Making Deconstruction Economies Work in Michigan:

A praxis-based framework for Deconstruction feasibility assessment in Michigan

Michigan State University Center for Community and Economic Development (CCED)

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Michigan Department of Environment, Great Lakes, and Energy (EGLE)

Summer 2023

Background and Purpose of Project

This project was funded under the Michigan Department of Environment, Great Lakes, and Energy (EGLE) FY 21 Recycling Market Development Grant program, specifically within the Targeted Partnerships Project subcategory. The purpose of this funding opportunity is to support multi-partner / multi-sector projects focused on developing and expanding recycling (and in this instance, reuse) markets across the state of Michigan. Beginning in Summer 2021, the Michigan State University Center for Community and Economic Development (CCED) partnered with The ReUse People of America (TRP), American Classic Construction (ACC), and the Muskegon County Land Bank to apply for funding from EGLE to support feasibility research and market development work around establishing a dedicated deconstruction and material reuse facility in West Michigan. Each of the project partners [see descriptions below] entered this project with a vested interest in exploring this pressing question and have worked closely together to develop a framework to aid in making this determination.

Advances in technology and policy which support deconstruction economies are helping to move this sector forward – for example, the 2022 North American Industrial Classification System (NAICS) now includes 'whole building deconstruction' as an accepted subcategory; whereas previous work conducted by MSU CCED in 2017 & 2019 found the lack of a NAICS code to be a major impediment towards the growth of the sector, and identified an overall dearth of aggregated data which can be easily used to assess and measure deconstruction economies. With increasing interest in deconstruction and material reuse globally, it is worth noting that at the time of this writing there exists no single resource which articulates a replicable and accessible methodology for assessing the market for deconstruction services on a regional level. In light of this – and considering the data-starved environment in which many deconstruction start-ups operate – this report aims to build a methodology for this assessment that utilizes publicly available data to define and articulate the aspects of a deconstruction services market.

This report is intended to layout an easily accessible and useful assessment framework which will allow for interested communities, aspiring deconstruction enterprises, and other stakeholders to understand easily and quickly: how deconstruction economies function, the essential components of deconstruction economies, conducting market assessments for deconstruction services, an overview of the tax-deductible donation incentive (commonly used by deconstruction enterprises), an overview of material reuse / used building material retailing, and evaluating impacts of a deconstruction enterprise. This information is designed to facilitate informed decision making on the potential to develop and sustain a structural deconstruction economic sector in a region. Each section of this report will show the methodology used and the findings from the project team's market assessment project, with a concluding section describing the overall determinations of the study. The hope of the team is to have created a framework which will allow for a broader array of Michigan stakeholders to explore whether deconstruction and material reuse make sense in their regional context; and to have elucidated a low barrier, novel approach towards defining and assessing regional deconstruction economies.

Project Partners

Owing to MSU CCED's decades long history of community engaged scholarship – this project utilized an advisory committee model and drew heavily from MSU CCED's existing nationwide Domicology network. One of the many benefits of pursuing such models is that it provides an ongoing platform for consultation in which key stakeholders are asked to advise on all aspects of the project, as well as an ongoing opportunity to identify and engage new stakeholders whose experiences are vital in helping the project team be most effective and impactful. Each of the organizations listed below are involved in this project as key partners; and have been involved historically with MSU CCED as supporting members of the Domicology network and other advisory committees.

MSU Center for Community and Economic Development (CCED)

MSU Center for Community Economic Development (CCED) grew out of the MSU Center for Urban Affairs, founded in 1968 to bring the land grant mission of uplifting the university community through research and development to the growing urban centers of the country. CCED has been leading the way in Michigan on sustainability in building, specifically through deconstruction and recycling, via Domicology. Domicology is the study of a building's lifecycle, with specific focus on waste diversion at the end of a building's lifecycle, and to keeping the economic benefits of construction and demolition within a given community.

American Classic Construction

American Classic Construction (ACC) is a statewide leader in building supplies wholesaling, roofing, and tear-offs on 600-1000 houses annually, shingle recycling and reprocessing, wood waste processing, and waste hauling. American Classic also features a statewide dumpster hauling business, with 3 currently running transfer stations, and 3 more in development across the west side of the state. ACC is dedicated to expanding its C&D recycling capacities and providing high-quality, well-paying jobs for the communities it serves.

The ReUse People of America

The ReUse People (TRP) is a non-profit organization based in Oakland, CA that is widely regarded as the premier Deconstruction and Material Salvage nonprofit in the country, with over 3000 successful deconstruction projects to date. TRP brings with it a deep capacity for conducting and training others in deconstruction, material salvage, and used building materials retailing. TRP is dedicated to recovering building materials destined for landfill, and making those materials accessible for reuse at well-below market rates. As of Fall 2020, TRP has diverted 425,000 tons of material from landfill with an estimated appraised value of $200 million; has established 15 branches across North America, and has trained 82 different crews in full deconstruction.

The Muskegon County Land Bank Authority

The Muskegon Land Bank Authority was formed in 2007 to transform vacant, tax delinquent and abandoned property for the benefit of the surrounding property, to improve the community, stabilize the area, give low-income families the opportunity to be homeowners and return the property to the tax rolls. The Muskegon County Land Bank Authority is heavily invested in pursuing sustainable and equitable development in the greater Muskegon area, and has been a longtime collaborator with the MSU Domicology research Team.

Figure 1: Table of Partner Features and Roles

Organization Name	Key Features / Roles
MSU CCED	Domicology Stakeholder Network, Conduct Market Assessment, Develop Feasibility Framework, Measuring Impacts, Feasibility Assessment Project Management
The ReUse People (TRP)	Experience establishing regional reuse economies, Training Programs for Deconstruction crews, trainers, and retail facilities, Deconstruction Project Management Services
American Classic Roofing and Construction (ACC)	Established regional presence (existing crews completing construction & demolition projects), Interest in developing capacity to

	complete deconstructions, C&D recycling Infrastructure
Muskegon County Land Bank	Manages tax foreclosed properties including blighted and abandoned structures, conducts demolitions and new-build infill housing, Interest in developing material salvage and reuse as a component of development activities,

The table above describes roles played by each of the project partners, including notes on key features such as specific experience, motivation for engaging in project, assets and relevant capacities, etc. This list is not exhaustive, but instead is provided to help better characterize the nature of each partner's participation in this project.

Defining Success & Key Assumptions

Though deconstruction and material reuse economies across the country share many similar characteristics and challenges, sustainability of these economies is heavily dependent on local and regional contexts – and as such, there is no single 'silver bullet' solution to guarantee easy adoption of these activities in a new market context. Significant factors to consider in assessing cluster feasibility includes but is not limited to: policy environment, characteristics of housing stock, quantity and quality of material embodied in housing stock, socio-economic factors and population density, the involvement of local/regional/state municipalities, workforce composition, cultural/aesthetic values attached to materials and structures, etc. In acknowledgement of this reality, the project team worked at the onset of this feasibility assessment to identify key operating assumptions that would guide the feasibility assessment process, as well as to identify specific measures of 'success' as informed by the experiences and goals of each of the partners on this project. These key parameters are as follows:

Key Assumptions:

- The project team is exploring the adoption of the ReUse People of America's (TRP) deconstruction enterprise model with key Michigan Partners;
- This model focused in part on utilizing a tax-deductible donation incentive to generate

new projects based on TRP experience;

- Vacant, Blighted, and Abandoned properties constitute potential projects as well; dependent on the involvement of Land Banks and Municipal level partnerships
- Revenue from retail sales, training & education, and project management services are key to sustaining the 501c3 component of the system
- Revenue from deconstruction services [homeowner to contractor] is key to sustaining deconstruction contractors operating in the system

Defining Success:

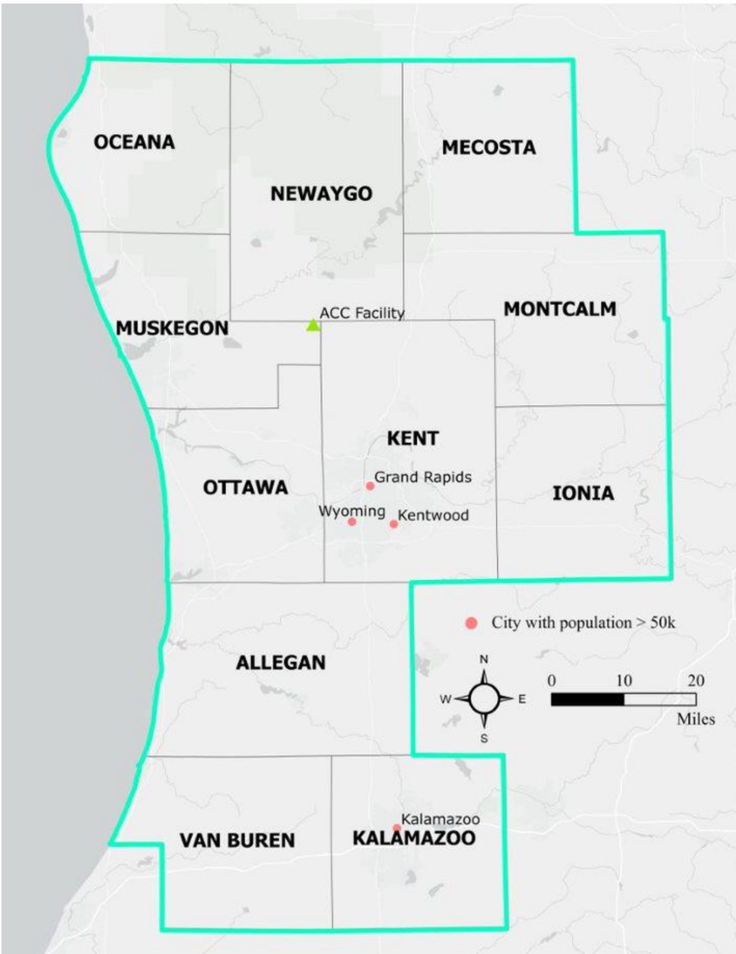
- Sustainable Operation as defined by project team means "the ability to remain financially solvent without the relying on grant funding to support operating costs of the enterprise"
- Essential Components of Cluster include: Trained deconstruction crews, deconstruction training capacity, dedicated material retail facility, nonprofit with 501c3 status, and the presence of an adequate market to support deconstruction services.
- Based on TRP practice knowledge, a retail facility requires a minimum of 10,000sf and 30-40 deconstruction projects annually to generate adequate inventory.

Based on the above assumptions and parameters, this feasibility study examines the degree to which our selected area of analysis (detailed in the following section) can viably support a successful deconstruction and material reuse enterprise. This includes an investigation into market conditions & ostensible demand for services; facility and equipment needs; and an examination of the way in which environmental impact can be accounted for in deconstruction enterprises.

Defining Catchment Area

At the onset of this assessment, the project partners worked to determine a specific geographic region to serve as the basis for this analysis – henceforward referred to as 'catchment area' in this document. Factors that were included in this determination included: existing ACC service area, travel time from ACC facilities, population and proximity to population centers, and other factors not listed. The project team elected to draw this catchment area using existing county boundaries to best take advantage of multiple datasets available at the county level. And to ease a replication by future users of this assessment tool. The following counties comprise the selected catchment area for this analysis: Allegan, Ionia, Kalamazoo, Kent, Mecosta, Montcalm, Muskegon, Newaygo, Oceana, Ottawa, and Van Buren.

Figure 2: Map Catchment area by county level with markers showing ACC facilities



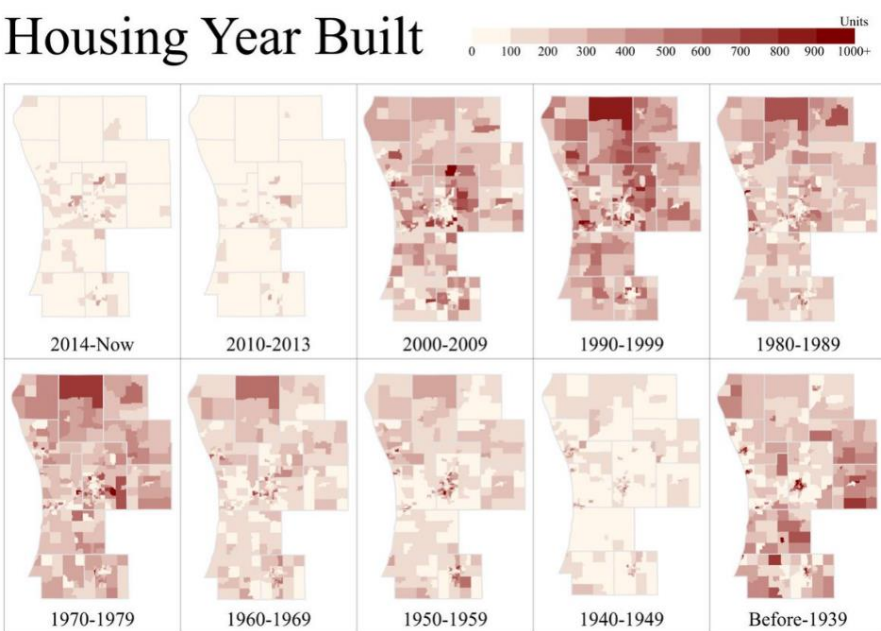
Profile of Catchment Area

The following is a selection of demographic and other descriptive data gathered by the project team that was utilized in the process of determining the feasibility of establishing a deconstruction enterprise in the catchment area described above. Data will be presented in this section with brief commentary on its utility in assessing deconstruction feasibility; but will be described in more detail specifically pertaining to the overall determinations of this study in the Findings and Implications section of this report. (*All data included in this section – except where otherwise noted - is publicly available Census data. The team utilized data.census.gov to gather relevant data and performed basic spatial analysis of said data utilizing ArcGIS.)*

Housing Stock Profile

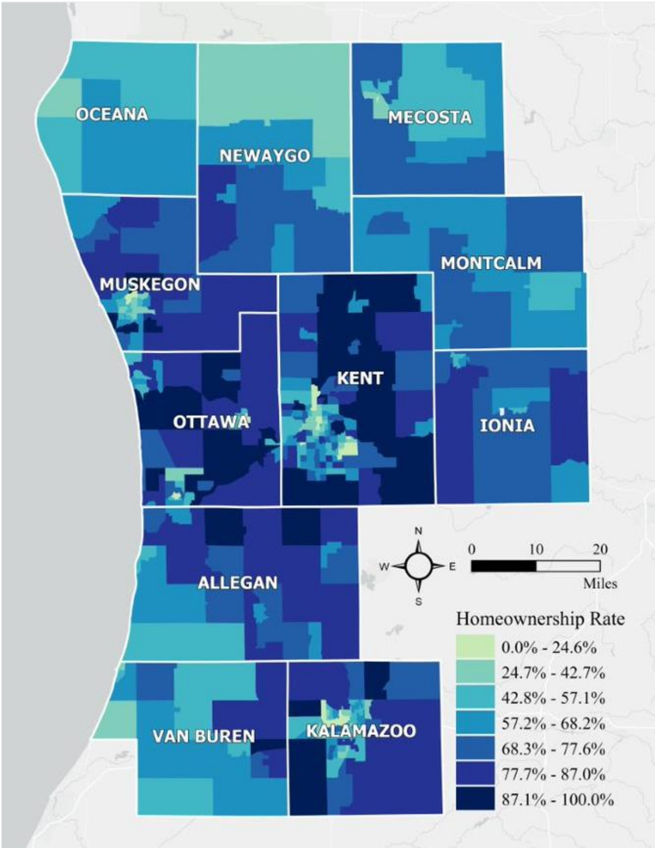
Developing a housing stock profile is an essential step towards understanding a region's market for deconstruction services; although an overall lack of accessible data describing structural characteristics makes this process more difficult. The annual American Housing Survey (AHS) conducted by HUD / US Census Bureau – for example – utilizes small sample sizes and is only available for certain geographies. At last check, the only available geography in the state of Michigan for the 2021 AHS is the Detroit metropolitan region with a sample size of approx. 1600 homes. As will be discussed in the latter 'public market assessment' section of this report, individuals interested in developing a housing stock profile are encouraged to contact their local governments, building departments, regional Michigan State Housing Development Authority (MSHDA) office, Land Bank, Economic Development District (EDD) to explore the availability of more precise structural data on a local level. In this case of this project's catchment area, the project team relied on Census data to begin developing a housing stock profile.

Figure 3: Structure Age



Understanding the age of structures in a catchment is a key step towards developing a housing profile. The age of structures can help to predict future demolition trends and can be useful in developing a profile of specific materials currently embedded in structures. For example, homes built prior to 1940 are likely to have higher quality lumber in harder to find dimensions (I.e., longer board length from balloon framed houses, true 2 x 4", presence of rarer woods, etc.) Conversely, homes built in the 1990s and newer may be more likely to have reusable components such as cabinets, counter tops, sinks, lighting, etc.

Figure 4: Owner Occupied Housing Units in Catchment Area



Owner occupancy data allows for stakeholders to better understand the various neighborhoods that comprise their potential deconstruction market. This information is relevant to identifying the private market for deconstruction services [see following section: Private Deconstruction Market Assessment] and has implications for predicting quality of material salvageable from housing.

Figure 5: Total Housing Units

Understanding the density of total housing units in a selected area can help to determine priority areas for engagement and advertising on the part of the deconstruction enterprise. Other data available from the census bureau articulates the presence of multi-family housing units and larger apartment style housing units.

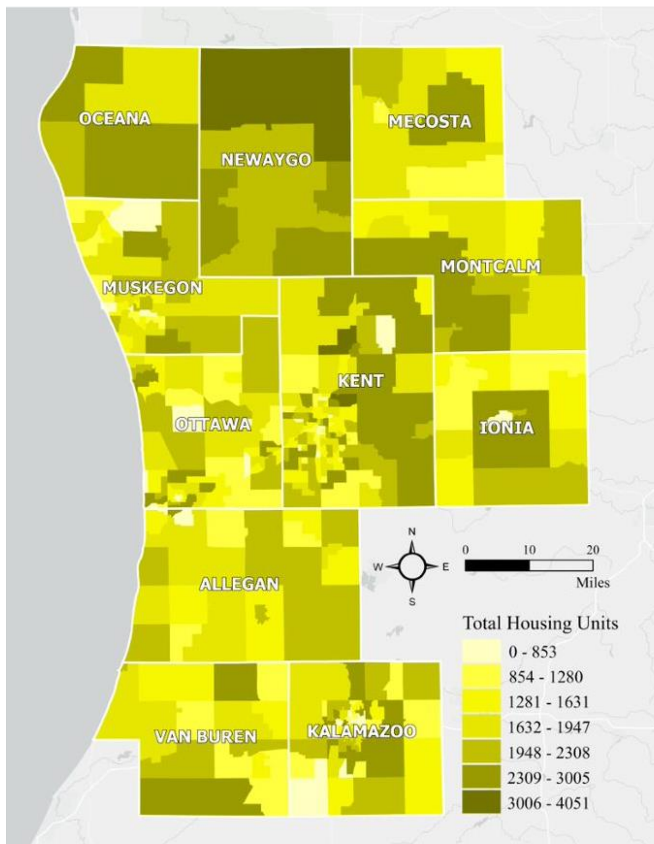
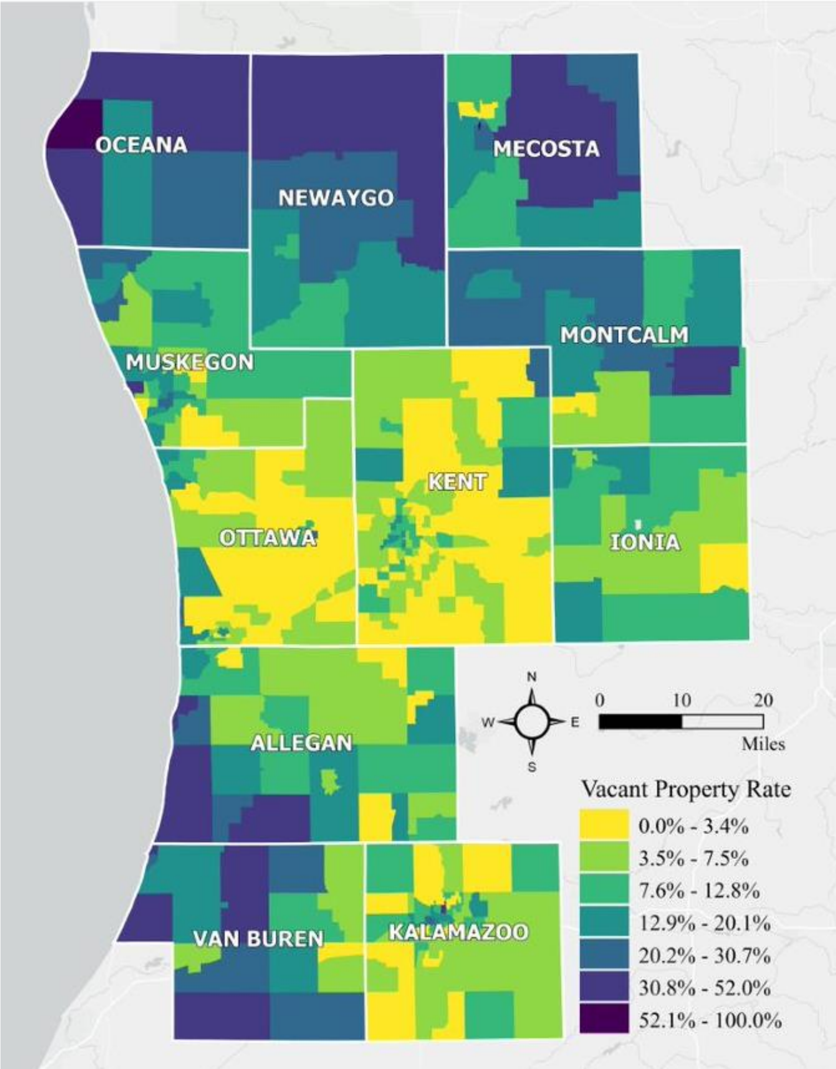


Figure 6: Household Vacancy Rate

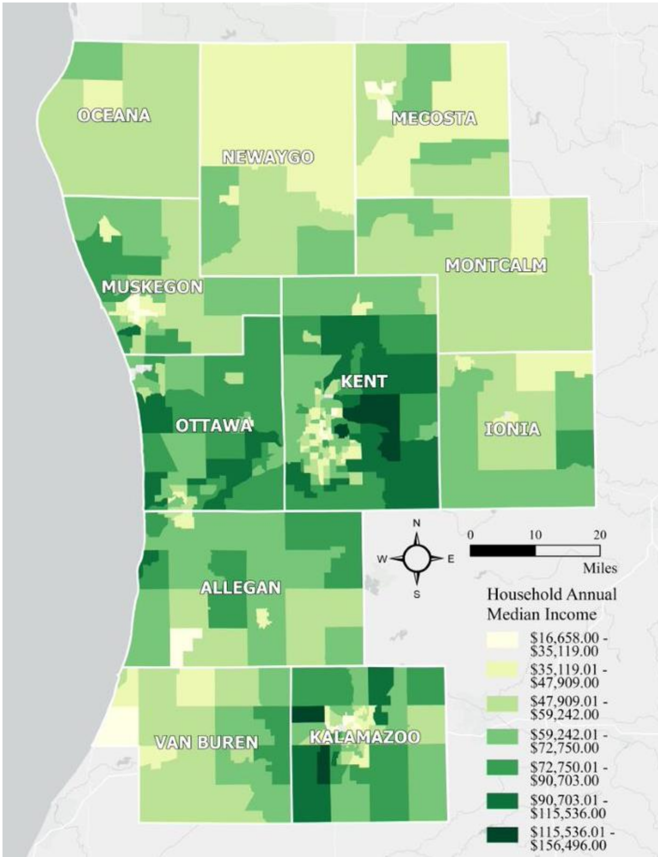


Household vacancy rate data is especially useful in understanding and assessing a region's public deconstruction market and is a useful analogue to predict future trends of blighting and abandonment in a region. [See following section: Public Deconstruction Market Assessment]

Economic Indicators

As will be examined throughout the following sections of this study, the deconstruction enterprise model examined in this feasibility analysis utilizes a tax-deductible donation process as a key incentive for generating deconstruction projects. The use of this incentive is widespread practice for deconstruction enterprises across the country. Subsequent sections of this report will examine in detail how this mechanism relates to the overall feasibility of establishing deconstruction enterprises, the equity implications of this mechanism, as well as additional policy strategies that can be utilized to maximize access to deconstruction services. The figures below represent a small selection of available economic data that can be valuable to understanding and pinpointing markets for deconstruction services.

Figure 7: Median Household Income



Median household income data is a key indicator used in this feasibility analysis, as it is useful in understanding and assessing the private market for deconstruction services in a region. Median (instead of mean) is favored because it is less likely to be skewed by ultra-high (or low) incomes and therefore provides a more accurate accounting of household incomes from census tract to census tract.

Figure 8: High Income Households

Like the above figure which shows the full distribution of household incomes across a region, identifying high income households (in this context, households making above 200k a year) allows for a deconstruction enterprise to identify target regions in which demolition projects are likely to be more easily substituted with deconstruction projects. [See following section: In Focus: Tax Deductible Donations & Deconstruction Enterprises]

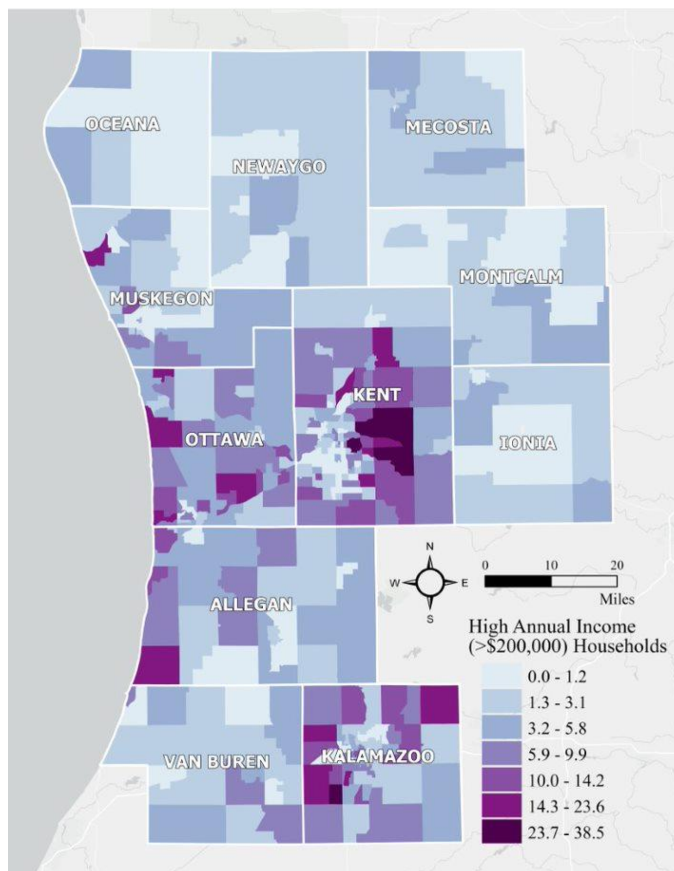
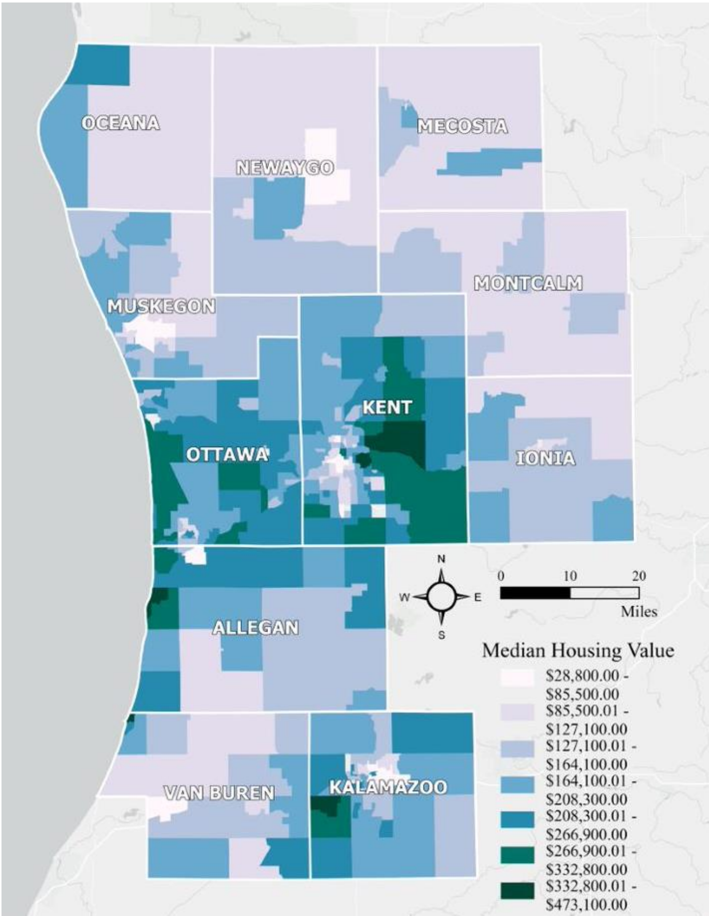


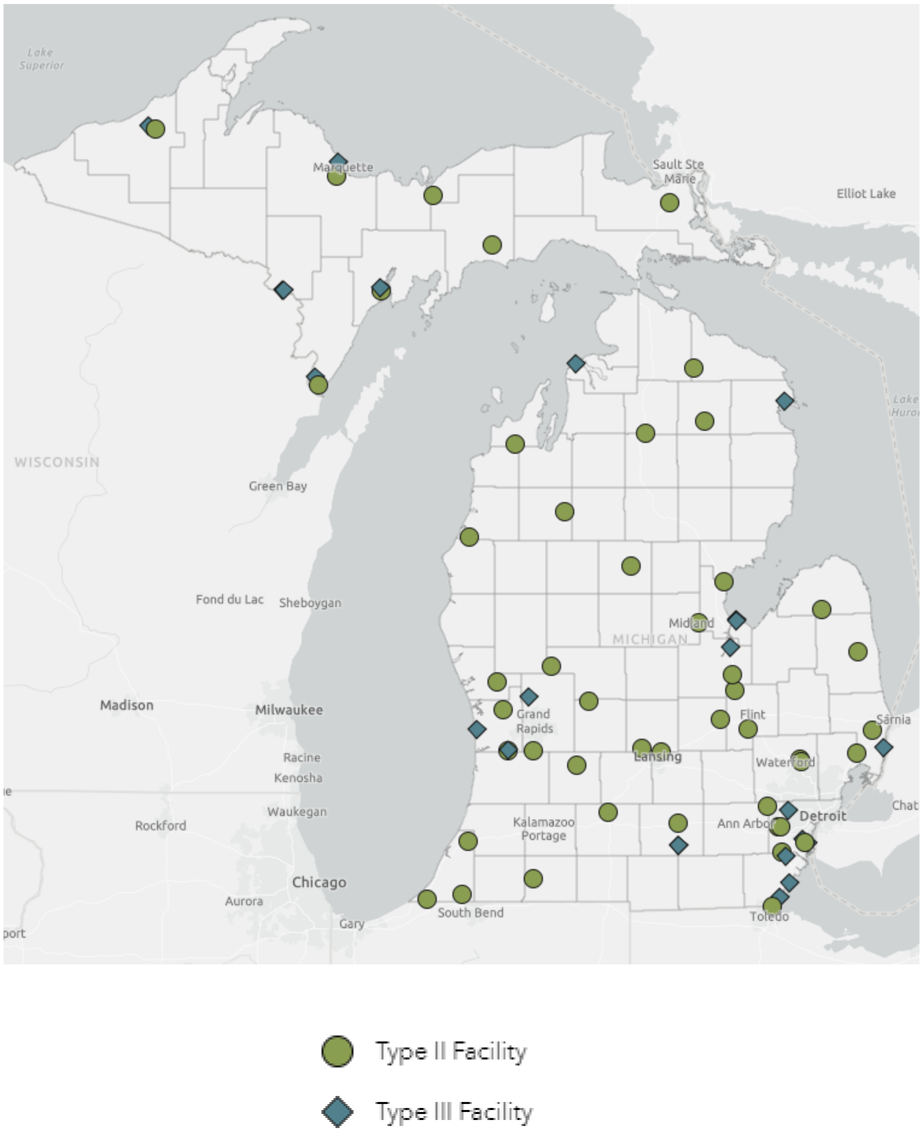
Figure 9: Median Home Values



Median Housing Value data can help a deconstruction enterprise develop a deeper understanding of the housing profile in their region and can be a useful tool in identifying key areas for marketing and advertising for deconstruction services.

Other Relevant Data

Figure 10: Landfills and MRFs in Michigan



It is important to understand the landfilling options in a deconstruction enterprises service area for two key reasons: factoring in hauling and waste disposal costs into deconstruction bids (even deconstruction projects with very high diversion rates will still generate some degree of non-recyclable/non-reusable material) and exploring the opportunity for C&D waste diversion partnerships with C&D landfills, potentially creating an additional source of reclaimed/reusable building materials to be managed by the deconstruction enterprise. The above figure was generated using an online GIS service provided by the Michigan Department of Environment, Great Lakes, and Energy to help stakeholders access Part-115 compliant waste disposal facilities across the state. (For more information go to https://egle.maps.arcgis.com/apps/webappviewer/index.htmlid=4ec28f2727554b0295b8b95ce804cd58) Generally Type II facilities are municipal landfills that accept all solid waste aside from hazardous materials, while Type III facilities can include more specialized landfills such as industrial waste, and C&D landfills.

Introduction to Deconstruction

The following section is intended to provide a basic overview of the processes of deconstruction and material reuse, as well as the various social, environmental, and economic benefits offered by deconstructing (as opposed to demolishing) a structure.

Deconstruction is an alternative to demolition that focuses on the careful dismantling of structures to maximize the reuse of materials reclaimed from said structure. Whereas demolition (the most used method of structural removal) is accomplished using heavy machinery that breaks apart the building into piles of mixed debris; deconstruction is generally accomplished by crews using hand tools to systematically dismantle, salvage, and sort materials and building components for reuse. Deconstruction crews are typically comprised of 6-14 individuals depending on the size of the structure and/or the material recovery goals of the project. Though demolition crews typically engage in some degree of material recycling (e.g., recycling concrete or steel elements), the 'smash and go' nature of demolition leaves very little opportunity for reuse or remanufacturing / reprocessing of building materials. Deconstruction projects invariably require longer time on site when compared to demolition. A typical single-family home can be demolished in a single day by a small crew of machine operators, whereas the same structure may require 10-12 days on site to fully deconstruct. This additional time on site – as well as the substantial increase in crew members necessitated by deconstruction – does widely result in deconstruction projects bearing a higher up-front cost than demolition projects. Figure 10 below describes the continuum of deconstruction processes and the relative amount of material salvage compared to time on site of deconstruction crews. The term 'full deconstruction' describes the complete removal of a structure; while terms such as 'skim' and 'partial deconstruction' describe processes that result in an incomplete removal of said structure. Depending on the goals and constraints of a given project, full or partial deconstruction may be pursued. (*Note: In the figure below, Full Deconstruction is described as "[best reserved] for the oldest homes with unique features". In the context of establishing a deconstruction enterprise to work in both public & private markets, full deconstruction should always be considered when possible.)*

Figure 11: Delta Institute Graphic of Deconstruction Activities

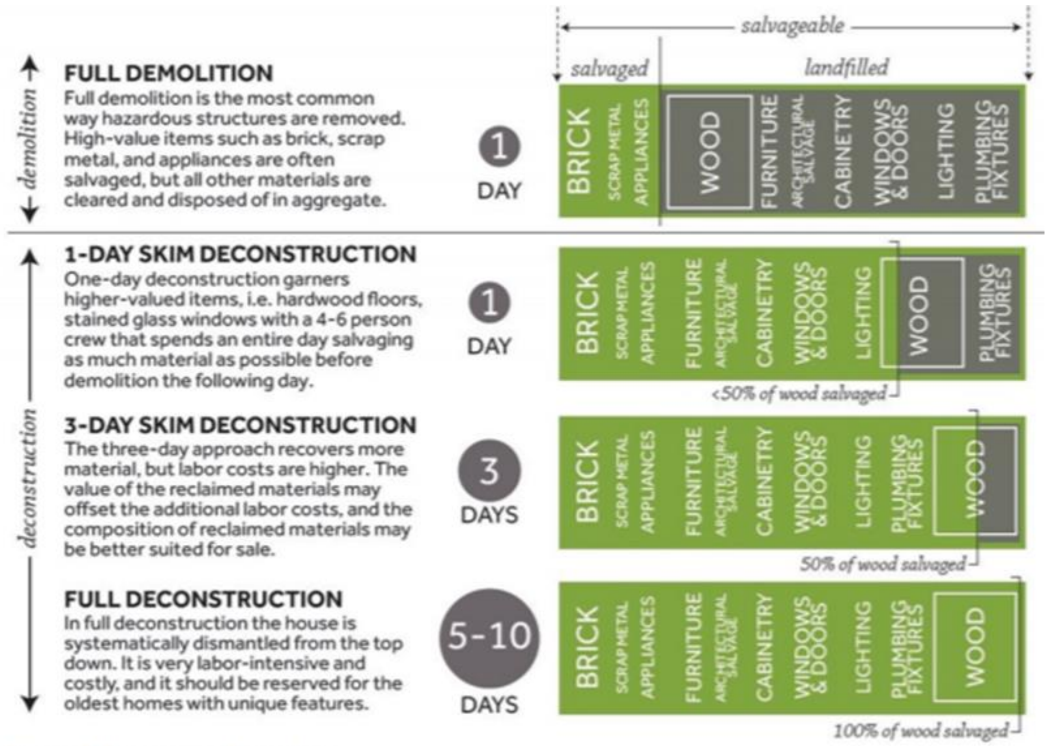


Figure 7: Three Skim Paradigm
Source: (Delta Institute, 2015)

Figure 12 (below) sourced from a similar 2017 study conducted by MSU CCED titled 'Muskegon Michigan Deconstruction Cluster Economic Feasibility Study' shows the array of material types that can be salvaged via the processes of full deconstruction. Note that regional differences in housing stock have a definite impact on the array and quality of recoverable materials netted from deconstruction projects -- e.g., houses in the western United States are much more likely to feature redwood (which has a very high resale value) when compared to comparable structures in the Midwest. Not included in this graphic are the numerous building features/components that are easily salvaged via deconstruction. These include but are not limited to appliances; sinks & vanities; kitchen counters & cabinets; lighting; Heating, Ventilation, and Air Conditioning (HVAC); doors & trim; windows & built-ins; and other architecturally significant features.

Figure 12: Types of Salvageable Materials after Full Deconstruction

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.

Social, Environmental, and Economic Benefits of Deconstruction

When compared to the demolition process – which relies on the operation of heavy machinery to physically break buildings apart – deconstruction offers a wide array of social, environmental, and economic benefits to communities. The table below represents a brief overview of said benefits, drawing from the ever-evolving body of scholarship conducted around deconstruction and material reuse.

Figure 13: Selected Benefits of Deconstruction and Material Reuse

Realm	**Benefit**	**Sources**
Social		
	Creates 6-8x more jobs than Demolition	Delta Institute, 2015
	Excellent Platform for Jobs Training (e.g. General Construction, Carpentry, Weatherization & Energy Audit, Hazardous Materials Contractor, etc.)	EPA, n.d.; LIUNA, 2010
	Preserve architecturally and culturally significant building components	McCarthy, 2019
	Increase access to low-cost building materials	The ReUse People of America, 2021
Environmental		
	Reduces exposure to Hazardous Material Particulate & Avoids potential for contaminated runoff via dust control	Crovella, Delaney, Kohan, 2018
	Reduces waste entering landfills	EPA, n.d.
	Conserves carbon via increased recycling and reuse opportunities	Portland Bureau of Planning and Sustainability, 2019
	Voided emissions of virgin materials via reuse	Portland Bureau of Planning and Sustainability, 2019
	Less reliance on GHG emitting mechanical equipment	Manuel, 2003
	Increase opportunities for Adaptive Reuse of Existing Structures	AIA, 2020
Economic		
	Cost savings for homeowners via tax deductible donation process	The ReUse People of America, 2021
	Job creation and new industry Development opportunities via reuse and reprocessing	Sustainable Earth, 2022
	Preserve economic value of materials recovered from waste stream	Sustainable Earth, 2022
	Lower disposal costs	MSU CCED, 2017
	Cost reduction for new projects via salvage material reuse	The ReUse People of America, 2021

Systems view of Deconstruction Economies

Across the country, deconstruction and material reuse economies are thriving, particularly in population centers such as Portland, OR; Chicago, IL; Oakland, CA; Salt Lake City, UT; and San Antonio, TX. Often regional deconstruction economies operating in these communities are best understood as clusters – that is, a geographic collection of interconnected businesses, suppliers, and associated institutions working in a shared field. In other contexts, deconstruction enterprises may elect to manage the essential functions of a deconstruction economy under one organizational umbrella. In general, both deconstruction clusters and self-contained deconstruction enterprises ultimately require the same set of basic functions in order to maintain a functioning deconstruction and material reuse economy. The essential components of deconstruction economies are listed below:

- Housing Stock to be Deconstructed
    - Homeowners
    - Partnerships with Land Banks, Local Governments, etc.
    - Developers
- Deconstruction Crews
    - Typically Trained by 501c3 organization; can be trained by private companies or workforce development partnerships
    - Can be managed by 501c3 internally, or externally as contractor
- Material Retail Facility (In this report, interchangeably called Retail Facility, Reuse Facility, Used Building Materials Facility, etc.)
    - Distributes reclaimed materials back into productive use
    - Can be managed by 501c3 internally, or externally using contractual agreement
- 501c3 Organization
    - Provides tax deductible donation to homeowners in exchange for materials
    - Provides training and education services
    - Manages or Subcontracts Retail Facility
- Auxiliary Functions
    - Environmental Services (Hazardous material assessment and abatement)
    - Certified Appraiser (Required for tax deductible donation process)

- Recyclers (to receive concrete and other hard to reuse materials)
- Dumpsters and Hauling
- Landfill (to receive materials that cannot be reused or recycled)

Visualizing Deconstruction Economies

The following two figures show key value layers associated with deconstruction and material reuse economies and are intended to demonstrate the high degree of interdependence and coordination amongst key functions within this system. Each of the components described in these system maps are an essential step in both the supply and value chains associated with deconstruction economies. Because the model being explored in this feasibility study is consumer dependent (most revenue sustaining the system comes from market activities, as opposed to grant funding) a deconstruction enterprise must find ways to deliver value to the various entities involved in the system, while simultaneously generating enough revenue to sustain and grow its own operations.

While the ultimate function of a deconstruction enterprise is dependent on the diversion of material from the landfill, the steps necessary to actualize these ends are often decoupled from the discrete value of the materials alone. Instead, the deconstruction enterprise must develop value propositions for the various entities involved in the system. These layers of value are at all times *related* to the materials flowing through the system but are realized based on the fulfillment of essential functions within the system. This is not to say that the central proposition of a deconstruction enterprise—that reclaimed materials have inherent value—is incorrect, but instead that the fulfillment of essential functions within the system is what helps leverage value *from* salvaged materials to be realized by a broader array of stakeholders. For example, the value proposition for a homeowner paying for deconstruction services does not change whether the retail facility sells 100% or 10% of materials from their project; but it does for the retail facility. Value to the homeowner is actualized through the tax-deductible donation process [more on this in following sections]; while value to the retail facility is actualized at the point of sale.

Figure 14 below shows the flow of materials through the deconstruction system – the basis upon which all other forms of value in the system are derived. Note that two material streams are present in this system, reusable/recyclable materials (denoted by a solid line) and difficult to reuse/non-recyclable materials (denoted by a dashed line), each with a directional flow indicated by the presence of an arrow. As materials move from their origin place (in a structure owned either by a homeowner, property owner, or a public entity) through the system, their ownership is transferred through the deconstruction contractor into the 501(c)(3) retail facility. At this point, a variety of interrelated loops occur, in which each potential end-user (represented by blue rectangles) simultaneously receives material via the retail facility (or from another end-user) and passes that material on to another end-user or customer. Eventually these materials end up in new projects via direct reuse, recycling, or upcycling – creating a second life for these materials and voiding the need for virgin materials.

Figure 15 shows two key derivative value layers associated with the flow of materials through this system: revenue/monetary value (denoted by a solid line) and technical assistance/training (denoted by a dashed line), each with a directional flow indicated by the presence of an arrow. Whereas materials demonstrated a linear flow left to right through the system, the value layers displayed in this systems map flow in a much more complex (and often-times, multi directional) manner. Beginning with the homeowner (indicated by a diamond) who pays for deconstruction services, revenue flows to the deconstruction contractor. The deconstruction contractor sub-contracts with environmental services and hauling contractors who are compensated for their services. The deconstruction contractor then pays a percentage of their earnings from the deconstruction project to the 501(c)(3) organization. The 501(c)(3) organization receives materials from the homeowner as a donation, and after going through a certified appraisal process (not modeled in this system), the homeowner receives a tax-deductible donation receipt with a 5-year carryforward that creates substantial tax savings for the homeowner.

As materials move through the retail facility into their respective end-use-consumers, revenue flows from the retail facility back into the 501(c)(3) organization who uses this revenue to support their continued operation. The training / education component of the 501(c)(3) generates revenue by offering technical assistance and training to deconstruction contractors, workforce development boards, land banks, and other entities. This technical assistance / training is essential, as it allows for the deconstruction contractor to adequately complete deconstructions and participate in the system, creating an entirely new revenue stream for said contractor. Many deconstruction enterprises heavily vet their deconstruction contractors, and often require that said contractors undergo the 501(c)(3)'s specific training and certification process. End users of these materials create value through various processes and generate revenue by selling their goods/services to one another and to other stakeholders outside of the system. (e.g., upcycle artisan purchases material from retail outlet, adds value, and sells the new product to a designer/architect, generating revenue. The designer/architect utilizes this upcycle product in a new project and is compensated by a homeowner for their services.)

Figure 14: Deconstruction Systems Map – Flow of Materials

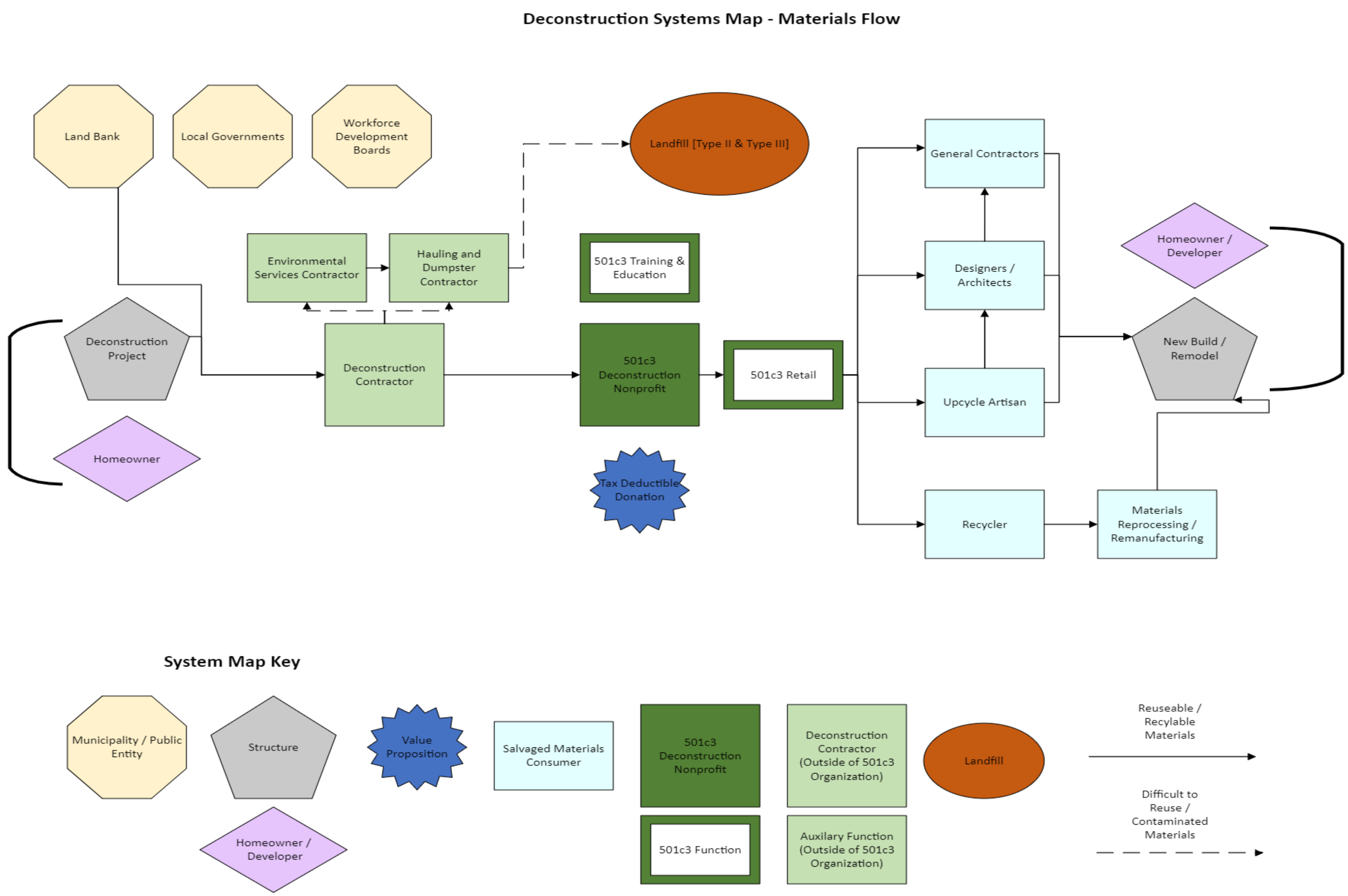
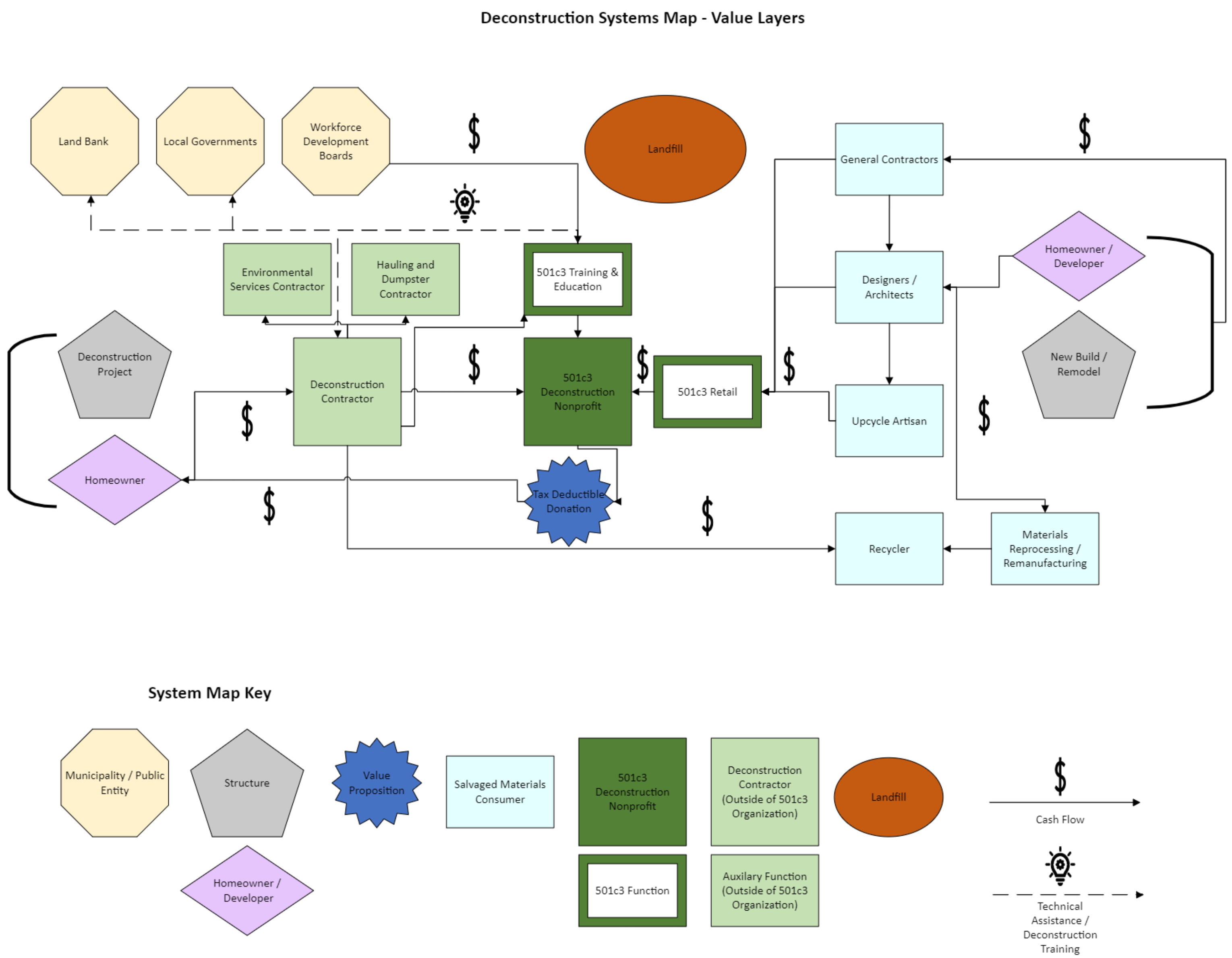


Figure 15: Deconstruction Systems Map – Value Layers



Deconstruction Revenue Streams

As was indicated in the above sections, a key consideration for exploring the feasibility of establishing deconstruction and material reuse economies is understanding the various forms of revenue that these clusters generate. Many deconstruction enterprises may design their business plans around grant funding or other 'soft dollars' to support their operations. Other enterprises may elect to forgo entirely grant funding and instead elect to develop a business plan that sustains operations based on a fee for service / retail revenue model. In the case of this feasibility assessment, the key partners (ACC & TRP) elected to explore the latter option – exploring the presence of an adequate market for deconstruction services in lieu of pursuing grant funding to support operating costs.

The below table provides a basic overview of the revenue generating capacity of key components of a deconstruction cluster. Note that depending on the organization structures of said cluster (e.g., whether a material reuse nonprofit manages deconstruction crews internally) the recipient of that revenue can change.

Figure 16: Revenues in Deconstruction Clusters

Organization	**Role**	**Possible Revenue Sources**	**Notes**
501c3 Nonprofit		Grants / Donations	Nonprofit status allows for these organizations to pursue a variety of grant funds to support operations. Allowable expenses change depending on the funding organization and the priorities of a given grant program
	Retail Facility	Revenue from Material Sales	Material reuse facilities price inventory based on market prices. General Pricing: $.40 for every $1 for lumber // $.25 for every $1 for other building materials and components

	Training & Education	Fee for Service Workforce Development Grants	Training and educational programming includes: deconstruction crew training (3 day), deconstruction crew training (14 day), retail facility start-up training, deconstruction crew leader training, & specific technical assistance on case-by-case basis
	Deconstruction Assessments	Fee for Service & Contractual	Many 501c3 organizations charge a flat rate for deconstruction assessments or include a provision for such in contracts with deconstruction contracting crews
	Project Management	Fee for Service & Contractual	For larger projects and those managed by the 501c3 organization (managing selecting contractors, bidding, permitting, etc.) a fee for service may be charged to either homeowner or deconstruction contractor
Deconstruction Contractor			
	Deconstruction Services	Fee for Service	Homeowner pays deconstruction contractor for deconstruction services (in the same way they would pay a demolition contractor). Generally, the up-front cost of deconstruction is twice that of demolition
	Environmental Services	Fee for Service	Asbestos and Lead assessments, abatement, and hazardous materials management are components of most deconstruction projects. Deconstruction contractors may offer these services themselves or subcontract them out. Fee for services paid by homeowner.
	Concrete Removal & Landscape Services	Fee for Service	Removal of concrete (foundations, driveways, slabs, etc.) and appropriate grading and seeding as indicated in scope of work agreement between

			homeowner and contractor/project manager.

Challenges in Deconstruction Enterprises

Choosing deconstruction can unlock an array of positive social, economic, and environmental benefits that are simply unmatched by conventional demolition practices. This includes (but is not limited to) the conservation of embodied energy / carbon via salvage and reuse, reducing waste streams, creation of new job opportunities for deconstruction practices, business development and job creation around recycling / reprocessing / reusing salvaged materials, etc. With such potential for positive impact, one might reasonably question why this alternative to demolition remains a largely unknown 'niche' industry in most regions of the United States. Though there are a multiplicity of factors to consider in addressing this question, two core concepts have been identified by the project team as significant and ubiquitous challenges for deconstruction enterprises across the country.

1. Deconstruction services bare a significantly higher up-front cost than demolition.

Deconstruction practitioners advise that though there are many caveats to consider, it is generally accepted that the cost of deconstruction will be around twice as much as the cost for demolition up-front. This is an important takeaway for understanding the realities of deconstruction and material reuse economies – that through a wide array of strategies – deconstruction enterprises must work to create a value proposition for their customers that overcomes this increased up-front cost. As will be expanded upon in the following sections, the nature of this challenge changes substantially based upon regional contexts.

2. Deconstruction economies require a high degree of interdependence between key players; key functions require high overhead cost.

This specialization of multiple organizations working within a deconstruction 'cluster' constitutes both a mitigation of risk as well as an increased level of interdependence amongst the members of that cluster. In the words of a nationally recognized deconstruction expert involved with this project, "It simply becomes too expensive to manage all the necessary business functions under one umbrella." This tendency towards specialization (as a sustainability factor of successful deconstruction clusters) creates additional challenges for organizations/groups looking to establish deconstruction and material reuse enterprises in unserved locations. In regions where deconstruction services are novel, it can be very difficult to manage the necessary co-development of essential services across multiple organizational structures (e.g. subcontracting deconstruction crews, managing consignment agreements with retailers, etc.) Conversely, managing all essential functions under a singular organizational structure can be more expensive than through subcontracting, and can make it harder for deconstruction enterprises to respond to developing market conditions because of substantial sunk cost and overhead. In an industry such as deconstruction – where understanding the local context is essential to success – this can have a deleterious effect.

Tax Deductible Donations & Deconstruction Enterprises

Deconstruction services will invariably cost more up-front when compared to the alternative of demolition. A review of the existing literature – corroborated by the experiences of TRP staff involved in this project – shows that on average deconstruction will cost twice as much per square foot when compared to demolition. Finding ways for customers to recuperate or overcome this higher up-front cost is the key towards unlocking a sustainable market for deconstruction services in a region. Though many individuals are likely to appreciate the environmental benefits that come from deconstruction and reuse; there are few individuals who are willing (or able) to incur this higher cost towards those ends alone. Instead, deconstruction enterprises work to develop strategies to overcome or offset this higher cost – creating a value proposition for deconstruction services that makes this choice (to deconstruct instead of demolish) economically feasible for the consumer. One key strategy used by deconstruction enterprises across the country to offset higher costs is the tax-deductible donations process. This incentive has proven to be extremely effective in generating demand for deconstruction services; and requires that the deconstruction enterprise be registered as a 501(c)(3) nonprofit (or be partnered with a nonprofit organization with 501(c)(3) status. This is the key incentive examined within this feasibility analysis – as this incentive is at the center of the TRP model being tested in the catchment area.

Tax Deductible Donations Explained

Individuals and corporations can claim a charitable donation deduction from either in-kind or monetary contributions to different kinds of organizations that are registered by the Internal Revenue Service (IRS) as a tax-exempt 501(c)(3) nonprofit organization. In the case of deconstruction tax deductions, these entities may use the in-kind value of the material after a qualified appraisal is conducted on the value of the material. This value, up to a certain amount depending on income, can be claimed by an individual or corporation and be applied as a taxable income deduction with a 5-year carry forward. These limits are determined by who is making the donation, who is receiving the donation, and the donation type. Factors in determining the limits include whether the entity is an individual or a corporation, which category the receiving organization has been placed in by the IRS, and whether the donation is monetary or in-kind. For individuals making deconstruction tax deductions for non-cash asset donations, they cannot claim more than 30% of their adjusted gross income. For corporations, the threshold is stricter at 10% (IRS, 2023).

The process for donating housing materials to a nonprofit to use as a tax incentive involves several steps. First, the individual must identify a deconstruction company that partners with a trusted nonprofit, especially one that specializes in deconstructing homes and handles materials well. These organizations are not allowed to speculate on the value of the materials, since this can result in erroneous valuations during tax filing. Additionally, donations to organizations that do not include the reuse or resale of building materials in their core mission could be given a reduction in value by the IRS several years after the deduction (The ReUse People, n.d.). Therefore, selecting reputable organizations that have targeted the reuse or resale of materials is important. Second, the material list must be made in collaboration with the donee organization independent of the appraisal process, since neither the contractor nor the appraisers can make the determinations (The ReUse People, n.d.). Third, if the dollar value of in-kind donation is over $5,000, a qualified appraisal must be made on the value of the materials to determine the total dollar amount of the charitable contribution (IRS, 2023). Only a qualified appraiser who specializes in building materials can accurately determine the amount that materials are valued at, so selecting someone who is trustworthy is essential. Cases like Mann v. United States (2021) and Loube v. Commissioner (2020) both represent case studies of how these situations can go wrong. Both involved the same nonprofit-deconstruction partnership, which recommended an appraisal company to the individuals who hired them. The main issue was that the company was not a reliable nor qualified appraisal service and used faulty methodology to value the materials. In both situations, the individuals lost their cases due to the faulty appraisal values and the deductions were disallowed. By not selecting a qualified appraiser, Mann and Loube both owed a significant amount of money to the IRS that they had previously tried to claim with the sale of their houses. To avoid these errors, qualified appraisers from the American Society of Appraisers, Appraisers Association of America, or International Society of Appraisers are preferred, since they are IRS qualified (Marschall, 2023). Finally, once deconstruction occurs and an appraisal is provided by a licensed appraiser, the homeowner must file IRS form 8283 and collect the confirmation signature of the appraiser to claim their noncash charitable contributions.

Tax Deductible Donations Create Value for Consumers

Because deconstruction services are usually rendered *in place* of demolition, any value proposition created by deconstruction enterprises must overcome the additional cost to deconstruct (usually about twice as expensive per square foot compared to demolition) to constitute a true market-driven incentive. The tax-deductible donation inventive – a commonly used incentive for deconstruction enterprises – overcomes this additional cost by generating tax savings for the material donor (owner of the structure) based on the appraised value of the materials, with a 5-year carryforward (the total sum of the donation amount can be claimed as a deduction for up to 5 years following the donation). The following figure displays an array of real deconstruction projects (and their associated donation values) completed by one of the key partners on this project, The ReUse People of America. Note that this table does not display tax savings (which will ultimately reduce or offset the additional cost of deconstruction), but instead shows donation values (the total amount which can be deducted over 5-years). This table also shows the average donation value per square foot (SF) of home – this figure should be used with caution, as there are a multiplicity of factors (project recovery rates, type/quality of materials salvaged, presence of historically / architecturally significant items) that relate to overall donation value.

Figure 17: Selected Deconstruction Projects & Donation Values

Location	**Square Feet (SF)**	**Appraised Donation Value**	**Donation Value per SF**
California			
Atherton	5523	$182,346.00	$33.02
Larkspur	2304	$129,425.00	$56.17
Oakland	1400	$74,144.00	$52.96
Connecticut			
Madison	2997	$177,450.00	$59.21
Idaho			
Boise	1325	$68,550.00	$51.74
Kansas			
Fairway	2204	$77,474.00	$35.15
Mission Hills	2996	$145,297.00	$48.50
Texas			

Austin	1272	$88,750.00	$69.77
Dallas	3200	$129,000.00	$40.31
Houston	2156	$78,843.00	$36.57
Washington			
Bellevue	3800	$175,600.00	$46.21
Redmond	800	$38,302.00	$47.88
Seattle	1600	$40,000.00	$25.00
Average Donation Value / SF			$46.35

To better understand the cost-savings potential offered by the tax-deductible donation process, a few key pieces of information are presented below:

- **Minimum Income Requirements to Itemize**
  a. All tax filers are eligible to claim a deduction on their annual filing by either itemizing their contributions or by taking the standard deduction.
     i. The standard deduction amount changes annually and is determined by filing status – in 2023 the standard deduction will be $13,850 for single filers. (IRS, 2023)
     ii. Itemizing is a more complex process that involves documenting different types of contributions via IRS prescribed processes (Schedule A), but it can allow for a larger deduction in some cases than the standard deduction.
  b. Contributions via Deconstruction projects are considered In-Kind charitable donations, the total amount of deductible In-Kind donations is capped at 30% of Adjusted Gross Income per year (.3AGI).
     i. Other types of contributions have different caps, but those are regarded as out-of-scope for the purposes of this guide.
  c. Minimum Income to benefit from Itemization is determined as follows:
     i. [Standard Deduction ≥ .3AGI] = $13,850 ≥ .3AGI

ii. [(Standard Deduction ÷ .3) ≥ Minimum AGI)] = ($13,850 ÷ .3) ≥ Minimum AGI

iii. **Minimum AGI ≥ $46,667**

- **Theoretical Max Tax Savings via Itemization**

  a. Tax deductible donations lower the filers overall taxable income. Cost Savings are derived from the reductions in tax burden associated with deductions.

  i. [Taxable Income (AGI) = Claimed Income – Deductions]

  ii. [Maximum In-Kind Deduction = .3AGI]

  iii. Because tax deductions ultimately reduce the overall taxable income on a filing, tax savings are determined by multiplying the highest tax rate (r) by the Maximum In-Kind Deduction (.3AGI). Because the filer is deducting up to (.3AGI) from their taxable income, they are avoiding paying taxes on the sum of the deducted amount.

  iv. **[Tax Savings = r(.3AGI)]** where r = Filers highest tax rate (determined by AGI)

The following figure demonstrates the maximum tax savings via in-kind deductible donations for a selection of Adjusted Gross Income amounts for 1-year. To extrapolate these savings up to the 5-year carryforward window assuming the same AGI year over year, multiply the possible maximum revenues by 5. For the purpose of demonstrating the relationship between tax savings and AGI, this table does not account for variance in donation value that can be assumed from real deconstruction projects. In some circumstances – Depending on the total donation value and the filers AGI – certain donations will 'run out' before the 5-year window, while others may not be able to claim the full donation amount before the 5-year window expires.

Figure 18: Theoretical Maximum In-Kind Deductible Donation Tax Savings in 2023

AGI	**Maximum Tax Rate (r)**	**Theoretical Maximum Tax Savings Via In-Kind Donation Deduction**	**Tax Savings from Standard Deduction**	**Maximum Revenue via Itemizing instead of Claiming Standard Deduction Per Year**
	Based on 2023 IRS tax brackets	*(r*(.3AGI))*	*($13,850*r)*	*(r*(.3AGI) - ($13,850*r))*
$75,000	22%	$4,950	$3,047	$1,903

$100,000	24%	$7,200	$3,324	$3,876
$125,000	24%	$9,000	$3,324	$5,676
$150,000	24%	$10,800	$3,324	$7,476
$175,000	24%	$12,600	$3,324	$9,276
$200,000	32%	$19,200	$4,432	$14,768
$225,000	32%	$21,600	$4,432	$17,168
$250,000	35%	$26,250	$4,848	$21,403

Consumer Choice Model in Deconstruction Tax Deductions

The model used in this section is a basic representation of the choice a consumer faces when deciding between deconstruction and demolition, as well as the additional opportunity costs and limits. This model focuses on isolating the impact of the Tax-Deductible donation incentive as pertaining to the overall cost borne by the consumer of deconstruction services; and as such, does not include the multiplicity of external factors that have real impact on the overall feasibility of choosing deconstruction: local/regional/state policy environment, value of materials in structure, tipping fees, etc. Each of these factors (and others not listed) impact the decision-making behavior of consumers of deconstruction services, and need to be considered in conjunction with this consumer choice model to fully understand the deconstruction value proposition.

Opportunity costs are the next best alternative that one gives up by making a decision, which means that the opportunity cost of deconstruction tax deductions is the difference between the costs in demolition and deconstruction, as well as the deduction process. In this case, deconstruction is being used as a substitute for demolition, so what the consumer gives up is the additional amount that they would be paying for deconstruction services instead of just demolishing their house. Also, if they did not already itemize their deductions, the consumer would have to do so instead of taking the standard deduction, imposing an additional cost of losing those tax savings. This model uses tax savings to standardize the dollar value derived from the deduction process, since the deduction itself is not comparable to the costs of deconstruction and demolition. To compare these amounts, the amount one would save by claiming the tax credit should be the maximum tax rate "r" that the IRS assigns to the consumer's annual adjusted gross income, or AGI. These opportunity costs are represented by the formula [Deconstruction Cost - Demolition Cost + r(Standard Deduction)]. If they already itemize, only the difference in deconstruction and demolition costs would represent the opportunity costs as long as they have not hit the limit for charitable contributions. These opportunity costs are then compared with the tax savings from the value of the charitable contribution derived from deconstructed materials. This value is determined by the mechanism [r(Charitable Contribution)]. Lastly, the maximum amount one can deduct from in-kind contributions is 30% of their AGI, so the most that one can earn in tax savings per year is determined by the function [r(0.3(AGI))].

Figure 18: Basic Consumer Choice Model in 2023

Single:
Deconstruction Cost - Demolition Cost + r($13,850) ≤ r(deduction) ≤ r(0.3(AGI))

Married:
Deconstruction Cost - Demolition Cost + r($27,700) ≤ r(deduction) ≤ r(0.3(AGI))

Head of Household:
Deconstruction Cost - Demolition Cost + r($20,800) ≤ r(deduction) ≤ r(0.3(AGI))

Itemizes:
Deconstruction Cost - Demolition Cost + ≤ r(deduction) ≤ r(0.3(AGI))

While these models serve as a general overview for the consumer choice model, there are some specific scenarios that change the formula. One of these changes is when either the standard deduction, charitable donation value, or maximum allowed deduction changes an individual's tax rate. Since deductions reduce the amount of an individual's income, their tax rate may slip into a lower bracket due to that reduction in income. For example, in 2023, a single individual called "Person A" with a 24% tax rate making $100,000 AGI will fall into a lower bracket if they have a deduction of $30,000, since the 24% threshold is set at $95,375 according to the IRS. In this case, the bracket would fall into the 22% range. By using $95,375 as a marker to divide the income ranges, anything over $4,625 would cause an individual making $100,000 to have their tax savings past that point to be calculated using the 22% rate. Therefore, the formula changes to the following in this scenario where Person A is taking the standard deduction and files as single:

Deconstruction Cost - Demolition Cost + r($13,850) ≤ r(deduction) ≤ r(0.3(AGI))

↓

Deconstruction Cost - Demolition Cost + **0.24(4,625) + 0.22(9,585) ≤ 0.24(4,625) + 0.22(25,375) ≤ 0.24(4,625) + 0.22(25,375)**

The other change that could occur is when the deduction is too big to fit within the annual charitable contribution limit, the value can carry over for up to five years. This would mean expanding the total maximum savings limit over time, but at the cost of multiple years of taking the standard deduction for those that do not already itemize. In another example, a single filing individual named "Person B" may have an income of $100,000 and a charitable contribution of over $30,000, which is their annual limit. Regardless of tax savings, Person B may want to carry over the value past $30,000 to the next year to claim the full value of the deduction. This decision would mean claiming the deduction for at least two years. However, that would mean also giving up another year of taking the standard deduction. To account for this difference, the formula changes to the following:

Deconstruction Cost - Demolition Cost + r($13,850) ≤ r(deduction) ≤ r(0.3(AGI))

⬇

Deconstruction Cost - Demolition Cost + **2**(r($13,850)) ≤ r(deduction) ≤ **2**(r(0.3(AGI)))

Equity Implications of Tax-Deductible Donations

While the deconstruction tax deduction is one viable method of incentivizing deconstruction for households, there are some issues concerning equity to be considered. Firstly, the deduction is only available to individuals who itemize their taxable income instead of taking the standard deduction. Usually, those who do so have a relatively high income in comparison to the rest of the population in Michigan. For example, in Michigan about 83% of taxpayers for the year 2020 had an adjusted gross income of under $100,000 dollars, with 3% of that population choosing to itemize (IRS, 2020). For context, the median filing size in Michigan for 2020 was $39,313 (St. Louis FED, 2022). There are no *technical* minimum income requirements for itemizing, but in many cases it would not make sense for those with lower incomes to switch from the standard deduction, as their ability to generate additional revenue (tax savings) beyond the standard deduction decreases substantially as AGI decreases. As calculated earlier in this section, the approximate AGI at which an individual will no longer net additional savings via itemizing is $46,667. Figure 19 below shows a breakdown of Michigan tax filers in terms of Adjusted Gross Income (AGI) and percentage itemized.

Figure 19: Profile of Michigan Tax Filers in 2020

Adjusted Gross Income Range	**Number of Tax Filers in MI (2020)**	**Percentage of Total Filings**	**Percentage Itemized**
Under $25,000	1,800,910	35.79%	0.96%

$25,000 – $50,000	1,216,410	24.17%	2.47%
$50,000 – $100,000	1,135,950	22.57%	7.58%
$100,000 - $200,000	666,220	13.23%	13.80%
$200,000 - $500,000	175,470	3.48%	32.13%
Over $500,000	36,310	0.72%	57.56%

For those who are already itemizing their tax deductions, the process is different. Instead, they only need to decide whether they can get more through the deductible value of the donated materials than the next best alternative. In this case, that alternative would be how much more they are paying for deconstruction than demolition. If they have already hit their maximum limit for in-kind donations, another cost would be the value of charitable deductions equal to the deconstruction cost that they are giving up. In many cases, the main problem is whether the individual's itemized deductions can outweigh the value of the standard deduction. For deconstruction tax deductions, the only way that an individual would be incentivized to itemize their deductions would be to look at the opportunity cost of losing the standard deduction. However, if the deconstruction deduction is large enough, the income one would need to be able to take advantage of the deduction would have to satisfy the maximum charitable deduction requirements while also outweighing the standard deduction and difference in costs of deconstruction and demolition. Even if the tax deduction were to be spread out over a few years, as long as the savings limit remains lower than these present opportunity costs those filing would not have any incentive to itemize if they can take the standard deduction for a larger value each year. Therefore, there would be a minimum income level that one would need to be able to take advantage of the tax deduction to offset additional deconstruction costs, however that income level would heavily depend on the costs of demolition and deconstruction If this difference in costs is too high, then the minimum income that one would need to benefit from the deduction would be unattainable for most of the population in the selected areas. Meanwhile, the annual limit is determined by one's AGI, meaning that those with lower income would have to spread the deduction over multiple years, giving up additional years of taking the standard deduction.

Secondly, in addition to an income threshold, there are multiple burdens that itemization places on taxpayers, including learning, compliance, and psychological costs. Changing from the standard deduction to itemization requires a lot of time and effort from those who are already relying on the former. The target population has to learn about the existence of the deduction and how they can fill out the section, spend additional time and effort on the itemization process, and undergo the stress of going through it. These costs are much less significant for those who have high incomes and itemize already since they already possess the institutional knowledge of the process. While these differences cannot be fully translated into monetary costs, they do play a large role in decision making and largely favor those with more resources.

Lastly, deductions themselves also inherently favor those with higher incomes more than those with lower incomes and provide no direct benefit to properties owned by the state or local governments and certain nonprofits like landbanks. Since deductions are the amount of money that can be removed from taxable income, the amount of tax savings that one receives is the dollar amount of the deduction multiplied by the federal tax rate. The problem with this process is that those with higher incomes receive higher tax savings than those with less income. Since they have a higher tax rate, they benefit more from the loss in income than someone in a lower tax bracket. While this process does work to incentivize those with the highest incomes to participate in charitable endeavors, those who make less income are less likely to benefit.

Tax Credits & Increasing Access to Deconstruction Services

The main tax alternative to the deduction process is a credit on the cost of deconstruction, which offers a more equitable way to incentivize individuals to participate in deconstruction at the cost of efficiency. The IRS reports that tax credits can reduce the amount that a taxpayer owes in taxes (IRS, 2023). Instead of needing to calculate tax savings from the loss of taxable income, the full amount is directly applied to the individual like a direct cash transfer, especially if the credit is refundable and the remainder can be pocketed. Those with lower incomes benefit much more from tax credits because the flat dollar value represents a higher percentage of their income than someone with more income. For example, a $1,000 credit would have more relative impact for someone who makes $10,000 than someone who makes $20,000, since it would be 10% of their income rather than 5%.

Figure 20: Tax Deductions and Tax Credits

Tax Deductions	**Tax Credits**
Are applied to taxable income to lower the calculated amount one owes in taxes.	Are applied to the taxes owed to decrease the overall tax liability and, in some cases, can serve as a direct cash transfer.
Tax savings are based on an individual's tax rate, meaning that higher tax rates equate to higher savings.	Tax savings are a flat value based on the amount of the credit, so the savings are more impactful with less income.

Favor those with more resources and income but serve to incentivize them to make more charitable decisions.	Favor those with less resources and income and allow them to make choices that are not normally open to them.

In addition, individuals do not need to itemize deductions to claim their tax credit, meaning that both the opportunity costs and administrative burdens imposed on low-income individuals would be bypassed. These gains in equity are also balanced by what is lost from the deduction process. The point of the deduction is to provide an incentive for individuals to recycle the materials derived from their house through the donation process. Whereas the tax deduction system requires the donation of building materials to a qualified nonprofit, a tax credit system alone would not guarantee that the materials derived from deconstruction would be diverted from the waste stream. In addition, it may be difficult to create an adjustment system to cover the variable costs of deconstruction and demolition if the price is fixed. To address the issue, the credit could be converted as a percentage of the deconstruction cost up to a certain monetary value, which would help with the variability in costs. Another option could be to subsidize a percentage of the donation itself up to a certain monetary value. However, the credit alone may not be enough to fully incentivize the process without substantial spending, nor would it be a viable substitute for the main purpose of the deduction program of reusing the materials harvested.

A way to bring out the strengths and offset the weaknesses of tax deductions and credits would be to offer a combination of both. Using a tax credit to offset the cost of deconstruction would allow the tax deduction to be more accessible to those with lower incomes. The deduction process is necessary for the materials to be donated and recycled and it would still incentivize those with high incomes and large amounts of property to choose deconstruction over demolition, especially if they already itemize. To expand the base of taxpayers who are able to take advantage of the credit, the cost of deconstruction can be offset up to a certain amount to allow larger projects to be more viable for those whom the deduction itself would be out of reach. The benefits of the tax credit would address the equity issues that the deduction faces. Therefore, the tax mechanism should have the deconstruction deduction as the primary focus with the equity implications to be at least partially addressed by a tax credit on a percentage of the cost of deconstruction up to a certain amount. There is already precedent for this type of tax credit in the Michigan's State Historic Preservation Tax Credit program, which allows filers to recoup 25% of their qualified expenses or until they hit their credit ceiling from the Certificate of Completed Rehabilitation (MEDC, 2023). Limits and mechanisms like the one set by the State of Michigan will prevent the tax credit from becoming too costly for large-scale projects while also protecting those who have lower incomes and smaller houses.

Deconstruction Market Assessment

The following section is intended to help elucidate the steps taken by the project team to understand and assess the potential public market for deconstruction services, as well as to provide an explanation as to why investigation into this underutilized market should be an essential component of any deconstruction startup. For the purposes of this report, 'public market' refers to all structures in a present state of disuse or nonuse (vacant, abandoned, blighted) that are likely to be either: presently owned & controlled by a public entity, or likely to come under control of a public entity (via foreclosure or other mechanism). We have further refined this definition to focus solely on single family detached structures, for two key reasons. First – despite differences in age and design, single family detached structures tend to be more homogeneous in terms of their composition and materials profile than commercial structures. For the purpose of generating an accurate account of potential material salvage (which is the ultimate function of completing this public market assessment), this is an important characteristic. Second, and namely, the key project partners identified single-family detached structures as their primary target market. This decision was informed by TRP's experiences in starting regional deconstruction economies and the interests of both TRP and ACC in targeting the residential market because of overlap with existing ACC services. Because of the high degree of variability amongst commercial and industrial structures (structure sizes, construction methods, materials profiles, salvage potential, environmental contamination / brownfield considerations, etc.) these sorts of structures are not included in the market assessment portion of this feasibility study.

Focusing on the potential public deconstruction market is an essential component of assessing the overall feasibility of establishing a deconstruction enterprise. This is especially true in communities where deconstruction services are novel; and in communities that have historically dealt with the immense burden of widespread structural abandonment and blight. Understanding the public market for deconstruction services in such regions is vital, as it allows for a more comprehensive understanding of the realities of the community in which a deconstruction enterprise looks to locate; and reveals a wider array of opportunities to leverage positive impact from deconstruction, such as job creation, blight removal, mitigation of environmental harm caused by structures deteriorating, etc.

There are an array of reasons why investigating the public market for deconstruction services is of strategic value for the establishment of a deconstruction economic sector. One such reason can be put simply – benefits of scale. The more deconstruction projects that a deconstruction upstart can accomplish, the better. With each project the amount of salvaged material (which generates revenue via retailing) increases as does the relative visibility of the deconstruction enterprise. This visibility can be vital towards the sustainability of a deconstruction enterprise – especially in regions where deconstruction and material reuse are novel – and can lead to new deconstruction projects, training & education opportunities, and other collaboration. In the words of a longtime national deconstruction expert "They [potential customers in such a region] likely don't even know what deconstruction is, let alone that it could be an option for them. Getting people to know that you exist – and teaching them what you are doing – is one of the biggest challenges in the startup phase." (Personal Communication, 2022)

Another reason – the ability to engage and attract supportive community partners – proved essential to the project team. Within this feasibility study's context, investigating the public market resulted in the addition of a key partner to the project – the Muskegon County Land Bank. The value of the Land Bank in this partnership cannot be overstated. With the Land Banks Collaboration, the project team was able to quickly expand its reach, taking advantage of existing networks to contact other relevant public sector stakeholders that would otherwise be difficult to engage without this support: the city building department, city of Muskegon heights, Muskegon chamber of commerce, the State Land Bank. The project team was also quickly able to gain access to a wide array of structures to be used for on-site training and education, as well as an array to a wide array of opportunities for additional funding and collaboration. In general, the support of any local unit of government is a boon for upstarting a deconstruction enterprise; but because the Land Bank's visionary leadership aligned so well with the vision of the project team, the resulting partnership was of substantial benefit to the project.

Methodology

The following section describes in detail specific steps taken during the public market assessment phase of this feasibility study. As indicated above, this portion of the feasibility assessment focuses on understanding and estimating the array of vacant, abandoned, blighted, or otherwise out-of-productive use properties within the catchment area. These properties constitute an essential component of a region's deconstruction services market and create the opportunity for the deconstruction enterprise to identify new public sector partners and to create projects that will net substantial volumes of material that will reach productive use (generating essential revenue in the process) via retailing. At a minimum, access to data elucidating these types of properties allows for deconstruction upstarts to understand the scale of their potential public market. As more advanced descriptive data becomes available (i.e., housing characteristics, structure age, etc.) deconstruction upstarts can craft increasingly complex strategies to capitalize on the public market.

As will be echoed in the private market assessment following this section, a key challenge in conducting a public market deconstruction services assessment comes from the general lack of availability of data describing the scope, scale, and overall quality of vacant, abandoned, blighted, and otherwise out-of-productive use properties. In Midwest communities – where deconstruction enterprises are likely to rely more heavily on public markets to support their operations – this poses a substantial challenge for aspiring deconstruction upstarts. In certain larger cities across the state local governments have endeavored to collect and build databases that articulate the scope, scale, location, and overall quality of abandoned, vacant, blighted, or otherwise out-of-use properties. An example of such a process can be seen in the City of Detroit – in which the Blight Removal Task Force organized and carried out a full-scale walking parcel assessment of the city to generate a comprehensive blight remediation plan. (DBRTF, 2014) Similarly, communities across the state with an operating land bank also are likely to have more comprehensive housing profile assessments than those without landbank jurisdiction; as are those with more established economic development planning functions via EDD's (Economic Development Districts) or CDC's (Community Development Corporations). Deconstruction enterprise startups should consult with Land Banks, Planning Offices, Building & Code Enforcement Offices, CDC's, housing related nonprofits, and other public / civil society entities to assess the availability of relevant housing data in their desired geographies.

Gathering Census Data

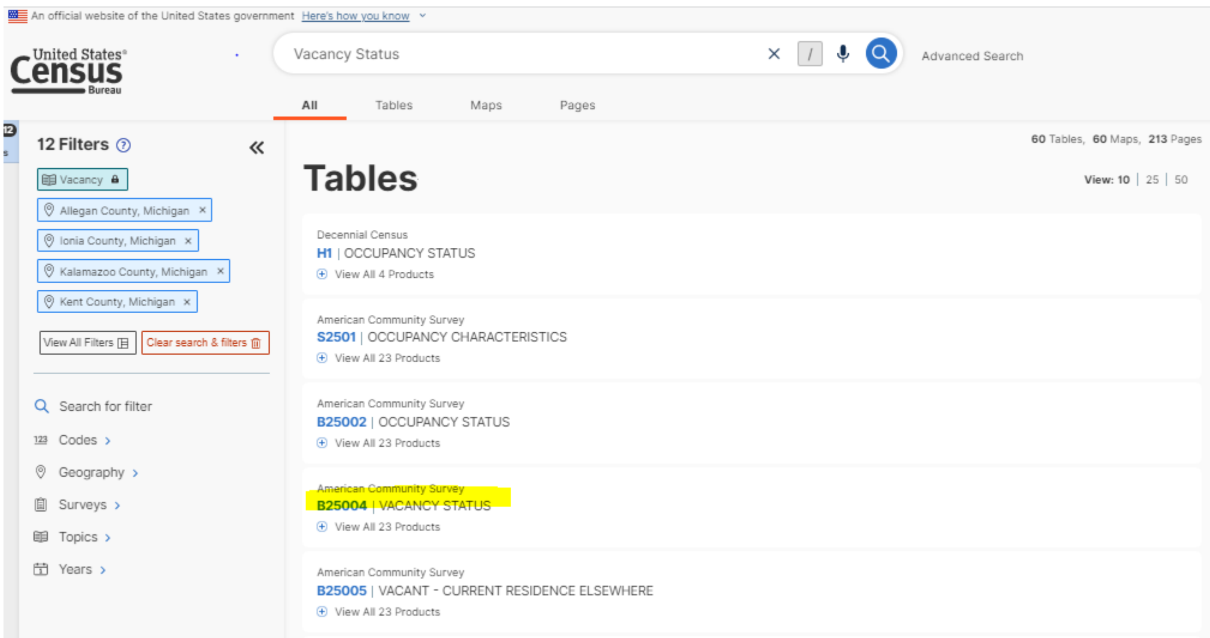
In geographies that do not have a comprehensive housing profile available – such as the catchment area focused on in this assessment – the project team has worked to develop a simple approach utilizing publicly available census data to develop an estimate of vacant, blighted, abandoned, or otherwise out-of-use properties in any desired geographic area. The specific steps for said approach are as follows: (*Note: The project team utilized Excel to conduct the calculations needed to complete this analysis, although the methodology presented can be easily replicated by hand)*

1. Go to data.census.gov and select the 'advanced search' option at the top of the screen

a. This allows for the user to search for census data across multiple geographies at once

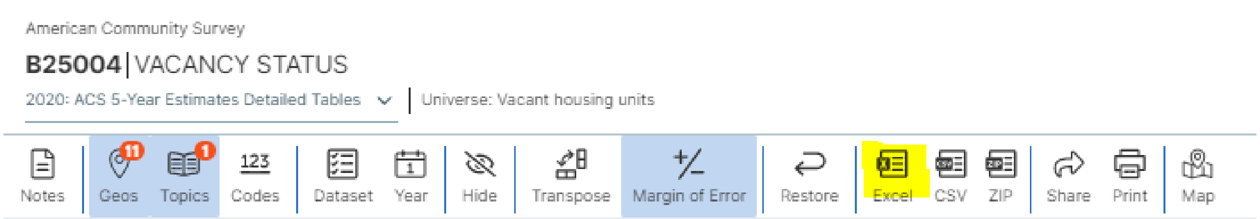
2. Select desired catchment area using the ‘geographies’ tab in the advanced search dashboard
   a. For best results select desired geography at the county level
3. Type ‘Vacancy Status’ into search bar and hit enter
4. Select ‘B25004 Vacancy Status’ from the Tables tab [See highlighted section in Figure 21 below]

Figure 21: US Census Advanced Search Dashboard



5. Using toolbar at the top of the data display [see Figure 22 below] download the dataset in the desired filetype
   a. For the purposes of this analysis, all data was downloaded utilizing .xcl filetype

Figure 22: Downloading Census Data



6. Ensuring the same geographies are still selected, search and download ‘DPO4: Selected Housing Characteristics

Developing Market Projections from Census Data

Once the two datasets described above have been downloaded, the next steps in the process involve preparing the data to be utilized in the market assessment process. This simple analysis utilizes three key variables reported in the census to develop an estimate of the total number of structures in the public market. These variables are ‘other vacancy’ included in the B25004: Vacancy Status datasets, as well as ‘total units’ and ‘1-unit, detached’ included in the DP04: Selected Housing Characteristics datasets. ‘Other Vacant’ was selected from the B25004 datasets as the most useful variable for this analysis because its definition most closely aligns with the working definition of ‘public market’ used in this assessment. Categories of vacancy that are reported in the census (and included in aggregate vacancy data) include structures listed for rent, structures listed for sale, seasonal / migrant worker housing, recreational use, etc. The ‘Other Vacant’ category, on the other hand, accounts for structures foreclosed on, condemned, undergoing repair, slated for demolition, abandoned structures, etc. Compared to other categories of vacancy reported in the Census, the ‘Other Vacant’ category are more likely to have a long duration of vacancy, likely to be older (pre 1969), and to be single family homes, (Kreslin 2013; MSU CCED, 2017). Because of these characteristics, the ‘Other Vacant’ category represents the most useful publicly available data to articulate the ‘public market’ as defined by the project team in the beginning of this section.

Note that each of the variables above are reported in terms of housing units, defined by the US Census as “... a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied as a separate living quarters.” (US CENSUS, 2020) For the purposes of this assessment – wherein the overall goal is to ascertain the potential volume of materials available in the public market – it is vital to translate the available data from ‘units’ into ‘structures’. The following steps describe the process for making that translation. Figure X below shows this methodology conducted for a single county selected from the catchment area. (*The figures provided using this methodology are estimates, and should whenever possible, be used in combination with other housing profile data as available*.)

7. For each selected county identify the ‘other vacant’ category and take note of the reported value

   a. The reported margin of error for this category can be used in this estimation to generate a range of results
      i. Low Boundary: Reported Total Vacant – Margin of Error
      ii. High Boundary: Reported Total Vacant + Margin of Error
8. For each selected county identify the 'total units' and '1-unit detached' categories and take note of the reported values
9. Develop a county specific estimate of % of total units that are single family detached
   a. 1-Unit Detached ÷ Total Housing Units = % of Units in County that are Single Family Detached
10. Determine the likely % of 'Other Vacant' units that are Single Family Detached
    a. Reported 'Other Vacant Units' x '% of Units in County that are Single Family Detached' = 'Estimated Other Vacant Single-Family Homes'

Figure 23: Estimating Vacant Single-Family Structures in Allegan County

All Data 2020 ACS	**Allegan County, Michigan**	
Label	**Estimate**	**Margin of Error**
Other vacant	1,615	±343

Units in Structure	**Estimate**	**Percentage**
Total Units	51,551	
1 Unit Detached	40,070	77.7%

Estimated Vacant Structures	**Estimate**	**Range (+/- Margin of Error)**
Estimated Vacant Single Family Homes	1255	988 - 1521

Figure 24: Total Estimated Vacant Single-Family Structures in Catchment Area

2020 Vacant Single Family Homes

County	Estimated Single Family Homes
Allegan	1255
Ionia	854
Kalamazoo	2186
Kent	3530
Mecosta	439
Montcalm	75
Muskegon	2889
Newaygo	544
Oceana	543
Ottawa	988
Van Buren	1278
Total	14581

After going through the above process for each of the selected counties in a desired catchment area, the outputs of this process (Estimated Vacant Single-Family Homes) can be aggregated to provide an overall profile of the array of blighted, vacant, and abandoned properties within a catchment area. Though determining this figure is a key step towards assessing the potential public market for deconstruction services; it is worth noting that the publicly available data used to generate this estimate does not describe the current ownership status of these properties, and as such, is considered a rough estimate of the total 'pool' of structures which may be under the public domain. Individuals looking to emulate this portion of the assessment would be wise to work with Land Banks, city development offices / building departments, Economic Development Districts (EDD's), and other such stakeholders to explore the availability of data describing the ownership status of identified structures. Though these findings alone are useful to help begin quantifying this portion of the overall deconstruction services market in a region, their true utility will be realized in the next phases of this market assessment. As such, the following section provides a similar methodology to generate an assessment of the private market for deconstruction services; and the section after provides a step by-step guide for utilizing these two market assessments combined to generate estimates of total volume of salvageable material, carbon savings implications, market value projections of said materials, and other useful projections that help to more fully elucidate and contextualize the true deconstruction services market profile in given region.

Private Market Assessment

The following section is intended to provide a framework through which individuals can easily assess current demolition activity in their region. Whereas the public market assessment explores the array of blighted, abandoned, and otherwise unused properties in a selected geography to establish an overall 'ceiling' estimate of salvageable material held in the public sphere; the private market assessment focuses on understanding and articulating current demolition activity as an analogue for the present demand for structural removal services (I.e., demolition or deconstruction). It is important to note that the delineation between 'public' and 'private' markets as defined in this study is not necessarily mutually exclusive. Because of the differing data-gathering strategies utilized in each assessment (which was necessary, due to the lack of a centralized database) there exists a theoretical overlap between the 'public' and 'private' markets – in short, structures which were demolished during the period of analysis (and thereby included in the private market) may also be reported in the 'public' market assessment during the same period of analysis. Just as in the public market assessment, this analysis will output an estimated number of structures that can be used to develop further projections of environmental and economic impact. (*To emulate the methodology listed below, individuals will need access to Microsoft Excel, Google Sheets, or another similar spreadsheet software.)*

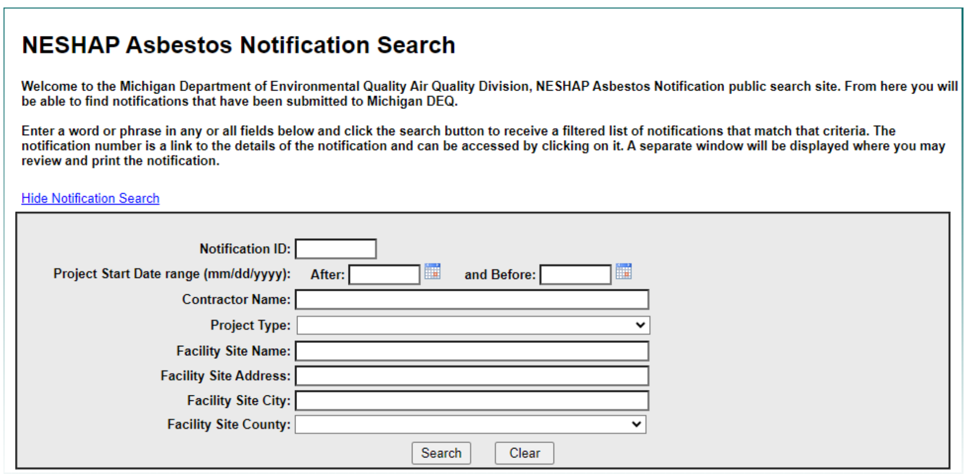
A key challenge that the project team encountered during this phase of the assessment – very much like the public market assessment – relates to an overall lack of unified and accessible demolition data in the state. In general, building permits (which include demolition permits) in Michigan are managed locally by various permit granting authorities, depending on the locality – at either the local, city, township, or county level. While there are means of accessing building permits at the county level in aggregate via the HUD SOCDS (State of the Cities Data System), this method does not allow for the user to further delineate these permits by type, vastly limiting the utility of this data in the context of estimating demolition activity (and therefore potential market for deconstruction services). Considering this challenge, the project team endeavored to create a workaround which could allow for a meaningful assessment of regional demolition activity under the present data environment.

Owing to the insight of a member of the MSU Domicology advisory group, the team developed a workaround which utilizes the state's NESHAP (National Emissions Standards for Hazardous Air Pollutants) data portal. In adherence with DEQ's federal charge of regulating

Hazardous Air Pollutants (HAP), the State Department of Environment, Great Lakes, and Energy (EGLE) requires that an asbestos assessment be conducted for any properties in which renovation or demolition is planned. Contractors who are completing demolition, deconstruction, or renovation are required to go through the NESHAP assessment and notification processes prior to the issuance of a building permit. For the purposes of measuring regional demolition activity, these NESHAP reports provide an incredibly useful analog for permitted demolitions occurring within a region – granted proper cleaning of the data (removing duplicative reports, etc.) The following is set of steps which can be used to identify and clean NESHAP reports as a means to measure regional demolition activity over a selected period of time:

1. Visit the state of Michigan Asbestos Notification Search database at https://www.egle.state.mi.us/asbestos_notifications/Pages/AbSearch.aspx
    a. Figure 25 below shows the landing page for this database

Figure 25: NESHAP Online Portal



2. Determine desired date range for analysis and input those dates
    a. The project team recommends selecting a full calendar year (e.g. 1/1/2022 - 12/31/2022) to account for seasonal differences in demolition activity
3. Select the desired county for analysis and input into ‘Facility Site County’
    a. This portal is only able to generate these reports for a single county at a time, depending on the goals the analysis, the user may wish to aggregate findings or keep them separated by county
4. Run the search function using both ‘Ordered Demolition’ and ‘Scheduled Demolition’ categories under ‘Project Type’

5. Click 'Print Grid Page' when prompted and select 'download as pdf' from the print dialogue box
6. Repeat this process for each desired county and time range
    a. Be sure to rename downloaded files to include the county name and year
        i. For example: 'AlleganDemolitions2020'
7. Upon downloading and renaming the desired datasets, the user must now work to convert this data (currently in pdf format) into an excel spreadsheet filetype (.xcl)
    a. To complete this step, the project team utilized Adobe's free 'Pdf to Excel converter tool
        i. This tool is available for free online from the following link: https://acrobat.adobe.com/link/acrobat/pdf-to-excel?x_api_client_id=adobe_com&x_api_client_location=pdf_to_excel
        ii. Once all desired datasets are converted to .xcl filetype, they can now be aggregated into a single spreadsheet, if desired
8. With all relevant data now available in the .xcl filetype, the next step of the process entails 'cleaning' the data to remove any redundant reports included in the dataset
    a. Because the permits presented in this dataset are reported according to the address associated with the project, the user can manually select and delete all duplicative reports
    b. The user can also take note of the nature of each reported demolition, as this information is available under the 'residence name' column. This is useful in further refining estimates as it allows for the user to delineate between residential, commercial, and industrial demolitions

Figure 26 below is pulled from this project's private market analysis and shows both duplicate reports as well as how residential and commercial demolitions appear in NESHAP reports. During the data cleaning process, the project team deleted duplicate reports for the residential demolition and removed altogether the commercial reports.

Figure 26: Selected NESHAP Reports

202208265-R001	08/10/22	08/26/22	Demolition Contractors, Inc. DBA Pitsch Wrecking, Inc.	SD	Residence	2006 Plummer Dr	Fennville	ALLEGAN
202208265-R000	08/02/22	08/12/22	Demolition Contractors, Inc. DBA Pitsch Wrecking, Inc.	SD	Residence	2006 Plummer Dr	Fennville	ALLEGAN
202207989-R018	10/11/22	01/03/23	Demolition Contractors, Inc. DBA Pitsch Wrecking, Inc.	SD	commercial	132 Helen St	Otsego	ALLEGAN
202207989-R017	10/11/22	12/30/22	Demolition Contractors, Inc. DBA Pitsch Wrecking, Inc.	SD	commercial	132 Helen St	Otsego	ALLEGAN

9. With the data now cleaned and aggregated according to the goals of one's analysis, these demolition reports can be used to begin calculating potential salvageable material available in the private market

Figure 27 below shows the total demolition activity for residential structures between 2020 – 2022 for the selected catchment area. This dataset does not include projects that were clearly marked commercial or industrial and has been cleaned to remove all duplicative reports. Depending on the goals of a deconstruction enterprise in assessing their potential private market, a user may elect to include industrial and commercial sites.

Figure 27: Private Market for Deconstruction Services in Catchment Area

County	**# of Demolitions 2020 - 2022**
Allegan	55
Ionia	14
Kalamazoo	118
Kent	327
Mecosta	10
Montcalm	12
Muskegon	107
Newaygo	8
Oceana	10
Ottawa	110
Van Buren	44
Total	815

The findings of this analysis will be used in the 'Evaluating Impacts' section of this report to reveal the potential salvage volume, value, and carbon savings generated via deconstruction.

What Makes a Successful Material Reuse Facility?

The following section is intended to provide a basic overview of used building materials retailing and the varying considerations that a deconstruction upstart may wish to consider in developing their own retail plan. Retailing is an essential component of most deconstruction and reuse enterprises operating throughout the country. Operating (or collaborating) with an active used building material reuse facility is fundamental in actualizing many of the environmental and economic benefits offered by deconstruction – simply put, for salvaged materials to realize a next useful life (and in-turn 'void' emissions that would be generated in the creation of virgin material), consumers of used building materials must have an easily accessible facility in which they can access these materials. Throughout this section, the terms 'Reuse Facility', 'Used Building Materials Retail Facility', 'Materials Retailing Facility', 'Retail Facility', and 'Material Reuse Facility' are used interchangeably.

While not all deconstruction enterprises operate their own materials retailing facility, the project team was unable to identify any deconstruction enterprises that operate without a significant retail-based partnership. Depending on the goals of an enterprise and the presence (or lack) of used building materials retailers (such as Habitat for Humanity's ReStore Program) in the region, a deconstruction start-up may elect to manage their own facility or to engage in a consignment-based agreement with existing retail outlets in the area. Managing a retail facility internally has an array of potential benefits: greater control over material being retailed, ability to set prices, control over store layout and inventory turnover, and the possibility of creating hybrid facilities that support other functions essential to a sustainable deconstruction economy (I.e. training and education, materials reprocessing and upcycling, etc.) Conversely, opening a used building materials facility necessitates a high degree of start-up costs in terms of: facilities, necessary equipment, labor costs, insurance, and other overhead. Additionally, because deconstruction economies often take years to fully scale, used building materials retail facilities will likely operate on a deficit basis for the first 2-4 years of their operation. While other outlets for building materials should absolutely be explored and developed (e.g. recyclers, upcycle artisans, donations of building materials to other nonprofits, selling materials back to manufacturers, etc.) the importance of developing or partnering with existing used building materials retail facilities cannot be overstated. Benefits of Reuse Centers:

- **Provide Cost Savings**: Using reclaimed building materials saves money for customers. Manufacturers may have off-specification materials that cannot be sold to retail stores, but can find new life via a building material reuse facility. Transportation costs will also be lower due to the materials being sourced locally.
- **Advance Green Building Movement**: Green building accreditation programs (such as LEED) are increasingly incorporating the use of reclaimed materials in new construction into their criteria.
- **Conserve Natural Resources and Reduce Embodied Energy Loss**: By reusing materials, there is no need to extract more materials by mining or cutting down more lumber. This will protect the environment. It will also bring down energy costs (embodied energy) which is the total amount of energy involved in the creation of the building.
- **Stimulate Local Economies**: Building material reuse centers can provide employment in the areas in which they are located. This allows for the creation of local markets for reusable materials
- **Support local Communities**: Building material reuse centers can provide materials for low income citizens and non-profits that build homes for low-income families
- **Conserve Landfill Space**: Using reclaimed building materials can divert material away from landfills.

Essential Features of a Material Reuse Facility

The following is a selection of key features of a material reuse facility, based on interviews with material reuse facility operators as well as customers of such facilities. Because this industry is largely undeveloped in many parts of this country, there is little research available to provide useful profile and characterization of used building materials retailers. (*This will be discussed further in the 'Findings and Implications' section of this report)*.

Figure 28: Key Features of Retail Facilities

Key Features of Retail Facilities
Warehouse Space & Layout

At least 10,000sf dedicated retail space to start. Reuse centers interviewed reported 30-40 projects annually to generate adequate inventory
Outdoor space for displaying and storing materials that will not be damaged by inclement weather (bricks, pavers, tile roofs, salvaged trees, etc.)
Adequate indoor (or covered outdoor) space for storage of materials that are moderately resistant to inclement weather (lumber, windows, etc.)
Multi-level metal racks (like those found in big-box hardware stores) enable simultaneous display and storage (above) of materials
Wide aisles to facilitate easy forklift operation
Minimum 20' Clear Ceiling Height (Distance from warehouse floor to lowest hanging item on the ceiling, e.g. HVAC, Sprinklers, etc.)
Entrances & Loading Zones
Multiple entrances to facilitate flow of customers
Dedicated donation drop-off and order pick-up facilities that do not impede customers from patronizing retail space
An elevated loading dock can be useful for facilitating transportation of materials using larger trucks (box trucks, 18-wheelers, etc.)
Floor-level loading zone will be useful for smaller pickup trucks and for other vehicles used by customers for pickup and transport
Material Processing Space
Dedicated space for de-nailing (removing nails and other metal fasteners from salvaged lumber)
Dedicated space for re-planing (cutting off thin layers from external surfaces) and resizing to convert damaged or odd-sized lumber into useable pieces
Dedicated space for cleaning and inventorying of materials; palleting and wrapping of like materials facilitates easy shipping and storage
Visibility and Signage
Customers (especially new customers) will be able to easily navigate the facility thanks to highly visible signage)

Key Points of Consideration for Reuse Facilities

Based on interviews with used building materials customers and operators of used building materials facilities, the following is a list of key considerations for developing a successful and accessible used building materials facility:

Figure 29: Key Considerations for Retail Facilities

<table>
<tr><th colspan="2">Key Considerations for Reuse Facilities</th></tr>
<tr><th colspan="2">Warehouse Space & Layout</th></tr>
<tr><td colspan="2">Ease of access to materials and visible signage help to cut down on time spent in the store. While relevant to all customers, this is an especially pertinent consideration for best supporting remodelers and other similar contractors. (Note: One remodeling contractor interviewed identified this challenge as a significant consideration. In his words "…it's very unlikely that all of the necessary pieces required to re-install the reclaimed component [i.e. sink, vanity, cabinets] are available at the reuse facility, meaning that we would have to spend additional time going to multiple retailers just to actually install the reclaimed piece."</td></tr>
<tr><th colspan="2">Inventory</th></tr>
<tr><td colspan="2">Proper inventory turnover is essential in keeping customers engaged – both new customers and longtime patrons. One facility interviewed estimated that they require 30-40 projects annually per 10,000sf of retail space to provide adequate inventory turnover</td></tr>
<tr><td colspan="2">Rotating displays and specials/sales help to appraise customers of the full breadth of inventory</td></tr>
<tr><td colspan="2">Diversity of items is both a strength and a challenge for used building materials retailers</td></tr>
<tr><td></td><td>While used building materials retailers provide unparalleled access to unique materials, fixtures, and components; certain customers may be required to source large quantities of homogeneous materials/components. (Note: This was identified in multiple interviews of general contractors - one contractor provided an example of wanting to utilize reclaimed plumbing fixtures in a project, only to be required by their client (apartment complex) to source identical fixtures for each unit)</td></tr>
</table>

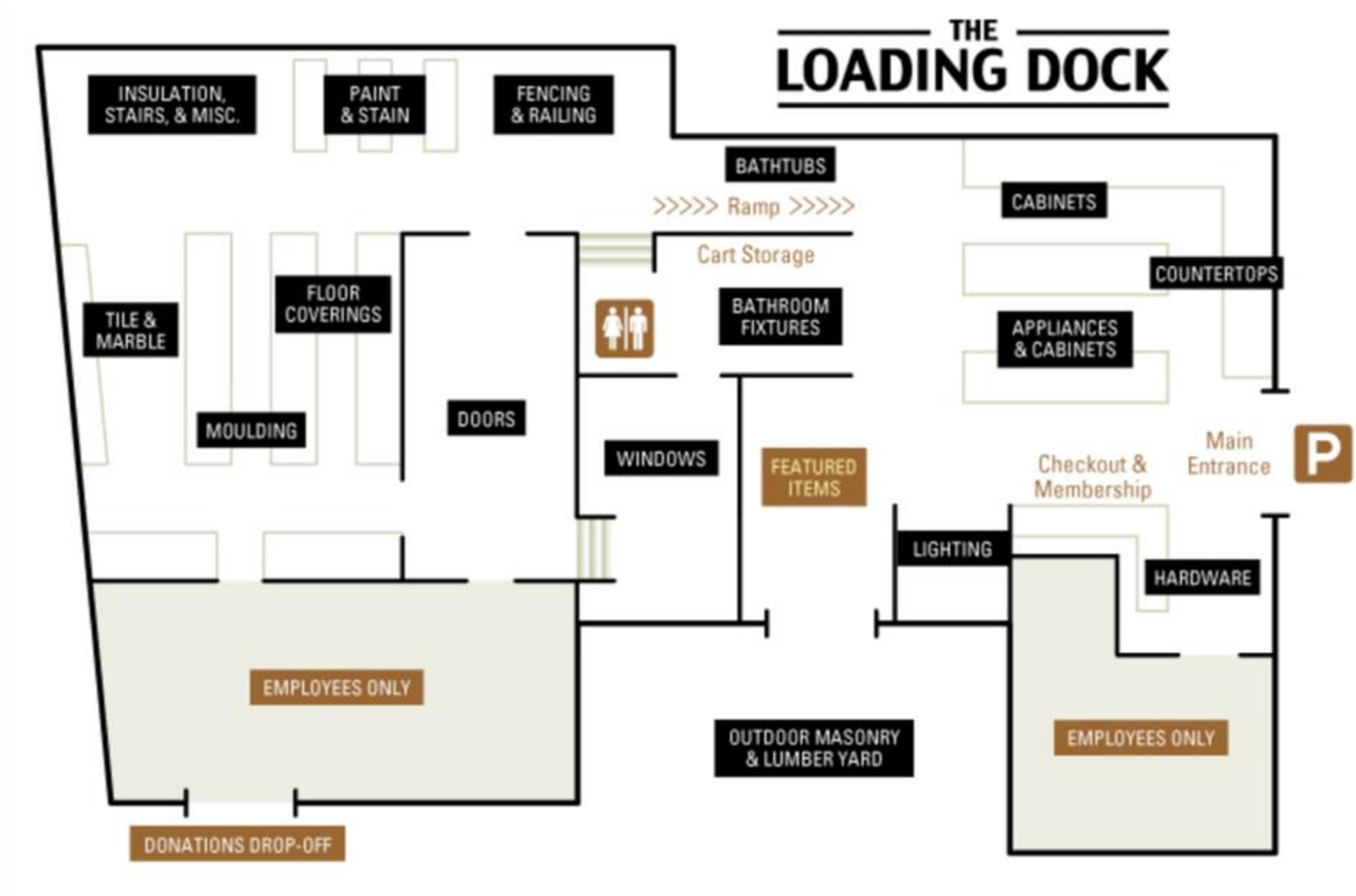
	Creating ‘ready-to-install’ bundles (including the necessary hardware/fittings along with the salvaged component/fixture) can increase likelihood of contractors patronizing reuse facilities for same-day repairs. (*Note: Based on interviews with remodeling contractors, tight timelines and the necessity of ‘same-day’ project completion heavily influence decision to choose ‘big box’ stores over reuse centers.)*
Rare & hard to find materials offer a unique market	
	Architectural salvage markets are distinct from used building materials markets because much of the value to the former customer lies in the age and uniqueness of the material; whereas ease of use and utility in a new project provide value to the latter
	Reuse facilities can offer a separate architectural salvage section of their facility with hand-picked high quality / rare materials to appeal to this customer
	Depending on the housing stock serviced by a deconstruction enterprise, retail facilities may need to be prepared to explore/develop unique markets for certain materials (*Ex: American Redwood can be commonly found in west-coast homes, while American Chestnut can be found in older homes in the Midwest and especially on the east coast. Both woods are considered rare (with the American Chestnut being effectively extinct for much of the 20th century) and have more established national markets than do other more common woods)*
Reclaimed Building Materials may contain hazardous contaminants	
	Asbestos and Lead Based Paint may be encountered during cleaning and reprocessing
	Ensure that all staff working on receiving, and reprocessing materials have access to the necessary PPE to ensure their safety
	Re-planing and resizing of reclaimed lumber should be completed in a well-ventilated and routinely cleaned space to reduce possibility of cross contamination due to Lead Based Paint
Pricing	
While many used building materials customers are likely to value either/both the environmental and social/cultural benefits that come from reclaiming and reusing material; cost will always be a key factor in attracting and retaining customers	
One successful facility interviewed reported using a basic derivative of market prices to price and re-price their inventory	

	20% of market price for most materials (counters, cabinets, vanities, doors, etc.)
	40% of market price for lumber and hardwood floors
Location & Visibility	
Used building materials retail facilities are best located close to major highways and within (or closely adjacent to) larger population centers	
	Proximity to major highways allows for lower transportation costs & better connectivity to other end-users (recyclers, etc.)
	Visibility of retail facility from highway serves as permanent advertising for the deconstruction enterprise
Based on interviews with used building materials retailers, most customers will travel up to an hour to patronize stores. Travel distance increases with diversity of inventory, size of facility, and presence in the community	
Co-Location and Cooperation	
Many successful used building materials facilities intentionally located adjacent to related facilities, such as big-box hardware stores, building materials distributors, and recycling facilities.	
Cooperation and Partnership amongst key industries can be mutually beneficial	
	Allows reuse businesses to gain additional exposure to related consumers patronizing other facilities
	Locating reuse facilities near 'big box' hardware or other similar stores increases access to essential tools, hardware, and fittings that are required to fully install reclaimed components in a new project. This also reduces time spent off-site for contractors, increasing the value proposition for reuse. Customers can also more easily engage in price comparison.
	One reuse facility interviewed benefitted from locating directly adjacent to a habitat for humanity store – materials which were not suitable for reuse facility (mattresses, couches, wall art, décor, lower quality doors, etc.) were donated to the adjacent habitat store. This lowered disposal costs for the reuse facility and increased the capacity for the reuse facility to accept materials donations. The Habitat store benefitted from increased donations to their facility.

	Other reuse facilities have benefited from co-locating with C&D waste recycling facilities. Both facilities benefitted from increased materials flowing through their respective stores; lowered disposal costs for the reuse facility, and increased patronage for both companies.
Innovative Opportunities for Reuse and Upcycling	
At scale, deconstruction enterprises can take advantage of national/global material markets with the proper shipping/logistics capacity.	
	Reuse facilities interviewed cited both commodity prices (i.e. prices of lumber), uniqueness of material (architecturally significant salvage), and regional markets (e.g. demand for Spanish Mission style roof tile in East Asia) as opportunities for tapping into national/global markets.
Deconstruction enterprises can partner with (or operate under their own organizational umbrella) remodeling and renovation contractors who can readily reuse salvaged materials in new projects.	
	One deconstruction contractor operating in Detroit stated that they maintain their own stockpile of salvaged materials which they can reuse readily in renovation/remodeling projects (decking, bricks, CMU, etc.) while simultaneously working with a local used building material retailer to manage/sell other materials (architecturally significant salvage, lumber, fixtures, and certain appliances).
Upcycle artisans can play a crucial role in generating a market for reclaimed building materials	
	Certain deconstruction and material salvage enterprises studied partner with upcycle furniture manufacturers as a primary outlet for salvaged material. Culturally / Historically significant buildings (and resulting salvaged materials) help create additional value for upcycled furniture products. [See 'Details Deconstruction Case Study' at domicology.msu.edu for more information]
	Partnering with local arts councils and artists groups to facilitate 'reuse challenge' events can bring visibility and attract new interest in reuse.
	Workshops and other skill sharing programs can help create visibility and empower customers to pursue higher degrees of material reuse in their own projects. *(Note: One retail facility based on Oregon offers a full array of remodeling, renovation, handy man [e.g. rewiring a light fixture, laying tile, etc.] courses that utilize materials reclaimed via deconstruction projects. Customers pay for these courses and materials, and use the knowledge and skill gained to complete reuse*

	projects in their own contexts using materials purchased from the retail facility.)

Figure 30: Floor Plan of Reuse Facility



The figure above was provided by The Loading Dock (organization profiled below) on their website, and shows the current layout for their used building material / reuse facility in Baltimore, MD. Note that many of the characteristics listed above can be observed in this floor plan (e.g. dedicated donation drop-off zone with processing space, separate entrances to reduce congestion, featured items section, etc.)

Locating a Reuse Facility

Figure 31: Travel Time Polygon

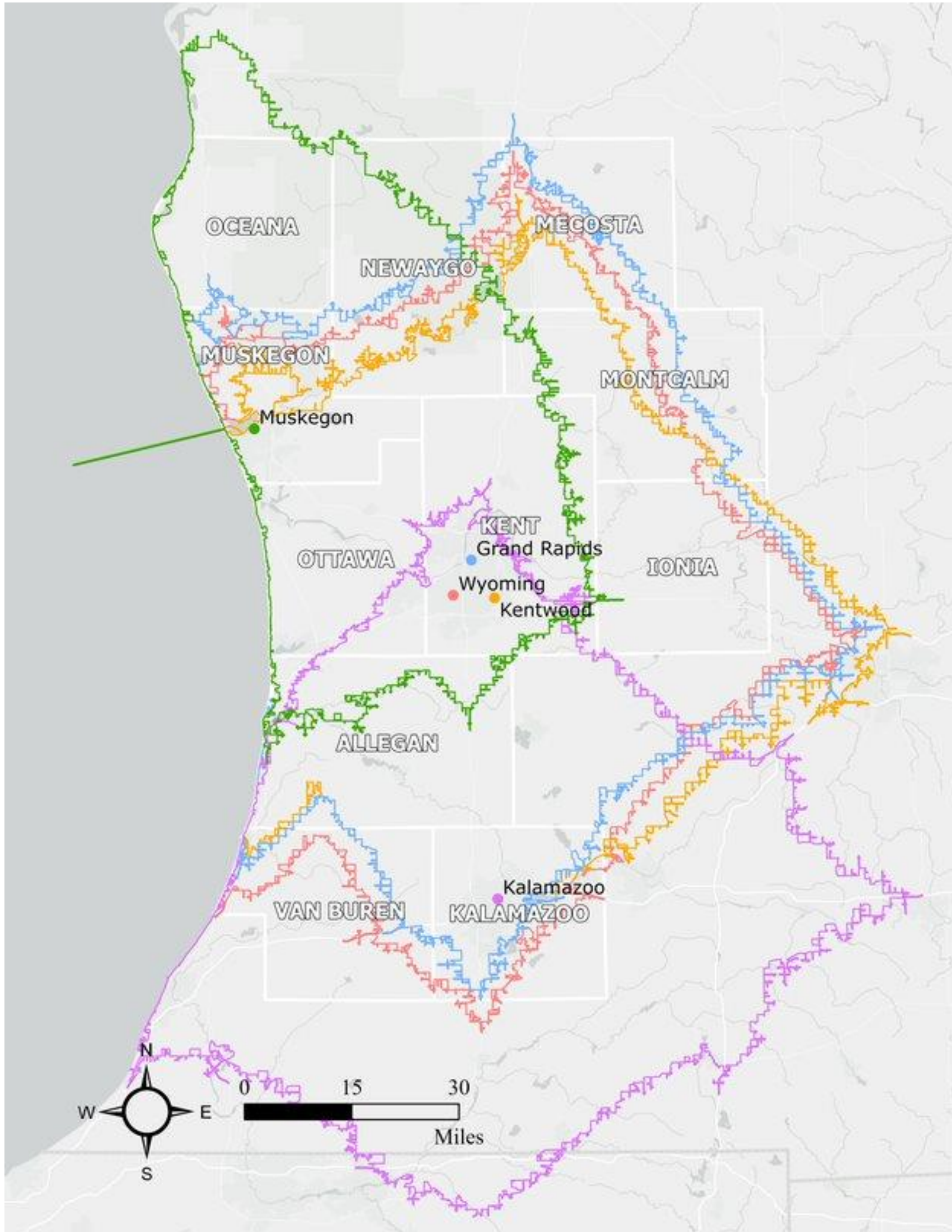
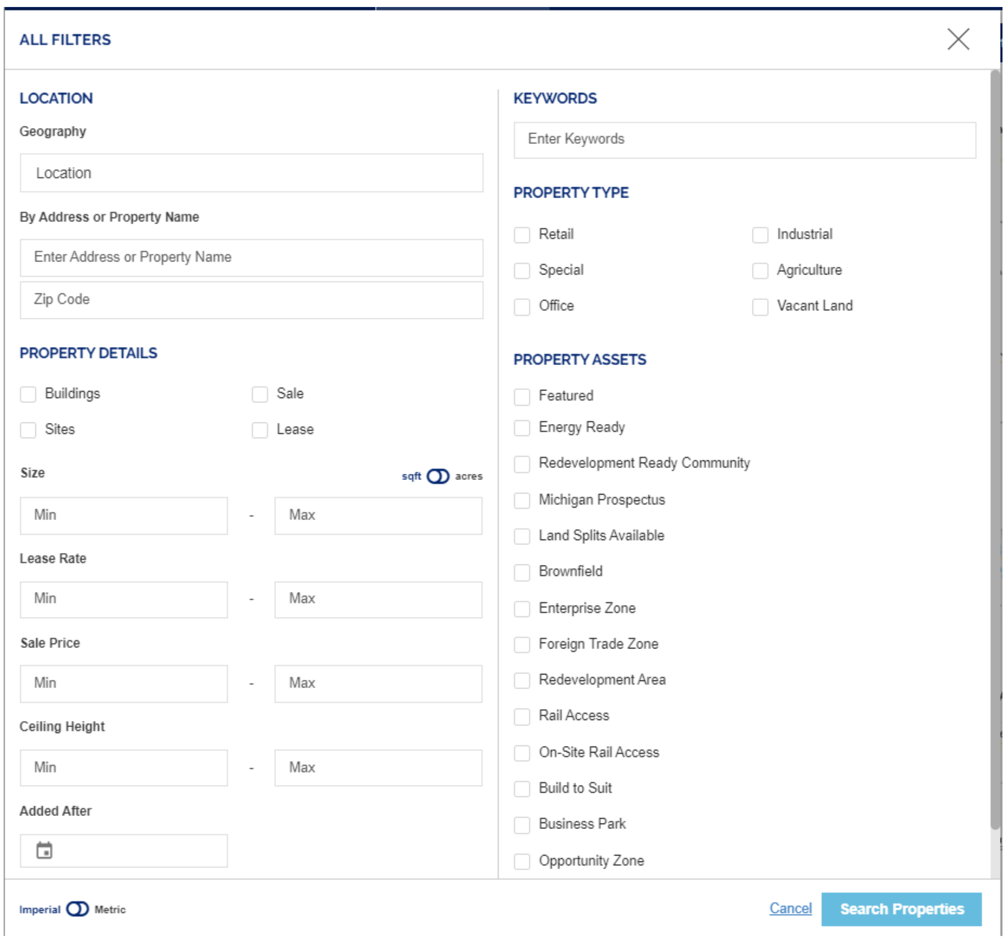


Figure 31 shows 1-hour travel time polygons for each of the major population centers (>50k) included in the catchment area, In order to identify a site in which all major population centers can reach the target facility location within a desired duration of travel. Muskegon is included in this definition (despite having a population of roughly 37k) because of the combined populations of the directly adjacent cities of Norton Shores (approx. 25k) and Muskegon Heights (approx. 10k). The 1-hour travel window from each population center was selected based on the experiences of TRP in establishing regional material reuse economies. The color of each polygon included in this assessment corresponds to the population centers marked in this map. Referring to Figure 31 below, note that the area surrounding the confluence of Kent, Ottawa, and Allegan counties (south of Grand Rapids) stands as the best region within the catchment area to maximize exposure to the population centers identified by the research team.

Based on the figures above showing essential retail facility features, prospective deconstruction & reuse facility operators can utilize the MEDC site selection tool (https://siteselection.michiganbusiness.org/) to easily search available commercial / industrial properties to identify potential sites that meet the desired qualifications. Figure 32 below shows an image of the available search filters that can be used to narrow the search – note that based on interviews with used building material facility operators, the recommended minimum square footage is 10,000sf, while the minimum ceiling height is 20'. It is recommended to conduct a county level search, as the tool allows users to select multiple counties simultaneously.

Figure 32: MEDC Site Selection Dashboard



A site location analysis of this study's 11-county catchment area was completed using the following inputs: Buildings: Yes, Property Type: Industrial, Retail; Minimum Size: 10,000sf; Minimum Ceiling Heigh: 20'. This tool revealed <u>27 sites</u> ranging from 20,000sf up to 1,500,000sf that met these characteristics within the 11-county catchment area.

Identifying End-Users Using NAICS Codes

As is described in the above ‘Key Considerations for Reuse Facilities’ section, many successful deconstruction and material reuse enterprises look beyond direct-to-consumer retailing to find end-markets for salvaged and reclaimed materials, such as commodity markets and architectural salvage markets. As the geographic scale of analysis increases (e.g. regional – national – global) to activate new markets, so too does the inherent complexity of the system and the costs associated with participating in said supply/value chains. One key strategy that can be used on a regional basis (either multi-county or multi-state) is to perform a NAICS code analysis to identify ostensible end-users of various materials, as well as related industries that can enjoy a mutually beneficial relationship with deconstruction and material reuse enterprises. This analysis is based on a methodology developed in 2019 by MSU Center for Community and Economic Development (CCED) in the ‘Structural Material Reuse and Market Study’ [available online at domicology.msu.edu]. Much like the previous market assessment sections, this analysis can be completed by utilizing publicly available data gathered via the US Census to identify county-level distributions of relevant businesses using the 2022 NAICS codes. Following the steps outlined in the aforementioned section, individuals can select desired geography and NAICS codes using the data.census.gov platform. The following figure shows a list of NAICS codes identified by the team as essential related industries.

Figure 33: Essential Related Industries NAICS Codes

238910- Specialized Site Contractors (Includes Whole Building Deconstruction)	Relates to companies or contractors that specialize in preparing a construction site. Activities include deconstruction, demolition, excavating and any other activity related to getting a site prepped for development
327120- Clay Building Material Manufacturers	Relates to companies that create clay-based materials used in construction such as bricks and refractory applications such as furnaces.
423930- Recycle Material Merchant Wholesales	Relates to businesses that buy and sell recyclable materials in large quantities. They mostly operate as the middleman in which they buy large quantities from manufacturers of recyclable materials (waste management companies) and sell them to retailers (those who want to use recycled materials)
423930- Salvage, Scrap, Merchant Wholesales	^ see above
444180- Other Building Material Dealers	Relates to businesses that sell various types of building materials. These building materials may include lumber, bricks, cement, roofing

	materials, doors, windows, flooring, paint, hardware, and other supplies needed for construction, repair, or remodeling. The product range is diverse from fixtures to structural purposes involved in construction.
453310- Used Merchandise Stores	Relates to businesses that sell used goods. These used goods can range from clothing to appliances. They promote sustainability by extending the lifecycle of a product.
459510- Architectural Salvage Dealers	^ see above
459999- Architectural Supply Stores	^ see above
562112- Hazardous Waste Collection	Relates to industry that involves the collection and management of hazardous waste materials. Examples include chemicals, batteries, electronic waste, medical waste, and contaminated metals etc.
562910- Remediation Services	Relates to industry that establishes remediation and cleanup of contaminated buildings, soil, mine sites, and any other place where there is harm to human health and/or environmental health.

The Project team completed this analysis for the 11-county catchment area defined at the beginning of this report, the findings of which are presented below. Because the focus of this portion of the analysis was to explore regional partnerships to develop additional end-markets, the team did not include any information from outside of the catchment area. Depending on the goals of an analysis and the anticipated material flows/volumes for a given deconstruction enterprise, individuals replicating this process may wish to expand their reach to a broader geography.

Figure 34: Essential Related Industries in Catchment Area

2022 NAICS Code	Description	ALLEGAN	IONIA	KALAMAZOO	KENT	MECOSTA	MONTCALM	MUSKEGON	NEWAYGO	OCEANA	OTTAWA	VAN BUREN
238910	Specialized Site Contractors (Whole Building Deconstruction)	31	13	16	73	6	8	13	8	9	63	17
327120	Clay building Material Manufacturers	0	0	0	0	0	0	0	0	0	0	0
423930	Recyclable Material Mechant Wholesalers	0	3	6	16	0	3	3	0	0	4	3
423930	Salvage, Scrap, Merchant wholesalers	0	3	6	16	0	3	3	0	0	4	3
444180	Building Materials Supply Dealers	0	0	0	0	0	0	0	0	0	0	0

453310	Used Merchandise Stores	9	3	21	59	3	5	9	3	0	19	0
459510	Architectural Salvage Dealers	0	0	0	0	0	0	4	0	0	0	0
459999	Architectural Supply Stores	0	0	0	0	0	0	0	0	0	0	0
562112	Hazardous Waste Collection	0	0	0	0	0	0	0	0	0	0	0
562910	Remediation Services	0	0	3	11	0	0	0	0	0	0	0
321///	Wood products manufacturi ng	9	5	7	44	0	0	6	0	0	27	0
3273//	Cement & Concrete Manufacture rs	3	0	8	21	0	3	7	3	0	9	0
3323//	Architectural & Structural Metals Manufacturi ng	12	4	11	35	0	4	11	5	0	24	7

Additional Resources in Used Building Materials Retailing

As will be discussed further in the 'Findings, Limitations, and Implications for Future Study' section of this report, used building materials retailing is perhaps the least studied component of a deconstruction and material reuse economy – and considering the relatively small amount of scholarship around other aspects of deconstruction and material reuse nationally, this creates a unique challenge for stakeholders looking to explore a deconstruction and material reuse start up. Many deconstructions and/or used building material enterprises incorporate training and education as core components of their overall model; a select few also include training and capacity building initiatives more specifically pertaining to used building materials retailing. Beyond reviewing the content included in this study, stakeholders looking to establish used building materials retail initiatives would benefit greatly from pursuing one-on-one consultation with an established used building material retailer to gain a better understanding of the realities of this sector. As such, the following organizations listed below are included in this report because of their emphasis on training and education, or because they offer valuable resources and networking to help connect aspiring deconstruction stakeholders to experts in the field.

- **The ReUse People of America** (https://thereusepeople.org/) – HQ: Oakland, California / Regional Offices Nationwide
  - National Leader in Deconstruction and Material Reuse, TRP is the only identified deconstruction nonprofit with a dedicated training and education program focused on retailing.
  - The ReUse Institute (TRI)
    - Training and Education:
      - Deconstruction 101
      - Deconstruction Crew Training (10-14 Days)
      - Deconstruction Crew Leader Training
      - Used Building Materials Retailing Training
    - Consultation:
      - Strategies for diverting reusable and recyclable building materials from landfills.
      - Tips and specifications on building for deconstruction
      - Implementation of deconstruction ordinances

        - Identification of markets for salvaged building materials
        - Cost-effective deconstruction procedures
        - Development of deconstruction and demolition specifications
        - Assistance with writing and implementing public policies encouraging building-materials salvage and reuse
        - Management of large-scale deconstruction and demolition projects

- **The Loading Dock** (https://www.loadingdock.org/) – Baltimore, MD
    - Claims to be the 'oldest used building materials nonprofit' in the country; publishes online substantial amount of information about the organization (including the floor-plan shown in Figure X above)
    - Useful Resources available for purchase online
        - Business Plan(s)
        - How-to guide for establishing building materials nonprofit
        - By-Laws
        - Old Grant Proposals
        - Monthly Financial Reports
    - Maintains a nationwide ReUse network with list of other reuse facilities
- **Build Reuse** (https://www.buildreuse.org/)
    - From 'About Us' section on website:
        - Build Reuse is a registered 501(c)3 nonprofit established in 1994 that serves as the premier national organization encouraging the recovery, reuse, and recycling of building materials in the United States. We are also committed to developing social investment and workforce development programs in the deconstruction industry.
    - Maintains national list of reputable deconstruction trainers
    - Developed deconstruction curriculum available for purchase
    - Piloting online reuse wiki / forums
    - Hosts Annual 'Build Reuse' conference

Evaluating Impacts in Deconstruction

The importance of measuring the environmental and economic impacts of deconstruction cannot be understated. Besides the creation of jobs related to the intensive processes of deconstruction, much of the economic value and environmental value come from the reclaimed materials themselves. Measuring these values is key to ascertain if deconstruction is a viable waste management practice in a certain catchment area; and allows for a deeper understanding of the ways in which deconstruction can be used to leverage broader positive impact in a community. The caveat is the assumption that these materials will be resold and reused – allowing for an additional useful life of the materials while simultaneously preventing these materials from entering the waste stream. As will be expanded upon below, certain materials sourced from deconstruction projects are more likely to be recycled than reused. The framework presented below for measuring environmental impact accounts for this by combining multiple end-of-life scenarios, prioritizing reuse (when feasible) and recycling (when reuse is unlikely, but recycling is feasible).

Environmental savings achieved through deconstruction can be understood using the concept of embodied carbon. Embodied carbon refers to the greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials. (Carbon Leadership Forum, 2020) This concept is often utilized in conjunction with Operational Carbon, which refers to the greenhouse gas emissions generated due to energy consumed to maintain the operation of a structure throughout its useful life. While operational carbon is key to understanding the full lifecycle impacts of structures, it does not account for all the carbon impacts of a structure. By including the estimates of embodied carbon, a full lifecycle analysis of a structures carbon impact can be estimated. As such, the analysis presented below includes only embodied carbon estimations of major building material types.

The processes associated with manufacturing new building materials are extractive of natural resources and result in substantial GHG emissions. Greenhouse gasses refer to atmospheric gases that contribute to the 'greenhouse' effect by absorbing and emitting Infrared radiation. These gases are distinct from one another in terms of their ability to absorb energy (Radiative Efficiency) and how long they remain in the atmosphere (Lifetime). (EPA, 2023) In order to understand the emissions impacts of these materials most effectively, GHG emissions are reported in terms of Carbon Equivalents – in the case of this report, measured in Metric Tons of Carbon Dioxide Equivalent (MTCO2E). This allows for a standardization of overall GHG impact relative to the impact of one ton of CO_2 in the earth's atmosphere. Understanding and articulating carbon emissions via GHG reduction will be a key factor in growing the deconstruction and material reuse sector in Michigan (and across the country). Measuring impacts in this manner allows for greater cohesion and collaboration with stakeholders across multiple realms and helps to solidify deconstruction and material reuse as 'green' alternatives to demolition. As carbon accounting technologies improve (and become more commonplace in environmental regulation and business circles), the relative value of the voided emissions generated by deconstruction increases. [See the 'Findings and Implications' section of this report for more on this topic.]

Embodied energy includes the total emissions produced by the extraction, manufacturing / processing, Transportation, construction, demolition (or deconstruction), and waste processing / disposal of a given structure. In the case of this analysis, the embodied energy of each major material type has been calculated – allowing for a more comprehensive understanding of the relative carbon impacts of various materials within a given structure. By reusing building materials via the process of deconstruction – rather than demolishing and landfilling the debris – there is an embodied carbon savings netted from the voided emissions of each virgin material that is replaced by a reused material (in this case, by reusing salvaged material instead of virgin material in new construction). As will be expounded upon shortly, the freely available EPA WARM (Waste Reduction Modeling) tool can be used to model the reductions in emissions that reuse & recycling net, when compared to the traditional practices of demolition & landfilling.

Estimating Salvageable Materials in a Deconstruction Market

To start, refer to the previous sections of this report titled 'Public Market Assessment' and 'Private Market Assessment' and proceed through the steps listed in each section to estimate a total number of single-family structures within each market subset. Though For this project's catchment area, those estimates are presented below in Figure 35 and Figure 36.

Figure 35: Estimate of Private Deconstruction Market

All Data 2020 - 2022 NESHAP Reports		
Object ID	**County**	**# of Demolitions 2020 - 2022**
1	Allegan	55

2	Ionia	14
3	Kalamazoo	118
4	Kent	327
5	Mecosta	10
6	Montcalm	12
7	Muskegon	107
8	Newaygo	8
9	Oceana	10
10	Ottawa	110
11	Van Buren	44
Total Demolitions of Single-Family Structures:		815

Figure 36: Estimate of Public Deconstruction Market

2020 Vacant Single Family Homes	
County	**Estimated Single Family Homes**
Allegan	1255
Ionia	854
Kalamazoo	2186
Kent	3530
Mecosta	439
Montcalm	75
Muskegon	2889
Newaygo	544
Oceana	543
Ottawa	988
Van Buren	1278
Total	14581

Next, refer to Figure 37 below which shows the estimated volume and mass per house for major material categories. These figures were developed in an earlier study conducted by MSU CCED in collaboration with the West Michigan Shoreline Regional Development Commission. Researchers on this project reviewed relevant literature and conducted multiple in-person visual assessments of Michigan homes to develop a material salvage profile for an archetypal Michigan home. [See 2017 Muskegon Michigan Deconstruction Economy Cluster Feasibility Study at domicology.msu.edu for more information] The project team then conducted a review of relevant literature to convert the material volumes provided by the earlier Muskegon Study into Mass.

Figure 37: Estimated Material Volumes and Mass for a 1500sf Michigan Home

Materials	**Estimated Quantity per House**	**Material Volume per SF (Unit of Volume / SF)**	**Estimated Mass per House (kg)**	**Mass per SF (kg/sf)**
Framing Lumber	4,000 board feet	2.667	8,043 kg	5.362
Standard Brick	5,000 bricks	3.333	10,000 kg	6.667
Asphalt Shingles	650 sq ft	0.433	811 kg	0.541
Flooring	1,125 sq ft	0.750	638 kg	0.425
Concrete	37 cubic yards	0.025	68,077 kg	45.385
Drywall	1,445 sq ft	0.963	1,049 kg	0.699
Siding	1,620 sq ft	1.080	1286 kg	0.857
Total	n/a	n/a	89,904 kg	n/a

For convenience, Figure 36 above also provides material volume and mass per square foot (sf) of a home. This allows individuals to easily estimate volume and mass for homes of varied sizes. Depending on the housing profile in each region, individuals may wish to increase or decrease the baseline home size to generate more accurate estimates. Once a target structure size is determined, the projection can be completed by multiplying the material volumes/sf by the structure size. (Ex: Framing Lumber in 1600sf home = 2.667 * 1650 = 4267.2 board feet) The same process can be conducted to determine material masses. Figure 38 below provides projected materials volumes while Figure 39 provides projected material masses for a selection of other home sizes.

Figure 38: Projected Material Volumes in Michigan Homes

Material	Estimated Volume (2000sf)	Estimated Volume (2500sf)	Estimated Volume (3000sf)	Estimated Volume (3500sf)
Framing Lumber (Board Feet)	5333	6666.25	7999.5	9332.75
Standard Brick (Bricks)	6666	8332.5	9999	11665.5
Asphalt Shingles (sq ft)	866	1082.5	1299	1515.5
Flooring (sq ft)	1500	1875	2250	2625
Concrete (cubic yd)	49	61.25	73.5	85.75
Drywall (sq ft)	1926	2407.5	2889	3370.5
Siding (sq ft)	2160	2700	3240	3780

Figure 39: Projected Material Masses in Michigan Homes

Material	Estimated Mass (2000sf)	Estimated Mass (2500sf)	Estimated Mass (3000sf)	Estimated Mass (3500sf)
Framing Lumber (kg)	10724.00	13405.00	16086.00	18767.00
Standard Brick (kg)	13333.33	16666.67	20000.00	23333.33
Asphalt Shingles (kg)	1081.33	1351.67	1622.00	1892.33
Flooring (kg)	850.67	1063.33	1276.00	1488.67
Concrete (kg)	90769.33	113461.67	136154.00	158846.33
Drywall (kg)	1398.67	1748.33	2098.00	2447.67
Siding (kg)	1714.67	2143.33	2572.00	3000.67

Next, determine the desired baseline structure size and decide whether to aggregate the estimated single family homes generated by the private and public market assessments conducted earlier. For this feasibility assessment, the project team decided on using 1500sf as a base, delineated between public and private markets, but aggregated county-level estimations of structures together into 'total' public and private market estimations for the targeted region. For each material type, multiply the total number of structures in catchment area * mass per structure to generate a projected total mass of materials in that catchment area. Figure 40 below shows this process for the Private and Public Market Assessment conducted for this project's target catchment area.

Figure 40: Estimated Mass of Materials in Catchment Area

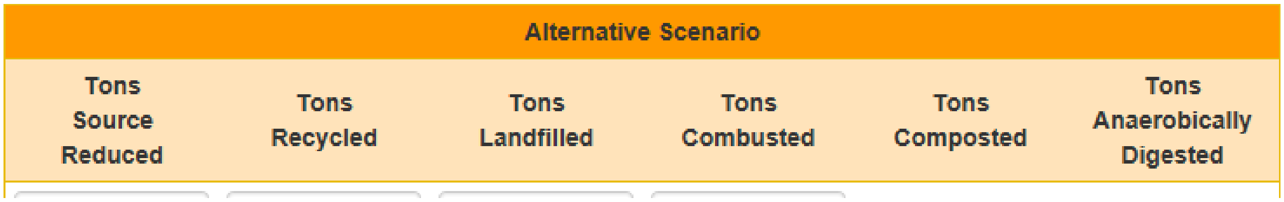
Private Market				
Total Structures:	Materials	Estimated Mass per House (kg)		Estimated Mass in Catchment Area (kg)
815	Framing Lumber	8,043		6,555,045
	Standard Brick	10,000		8,150,000
	Asphalt Shingles	811	*Note: Material Mass per House * Total Structures*	660,965
	Flooring	638		519,970
	Concrete	68,077		55,482,755
	Drywall	1,049		854,935
	Siding	1286		1,048,090
	Total	89,904		73,271,760
Public Market				
Total Structures:	Materials	Estimated Mass per House (kg)		Estimated Mass in Catchment Area (kg)
14581	Framing Lumber	8,043		117,274,983
	Standard Brick	10,000		145,810,000
	Asphalt Shingles	811	*Note: Material Mass per House * Total Structures*	11,825,191
	Flooring	638		9,302,678
	Concrete	68,077		992,630,737
	Drywall	1,049		15,295,469
	Siding	1286		18,751,166
	Total	89,904		1,310,890,224

Estimating Carbon Impacts of Deconstruction

The following portion of this feasibility assessment utilizes the EPA Waste Reduction Model (WARM) tool. This tool is available free for download at (www.epa.gov/warm). Using the same link, individuals can also gain access to the WARM Handbook – a user's guide published by EPA that describes in great detail methodology and best practices for using this tool. The WARM tool utilizes aggregate LCA data to provide embodied carbon estimations for varying end-of-life scenarios and can be used to provide estimations of carbon savings / GHG emissions reductions netted from deconstruction projects. Currently, this tool offers a wide array of material categories that the user can select to conduct their analysis, with new material categories being added to the tool regularly. The seven material categories included throughout this analysis (Framing Lumber, Standard Brick, Asphalt Shingles, Flooring, Concrete, Drywall, and Siding) are selected because they represent the largest contributors of C&D waste from residential structures, and because they overlap with the material categories provided by WARM.

The WARM tool functions by comparing two waste-diversion scenarios input by the user. For the purposes of this assessment, the Baseline Scenario represents waste management practices associated with demolition – landfilling most materials and recycling concrete. For the purposes of this assessment, 50% of concrete will be recycled in the demolition scenario, while 100% will be recycled in the deconstruction scenario. This is to reflect the realities that: many demolition projects currently recycle concrete to some degree; and deconstruction allows for higher degrees of material salvage for all material types. The Alternative or 'Test' scenario represents deconstruction practices – where a sizable portion of Materials are reused, and those that cannot be readily reused are recycled. Figure 41 below shows a small portion of the WARM interface – note the Six end of life scenarios provided in the tool: Recycling, Landfilling, Combustion, Anaerobic Digestion, Composting, and Source Reduction. For the purposes of modeling deconstruction and material reuse, the 'source reduction' pathway is used, because implicit within material reuse are the 'voided' emissions garnered by substituting salvaged materials for virgin ones in a new project.

Figure 41: WARM Tool Interface



To make use of the WARM tool, the user must now convert the estimated material masses generated in the public and private market assessments from kilograms (kg) to short tons (tons). This conversion can be accomplished easily in excel by inputting the following: (Material Mass (kg) / 907.185 = Material Mass (Tons)) Figure 42 below shows this conversion for the Public and Private markets identified within this project's catchment area. Figure 43 displays these material volumes for Private and Public markets in aggregate.

Figure 42: Tons of Material in Catchment Area

Private Market		
Materials	Estimated Mass in Catchment Area (kg)	Estimated Mass in Catchment Area (Tons)
Framing Lumber	6,555,045	7,226
Standard Brick	8,150,000	8,984
Asphalt Shingles	660,965	729
Flooring	519,970	573
Concrete	55,482,755	61,159
Drywall	854,935	942
Siding	1,048,090	1,155
Total	73,271,760	80,768
Public Market		
Materials	Estimated Mass in Catchment Area (kg)	Estimated Mass in Catchment Area (Tons)
Framing Lumber	117,274,983	129,274

Standard Brick	145,810,000	160,728
Asphalt Shingles	11,825,191	13,035
Flooring	9,302,678	10,254
Concrete	992,630,737	1,094,188
Drywall	15,295,469	16,860
Siding	18,751,166	20,670
Total	1,310,890,224	1,445,009

Figure 43: Aggregated Tons of Material in Catchment Area

Materials	Estimated Mass in Catchment Area (Tons)
Framing Lumber	136,499
Standard Brick	169,712
Asphalt Shingles	13,764
Flooring	10,828
Concrete	1,155,347
Drywall	17,803
Siding	21,825
Total	1,525,777

Once material masses have been converted to short tons, the user can now input material mass figures into the WARM tool to begin modeling the potential GHG emissions impacts associated with demolition and deconstruction. Before entering the total mass of selected materials into this tool, the user will be asked to review a series of other characteristics that will inform the outputs generated by the WARM tool. These additional factors are as follows:

- Location

    - Individuals can select their state from a drop-down menu. Specifying location allows for the WARM tool to account for energy generation impacts related to landfilling and combustion pathways.
- Waste Transport Characteristics
    - For each of the following pathways modeled in WARM, the user will be able to specify distances from the project site (or storage area) to the location where each selected pathway will be actualized (I.e., distance to landfill, distance to recycler, etc.) This allows for the WARM tool to incorporate more accurately carbon costs associated with the transportation of materials.
    - For this report's purposes, the project team used the standard distance (20 miles) for each pathway provided by WARM. Standardizing these distances was intentional, as doing so allows for a better comparison of the carbon impacts of each material by removing the variability of transportation related carbon expenditures.
    - Users may wish to determine actual distances associated with each pathway in their region to generate a more refined estimate of the carbon savings potential.
- Source Reduction
    - Users are asked to choose between '100% virgin' and 'national average' in calibrating the source reduction pathway in this tool. EPA states that WARM accounts for national average of recycled inputs into the manufacturing of certain materials; while other materials that do not have this information are assumed to be '100% virgin'.
    - For the purposes of this report, the project team elected to standardize this variable and selected 100% virgin for all inputs. Though factoring in recycled content in new products does allow for a more refined estimation – similar to the waste transport characteristics, the team felt that standardizing this variable allowed for a more meaningful comparison between material types.
- Landfill Characteristics & Anaerobic Digestion
    - Users will then be asked to provide additional information about gas recovery, moisture, decay rates, wet/dry digestion, and cure rates. If this information is readily available for a selected landfill in the region, it is advisable to input specific information to generate a more accurate end-of-life pathway in the tool. Because

the project team was operating within an 11-county region that features multiple landfills, the team elected to choose the 'default' settings for the each of these choices, because the 'default' setting is based on national averages of landfills and anaerobic digestors.

As described above, the baseline scenario used in this analysis is intended to model business-as-usual demolition, and as such uses 'Landfilling' pathways for all material types, as well as a 50% recycle rate for Concrete. The deconstruction scenario will utilize 'Source Reduction' for all categories where reuse is a feasible and realistic option and will utilize recycling for materials which do not have feasible reuse pathways. In this analysis, the project team utilized 'recycling' in the deconstruction scenario for concrete, asphalt shingles, and drywall. Figures 43 and 44 below shows inputs for the two scenarios modeled by the project team. (*Note that because of a lack of end-use pathways for PVC (closest analogue to Vinyl Siding) in WARM, siding has not been included in this assessment.*

Figure 44: WARM Tool Modeling of Deconstruction vs Demolition (Private Market)

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **MSU CCED**
Prepared by: **Private Market Assessment**
Project Period for this Analysis: to

Material	Baseline Scenario						Alternative Scenario							
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Change (Alt-Base) MTCO2E
Asphalt Concrete	30579.00	30579.00	N/A	N/A	N/A	-1855.39	0.00	61158.00	0.00	N/A	N/A	N/A	-4949.51	-3094.12
Asphalt Shingles	0.00	729.00	0.00	N/A	N/A	14.77	0.00	729.00	0.00	0.00	N/A	N/A	-65.52	-80.28
Clay Bricks	N/A	8984.00	N/A	N/A	N/A	181.97	8984.00	N/A	0.00	N/A	N/A	N/A	-2397.03	-2579.00
Dimensional Lumber	0.00	7226.00	0.00	N/A	N/A	-6672.55	7226.00	0.00	0.00	0.00	N/A	N/A	-15410.84	-8738.29
Drywall	0.00	942.00	N/A	N/A	N/A	-57.50	0.00	942.00	0.00	N/A	N/A	N/A	24.57	82.07
Wood Flooring	N/A	573.00	0.00	N/A	N/A	-492.60	573.00	N/A	0.00	0.00	N/A	N/A	-2309.82	-1817.21
						-8881.31							-25108.14	

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

d) The equivalency values included in the box to the right were developed based on the EPA Greenhouse Gas Equivalencies Calculator and are presented as an example of potential equivalencies. Additional equivalencies can be calculated using WARM results at the Greenhouse Gas Equivalencies Calculator website or using alternative data sources.

Total Change in GHG Emissions (MTCO2E): **-16226.83**

This is equivalent to...
Removing annual emissions from **3445** Passenger Vehicles
Conserving **1825906** Gallons of Gasoline
Conserving **676118** Cylinders of Propane Used for Home Barbeques
0.00001% Annual CO2 emissions from the U.S. transportation sector
0.00001% Annual CO2 emissions from the U.S. energy sector

Figure 45: WARM Tool Modeling of Deconstruction vs Demolition (Public Market)

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **MSU CCED**
Prepared by: **Public Market Assessment**
Project Period for this Analysis: to

Material	Baseline Scenario						Alternative Scenario							Change
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	(Alt-Base) MTCO2E
Asphalt Concrete	547094.00	547094.00	N/A	N/A	N/A	-33195.10	0.00	1094188.00	0.00	N/A	N/A	N/A	-88552.45	-55357.35
Asphalt Shingles	0.00	13035.00	0.00	N/A	N/A	264.02	0.00	13035.00	0.00	0.00	N/A	N/A	-1171.53	-1435.54
Clay Bricks	N/A	160728.00	N/A	N/A	N/A	3255.47	160728.00	N/A	0.00	N/A	N/A	N/A	-42884.08	-46139.54
Dimensional Lumber	0.00	129274.00	0.00	N/A	N/A	-119372.65	129274.00	0.00	0.00	0.00	N/A	N/A	-275701.74	-156329.09
Drywall	0.00	16860.00	N/A	N/A	N/A	-1029.16	0.00	16860.00	0.00	N/A	N/A	N/A	439.82	1468.98
						-150077.42							-407869.97	

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

d) The equivalency values included in the box to the right were developed based on the EPA Greenhouse Gas Equivalencies Calculator and are presented as an example of potential equivalencies. Additional equivalencies can be calculated using WARM results at the Greenhouse Gas Equivalencies Calculator website or using alternative data sources.

Total Change in GHG Emissions (MTCO2E): **-257792.55**

This is equivalent to...
Removing annual emissions from **54733** Passenger Vehicles
Conserving **29007826** Gallons of Gasoline
Conserving **10741356** Cylinders of Propane Used for Home Barbeques
0.00014% Annual CO2 emissions from the U.S. transportation sector
0.00014% Annual CO2 emissions from the U.S. energy sector

Interpreting WARM results

The above figures are taken directly from the WARM tool and demonstrate the comparative carbon savings impacts from the two scenarios tested in WARM. The column labeled 'Change (Alt-Base) MTC02E' describes the difference between the baseline scenario (demolition) and the alternative scenario (deconstruction). Examining this column, two key observations can be made that may be a bit surprising – that the demolition pathway in-and-of itself netted substantial carbon savings (although dwarfed by the carbon savings offered by the deconstruction pathway); and that certain material pathways in the deconstruction scenario ended up emitting more carbon than their demolition pathway counterparts.

Though these observations may at first be a bit confounding – a review of the various WARM tool supporting documents available through EPA (https://www.epa.gov/warm/documentation-waste-reduction-model-warm) provides clarity on these outputs. The landfilling pathway – for example – incorporates both GHG emissions generated by the decomposition of these materials in a landfill (including the generation of CH4, which would not occur under natural decomposition for most materials), but also accounts for percentage of material in landfill that is unlikely to achieve any state of decomposition, and therefore, is counted as a carbon sink. For many materials (in the case of this assessment, dimensional lumber) this results in an overall carbon savings impact via landfilling – though deconstruction and source reduction are still twice as effective at conserving carbon. For certain materials (for example Drywall, as seen in this assessment) the current processes for recycling are so energy intensive that – when compared to landfilling – they end up emitting more carbon than would be netted via landfilling. The project team did not alter these pathways in the alternative scenario (despite the frustrating reality that sometimes-recycling nets more emissions than landfilling), because the pathways selected in each scenario represent the most likely to occur end-use decision for each material type.

Findings of WARM Analysis

As described previously, this WARM Analysis compared demolition (baseline scenario) and deconstruction (alternate scenario) for both public and private markets identified within the project's catchment area. Based on the scenarios described in the prior section, this analysis found that deconstruction and material reuse on average tended to reduce or sequester 3 times (3x) as much carbon (MTCO2E) when compared to demolition and landfilling. The projected impacts of deconstruction and material reuse within the private market is estimated to generate an additional -16,226.83 MTCO2E of carbon savings, while these same activities within the public market are estimated to generate an additional -257792.55 MTCO2E of carbon savings. This is equivalent to removing the annual emissions of 3445 and 54733 passenger vehicles respectively.

Figures 46 and 47 below provides a more comprehensive overview of the relative impact of specific materials and waste management pathways (i.e., landfilling, recycling, etc.) within this analysis. In this figure, the demolition scenario is represented in blue while the deconstruction scenario is represented in red. Note that the relative impact of reusing lumber, wood flooring, and brick (modeled in WARM using the source reduction pathway) nets substantial carbon savings. Depending on process carbon (carbon emitted during the phases of harvesting, transporting, and processing materials) associated with each material, the relative impact of reuse conserves 2x – 5x more carbon than sequestration via landfilling.

Figures 48 and 49 demonstrate the overall emission or carbon savings sources for both tested scenarios in the public and private market. Echoing figure 45, note that relative carbon savings from forest storage (the voided demand for virgin lumber resulting from wood reuse) are twice those netted via the sequestration of carbon via landfilling.

Figures 50 - 53 provide a more detailed breakdown of the carbon impacts associated with specific material masses and their corresponding waste pathways in both the public and private market components of this assessment.

Figure 46: Material Contributions of MTCO2Ein Private Market

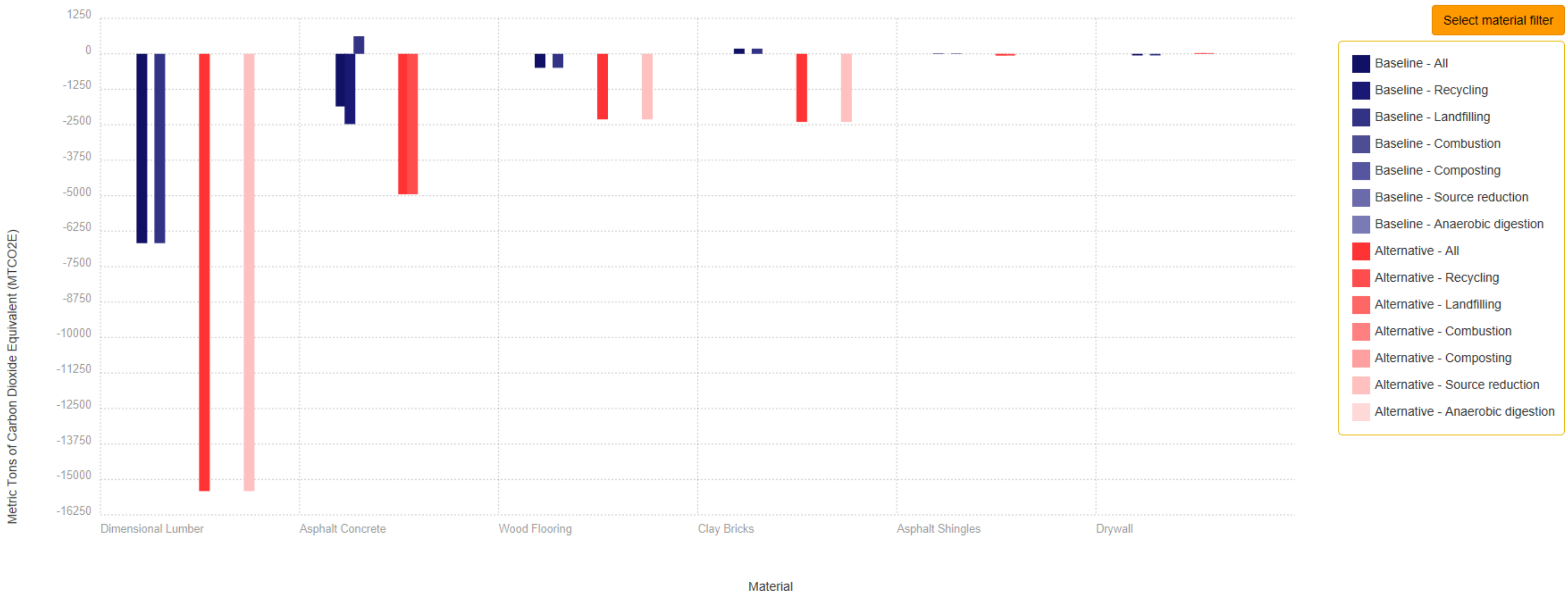


Figure 47: Material Contributions of MTCO2Ein Public Market

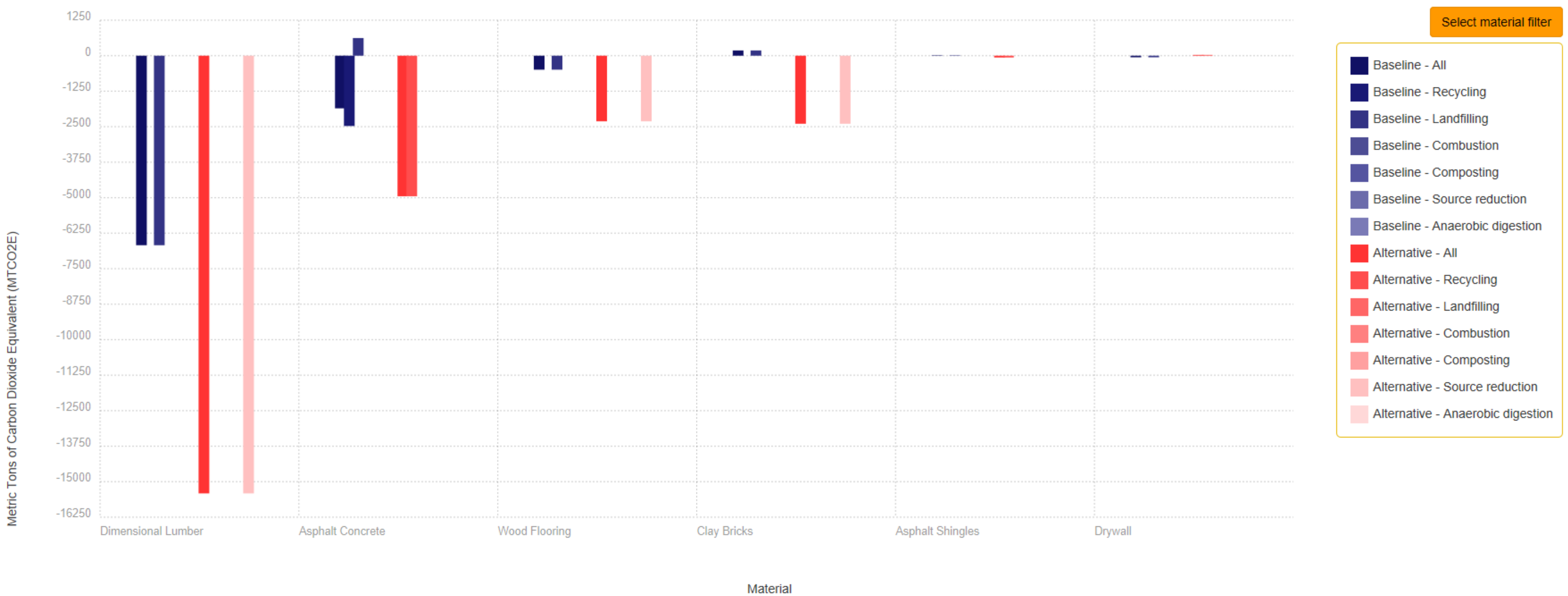


Figure 48: Source of Carbon Savings and Emissions in Private Market

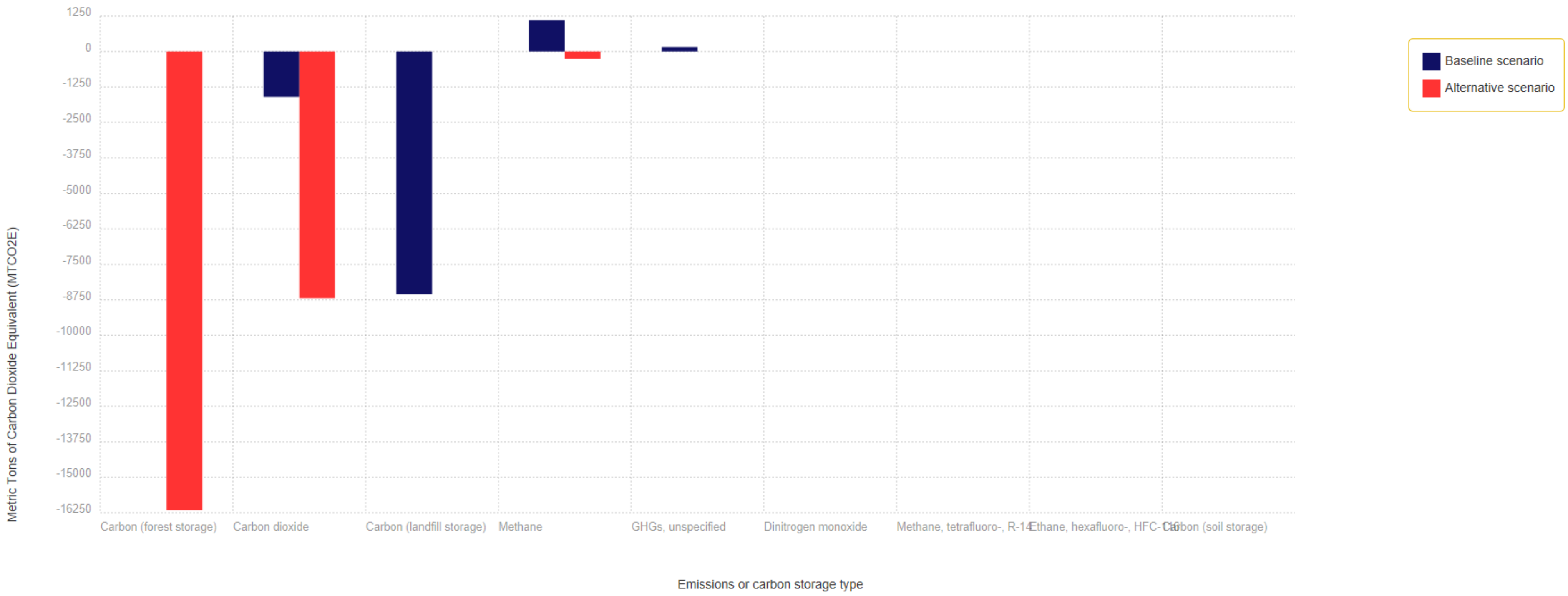


Figure 49: Source of Carbon Savings and Emissions in Public Market

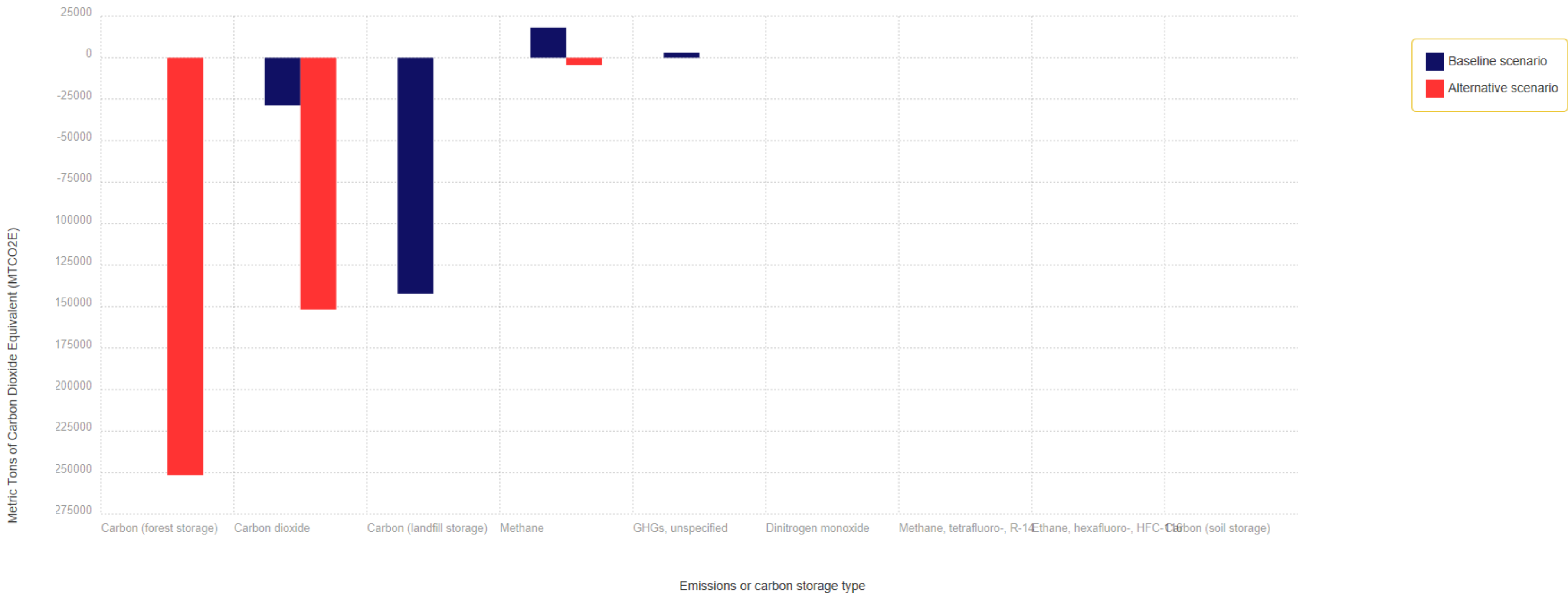


Figure 50: Expanded Carbon Impacts in Private Market

Total GHG Emissions from Baseline MSW Generation and Management (MTCO2E): **-8881.31**
Total GHG Emissions from Alternative MSW Generation and Management (MTCO2E): **-25108.14**
Incremental GHG Emissions (MTCO2E): **-16226.83**

MTCO2E = metric tons of carbon dioxide equivalent

Emission Factors | **Emissions from Baseline** | Emissions from Alternative | Incremental Emissions from Alternative

Material	Baseline Generation of Material (Tons)	Baseline Recycling (Tons)	GHG Emissions from Recycling (MTCO2E)	Baseline Landfilling (Tons)	GHG Emissions from Landfilling (MTCO2E)	Baseline Combustion (Tons)	GHG Emissions from Combustion (MTCO2E)	Baseline Composting (Tons)	GHG Emissions from Composting (MTCO2E)	Baseline Anaerobic Digestion (Tons)	GHG Emissions from Anaerobic Digestion (MTCO2E)	Total GHG Emissions (MTCO2E)
Asphalt Concrete	61158.00	30579.00	-2474.75	30579.00	619.36	N/A	N/A	N/A	N/A	N/A	N/A	-1855.39
Asphalt Shingles	729.00	0.00	0.00	729.00	14.77	0.00	0.00	N/A	N/A	N/A	N/A	14.77
Clay Bricks	8984.00	N/A	N/A	8984.00	181.97	N/A	N/A	N/A	N/A	N/A	N/A	181.97
Dimensional Lumber	7226.00	0.00	0.00	7226.00	-6672.55	0.00	0.00	N/A	N/A	N/A	N/A	-6672.55
Drywall	942.00	0.00	0.00	942.00	-57.50	N/A	N/A	N/A	N/A	N/A	N/A	-57.50
Wood Flooring	573.00	N/A	N/A	573.00	-492.60	0.00	0.00	N/A	N/A	N/A	N/A	-492.60

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Total GHG Emissions from Baseline MSW Generation and Management (MTCO2E): **-8881.31**
Total GHG Emissions from Alternative MSW Generation and Management (MTCO2E): **-25108.14**
Incremental GHG Emissions (MTCO2E): **-16226.83**

MTCO2E = metric tons of carbon dioxide equivalent

Emission Factors | Emissions from Baseline | **Emissions from Alternative** | Incremental Emissions from Alternative

Material	Baseline Generation of Material (Tons)	Alternative Source Reduction (Tons)	GHG Emissions from Source Reduction (MTCO2E)	Alternative Recycling (Tons)	GHG Emissions from Recycling (MTCO2E)	Alternative Landfilling (Tons)	GHG Emissions from Landfilling (MTCO2E)	Alternative Combustion (Tons)	GHG Emissions from Combustion (MTCO2E)	Alternative Composting (Tons)	GHG Emissions from Composting (MTCO2E)	Alternative Anaerobic Digestion (Tons)	GHG Emissions from Anaerobic Digestion (MTCO2E)	Total GHG Emissions (MTCO2E)
Asphalt Concrete	61158.00	0.00	0.00	61158.00	-4949.51	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	-4949.51
Asphalt Shingles	729.00	0.00	0.00	729.00	-65.52	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-65.52
Clay Bricks	8984.00	8984.00	-2397.03	N/A	N/A	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	-2397.03
Dimensional Lumber	7226.00	7226.00	-15410.84	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-15410.84
Drywall	942.00	0.00	0.00	942.00	24.57	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	24.57
Wood Flooring	573.00	573.00	-2309.82	N/A	N/A	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-2309.82

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Figure 51: Expanded Carbon Impacts in Public Market

Total GHG Emissions from Baseline MSW Generation and Management (MTCO2E): **-150077.42**
Total GHG Emissions from Alternative MSW Generation and Management (MTCO2E): **-407869.97**
Incremental GHG Emissions (MTCO2E): **-257792.55**

MTCO2E = metric tons of carbon dioxide equivalent

Emission Factors | **Emissions from Baseline** | Emissions from Alternative | Incremental Emissions from Alternative

Material	Baseline Generation of Material (Tons)	Baseline Recycling (Tons)	GHG Emissions from Recycling (MTCO2E)	Baseline Landfilling (Tons)	GHG Emissions from Landfilling (MTCO2E)	Baseline Combustion (Tons)	GHG Emissions from Combustion (MTCO2E)	Baseline Composting (Tons)	GHG Emissions from Composting (MTCO2E)	Baseline Anaerobic Digestion (Tons)	GHG Emissions from Anaerobic Digestion (MTCO2E)	Total GHG Emissions (MTCO2E)
Asphalt Concrete	1094188.00	547094.00	-44276.22	547094.00	11081.12	N/A	N/A	N/A	N/A	N/A	N/A	-33195.10
Asphalt Shingles	13035.00	0.00	0.00	13035.00	264.02	0.00	0.00	N/A	N/A	N/A	N/A	264.02
Clay Bricks	160728.00	N/A	N/A	160728.00	3255.47	N/A	N/A	N/A	N/A	N/A	N/A	3255.47
Dimensional Lumber	129274.00	0.00	0.00	129274.00	-119372.65	0.00	0.00	N/A	N/A	N/A	N/A	-119372.65
Drywall	16860.00	0.00	0.00	16860.00	-1029.16	N/A	N/A	N/A	N/A	N/A	N/A	-1029.16

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Total GHG Emissions from Baseline MSW Generation and Management (MTCO2E): **-150077.42**
Total GHG Emissions from Alternative MSW Generation and Management (MTCO2E): **-407869.97**
Incremental GHG Emissions (MTCO2E): **-257792.55**

MTCO2E = metric tons of carbon dioxide equivalent

Emission Factors | Emissions from Baseline | **Emissions from Alternative** | Incremental Emissions from Alternative

Material	Baseline Generation of Material (Tons)	Alternative Source Reduction (Tons)	GHG Emissions from Source Reduction (MTCO2E)	Alternative Recycling (Tons)	GHG Emissions from Recycling (MTCO2E)	Alternative Landfilling (Tons)	GHG Emissions from Landfilling (MTCO2E)	Alternative Combustion (Tons)	GHG Emissions from Combustion (MTCO2E)	Alternative Composting (Tons)	GHG Emissions from Composting (MTCO2E)	Alternative Anaerobic Digestion (Tons)	GHG Emissions from Anaerobic Digestion (MTCO2E)	Total GHG Emissions (MTCO2E)
Asphalt Concrete	1094188.00	0.00	0.00	1094188.00	-88552.45	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	-88552.45
Asphalt Shingles	13035.00	0.00	0.00	13035.00	-1171.53	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-1171.53
Clay Bricks	160728.00	160728.00	-42884.08	N/A	N/A	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	-42884.08
Dimensional Lumber	129274.00	129274.00	-275701.74	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-275701.74
Drywall	16860.00	0.00	0.00	16860.00	439.82	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	439.82

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Commodity Value of Salvaged Materials

Included below is a table showing the estimated total commodity (wholesale) values associated with the major salvaged material categories included in this analysis. This is intended to provide just one potential measure of the economic value of recoverable materials within the catchment area. Prices for these materials fluctuate greatly, and as such, should be double checked routinely to ensure accurate commodity value projections. [See references for list of resources used to determine material prices] Specific material values shown in this table were generated as of Early July 2023; and as such projected material values shown represent only a snapshot of approximate market values of these materials. It is worth noting that because commodity prices were used as the basis for this calculation, the overall values shown in this table are not necessarily representative of the retail value of these materials, but instead better represent the potential wholesale value associated with these materials. Additionally, this method of pricing salvaged materials does not account for the diversity of material found within each home – as certain materials may hold additional value beyond their wholesale pricing based on: region specific materials markets, higher/lower than mean material quality, uniqueness of salvaged material/feature, architectural salvage value, etc.

Figure 52: Commodity Values of Salvaged Materials

Material	Estimated Quantity per House	Average Estimated Value per unit of Material	Potential Monetary Value from a Single House	Total Potential Volume in Public Market	Total Potential Volume in Private Market	Total Potential Volume in Aggregated Market	Potential Monetary Value from Catchment Area
Framing Lumber	4,000 board feet (bf)	$0.55	$2,200	58,324,000	3,260,000	61,584,000	$33,871,200
Standard Brick	5,000 bricks	$0.55	$2,750	72,905,000	4,075,000	76,980,000	$42,339,000
Asphalt Shingles	650 sq ft	$4.50	$2,925	9,477,650	529,750	10,007,400	$45,033,300
Flooring	1,125 sq ft	$12.50	$14,062	16,403,625	916,875	17,320,500	$216,506,250
Concrete	37 cubic yards	$117	$4,329	539,497	30,155	569,652	$66,649,284
Drywall	1,445 sq ft	$2.50	$3,612	21,069,545	1,177,675	22,247,220	$55,618,050
Siding	1,620 sq ft	$12	$19,440	23,621,220	1,320,300	24,941,520	$299,298,240
Total	n/a	n/a	$49,318	n/a	n/a	n/a	$759,315,324

Findings and Determinations of Study

The following section describes the overall determinations of this feasibility study, describes the assessed limitations of this study, and articulates a vision for future policy & scholarship that can help to make deconstruction and material reuse economies more feasible in Michigan. The determinations highlighted in this section were arrived at based on a review of relevant data collected throughout the assessment and in consideration of the points articulated in the 'key assumptions' and 'defining success' portions of this feasibility study.

<u>Key Determination #1: The tax-deductible donation incentive is key to developing a private market for services; income 'requirements' for this incentive limit market potential.</u>

Deconstruction enterprises across the country widely utilize the tax-deductible donation incentive to generate markets for deconstruction services, as this incentive creates the potential for tax savings which can potentially offset the additional costs associated with deconstruction. As expounded in prior sections of this report, the likelihood that this incentive can offset deconstruction costs is linked to the income of the homeowner and the overall donation value. Similarly, there is an effective 'minimum income'- approximately 47k per year- at which a person can technically benefit from itemizing instead of taking the standard deduction. [See 'Tax Deductible Donations and Deconstruction Enterprises' Section] Figure 53 below shows two projected tax-deductible donations that help to illustrate this effect. Note that the projected donation value is held constant in both examples – the specific value is calculated using the average donation value/sf from figure 16, as well as the 1500sf Michigan archetypal home described in figure 37. This projection shows that with all other variables held constant, the 200k income household can actualize twice the cost savings than the 100k household in half the amount of time. Without additional incentives resulting from local / state policy, the tax-deductible donation incentive alone is disproportionately beneficial to higher income households, limiting the potential private market for deconstruction services.

Figure 53: Projected Deductions for selected household incomes in Michigan

Homeowner Income	**Notes**	**100k**	**200k**

Projected Donation Value (Total Deduction Value)	*($45.35 * 1500sf)*	$68,025	$68,025
Year 1 Tax Savings with Maximum Deduction	*(r*(.3Deduction) - ($13,850*r))*	$3,876	$14,768
Remaining Deductible Donation after year 1		$38,025	$8,025
Year 2 Tax Savings with Maximum Deduction	*(r*(.3Deduction) - ($13,850*r)))*	$3,876	***
Remaining Deductible Donation after year 2		$8,025	n/a
Year 3 Tax Savings with Maximum Deduction	*(r*(.3Deduction) - ($13,850*r)))*	***	n/a
Total Tax Savings		$7,752	$14,768
*** With no other deductions from in-kind donations, the individual will save more by taking standard deduction than by deducting remaining amount			

A review of the economic profile data provided in section one of this report provides additional evidence as to the limitations of using the tax-deductible donation incentive within the selected catchment area. Referring to Figure 7, note that of the entire 11-county region, only 4 census tracts are shown to have a median income higher than $115,536. Additionally, Figure 8 shows that across the entire 11-county region the highest concentration of high-income households (defined as over 200k/year) per census tract is between 23 and 38 households, while the vast majority of the catchment area have fewer than 5 households making over 200k/year per census tract. Noting that a Census tract is on average 4000 people / 1,333 households (Statista, 2023), it is clear that high-income households represent a very small portion of the overall population within the catchment area. It is unfortunate that household income plays such a significant role in determining whether a household can financially benefit from deconstruction; but barring policy changes [See implications for future study section], the tax-deductible donation incentive remains largely out-of-reach for most households in the catchment area.

Key Determination #2: Demolition Activity in the Region is inadequate to support a deconstruction enterprise via substitution alone.

A key caveat to contextualize this determination can be found in the ‘defining success’ portion of this report – that the project team defined a sustainably operating enterprise as “the ability to remain financially solvent without the necessity of soft dollars [grant funding] to support operating costs of the partnership”. Because of this articulated goal at the onset of the project, the subsequent feasibility assessment placed a larger emphasis on exploring the generation of a private market via substitution of demolition activity and the tax-deductible donation incentive, as opposed to building public sector partnerships to pursue external funding for operation. This is not to say that there is any inherent detriment to pursuing grant funding to support a deconstruction enterprise – in fact, support of this kind is likely essential for successful operation in most of the state – but instead that the model of deconstruction enterprise pursued by the project team’s industry partners prioritizes developing and capitalizing on the private market as the key growth factor.

Because of this focus, the project team assessed the current state of Demolition activity in the region to explore the ostensible market for deconstruction services as a substitute for demolition. Based on the practice experience of the project team’s deconstruction and material reuse industry partner, the project team determined that 30-40 projects annually would be necessary to fully support a 10,000sf warehouse with the adequate inventory (and inventory turnover) to meet the needs of used building materials customers. Referring to Figure 27, note that the region experienced 815 recorded demolitions between 1/1/2020 and 12/31/2022. Based on this assessment of market activity, the deconstruction enterprise (to sustainably operate without grant funding) would need to capture approximately 13% of all currently occurring demolitions across the 11-county region. While this figure alone may not seem improbable, Key determination #1 casts significant doubt as to the viability of market substitution as a primary growth factor for a deconstruction enterprise. As indicated in the ‘challenges in deconstruction’ section of this report – all deconstruction enterprises must develop a value proposition which offsets the additional cost of deconstruction to feasibly substitute demolition. While this value proposition is impacted by a multiplicity of factors (local / state policy, access to grant funding to support deconstruction enterprise, property owner's income, etc.), the ultimate task is to create additional value for the consumer (of deconstruction services) that overcomes the additional costs that consumer will pay to deconstruct. Because of the aforementioned economic profile of the region, as well as the current policy environment [more on that in the 'implications for future study' section], the project's industry partners determined that it was very unlikely the region (under current circumstances) could meet the target market substitution threshold necessary to support a retail facility.

<u>Key Determination #3: The Public Market for Deconstruction services offers robust opportunity but requires a high degree of cross-sector partnership and reliance on grant funding.</u>

Throughout the 2-year process of conducting this feasibility assessment, one of the true watershed moments came from the addition of the Muskegon County Land Bank as a key project partner. Said plainly, partnering with the Land Bank created an array of new opportunities and partnership potentials that were simply not within reach of the original partnership (industry partners and MSU CCED alone). While much of this is owed to the Visionary Leadership of the Muskegon County Land Bank (and their willingness to innovate within their field), the very nature of the Muskegon Land Banks Charge – "to transform vacant, tax delinquent and abandoned property for the benefit of the surrounding property, to improve the community, stabilize the area, [and] give low income families the opportunity to be home owners and return property to tax rolls" – creates immense opportunities for advancing deconstruction. (Muskegon County Land Bank Authority, N.D.) With the support of the Land Bank, the project team was able to identify and secure a structure to serve as a training site for deconstruction contractors, make inroads with local units of government and other community partners who were otherwise difficult to engage, and begin to develop end-markets for used building materials via the Land Bank's involvement in new construction in-fill projects throughout the city. The Land Bank also expressed a high degree of willingness to apply for funding via the State Land bank specifically to incorporate deconstruction into their structural removal capacities.

In assessing the potential public market for deconstruction services – defined as those properties which are under a state of nonuse or disuse and already (or likely to be) controlled by the Land Bank or municipality – the project team identified an ample supply of properties within the region. Referring to figure 24, note that the team identified over 14,000 suitable single-family properties which fit this criterion within the catchment area. Whereas within the private market deconstruction projects are actualized because of a value proposition which makes viable deconstruction services, deconstruction projects within this public market would by necessity be supported using funding from a variety of sources such as: foundations and charities, workforce development funding, blight removal and remediation funding, HUD block grants, and State Land Bank funds. Collaboration with the Land Bank (and other community organizations connected to the partnership via the Land Bank) majorly increases the likelihood of qualifying for such funding.

Based on the project team's experience working with the Land Bank in this context, it is within the realm of possibility that a public-market focused deconstruction initiative could operate within the boundaries of this catchment area. However, because of the project team's stated goal of exploring the establishment of a deconstruction enterprise without the necessity of grant funding to support operation, it was determined that the deficits in the private market created a reliance on public funding (and/or funding from foundations) that was beyond the desired parameters under which the industry partners wanted to move forward with implementation. Still, the experiences gained while exploring public sector partnerships with the Land Bank are a testament to the immense benefit that cross-sector collaboration offers to deconstruction enterprises. Until additional supportive policy is developed which can change the private market value proposition for deconstruction in Michigan, partnerships such as the one described above may well be considered a necessity for the establishment of sustainable deconstruction and material reuse economies in Michigan.

Key Determination #4: A lack of supportive policy in Michigan is greatly limiting market feasibility of deconstruction initiatives.

The current policy environment in the selected catchment area – both in terms of local policy (county, city, etc.) and state level policy – stands as a fundamental barrier to the widespread adoption of deconstruction and material reuse enterprises. Within the private market, deconstruction enterprises largely rely on the tax-deductible donation process to incentivize projects – and as has been demonstrated in this report – this incentive alone only works for a significantly small amount of the population. Figure 19 in the 'Tax Deductible Donations' section of this report provides a profile of all 2020 Tax filings in Michigan; note that only 16% of all filings claimed over $100,000 in income, while over 35% claimed less than $25,000 in income annually. Combining this profile with the effective minimum income to itemize (approximately $47,000), and the percentage of itemized filings outlined in Figure 19 (which demonstrates a higher likelihood of itemizing again), it appears that only a very small proportion of the overall population in Michigan could feasibly utilize the tax-deductible donation incentive. Furthermore, as demonstrated in Figure 52 – the relative benefit of itemizing an in-kind donation grows substantially as income increases. In the scenarios projected in Figure 52 – which utilizes the estimated average Michigan donation value – the $100,000 household could only capture a maximum of approximately $7,000 in tax savings over two years. Being that the overall function of this incentive is to overcome additional deconstruction costs, it stands to reason that even at the $100,000 income level (just 13% of all filers in Michigan who are at or above this income) many deconstruction projects are likely to bare an additional cost larger than $7,000, and therefore would not be economically feasible under this incentive.

Contributing to this dilemma is the reality that Michigan has one of the lowest tipping fees in the nation – at last check, approximately $42 / ton – meaning that the state is one of the cheapest places in the nation to discard materials in a landfill. The cost to dispose of materials in Michigan is so low, that the state has disparagingly been called a 'garbage importer', with nearly 22% of all waste entering Michigan landfills being imported from other states and internationally. (EGLE, 2021) This reality has a substantial impact on the overall feasibility of deconstruction initiatives in Michigan, as both the public and private markets are under very little pressure (in this case, economic pressure) to pursue any amount of waste diversion via deconstruction and reuse. In other states with more developed tipping fees (and/or waste diversion requirements for structural removal projects), the increased cost of disposal creates a natural incentive for deconstruction and reuse. Even within the public market – which does offer a wide array of potential opportunities for funding to support deconstruction initiatives – the financial 'bottom line' often drives most decision making, meaning many public sector stakeholders involved in the removal of structures are largely dis-incentivized to pursue any additional waste diversion goals, due to the real (and perceived) reality that under current conditions, it's often cheaper and easier to pursue landfilling. The section titled 'Deconstruction Supportive Policy' provides a more in-depth analysis of the array of deconstruction supportive policies that can have a positive impact on the overall market feasibility of deconstruction in Michigan.

Limitations of Study

The following section provides an overview of the assessed limitations of this study, with consideration as to how these factors impacted the overall determination outlined in the above section, as well as discussion of potential next steps.

Limitation #1: Renovation and Remodeling industries offer additional market opportunities; available data proved inadequate to incorporate in assessment.

Beyond sourcing exclusively from full deconstructions, many material reuse enterprises work closely with renovation and remodeling contractors to conduct partial deconstruction projects, resulting in additional material flows into a retail facility. Much as is the case with full deconstructions, the tax-deductible donation incentive can also be used to incentivize homeowners to pursue partial deconstruction and material salvage within the context of renovation and remodeling projects. Based on interviews with deconstruction and material reuse enterprises across the nation, the project team found that remodeling and renovation projects do constitute a significant source of materials for reuse and should be considered in determining the ostensible market for deconstruction services in a region.

The project team endeavored to include renovation and remodeling material streams as a component of the private market assessment, but soon discovered that the lack of availability of key data in this realm prevented a meaningful projection of the overall market presence / quantity of material available via these industries. The project team was able to locate state-level industry reports via IBISWorld that articulated basic information about renovation and remodeling industries including overall revenue generated and the number of operating firms within this sector. Despite numerous attempts, the project team was unable to identify any additional data beyond that described above. This information alone proved inadequate to meaningfully assess how renovation and remodeling industries factored into the overall deconstruction market in the region, as the available information provided little more than a statewide profile of this industry. Information of the following sort was not available to the team, but would have allowed for the inclusion of these industries into the market assessment: case studies of remodeling projects with associated material salvage volumes, average waste generated via remodeling projects in Michigan, estimations of the total number of remodeling projects and associated square footage in Michigan, etc.

Limitation #2: Commercial and Industrial structures are viable candidates for deconstruction; available data proved inadequate to incorporate in assessment.

The public and private sector market assessments featured in this report are both focused solely on single-family homes. Partially, this decision was intentional, as it aligned with the industry partner's experiences in establishing deconstruction initiatives – with single family homes being the 'bread and butter' of successful operations in other locations across the nation. This is not to say that structures of this kind do not offer immense opportunities for deconstruction and reuse; on the contrary, projects on this kind often net unique materials, equipment, and components (i.e., appliances from commercial kitchens, storage systems/racks that can be reused easily, etc.) that have an enduring reuse market. Partially, however, the exclusion of these structures from this assessment reflects the high degree of variability (in terms of square footage, type of construction, potential salvage inventories, and difficulty of deconstruction) amongst commercial and industrial structures.

The single-family home market projections of salvageable materials included in this report were ultimately made possible due to earlier research conducted by MSU CCED and other partners in the 2017 Muskegon Michigan Deconstruction Feasibility Study. [see domicology.msu.edu or the works cited page of this report] This research resulted in an archetypal Michigan structure profile which provided evidence-based estimations of the average structure size and material salvage potential for single-family homes in Michigan. Because of the lack of availability of a similar profile of industrial and commercial structures in Michigan, the project team was unable to meaningfully generate projected material volumes that could be netted from such structures within the catchment area. Note that within the methodology of both the private and public market assessments, steps were taken by the project team to filter out industrial and commercial structures to 'clean' the data to provide a more meaningful estimate of salvageable materials. Individuals who wish to emulate this assessment may elect to forgo those specific steps in order to identify commercial and industrial structures that could be included in the public and private markets as defined.

<u>Limitation #3: Data describing Blight and Abandonment is not available in an aggregated form; vacancy data workaround provides coarse estimate with certain limitations.</u>

As is mentioned in the public market component of this assessment; Land Banks, City demolition departments, Economic Development Districts (EDD's) and other such partners may collect information regarding the state of blighted and abandoned structures within their jurisdictions. Barring these potential outlets, data describing blighted and abandoned structures is generally not collected or aggregated on a regional or statewide basis, creating distinct challenges for assessing the overall potential salvage market for materials in these structures. Within this study, the project team developed a workaround using vacancy data from the US Census to estimate the total volume of vacant single-family homes as an analogue for blighted and abandoned structures. Though this methodology is effective at generating a baseline overview of the presence of these structures within a catchment area, this methodology does not adequately incorporate the reality that blight is a dynamic process which has real implications for the availability of salvageable material in a catchment area. Similar to the recommendation made in Limitation #2, individuals may wish to complete an augmentative assessment of the present state of deterioration and other physical characteristics of blighted and abandoned structures in their region, in order to generate a more accurate estimate of the availability of reusable materials currently embodied in these structures. Generally, structures that are blighted continue to deteriorate unless protective measures (such as tarping roofs, boarding up doors and windows, etc.) are taken, resulting in lower and lower reclaim potential and salvage value. Studies which link the state of deterioration to the overall salvage and reuse potential for blighted structures could be immensely helpful in augmenting the methodology presented in this report to better encapsulate the unique challenges (and opportunities) that come from incorporating blighted and abandoned structures into a deconstruction enterprises target market.

Limitation #4: WARM Tool has incomplete factors for source reduction; limiting the ability of the tool to measure economic impacts of deconstruction.

The Waste Reduction Model (WARM) tool available freely through the EPA website (https://www.epa.gov/warm) is an incredibly useful tool that allows for users to model the potential environmental impacts of different waste management scenarios – within the context of this feasibility assessment, this tool was used to the generate carbon savings estimations overviewed in the 'Evaluating Impacts' section. Beyond its ability to articulate environmental impacts via carbon dioxide equivalents (MTC02E) and units of embodied energy (BTU); the WARM tool can also be used to generate estimates of a selection of economic indicators. These indicators include labor hours (employment supported by materials management), Wages (all forms of employment income from materials management), and Taxes (taxes collected by federal, state, and local government from materials management). Each of these economic indicators offers a vital lens through which stakeholders can better contextualize the market opportunities inherent in pursuing waste diversion across many industries– as so often carbon emissions reduction / waste reduction initiatives are broadly cast as 'too expensive' by established shareholders to invalidate movement away from status quo 'take-make-waste' behaviors across the supply chain. This 'stonewalling' is widely observed within the construction industry – and one of the most common 'myths' lobbed to weaken arguments for deconstruction and material reuse initiatives.

It is important to note that in its current state, the WARM tool is unable to meaningfully provide economic impact figures for deconstruction and material reuse – and unfortunately presently generates outputs in terms of wages, taxes, and employment that are wholly inaccurate and heavily misleading. Whereas all other waste management pathways used throughout the WARM tool (landfilling, anaerobic digestion, combustion, recycling, etc.) can be modeled in terms of their economic impacts, the source reduction pathway (which is used as an analogue for reuse) does not have any economic impacts factors included in the tool. In effect, this means that any waste management scenario modeled in WARM using the economic impact indicators will always output '0' for any amount of material included in the source reduction pathways. In some contexts, this does make sense – as source reduction is mostly simply defined as "the elimination of waste before it is created". (US EPA, n.d.) Within the context of modeling waste management strategies which include material reuse (such as deconstruction) – source reduction does not adequately describe the array of activities (all of which generate labor hours, earned wages, value-added [to products], and tax generation) which are necessary for the reuse of salvaged materials. Under it's current configuration, any attempt to model economic impact of material reuse through WARM will display results that can easily be interpreted as showing a substantial negative economic impact netted from reuse; when in reality, it the results are *incomplete* because of incomplete economic impact factors in the WARM tool.

The project team acknowledges the complexity that comes from developing economic impact factors associated with material reuse; as the multiplicity of unique contexts within which reuse occurs (direct reuse vs reprocessing vs remanufacturing vs upcycling, complexity of steps therein, logistics and transportation associated with reuse, etc.) certainly do not lend themselves easily to generalization. Still – more can be done within the WARM tool to increase its utility for modeling deconstruction and material reuse. The project team recommends developing a 'reuse' pathway for use in the WARM tool that can more accurately capture the nuances of material reuse than the current best analogue – source reduction. Time motion studies of deconstruction and material reuse projects can help to create baseline estimates of labor hours created, and further market research into deconstruction and material reuse economic can provide estimates for wage creation, value-added, and tax generation. Because most of the material included in the WARM tool may not be realistic candidates for the reuse pathway, it is recommended that new pathway be limited to the major materials categories utilized in this feasibility study, as these materials represent the most likely candidates for reuse (of the available materials currently indexed in the WARM tool).

<u>Limitation #5: Delineation between 'Public' and 'Private' markets as defined is not mutually exclusive.</u>

Due to the limited availability of key data articulating the number and condition of structures in the catchment area, the project team developed a delineation between 'public' and 'private' markets to provide two differing frameworks through which the market for deconstruction services can be assessed within a region. Within the 'public' market, researchers utilized Census data and developed methodology to garner estimates of overall blighted, abandoned, and out-of-use structures; while within the 'private' market, researchers quantified existing demolition activity by way of NESHAP asbestos reporting requirements. Because of these differing data sources, the project team is aware of the possibility that structures included in the 'private' market (those which were demolished within the period of analysis) may also be reported in the 'public' market assessed over the same period. This overlap is theoretically possible, but not guaranteed by virtue of the differing methodologies – that is, in order for a structure to be included in both markets, it would need to be both: identified as vacant, abandoned, or otherwise out-of-use within the Census data utilized; and, have been demolished within the same period of analysis. Because the data environment at present does not allow for easy cross comparison between the two markets as defined in this assessment, there is no clear path in which the two quantified markets can be completely reconciled. As such, the project team recommends utilizing both market assessment methodologies in tandem – by using the 'private' market component to understand the current state of demolition activities being completed in the region, and the 'public' market component to understand the overall volume of likely-to-be-demolished structures that are either within (or soon likely to enter) the public domain.

Implications for Future Study

As was described in the above 'determinations' and 'limitations of study' sections, a general dearth of scholarly inquiry into the deconstruction and material reuse industries creates a substantial array of challenges for meaningful inquiry in the further development of this industry – resulting in somewhat of a 'catch-22' scenario. Wherein, the lack of available data and peer-reviewed information around deconstruction economies limits the capacity of individuals (such as the project team) to conduct applied research with data-driven outputs towards more widespread adoption of these practices. While the feasibility assessment framework presented throughout this report is intended as a synthetization of practice knowledge, scholarly inquiry, and new methodology for assessing deconstruction economies; there remains a wide array of opportunities for further study which can be of immense benefit to deconstruction and material reuse stakeholders across the state. The following is a list of such implications for future study including reference to relevant portions of this report for additional context.

- Develop salvage profiles of commercial and industrial properties.
    - High variability amongst these types of structures combined with a lack of relevant literature makes it very difficult to project salvage material potential of commercial and industrial properties. Further inquiry can create archetypal structure profiles (such as the single-family-home archetype used in this analysis) which will allow for more accurate projection of the total volume/mass of salvageable materials, and the economic value created by deconstruction and reuse within this context.
- Develop blight / abandonment specific salvage profiles.
    - Like the above recommendation, additional inquiry into the relationship between blighting/deterioration and the overall state of salvageable materials within a structure can allow for a more meaningful understanding of this component of a public deconstruction services market.
- Develop renovation / remodeling project profiles to generate salvage profiles.
    - Renovation and Remodeling industries represent immense opportunities for deconstruction and material reuse economies, as the involvement of renovation/remodeling contractors can vastly expand the overall 'pool' of potential deconstruction projects within the public market to include partial deconstructions. The availability of data describing renovation and remodeling industries is limited to whole-state industry profiles; studies measuring the average project size, cost, and C&D waste created by renovation /remodeling activities in a region would greatly augment the private market assessment methodology presented in this report.
- Further inquiry into the Tax-Deductible Donation incentive.
    - The Tax-Deductible Donation incentive stands as the most widely used private market incentive for deconstruction services across the country. As this report has

shown, relying on this incentive alone to generate projects within the private market results in a highly inequitable pattern of access [to deconstruction services] ultimately tied to the claimed income of the tax-filers. Though this report has taken steps towards better elucidating these inequities – establishing effective minimum income limits and theoretical max tax savings calculations – much can be done to further understand the extent to which the potential market for deconstruction services in Michigan is limited by this incentive. Projects which quantify the ostensible market for 'gatekept' deconstruction projects (those individuals who would desire to deconstruct instead of demolishing, but cannot use the incentive to overcome the additional cost) could be of immense value in demonstrating the lost economic opportunity that comes from this segment of the deconstruction services market.

- Explore the creation of Tax Credits and other incentives to support deconstruction.
    - As indicated in the 'Tax Deductible Donations in Deconstruction Enterprises' section, the development of a deconstruction Tax credit pilot could radically address the equity and access issues inherent to the Tax Deductible donation incentive. Similarly, local/regional/state level programming which created additional incentives for deconstruction projects (either by incentivizing deconstruction outright or incentivizing higher level so waste diversion / reuse requirements for new developments) could be an immense boon to this sector. The 'Deconstructive Supportive Policy' attachment in Appendix 1 provides an overview of an array of deconstruction supportive policies which could immensely increase access to deconstruction service within the private market, generate a higher impetus within the public market.
- Develop wage, labor, and tax impact factors for material reuse in WARM tool.
    - As described in Limitation #4, the WARM tool cannot presently be used to model economic impacts resulting from material reuse due to a lack of impact factors associated with material reuse being included in the tool. This gap is not necessarily surprising – and in fact is illustrative of the general lack of scholarship dedicated to understanding and articulating material reuse economies. Studies which seek to understand and describe the wages, job creation, and value-added via deconstruction, material re-processing, and material reuse can be instrumental in

understanding the true economic impact of this sector and can be used to further develop economic impact factors to be used in modeling software such as WARM.

- Deepen scholarship into material reuse facilities.
    - Material reuse facilities constitute complex drivers of economic activity that by-necessity involve coordination with multi-sector stakeholder networks (private sector customers, deconstruction and demolition contractors, renovation/remodeling contractors, general contractors, material recycling operations, materials brokers, etc.) A general lack of scholarly inquiry into the supply and value chains associated with material reuse facilities creates unique challenges in measuring economic impact of material reuse as well as a lack of easily available 'best practice' information for aspiring material reuse start-ups. One key development towards better scholarship of this kind could be the development of a mixed qualitative and quantitative 'used building materials' consumer market profile. Such a study could shed light on the market behaviors of this under-studied consumer base and could provide meaningful correlation between a variety of socio-economic data and material reuse focused consumer behaviors.
- Explore consumer preferences regarding tipping fees.
    - Tipping fees represent a powerful policy venue through which deconstruction and material reuse can be broadly incentivized. With a growing range of supporters across multiple sectors calling for increases in tipping fees in Michigan, a consumer preference study regarding increased tipping fees could help better elucidate the relationship between material reuse and tipping fees. Furthermore, such a study could be essential in developing specific fee increases, as well as a transition plan to help 'ease' this transition

Appendix #1: Deconstruction Supportive Policy

The following document was developed in Spring 2023 by MSU CCED researchers to aid the Michigan State Housing Development Authority (MSHDA) in its stated goal of reducing the carbon footprint of buildings and construction activities in the state of Michigan. The array of policy directives included in the table below are of equal relevance for Deconstruction and Material reuse stakeholders broadly writ; and are included as an appendix attachment to provide actionable policy concepts which can positively impact the overall feasibility of establishing deconstruction and material reuse economies across the State.

Key Concept: The Built Environment Sequesters Carbon

The American Institute of Architects (AIA) 2023 'Blueprint for Better Campaign' shows that "over the next 10 years embodied carbon will be responsible for 74% of all emissions of new buildings constructed during that period." Our ability to estimate carbon impacts has grown significantly and illuminated the necessity to reduce embodied carbon emissions related to structural construction, renovation, and demolition processes. Recently published statewide strategic plans from the Department of Energy, Great Lakes and the Environment,(EGLE) and the Michigan State Housing Development Authority. (MSHDA) emphasize the need to "decarbonize" the built environment, without adequately accounting for the Carbon embodied in building materials and processes of construction and demolition. MSHDA is uniquely positioned to affect rational and evidence-based progress in Michigan's built environment policy discourse.

Directive:

In order to meet the goals already set by the MI Healthy Climate Plan which calls specifically for increased Carbon sequestration and capture the MSHDA Statewide Housing Plan in calling for the construction of approximately 75,000 new/renovated units will need to recognize the role of embodied Carbon in the built environment. Relevant work is already underway around the country, and there are a variety of policies and programs that may guide MSHDA in achieving this objective. The materials below are an initial guide to some of those resources and information sources.

Strategy	Description	MSHDA Role	Resources
Design for Deconstruction (DfD)	Designing structures for easier deconstruction and material salvage at end of useful life. Includes but not limited to: homogenizing fasteners, minimizing adhesives, utilize modular building systems, stacking utilities in multi-story structures, create a deconstruction guide and	Incentivize DfD strategies in ongoing and future MSDHA funding opportunities	EPA DfD

	building material inventory as part of the design process		
Deconstruction Bonding and insurance	Similar to current practices of decommissioning cell towers, wind farms, railroads, and other heavy industry developments; create insurance bonds at a structures inception that can be used at the end of life to support deconstruction and salvage	Collaborate with relevant insurance & trade associations; create position paper supporting the expansion of insurance bonding requirements	Domicology Deconstruction Insurance Policy
Deconstruction Building Materials Assessment	Systematic processes that easily assess and inventory existing structures to help determine salvage and reuse potential. (Trained assessors can inventory a 1500sf home in a few hours)	Include deconstruction assessment as voluntary or required process for MSHDA supported demolitions and/or renovations	Deconstruction Go Guide
Material Diversion Requirement	All projects must divert a given proportion of the material leaving the site according to either mass, volume, or specific material types. Municipalities throughout the United States (Austin, TX; Palo Alto, CA' Cook County, IL; etc.) utilize material diversion ordinances to help incentivize deconstruction and reuse	Introduce Material diversion requirements for MSHDA supported developments with or without demolition/renovation components. (Salvage and diversion can be accomplished via the construction processes as well as deconstruction processes)	Domicology Ordinance Study
Deconstruction Requirement	Requiring deconstruction 'by name' as an alternative to demolition. Municipalities utilize ordinances with specific deconstruction language to support entire deconstruction and reuse economic clusters. Examples include:	Introduce deconstruction specific language into MSHDA supported developments/programs that will require removal of existing structures.	Domicology Ordinance Study

	(Portland, Or; Palo Alto, CA; Milwaukee, WI; etc.)		
Adaptive Reuse Assessments	Assessing structures to account for anticipated future use and potential expansion of structure to better serve the needs of future generations of users. Ex: overengineering structural components to account for additional building load from continued expansion of structure.	Include adaptive reuse plan incentives to MSHDA supported development activities, with specific attention to the unique advantages in adaptive reuse that Mass Timber construction offers (lighter than steel construction, enabling larger expansion on existing building components)	
Mass Timber Incentives	Mass Timber construction features wood-based structural components that replace/greatly reduce the need for steel and concrete components in buildings. MSU Research shows that Mass Timber can be manufactured using salvaged wood	Create a mass timber incentive program for projects of a given size, budget or height, with special focus on developments in areas of mid-high density, and/or developments in areas with projected population growth	USDA Wood innovations and community wood grants https://www.canr.msu.edu/masstimber/
Reuse Incentives	Simple grant program that closes upfront cost differences between adaptive reuse and demolition by offering reimbursement for verified reuse	Offer a reuse incentive program for projects in areas of moderate to high density to incorporate salvaged/reused materials into new building projects. [See Hennepin County Deconstruction & Reuse Grants Program]	https://www.hennepin.us/building-reuse
Deconstruction Incentives	Simple grant program that closes upfront cost differences between deconstruction and demolition by offering reimbursement for verified deconstruction	Offer a deconstruction incentive program for projects with suitable characteristics. [See Hennepin County Deconstruction & Reuse Grants Program]	https://www.hennepin.us/building-reuse

Seed Funding for Deconstruction & Reuse	In support of Deconstruction and Reuse incentives. Most residential deconstruction projects require less than $10,000 in additional funding to make deconstruction an economically viable alternative to demolition	Develop seed funding program to support local development offices, housing authorities, and other municipal level partners to manage deconstruction and reuse reimbursement grant programs.	https://www.hennepin.us/building-reuse
Carbon Tracking	Report the carbon impacts of C&D activities according to a standard tool	Implement Carbon tracking requirement as requisite for suitable funding opportunities	State of Washington Mandatory Greenhouse Gas Reports;
Carbon Trading	Create and sell Carbon credits that are independently verified by a third-party that account for	Collaborate with a third-party organization to design and verify a carbon credit system that will generate credits to be sold to carbon-emitting industries	DNR Carbon

References

(2021). (rep.). *REPORT OF SOLID WASTE LANDFILLED IN MICHIGAN October 1, 2019 - September 30, 2020*. Lansing, MI.

(2022). (rep.). *FY 2021 Report of Solid Waste Landfilled in Michigan*. Retrieved from https://assets.website-files.com/602b605a94315c491a4fb4b8/610aed49f0ef85f4566dbe3f_Tipping-Fees-Data-Summary%20Jan%202021.pdf.

1 - Embodied Carbon 101. Carbon Leadership Forum. (2023, April 2). https://carbonleadershipforum.org/embodied-carbon-101/

2023 brick prices - per pallet, square foot, & 1,000. HomeGuide. (n.d.-a). https://homeguide.com/costs/brick-prices

2023 drywall installation cost: Hang Drywall cost per sqft. HomeGuide. (n.d.-b). https://homeguide.com/costs/drywall-installation-cost#:~:text=Drywall%20installation%20costs%20%241.50%20to,to%20%242.70%20per%20square%20foot

About build reuse. Build Reuse. (n.d.). https://www.buildreuse.org/about

Aceves, J. (2021, April 19). *Industrial Basics - why care about ceiling height?*. Meybohm Commercial. https://meybohmcommercial.com/industrial-basics-why-care-about-ceiling-height/#:~:text=Clear%20height%20under%2020%20feet,as%20high%20as%2040%20feet

The American Institute of Architects (AIA). (2020). (rep.). *BUILDINGS THAT LAST: DESIGN FOR ADAPTABILITY, DECONSTRUCTION, AND REUSE* .

Bartolone, G. (2023, May 31). *Siding Costs 2023*. Forbes. https://www.forbes.com/home-improvement/siding/siding-cost/#:~:text=On%20average%2C%20installing%20siding%20on,%2C%20metal%2C%20vinyl%20and%20stone

Boxman, S., & Staley, B. (2021). *Analysis of MSW Tipping Fees 2020*. Environmental Research and Education Foundation. https://assets.website-files.com/602b605a94315c491a4fb4b8/610aed49f0ef85f4566dbe3f_Tipping-Fees-Data-Summary%20Jan%202021.pdf

Boyd, S., Stevenson, C., & Augenbraun, J. (2014, April). Deconstructing deconstruction: Is a ton of material worth a ton of work? https://env-center.williams.edu/files/2014/04/Boyd-et-al.-Kellogg_deconstruction-2012.pdf

City of San Antonio Office of Historic Preservation. (2021). (rep.). *Treasure in the Walls: Relcaiming Value through Material Reuse in San Antonio*. Retrieved from https://www.sanantonio.gov/Portals/0/Files/HistoricPreservation/Deconstruction/Treasure%20in%20the%20Walls.pdf?ver=2021-04-25-115830-417.

Crovella, P., Delaney, M., & Kohan, M. (2018). International Buildings Physics Conference 2018. In *Syracuse University*. Retrieved from https://library.syracuse.edu/.

Davis, A. (2019, March 15). *All landfills are not the same*. Granger. https://www.grangerwasteservices.com/all-landfills-are-not-the-same/#:~:text=Landfills%20can%20be%20licensed%20by,materials%20designated%20as%20hazardous%20waste

Deconstruction go guide. Delta Institute. (2018, June 13). https://delta-institute.org/publication/deconstruction-go-guide/

Demolition vs. deconstruction: How shifting to reuse impacts the environment and Economy - Sustainable earth. Sustainable Earth - Where People and the Planet Thrive. (2022, September 6). https://sustainable-earth.org/demolition-vs-deconstruction/

Denhart, H. (2010). Deconstructing disaster: Economic and environmental impacts of deconstruction in post-Katrina New Orleans. *Resources, Conservation and Recycling*, *54*(3), 194–204. https://doi.org/10.1016/j.resconrec.2009.07.016

Diyamandoglu, V., & Fortuna, L. M. (2015). Deconstruction of wood-framed houses: Material recovery and environmental impact. *Resources, Conservation and Recycling*, *100*, 21–30. https://doi.org/10.1016/j.resconrec.2015.04.006

Environmental Protection Agency. (2023a). *Reuse and Recycling Opportunities and Demolition*. EPA. https://www.epa.gov/large-scale-residential-demolition/reuse-and-recycling-opportunities-and-demolition

Environmental Protection Agency. (2023b, April 18). *Understanding Global Warming Potentials*. EPA. https://www.epa.gov/ghgemissions/understanding-global-warming-potentials#:~:text=The%20Global%20Warming%20Potential%20(GWP,carbon%20dioxide%20(CO2

Framing lumber prices. NAHB. (2023). https://www.nahb.org/news-and-economics/housing-economics/national-statistics/framing-lumber-prices

Gromis, A. (2019, May 22). *Eviction: Intersection of poverty, inequality, and housing*. un.org. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2019/05/GROMIS_Ashley_Paper.pdf

HomeAdvisor. (2022a, August 3). *2023 Asphalt Shingles Costs*. What Is the Average Cost of Asphalt Roofing? https://www.homeadvisor.com/cost/roofing/asphalt-shingles-install-replace/

HomeAdvisor. (2022b, December 13). *Flooring costs 2023*. 2023 Flooring Installation Cost: How Much Does Flooring Cost? https://www.homeadvisor.com/cost/flooring/install-flooring/

Internal Revenue Service. (2020). *SOI Tax Stats - Historic Table 2.* Accessed at https://www.irs.gov/statistics/soi-tax-stats-historic-table-2

Internal Revenue Service. (2022). *IRS provides tax inflation adjustments for tax year 2023*. Accessed at https://www.irs.gov/newsroom/irs-provides-tax-inflation-adjustments-for-tax-year-2023

Internal Revenue Service. (2022). *Publication 526 (2022), Charitable Contributions*. Accessed at https://www.irs.gov/publications/p526

Internal Revenue Service. (n.d.). *Credits and Deductions for Individuals*. Accessed at https://www.irs.gov/credits-deductions-for-individuals

Justia Law. (2021). *Mann v. United States, No. 19-1793 (4th Cir. 2021)*. Accessed at https://law.justia.com/cases/federal/appellate-courts/ca4/19-1793/19-1793-2021-01-06.html

LaMore, R., & Jordan, A. (2017). (rep.). *Muskegon, Michigan Deconstruction Economic Cluster Feasibility Study*.

Landfill carbon storage in warm - U.S. environmental protection agency. US EPA. (2010, October 27). https://www.epa.gov/sites/default/files/2016-03/documents/landfill-carbon-storage-in-warm10-28-10.pdf

Lifecycle Building Center. Programs. (2023). https://www.lifecyclebuildingcenter.org/programs

Lumber2023 data - 1978-2022 historical - 2024 forecast - price - quote - chart. Lumber - 2023 Data - 1978-2022 Historical - 2024 Forecast - Price - Quote - Chart. (2023). https://tradingeconomics.com/commodity/lumber

Lynch, N. (2022). Unbuilding the city: Deconstruction and the circular economy in Vancouver. *Environment and Planning A*, *54*(8).

Melchiorre, T. (2020). *Office of Chief Counsel Internal Revenue Service Memorandum: 202020002*. Internal Revenue Service. Accessed at https://www.irs.gov/pub/irs-wd/202020002.pdf

Melissa Kressin. (n.d.). *"Other" Vacant Housing Units: An Analysis from the Current Population Survey*. Retrieved from https://www.census.gov/housing/hvs/files/qtr113/PAA-poster.pdf.

Michigan Economic Development Corporation. (2023). *Michigan's State Historic Tax Credit Program*. Accessed at https://www.miplace.org/historic-preservation/programs-and-services/historic-preservation-tax-credits/state-historic-tax-credit-program/

Mooallem, J. (2008). This old recyclable house. *New York Times*.

National reuse: The Loading Dock, inc.. National ReUse | The Loading Dock, Inc. (2020). https://loadingdock.org/reuse_national/index.html

Nunes, A., Palmeri, J., & Love, S. (2019). (rep.). *Deconstruction vs. Demolition: An evaluation of carbon and energy impacts from deconstructed homes in the City of Portland*. March: Oregon DEQ.

Part 115 Solid Waste Active / Accepting Facilities. ArcGIS Part 115 Solid Waste Active / Accepting Facilities Map. (2023). https://egle.maps.arcgis.com/apps/webappviewer/index.html?id=4ec28f2727554b0295b8b95ce804cd58

Perdomo, C. (2023, January). Demolition & Wrecking in the US.

Pricing guide: How much does concrete cost per yard?. Lawnstarter. (2023, July 25). https://www.lawnstarter.com/blog/cost/concrete-price-per-yard/

Published by Statista Research Department, & 7, J. (2022, January 7). *Average U.S. detached single-family home size 2015-2023*. Statista. https://www.statista.com/statistics/1072431/average-detached-single-family-home-size-usa-timeline/

St. Louis Deconstruction Market Assessment - Delta Institute. Delta Institute. (2019, April 1). https://delta-institute.org/wp-content/uploads/2019/05/St.-Louis-Deconstruction-Market-Assessment.pdf

Telander, L. (2014, March 31). *Breaking down deconstruction: What Detroit gained from dismantling instead of destroying*. Center for Community Progress. https://communityprogress.org/blog/deconstruction-interview/

The Green Mission. (2021). *Non-Cash Charitable Donations and Appraisals*. Accessed at https://www.thegreenmissioninc.com/article/non-cash-charitable-donations-and-appraisals

The ReUse People. (n.d.) *Owner's Guide to Donating Used Building Materials*.

U.S. Census Bureau. (2022). *Median Adjusted Gross Income for Michigan*. St. Louis Federal Reserve. Accessed at https://fred.stlouisfed.org/series/MEDAGIMI26A052NCEN

University of Michigan. (n.d.). *Residential buildings factsheet*. Center for Sustainable Systems. https://css.umich.edu/publications/factsheets/built-environment/residential-buildings-factsheet

US Census Bureau. (n.d.). *U.S. Census Bureau quickfacts: United States*. Census.gov. https://www.census.gov/quickfacts/fact/map/US/HSG010222