



ELLEN
MACARTHUR
FOUNDATION



**ACCELERATING
THE CIRCULAR
ECONOMY
THROUGH
COMMERCIAL
DECONSTRUCTION
AND REUSE**



● **Acknowledgements and Scope**

● This paper provides an initial exploration into the importance of deconstructing commercial buildings (frequently referred to herein as “commercial deconstruction”) and reuse of building materials for an increasingly circular built environment. It was developed based on insights from over 25 interviews with leading deconstruction and reuse experts, primarily in the US and Europe. The research for this paper was supported by Google and undertaken by Building Product Ecosystems, Ellen MacArthur Foundation, Google, and Ackerstein Sustainability in 2019. Many thanks to all those who contributed their experience and insights.

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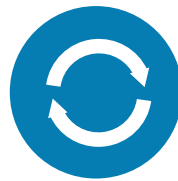
Introduction

The Ellen MacArthur Foundation was launched in 2010 with the aim of accelerating the transition to the circular economy, one that is restorative and regenerative by design. Under the prevalent linear economic model, most of the materials we produce, we lose, and the things we make are consistently under-utilized. At the Foundation, we believe there is a compelling case for generating economic value and environmental benefit from putting materials into perpetual use cycles – rather than just consuming them. This vision has seen rapid uptake in recent years and has been embraced by businesses across different industries, including large companies such as Google.

A circular economy relies on three key principles:



**DESIGNING OUT WASTE
AND POLLUTION**



**KEEPING PRODUCTS AND
MATERIALS IN USE**



**REGENERATING
NATURAL SYSTEMS**

Achieving a circular economy not only requires adoption of circular design principles and the establishment of appropriate recovery systems, but also invariably challenges us to rethink how we source, design, manufacture, transport, use, repair, and recycle everything. The Foundation therefore directs its activities towards the most catalytic actions and actors that shape and influence the global economy, such as consumer products, cities, food systems, and the built environment.

The transition to a circular economy is particularly relevant for the built environment due to the fact that construction is one of the largest sectors of today's global economy, representing 13% of GDP and employing 7% of the world's working age population.¹ Additionally, the built environment uses almost half of the world's materials extracted every year and current projections estimate that by 2060, across the world, the equivalent of the city of Paris will be built each week.² Moreover, buildings and construction account for more than 35% of global final energy use and nearly 40% of energy-related CO₂ emissions.³ If current urbanisation trends continue, it has been estimated that material consumption by the world's cities will grow from 40 billion tonnes in 2010 to about 90 billion tonnes by 2050.⁴ These negative externalities are, in large part, a product of our current linear 'take-make-waste' economy, which relies on fossil fuels and does not manage resources already in use for the long-term. There is a clear and urgent need to reverse this trend of growing resource extraction, replacing it with a system that works.

The Foundation has therefore been working with its partners to explore how a circular economy approach can address these systemic challenges in the built environment sector. As part of this, we are working with our global partner Google to explore the role of deconstruction as one approach that facilitates the application of circular economy principles in the built environment. Deconstruction presents a valuable alternative to traditional demolition and involves the disassembly of buildings to recover the maximum amount of reusable materials. It employs the key circular economy principles of designing out waste and keeping products and materials in use, bringing clear environmental, social and economic benefits. This paper presents lessons from Google's own experience of implementing deconstruction projects and explores some of the key challenges and opportunities associated with deconstruction over demolition. Finally, the paper presents important recommendations for industry and policy actions that can help overcome systemic barriers, expand deconstruction to enable reuse of materials, and highlight key design strategies that will enable greater reuse in the future.

Circular Economy at Google

At Google, we believe in the democratizing effect of putting knowledge in the hands of everyone, organizing the world's information, and making it universally accessible. We are committed to doing this in a way that has a positive impact on people and the planet. We believe that the path to a cleaner, healthier future begins with the small decisions we make each day. That's why we're committed to building sustainability into everything we do, making smart use of the earth's resources, and creating products with people and the planet in mind. We recognize that realizing a sustainable world means that we must accelerate the transition to a circular economy so our vision is simple: **We want a circular Google within a sustainable world.** Our approach starts with a clear mission, which is to accelerate the transition to a circular economy in which business creates environmental, economic, and community value through the maximum reuse of finite resources. Within this mission we define 'maximum reuse' as the implementation, to the fullest extent possible, of our circular principles, which are to design out waste and pollution, keep products and materials in use, and promote healthy materials and safe chemistry.

Our circular principles are the heart of our approach to becoming a circular Google, inspired by the breakthrough work of our partners at the Ellen MacArthur Foundation, adapted for Google's specific impact and opportunity, and facilitated in our built environment through collaboration with partners like [Building Product Ecosystems](#). Together, we believe there is a compelling case for generating economic value and environmental benefit from putting materials into perpetual use cycles, rather than just consuming and disposing of them. To date, Google has offices in over 150 cities spanning nearly 60 countries. This means we have a significant opportunity and responsibility to address waste in design, construction, and renovation of the buildings and spaces that we own or manage. We believe there are opportunities to increase deconstruction of existing commercial buildings to unlock the value and function of salvaged material resources such that they are retained, reinvested back into local communities, and prevented from becoming waste in landfills. When we salvage components of buildings, our aim is to keep products at their highest value and use. Ultimately, we believe that a key enabler to making cities and our built environment more restorative and regenerative is a circular economy where our infrastructure is designed to be dismantled, redistributed, and reused.

1. IMPACT + OPPORTUNITY

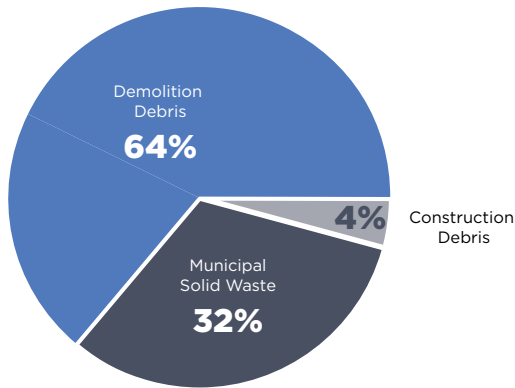
Impacts of Current, Linear Construction and Demolition

Our built environment, which is composed of buildings and physical infrastructure, continues to utilize the linear ‘take-make-waste’ model in which resources are taken from the ground, used and then disposed of as waste. This approach makes the built environment one of the world’s largest consumers of global raw materials and largest sources of waste and negative environmental externalities such as increased air, water, and soil pollution.⁵

In the current linear system, when buildings reach the end of their useful life, they are typically demolished using a wrecking-ball and bulldozer for site clearance. These habits are driven by efficiency of time, labor, and cost. One of the consequences is the generation of large quantities of small pieces of wood, concrete, drywall, and rock - called ‘fines’. Fines are very challenging to collect, manage, and recycle. In many cases, the only viable use of this material grade is as landfill cover. Demolition sites produce dust, smoke, noise and sometimes other forms of hazardous pollution in communities. Additionally, valuable materials within buildings are irreversibly damaged which prevent reuse.

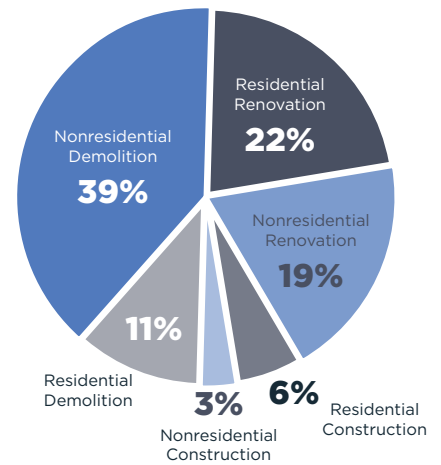
The US Environmental Protection Agency (EPA) estimates that 548 million tons of construction and demolition (C&D) debris were generated in 2015 including buildings, bridges, and roads—more than double the amount of municipal solid waste generated that year—and that more than 90% of the total C&D debris was produced by demolition activities.⁶ Of the C&D debris generated in the US, 169 million tons came from buildings. An analysis from the EPA indicates that non-residential demolition and renovation generates 60% of the building related C&D waste, much of which ends up in landfills.⁷ Overall, landfill diversion rates for mixed C&D waste in the US are less than 40%.^{8,9} Concrete comprises about half of the volume of building-related C&D debris, followed by wood, gypsum wallboard, asphalt shingles, brick and clay tiles, and steel, respectively.¹⁰ These high-volume materials in the C&D waste stream represent a range of opportunities for reuse and recycling. For example, concrete can be crushed onsite and reused in new construction, while wood and bricks have high reuse potential as structural and non-structural building components. Applying circular economy principles to C&D debris generated in the US can drastically reduce the volume of materials going to landfill by catalyzing circular material flows in the built environment.

US Waste Generation by Sector and Activity⁶



21% of construction and demolition debris is generated from buildings.

C&D Debris Generated by Each Building Sector⁷



Key Definitions:

- **Deconstruction** - The systematic dismantling and removal of a structure or its parts, in the reverse order of construction, for maximum value through the salvage and harvest of components, primarily for reuse in their original purpose and secondarily for recycling.
- **Demolition** - The efficient tearing down of a structure or its parts to clear the site as quickly as possible, resulting in debris suitable for some bulk, mixed commodity recycling, and disposal.
- **Salvage** - Removal of disassembled building materials for the purpose of reuse, refurbishing, or recycling.
- **Selective Deconstruction** - Disassembly of part of a building or attached structure, targeted materials, finishes, or systems, leaving part of a building standing.
- **Strip-out** - Harvesting a building's most valuable and easily removable components, typically limited to finish materials, equipment, kitchen cabinets, doors, plumbing fixtures, lighting, and bathroom fixtures.

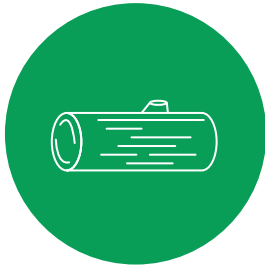
The Circular Economy Opportunity for Deconstruction of Commercial Buildings

A truly circular built environment embeds the principles of a circular economy across all its functions, establishing a system that is regenerative, accessible and abundant by design. This means buildings are designed from the outset in a modular and flexible way, sourcing healthy materials that improve occupant wellbeing and minimize use of new materials. They are built using efficient construction techniques, and are well utilized thanks to shared and flexible spaces. Components of buildings are maintained and renewed when needed, while building energy use is conserved due to smart technology and product-as-a-service business models. The buildings themselves are designed to be able to adapt to different uses over time, making them resilient to changing market conditions and avoiding premature redevelopment. When they finally reach the end of their life, the materials and construction techniques deployed allow the buildings to be taken apart in a way that protects the true value of the materials so that they can be used again.

From this vision of a circular built environment, we can see that deconstruction is one of many tools that will be required in order to support and facilitate the transition to a circular economy.¹¹ To date, deconstruction efforts in the U.S. have largely been focused on single-family residential buildings because the smaller scale construction techniques and types of materials used in these structures make them better suited to be dismantled. For example, 93% of new homes are wood-framed, rather than framed with the heavy concrete, block, or steel commonly found in commercial building structures.¹² This means human labor, rather than large machines, can disassemble a residential building more easily than a commercial building. Furthermore, common commercial building components, such as larger and heavier plumbing systems, complex lighting fixtures, and industrial-strength attachments, increase the difficulty of disassembly.

Commercial floorspace in the US has increased by 21% since 2003, and about half of all existing buildings were built before 1980.¹³ As the aging commercial building stock is repurposed and replaced, deconstruction emerges as a key solution for unlocking opportunities for salvaging valuable materials from buildings which will also significantly increase diversion rates for C&D debris. Implementing deconstruction as a strategy for achieving reuse will catalyze a host of environmental, social, and economic benefits.

Triple Bottom Line Opportunity of Commercial Deconstruction



Environmental

- Resource Conservation
- Carbon Reduction
- Decreased Landfill Volume



Economic

- Reduced Tipping Fees
- Strengthened Local Economy and Job Creation
- Materials Kept at Highest Value



Social

- Green Workforce Training
- Creation of Local Jobs
- Respect for History of Communities

Environmental Opportunity

According to the Delta Institute, deconstruction of buildings can help reduce toxic dust from job sites, reduce metal leaching into soil, reduce waste sent to landfills, and reduce consumption of new raw materials.¹⁴ Deconstruction can also reduce a project's total waste when salvaged materials are donated, resold, or reused on the existing site. The materials that are best suited for recycling, are source-separated onsite and sent to material recovery facilities that can ensure 100% diversion from landfill.

There is evidence that prioritizing deconstruction before demolition also reduces the embodied carbon impact associated with the redevelopment of buildings. For example, the Oregon Department of Environmental Quality recently published a study that compares the carbon impacts of deconstruction and demolition of single-family homes in Portland, Oregon, finding that the average deconstructed home resulted in a carbon benefit of 13.8 MTCO_{2e}, while demolition resulted in a carbon benefit of only 6.2 MTCO_{2e}.¹⁵ The doubled carbon benefits from deconstruction are mainly attributed to the avoided production of new materials plus continued sequestration of biogenic carbon in the wood. While we lack studies on carbon savings due to deconstruction of commercial buildings with different material mixes from residential buildings, we recognize that the same principles hold true there will be significant carbon savings if we don't need to create new materials. The greenhouse gas calculator available from [Build Reuse](#) can begin to help us compare impacts of using new building materials versus reused materials.¹⁶ We know there is great untapped embodied carbon savings in the reuse of many commercial building products, such as carpet tile, ceiling tile systems, door systems, cabinetry, partitions, and plumbing fixtures. Considering that a building typically undergoes many renovations in its lifetime, it is important to consider salvaging components for reuse in order to reduce embodied carbon and other environmental impacts.^{17, 18}

Economic Opportunity

The deconstruction of commercial buildings is an underexplored topic, but the potential economic gains could be significant. From a circular economy perspective, proper deconstruction makes sense not only because it provides environmental and social benefits, but also because the building material resources that can be salvaged have financial value, and there is economic opportunity in giving these materials a second life.

Research has shown that up to 25% of materials slated for decommissioning or deconstruction from homes can be reused, while up to 70% can be recycled in some form. This means that 5-10% of the materials in residential buildings have little or no value.¹⁹ These rates can vary significantly depending on the project type and local conditions, making estimates of savings resulting from deconstruction of commercial buildings difficult. For example, the material composition of commercial buildings differs from that of single family homes. Typical concrete and steel structure is more likely to be recycled than reused, but wood beams can be reused or repurposed. Also, established secondary markets for commercial finishes are less developed than those for residential, though local refurbishing options can expand these markets over time. Importantly, commercial building sites tend to have more space than house plots for disassembly and sorting, along with the critical mass of materials often needed to warrant dedicated pick-up and transfer to reuse markets, all of which facilitates reuse. With nearly 600 million square feet of new commercial office space constructed in the US per year, there is potential for reuse of these salvaged materials if owners and their design build teams prioritize their inclusion in new projects. Keeping salvaged products in use at their highest value can reduce or offset new product procurement budgets.

Economic value also lies in the opportunity for project teams to avoid costly landfill and disposal fees. Landfill diversion is increasingly important as average tipping fees continue to rise in the U.S. due to diminishing landfill capacity. When materials are reused within the United States, there is additional assurance that the materials will be processed under more stringent environmental regulations than when exporting waste to developing countries. U.S. landfill tipping fees have risen 5.2% over the past year, with a current average national tipping fee of \$55 per ton, soaring to \$73 per ton in the Pacific States.²⁰ Project teams can minimize these fees by incorporating deconstruction practices and reuse policies, and recycling where reuse is not viable, reducing total materials sent to landfill.

Finally, deconstruction and reuse stimulates broader economic opportunity through job creation and new regional markets for the removal, sale and distribution of salvaged materials. Deconstructing buildings requires more skilled contractors than demolition. Jobs are created not only for the work of deconstructing and removing materials, but also related to the creation of businesses to transport, store, refurbish, and resell them. According to the Delta Institute, 6-8 more jobs are generated from deconstruction compared to each job created from traditional demolition.²¹

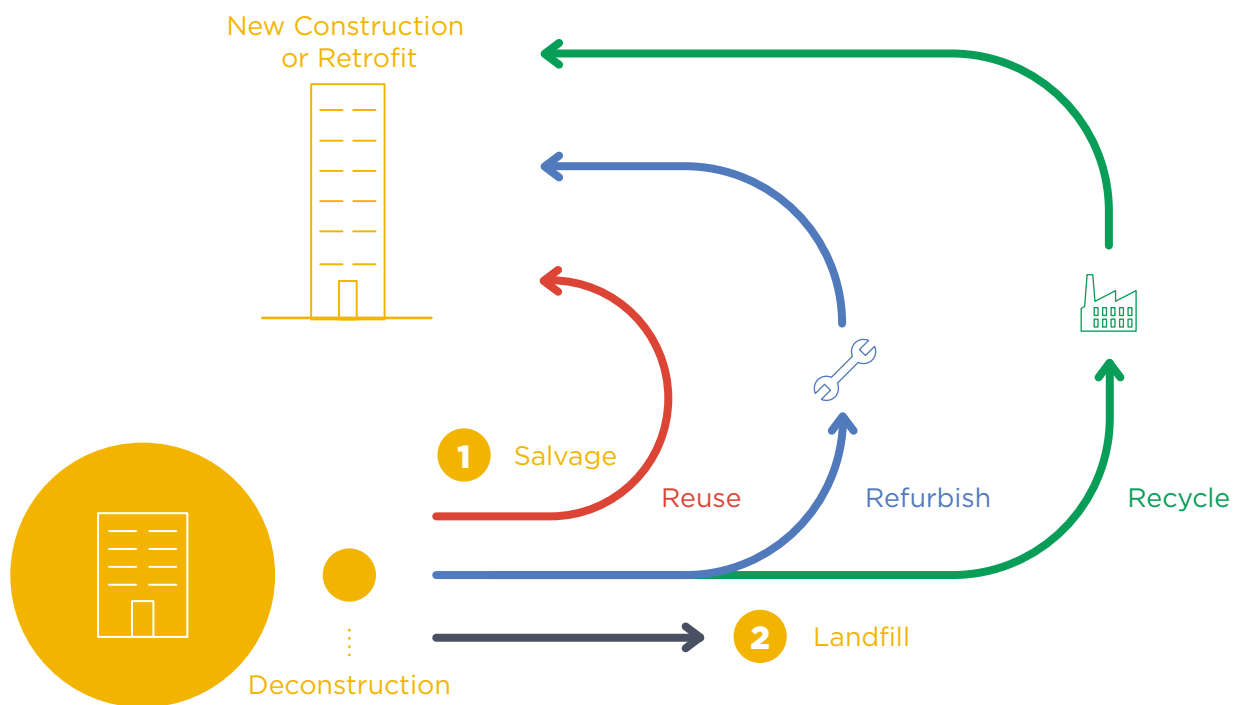
Social Opportunity

Salvaging resources from local buildings can help to preserve our vernacular building styles, materials, and culture. While our architectural past is sometimes preserved through protection of whole buildings within communities, such preservation can also happen at a smaller scale through the careful salvage of materials and artifacts from buildings. Sometimes these materials are reclaimed for use in the restoration and preservation of other historic buildings from a similar era. These pieces can tell stories of our communities' past and nurture respect for both people and places.

Salvage from our more generic commercial buildings most likely won't be motivated by architectural significance, but rather by the desire to maximize reuse of resources. When our existing buildings become unable to support future needs or fall into disrepair and abandonment, valuable materials can be reclaimed, either for charitable donation or low-cost resale. These materials can be an important resource for communities that struggle to afford full-priced building materials through traditional retail. Meanwhile, decay and blight are mitigated to improve the safety of our neighborhoods.

Deconstruction also provides the opportunity to train an existing workforce in the necessary skills of deconstruction. The combination of similar methods and tools between construction and deconstruction with improved accessibility on deconstruction sites opens up opportunities for development of a new capable workforce of contractors at all experience levels. Additional jobs, and social benefits can also occur through the creation of new markets, reuse warehouses or local community hubs. These reuse hubs can create a local place to connect with others, provide training to learn the craft of refurbishing materials for reuse, and provide for the efficient sale and purchase of salvaged materials.

Resource Cycles from Commercial Deconstruction



2. GOOGLE'S HISTORY OF DECONSTRUCTION FOR REUSE

Google is a growing company with an expanding real estate footprint that stretches from our headquarters in Mountain View, California, to our offices in more than 150 cities around the world. Google's Real Estate and Workplace Services (REWS) team plays a vital role in helping Google move towards a circular economy. The REWS team has been practicing deconstruction and salvage for our tenant interior construction since 2012, and have been able to salvage over 1,000 tons of materials for reuse. Google also has a program in place to help refurbish and reuse as much furniture as possible. Through the effort of Google's warehouse team, each year, roughly 70-75% of furniture taken from remodel projects is diverted from landfill. We are now interested in figuring out how to scale our initial deconstruction and salvage efforts, not only for Google's benefit but also for the building industry more broadly.

For most of its existence, Google has primarily operated by moving into larger existing 'shells' (buildings) as teams outgrew their previous spaces. Interior spaces were renovated to be as "Googley" as possible, but have sometimes been fundamentally limited by what the existing structure offered, particularly in terms of daylight and building systems. While still utilizing existing structures wherever viable, Google is also now starting to construct its own buildings from the ground up in these recent years of continued growth. Consequently, we are more often removing existing buildings to clear space for the new construction. We've engaged in interior salvage and reuse both at the time of taking over a space previously occupied by another tenant, and also in instances where we are refreshing our own spaces. We've also participated in carpet and ceiling tile take back programs, where local product manufacturers take back their own products, and sometimes other manufacturer's products, for recycling.

Our new ventures in ground-up development present opportunities to apply the lessons we've learned from salvaging materials during interior retrofits to selective deconstruction across entire existing commercial buildings. For instance, we know that the work of an initial salvage assessment, where we inventory potentially reusable items, is essential to setting the stage for deconstruction of any space. We also know that modular components, such as stackable doors, offer the greatest opportunity for reuse. It's also important to address logistics around material transportation to ensure truck loads are as efficient as possible to save cost and reduce the carbon footprint of transportation. Finally, the demand for reuse of our materials in a secondary market is primarily driven from the residential market. Therefore, products such as workplace cabinetry is often reused in homes, which expands the opportunity and likelihood for reuse. However, not all items go into the residential market. For example, salvaged kitchen equipment can be put back into the commercial restaurant market.

Recognizing the outsized proportion of waste resulting from typical commercial demolition has motivated us to explore deconstruction and reuse of materials from commercial buildings that were not originally built with component disassembly in mind. Our desire is to advance and refine our deconstruction efforts, but to use our scale to learn, innovate, and share with everyone. Keeping products and materials in use longer leads to substantial savings in environmental, economic, and social value. Our growing focus on deconstruction will also help us build the value proposition for internal and external policies around deconstruction and salvage, improve diversion rates from landfill for valuable materials, and improve future design of buildings and spaces for reuse. We hope to institutionalize new practices over the long term as part of our efforts to become increasingly circular.

As we work to scale deconstruction across Google's real estate portfolio, sharing our lessons with the broader industry enables us to collectively evaluate and address the challenges and opportunities before us. Below, we have identified some existing challenges and opportunities around the process of deconstruction, salvage, and reuse. Some of these challenges and opportunities have been addressed internally at Google, but several require collaboration with the broader industry, including other building owners' project teams, and regional governments.

3. SYSTEMIC BARRIERS TO SCALING COMMERCIAL DECONSTRUCTION



A. Existing Commercial Buildings Aren't Designed for Easy Deconstruction

- **Buildings aren't designed for deconstruction:** Many commercial buildings lack modular components and mechanical joinery that can be easily taken apart. Commercial buildings are typically designed and built without consideration for how assemblies can be reversed for adaptation to another use, or disassembled for removal. Nearly 60% of today's commercial building stock was built between 1960-1999.²² Buildings of this era typically feature adhesives as dominant connectors between layers of structure and finish, which presents challenges for deconstruction.
- **Buildings contain toxic materials:** Salvage is not sensible when building materials contain toxic substances. For decades, asbestos and lead have needed to be carefully abated from our buildings before renovation, demolition, or deconstruction. These and other substances pose human and environmental health hazards, schedule delays, inconvenience, and waste. Recirculating materials with toxic substances does not support the health and wellbeing of people, the planet, or the circular economy.
- **Lack of building component documentation:** Salvage is hindered by a lack of transparent documentation of a building's component materials and their suitability for reuse in future products and buildings. This hindrance is caused by insufficient "as-built" drawing and specification records that do not capture 1) the make and model of installed products, 2) instructions on the disassembly of the system within which products are installed, and 3) transparent product ingredient and hazard data. Without this information, adaptation, reuse, and recycling materials in a circular economy proves difficult.



B. Permitting and Regulatory Environment discourages deconstruction

- **Schedule constraints:** To avoid construction delays whenever possible, project teams are motivated to clear a site as soon as the structure is vacant and full permitting is issued to proceed with its removal. As a result, full demolition becomes the preferred method because it is reliable and has well-honed efficiencies. Deconstruction can add to a project team's timeline if not accounted for from the outset.
- **Permit fees:** Many cities want to encourage deconstruction and salvage but require payment of permit fees to salvage common, easy to remove items inside vacant buildings such as faucets, decorative lighting and other mechanical, electrical, and plumbing (MEP) items. It is also common that an architect needs to be hired at additional cost to catalogue the existing building and create drawings that identify where certain items will be removed.
- **Lack of tax incentives:** Tax incentives for deconstruction differ between commercial and residential deconstruction. Donating recovered assets to charities often creates administrative burdens around accounting, appraisals, and potential legal defenses in the event of a tax audit.
- **Lack of alignment between city agencies:** Interagency coordination is needed to prioritize and enable salvage through deconstruction. In some instances, we received approval from one agency to remove mechanical, electrical and plumbing items upon building vacancy, but then rejected by another agency.



C. Insufficient Skilled Labor Exists for Deconstruction

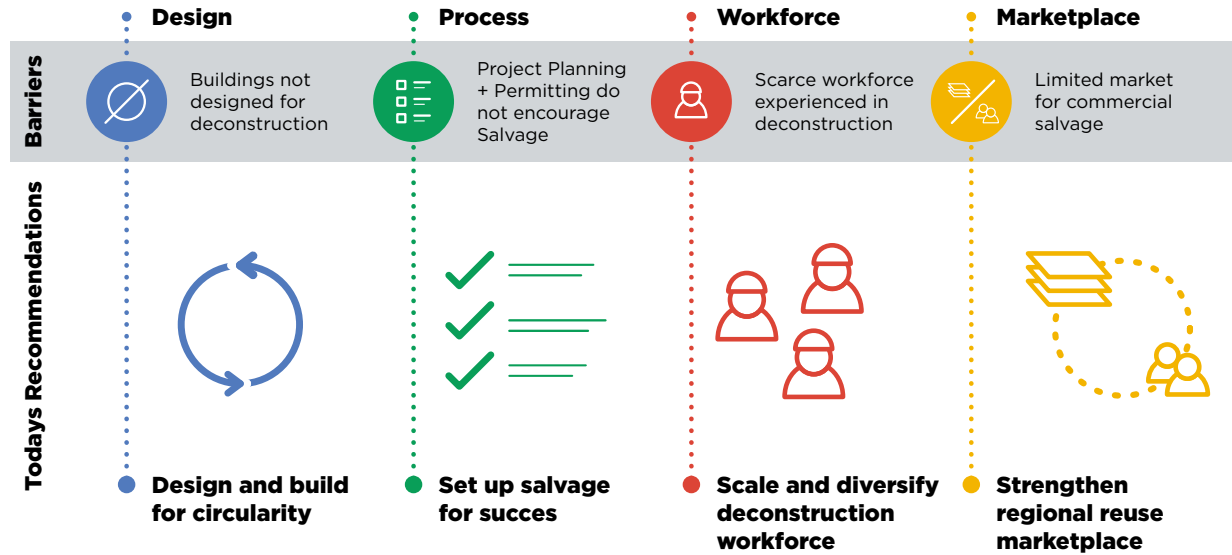
- **Need commercial deconstruction workforce:** Trained and experienced deconstruction contractors are needed to reap the maximum potential value from existing buildings. In a recent study on the carbon impact of deconstructing single family residences, the City of Portland found that deconstruction training and the experience level of contractors was the largest factor affecting the degree of effective salvage possible from their existing residential building stock.²³ While the material and construction of commercial buildings differs from residential, the insights are still relevant for commercial buildings.



D. Marketplace for Salvaged Materials is Underdeveloped

- **Balancing supply, demand, and storage of materials:** It takes time, money, and space to establish a sufficient quantity of skilled deconstruction contractors to generate a critical volume of salvaged materials on a continuous basis to foster and grow regional reuse outlets.
- **Managing storage requirements:** The cost of storing salvaged materials may outweigh the cost savings from reuse. It's important to quantify the space needs for storage of salvaged or reusable materials and how those costs may accrue over time. We have found that some modular products (e.g., movable walls) that are designed for reuse and adaptability require plans for long term storage at an additional cost.
- **Cumbersome tracking of salvaged assets and donation locations:** A company might temporarily store salvaged and excess materials co-mingled in the same or multiple locations. Better tools are needed to improve clarity on the types, quantities, and condition of materials available for reuse. When donation is a preferred outlet, there are additional complexities managing the supply and demand, particularly because inventory and needs fluctuate.
- **Evolving aesthetic trends:** Design aesthetics are continuously evolving so the reuse of salvaged materials from an older commercial building might be less appealing in new construction or a remodel. Therefore, the uptake of salvaged fixtures and fittings go to those who are more open to making best use of salvaged materials or one-off pieces such as non-profits, residential home owners, and the film industry.
- **Lack of refurbishing services:** Without local refurbishing services, materials aren't able to be easily updated. If commercial salvage expands, the volume of materials may overwhelm the current limited reuse market.

Key Recommendations to Overcoming Commercial Deconstruction + Reuse Barriers



- **Document a deconstruction plan:** While the building is being designed, the project team should create a plan for deconstruction describing how the building could be deconstructed at its end of life. The plan can include important building information such as key drawings describing assemblies or photos of utilities before they are hidden behind walls or ceilings.²⁴

Municipalities

- **Leverage the power of public procurement for healthy materials:** Public or municipal project procurement can drive the use of healthy materials by requiring transparent material ingredient and safer chemistry for all products included in public projects. For example, the City of San Francisco has adopted [sustainable purchasing requirements](#) into regulation that apply to purchases made by or on behalf of city departments (e.g., free of certain hazardous chemicals).
- **Leverage public procurement power to encourage and require design for disassembly:** Cities can provide design for disassembly guidance and can implement policy that requires aspects of design for disassembly to be required in public projects.
- **Document building assets:** Cities have the opportunity to collect data relevant to building component recyclability during the permitting process. In turn, they can develop better information and insights to further improve and support deconstruction and salvage in the future. [Buildings As Material Banks \(BAMB\)](#) is an EU project focusing on enabling greater circularity through the use of materials passports and reversible building design. This offers an interesting approach and model for how to address gaps in data surrounding reuse of salvaged materials.



Case Study:

Healthy Materials are the Foundation for Reuse

At Google, our healthy materials journey began when co-founder Larry Page walked through our offices with a handheld particle counter, prompting tough questions about the impact of building products on the air we breathe. Since then, we've worked hard to understand what's in our building materials and to apply that knowledge in creating the healthiest workplaces possible by using products that are low emitting and avoid worst-in-class chemicals. Over time, we've realized that the importance of material health extends far beyond the impacts on building occupants. We partnered with the Ellen MacArthur Foundation in 2018 to make the case that safer chemistry is key to [unlocking the circular economy](#). In short, we need to ensure that the materials we intend to keep in infinite loops are, to the best of our ability, inherently safe for people and the planet.

Today, our [Healthy Materials Program](#) takes aim at the broader context of the circular economy: we hope to drive the building industry toward safer chemistry not only to ensure healthy indoor environments in our workplaces, but also to establish the long-term conditions for circularity in the built environment. In order to make progress toward this goal, we've learned that quality, transparent ingredient data on building materials is a critical first step toward safer chemistry: we have to understand what's in products in order to assess their impacts on health throughout their life cycles. Furthermore, initiatives such as [Material Passport](#) are doing important work to make sure this information is publicly available and accessible over time. We're working with industry partners—one step at a time—to build momentum toward transparency in the broader market.

For Google’s own construction projects, we are advancing our strategies for eliminating hazardous substances from our buildings. For example, at Charleston East—our boundary-pushing campus development in Mountain View, CA—we are reviewing each and every building component for “[Red List](#)” ingredients, from underground utilities to steel primers to art installations. As our real estate footprint grows, we are focusing our efforts on product categories that are ubiquitous in our buildings and proven to deliver better human health outcomes, specific to a project’s scale, such as wall insulation, resilient flooring, and paints and coatings or envelope for ground-up construction. As we make progress in these categories, we’ll continue to expand our scope. We require project teams to procure products that are low emitting and have transparent ingredient lists that leverage industry standards such as [Health Product Declarations](#), [Declare Labels](#), and [Cradle to Cradle Certification](#). Finally, we are instituting reporting requirements to document what’s been installed in our buildings so that we can better track our outcomes.

As developers, we have a responsibility to ensure our buildings foster circularity, even after we no longer occupy them. From this perspective, procuring materials with healthy, transparent ingredients and documenting ‘as-built’ material lists help to set the stage for salvage and reuse over time for Google or the next owner or tenant.

We know there’s a long way to go until the building industry is optimized for health. As we scale our salvage efforts to entire buildings, we are consistently reminded of the health risks that legacy building materials often pose, limiting their reuse potential. However, we have an opportunity to disrupt this cycle by incorporating health criteria into the design decisions we make today so that our new building components can be safely reused in the future. Furthermore, Google’s healthy materials journey underscores that creating a safe and circular built environment hinges on collaboration across sectors—architects, designers, manufacturers, builders and beyond are all critical players in ensuring deconstruction is viable in the long term.



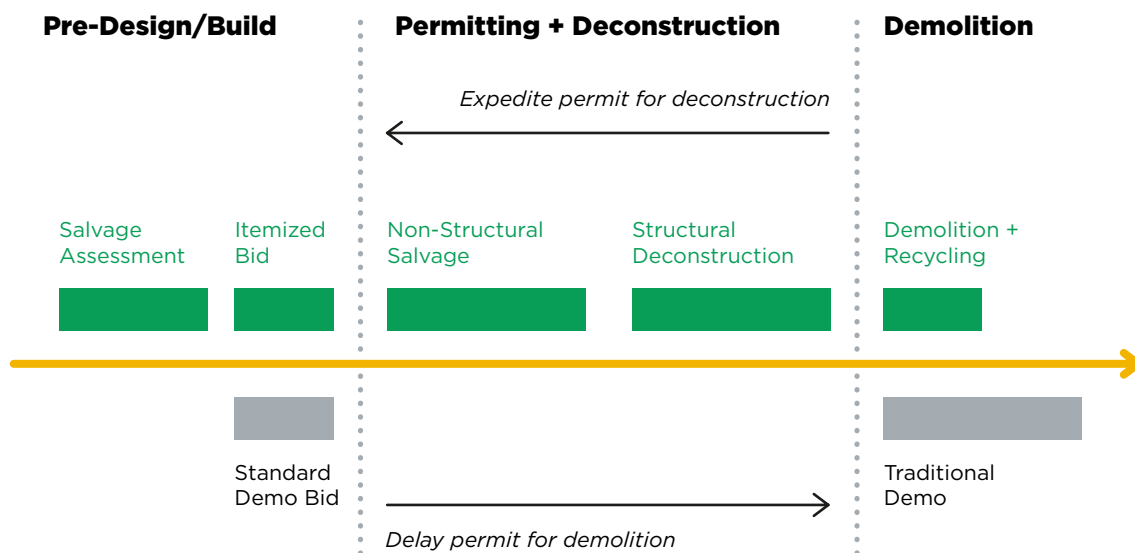
B. Set Up Deconstruction Projects for Success

Create the space, time, and cost parity to enable deconstruction to compete with demolition.

Project Teams:

- **Require deconstruction in projects:** Project teams should develop clear deconstruction criteria and ensure those requirements are a part of the Request for Proposal (RFP) and contracting process.
- **Walk site with architectural design team of new construction:** In instances where the existing buildings will be torn down and then replaced with a new building, architects for the new construction project should walk the site to see if there are certain materials that can be targeted for reuse onsite.
- **Establish an accurate salvage inventory:** An accurate and comprehensive inventory of the existing building is critical for effective salvage and reuse. Project teams should have a qualified third party salvage contractor or consultant perform an inventory of all materials capable of being salvaged and reused. This step should happen immediately after awarding business to the construction management company or general contractor.

- A detailed inventory is required in order to obtain accurate and comparable bids for deconstruction. This is especially true if multiple buildings with variable asset mix are in scope. The [Seattle Salvage Assessment Form](#) provides a helpful template for auditing an existing building for salvage.
- It's important to ensure that the project team and contractor conducting the inventory only assesses items that have a reuse market in place. When contractors salvage materials that have no market, they end up creating expensive waste.²⁵
- **Account for savings:** Project teams should clearly and holistically account for reductions in 1) landfill and recycling facility tipping fees, 2) procurement budget on subsequent projects where salvaged materials are reused from the current deconstruction work, and 3) embodied carbon, alongside any increases in labor fees for deconstructing. The savings, which are often missed in budgeting and feasibility assessments, are all likely to result from deconstruction and will help to offset the additional upfront labor cost of deconstruction.



Modified permitting timelines can be utilized to incentivize deconstruction.

Municipalities

Local agencies can play an important role in incentivizing deconstruction over traditional demolition.

- **Require salvage assessment in permitting:** Cities can support deconstruction for salvage by requiring that a salvage assessment be submitted for commercial projects as part of permit applications. Though it may not be feasible or sensible for all projects to pursue deconstruction, a required salvage assessment creates a consistent signal that there is an inherent opportunity baked into existing buildings.
- **Coordinate between local agencies:** There is an opportunity for municipal agencies in the same region to collaborate with each other to make permitting friendlier to common commercial deconstruction scenarios. For instance, building departments and fire departments could work together to enable interior salvage to take place sooner in vacated buildings, upon receipt of the full permit.
- **Permitting incentives:** Municipalities can decrease the added time burden of deconstruction compared to traditional demolition by expediting the permit timeline for projects planning for deconstruction to achieve a predetermined salvage threshold.

- **Reduce or refund permit fees:** Municipalities can refund a permit “deposit” upon documented achievement of a predetermined salvage threshold. This could also potentially connect to achieving a required overall project landfill diversion threshold or carbon reduction. For example, San Jose implemented a refundable deposit system in 2001, where the city began collecting a deposit refunded after achieving diversion (initially 50%, now 75%) through reuse, donation, or recycling by a local pre-certified facility.²⁶

Case Study

Palo Alto: Leadership in Commercial Deconstruction

In June 2019, the City of Palo Alto adopted an ordinance that introduced new deconstruction and reuse requirements to the city’s municipal code. The ordinance outlines two primary actions for any residential or commercial project that requires a demolition permit for a whole structure: (1) a required salvage assessment of the existing structure and (2) mandatory deconstruction of the structure, with on-site source separation of deconstructed materials. This two-pronged approach prioritizes reuse when possible and then maximizes the recyclability of remaining materials by generating single-stream inputs for local recycling facilities.

Palo Alto’s ordinance is a direct result of the city’s 2018 Zero Waste Plan, which sets aggressive targets for 2030—to divert 95% of materials from landfill and reduce greenhouse gas emissions by 80%. Although construction projects in Palo Alto on average divert a relatively high percentage of materials from landfill (72%), C&D debris still accounts for more than 40% of the materials landfilled in Palo Alto due to the large volume of construction in the city. Therefore, decreasing the amount of C&D debris sent to landfill is an imperative step in achieving the citywide zero waste goal.

The ordinance makes deconstruction a key strategy for increasing diversion rates for C&D debris. Palo Alto’s 2017 Waste Characterization Study found that although 92% of the materials in C&D debris sent to landfills are recyclable or compostable, commingling these materials during demolition significantly decreases diversion rates. In fact, each of the six most common materials found in Palo Alto’s landfilled C&D debris could be recycled with diversion rates greater than 90% if separated on site. Palo Alto’s ordinance demonstrates that deconstruction not only unlocks opportunities for salvage and reuse, but also creates the conditions to make ambitious C&D zero-waste goals achievable.

While a number of US cities mandate deconstruction for historic residences, Palo Alto paves the way for commercial deconstruction by extending such requirements to commercial buildings. At Google, we are especially excited to see Palo Alto build momentum in the deconstruction space in the Bay Area. We hope that, in combination with Google’s growing deconstruction portfolio, this increase in commercial building deconstruction will rapidly bolster the regional reuse marketplace, grow the deconstruction workforce, and accelerate our collective understanding best practices for commercial deconstruction.



C. Scale and Diversify Deconstruction Work Force and Removal Techniques and Logistics

Increases in skilled labor and efficient processes are necessary to accommodate large commercial deconstruction projects.

Project Teams

Project teams have the opportunity to take the following actions to support deconstruction, salvage, and reuse:

- **Require contractors to be ‘salvage-ready’:** To best facilitate salvage from buildings otherwise destined for demolition and landfill, we need proactive contractors with demonstrated experience in deconstruction techniques. To increase competitive bids for this work, contractors can be 1) traditional demolition contractors or builders who have been trained to evolve their practices to perform some deconstruction for salvage, or 2) specialized deconstruction-specific contractors, or 3) a combination. Salvage rates trend higher among more experienced contractors.

A key step during the bidding process is to ensure that the salvage contractor is well-versed on the regional reuse opportunities so that the salvaged material types and quantities are likely to be absorbed into the local reuse outlets.

- **Obtain competitive bidding:** Competitive bids ensure that pricing is fair and schedules are met. This can be challenging to achieve with a lack of trained and experienced deconstruction workforce. Project teams should assess and factor the experience level of potential contractors into their award decision process because more experience can translate into greater savings. Less experienced contractors may add a buffer into their bid to reduce the risk of the unknown in their pricing.
- **Integrate various deconstruction techniques to reduce timelines and cost:** Consider a combination of deconstruction techniques, to achieve optimal recovery of materials for reuse and recycling. Examples include selective salvage, panelized/hybrid/modular deconstruction, and strip-out.²⁷ These techniques can aid in faster timelines for effective removal of the large quantities of material typical of commercial-scale buildings.

To further illustrate this concept, teams may strip-out easily removable interior components, such as carpet and ceiling tile that may already have regional take-back or reuse programs. Next, teams can employ hybrid deconstruction techniques where mechanical equipment is used to safely assist the hand removal of material. In modular or panelized deconstruction, machinery is used to break down a building by its full walls or roofing components, and then take that material to a location where it can either get reused in its structural form or to be broken down further.

- **Streamline transport logistics:** Project teams must account for efficient redistribution and uptake of salvaged materials to support their deconstruction efforts. Partnerships with specialized logistics companies can help coordinate between the recovery of assets from buildings and tying them to a cluster of end users along a common delivery route for efficiency. One such company that offers this service is Madrone, which offers logistics and matching of salvaged materials to a network of over 300 charities. This approach prevents having to warehouse large volumes of salvaged materials.

Municipalities

- **Support workforce training initiatives:** Municipalities can work with communities and local organizations to encourage workforce development training and offset skilled labor shortages for deconstruction. For example, the city of Portland has issued deconstruction workforce training and certification grants to local non-profits and worked with the national non-profit [Build Reuse](#), to establish the skilled workforce necessary to meet its deconstruction ordinance requirements.²⁸



D. Streamline Reuse Marketplace for Commercial Salvage Uptake

A concerted multi-sector effort is needed to develop logistics, tools, and local markets to efficiently redistribute salvaged materials for new construction.

Project Teams:

- **Set salvage reuse uptake targets:** Project teams should nurture internal and external marketplaces by designing for, purchasing, and installing an amount of salvaged materials into new construction projects.
- **Participate in virtual marketplaces and asset management technology:** Virtual marketplaces and related services offer a valuable opportunity to connect idle or unneeded assets to others for reuse. Online databases provide a forum for companies to list their materials from deconstruction projects to connect them with others. These systems offer automatic matchmaking, tracking and reporting as added benefits. Online asset exchanges, such as [Rheaply](#), also enable phased postings, prioritizing internal reuse and then offering to external interested parties.

Case Study

The Challenges of Reuse at Google

As the scale of development increases at Google, our strategies for tracking and managing salvaged building components must evolve to keep pace with the growing volume of materials salvaged from whole-structure deconstruction. Today, Google's Workplace Operations team manages the logistics of storing and moving workplace assets—such as furniture, finishes, and one-off sculptural pieces—for interior refreshes and renovations. While this current system successfully navigates the material flows generated by thousands of team moves per year, we're learning first-hand the challenges of scaling these logistics for ground-up development. As a result, we see significant opportunity for developing digital solutions to address our current reuse marketplace constraints.

From the supply side, whole-structure salvage efforts will introduce a high volume of new materials that need to be managed for reuse, introducing a new dimension of complexity to existing storage and logistics constraints. We've already encountered instances when we've been able to identify valuable large-scale assets for reuse—such as glulam beams—but have lacked sufficient storage capacity. Furthermore, tracking each salvaged component for internal reuse and external donation opportunities would require a new and sophisticated software solution.

In terms of demand, connecting design and construction teams to salvage stock has introduced unexpected challenges for development projects. For example, our Charleston East project in Mountain View, CA, has a goal of incorporating salvaged materials into the building's 600,000 square feet of new office space. To meet this target, our team is relying heavily on internal assets, reusing salvaged and excess materials such as lockers, bike racks, and tiles. Throughout this process, we've experienced how challenging it is to manage communications with design teams—in terms of what assets are available, how much, in what quality, and for how long—to support the ongoing design revisions that occur during longer-term development projects.

At this juncture, we believe that the future reuse marketplace will need to leverage digital connectivity in order to accommodate large-scale commercial salvage projects. Though we are still early in our deconstruction pilots, our experiences have highlighted features that we see as key components for a successful virtual marketplace for salvaged commercial assets:

- The ability to control and phase the visibility of available salvaged materials, from internal parties, to local charities, to the entire marketplace.
- The ability to create custom criterion for product profiles specific to internal needs.
- Third-party tracking and reporting on reuse.

We are excited to see emerging technologies in the asset reuse space that could evolve to accommodate the needs of commercial salvage. For example, Rheaply is a platform with promising potential to accelerate a circular commercial salvage market. Originally developed to facilitate the reuse of laboratory materials, [Rheaply](#) offers a digital solution for managing, moving, and tracking assets. In addition, companies such as [Materials Marketplace](#), [Planet Reuse](#), [GlobeChain](#), and [Madaster](#) are providing asset management tools to solve for the challenges of scaling reuse. At Google, we believe that technology plays a key role in enabling sustainable actions, and we are excited to apply this vision to the specific conditions presented by commercial salvage reuse.



Municipalities

- **Salvage Procurement Policy:** Public projects can require a predetermined threshold of salvaged materials designed and purchased into new construction.
- **Develop Recycling Market Development Zones:** Cities can implement economic development programs that utilize a growing supply of reusable or recyclable materials in order to jumpstart new businesses, further expand existing ones, create jobs, and divert waste from landfills.²⁹
- **Provide Incentives for Reuse and Refurbishment:** Cities can provide economic, real estate, or contract incentives support with establishing deconstruction, salvage, and reuse networks.

5. CONCLUSION

Deconstruction for reuse is a circular economy strategy that offers us an opportunity for recapturing value in the built environment that is largely untapped. By keeping materials in use for longer, deconstruction and reuse can help further reduce the need for raw materials and the emissions linked with their extraction. These strategies can also help reduce further environmental impacts associated with climate change, pollution, resource depletion, and ecosystem degradation. Deconstruction leads to social and economic benefits associated with job creation and support for new markets.

Presently, deconstruction is underutilized due to barriers related to data, process, reuse markets, regulatory frameworks and technical know-how. In order to enable deconstruction and salvage of valuable resources from commercial buildings, design build teams and municipalities can begin to take steps that improve the permitting process and experience, incentivize the right enablers and actions, and support project process and infrastructure that nurtures reuse of salvaged materials from commercial buildings.

We need longer-lived, more adaptable buildings, whose material layers lend themselves to reuse. As part of our mission to accelerate the transition to the circular economy, we commit to sharing lessons learned and experience exploring deconstruction and reuse, to help build momentum to more circular outcomes for the built environment. We understand that this is a journey of continuous learning and we are seeking like-minded organizations to join us.

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