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Dr. Fraser Pick
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[WASTE AS A RESOURCE: TOOLS FOR CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT]

Contents

Introduction

Efficient use of resources will be one of the biggest societal challenges in the 21st century. As urban living becomes more prevalent throughout the world, cities will play a central role in how we efficiently use natural resources and dispose of our waste. As we increase our consumption of raw materials and production of waste key resources become more scarce and the economic and environmental burdens caused by waste management become more severe. These issues will be exacerbated by the increasing global population, set to hit 9.8 billion by 2050.[1] In a recent estimate, 54% of the global population lives in cities and this is expected to rise to 66% by 2050.[2] Within cities, the built environment and the construction renovation and demolition (CRD) sector consume huge amounts of resources. This sector influences 40-50% of the world's raw material consumption, 35% of the world's greenhouse gas (GHG) emissions, 30-40% of the world's energy consumption and produces 60% of the world's solid waste.[3-5] Due to its high resource usage and emissions, the CRD sector will be a key player in reducing consumption of natural resources and waste production. As the global population and urbanization continues to increase, we must begin to decouple economic growth from the consumption of finite natural resources by transitioning from a linear to a circular economy.

The Case for a Circular Economy

A circular economy is an economy where all outputs are collected and reintroduced as inputs. Any outputs not reintroduced to the economic cycle, such as solid waste to a landfill, are referred to as leakage. The cycle is usually divided into two halves: inorganic materials which circulate through the technosphere and organic materials which circulate through the biosphere. The ultimate goal would be to return all organic materials to the biosphere and to keep all inorganic materials within the loops of the technosphere for as long as possible. A recent report from the Ellen McArthur Foundation[6] outlines a structure for the circular economy which is illustrated in Figure 1. The potential benefits to a circular economy are enormous. McKinsey and Company recently estimated that 2.9 to 3.7 trillion dollars in savings could be achieved worldwide by the increasing resource productivity.[7] In addition, a circular

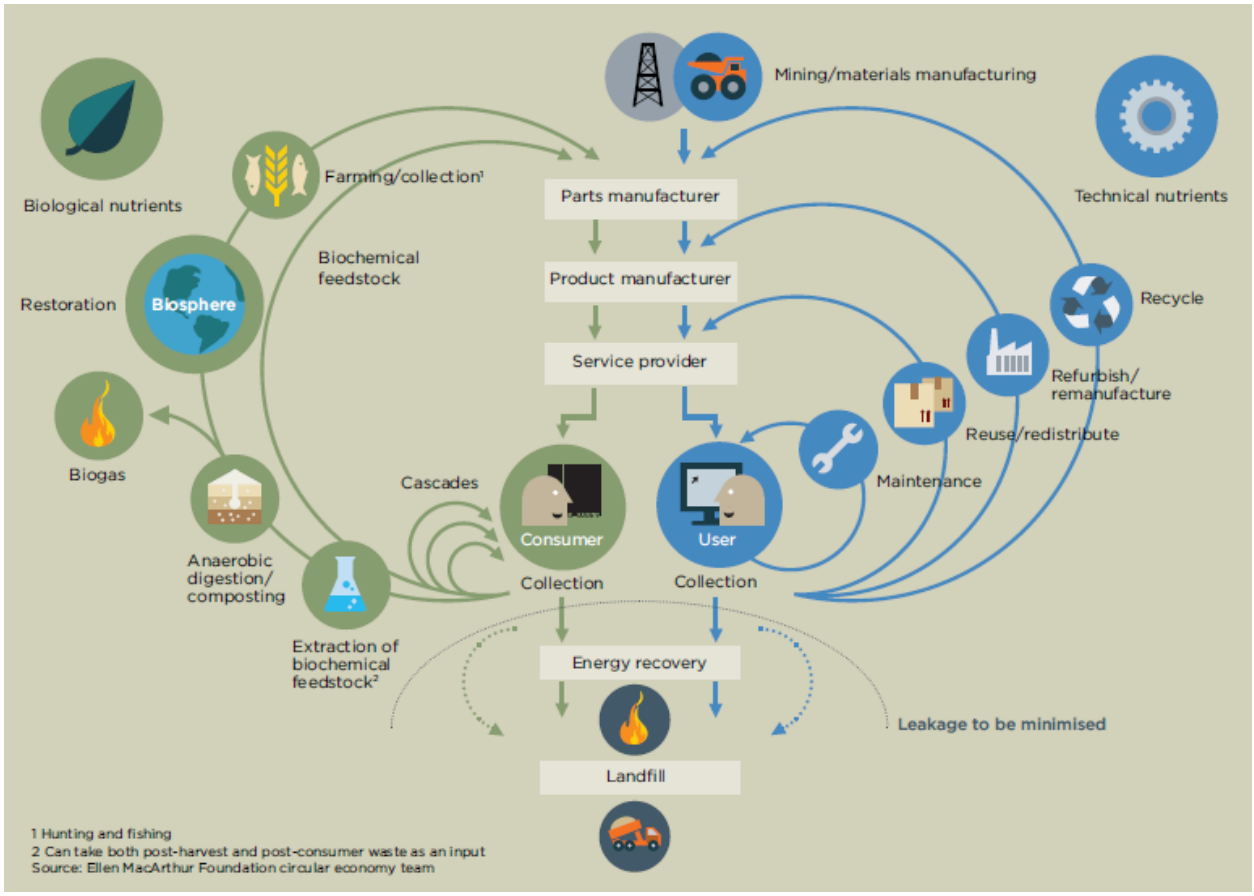

Figure 1: Two Halves of the Circular Economy

economy can trigger innovation, create new businesses and jobs, and increase the security of the resource supply chain. Current barriers to the transition to a circular economy include:[8]

1. Economic barriers resulting from vested interests in current economic models.
2. Legal barriers caused by existing legislation that impedes development or implementation of innovative technologies.
3. Behavioral barriers caused by consumers who shy away from adopting new technologies or ways of doing business
4. Technological barriers resulting from a lack of research on and/or funding of technological solutions.

There are multiple routes by which the inorganic products of our built environment can be returned to the technosphere. The most efficient routes are the ones where the building or building material is kept in a higher value state. For example, maintaining existing buildings, renovating a building, or reusing products and existing structures keep the higher value elements of our built environment intact. This requires less energy than recovery of raw materials through recycling due to the large amounts of energy needed to recycle and remanufacture materials. In a case where reuse or recycling are not viable options some organic materials can be used directly as fuels or converted into biofuels. All of these processes

minimize the amount of waste destined for landfill and while all these methods can be effective, in general the smaller the loop the higher the efficiency. Maintaining a material as a high value product is preferable to "downcycling" which occurs when a high-value product is converted into a lower value product. For example, an engine which is recycled as scrap metal has been downcycled because more energy will have to be consumed in order to reform a new engine from the recovered metal. In contrast, if an engine block can be salvaged and refurbished, far less energy will have been consumed because the block will not have been melted and reformed.

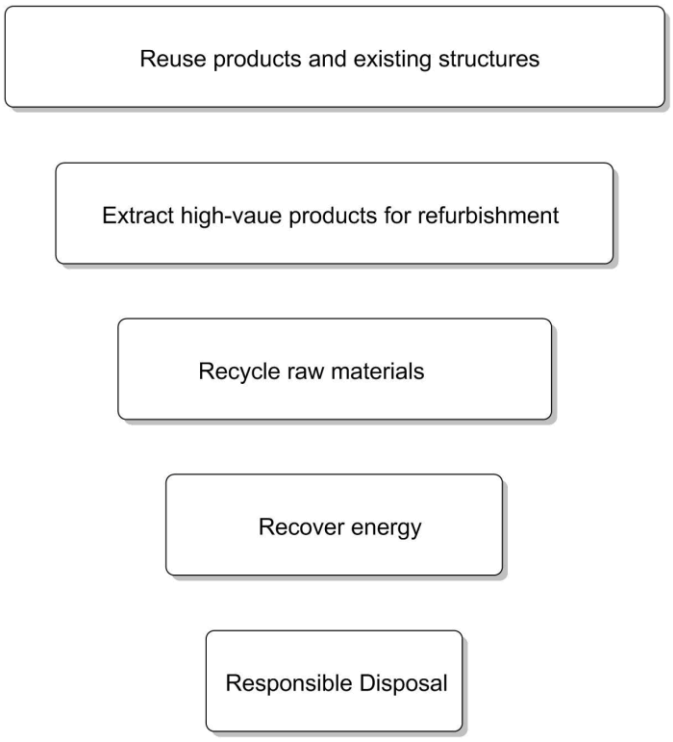

Figure 2: CRD Waste Management Hierarchy

Due to the complexity of the built environment, multiple approaches must be used to return all the various building materials to the technosphere. Factors which can affect this include, the types of building materials used in the original construction, the condition of those materials and toxicitiy of materials used in older buildings (asbestos insulation as an example). If maintenance and renovation efforts have been exhausted and a building must be deconstructed, a waste management hierarchy for CRD waste, shown in Figure 2, can help prioritize different types of waste management. Keeping materials in their highest value form for as long as possible results in maximal resource efficiency. By utilizing the lower forms of waste management like recycling, material leakage associated with CRD activities can be minimized. The best waste management is to not produce waste in the first place. Reusing existing products and structures, for example foundations, windows, HVAC systems and light fixtures results in significant energy savings when compared to manufacturing new products and disposing of old ones. If these products are not suitable for reuse they can be extracted, repaired or retrofitted and returned as building materials with minimal energy input. If the material is beyond repair, recycling of all the raw components reduces any leakage and ensures that natural reserves of these materials are preserved. If the quality of the raw material is too poor or if the market/technology of the recycling process is not yet mature, some raw materials including plastic, wood and rubber can be used as fuel. Finally, any material left over is disposed of in a landfill. By reducing the amount of construction and demolition required through reuse and repair when possible and

following the CRD waste management hierarchy when demolition is necessary, the amount of leakage can be minimized. This results in less stress on natural reserves, lower overall waste management costs and economic growth for companies focused on recycling, repair, and responsible demolition.

Municipalities and Sustainable Procurement

As of 2011 the fifteen largest municipalities in Canada spent 10 billion dollars annually on services, goods and capital projects.[9] If those services, goods and capital projects were not only reasonably priced, effective, and constructed with quality materials but also contributed to a more sustainable economy, the result would have a substantial influence on the market for those products. The National Zero Waste Council occupies a unique position with the ability to bring together municipal decision makers and the business leaders whose products and services are being procured. The council should take advantage of that position and encourage sustainable procurement as a mechanism for driving sustainable change.

In the 2016 Metro Vancouver budgeted:

- **42 million** dollars on new infrastructure related to the Greater Vancouver Water District

- **49 million** will be spent on new sewers

-**5.7 million** on renovations for the Metro Vancouver Housing Corporation

-**17.2 million** for upgrades at solid waste facilities in the region

- **6 million** on Sustainability Opportunity Projects

Sustainable procurement is a term which encompasses ethical procurement, socio-economic procurement, and environmentally conscious procurement. The large amount of waste generated from CRD activities means that sustainable procurement in this sector will result in a large environmental impact. In addition, sustainable procurement has the potential to act as a demand-side market force influencing local producers, and encouraging development of sustainable products and practices. More specifically sustainable procurement can offer the following benefits:

- Enhance the city's brand as a sustainable city
- Stimulate the local economy
- Contribute to the brand of 'Zero Waste' and other sustainability goals
- Reduce municipal operating costs by selecting durable and reusable materials

Many municipalities across Canada have begun constructing sustainable procurement policies.[8] However, the planning has outpaced the "doing" in many municipalities. Much of this can be attributed to the limited resources available to a sustainable procurement program, because

planning requires less technical expertise and resources than implementation. Nowhere is this more apparent than in the CRD sector. The complexity of a major capital construction project and the number of vendors responsible means that the initial sustainable procurement process is a long and often novel process for a municipality. Additionally, financial or political pressures might force a project to be done in a short period of time, limiting the ability of procurement teams to evaluate metrics such as lifetime assessments, embodied CO_2 or total cost ownership models. From the other side of the request for proposal (RFP) process, many producers feel as though the sustainability criteria in an RFP are not emphasized and that they can only win a bid by having the lowest possible price. Also, in many cases large capital projects must follow specific guidelines for construction which are set by an outside body. The Master Municipal Construction Documents Association (MMCD) sets out guidelines for standard construction that are used by many municipalities when determining product reliability. These guidelines may not have sustainability as a core value, and are often slow to update when compared to the fast pace of innovation in sustainable building materials. The lack of resources devoted to implementing sustainable procurement, perception regarding sustainability criteria in RFP's, and restrictions imposed by outside organizations creates a situation where sustainable procurement is not used in large scale projects. However, these large projects offer some of the greatest returns on investment (ROI) to municipalities, as their scale increases the possible financial recuperation.

Characterization of CRD Waste in Metro Vancouver

To begin looking for opportunities for the circular economy, we must examine current waste generation. Metro Vancouver commissioned a study by Tetra Tech to determine the composition of Demolition Land Clearing and Construction (DLC) waste that reached landfills in 2015. Using the data found in the 2015 Metro Vancouver Regional Recycling and Solid Waste Management report allows for a comparison of the diversion rates of various building materials (Table 1). The diversion rates look very promising, as the DLC diversion rate for 2015 was 74%, which is well above the 62% diversion average of all municipal waste.[10] A limitation of this data is unregulated disposal is not accounted for. Speaking with municipal leaders from the region, it is clear that illegal dumping is still a concern in many areas, particularly the more sparsely populated areas of Surrey.[11]

While high diversion rates reflect a reduction in the economic and environmental costs of landfill disposal, they do not quantify how much of that material is actually reintroduced to the production cycle. In addition, because the numbers are reported as percentages an increase in diversion rates could occur while the total tonnage of waste received by landfills increases. This is especially true of municipalities experiencing a high rate of growth. Examining the

tonnages of different waste streams we can see that concrete, asphalt and wood make up over 80 % of the waste produced by the CRD sector. Therefore increasing the quantity of these materials that are reintroduced into the production cycle would result in the largest impact. Collecting information about the fraction of diverted material which is returned to the production cycle would give policy makers a metric by which to gauge the circularity of various waste streams.

Material	Produced (kT)	Recycled (kT)	Landfills (kT)	Diversion Rate (%)
Concrete	530.9	530.4	0.5	99.9
Asphalt	217.2	182.6	34.6	84.1
Wood	472.2	254.3	217.9	53.9
Metal	37.7	29.9	7.8	79.3

Table 1: Estimated Diversion Rates for Metro Vancouver

The current state of concrete and asphalt recycling (the two materials with the highest diversion rates) in Metro Vancouver is not sustainable. During interviews, many companies responsible for concrete and asphalt recycling spoke about a small local market for their materials leading to over-full recycling yards. Some recyclers have temporarily stopped accepting concrete and/or asphalt due to these concerns. Others have dramatically increased their tipping fees in order to discourage customers from bringing in more material and to offset the cost of hauling this recycled material to landfill facilities outside of the region where tipping fees are lower and more CRD materials are accepted. These increased tipping fees proceed to discourage recycling and lead to a higher rate of illegal dumping. The diversion rates for concrete are nearly perfect because transfer stations do not accept concrete and rubble, however, there is over 30 kT of asphalt heading for regional landfills and the vast majority of it comes from one source, roofing shingles which are not recycled at any regional facility.

Figure 3: A Rubble Pile in Port Kells

Wood and metal wastes are in a different situation for a couple of reasons. Most noticeably both are still accepted at regional landfills and therefore the tipping fees of the recycler play a smaller role in encouraging illegal dumping. For wood waste many municipalities currently operate or are planning to operate biofuel facilities where some types of this material can be consumed as fuel (the second lowest form of CRD waste management). This would occur when the market conditions for recycled wood products are poor or, in the event that the material is too poor to be used in recycled products. However, recycled metal has a fairly robust market and many recyclers have negative tipping fees, which has a great impact on recycling rates. Due to the strong market for recycled metals, this is a waste stream where an increase in diversion rates is a strong indicator of the amount of material being recycled and returned to the production cycle.

Currently, the CRD sector has a very good reported diversion rate but conversations with recyclers indicate that this rate is misleading. In particular, the ratio of the recycled aggregates purchased relative to the amount of concrete and asphalt brought to these facilities is low. There is room for improvement in the way concrete, asphalt, and wood waste are managed in Metro Vancouver. For example, concrete and asphalt are two of the largest waste streams with poor rates of recycled product reincorporation. Wood has poor diversion rates, and most programs which divert wood from landfill result in downcycling (wooden beams to wood chips) or use in fuel. In order to move towards a more circular approach to waste management, more attention must be paid to the reincorporation of recycled material compared to the amount of waste being diverted.

Municipal Survey

Part of this report involved interviewing municipal staff from Halifax, Surrey, Toronto, and Vancouver. The focus in these interviews were:

1. sustainability goals or programs regarding the reduction and utilization of solid waste
2. physical limitations and/or engineering concerns about materials made from waste
3. circular economy consideration in procurement scope
4. quantities and types recycled aggregates used in municipal projects

All of the municipalities surveyed have goals regarding the diversion of solid waste. Goals were either expressed as a percentage of solid waste diverted from landfill or a reduction in the total quantity of landfilled waste. While the former allows municipalities experiencing rapid population growth to measure improvements to the recycling programs, the latter gives a more accurate picture of progress towards zero waste. In contrast, none of the municipalities surveyed have goals regarding the procurement of recycled materials. All of the municipalities surveyed reported that they either had a sustainable procurement plan in place or were in the

process of developing one. None of the procurement plans had specifics regarding building materials and all of them focused on the sustainability practices of the businesses which provide the goods and/or services rather than the goods and/or services themselves. The imbalance between solid waste diversion and procurement causes a glut of recycled materials, which over time hinders the profitability of recycling operations. Measuring how much recycled content is being purchased by municipalities and then setting targets for improvement would help create better markets for recycled material.

As mentioned previously, concrete rubble is the single largest component of CRD waste in Metro Vancouver. One of the simplest ways to recycle that content is by crushing the concrete to produce recycled aggregate which can be used in place of virgin aggregate for things like road base and subbase. By using recycled aggregate, landfilled material is reduced, natural rock reserves are left intact, and emissions from mining virgin aggregate is avoided. Due to the high weight and low cost of aggregate the most expensive part of aggregate is often the transportation costs from hauling aggregate from quarries to work sites. Recycling aggregate in multiple yards, spread throughout a city, results in local sources of aggregate leading to lower transportation fees and a more efficient supply chain. In addition, when waste concrete is crushed to form recycled aggregate, volumes of the concrete that were not fully carbonized become exposed to the air, which results in CO_2 absorption.

There were large variations in the amount of recycled aggregate allowed by RFPs in projects between the municipalities surveyed. The allowed content varied from 0 – 25%. In other municipalities across Canada and into the United States, recycled aggregate can make up to as much as 80% of aggregate used in road construction. For asphalt, the allowed recycled content was consistently capped at 10% and excluded the use of crushed shingles from the mix. Again, many states in the USA use far more recycled asphalt in their roadwork and mixes of up to 30% are used without any drop in quality[12] and mixtures using as much as 90%-100% recycled content are feasible. The most common issues raised by the municipalities around the use of recycled aggregate were being able to trust the quality of the material, and a desire to make the bid process open to a wide array of contractors. In addition, some municipalities were unable use recycled materials not included in construction specification documents like the MMCD for municipalities within Metro Vancouver. An issue brought up by the City of Vancouver, which uses the largest fraction of recycled aggregate of any municipality in Metro Vancouver, was that education of the foreman and installation crews is critical because of the slightly different techniques and mix ratios needed to work with recycled aggregate.

From the interviews conducted with the four municipalities, it is clear the there is an appetite for increased sustainability in CRD sector, however, regulatory issues and a lack of trust are current barriers to increasing the use of recycled aggregate. These same issues could

arise as barriers to increasing the use of other types of recycled building materials. In the next section some case studies are presented which showcase programs from across Canada which help drive a circular economy.

Best Practices

Simcoe County's Diverse Portfolio of In-House Recycling

Simcoe County in Southern Ontario operates recycling programs for more than 20 different types of material including waste streams relevant to CRD activities like rubble, shingles, windows, wood, scrap metal, drywall and brush. The county incentivizes the waste producer (commercial or residential) to sort their own waste by charging variable tipping fees ($0 - $155 / tonne) which are lower than the mixed-waste fee ($310 / T). By passing this responsibility to the waste producer, systematic deconstruction rather than demolition is incentivized. When using systematic deconstruction, waste can be disposed of directly without the need for sorting at the transfer station. In the case of materials such as metal, rubber and clean fill, where there is a robust market, the segregated waste is accepted at no cost.

The county has noticed a dramatic increase in the quantity of material received after changing tipping fees. For asphalt shingles, lowering the fee from $155.00 / T to $75.00 / T resulted in twice the amount of shingles received, indirectly showing that the amount of shingles ending up in landfill or illegal dumping sites had been decreased.

Figure 4: Shingle Processing at Simcoe County Facility

The county then processes the shingles and sells the crushed shingles to to asphalt companies in the region. Rubble and clean fill are currently accepted for free to increase diversion, however the ability to market these products is restricted by municipal regulations. Nevertheless, Simcoe County is planning on using this material in their projects as soon as possible and currently sell rubble and clean fill to paving companies in the region for use in private projects which are not bound by the same regulations.

Another innovative program relevant to the CRD sector is window pane recycling. The windows are first separated into glass, wood and aluminum, which makes up the window. The

high price fetched from the recycled aluminum pays for the recycling of the glass, which is one of the recycled materials with the poorest market. As an added benefit, because the recycled glass is more homogenous (no residential glass bottles are mixed in) the recycled glass is more valuable, again illustrating the benefit of increased waste segregation.

Figure 5: Recycled Window Panes

The wide array of recycling programs offered by Simcoe County is an effective strategy to manage solid waste. Through these programs, diversion rates of over 70% have been achieved. These rates are also based on better data: the quantity of material sold to producers or used directly by the county instead of material simply diverted and is sitting in a pile across the street from the landfill. By using this method of calculating diversion rates, a more accurate picture of recycling is obtained because it focuses on the circularity of the process in addition to the landfill diversion. The recycling programs in Simcoe County are especially impressive considering the relatively small volumes of waste received in comparison to large urban municipalities.

A municipality looking to increase the diversion of CRD waste from its landfills, and return the material to the production cycle, should examine some of the programs already in operation in Simcoe County. There is no point trying to re-invent the wheel.

City of Edmonton's Usage of Recycled Aggregate

Figure 6: Blair Buchholtz, general supervisor of Transportation Services' aggregate recycling services standing near a pile of recycled aggregate. Source: transformingedmonton.ca

The city of Edmonton has a robust market for recycled aggregate . Much of this market can be attributed to the geography of the Edmonton area. The soil in the area has high water content and there are no high quality quarries within 200km of Edmonton. Because recycled aggregate is produced in and around the city of Edmonton, transportation costs and emissions associated with transportation are reduced compared to virgin aggregate. The city is able to save $10 - $15 / metric tonne in

haluing fees by using the recycled aggregate reserves in the city which works out to over two million dollars annually. Due to the poor quality of natural rock reserves in the Edmonton area, recycled aggregate is actually seen as a premium product in the Edmonton area and is priced accordingly. This means that any recycled aggregate not used in city projects can be sold to companies in the region at a profit. By eliminating the need for long haul trucking of waste out of the region and aggregate into the region, the City of Edmonton saves an estimated $14.3 million every year.[13]

The city of Edmonton conducted a study in the early 2000's on a section of roadway in west Edmonton. In this section, they tested different formulations of sub-base and sub-structure. The best section of road contained a sub-base made from 100% recycled aggregate and a top layer of fine virgin aggregate. This is the specification that the city uses for all their roadwork projects, which drive the market for recycled aggregate. The direct procurement of recycled aggregate by the City of Edmonton has led to a competitive market for recycled aggregate produced by municipally operated yards, aggregate suppliers and demolition companies. Demand is typically slightly higher than the supply, which varies from year to year, so clean concrete is a sought after waste commodity and there is minimal leakage of this material. Due to the high demand, the city of Edmonton mandates that all concrete produced when demolishing a capital project must be cleaned and returned to the city operated yards for recycling. In addition clean concrete rubble is accepted for free at municipal and privately run facilities across the region. At the time of this report, the city does not operate a crusher, choosing to subcontract that work. Even with this excellent market for recycled aggregate, there are still old stockpiles of concrete around the Edmonton area. These piles typically contain dirty concrete, which is no longer accepted at most facilities, or concrete structures which ae difficult to break apart. This illustrates the impact deconstruction and waste sorting have on the recyclability of building materials. Much of these old stockpiles will most likely be reduced over time as the demand for recycled aggregate increases.

The city of Edmonton and aggregate suppliers in the region are investigating ways to replace the top layer of virgin aggregate with recycled aggregate, but so far have not found an optimal size of recycled aggregate. Other investigations are ongoing to investigate how much recycled aggregate can be used directly in new concrete, which would continue to increase demand

Figure 7: Mammoet Headquarters in Edmonton, AB

for this product. The asphalt waste stream is utilized in Edmonton as up to 25% w/w of the recycled aggregate and can contain up to 5% recycled shingles, although currently only new shingles which fail quality control during production are used.

The City of Edmonton has shown that recycled aggregate can be used as 100% of the sub-base without a loss in strength. As an example, Mammoet operates a facility just outside of Edmonton where cranes and other large pieces of equipment are stored in an asphalt parking lot. The large temperature swings common in northern Alberta combined with the movement of heavy equipment creates very demanding environment for paving. The Mammoet lot was repaved using recycled aggregate as a base more than 8 years ago and shows no sign of wear and tear in this very difficult environment.[14] In addition to the showing the utility of recycled aggregate the city has shown that by specifying that recycled material be procured for capital projects they were able to stimulate the market for recycled aggregate to the point where there are no tipping fees for clean concrete and asphalt waste in the region and very little leakage of this material.

City of Vancouver Deconstruction Bylaw

In 2014 the Green Demolition By-Law came into effect. This bylaw outlines the amount of material that must be diverted from landfills or various types of demolition work. For example, homes built before 1940 must have waste diversion rates over 75%, and character homes of that era must meet an even stricter 90% diversion rate. In the 13.5 months since the bylaw came into effect, 296 pre-1940 homes were demolished and those homes averaged an 87% diversion rate. This is much higher than the average residential demolition rate of 50%. As a result of not landfilling the wood from these homes over 3000 tonnes of GHG emissions were avoided.[15] The success of this program has led city officials to expand this program to pre-1950 built houses and plans are in place to eventually include all residential one and two family homes.

Figure 8: Wood Salvaged by Naturally Crafted

The Green Demolition bylaw is an excellent starting point for waste management? However, the fate of this diverted material needs to be monitored in order to ensure that the material is

being utilized in its highest value form. For example, reusing a structural beam, or using said beam to build a counter top results in a high value product compared with crushing the beam into mulch. According to a recent report,[15] the city of Vancouver is considering ways to incentivize the salvage process, as opposed to simply recycling. One way this can be done is to allow deconstruction to begin before a building permit is approved, if the contractor agrees to salvage a significant amount of wood from the home. However, before implementation of a regulation change, the amount of wood that can be realistically salvaged from a home must be determined. Naturally Crafted is a demolition company based in Vancouver that is trying to answering the question of how much wood can be salvaged. In the deconstruction projects they have done in the past year, they estimated that 80-90% of the wood in a home can be salvaged which results in 10.5 T of reclaimed wood per home. The remaining 10-20% can be recycled by conversion to wood chips for landscaping or hog fuels. The salvaged wood is currently used for finishing and furniture but in the future, the company plans to produce new building materials from the salvaged wood. By salvaging the vast majority of wood used, they are able to reduce the amount of wood that must be brought to recyclers, which is typically downcycled to wood chips or burned for energy extraction, and maintain the materials' inherent value.

The Green Demolition bylaw will be continually expanded and revised over the next few years and hopefully the expansion will encompass all residential demolition. Moving forward, future iterations of this type of program should ensure that salvage is prioritized over recycling. Another way to promote deconstruction would be to increase the tipping fees for mixed-waste at Vancouver transfer stations. While this bylaw is not a procurement based approach, it is a municipal program which supports companies that recycle and reclaim waste from demolition. This decreases the burden on landfills, reduces GHG emissions and moves the demolition sector towards a more circular approach to waste management.

Figure 9: Renovation by Naturally Crafted using reclaimed wood for floor, posts and mantel

Future Directions in Metro Vancouver

The National Zero Waste Council is able to facilitate a wide variety of changes that will move the CRD sector towards a more circular economy. There are four main areas the CRD working group of the NZWC can help facilitate this change in Metro Vancouver:

- Promote deconstruction and improve the waste segregation and diversion for CRD activities.
- Set up sub-committees to assess ways the market for recycled content can be improved. This could be through municipal procurement, regulating the disposal of certain materials or encouraging the growth of recycling companies through municipal partnerships.
- Create a plan for future building design, which would include increased modularity, easier deconstruction and the use of recycled building materials.
- Help with knowledge transfer between Canadian municipalities who have had success with certain recycling programs.

Low-Hanging Fruit

1. Promote the Increase use of Recycled Aggregate

The amount of recycled aggregate used in roadwork in Metro Vancouver is highly variable between municipalities. On average the recycled content allowed in bids by municipalities within Metro Vancouver is far lower than what is allowed in other organizations such as the City of Edmonton of the Federal Highway Association of the United States. Within Metro Vancouver, changing the local requirements and MMCD specifications regarding recycled aggregate to allow the higher ratios employed in other parts of the world would give recycled aggregate a level footing compared with virgin aggregate. This would allow the economics of different projects to determine the aggregate used. The standard could be based on formulations used in other municipalities or a test section of roadway could be used to find an ideal mixture for the Metro Vancouver region. In either case, a dramatic increase in the amount of recycled material used in paving would begin to reduce the piles of rubble in the region, preserve natural reserves and reduce GHG emissions. To achieve this, a board comprised of engineers and waste management staff from all regional municipalities would need to be assembled with the goal of creating a regional plan. This plan should cover recommended fractions of recycled aggregate as well as create educational material for road crews concerning how to deal with the different products.

2. Begin Recycling Shingles

While asphalt has a fairly high diversion rate of 84% (See Table 1) a large component of the remaining 16% is roofing shingles. These shingles can be crushed and used in recycled aggregate in as high as 10% loading, although 3-5% is more common. This type of recycling is already being done in Edmonton for new shingles and in Simcoe County, all ages and qualities of shingles are accepted. Establishing a regional center to process shingles could remove up to 34 kT of asphalt from landfill each year.

3. Promote and Expand Deconstruction in the Region

Currently only the City of Vancouver has deconstruction regulations and their plan is to slowly expand the scope of these regulations to include all single and double occupancy homes over the next 2 years. As was mentioned previously, deconstruction and salvage create economic value by utilizing materials in their highest value form and allow for easier recycling of materials which cannot be salvaged by properly segregating waste on site. The National Zero Waste Council should promote these types of regulations to other municipalities in the region. For municipalities who are averse to setting up a deconstruction regulation, variable tipping fees can affect a similar change. Utilizing high tipping fees for mixed-waste and low tipping fees for sorted waste can produce easier recycling and high diversion rates while still allowing individual contractors the decision in how to deal with the waste they produce.

4. Explore Ways of Preventing Waste from Leaving the Region

If waste can freely leave Metro Vancouver, increased tipping fees is a far less effective way to drive behavioral change. Due to the close proximity of Metro Vancouver to the US border, waste can be hauled across the boarder where tipping fees are much lower. By keeping waste inside the region while continuing to increase diversion rates, the Metro Vancouver area will have a surplus of recyclable material which will assist with the economic viability of regional recycling companies.

Medium - Long Term Targets

1. Develop a Circular Design Culture in the Building Community

In order to better manage CRD waste and reuse as much material as possible, new buildings can be designed with circularity in mind. Aspects of this type of design include: designing buildings which use as much recycled material as possible, designing a building which can be easily modified or expanded as the role of the building changes, submitting a deconstruction plan along with the application for a building permit, using construction techniques that make deconstruction easier and result in less waste, purchasing materials from suppliers who use minimal packaging, and outfitting the building with green building design

features. Green design features include solar orientation, green roofs, PVC panels, well insulated windows and heat recovery ventilation systems. Many of these design concepts, building practices and design features are part of the Canadian Passive House initiative (CanPHI) which is based off the original Passive Haus institute in Germany. Municipalities can play a leading role in using Passive House design principals in their own projects, and by incentivizing builders who build passive homes. By fostering circular design concepts, encouraging modularity in design and supporting innovative builders, municipalities can ensure that future construction, renovation and demolition projects can be less wasteful.

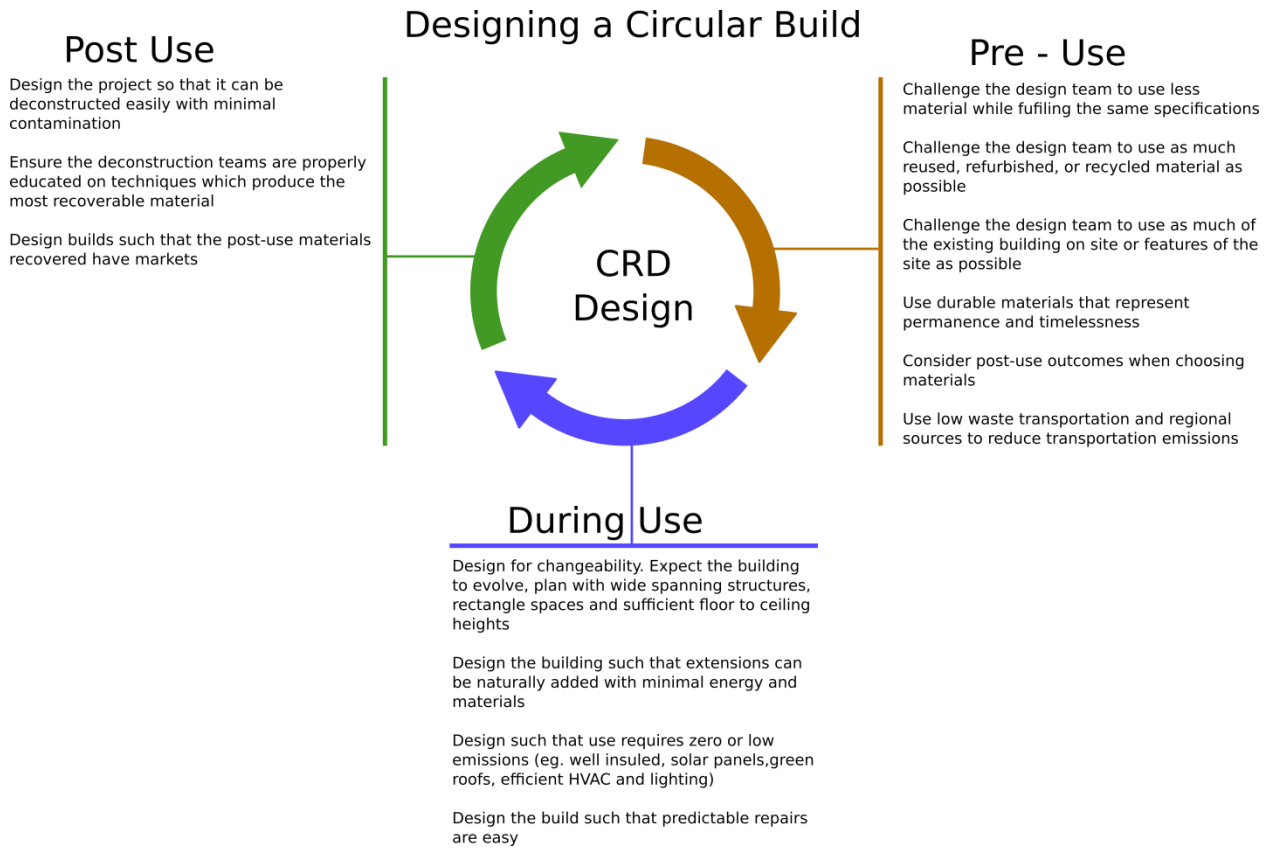

Figure 10: Principals of a Circular Design

2. Leasing of Building Materials

An innovative idea that is gaining traction in the Netherlands is a pay-for-access model to building materials. For example, Schiphol airport in the Amsterdam recently partnered with Royal Philips and Cofely to lease lighting solutions for the airport. In this arrangement, Philips retains ownership of the light fixtures and bulbs, the maintenance of the light systems are done by Philips and Cofely, and the Schiphol group pays for the light it uses. Because Philips retains ownership of the light fixtures, they will be responsible for their re-use and recycling at end of life. By passing the responsibility of maintenance and recycling to the supplier of the product, the supplier is incentivized to use long lasting materials which are easily re-used to cut down on

costs. In the Schiphol airport, Philips worked with design firm Kossman.dejong, to design fixtures that would last 75% longer and whose components can be individually replaced. This makes service easier and because the entire fixture does not have to be recycled, it optimizes the amount of raw materials needed to supply the light as a service. Similar lease arrangements are available for carpet from in the Netherlands and in Canada the office equipment leasing is available. Municipalities have two ways in which they can encourage these types of partnerships. First, municipalities can participate in leasing programs for their buildings. These programs could include light fixtures at transit stations or furniture and carpeting in municipal buildings. Second, municipalities can ensure that these types of arrangements are easy to initiate and that building codes have sections relating to these types of partnerships.

Figure 11: Lighting in a passenger lounge at the Schiphol airport. Source: lighting.philips.com

Conclusions

The CRD working group of the National Zero Waste Council occupies an advantageous position to cause a shift towards a circular economy in our built environment due to its diverse membership of municipal and business leaders. In consultation with business leaders, municipal governments can use procurement, waste management, zoning bylaws and policies as tools to drive this change. Within Metro Vancouver there are numerous opportunities to improve the

way CRD waste is handled that will lead to less waste ending up in landfills, fewer GHG emissions, savings for the taxpayer and a more sustainable city.

This report is recommending a number of changes to municipal practices, bylaws and zoning be implemented. The main recommendations for municipalities are to use their buying power to drive the market for recycled materials and amending bylaws that create barriers to using recycled products. Measuring the amount of recycled content purchased by municipalities and setting future goals for increased procurement will strengthen the recycled economy and promote municipal accountability. Sustainable procurement policies should be amended to include full life-cycle analyses and an embedded CO_2 analysis of products being purchased. On the waste diversion side, Metro Vancouver and the municipalities within can use variable tipping fees and deconstruction regulations respectively to increase diversion rates and encourage high-value reuse.

Working in partnership with builders and architects, a set of circular design principals should be written that address our regional needs. Once complete, these principals can be used as criteria for building incentives. Forming working relationships with organizations like LEED, Passive House Canada and BAMB would be an excellent way to build relationships and share expertise with leaders in the field. By working together through the National Zero Waste Council, municipalities and businesses from the CRD sector can change the way we think about the built environment, and create the sustainable cities the future needs.

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