to report the number of abandoned properties in their target area as well as the number of abandoned properties under their organization's control. The higher value of these two is reported herein.

b) Data source: "Vacancy Status" 2010-2014 American Community Survey 5-Year Estimates - "Other Vacant" category

Of the ten survey respondents, six reported a number of abandoned buildings within their target area; four responded as "unknown" or "not sure." Of the six reporting a number, values ranges from 0 to 6,000 (Table 19). Table 19 also compares these reported numbers with values of "other vacant" properties retrieved from the U.S. Census Bureau. Reasons for the variance between the two values may include differences in years for reported data, differences in jurisdictional boundaries applied to the data from different reporting sources, and respondents restricting themselves to buildings only within their organizational control.

Number of Units Demolished

All ten respondents reported on conducting demolition activity. Of the ten respondents, two reported undertaking deconstruction activity. Five respondents indicated that they have undertaken and/or plan to undertake renovation activity on abandoned buildings. The latter point is noteworthy, since the majority of respondents were land banks, who typically rehabilitate and then attempt to resell tax-foreclosed properties in an effort to recover foregone tax revenues.

Aggregate data for demolition, deconstruction, and rehabilitation/renovation activity is presented in Table 20.

Table 20: Demolition, Deconstruction, and Rehabilitation Activity

Table 20: Demolition, Deconstruction, and Rehabilitation Activity			
	Past 12 Months	**Next 12 Months**	**Next 13-24 Months**
Demolition	Average = 45.5 Range = 0-281	Average = 22.7 Range = 0-100	Average = 55.4 Range = 0-300
Deconstruction	Average = 33.9 Range = 0-233	Average = 57.4 Range = 0-400	Average = 83.7 Range = 0-500
Rehabilitation	Average = 2.6 Range = 0-13	Average = 2.9 Range = 0-10	Average = 3.3 Range = 0-12

Demolition and Deconstruction Cost Data

Eight respondents provided demolition cost data on a cost per house basis; two provided square footage cost data. The same two respondents provided cost per house and per square foot data for deconstruction and rehabilitation. Eight out of ten respondents provided average costs for lead and asbestos abatement on a per house basis. These data are summarized in Table 21.

Impediments to Increased Deconstruction Activity

Survey respondents were given the opportunity to provide open-ended responses about their experiences with demolition and deconstruction. One respondent reported not undertaking any demolition or deconstruction activity at all, saying, “No, we haven't had any demolition since we have had the land bank.”

Table 21: Demolition, Deconstruction, Rehabilitation, and Abatement Costs

Table 21: Demolition, Deconstruction, Rehabilitation, and Abatement Costs		
	Cost per House ($)	**Cost per Square Foot ($)**
Demolition	Average = $10,812.50 Range = $7,500-$15,000	Average = $8 Range = $1-$15
Deconstruction	Average = N/A[a] Range = $275-$20,000[b]	Average = N/A[a] Range = $1-$16.66
Rehabilitation	Average = N/A[a] Range = $75-$150,000[c]	Average = N/A[a] Range = $0-$125c
Lead and Asbestos Abatement	Average = $9,514 Range = $1,000-$42,500	N/A - data not collected in this form
Notes: a) Average values were not calculated since only two respondents provided data. b) It is believed that the $275 value provided for deconstruction reflects only a minimal "skim" effort and not a complete building deconstruction. c) The same respondent who provided seemingly artificially low values for deconstruction costs provided very low values for rehabilitation costs as well.		

Generally speaking, respondents indicated an interest in learning more about or actually undertaking deconstruction projects. Only two out of ten respondents reported having already undertaken deconstruction and plans in place to complete more such projects in the next 13-24 months. One respondent indicated, "We have not done deconstruction yet. We do have some interest in partial deconstruction -- salvage of some components."

Respondents were very clear that major impediments to completing more deconstruction revolve around timelines imposed by funders and the increased time it takes to deconstruct as opposed to demolish, a lack of available contractors, and increased cost and liability. Example responses included:

"We don't have many abatement companies from which to choose. Or else they don't advertise their services very well."

"*Although there is desire to implement deconstruction more widely, it is significantly slower and more expensive than demolition, and more difficult to find contractors who will deal with it."*

"Deconstruction would be much more feasible with reasonable timeframes of federal demolition grants. The feds need to get on the same page as those who wish to save resources."

"Timeframe and deadlines are a big factor. Consider the [environmental protection and safety enforcement agencies], and their effects on projects."

"Liability, time involved, and cost continue to be an impediment to deconstruction of homes."

Other Comments

Of the respondents, one land bank reported through follow-up communications their ongoing activity and interest in recycling and repurposing operations. Currently, the land bank has one deconstruction contractor who also operates a salvage yard approximately 80 miles north of the land bank. These contracts are therefore inclusive of salvage rights for the contractor, freeing the land bank from the need to operate a salvage facility, but also reducing the opportunity that is represented by that potential revenue stream. This land bank, on the basis of a previously completed Deconstruction Feasibility Study, is presently exploring the creation of a deconstruction hub/salvage warehouse and identifying possible third-parties to operate that facility.

Another survey respondent was a Habitat for Humanity affiliate which operates a ReStore facility. They were one of two respondents who reported that they directly undertake building demolition/deconstruction/rehabilitation projects.

Appendix C: Possible Funding Sources

The following is a list of potential sources of financing and funding sources for advancing this deconstruction sector.

Financing

Venture Capital Firms

In the startup financing cycle, funding from venture capital is typically preceded by seed capital investment from "angel investors." Many venture capital firms have funds and staff that focus on one or more aspects of environmental or social responsibility. Sometimes known as "social venture capital" some VC firms explicitly incorporate additional investment criteria, such as social or environmental benefits, in their mission and investing activities.

Below are some examples of venture capital firms specializing in social venture capital:

Community Development Venture Capital Alliance (CDVCA):

Community Development Venture Capital Alliance is the network for the field of community development venture capital investing. CDVCA funding provides early capital investments to businesses in underinvested and distressed markets, and, in addition to seeking market-rate financial returns, seeks the creation of employment opportunities, wealth, and entrepreneurial capacity in its investments. CDVCA combines advocacy, education, communication, and financing.

http://cdvca.org

City Light Capital (CLC):

City Light Capital is an early-stage venture capital firm that considers both the social impact of their investments, as well as their potential financial return. City Light Capital focuses its investments primarily in education, safety, and the environment. Specifically, CLC invests in companies devoted to energy efficiency, waste and water management, and carbon reduction. CLC's investment criteria demands U.S. based companies that have:

- A clear plan to create quantifiable social impact
- At least $1M in revenue
- Core technology that create measurable change

http://www.citylightcap.com

Fresh Coast Capital (FCC)

An "impact-driven investment and real estate development firm," Fresh Coast Capital focuses on revitalizing post-industrial communities through investment solutions. Specifically, Fresh Coast Capital partners with cities to revitalize blighted and environmentally contaminated properties through green infrastructure investments. By planting hybrid poplar trees on environmentally contaminated properties, Fresh Coast can remediate contamination, revitalize property, and then sell the trees for profit. Poplars can clean soil and groundwater from contaminants including petroleum hydrocarbons, chlorinated solvents, metals, pesticides, explosives, and excessive nutrients. Hybrid poplars can be processed into

biomass for renewable energy purposes in as soon as five years or as a sustainable and local source of wood for local businesses and manufacturers in as few as 10 years. Fresh Coast is currently invested in Gary and Elkhart, Indiana; Flint and Battle Creek, Michigan; Youngstown, Ohio; and Kansas City and St Louis, Missouri.

Fresh Coast Capital has indicated that they are considering adding deconstruction to their portfolio. They envision their role in deconstruction as two-fold. They could serve in an advisory capacity to municipalities, and assist with the organization of the supply chain, or they could create a "special purpose fund" to invest in deconstruction pilots and processing facilities with the understanding that Fresh Coast Capital would be involved with the selection of target deconstruction sites.

http://freshcoastcapital.com

Closed Loop Fund (CLF)

The Closed Loop Fund is a social impact fund focused on increasing the recycling rate of products and packaging by investing $100 million in zero interest loans to cities and below market loans to companies. Each investment must divert significant tonnage from landfills to the recycling stream, and provide transparent reporting and clear lines of site to allow for easy replication by other cities and companies. The Closed Loop Fund seeks to invest in financially viable recycling infrastructure across three primary categories: collection, sorting, and processing.

Although the Closed Loop Fund has not been involved to-date with funding deconstruction projects, it's likely because no one has approached them with the concept. They accept applications on a rolling basis, and proposals can either come from municipalities or private companies.

http://www.closedloopfund.com

Public

The demolition of blighted structures is primarily funded by government organizations like the U.S. Department of Housing and Urban Development (HUD), the U.S. Economic Development Administration, and the U.S. Treasury's Hardest Hit Fund.

Below are some examples of public funding sources:

Federal-Level Funding: U.S. Department of Housing and Urban Development (HUD)

The Neighborhood Stabilization Fund (NSF), operated by the U.S. HUD, disperses funds to land bank authorities for the removal of blighted structures. Land banks can elect to use these funds for deconstruction rather than demolition; however, NSP funds typically stipulate that blight removal funding must be used in a particular time frame, putting pressure on land banks to remove structures quickly, which often discourages deconstruction practices.

Federal-Level Funding: U.S. Economic Development Administration (EDA)

The Muskegon Deconstruction Feasibility Study is primarily funded through a Local Technical Assistance grant from the U.S. Department of Commerce at the EDA. An additional EDA grant funding source is known as Partnerships for Opportunity and Workforce and Economic Revitalization Initiative (POWER). The POWER grant seeks to "invest federal economic and workforce development resources in communities

and regions negatively impacted by changes in the coal economy" (EDA, 2016). In light of the BC Cobb coal-fired power plant closure in Muskegon in April, 2016, the municipality is well-situated to pursue POWER grants.

Federal-Level Funding: U.S. Environmental Protection Agency (EPA)

The EPA offers funding opportunities to promote the remediation of high-priority environmentally contaminated urban development sites known as "brownfields". The funding can be used to conduct research and technical assistance activities culminating in area-wide plans for brownfields assessment, cleanup, and subsequent reuse. Total available funding is $4 million, with a maximum amount of $200,000 available for each proposal. The Muskegon Deconstruction Feasibility Study targets Great Lakes cities with large-scale blight and environmental contamination. Deconstruction offers better remediation and redevelopment for brownfield sites as compared to demolition, and therefore can utilize EPA funding for the deconstruction of industrial and commercial abandonment.

State-Level Funding: Michigan Department of Environmental Quality (MDEQ)

In an attempt to increase the low residential recycling rate in Michigan of 14.5%, Governor Rick Snyder introduced his "Proposed Plan of Action on Recycling" in April 2014, in coordination with the MDEQ. The plan attempts to increase access to residential recycling and increase market development and opportunities for recycled products. A goal of a 30% residential recycling rate within two years was outlined by the Governor's Residential Recycling Plan. As part of the plant, the MDEQ is working to grow market opportunities for Michigan businesses to secure high-volume, clean, recycled commodities for manufacturing processes. "Recycle by Design" is a competition designed to incentivize the development of innovative recycling strategies in Michigan. Local, regional, and state level teams comprised of private and public sector partners are supported to help create a more dynamic recycling infrastructure, and therefore increase Michigan's residential recycling rate, and it is possible that deconstruction could play a role. In April 2016, the MDEQ and the Governor's Recycling Council announced that Recycle by Design has been put on hold. Currently, no funds have been distributed.

Local-Level Funding: County and City initiatives

No local-level funding opportunities were identified during the course of the feasibility study.

Private Financing

Some national non-profit advocacy and financing groups exist to provide capital and resources such as research and technical assistance for sustainable community development projects.

Institute for Local Self-Reliance (ILSR):

The Institute for Local Self-Reliance is a non-profit advocacy group that promotes urban community development and sustainability with advocacy, technical assistance, and research. The ILSR's Waste to Wealth program is devoted to helping communities address both environmental concerns and economic needs by reducing pollution via the promotion of rules, policies, and programs that stimulate economic development through the efficient use and reuse of local resources. This includes increasing recycling and recovery rates and reducing solid waste management costs. The program invests in the creation of recycled material economies, and the establishment of new employment opportunities. Through three

decades of investment, the ILSR Waste to Wealth program has worked with activists, policymakers, business and community development organizations to "reduce waste generation and maximize the ruse, recovery, and remanufacturing" of recycled materials., The ILSR primarily provides assistance in the form of advocacy, research, and technical assistance, rather than outright financial funding. In the form of technical assistance, the ILSR provides advocacy and outreach in an effort to raise funding, along with on-site deconstruction training services, and business recruitment, among other various services devoted to the establishment of sustainable economic practices.

https://ilsr.org

Capital Impact Partners (CIP)

Capital Impact Partners seeks to invest in the revitalization of communities who have suffered from depopulation, and the loss of manufacturing jobs. CIP specializes in funding to underserved communities and areas often overlooked by traditional banks, that therefore lack critical investment capital. A Certified Community Development Financial Institution (a designation given to specialized organizations that provide financial services in low-income communities and to people who lack access to financing), CIP provides acquisition loans, construction loans, working capital loans, and tenant improvement loans. In addition to strategic financing for underserved communities, CIP advocates the adoption of public policies that promote equitable economic opportunity and inclusive growth, and will provide technical assistance to community revitalization projects. CIP has focused on place-based revitalization by promoting economic development in cities like Detroit, Los Angeles, Oakland, and Washington D.C. In Detroit, CIP has provided financing for neighborhood revitalization to promote economic growth in the area. Capital Impact Partners offers financing to collaborating partners who are involved in neighborhood revitalization and the promotion of economic opportunities in their designated cities.

http://www.capitalimpact.org

Crowdfunding

Similar to venture capital, there are websites designed to allow entrepreneurs, non-profits, and charities to solicit funds from individuals, specifically for socially and environmentally conscious projects. Most "green" crowdfunding platforms feature businesses that seek funding for innovations in renewable energy, rather than community revitalization, blight removal, and building sustainability. Crowdfunding that focuses on community development, known as "civic crowdfunding," is often place-based, focusing fundraising around the area the project is targeted towards.

Crowdfunding offers the field of community development new financing options for projects that typically rely on government subsidies for funding. It also offers organizations the ability to receive input on the preferences of the community in the form of financial contributions. Some crowdfunding platforms that market themselves toward environmentally-focused and sustainable projects are listed below:

CauseVox

CauseVox offers online fundraising for nonprofits and socially conscious business ideas. CauseVox supports non-profits and individuals who seek to fund projects within the fields of community service, economic and community development, education, and health.

https://www.causevox.com

Divvy

Divvy is a crowdfunding platform for community sustainability projects. Divvy supports green-minded community-based projects. Projects funded by Divvy have received between $2,000 and $11,000, and typically focus on small scale renewable energy infrastructure.

http://divvygreen.com

Foundations

Potential funding is available from foundations that focus on promoting community revitalization, workforce development, environmental conservation, and sustainable building practices. Foundations and non-profit organizations that are focused on improving Michigan communities, particularly in western Michigan and Detroit, are also likely to help fund the establishment of deconstruction facilities and supply chains. If the study's goals and mission strongly align with those of a foundation, then funding is more likely. Listed below are a number of foundations whose mission statements at least partially align with the goals of this study.

Erb Foundation:

The Erb Foundation's mission is to use sustainable business models to cultivate environmentally healthy and culturally vibrant communities in metropolitan Detroit. Stressing the importance of a triple bottom line, the foundation seeks to fund innovations that take into consideration economic, environmental, and social outcomes. In particular, the foundation seeks to encourage responsible business solutions to the region's environmental issues.

Ford Foundation:

The Ford Foundation, created in 1936 by Edsel and Henry Ford and now headquartered in New York, is one of the largest, most globally influential foundations in the world. The foundation focuses on fighting inequality through equitable development, correcting for the problems associated with urbanization and economic growth. In the past, the Ford Foundation has specifically funded programs in metropolitan Detroit that created regional land bank authorities in an attempt to revitalize blighted areas and increase quality housing opportunities, as well as community development projects that connected residents to job opportunities. While the time frame for Ford's most relevant specific funding opportunity, the Metropolitan Opportunity Target, has expired, it can be expected that the Ford Foundation will still fund projects that focus on job creation, and community development and revitalization in Michigan. In 2015, the Ford Foundation approved 12 grants to seven grantees in Michigan, totaling $9,575,000 in funding, approximately 1% of total national funding. While the Ford Foundation does consider unsolicited grant proposals, less than 1% result in funding.

http://fordfoundation.org

Frey Foundation

Established in 1974, the Frey Foundation invests in western Michigan through projects that focus on community development, environmental protection and restoration, and arts and culture in the community. Specifically, the foundation prioritizes projects that improve downtown and neighborhood development and foster public/private partnerships to enhance local and regional impact. The foundation

funds organizations that serve communities primarily in Kent, Emmet, or Charlevoix counties, or the broader northwest Michigan region. The Frey Foundation is generally willing to fund up to 15% of a total program budget. Grant requests should first submit a brief inquiry, at which point the request may be invited to submit a full grant application. If an organization believes its project is well-aligned with the foundation's current priorities, they should submit a short letter of inquiry regarding the proposed grantee organization, the proposed program, requested funding, and contact information.

http://freyfdn.org

Hudson Webber Foundation:

The Hudson Webber Foundation's mission is to "improve the quality of life in Detroit." Specifically, the foundation invests in projects that assist with physical revitalization, economic development, community safety, or the arts. The foundation supports projects that are designed to "increase the concentration and quality of housing, commercial districts, public space, and pedestrian infrastructure." The foundation's grant award process is informed by how projects align with its four mission areas. The foundation is primarily interested in providing "seed money" for stimulating innovative projects. It is expected that projects will later be able to secure their own funding. In 2015, the Hudson Webber Foundation paid out over $7.5 million, 59% of which was allocated to projects that were designed for the physical revitalization or economic development of Detroit.

http://www.hudson-webber.org

Kresge Foundation

The Kresge Foundation is committed to investing in environmentally sustainable innovations in infrastructure, building design, land use, transportation, and other policy and funding issues that strengthen Michigan communities. The Kresge Foundation focuses on environmentally conscious projects that combat climate change and develop solutions for the reduction of greenhouse gas emissions. Specifically, the Kresge Foundation will devote funds to promote "Urban Energy Resilience," helping low income communities develop long-term plans for reducing greenhouse gas emissions by supporting networks of practitioners who work to enhance the energy performance and resilience of structures in urban systems. Funding opportunities for the Kresge Foundation take three different forms:

- Open on an ongoing basis, without deadlines,
- Open for a limited time, with specific deadlines,
- By invitation from a Kresge program officer

http://kresge.org

W.K. Kellogg Foundation

The Kellogg Foundation, located in Battle Creek, Michigan, is the seventh largest philanthropic foundation in the U.S. The W.K. Kellogg Foundation considers optimal development of children at the center of all its investments. Within and around those goals of childhood development, the Kellogg Foundation is committed to Community and Civic Engagement, considering it necessary for communities to create the conditions under which all children can thrive. Kellogg's Community and Civic Engagement division works to increase the effectiveness, capacity, collaboration, and community responsiveness of philanthropic and

nonprofit institutions that are aligned with Kellogg's beliefs, goals, and missions. The Kellogg Foundation is particularly interested in investing in Michigan's population centers of Battle Creek, Grand Rapids, and Detroit, seeking to break down barriers to success among the state's most vulnerable children and their families.

wkkf.org

Mott Foundation

The Charles Stewart Mott Foundation is a Michigan grantmaker that seeks to fund advancements in sustainability, particularly in the Flint area. Specifically, the foundation invests in projects that support sustainable development and reduce environmental degradation. The foundation awards grants to organizations that provide infrastructure and energy investments contributing to environmental sustainability and offering local economic opportunity.

mott.org

Knight Foundation

The Knight Foundation is committed to the revitalization of Detroit, seeking to invest in public and private partnerships that drive economic growth, job creation, and neighborhood revitalization. The Knight Foundation's investment in Detroit is part of their larger community strategy project, designed to invest in civic innovation to expand economic opportunity and create a culture of engagement. For its 2016 funding round, the Knight Cities Challenge allocated $5 million in funding to 37 submitted ideas in 26 communities where Knight already invests.

http://www.knightfoundation.org

Incubation Capacity

A "business incubator" is an organization "geared toward speeding up the growth and success of startup and early stage companies" (Entrepreneur, 2016). They typically help link start-ups to capital in the form of government grants and angel investors. Two main types of incubators exist: the first type provides a physical space to lease to the start-up, along with share office equipment, business advice and networking, and opportunities to obtain capital; the second type is a virtual incubator that provides the services of the first type without providing any office space for the start-up.

According to the Michigan Business Incubator Association, West Michigan has two relevant organizations that work to incubate start-up companies. The Grand Valley State Muskegon Innovation Hub is located at the Port of Muskegon and provides leasable office space, networking, mentorship, and funding opportunities for start-ups. The second incubator organization is called Blue Banyan Equity and is located in Hudsonville, Michigan. Blue Banyan does not provide a physical working space, but instead specializes in funding start-ups and offering additional support services such as back-office support, regulation compliance support, and accounting in exchange for an equity stake in the start-up.

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This study explores the feasibility of establishing a deconstruction economic sector in Muskegon, Michigan. Deconstruction is an alternative solution to the problem of structural abandonment that repurposes and recycles deconstructed building materials in contrast to the practice of demolition and landfilling blighted housing. This study designates Muskegon, Michigan as the economic hub for repurposing construction materials. Muskegon was chosen for this study because of its deep water port, considered to be underutilized, and community leadership interest in this sector.

The high concentration of abandoned structures in Midwest cities offers an opportunity to utilize the Great Lakes marine transportation system to transport deconstructed building materials to Muskegon to be repurposed, recycled, and reused.

The findings and recommendations of this study are intended to guide policymakers and practitioners in increasing deconstruction practies in the Midwest. Several steps are outlined that may be taken by the Muskegon area specifically in order to improve usage of their unique, deep-water port on the west coast of the state.

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