Circular Economy in the Built Environment:

Opportunities for Local Government Leadership

StopWaste & ARUP

June 2018

About this Document

Authored by StopWaste and Arup, this primer provides an overview of a circular economy framework for the built environment at the community, neighborhood and building scales. The ideas and concepts included here are intended to stimulate local government decision-makers and staff in Alameda County and beyond to consider policies and actions in their jurisdictions. It illustrates concepts with real-world examples of sites and policies. The document is intended to initiate conversation and action among public policymakers, public agency staff and other partners.

This primer represents an effort undertaken as part of StopWaste and Arup's involvement with the Ellen MacArthur Foundation (EMF). StopWaste is an EMF Circular Economy 100 member and Arup is the EMF Global Knowledge Partner for the Built Environment.

It should be noted that this topic will evolve as more partners begin to engage. This is intended to be a fluid document and StopWaste anticipates updating this primer or expanding upon specific concepts in the future. To get involved, email miya@stopwaste.org.

Acknowledgments

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The following industry experts provided content or review of the primer. We thank them for their contributions. The primer content does not necessarily represent the perspective of any of the contributors or reviewers.

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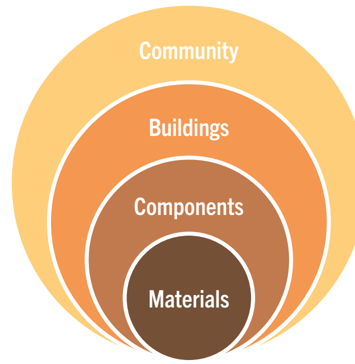
Drafts of the primer were circulated to the following groups:

- Embodied Carbon Network Policy Task Group
- Ellen MacArthur Foundation Circular Cities Network
- AIA Material Knowledge Working Group TOV
- West Coast Climate and Materials Management Forum Leadership Team

Executive Summary

Local governments today must balance multiple interrelated community needs including quality of life, economic vitality, housing choices, sustainability, and resiliency. Transitioning the built environment from linear to circular systems holds the potential to help address these converging goals. A linear economy of take-make-use-dispose wastes resources and externalizes costs and harmful impacts to the public. A circular economy designs waste out of the system and optimizes assets' utilization and value.



Local governments have a unique perspective and role to contribute to advancing circularity, particularly within the built environment. They consider and influence new construction in the context of an existing built environment, and shape the built environment at multiple scales: Community, buildings, components, and materials. This primer identifies goals and strategies to increase circularity for both existing built environment and new construction at each scale. It is introductory in nature, providing brief context and short descriptions of **strategies**, **a list of potential actions** (policies, programs, public education, etc.) that local governments can explore to advance those strategies, and **real life examples** of many of the strategies (Appendix A).

Circular System Goals at Multiple Scales

	Existing Built Environment	New Construction
Community	Goal 1A: Maximize the use of existing infrastructure through land use planning and infill.	Goal 1B: Use infrastructure materials efficiently and minimize environmental impacts of new infrastructure.
Buildings	Goal 2A: Gain more use out of existing buildings through increased utilization and occupancy, retrofits, and adaptive reuse.	Goal 2B. Design new buildings to be resilient and flexible, encouraging high usage rates and adaptability to changing future conditions.
Components	Goal 3A: Extract more value out of components in the existing built environment through deconstruction, salvage, and reuse.	Goal 3B: Design new construction and select components to enable recovery and reuse in the future.
Materials	Goal 4A: Maximize recycling rates of materials at end of life.	Goal 4B: Use materials efficiently and select materials for minimal impact by considering lifecycle impacts and end-of-life recovery.

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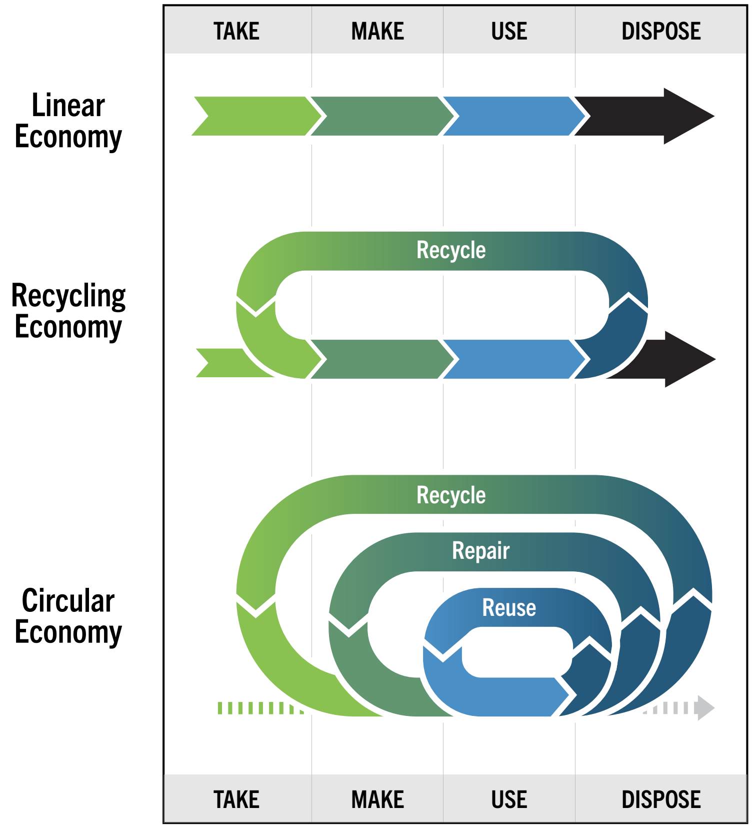
An Introduction to the Circular Economy

Take. Make. Use. Dispose. The linear economic model, in which natural resources are extracted from the environment and transformed into products that are consumed and ultimately disposed as waste, has underpinned modern developed economies. This linear model has prevailed thanks to an abundance of natural resources and fossil fuels, and the externalization of costs and harmful impacts.



As the world's population grows, finite natural resources become increasingly difficult and expensive to access. Across the globe, societies are struggling with the negative consequences of take-make-use-dispose, including increased pressures on natural resource extraction and landfills, rising greenhouse gas emissions and climate disruption, unsustainable aquifer depletion, and toxic pollution.

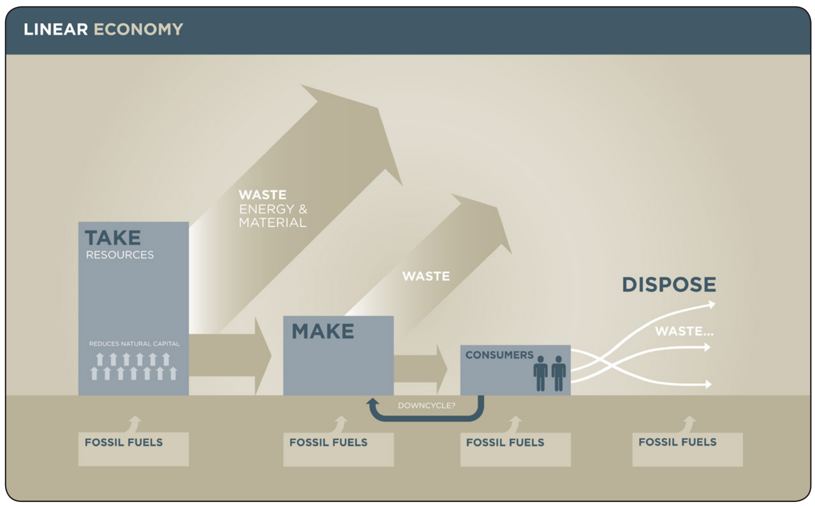
Governments, communities, and businesses have long recognized the need for a different model. There have been efforts to increase recycling, green business, and green building practices that reduce energy and material waste. Policies like zero waste aspire to keep all materials out of landfills through recycling and waste prevention.

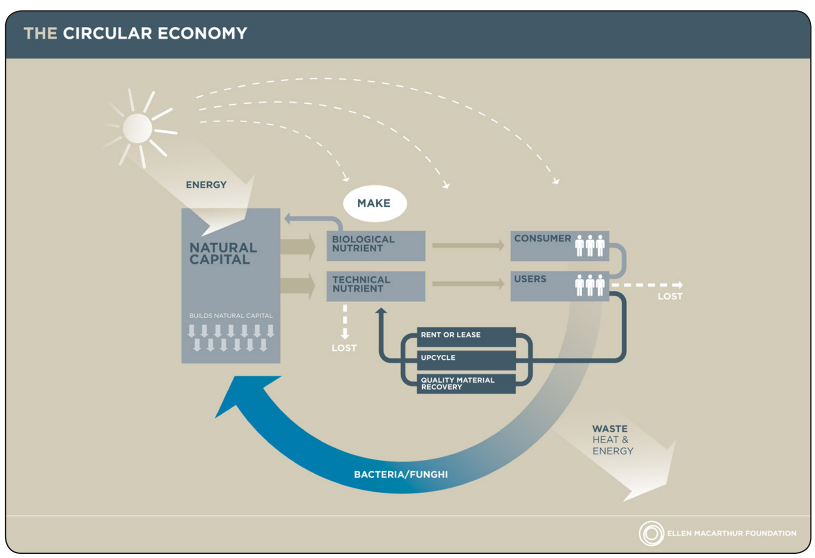
These initiatives have led society away from a linear economy and must be expanded upon. **Future economic growth and global prosperity will depend on not only reducing waste at the end of life, but also designing the whole economy to eliminate the concept of waste**.

At the macroeconomic level, this closed-loop system is still theoretical. However, there is growing interest and momentum, and technological innovations that enable previously impossible systems. To be effective, no sector can tackle this issue alone. Leaders in business, government and academia are exploring how to reduce environmental impacts while meeting society's needs for economic vitality and quality of life. Local governments have a role, particularly in shaping the built environment within their jurisdictions along with partners.

> "In contrast to the current linear model, the circular economy aims to decouple growth from finite resource consumption. It relies on three principles:
>
> - **Design out waste and pollution:** Reveal and design out the negative externalities of economic activity that cause damage to human health and natural systems. This includes release of toxic substances, greenhouse gas emissions, air, land and water pollution, traffic congestion.
> - **Keep products, components, and materials at their highest value and in use:** This means designing for re-use, remanufacturing, and recycling to keep components and materials circulating in and contributing to the economy. [Circular systems] preserve more value, such as embedded energy and labour.
> - **Regenerate natural systems:** A circular economy enhances natural capital by encouraging flows of nutrients within the system"
>
> *Cities in the Circular Economy: An Initial Exploration, Ellen MacArthur Foundation, 2017*

The circular economy offers many potential benefits beyond simply reducing the amount of material going to landfills. As the figures show, moving away from a linear economy can reduce greenhouse gas emissions associated with the fossil fuels consumed in an inefficient economy. By removing toxicity, circular economy also improves the health of consumers and workers. New circular business models can create new jobs that maximize and maintain the economic value of materials in the economy. Finally, circular systems are designed for resiliency - to changing needs of consumers and communities, and against the "linear risks" inherent in increasingly volatile supply chains.[14]





Courtesy of the Ellen Macarthur Foundation

Cities as Places of Innovation

A primary goal of many cities is to create economically sustainable, vibrant and livable communities. While interpretations of what this means varies by community, it increasingly translates to embracing sustainability, economic vitality, housing choices, and a connected citizenry. Cities today are grappling with pressures to grow while pursuing these goals.

The San Francisco Bay Area has grown to be the fourth largest metropolitan region in the United States today, with over 7.7 million people and 3.4 million jobs in the nine-county, 7,000 square-mile area. By 2040 the region is projected to grow to 9.6 million people and 4.7 million jobs.[1] There is already a housing crisis and the Bay Area needs to add 187,990 housing units by 2022.[2] Plan Bay Area 2040 creates a long-term vision and provides a regional road map for accommodating growth and investing in transportation solutions.

> "At the heart of creativity, innovation and growth, cities play a central role as motors of the global economy. 54% of the world's population live in urban areas, and cities account for 85% of global GDP generation. Cities are also aggregators of materials and nutrients, accounting for 75% of natural resource consumption, 50% of global waste production, and 60- 80% of greenhouse gas emissions."
>
> *Cities in the Circular Economy: An Initial Exploration, Ellen MacArthur Foundation 2017*

City Planning

Alameda County anticipates up to a 36% increase in population, requiring up to 162,000 new housing units, and 40% increase in jobs from 2010 to 2040.[3] Cities use a variety of tools and initiatives to plan for this growth. **General Plans** are the blueprints for development, the guide to achieving a city's long-term vision. California law requires each local government to adopt a local General Plan, which must contain certain elements including Land Use, Transportation, Housing, Open Space and others; and can contain other optional elements including Sustainability. Cities update these plans periodically, and use them as a tool for structured community engagement.

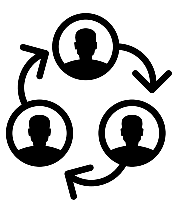
Many Bay Area cities also have **Climate Actions Plans** or **Sustainability Plans** that set goals and strategies to reduce greenhouse gas (GHG) emissions and increase the community's environmental sustainability and resiliency. Increasingly, cities are considering the lifecycle impacts related to the supply chains of the materials consumed in their communities (i.e. "consumption-based" GHG inventories[4]) and exploring strategies to address these "upstream" emissions. The consumption lens reveals new opportunities for communities to contribute to global GHG reductions.

Emerging Trends

In addition to planning documents and processes, cities have the opportunity to use new trends to meet their goals and pursue previously elusive solutions. Cities are increasingly leveraging technological innovations, evolving social norms, and more robust public-private partnerships to provide services.

Smart Cities use data and communication technologies to increase operational efficiency, share information with the public and improve quality of government services and community welfare. Through new technological platforms and widespread use of social media, citizens have gained the power to be involved in decision-making and cities are becoming centers of open source data. One application could be using data about the in-use or idle status of cars, buildings, or equipment to inform potential users when an underutilized asset is available.

Internet of Things (IoT) in a city is a giant network of connected relationships between people-people, people-things, and things-things. Some of the key services that IoT can improve at a metropolitan scale include resource management for energy and waste, and in emergencies; parking, traffic, public transportation and autonomous vehicles; law enforcement and environmental safe; and citizen engagement. With IoT, products or parts can be tracked and cataloged to enable "reverse logistics" to get them to reuse, refurbishment, or recycling as and when appropriate.



Sharing Economy models are emerging in cities around the worlds. City governments have the role of making the sharing economy work well and equitably in their communities. The sharing economy is also commonly referred to as collaborative consumption, the collaborative economy, or the peer-to-peer economy. Innovative technologies, new business models, and increasing social acceptance of sharing goods are allowing goods to be used more intensively.

Using the Tools

How can Bay Area cities use these tools, technologies and trends to answer their most pressing questions? They hold the potential to increase circularity and decouple population and economic growth from the negative environmental impacts of resource consumption. This primer explores how circular economy principles applied to the built environment can help Bay Area local governments balance urgent, converging demands:

How do we optimize resource use and minimize environmental impacts while accommodating more people and jobs and maintaining or improving quality of life?

The Potential of a Circular Built Environment

The term **built environment** refers to the human-made surroundings that provide the setting for human activity, ranging in scale from buildings and parks to neighborhoods, transportation systems, and entire cities. A city's built environment today can contain over 300 tons of building materials per capita, more than triple the material intensity compared to 1960.[5] The environmental impact of adding all of this material – building and infrastructure construction, including the full supply chain related to building materials – accounts for 6%–20% of global greenhouse gas emissions.[6,7]

In the current linear economic model, most building materials are eventually removed and replaced, either as part of a renovation or redevelopment process, and they exit the built environment as waste. Buildings tend to have long lives and typically change ownership, occupancy, and use over time. People involved in the building's development (owners, financing entities, planners, architects, builders and developers) rarely consider future outcomes including the building's operation over the long term or its end-of-life disposal. Buildings at their end of life can represent a liability with potential costs for municipalities and communities to landfill or otherwise manage vast volumes of material, some of which can contaminate air, water or soil.

Whole Building LCA and Embodied Carbon

Whole building Life Cycle Assessment (WBLCA) quantifies the total impact of a project throughout its lifecycle including embodied, operational, and its end of life. Embodied carbon refers to the total amount of GHG emissions that were released during the sourcing and manufacturing of a product; it is said that these emissions are "embodied" in the object. Operational carbon refers to the emissions released during the building's useful life, including energy usage and transportation by users. WBLCA is one tool to determine the best design and material selection, or best use of a site with an existing building.

To keep building and infrastructure materials at their highest value use for as long as possible, upfront design must plan for longevity and flexibility, optimized utilization and service, reuse and refurbishment, and material recovery. This requires the entire value chain to operate differently, including new business models and financial cases for designing without waste. It will take greater collaboration and integration across stages of a building's development and life cycle (planning, financing, procurement, design, construction, operation, maintenance, repurposing and recycling). Local government interventions can facilitate the economic, political, and technical infrastructure needed to realize this potential.

Guiding Principles

To create a circular built environment, planning and construction practices should consider the following guiding principles:

Utilization: Some studies estimate that buildings are underutilized, with as much as 30%–40%[8] of the capacity of some space types such as offices being underused. Even when a building is fully leased, it is rarely physically meeting its occupancy potential. Increasing the utilization rate of buildings means getting the most housing, service, or economic productivity out of each square foot of built environment.

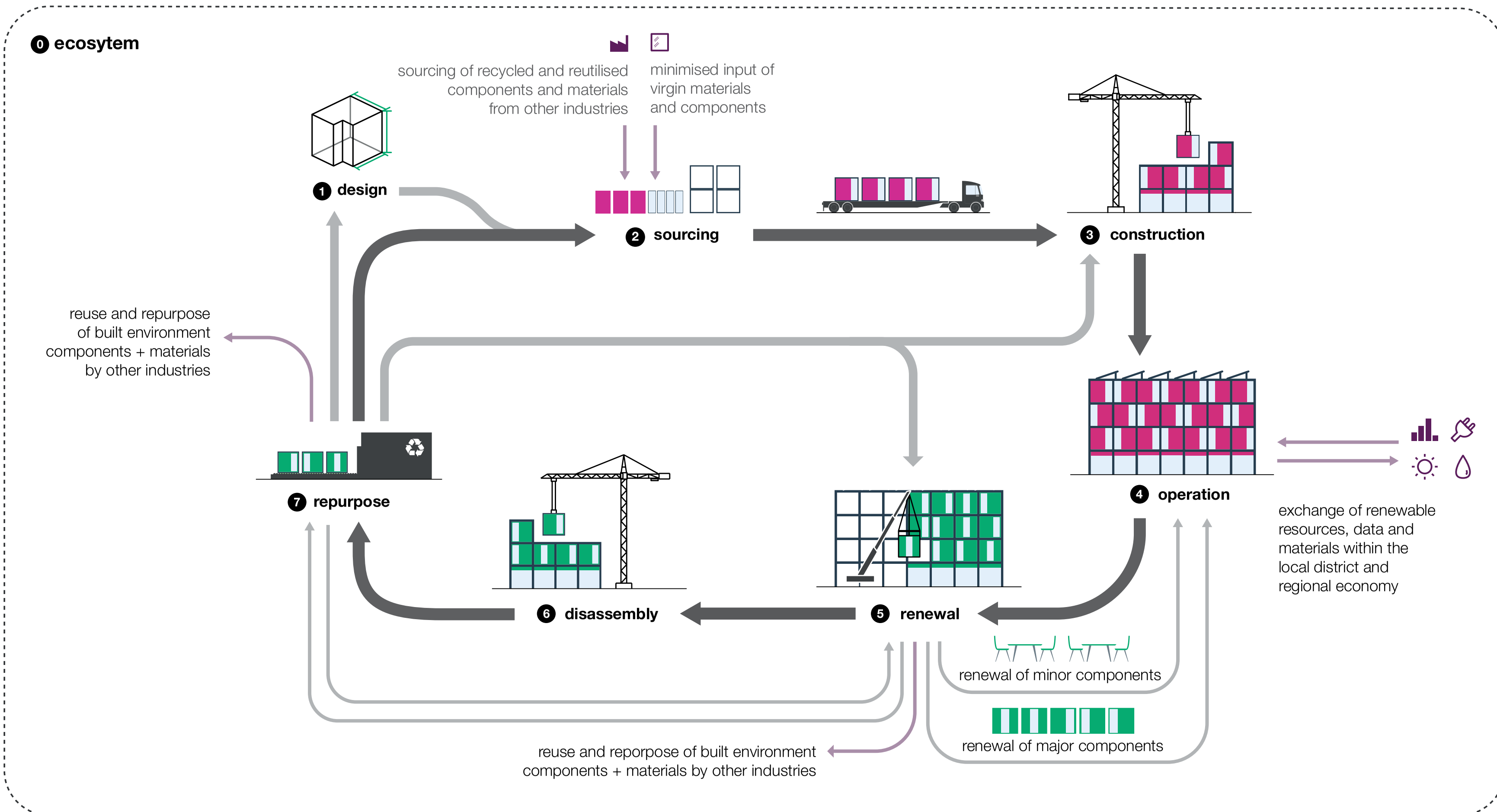
Flexibility: The principle causes for building demolition are change in use and redevelopment of the area.[9] Designing buildings to be adaptable as needs change over time and flexible for multiple concurrent uses increases their longevity and lifetime utilization, minimizing loss of materials, energy, and value. Local governments can increase flexibility through building codes.

Asset Value: Nearly 120 billion metric tons of accumulated mass was stored in buildings and infrastructure in the United States as of 2010.[10] Each year, private and public sector construction adds approximately $1.2 trillion of investment to the built environment.[11] Buildings should be designed to maximize asset value today while also enabling the extraction of material value from buildings in the future. This requires a new approach to economic analysis.

Lifecycle Impacts: Life-cycle assessments consider all the stages of making, using, refurbishing and disposing/recycling an object and the associated environmental impacts, such as greenhouse gases, smog-formed chemicals, or potentially toxic substances emitted. LCAs for whole buildings can be used to compare the consequences of decisions during the planning, design, and materials procurement process, such as whether to build new or renovate an existing structure, or which assembly options to use. Local governments can advance the field of whole building LCAs through mechanisms like Environment Impact Reports under the California Environmental Quality Act (CEQA).

True Cost Accounting: Costs to society and the environment from activities that lead to effects like pollution, blight, congestion, and climate change, are often externalized from the payers' costs and local government agencies are often left to pick up the expense to remedy negative consequences, especially the impacts on those who cannot afford to recover from the effects themselves. Some agencies are asking for Triple Bottom Line analysis which estimates these normally externalized costs, as well as benefits, and attempts to evaluate options more holistically.

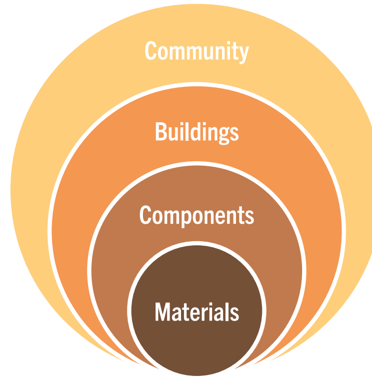
Application of Circular Economy Principles to Commercial Property



Courtesy of ARUP, *The Circular Economy in the Built Environment*, Sep 2016

The Role of Local Government in the Circular Economy Transition

Local governments can guide the built environment toward circularity through planning, permitting, incentives, and education to property owners and developers. To date, much of the momentum and strategies of circularity have been at the scale of individual buildings or products. Local governments bring a unique perspective because they consider how buildings or projects interact with each other and the existing community. They can influence the built environment at multiple scales:



- **Community Scale:** City and neighborhood planning and infrastructure
- **Building Scale:** Building design and utilization
- **Component Scale:** Current and future component recovery and reuse
- **Material Scale:** Current and future material recovery and recycling

The existing built environment in the United States contains over 120 billion metric tons of material.[12] New construction adds to this existing tonnage. Between 1964 and 2017, the construction industry invested about $57.6 trillion cumulatively into buildings and infrastructure in the US.[13] The existing built environment represents investments in assets that should be used and reused to extract the most value possible. Better utilization of existing buildings, components, and materials reduces the need for new construction and materials (and the associated environmental impacts) while creating new economic opportunities. These include building maintenance, retrofit, and renovation; growth of a deconstruction workforce; and creation of a marketplace for reused and upcycled components and materials. At each scale, this primer emphasizes the opportunity to increased use of existing resources first, followed by circularity principles for new design and construction.

The potential local government actions are a starting place to inform future policies or initiatives. A city may choose to prioritize one or more actions to explore. They may adapt and adopt several actions to add to broader plans such as Sustainability or Climate Action Plans. Each potential action, while summarized succinctly for the purpose of this primer, will require varying levels of effort to implement and staff collaboration across departments and with private sector partners.

Councilmembers and community leaders will need to lead policy discussions and provide leadership for new and innovative approaches. Circularity solutions require replacing traditional siloed approach with collaborative, multi-department teams working together toward circularity and community benefits.

1. At the Community Scale

Land use planning informs how new buildings and infrastructure are added to an existing community. Increasing the utilization of space in infill locations (with new structures or adapting existing buildings) makes better use of existing roads, utilities, transit and other infrastructure. It is also a common strategy for reducing vehicle miles traveled (VMT) and the associated transportation emissions.

Intensifying the use of infill spaces relieves the pressure to grow outwardly which would require additional infrastructure to be added and result in associated economic and environmental costs. The impacts of building and maintaining infrastructure within Alameda County—roads, utilities, transit systems, etc.—are roughly on par with building construction in terms of materials, energy, and emissions.[15] The Metropolitan Transportation Commission (MTC) estimates maintaining existing transportation infrastructure alone will cost over $200 billion over 24 years, more than half of which is expected to be from local funding sources.[16]

When infrastructure does need to be added or maintained, local governments can reduce their impacts by reusing existing materials (in place or waste from other industries), deconstructing/repurposing elements of decommissioned infrastructure, and specifying low-impact materials and practices for new infrastructure.

Reducing Automobile Dependence:

Smart Growth (planned economic and community development that attempts to curb urban sprawl) is already a common practice among Bay Area governments as a way to ease congestion and environmental impacts. Automobiles and the infrastructure dedicated to them are a significant source of greenhouse gas pollution and inefficiencies.

Local governments can help decrease reliance on automobiles and encourage a “mode-shift” to alternative transportation options. They can work with transit providers to increase transit services. They can require or support developers to install bike and pedestrian road improvements, bike lockers and showers, or offer transit passes. Local governments control or influence parking space location and quantity. They can reserve priority spaces for carpool or share cars, and eventually reduce overall availability of parking as alternative options improve, freeing up land space in the built environment for better uses.

5%

The utilization rate for automobiles and their dedicated infrastructure

– *Ellen MacArthur Foundation’s The Growth Within report*

Goal 1A: Maximize the use of existing infrastructure through land use planning and infill

Strategies

1A-1: **Infill development** adds new buildings in areas that already have access or connectivity to infrastructure. Cities have identified Priority Development Areas (PDAs) that are proximate to transit and amenities as referenced in Plan Bay Area, the regional plan that complies with a Sustainable Communities Strategy for growth. Cities should consider policies to incentivize building in vacant and under-utilized sites within the urban fabric or enforce a penalty on vacant land. Cities can use many strategies to make residential infill development easier and less expensive. The Affordable Housing and Sustainable Communities (AHSC) guidelines for 2016-17[17], which allocate cap and trade dollars toward housing near transit, contain many relevant strategies.

1A-2: **Accessory dwelling units** (ADUs) allow additional housing units to be built in the backyards or other open space on parcels with low-density or single-family housing. Such units add overall housing units without large construction projects that can potentially change the character of an established neighborhood. ADUs also tend to be smaller and more energy efficient. Homeowners find ADUs appealing because they can provide supplemental income or allow grown children or aging parents to live on their property. State laws codified requirements for municipalities to create ordinances that expedite permitting, eliminate certain parking requirements, and align fees to the scale of the unit being built, or eliminate them when the accessory unit is created inside existing building footprints.

1A-3: **Smaller units create affordability by design**, allowing for more housing units to be developed in a given area, optimizing road and utility usage, while also increasing the overall supply to improve affordability. As the population ages, policies that make it easier for homeowners to downsize to smaller units could lead to more efficient use of homes.

1A-4: **Land Banking** is using parcels for transitional uses that have minimal impact upon conversion. For instance, surface parking lots, while highly discouraged, can be designed to be easily converted to a more intense building with the right market conditions instead of being built with a low intensity use which is hard to change.

Potential Governmental Actions

★ **Increase infill and density where appropriate. Encourage infill development through zoning, financial incentives, and streamlined permitting (tier CEQA GHG analysis from a qualified GHG reduction plan; reduce the need for, or time and cost of, variances). Reevaluate height limits to allow for greater use intensity where appropriate.**

- Support Accessory Dwelling Units through codes, education, and incentives. Build upon State law to permit ADUs and assist homeowners through the ADU planning, financing, and construction process. Provide financial incentives for homeowners to build ADUs rented at an affordable rate. Ease the process for homeowners and independent developers to add ADUs or move existing homes to new lots by streamlining permitting and dedicating a portion of permitting review capacity to these types of projects.
- Establish a public list of previously developed, underutilized, and infill potential sites.
- Be proactive in gaining title to blighted properties and tighten up existing laws that allow abandoned or neglected properties to sit idle (e.g. interventions within the Detroit Blight Removal Task Force Plan[18]).
- Incentivize smaller or more space-efficient units through tiered fee structures or other financial incentives.

Real Life Examples

- Local governments in Alameda County have pursued strategies recommended in this section related to infill and increasing density. Recent examples that specifically support the strategies described here include the City of Berkeley's ADU Task Force to enable and encourage more homeowners to build "backyard cottages," and the City of Fremont's updated fee structures to encourage construction of smaller dwelling units to increase affordable housing supply.

  See the appendix for more details.

★ indicates actions of greater possibility, innovation, or potential impact, as expressed by some local governments.

Goal 1B: Use infrastructure materials efficiently and minimize environmental impacts of new infrastructure

Strategies

1B-1: **Reduced parking and automobile infrastructure** allows greater density in infill sites, along with a more pedestrian-friendly environment and better community design near transit. In some places, roads reach peak throughput only 5% of the time while 50% of most city land is dedicated to automobile infrastructure including roads, parking, driveways and service stations.[19] Limited parking supply reduces private car use, especially when coupled with other traffic reduction strategies like bicycle lanes, transit passes, unbundled parking (paid for separately from rent), and car share availability. Reducing the costs associated with constructing parking makes infill development feasible.

1B-2: **Alternate means of pavement rehabilitation** introduces various methods that save energy, materials, and transport compared to traditional remove-and-replace practices. These include a variety of systems such as cold in-place recycling, full depth reclamation, and use of waste streams such as used tires in Rubberized Asphalt Concrete Hot-Mix, Recycled Asphalt Pavement (RAP), cold-in-place recycling (CIR), Crushed Concrete Aggregate (CCA), and crushed glass as aggregate "Glassphalt."

1B-3: Creation of **shared utilities** allows for a more robust use of resources. For example, a school district and city can share park or playground space. Tools to enable shared uses include financing mechanisms such as Infrastructure Financing Districts (IFDs) for public works projects.

Potential Governmental Actions

★ **Reduce parking infrastructure to make space for other uses and reduce VMT. Reduce parking requirements for infill development, particularly when it would be required to be below grade, which adds significantly to the material inputs and embodied carbon impact of a new construction project. Identify parking infrastructure that will be underutilized with future mobility options. Support installation of innovative, space saving parking technologies. Reduce parking requirements, making a maximum number of spaces allowed with no minimum. Require "unbundled" parking - separating the cost of parking from rent/housing. Identify areas in the city where each approach would be appropriate.**

- Update regional specifications for standard components such as sidewalks, civic infrastructure, and roads (e.g. transition all concrete specifications in public works projects to performance based design and permit use of recycled aggregate).
- Support the creation of shared utilities, e.g. transportation, water systems, renewable energy generation sources, commercial broadband.

★ indicates actions of greater possibility, innovation, or potential impact, as expressed by some local governments.

Real Life Examples

- Alameda County is home to private-sector innovations that aim to maximize use of urban space, such as CityLift which fits 39 parking spaces in a vertical structure where only 7 cars fit previously.
- Local cities have also led with innovations in infrastructure projects, including Berkeley's pavement rehabilitation example and San Leandro's public-private-partnership to develop a community telecom network called Lit San Leandro that supports businesses to do advanced manufacturing.

  See the appendix for more details.

2. At the Building Scale

2. Building Scale

Within any community, there are vacant and underutilized buildings. These present an opportunity to increase a community's capacity to accommodate more residents and jobs. Vacancies and inefficient use of space result in economic losses and exacerbate housing shortages. Reasons for underutilization include oversizing (surplus of square footage per occupant) or a mismatch in occupancy types built versus needed. Desired space per occupant and a community's programming needs can change over time, resulting in unintended underutilization. Optimizing the use of existing buildings, where the financial investment, natural resources, and GHG emissions of building materials and construction have already occurred, can reduce the need for new construction and associated environmental impacts.

The East Bay region has experience increasing construction activity in the last decade. This includes over 18,000 housing units in Alameda County between 2010 and 2015[20] and $4.5 billion spent on non-residential building construction in the East Bay between 2010 and 2013.[21] Assuming a typical material intensity, this 5-year period of new construction added over 100 million square feet to the county's building stock, which equates to approximately 3.5 million tons CO_2e (carbon dioxide equivalent) of GHG emissions related to construction and material production.[22] New construction should evaluate the whole building lifecycle impacts of various design options.

Buildings should be designed and built to last – resilient and address the impacts of climate change – and serve as many residents and businesses as possible. If their physical structure lasts many decades, it is highly likely that the programming or use intensity needs of that building will change—an approach of "long life, loose fit" is required to achieve optimal utilization, now and throughout their long lifetimes.

Goal 2A: Gain more use out of existing buildings through increased utilization and occupancy, retrofits, and adaptive reuse

Strategies

2A-1: **Shared spaces** increase the utilization rate of building square footage, by allowing multiple users to use the space simultaneously or at different times.[23] Sharing can apply to different programming or tenants, or to intensified use of a given space by one tenant or business through flexible workstations and schedules. It can also mean subdividing a large space to house multiple users. For residences, this could mean converting portions of existing single-family homes into accessory dwelling units, consistent with California state legislation passed starting in 2016.[24] Co-living, where several individuals share a house, is becoming more mainstream. The report Sharing Cities: Activating Urban Commons available at http://www.shareable.net/sharing-cities offers many recommendations for local governments to enable greater sharing in their communities.

2A-2: **Increasing occupancy rates** in residential properties helps address the housing crisis by housing more people within existing buildings. Up to 5% of residential units in Alameda County are vacant for various reasons, and over 90% of homes are currently occupied at a rate of less than one person per room.[25] While some underutilization is a natural part of units turning over, unintentional or undesired underutilization can be addressed through local government actions that discourage unnecessary vacancies or by removing obstacles for people that wish to live in smaller units or other housing prototypes.

2A-3: **Retrofits** to improve the resiliency and quality of existing buildings extends their useful lives, generating additional square-footage-years of utility with minimal new material investment. In particular, deep energy retrofits to minimize and decarbonize the operational energy usage of buildings can significantly reduce their lifetime carbon pollution impacts.[26] Energy usage in the 310 billion square feet of existing buildings in the United States causes more than 50 times the energy usage in the 6 billion square feet of new construction per year.[27] Retrofits for climate change resiliency and earthquakes also protect building asset values and enhance public safety.[28]

The United Nations complex renovation in New York is a high-profile example of the carbon emissions benefits of retrofitting over demolition and replacement. “If the UN complex had been demolished and replaced with new construction of similar size, it would have taken between 35-70 years before the improved operating efficiencies of the new complex would have offset the initial outlays of carbon emissions associated with the demolition and new construction process.”[29]

2A-4: **Adaptive reuse** is the renovation of an existing building that changes that building’s programming. This allows underutilized buildings whose current form and programming are no longer ideal for the location to be reprogrammed and made to be a better fit with the community's new needs. For example, in a community that is no longer industrial but needs to house more residents and offices, a factory can be adaptively reused into an office or a warehouse can be converted into multifamily housing. Adaptive reuse offers the same benefits as retrofits plus the flexibility to accommodate a community's changing needs.

2A-5: **Whole house reuse** can occur by relocating an existing house on a parcel destined to be redeveloped. While only implementable in specific circumstances, this strategy can help address blighted vacant buildings, preserve community character and history, and add density in low-density zones in an architecturally and historically appropriate way.

2. Building Scale

Potential Governmental Actions

Improve Utilization:

★ **Review zoning, business license, tenant improvement policies to remove obstacles for sharing across uses and proactively facilitate co-location of businesses with complementary schedules, programming, or waste-to-feedstock relationships**

★ **Allow and encourage residential conversion of large dwelling units into multiple smaller units. Encourage internal carve-out accessory dwelling units in residential homes (converted basements, attics, etc.)**

- Provide educational resources to support building space uses with multiple users (e.g. co-working), with single employers (e.g. flexible work spaces with telecommuting options), and other shared space models
- Use financial mechanisms or policies to discourage corporate or non-resident owners from purchasing residential properties but not occupying them, thus shrinking the available housing stock. Address this issue with a lens of increasing equity and affordability.
- Educate senior homeowners about resources to help them downsize, such as the state's property tax portability law that allows them to downsize without giving up the low property-tax assessment of their current home.
- Provide resources to developers to help them through code and other challenges to realize opportunities for their existing buildings.
- Explore incentives for allowing vacant, unleased facilities (or those that are planned for demolition without safety hazards) to serve temporary uses, including public services. Find solutions for potential liability issues.
- Lead by example: Optimize use of municipal facilities through workspace design and sharing underutilized facilities with other users.

★ indicates actions of greater possibility, innovation, or potential impact, as expressed by some local governments.

Retrofits and Building Reuse:

- ★ **Identify buildings that are good candidates for retrofits over replacement. These include buildings with high-quality construction or benefits to community character, equity and affordability. Create a conservation overlay if appropriate for a district.**
- ★ **Review zoning and building requirements and remove obstacles for retrofits and adaptive reuse.**
- Continue to encourage retrofits and updates (e.g. energy, seismic, climate change resiliency upgrades) in private-sector buildings to reduce resource losses in current building stock.
- Compile and actively disseminate educational resources on circular materials for remodels and tenant improvements.
- Provide preliminary review by building department for agreement on retrofit or adaptive reuse approach before detailed design process.
- Offer financial incentives (grants, tax credits) and/or fast-track/streamlined permitting for rehabilitation.
- Require redevelopers of large properties to preserve or relocate buildings existing on the site, particularly if the relocated buildings provide affordable housing.
- Lead by example: Retrofit municipally owned buildings and adapt old buildings to house municipal operations.

Real Life Examples

- There are many examples of building retrofits and reuse in Alameda County. The Zero Net Energy Center in San Leandro is an excellent example of a deep energy efficiency retrofit, demonstrating the potential to minimize the operational carbon impacts of existing buildings.
- The Noodle Factory in Oakland and a whole house relocation of a duplex in Berkeley illustrate strategies to preserve or increase the supply of housing. The Noodle Factory adapted an industrial building to house low-income tenants. The Berkeley duplex, which sat on a lot that was being upzoned, was physically moved, thereby allowing for higher density housing on the lot while preserving the function and character of the old duplex.

See the appendix for more details.

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Goal 2B: Design new buildings to be resilient and flexible, encouraging high usage rates and adaptability to changing future conditions

Strategies

2B-1: **Resilient buildings** are designed to resist damage under extreme conditions including fire, earthquake, soil movement, flooding, wind and extreme weather. Durable structures and mechanical systems allow buildings to withstand typical wear and tear over time. Existing local, state and federal building codes address known risks and new resiliency audit and rating systems for buildings are emerging. Depending on the hazards being considered (ideally, studying all realistic hazards) options can include structural engineering, envelope design, site design, and material selection. Building to withstand extreme conditions conserves materials by preventing building losses and the generation of disaster debris. To ensure that durability initiatives do not inadvertently introduce materials and assemblies that are toxic and difficult to reuse/recycle, non-toxic solutions such as Integrated Pest Management should be prioritized.

2B-2: **Flexibility or planning for adaptive reuse** assumes that programming in a building will likely change. This principle may be applied to individual buildings, where a predicted next use is designed into the initial construction so that retrofits and conversions between the first and second use will be possible—for instance, providing lower foundations and flat floors with enough height in a parking garage to allow future conversion to residential use. It could also be applied to districts or zones that the jurisdiction is actively trying to transform into a different use. Even if the next use is unknown, there may be some basic structural requirements to allow for a minimum amount of flexibility. The Urban Land Institute produced an informative guide on universal structures: http://urbanland.uli.org/planning-design/universal-structures-long-term-sustainable-assets.

2B-3: **Design for sharing between different users** can optimize building utilization as described in Section 1A. This may require collaboration among different users in designing the building, which can complicate the design process but can also yield innovative and impactful results for the longer term.

2B-4: **Cohousing** is an intentional residential community of private homes clustered around shared space that may include common house areas and recreational and outdoor spaces. When carefully designed, a co-housing development uses less building material per capita than a comparable development of single-family homes that do not have shared spaces because of smaller individual spaces. In cohousing, residents are also more likely to share tools, equipment, vehicles and other items. Proponents of cohousing also highlight the quality of life benefits of living in a close-knit community.

Potential Governmental Actions

★ **Encourage flexible building design to allow multiple tenants and programming to share the space. Facilitate connections and partnerships between developers to design joint / shared projects for multiple clients.**

★ **Update zoning to require building for adaptive reuse within districts whose future programming is known or anticipated. Adopt form-based codes or codify in zoning and allow applicants to obtain future use permits to provide certainty that next use will be allowed.**

★ **Require adaptive reuse or deconstruction plan for parking structures and limit life of parking use permits.**

- Set minimum service life for building life-cycle cost analyses (and life-cycle environmental assessments) and create incentives for developer to invest in durability and flexibility if it will not be developer-owned.
- Enable – through necessary zoning or other policy changes – and encourage intentional communities like Cohousing, co-living or Co-ops that emphasize shared resources (tools, amenities, open space).
- Prepare resources or guidelines/requirements to allow developers to easily consider resiliency and adaptation when rebuilding after disasters at initial permitting to ensure longevity of facilities.
- Address infrastructure resiliency, connecting with regional initiatives, or launching a resiliency audit program that address vulnerabilities to seismic and climate events, potentially in partnership with regional entities such as ABAG. Emphasize the importance of building for resiliency in their local hazard mitigation plans and climate change adaptation plans.
- Lead by example: Apply design considerations for durability, resilience, and flexible use to new municipal facilities.

Real Life Examples

- Parking structures present an excellent case study for applying flexible design to consider potential future uses, as many city planners anticipate a decrease in parking demand through transportation technologies. Examples are appearing around the Bay Area, including Broadway Plaza in Walnut Creek.
- Emeryville hosts several examples of innovative building and use designs. The Emeryville Center of Community Life allows municipal and school district uses on one site, which required changes to state law. The Doyle Street Cohousing project converted a warehouse into 12 dwelling units with shared common spaces.

See the appendix for more details.

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3. At the Building Component Scale

While a building may last several decades, most building equipment will likely need replacement within 20 or 30 years and many interior materials are replaced in 10 years or less. Structural components may last as long as the building, or be replaced when the building undergoes a significant retrofit or is adapted for reuse. In these cases, the design and purchasing choices, construction methods, and cataloging of components can increase the likelihood of component reuse at the end of its life.

Alameda County alone sends over 100,000 tons of construction and demolition (C&D) waste to landfills each year.[30] Concrete, wood, asphalt, carpet, and wallboard were the dominant C&D waste materials. The current practice for these materials is to either downcycle them or send them to landfill. This volume and pace of waste generation from the construction sector is not sustainable and needs to be addressed at the source of waste generation, not merely relying on material recovery.

In a circular economy, the value inherent in these materials could be more effectively recouped through deconstruction, salvage, remanufacturing, and reuse at the component level. Utilizing components at their highest materials value – during extraction of existing building components or by designing for future extraction – also bypasses production stages such as raw resource extraction and manufacture, along with the associated environmental impacts and costs.

Goal 3A: Extract more value out of components in the existing built environment through deconstruction, salvage, and reuse

Strategies

3A-1: **Deconstruction** is the disassembly of a building into reusable parts. In contrast to demolition, which generates waste whose value can only be reclaimed through recycling processes, deconstruction allows greater access to valuable building materials more ready to serve their next life, and reduces the labor and greenhouse gas emissions related to processing of recycled materials. While a deconstruction ordinance results in the most material recovery, jurisdictions that encounter political reluctance or workforce and market capacity limitations may need to begin with less stringent requirements or work only on permit timing and fee structures.

3A-2: **Salvaged materials from deconstruction** can be reused in new buildings or retrofits, but using salvaged materials can increase design and construction time and introduce uncertainty. Local governments can support the creation of a market for deconstructed materials, incentivize use of salvaged materials, and help remove obstacles such as requirements applied to the condition of salvaged materials.[31] Material reuse marketplaces can facilitate the transactions between deconstruction services and project teams using salvaged materials: at present, used building material yards typically serve the residential market, while the commercial market mainly sees offerings of high-end deconstructed timbers, lighting fixtures and specialty equipment. The Public Architecture's primer on Design for Reuse contains many case studies of projects that reused materials.[32]

3A-3: Local governments can **support Recycling Market Development Zones**, where salvaged building materials and other products are tracked and stored for future reuse. This may be part of a comprehensive solution that balances supply and demand, and creates a physical location for both. Local governments can use land use policies and incentives or can develop a database, examples, and standardization to encourage development of these material banks in their jurisdictions. For information about using buildings as vessels to store materials, please see the Buildings as Material Banks in the Designing for Reuse section.

Potential Local Government Actions

★ **Adopt a deconstruction ordinance that requires deconstruction for all or a subset of buildings, deconstruction walk-through audits prior to demolition, or a wait period between receiving the demolition permit and start of demolition. Require that construction and demolition debris is taken to third-party certified (as defined under LEED) recycling facilities. Alternatively, reference and advocate for deconstruction requirements in CALGreen.**

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★ **Develop or expand local deconstruction markets through workforce development and by supporting businesses that provide deconstruction services or sell deconstructed materials.**

★ **Encourage or require new projects to use salvaged materials through mandatory or voluntary codes and standards (see Tools section) and by clarifying performance requirements, especially for structural materials that may lack historical documentation.**

- Advocate for modification of State building codes that create barriers to reusing components in commercial construction.
- Issue deconstruction permits before building permit review is completed and have preferable deconstruction permits – expedited or lower fee – than demolition permits.
- Provide financial assistance for salvaged materials to offset incremental cost increase over new materials while the reuse market is nascent for those materials.
- Facilitate reclaimed building material resale. Establish or enable (through zoning, etc.) individual sites such as a reclaimed lumber sales location specifically to serve contractors.
- Track the development of cataloging materials contained in existing buildings (i.e. post-construction "material passports") and promote this practice when protocols emerge. Conduct post-construction materials cataloging for local-government owned resources that will be de-acquisitioned at end-of-life. Encourage private-sector developers to create passports that link to a material banks database hosted by the local government or other entity.
- Lead by example: Deconstruct municipal facilities that would normally be demolished, and document as case study. Show how the environmental benefit contributes to sustainability goals and climate action plans.

Real Life Examples

- The City of Portland, with support from Oregon Department of Environmental Quality, has led the nation with their deconstruction policy. They require full deconstruction of homes older than 1917 and have supported market development through workforce training and grants.
- In the Bay Area, the City of Palo Alto leads with their policy that requires a walk-through audit of the value of the materials that could be extracted through deconstruction. There are businesses that already perform deconstruction services like The ReUse People, which serves the Bay Area and resells the salvaged materials from a retail warehouse in Oakland.

See the appendix for more details.

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Goal 3B: Design new construction and select components to enable recovery and reuse in the future

Strategies

3B-1: **Design for Disassembly** (DfD) is a suite of principles that allow building components to be extracted from buildings in a reusable form. While recycling of construction materials saves anywhere from 25% to 80% of energy and embodied GHG emissions, reuse can often save over 90%.[33] The principles of DfD consist of simplifying and repeating building layouts, components, and connections; using mechanical fasteners instead of adhesives and welds; recognizing the layers of building systems tied to their frequency of change-out or repair. A report for King County describes these concepts in more detail: https://kingcounty.gov/~/media/depts/dnrp/solid-waste/green-building/documents/Design_for_Disassembly-guide.ashx?la=en

3B-2: **Buildings as Material Banks** (BAMB) is the concept of maintaining the asset value of materials while they are in use in a building (or other product). Assets then can be extracted for high resale value when removed from its current use, such as when a building is renovated or deconstructed.

3B-3: **Material passports** are a way to document the materials in a building when it is constructed and storing alongside the materials information needed for future reuse. This data would remain with the building, and possibly with the local building department if the data infrastructure exists. Material passports enable developers planning a demolition or deconstruction to plan for extraction of valuable materials. They could also enable future buyers of the building to know what reclaimable assets it contains, which could increase its value. The more widely material passport data is stored and shared in central databases, the easier it becomes to match potential users with available materials. A video at https://www.madaster.com/en explains the BAMB concept.

3B-4: **Extended producer responsibility** (EPR) policies shift the responsibility (physically and/or economically) of a product's lifecycle from the end users and municipalities to the producers. This creates an incentive for producers to design products so they cost less to process at the end of the product's life. EPR is based upon the principle that producers have the greatest control over product design, marketing, and reuse potential, as well as the greatest ability and responsibility to reduce toxicity and waste. EPR may take the form of reuse, buy-back, or recycling programs operated by the producer or delegated to a third party responsibility organization (PRO) that takes on responsibility for the material or product. Many places around the world have EPR laws that address a specific product type. In California, for example, there are EPR laws regulating mercury thermostats, paint, carpet, mattresses and more.

3B-5: **Take-back programs** create a built-in channel for returning decommissioned components and materials to the manufacturer or vendor. The program could be offered by the original manufacturer or vendor in the case of extended producer responsibility, or be offered by other businesses or organizations that create a secondary market for a variety of manufacturer's products. Product manufacturers that offer EPR or take-back programs cite drivers that encourage EPR: Developer commitment and demand; commodity prices, often impacted by other sectors competing for same materials; robustness and proximity of reverse logistics, storage, and remanufacturing facilities. Although many of these forces occur on the national or global level, local governments can support through developer and contractor education, and greater diversion incentives such as increased landfill fees or accelerated permits for projects committed to higher diversion rates.

3B-6: **Product leasing or product-as-service** is a business model in which a service is sold rather than a product. Vehicle and equipment leasing are familiar examples; more recent examples include car or bike share programs, online streaming video and even clothing rental subscriptions. In the building sector, this can take the form of companies providing the use of a product (such as carpet tiles) for a specific amount of time, or selling the service (such as lighting in lumens, not the lamp fixtures) without ever transferring ownership of the physical object to the building owner or tenant. As with extended producer responsibility, the vendor is responsible for the product at the end of its life, creating an incentive to design products to be reusable, remanufacturable or recyclable. The product-as-service financial model means that revenue accrues gradually over the life of the service contract, rather than as lump sum at time of sale. Moving to such a financial model will require a shift in mindset across multiple parties involved in the transactions throughout the value chain.

Potential Local Government Actions

Design for Disassembly and Reuse:

★ **Encourage design for disassembly by referencing the strategies in the EPA Design for Deconstruction guide as a checklist, providing educational resources to developers and highlighting qualified architects and building industry professionals. Require or mandate design for disassembly or advocate for it in State building codes.**

★ **Lead by example: Apply design for disassembly principles to new municipal facility design, and provide as case study. Include component reuse plans, disassembly specifications and evaluation of economic factors.**

- Provide certainty that next use of components is allowable by codifying minimum specifications for reusable components.

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- Encourage that the region/state create a market for "materials passports" (information tagged to building materials that stays with the product throughout its lifecycle, e.g. with a QR code, enabling recovery and reuse) as part of building models and blueprints, and create or expand a building department database to store the data.

Extended Producer Responsibility, Take-back, and Product-as-Service Business Models:

★ **Support state legislation for extended producer responsibility and take-back programs. Work with other jurisdictions to design a unified approach with performance standards and goals. This levels the playing field for producers and makes it easier to pass legislation. Sign on to efforts led by other jurisdictions or entities like StopWaste.**

★ **Lead by example: Use of product-as-service for municipal contracts. Requires shifting budget from capital to operations.**

- Lead by example: Adopt purchasing practices that support products that are covered under EPR programs.
- Encourage local businesses, vendors, and manufacturers to initiate or expand take-back programs. Negotiate with producers and other stakeholders when EPR programs are being planned and implemented. Assist producers with designing collection systems, making existing collection infrastructure available. Support local businesses to introduce leasing or product-as-service models by providing education and assistance on financing and operations, and public recognition or promotion of their business.
- Inform the public and contractors about EPR and existing take-back programs.

Real Life Examples

- In Seaside, CA, the Chartwell School employed DfD principles such as no internal walls being load-bearing and utilities being visibly, centrally located and not entangled with the structural walls (therefore enabling easier changes to internal wall configuration). The project used larger and fewer structural framing pieces and their connections were designed to simplify deconstruction.
- The development of innovative products will spur the designing for disassembly trend. One local example is ConXtech, with locations in Pleasanton and Hayward. They offer ConX, a structural steel framing system based around standardized connections that rapidly assemble on the project site. The connections can be designed for deconstruction and reconstruction in whole or in part, allowing for adaptation or relocation of a structure.

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- California and other states have passed legislation that requires take-back of paint. PaintCare now services the paint industry in those states to collect and process left-over paint. Armstrong Ceilings also offers a take-back program whereas new systems for material reutilization are appearing in wallboard recycling, and glass in concrete.

  See the appendix for more details.

4. At the Materials Scale

A study of international material flows estimated that demolition waste from buildings, infrastructure, and equipment in the US alone rose from 200 million metric tons in 1950 to 1.1 trillion metric tons in 2015.[34] Construction and demolition (C&D) waste constitutes about 40 percent of the total solid waste generated in the U.S.[35] In Alameda County, C&D waste constitutes 12% of the total solid waste stream that goes to landfill.[36]

Local governments can use requirements, incentives, and education to gain greater recycling rates and influence material usage in new construction. CALGreen, California's state building code (Title 24 Part 11) requires 65% of C&D materials to be diverted from landfill. Local governments often have control in a greater number of areas than states or the federal government to implement waste recovery measures. These measures include landfill fees, permits for recycling facilities, diversion requirements on municipal and private projects, builder education, and support for programs and services to manage C&D waste so that it stays out of landfill.

Developers of new construction can select durable materials and use materials efficiently during construction to minimize waste and increase the asset value of the final product. Material efficiency reduces the need for extraction, mining, and deforestation for virgin materials. Selecting low-carbon and non-toxic materials also reduces embodied carbon emissions and improve occupant and environmental health.

Goal 4A: Maximize recycling rates of materials at end of life

Strategies

4A-1: **Demolition debris**, or materials leaving the built environment at end of life, represents 90% of all C&D materials generated in the U.S.[37] The volume of demolished materials should first be reduced through the deconstruction strategies under Goal 3A. Materials that are not salvaged should be taken to a processing facility that has obtained a third party certification for the facility's recycling rates, as identified in US Green Building Council's LEED green building rating system. A third party certified recycling rate ensures that a facility is diverting and recycling C&D materials to the highest degree possible. Projects with a demolition permit only, and not a construction permit, do not fall under CALGreen's requirement for 65% diversion, so local governments may need add requirements for demolition-only projects.

Potential Local Government Actions

★ **Require that demolition debris be taken to third-party certified recycling facilities as defined under LEED.**

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Goal 4B: Use materials efficiently and select materials for minimal impact by considering lifecycle impacts and end-of-life recovery

Strategies

4B-1: **Zero Waste** is a popular concept in the waste and materials management industry lexicon. Construction sites can strive for zero waste to landfill through efficient construction processes, accurate estimating and purchasing of materials, and instituting an effective on-site recycling program to source-separate extra material, demolition debris, and packaging. At the product level, those certified for Zero Waste under a program by Intertek or UL Environment demonstrate that a manufacturer has exceeded standard industry practices in minimizing waste to landfill. (www.intertek.com/business-assurance/zero-waste-to-landfill/ | industries.ul.com/environment/zero-waste)

4B-2: **Modular construction** is a technique using prefabricated sections that are manufactured off-site and transported in modules and assembled at the final building site. It also potentially allows for greater flexibility in reconfiguration of spaces. Prefabrication typically produces less construction waste due to greater precision achievable in a fabrication facility's controlled environment compared to a construction site.

4B-3: **Lighter buildings use less material than heavier buildings**. They tend to be constructed from wood which has lower embodied carbon emissions (GHG emissions caused by the sourcing and manufacturing of a product). Buildings over a certain size typically have steel or concrete systems, which weigh more and have higher embodied emissions per square foot of constructed space. It is possible, however, for larger buildings to reduce their total mass and embodied emissions per square foot, by designing more efficient structural systems; minimizing energy and emission intensive materials such as cement, aluminum, and glass curtain walls; and using materials like wood which is becoming viable for larger buildings through innovation in mass timber construction. Projects should use whole building lifecycle assessments to evaluate the different material and design options.

4B-4: Some **bio-based materials**, rapidly renewable materials, and low-carbon intensity materials can reduce the impact of new construction or at least reduce our dependence on fossil fuels which is not a renewable feedstock. Third-party certification standards provide verification for these attributes or zero waste in product manufacturing.

4B-5: **Certified products** from transparent manufacturers are more successfully reused because the components and material they are made of are known such that they can be more practically recovered and reprocessed (when necessary). Product content disclosures, such as the Health Product Declaration™ or the Declare™ label, indicate the chemical composition of materials, informing users of their content and thus enabling reuse. Some product certifications indicate whether a product is already part of circular manufacturing

4. Materials Scale

process and demonstrate a level of rigor, consistency, and assurance of best practices through third-party verification against a set of voluntary standards defined by the certification program.

Under Cradle-to-Cradle Certified™ (C2C), manufacturers demonstrate improved manufacturing and supply chain choices under the categories of material health, material reutilization, renewable energy and carbon management, water stewardship, and social fairness. Of these, material health and material reutilization are particularly central to circular principles for products. In 2016, the Cradle to Cradle Products Innovation Institute started an initiative titled "Built Positive" aimed at promoting and accelerating these principles in the built environment.

Potential Local Government Actions

Minimize Construction Related Waste: Practices, products, and business models that result in less on-site and supply chain waste.

★ **Encourage or require zero waste construction and emerging technologies, such as modular pre-fabricated construction. Update existing C&D ordinances to include zero waste construction certification.**

- Support the modular construction industry by educating building departments and permit checkers to understand modular projects. Support local modular factory development and local job opportunities.
- Encourage or set minimum standards for warranty to facilitate selection of durable materials, and/or Environmental Product Declarations disclosing the lifecycle impacts of materials.
- Lead by example: Pursue zero waste, material-efficiency, and low-carbon (LCA-informed) construction methods and products for municipal construction and municipally controlled infrastructure. Require or encourage the same of utilities (e.g. water, energy, telecommunications).

Select Low-Impact Materials: Materials that have lower embodied carbon, toxicity, and other lifecycle impacts.

★ **Require or encourage specification for environmentally preferable materials, including references to third party certification programs, Environmental Product Declaration or EPD credits in LEED certified projects, and/or embodied emissions accounting related to LEED or CALGreen Tier credits.**

★ **Promote alternate means of pavement rehabilitation. Convene public works agencies, or participate in current regional meetings, to share lessons learned and showcase successful use of innovative methods.**

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- ★ **Require whole building LCA to determine the best use of an existing building (e.g. leave as-is, retrofit, adapt, or replace with higher density building) at appropriate trigger events. Explore which trigger events (such as rezoning or demolition permits) and thresholds (e.g. building size) would most effectively address embodied carbon. Alternatively, evaluate the LCA impacts of typical scenarios and develop "rule of thumb" policies that aim to minimize lifecycle carbon emissions.**
- ★ **Support state action to address life-cycle impacts of materials, such as embodied carbon, in CALGreen updates, CEQA guidelines, GHG inventories, and State construction projects.**
- Identify and remove barriers that inhibit construction with renewable, carbon-sequestering materials in place of carbon-intensive materials currently dominant in particular types of construction (e.g. cross-laminated timber in place of concrete and steel structures for buildings over the prescriptive code limits on wood).
- Encourage specification of products that avoid toxic chemicals and provide full content disclosures, down to toxicity presence levels as small as 1000 parts per million or 100 parts per million.

4. Materials Scale

Real Life Examples

- BRIDGE Housing's modular construction project Marea Alta in San Leandro is an example of several strategies described in this primer, including infill and partnership between public and nonprofit/private sector to maximize utility of infrastructure.
- The Cradle to Cradle Products Innovation Institute leads in certifications of products and materials that are designed for circularity, including a focus on non-toxicity. Among their certified biobased materials is Ecovative's Mycoboard and Mycofoam made out of mycelium grown in agricultural waste.
- San Francisco recently approved a high standard for carpet selection that addresses toxicity and recycled content.
- Whole construction projects can prioritize use of bio-based materials such as earth, adobe, and strawbale. The owners of a home that survived the 2017 North Bay fires in Sonoma County attribute the home's resiliency partially to its building materials.
- Governments are beginning to include LCA analysis in their policies. City of Vancouver now requires a Whole Building LCA analysis with rezoning permits. California's "Buy Clean Act" AB 262 requires state agency construction projects to have LCA global warming potential disclosed for four building materials.

See the appendix for more details.

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Next Steps

The challenges facing local governments in reducing the solid waste, greenhouse gas emissions and other environmental impacts associated with the built environment are complex. Addressing these challenges requires new approaches and cooperation between various sectors, agencies and unusual partnerships. Local governments can benefit from using circular economy principles to reduce environmental impacts while they address issues of growth, housing, affordability, and equity.

This primer is merely an introduction. It outlined circularity principles for buildings and infrastructure when considered from a local government's perspective of multiple scales and new construction in the context of an existing built environment. It introduced potential local government actions that may be pursued individually or considered in tandem with other local government initiatives. They can be incorporated into sustainability or climate action plans, economic development strategies, or general plans.

StopWaste's next step is to support its member agencies that are interested in pursuing the actions in the primer or other circularity strategies. This could take the form of assisting local governments with model policies, developing circularity metrics, advocating for state or regional actions, and applying circular design to specific construction projects.

For updates on StopWaste projects on this topic, visit http://www.StopWaste.org/builtenvironment.

For input and feedback to inform next steps, email miya@stopwaste.org.

Appendix A: Policy And Project Examples

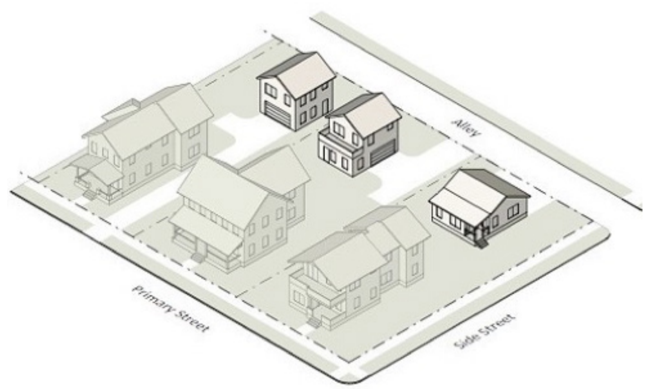
1A. Community Scale & Existing Infrastructure

Smaller units policy example: City of Fremont

The affordable housing ordinance adopted by the City of Fremont in 2015 requires developers of new market-rate housing to either set aside some of their units as affordable or pay a fee to the City for use in affordable housing construction. When setting the fee levels for different types of market-rate units, the Fremont City Council acknowledged that small market-rate rental units (defined as those smaller than 700 sq. ft.) are generally more affordable than larger units, and therefore set the fee level for those units at $8.75/sq. ft. (compared to fees ranging from $17.50-$27.00/sq. ft. for units larger than 700 sq. ft.) The lower fee provides an incentive for market-rate developers to include more of these smaller units in their rental projects, which in turn creates more relatively affordable units in the community. Although it is difficult to establish a direct cause and effect, early results suggest that rental housing developers are including more smaller units in their projects.

» http://fremont.gov/2394/Affordable-Housing-Ordinance

Accessory Dwelling Unit policy example: City of Berkeley ADU Task Force



In 2016, City of Berkeley's Council member Ben Bartlett spearheaded the creation of a citizen-based ADU Task Force and developed a target of 3,000 ADUs. The Task Force members include real estate agents, architects and designers, planners, developers, mortgage specialists, and others. The Task Force assisted the City with aligning with State ADU law and members are assisting state agencies with "clean-up language" for the state law, building alliances with UC Berkeley, and other cities to learn best practices, as well as providing assistance to homeowners (fee-based) who have questions about how their jurisdiction is interpreting the law for their properties. The Task Force holds educational homeowner workshops and townhalls in each Council member's district, expanded by request into other cities and policy think-tanks beyond Berkeley borders, speaking during Affordable Housing Week and industry associations including several Boards of Realtors. The Task Force gathers research and case studies.

HIP Housing: City of Fremont

In an effort to assist home seekers who currently live, work, or go to school in Fremont, the City of Fremont and HIP Housing (Human Investment Project) formed a partnership to offer a home sharing program. Home Sharing is a living arrangement in which two or more unrelated people share a house or an apartment. With today's economic challenges, Home Sharing can provide a means to meet the needs of people who have extra rooms and those in need of a place to stay.

This program is run by HIP Housing, a nonprofit organization which has been connecting homeowners or renters (Home Providers) who have a residence with one or more bedrooms with persons seeking housing (Home Seekers) to pay rent or exchange services for reduced rent. Fremont Home-Sharing-Program

Parking solutions business example: CityLift

CityLift offers automated vertical car parking. Compared to conventional parking lots, the company says their system uses 69% less construction material per parking space, including 31% less concrete, and has 68% smaller land footprint. Their embodied carbon emissions in materials is 67% lower, and their total lifecycle emissions are 91 lower due to the reduction in vehicle miles driven looking for parking within a conventional structure. The construction is primarily steel and modular, lending itself more readily to reuse and recycling. The structures housing the systems can also be better designed for future adaptive reuse than conventional structures. CityLift's Hive parking structure in Oakland is the first fully automated parking structure in the Bay Area and houses 39 spaces in the footprint of seven surface-level spaces, or 1,600 square feet.

1B. New Infrastructure

Pavement rehabilitation example: City of Berkeley

The City of Berkeley used full depth-reclamation (FDR) to rehabilitate several segments of pavement instead of traditional remove and replace methods. FDR, and other forms of Cold In-Place Recycling, uses specialized equipment to replace existing pavement by pulverizing and recasting it onsite. This avoids the need to haul off waste and bring in virgin materials, and the transport emissions and congestion associated with each. Rubberized Asphalt Concrete Hot-Mix (RAC Hot-Mix) was also used in several street overlays and funded through a grant disbursed by CalRecycle. It has resulted in the diversion of 9,760 California waste tires from the waste stream.

» http://cityofberkeley.info/Public_Works/Bids_-_Contracts/Recently_Completed_Projects_1.aspx

Community telecom network example: Lit San Leandro

Lit San Leandro

To attract high tech businesses to San Leandro, a broadband network with world-class connection speeds was created through a public-private partnership between San Leandro (who constructed the 20 miles of underground conduit), San Leandro Dark Fiber (who owns the fiber optic cable that runs through the City's conduit), and Lit San Leandro (who owns and operates the switch and routing facilities). The first business that the network drew to San Leandro is now one of the city's largest and best-paying employers.

» http://litsanleandro.com

2A. Existing Buildings

Retrofit example: Zero Net Energy Center`

The Zero Net Energy Center in San Leandro is an educational facility, co-sponsored by the local electricians' union (IBEW) and the National Electrical Contractors Association (NECA), that supports training of over 2,000 electricians annually. The building is a deep energy retrofit of a 1980s office building. Its innovative design and state-of-the-art technologies in solar, wind, solar thermal, lighting, and building automation systems are regularly used in the curriculum. These features enable an energy use reduction of 75% compared to similar US buildings and lower its carbon footprint to an estimated 175 tons of CO2 per year, all at comparable construction cost to conventional construction methods.

» http://znecenter.org/about

Adaptive reuse example: Noodle Factory

In 2009, Northern California Land Trust (NCLT) renovated a former noodle factory in West Oakland to help address the chronic shortage of work and performance space for artists and artisans. The rehabilitated 19,000-square-foot building now houses 11 work/live condos for low-income artist and craft-worker households, as well as a performing arts center with rehearsal space and a 90-seat theater for music, film, theater, dance and other events. To ensure the homes will remain permanently affordable NCLT used the community land trust model, establishing a nonprofit corporation that retains ownership of the land underneath the Noodle Factory while the residents own (or lease-to-own) the condos on top of the land.

» http://www.StopWaste.org/node/1190

Whole house reuse example: Berkeley Duplex

Tom White and Dmitri Belser purchased an iconic two-story 1902 duplex in downtown Berkeley for $1 and moved the entire structure eight city blocks to a lot with an existing commercial storefront. They plan to restore both the duplex and storefront, preserving the buildings' historical character. When a 205-unit multifamily housing development was approved for the original site, the City of Berkeley required the developer to either move and refurbish the duplex, or put six rent-controlled apartments in the buildings. In its new site and after restoration, the duplex will be affordable and rent-controlled. White and Belser have preserved and/or relocated a portfolio of buildings throughout the area.

» http://rockheadandquarry.com/properties

2B. New Buildings

Adaptive reuse policy example: City of Hayward Form Based Codes

A form-based code is a land development regulation that defines the physical form (rather than separation of uses) as the organizing principle for the code. A form-based code is a regulation, not a mere guideline, adopted into city, town, or county law. A form-based code offers a powerful alternative to conventional zoning regulation and regulates the envelope of the built form in 3-dimensions. Form-based codes address the relationship between building facades and the public realm, the form and mass of buildings in relation to one another, and the scale and types of streets and blocks. The City of Hayward has adopted form based codes for several of its neighborhood plans.

» https://www.hayward-ca.gov/your-government/documents/planning-documents

Nonresidential sharing project example: Emeryville Center of Community Life

Emeryville Center of Community Life was created through a joint effort of the City of Emeryville and the Emeryville School District and opened in 2016. ECCL's utilization rate was increased by having two entities—the city and the school—share the facility. Some of the shared amenities include a pool and gym, outdoor rec facilities and other community spaces. State legislation (AB1080 Skinner 2009) was required to allow the construction of a shared facility combining a K-12 school and a community recreation center.

Cohousing project example: Doyle St. Cohousing

In 1992, a warehouse in Emeryville was converted into a 12-unit cohousing project. Doyle St. Cohousing features an urban landscaped garden with a shared common house where residents eat together three nights a week. The workroom houses tools, ladders, camping equipment, laundry facilities, and other shared resources. Neighbors regularly borrow before buying new things, and one of their common sayings is "It must already be on the property."

Planning for adaptive reuse project example: Adaptable parking structures

While technology seems to promise that looking for a parking spot will one day be obsolete, our cities currently struggle to meet demands for parking. Some developers are turning to adaptable parking structures as a way to protect their new assets through temporary expansion and then future contraction of square footage dedicated to parking stalls. The Urban Land Institute has provided a guide noting key elements for consideration, such as floor-to-floor heights, ramp and service riser locations, facade change-out, and floors capable of supporting higher loads. The Broadway Plaza in Walnut Creek was designed to convert parking area to retail.

» http://info.clarkpacific.com/clarkpacificcom-a4Bep/pages/0af7b7b7e646e711be9c00155d23f918.html

3A. Existing Building Components

Deconstruction policy example: City of Portland

In October 2016, a new City of Portland ordinance came into effect requiring those seeking a demolition permit for houses built in 1916 or older to deconstruct the building by hand (as opposed to mechanical demolition). Knowing that this would result in a surge in both deconstruction work and reclaimed building materials, the city began to prepare. The first step was to train contractors to become certified deconstruction contractors to ensure correct processes and material recovery. A second training for on-the-ground deconstruction workers was held in early 2017, with a focus on trainees from underserved populations (all of whom ended up with living wage jobs in deconstruction). Oregon Department of Environmental Quality supported both trainings, as well as a small grants program for individual deconstruction projects, and a project to create a reclaimed lumber sales location specifically to serve contractors. DEQ also awarded several grants to fund additional infrastructure including trucks, equipment, and capital for Habitat for Humanity ReStores. Deconstruction and material reuse is thriving in Portland, and will be helped further by an Oregon building code change to allow reclaimed structural lumber in new construction which takes effect in 2018.

» http://portlandoregon.gov/bps/68520
» http://earthadvantage.org/education/2290-402

Deconstruction business example: The ReUse People

The ReUse People, also known as Deconstruction Bay Area, is a nonprofit organization that trains deconstruction contractors and then deploys them across the Bay Area to salvage building materials from residential properties so they may be sold for reuse in new construction and renovation projects. Since 1993 TRP has deconstructed over 2,000 buildings and diverted 350,000 tons of material. They have also trained 500 unemployed, underemployed, or disadvantaged workers

and over 70 contractors. Some key aspects that keep their operations viable are high turnover of homes in affluent communities, tax conditions that favor donating salvaged building materials rather than demolition, a large local market of environmentally aware, DIY homeowners who wants quality of interiors at a low price, and experienced staff running the TRP warehouse and operations. According to TRP, the most supportive local policy affecting their business is the City of Palo Alto's deconstruction policy (see below).

» http://deconstructionbayarea.com

Deconstruction policy example: City of Palo Alto

The City of Palo Alto requires all single-family homeowners to conduct a deconstruction audit before they can apply for a demolition permit. This does not require that the home be deconstructed, but often results in homeowners choosing to deconstruct once they see the financial savings compared to demolition. In contrast, there are some municipalities that do not allow splitting the demolition permit from the construction permit, which limits the amount of time in which both must occur, and favors the faster speed of demolition over deconstruction.

» http://cityofpaloalto.org/civicax/filebank/documents/2856

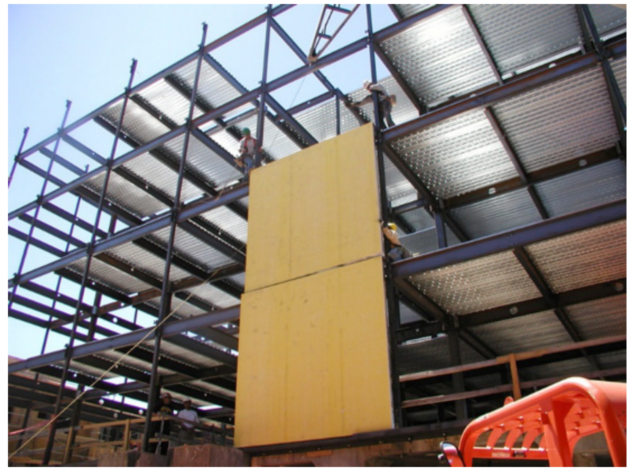
3B. New Building Components

Design for deconstruction building example: Chartwell School, Seaside, CA

The Chartwell School enlisted the architecture firm EHDD to design a new education facility for children with learning variations. The challenge was to incorporate design for deconstruction principles to provide future flexibility. While it was difficult to predict future needs, the project team believed that the need to for future modification would be more likely for their alternative learning facility than for traditional classrooms. The new design employed several DfD techniques to accommodate future changes to technology, classroom sizes and configurations, and space uses.

For example, none of the internal walls are load-bearing, which makes shifting the walls to shrink or enlarge the classrooms easier. Also, all utilities visibly run down a central corridor and into utility closets in the same location for each classroom. The utilities are kept separate from structural walls to facilitate future disassembly, and the chance of reusing the walls is not compromised by utility punch outs in them. Additionally, the project team chose concrete pavers over poured continuous concrete slabs, used larger and fewer structural framing pieces, and devised numerous connections to enable or simplify deconstruction—all in order to ease future disassembly.

Design for disassembly product example: ConXtech



ConXtech, a company operating out of Pleasanton and Hayward, offers ConX, a structural steel framing system based around standardized, seismically resistant and manufactured special-moment-frame connections that can be rapidly assembled on the project site. The system reduces structural variables and details, while remaining configurable and architecturally flexible. It utilizes steel shapes and sizes available in the commodity market. Regularity in framing elements enables more efficient design and predictable integration of other systems.

ConX is prefabricated which reduces time, waste, and disruption to the community during construction. These structures can be designed for deconstruction and reconstruction in whole or in part, allowing for expansion, contraction, or relocation of a structure over time. ConX has been used in healthcare facility construction as well as high-rise residential construction. In Santa Clara, a developer proposing a 4-story condominium was able to meet the city's preference for an 8-story condominium tower because the system was more affordable than anticipated. conxtech.com/conx-system/comparisons

EPR policy example: PaintCare

PaintCare operates paint stewardship programs on behalf of paint manufacturers in states that have passed paint stewardship laws. It is a program of the American Coatings Association (ACA), a membership-based trade association of the paint manufacturing industry. In parts of the United States where PaintCare operates, households and businesses are encouraged to take their unwanted, leftover paint to a PaintCare drop-off site. There it is sorted and managed for reuse, recycling, energy recovery, or safe disposal.

PaintCare began in Oregon as a three-year pilot program. After successfully demonstrating that the industry can design and deliver a program for post-consumer paint management, the Oregon program became permanent through new legislation in 2013. Similar laws have passed in California, Colorado, Connecticut, the District of Columbia, Maine, Minnesota, Rhode Island, and Vermont, and additional states are expected to pass legislation in the future.

Without a PaintCare program, the best options for consumers to recycle or dispose of leftover paint are government-run household hazardous waste (HHW) facilities and one-day "round-up" events. However, these programs offer limited days and hours, are not always located conveniently, and may not serve painting contractors and other businesses. In states with PaintCare programs, additional paint drop-off locations have been established to increase convenience and provide service to all paint users. Most locations are paint retailers, which are convenient locations open year-round and seven days a week.

Across the nine PaintCare states, there are more than 1,750 drop-off sites, 77% of which are paint retailers.

PaintCare is funded through fees on each container of architectural paint sold in states and jurisdictions with paint stewardship programs. Budgets and fees are set on a state-by-state basis.

Product take-back and recycling business model examples: Armstrong Ceilings, wallboard recycling, and glass in concrete

The following initiatives seek to increase value through greater circularity within some of the most common commercial building products.

Armstrong Ceilings Recycling Program is a take-back program that will pick up asbestos-free ceiling tile and turn it into new ceiling tile. The program's website has resources for materials approval, scheduling and logistics, as well as a recycling calculator to estimate savings, case studies, a sample specification, and more. This program has diverted over 195 million square feet of old ceiling materials over the last 18 years; however, ceiling tile recycling is not yet standard practice among general contractors in Alameda County. armstrongceilings.com/commercial/en-us/performance/sustainable-building-design/ceiling-recycling-program.html

The Closed-Loop Wallboard recycling pilot, led by Building Product Ecosystems, is collaborating with partners to trial the recycling of clean wallboard from New York City and Bay Area construction sites into new wallboard. About 12% of drywall is wasted in new construction, which amounts to 200,000 tons annually in California and is more than five times the amount of drywall coming from demolition. Toxic hydrogen sulfide gas, an asthmagen, can result from landfilling wallboard in humid, anaerobic conditions. Massachusetts bans sending wallboard to landfill, and California discourages both incineration (due to toxic sulfur dioxide gas) and use of drywall waste in agriculture. calrecycle.ca.gov/condemo/wallboard

Glass in Concrete is a collaboration, also led by Building Product Ecosystems and partners, to replace Portland cement in concrete with finely ground post-consumer glass fines that have no other end use. The manufacture of Portland cement accounts for 7% of global GHG emissions and the most common cement replacement, fly ash, contains trace heavy metals that has concerned some building owners. Fly ash availability is also increasingly inconsistent, with coal fired power being supplanted by natural gas and renewables in many regions of the US. The Durst Organization, Google, Facebook, and NYC Department of Design and Construction are piloting glass pozzolan cement replacement in concrete for NYC and San Francisco Bay Area projects. Whereas the first two projects are examples of closed-loop systems for two large sources of C&D waste, this third example is a case of a circular solution that crosses material supply chains and economic sectors. http://www.buildingproductecosystems.org/

4B. New Materials

Modular construction project example: Marea Alta by BRIDGE Housing

Marea Alta in San Leandro is the first modular project built by nonprofit affordable housing developer BRIDGE Housing. The project optimizes land use by converting a street-level BART parking lot into housing for 115 low-income households, a child care center, and 240 below-grade parking spaces for BART patrons. The general contractor Cannon Constructions North produced a series of videos documenting the modular construction process.

» http://youtube.com/channel/UC1CZMq0wkKSvaH_V5eZ7GjQ

Biobased material example: C2C certified Ecovative Mycoboard and Mycofoam

Ecovative uses what they call “mushroom technology” to grow mycelium within agricultural waste such as straw and rice husk to create custom forms. Initially used to create packaging and planters, the technology is now being used to create to building products including insulation, acoustic wall tile, chair components and countertop substrate. In 2013, a project team in New York decided to try to use it as structural building blocks for PS1, an outdoor temporary exhibit for the Museum of Modern Art. Extreme thunderstorms that summer compromised its structural integrity, requiring that it be taken down prematurely, but dismantling was slow enough that the blocks were used in educational displays about their next life as fertilizer, right beside the structure.

» http://archdaily.com/521266/hy-fi-the-organic-mushroom-brick-tower-opens-at-moma-s-ps1-courtyard
» http://interiors.ecovativedesign.com

Bio-based materials project example: Sonoma County Fire Survivor

A Berkeley-based architectural firm designed a single family home in Sonoma County that used renewable and salvaged materials. The materials selected included straw bale walls, salvaged wood, lime plaster, Corten steel roofing, and heavy timber Douglas fir posts on a noncombustible patio. A lap pool on the site stores water for fire protection and is also an integral part of the home’s heating system, with solar hot water collectors on the pool house roof that heat radiant floors in the winter. The home was sited with consideration of the land’s contours and existing vegetation. This project is notable because it survived the destructive fires that swept the North Bay in October 2017. When the owners returned to their home after the fires, they found scorched earth everywhere, but hardly any damage to the buildings. While the reason for its survival has not been explicitly examined, the properties of the selected materials as well as the site planning for defensible space may have contributed.

Material selection policy example: City and County of San Francisco Carpet Regulations

San Francisco has adopted new sustainable carpet purchasing requirements into regulation that are among the strictest in the nation. The specification requires, among others: carpet tiles; Cradle to Cradle™ Silver certification; 45% recycled content (10% postconsumer); Environmental Product Declarations (EPDs), Health Product Declarations (HPDs); and no poly- or perfluorinated compounds, flame retardants, antimicrobials, polyvinyl chloride, coal fly ash, polyurethane, styrene butadiene latex.

» http://www.sfapproved.org/san-franciscos-new-carpet-regulation-pushing-boundaries-green-products

Whole building LCA policy example: City of Vancouver

The City of Vancouver's updated Green Buildings Policy for Rezonings requires projects to either pursue Passivhaus standards or to report the life-cycle equivalent carbon dioxide emissions (i.e., global warming potential impact, or embodied carbon) of each building as calculated by a whole-building life-cycle assessment (LCA). The goal of this policy is to make the embodied carbon impacts visible during the building design phase to encourage lower-impact decisions, and for the City to build a dataset of WBLCA data for real local projects. The policy does not provide a benchmark or require meeting a threshold. It was developed in close consultation with the development industry.

Product LCA legislation example: California "Buy Clean Act" AB 262

In 2017 California passed AB 262, the "Buy Clean Act" which requires State agencies (including universities) to require construction contractors to produce Environmental Product Declarations (EPDs) for global warming potential (embodied GHG emissions) for four materials: carbon steel rebar, flat glass, mineral wool board insulation, structural steel. The State's General Services Agency will establish maximum GWP by facility type and material, based on current industry average (researching national and international EPD databases), and will revisit and may lower (never raise) every three years. AB 262 sets a precedent for EPD's and embodied emissions requirements in public projects, which local governments could emulate.

End Notes

1 Plan Bay Area 2040
http://2040.planbayarea.org/forecasting-the-future

2 Regional Housing Need Plan for the San Francisco Bay Area: 2014-2022.
https://abag.ca.gov/planning/housingneeds/pdfs/2014-22_RHNA_Plan.pdf

3 Plan Bay Area 2040 Focus on Alameda County.
https://www.planbayarea.org/counties/focus-alameda-county

4 The Bay Area Air Quality Management District commissioned UC Berkeley's Cool Climate Network to produce a consumption based emission inventory for every jurisdiction in the Bay Area
http://coolclimate.berkeley.edu/inventory

5 Krausmann et al. Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use (2017)

6 Architecture 2030 Challenge for Products
http://architecture2030.org/2030_challenges/products/

7 Zizzo, et al., "Embodied Carbon of Buildings and Infrastructure: International Policy Review," Forestry Innovation Investment, Sept 2017. [References: Tatsuo, O. et al. 2014. "Introduction of Annex 57 – Evaluation of Embodied Energy and Carbon Dioxide Emissions for Construction Worldwide". Proceedings SB 14, Barcelona.
http://www.irbnet.de/daten/iconda/null_DC28086.pdf

8 Ellen MacArthur Foundation. Growth Within, 2015.
https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf

9 The Athena Institute. Minnesota Demolition Survey: Phase Two Report, 2004.
http://www.athenasmi.org/wp-content/uploads/2012/01/Demolition_Survey.pdf

10 A. Miatto et al. "How important are realistic building lifespan assumptions for materialstock and demolition waste accounts?" Resources, Conservation and Recycling, 122 (2017) p. 143–154
http://dx.doi.org/10.1016/j.resconrec.2017.01.015

11 US Census Bureau
https://www.census.gov/construction/c30/c30index.html

12 http://www.sciencedirect.com/science/article/pii/S0921344917300265

13 https://tradingeconomics.com/united-states/construction-spending

14 World Business Council for Sustainable Development. Linear Risks. May 2018.
https://www.wbcsd.org/Programs/Energy-Circular-Economy/Factor-10/Resources/Linear-Risks

15 On national scale, concrete is used a little more than half in infrastructure and little less than half in buildings (per USGS Cement End Use Statistics), and globally steel is used about 3x more in buildings than in infrastructure (from a Cambridge Univ study).If we assume the global %'s apply to the US, then infrast steel+conc = 3% and buildings are 4%, which seems right per the 6% estimated for all building materials per Arch 2030. But infrast also includes a notable amount of PVC and HDPE utility conduit than is not in the 3% number.

16 Plan Bay Area 2040
http://2040.planbayarea.org/forecasting-the-future

17 http://www.hcd.ca.gov/grants-funding/active-funding/ahsc.shtml

18 http://jack-seanson.github.io/taskforce/interventions/

19 Growth Within, Ellen MacArthur Foundation

20 MTC Vita Signs
http://www.vitalsigns.mtc.ca.gov/housing-growth

21 East Bay Economic Development Alliance, "East Bay Economic Outlook 2014-2015"
http://eastbayeda.org/ebeda-assets/reports/2014/EDA-Outlook-2014-2015.pdf

22 Total gross floor area calculation assumes 1000-2000 sf per unit for residential and $200/sf for commercial.Embodied carbon calculation uses average of 300 kg CO2e/m2 for residential and 600 kg CO2e/m2 for commercial construction taken from Carbon Leadership Forum "Embodied Carbon Benchmark Study"
http://www.carbonleadershipforum.org/data-visualization/

23 The "sharing economy" is gaining strong private sector momentum. Local governments should be mindful of impacts that may exacerbate inequity, such as displacement of residents for short-term rentals, and changes in access to products created by disruptive non-ownership models. Smaller spaces should still be held to a minimum level of health, safety, and livability.

24 Senate Bill 1069 (Chapter 720, Statutes of 2016) made several changes to address barriers to the development of ADUs and expanded capacity for their development. SB 1069 addresses parking, fees, fire requirements, ADU's within existing space, and prohibits a local governments from adopting an ordinance that precludes ADUs. Assembly Bill 2299 (Chapter 735, Statutes of 2016) generally requires a local government to ministerially approve ADUs if the unit complies with certain parking requirements, the maximum allowable size of an attached ADU, and setback requirements. Senate Bill 229 and Assembly Bill 494 added more specific details including allowing ADUs to be built concurrently with a single-family home, opening areas where ADUs can be built to include all zoning districts that allow single-family uses, modifying fees from special districts, and reducing parking requirements.
http://www.hcd.ca.gov/policy-research/AccessoryDwellingUnits.shtml

25 Data from 2012-2016 American Community Survey 5-Year Estimates reports: Occupancy Characteristics; Occupancy Status; Vacancy Status.

26 Whole building Life Cycle Assessment (WBLCA) can reveal that sometimes retaining the existing structure is not the best use of a site from a total emissions perspective. For example, replacing certain low-density buildings, particularly near transit, with high-rise, high-density new construction results in higher embodied emissions but a net reduction in emissions due to reduce transportation emissions. WBLCAs quantify the total impact of a project throughout its lifecycle including embodied, operational (including energy usage and transportation by users), and its end of life. An assessment of full lifecycle impacts of alternatives (e.g. retrofit versus new high-density construction) that extends beyond the embodied impacts and takes into account the number of occupants served, provides a more complete comparison for decision makers than embodied impacts alone.

27 Larry Strain, Time Value of Carbon
https://westcoastclimateforum.com/sites/westcoastclimateforum/files/related_documents/10.12.17%20Built%20Environment%20and%20Embodied%20Carbon.pdf

28 In rental properties, local government programs and policies must consider the "split incentive" wherein benefits may accrue to the tenant while the property owner is making the upfront investment. Encouraging the transparency of upgrades to give them value in the market is one way for property owners to have a financial case for retrofitting their existing buildings.

29 http://www.vidaris.com/uploads/files/assessing-the-carbon-saving-value-of-retrofitting-versus-demolition-and-new-construction-at-the-united-nations-headquarters-199.pdf p. 2

30 CalRecycle Waste Characterization Tool
https://www2.calrecycle.ca.gov/WasteCharacterization/

31 For example, the State of Oregon is addressing the issue of requiring structural lumber to be graded and stamped in their Residential Building Codes. The City of Portland, as part of their deconstruction initiatives, noted that “older lumber, such as that coming out of deconstruction projects, is often not graded and stamped. However, given the old-growth nature of this salvaged material, it is equivalent or greater in strength when compared to conventional graded and stamped lumber.” Quote from Portland’s Deconstruction Program Six-Month Status Report.
https://www.portlandoregon.gov/bps/article/647940

32 While reuse of materials and building products already manufactured saves on the environmental impact of using virgin resources and fossil fuels, many contain trace amounts of toxic chemicals for building products to meet performance requirements of durability, water- or stain-repellency, fire-retardancy, hardness, stability, and other characteristics that are commonly demanded today. If these toxic substances become perpetually reintegrated in our built environment, our population and plants face repeated exposure, which leads to accumulation and pervasiveness that is difficult to contain or control, particularly for the health of the most vulnerable populations. Thus, in targeting circular economy principles, it is imperative to push for cleaner ingredients, and better disclosure of them, so we understand what products are made of to most judiciously determine where they should be going next.

33 Victoria University of Wellington, Table of Embodied Energy Coefficients, circa 2003.
https://www.victoria.ac.nz/architecture/centres/cbpr/resources/pdfs/ee-coefficients.pdf

34 A. Miatto et al (2017)

35 USGBC LEEDv4 Reference Guide
https://www.usgbc.org/guide/bdc

36 StopWaste 2017-2018 Waste Characterization Study, June 2018 draft

37 U.S. Environmental Protection Agency: Sustainable Management of Construction and Demolition Materials
https://www.epa.gov/smm/sustainable-management-construction-and-demolition-materials#what

StopWaste helps Alameda County's businesses, residents and schools waste less, recycle more and use water, energy and other resources efficiently. We're a public agency governed by the Alameda County Waste Management Authority, the Alameda County Source Reduction and Recycling Board, and the Energy Council.

Our work helps people make better decisions everyday about the products they buy, the resources they use, and the stuff they throw away. The less we waste and the more we recycle, the better off we all are.

www.StopWaste.org

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