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The Circular Economy: Quantifying the Gross Maximum Economic Contribution of Materials in the City of Phoenix Waste Stream

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Sustainability
Solutions Initiatives

L. WILLIAM SEIDMAN RESEARCH INSTITUTE

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Using tools that support sophisticated statistical modeling and planning, supplemented by an extensive understanding of the local, state and national economies, Seidman today offers a host of economic research and consulting services, including economic impact analyses, economic forecasting, general survey research, attitudinal and qualitative studies, and strategic analyses of economic development opportunities.

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EXECUTIVE SUMMARY

- This is the second of a two-part circular economy study implemented by the Seidman Research Institute on behalf of Walton Sustainability Solutions Initiatives (ASU) and the city of Phoenix.
- The first study, published in fall 2016, estimated that circular economy activities in Maricopa County in 2014 could contribute a maximum \$1.9 billion to Gross State Product and generate 35,454 jobs.
- An estimated 15.94% of materials (or 78,509 tons) were recycled through the city’s curbside programs in 2014.¹
- The purpose of this second study is to identify and quantify the gross maximum economic impact of waste diversion options for the currently recycled and additionally recoverable tons of plastic, glass, metals, and paper in the city of Phoenix municipal waste stream.
- Consistent with the first study, Seidman’s economic impact analysis assumes that the local processing of waste-diverted feedstock generates additional demand, rather than replace existing demand for “virgin” or prime inputs. As a result, the economic impact estimates in this study are **gross** and represent a **maximum** potential impact. That is, they take into account the capital and operational costs of processing the recycled materials, but do not account for any corresponding fall in the demand for “virgin” or prime feedstock, or the cost of any incentives potentially offered by state and local governments to attract recycled processors to establish plants in Maricopa County.
- The estimates of recycled and additionally recoverable materials in the city of Phoenix single-family residential (municipal) waste stream are sourced from Cascadia’s 2014 Waste Characterization study, summarized in the table below:

Estimates of Recycled and Additionally Recoverable Materials in Phoenix’s Municipal Waste Stream

| MATERIAL | CURRENTLY RECYCLED ² <i>Tons</i> | ADDITIONALLY RECOVERABLE ³ <i>Tons</i> | TOTAL <i>Tons</i> |
|----------|--|--|----------------------|
| Plastic | 11,558 | 11,848 | 23,406 |
| Glass | 9,527 | 4,591 | 14,118 |
| Metal | 3,976 | 6,799 | 10,775 |
| Paper | 53,448 | 47,316 | 100,764 |

Source: Cascadia, (2014)

¹ The city’s recycling rate has increased since 2014. However, in the absence of a waste characterization study since that year, this study is reliant on 2014 base data.

² This excludes non-recoverable materials that are currently recycled, but includes compostable materials.

³ This includes compostable materials.

- Seidman’s insights for each of the four materials are as follows:

PLASTIC

- There are seven different types of plastic in the city of Phoenix waste stream. The material recovery facilities (MRFs) pile and separately bale PET and HDPE, but collate the five other types of plastic into a single bale.
- The demand for recycled plastic resin is correlated with the cost of crude oil. When the cost of crude oil falls, virgin (prime) plastic resin is cheaper to purchase than its recycled counterpart.
- Plastic manufacturers can interchange between virgin (prime) and recycled plastic based on availability and price; but the current demand for recycled plastic in the State of Arizona is negligible.
- One of the quickest potential opportunities for the city of Phoenix from a recycled plastic perspective could be to focus on the processing of post-consumer PET into flakes or pellets, for sale as a feedstock for domestic manufacturers.
- The 2014 waste characterization study estimates that the city of Phoenix already recycles 4,859.8 tons of post-consumer PET each year, and could potentially divert an additional 4,245 tons from its municipal waste stream. This is sufficient volume to supply a post-consumer PET flake or pellet processing facility similar to ORPET in Oregon, which handles over 7,500 tons of recycled material a year.
- If a plant similar in size and output to ORPET is established in the city of Phoenix, the construction of this facility and five consecutive years’ operations could cumulatively increase Gross State Product (GSP) by a gross maximum of \$113.5 million in the State of Arizona, and real disposable personal income by a gross maximum of \$57.2 million.⁴ It could also result in the diversion of over 9,000 tons of PET annually.
- Approximately 50 people could be directly employed at the plant during each year of operation. For every 1 job year of direct employment created at the processing firm, up to 3.1 job years of additional employment could be created elsewhere in Maricopa County.

⁴ Gross State Product (GSP) represents the dollar value of all goods and services produced for *final* demand in a state. It is the state equivalent of Gross Domestic Product (GDP), used by economists to demonstrate the health of a national economy. Real Disposable Personal Income is a measure of the household income that is available to be spent after tax payments

- To utilize five other types of plastic currently available in the waste stream (SPI 2-5 and 7), the city of Phoenix could consider ByFusion’s mobile processor, which converts the recycled plastic into RePlast.⁵ This is a usable green construction building block similar in size and shape to a typical CMU block.⁶

GLASS

- Glass is one of the heaviest things in the municipal waste stream, which impacts both transportation costs and the environment.
- A glass recycler will purchase or acquire comingled recycled glass from MRFs. When they receive the recycled glass material, they will put it through a sizing screen, crush it, and then optically sort it into different types (flint, emerald, and amber).
- It is possible for recycled glass (cullet) to constitute up to 95% of the raw materials used in the manufacture of glass products. The use of cullet also offers significant energy savings to manufacturers.
- The 2014 waste characterization study estimates that the city of Phoenix already recycles 9,527.1 tons of glass each year, and could potentially divert an additional 4,591.4 tons of recoverable glass from its municipal waste stream.
- The city of Phoenix is currently home to a recycled glass processor employing 15 people and handling 50,000 tons of recycled glass each year. 73% of this glass is currently sourced from metro Phoenix/Maricopa County, and the balance from other parts of the state.
- If all the additionally recoverable glass in the city of Phoenix municipal waste stream could be exclusively handled by the existing recycled glass processor, they could source over 75% (or 41,091 of the 54,591 tons) from metro Phoenix/Maricopa County.
- To handle this additional 4,591.4 tons supply of recycled glass, the firm estimates that it will need to employ an additional 5 people in Phoenix, and invest a further \$1.5 million in new equipment.
- The economic impact of processing the additional 4,591.4 tons of recoverable glass alone during the six-year study time horizon could increase GSP in the State of Arizona by a gross maximum of \$11.4 million, and real disposable personal income by a gross maximum of \$5.7 million over the 6 years.
- For every 1 job year of additional direct employment at the firm, Seidman also estimates that up to 3.0 additional job years of employment could be created elsewhere in Maricopa County.

⁵ RePlast also converts SPI 1 (PET) into RePlast, but the study assumes that this would be handled by a PET flake or pellet processing facility.

⁶ The potential economic impact of a RePlast operation are not included in the current study.

- A source-separated (glass only) system within the city of Phoenix could also increase the value of, and recovery rate for, glass in the Valley.

METAL

- There are two kinds of scrap metal – obsolete scrap and production scrap. Most of the scrap metal in Phoenix is obsolete because it's predominantly sourced from automobiles, appliances, air conditioners, and other metallic objects that have ended their useful lives.
- There are three key stakeholders in the scrap metal logistics chain: the brokers that purchase metals from residents; the merchants or dealers; and large-scale metal shredders.
- There are several scrap metal brokers and dealers, and two large-scale shredders currently operating in the city of Phoenix.
- Phoenix is also home to an aluminum can manufacturer and a steel mill, both of which accept recycled metal inputs.
- The 2014 waste characterization study estimates that the city of Phoenix already recycles 3,975.8 tons of metal each year, and could potentially divert an additional 6,799.3 tons from its municipal waste stream.
- This increase in volume could be easily handled by the existing scrap metal stakeholders, without any additional investment in jobs and equipment.
- At present, the city's supply of recycled metal is greater than the demand from its aluminum can manufacturer and steel rebar mill.
- To generate additional local economic benefits, the city therefore needs to either encourage existing manufacturers to expand their local operations, or attract new manufacturers that utilize recycled metal to the Valley.

PAPER

- Post-consumer paper-based waste includes old corrugated boxes or containers, newspapers, magazines, and other printed papers.
- The 2014 waste characterization study estimates that the city of Phoenix already recycles 53,447.7 tons of newspaper, OCC/Kraft paper, and other papers each year. The city could also potentially divert an additional 47,315.9 tons from its municipal waste stream, 44.8% of which could be used for composting.

- To create pulp from old newspapers, magazines, and other printed papers requires a deinking or cleaning system. This will be difficult to attract to Phoenix, due to the water-intensive nature of deinking systems.
- There is also an insufficient supply of currently recycled and additionally recoverable OCC within the city of Phoenix waste stream to meet the fiber inputs of a recycled corrugated box plant.
- The economic viability of a recycled corrugated box facility in the city is therefore predicated on the sourcing of additional material from neighboring states.
- Based on the assumption that 156,000 tons of corrugated box fiber could be sourced throughout the Southwest, the construction of a facility in the city and five consecutive years' operations could cumulatively increase GSP by a gross maximum of \$437.4 million in the State of Arizona, and real disposable personal income by a gross maximum of \$219.2 million.
- Approximately 140 people could also be directly employed at the facility during each year of operation. For every 1 job year of direct employment at the recycled box mill during the six year study horizon, up to 4.4 additional job years of employment could be created elsewhere in Maricopa County.
- A multi-state approach to paper recycling could also result in reciprocal circular economy benefits. For example, the city could potentially ship its recycled newspaper, magazines, and printed materials to an existing deinking/pulp manufacturer operating in Nevada in return for the latter's corrugated boxes.

GROSS MAXIMUM TOTAL IMPACT IN MARICOPA COUNTY & ARIZONA

- The gross maximum total economic impact of a new PET processor alongside additional glass and metal feedstock recycling in the city of Phoenix, could cumulatively add up to \$124.9 million to GSP and \$63.0 million to real disposable income over the six-year study horizon. This excludes a new paper recycling facility due to the insufficient volume of recycled paper available in the city.
- An additional 55 people could be *directly* employed each year to handle the recycled PET, glass and metal materials.
- For every 1 job year of additional direct employment as a result of this new waste diversion, up to 3.1 additional job years of private, nonfarm employment could be created elsewhere in Maricopa County.

- The city's total amount of curbside recycling would also increase by 15,635.7 tons, resulting in a revised recycling rate of 19.11% based on the 2014 data.⁷
- As a result, Gross State Product (GSP) in Arizona could increase by a gross maximum total of \$124.9 million, 2017-2022; and real disposable personal income could increase by a gross maximum total of \$63 million, 2017-2022.⁸
- Longer-term, if a multi-state supply could be agreed for a recycled corrugated box plant located in the city of Phoenix, this could further increase the municipal waste recycling rate to 20.21% (based on 2014 data). It could also increase the annual gross maximum economic impacts previously estimated for PET, glass, and metal (combined) by up to more than 300%.

⁷ Please note: this is based on the 2014 waste characterization study data, and does not reflect any changes to the rate of recycling in the city of Phoenix since that time.

⁸ Please note: this is based on the 2014 waste characterization study data, and does not reflect any changes to the rate of recycling in the city of Phoenix since that time.

1.0 INTRODUCTION

This is the second of a two-part study implemented by the Seidman Research Institute on behalf of Walton Sustainability Solutions Initiatives (ASU) and the city of Phoenix.

Seidman's first study, completed in fall 2016, applied a series of local and national recycling, repair and reuse rates to 43 sectors and sub-sectors in Maricopa County to estimate the **maximum gross impact** of circular economy activities in 2014.⁹ The first study estimated circular economy activities could contribute a maximum \$1.9 billion to Gross State Product in Maricopa County in 2014. It also estimated that circular economy activities could account for up to 35,454 jobs and \$1.2 billion in labor income in Maricopa County in 2014, thereby generating \$158.5 million in tax revenues for state and local governments.

The objectives of this second study are to:

- Quantify the extent to which the current recycled and additionally recoverable tons of paper, plastic, glass, and metal in the city of Phoenix could meet the annual production needs of locally-based circular economy firms.
- Identify an example of one circular economy firm for each material already in operation either inside or outside the State of Arizona
- Estimate the potential changes to Gross State Product (GSP), employment, and labor impact by material type if the city of Phoenix's recyclable and additionally recoverable feedstock could supply circular economy firms operating in Maricopa County.

The remainder of the current Section offers brief insights into the concept of a circular economy, and the current nature of the city of Phoenix waste stream.

Section 2 addresses market dynamics, based on a series of interviews with local and national stakeholders.

Section 3 attempts to estimate the extent to which the recycled and additionally recoverable plastic, glass, metal and paper from the city of Phoenix waste stream could add to economic activity, albeit primarily earlier in the value chain than the manufacturing of recycled products.

⁹ Seidman's first study excluded repurposing and refurbishing activities due to the absence of relevant data in Maricopa County.

Conclusions and implications for the city of Phoenix are presented in Section 4.

1.1 THE CIRCULAR ECONOMY

The circular economy is defined by the Ellen McArthur Foundation as:

“...a continuous positive development cycle that preserves and enhances natural capital, optimizes resource yields, and minimizes system risks by managing finite stocks and renewable flows.”¹⁰

The origins of the concept can be traced back to two environmental economists, Pearce and Turner, who 27 years ago wrote that a traditional open-ended linear economy has no built-in tendency to recycle and therefore simply treats the environment as a waste reservoir.¹¹

Primarily intended as a practical solution to the planet’s diminishing resources, a circular economy redesigns the way that mankind makes things, replacing the high levels of waste associated with the current ‘take-make-dispose’ linear approach of the first world in the late twentieth and twenty-first centuries. Decoupling economic growth from economic consumption, the concept of a circular economy is based on three key principles summarized by the Ellen McArthur Foundation as follows:

1. Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.
2. Optimize resource yields by circulating products, components, and materials at the highest utility at all times.
3. Foster system effectiveness by identifying and removing negative externalities such as land use; air, water and noise pollution; the release of toxic substances; and climate change.¹²

Drawing from these three guiding principles, the Ellen MacArthur Foundation describes a pure circular economy in terms of five key characteristics:

¹⁰ Ellen McArthur Foundation, (2015).

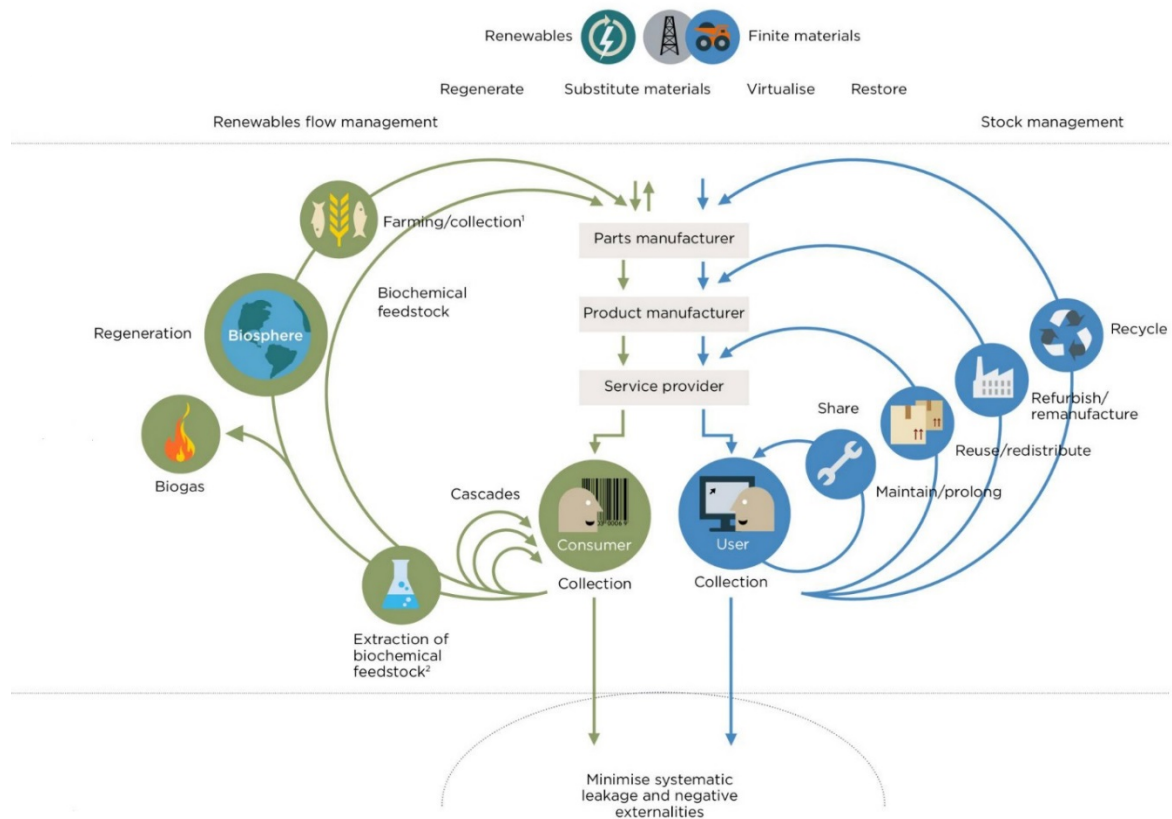
¹¹ Pearce, D.W., and Turner, R. K., (1989).

¹² Ibid.

- Design out waste, composting biological materials and reusing technical materials with minimal energy and highest quality retention.
- Build resilience through diversity.
- Work towards running all systems from renewable energy sources.
- Understand the influences and relationships within a system.
- Extract additional value from products and materials by cascading them through other applications.

Figure 1 visualizes the Ellen MacArthur Foundation’s concept of a circular economy.

Figure 1: The Circular Economy



Source: The Ellen MacArthur Foundation (2015)

The Ellen MacArthur Foundation estimates that 65 billion tonnes of raw materials entered the global economic system in 2010, and forecasts that this will grow to 82 billion in 2020. It also concludes that the manufacturing of products in OECD countries consumes an estimated 21 billion tonnes of materials that are not physically incorporated into the products themselves.¹³

It is clear from Figure 1 that a circular economy encompasses far more than recycling. At the heart of a circular economy, there are 6Rs:

- **Redesign:** this refers to designing for easier maintenance, repair, recovery and reuse of components and materials.
- **Recycle:** this refers to the conversion of waste into reusable material – for example, plastics, compost, glass, metals and batteries.
- **Repair:** this refers to fixing or mending a product, rather than discarding it in favor of buying a new product – for example, repairing the broken screen of an iPhone.
- **Reuse:** this refers to the reuse of a product in the same way that it was originally intended – for example, a jar.
- **Repurpose:** this refers to a change to the purpose or function of an object – for example, changing glass to glassphalt, or tires to rubber scraps for use under fake turf.
- **Refurbish:** this refers to the rebuilding of a product to the specification to the original manufactured product – for example, an engine.

Circular economy material flows, then, are intended to represent a closed-loop, self-sustaining pipeline of resources that are reused and recycled, thereby minimizing and/or eradicating waste.

Drawing from a series of case studies to demonstrate how reuse and better design can significantly reduce material costs and the expense of waste disposal, the Ellen McArthur Foundation estimates a net material annual cost saving of US\$340-380 billion in the European Union, potential downward shifts in the cost curves for raw materials, reduced externalities, and the creation of a user-centric economy focused on innovation. This is based on 2010 total input costs in EU manufacturing, a circular economy product

¹³ Ellen MacArthur Foundation, (2013). Vol. 1, pp. 15.

collection rate increase of 20-30%,¹⁴ and a 30% shift from recycling to refurbishing or remanufacturing activities.

In Europe, the Waste Framework Directive (2008/98/EC) currently imposes specific guidelines for waste management, including definitions of waste, recycling and recovery for all European Union (EU) members.¹⁵ Setting national waste prevention programs, the directive includes two recycling and recovery targets to be achieved by 2020. These are 50% reuse and recycling of household waste materials, and 70% reuse, recycling and other recovery of construction and demolition waste.

In the UK, it's estimated that a fine of up to US\$650 million could be applied if it fails to comply with this directive by 2020.¹⁶ As a result, the Local Government Association (LGA) in England has called for the EU to ensure the costs of member state compliance are not predominantly met by tax payers.¹⁷ In particular, the LGA has called for:

- Producers of goods ending up in the waste stream to contribute at least 50% of the costs of waste collection and subsequent reuse, recycling or disposal of their products, rising to 100% by 2030.
- A set of EU expectations on product design that encourage greater waste prevention, resource efficiency, reuse and recycling.
- Additional action by the EU to drive demand for, and financial viability of, secondary materials, including the imposition of minimum recycled content in product manufacture.

The likelihood of a similar directive in the U.S. is currently very low.

1.2 THE CITY OF PHOENIX WASTE STREAM

Garbage services in the city of Phoenix are managed by the Public Works Department. This includes a curbside residential trash and co-mingled recycling service. The city of Phoenix currently does not offer commercial or multi-family housing waste or recycling collection services. Monthly residential solid waste

¹⁴ The Ellen MacArthur Foundations states that the rates of conventional recovery for materials after the end of their (first) functional life are low. For example, 60% of total waste was not recycled, composted, or reused in Europe in 2010 (Source: Eurostat Waste Statistics, 2016).

¹⁵ European Commission, (2016).

¹⁶ This is based on an estimated UK fine of £500 million, converted at a rate of \$1.30 to £1. It is also a pre-BREXIT estimate.

¹⁷ Local Government Association, (2015).

fees are established by the city of Phoenix Council as part of the annual budget process. The current rate for a large single-family residential waste container and a large blue recycling container is \$26.80 a month. The monthly fees per household vary in accordance with the size, number, and type of containers collected.

The city of Phoenix also owns two strategically placed transfer stations – North Gateway Transfer Station, ½ mile northeast of exit 220 on the I-17; and 27th Avenue Transfer Station, south of Lower Buckeye Road on 27th Avenue. The two transfer stations temporarily house all of the city’s trash prior to hauling the materials to the SR85 Landfill facility in Buckeye. Recyclables are sorted by materials recovery facilities (MRFs) adjacent to the two transfer stations. Both MRFs consist of a series of machines and conveyors to sort the recyclable materials into separate bales.

Increasing recycling or waste diversion is a high priority for the city of Phoenix. In 2013, Mayor Stanton announced a 40 percent landfill diversion goal by 2020. The city also hopes to achieve zero waste by 2050. The Public Works Department offers various solid waste programs to divert and capture as much material as possible for reuse, repurposing or recycling. Eight single-family residential programs are listed in Table 1. The city also offers a Certified Clean Green disposal savings program for businesses who frequent Phoenix transfer stations to dump their green waste loads.

To monitor progress towards their waste diversion goals, the city of Phoenix commissioned Cascadia to implement a waste characterization study in 2014. This updated an earlier study in 2003. The 2014 results were published in 2015.

Drawing from random samples of pre-selected residential garbage and recycling routes examined during two distinct seasons, Cascadia’s 2014 team hand sorted 262 samples into 84 material types, and recorded the weight for each material type. The average residential garbage sample in the city of Phoenix in 2014 weighed 217 pounds (down from 228 in 2003). The average residential recycled sample in the city of Phoenix in 2014 weighed 136 pounds.¹⁸

¹⁸ The 2003 study did not include any recycling samples.

Table 1: Current Residential Waste Diversion and Recapture Programs in the city of Phoenix

| PROGRAM | WASTE MATERIALS | COST |
|--|---|--|
| Curbside Green Organics Collection ¹⁹ | Yard waste, such as grass clippings, twigs, branches and shrubs | \$5 per month per container |
| Save as you Reduce & Recycle | Downsize 75 to 52 gallon trash container | \$3 saving per month |
| Household Hazardous Waste & Electronics Collection | Auto parts; batteries; chemicals; electronics; fire extinguishers; propane gas cylinders | |
| Composting & Mulching | Wood and green organics or yard waste (except palm fronds and oleanders) | \$5 to purchase a home mulch container; free drop off at a station |
| Christmas Trees & Wreath | Christmas trees and holiday wreaths | Free |
| Elections Signs Recycling | Disassembled signs cut into pieces no larger than 3 feet x 3 feet | Drop-off for free at 27 th Transfer Stations |
| Appliance Recycling & Pick-up | Refrigerators; washer/dryers; water heaters; freezers; air conditioners; evaporative coolers; stoves; dishwashers | Pick-up or drop-off. \$20 per refrigerator; \$20 for up to 5 other items |
| Cardboard Recycling | Cardboard and cartons | Part of blue recycling collections. Free pick-up for larger quantities |

Source: City of Phoenix, (2017)²⁰

To quantify diversion opportunities, Cascadia grouped the hand sorted materials according to four recoverability groups. These were:

- Materials currently accepted in the curbside recycling program with well-established markets such as glass, paper, and some types of plastic.
- Organic materials used in commercial compost systems.
- Materials for which recycling technologies, programs, and markets exist, but are not well developed and area not part of the curbside recycle program such as merchandise bags and *batteries*.
- Any trash and garbage materials that cannot be easily recycled or face barriers to diversion such as disposable diapers and treated wood.

¹⁹ This is currently in pilot.

²⁰ <https://www.phoenix.gov/publicworks/recycling>

Three findings in particular stood out in Cascadia’s 2014 study:

- Nearly two-thirds (63.7%) of the residential garbage consists of material that could be diverted through standard recycling and composting programs.
- Yard waste and food waste accounted for more than 40% of disposed residential garbage. However, more than 53,400 tons of recyclable material that could be collected via the existing curbside collection program was being disposed annually.
- More than 55% of residential disposed garbage could be diverted through standard recycling and composting programs citywide.

Table 2 summarizes Cascadia’s estimates of recycled and additionally recoverable select materials in the city of Phoenix waste stream in 2014. Table 2 suggests that the city of Phoenix could almost double the amount of plastic, metal and paper recycled, and increase by 50% the amount of glass recycled.

Table 2: Estimates of Recycled and Additionally Recoverable Materials in the city of Phoenix

| MATERIAL | CURRENTLY RECYCLED ²¹ <i>Tons</i> | ADDITIONALLY RECOVERABLE ²² <i>Tons</i> | TOTAL <i>Tons</i> |
|----------|---|---|----------------------|
| Plastic | 11,558 | 11,848 | 23,406 |
| Glass | 9,527 | 4,591 | 14,118 |
| Metal | 3,976 | 6,799 | 10,775 |
| Paper | 53,448 | 47,316 | 100,764 |

Source: Cascadia, (2014)

Cascadia’s 2014 waste characterization study data summarized in Table 2 was for single-family residential (municipal) waste. Their study does not provide a total picture of waste and recycling in the city as it excludes commercial and industrial waste, or any waste produced by multi-family residences.

The American Community Survey (ACS) estimates that there were 598,176 housing units in the city of Phoenix in 2014, 87.1% (520,856) of which were occupied.²³ Approximately 32% of the homes were multifamily residential. That is, multiple separate housing units contained within a complex, such as an

²¹ This excludes non-recoverable materials that are currently recycled, but includes compostable materials that are currently recycled.

²² This includes compostable materials.

²³ U.S. Census Bureau, (2015). *2010-2014 American Community Survey 5-Year Estimates*.

apartment building. Around a third of city of Phoenix residents were therefore excluded from Cascadia's 2014 study.

As for commercial and industrial waste, the city of Phoenix estimates that over one million tons of solid waste is taken to its SR85 Landfill each year. Approximately half of this waste is from single-family residences, and the other half from commercial entities like schools, apartments, factories, stores and offices.²⁴ This equates to about one ton of garbage per resident per year, or 28 full garbage curbside containers per year.

²⁴ <https://www.phoenix.gov/sustainability/waste>

2.0 MARKET DYNAMICS

The current study examines the potential of four types of material in the city of Phoenix waste stream for the circular economy. These are: plastics, glass, metal, and paper. To understand market dynamics, a series of semi-structured telephone interviews were held with 21 representatives at 20 firms and organizations, listed in Table 3.

Sections 2.1 to 2.5 summarize the key findings by material, with particular emphasis on: the recycling process; national supply and demand considerations; resource and capital cost implications during the manufacturing process; and local and national developments.

Table 3: Firms & Stakeholders Interviewed

| PLASTICS | |
|---|------------------------|
| Dow Chemical Company | MBA Polymers |
| Plastic Industries Association | QSR Recycling |
| Tetrapak | Western Container |
| GLASS | |
| Refresh Glass | Strategic Materials |
| METAL | |
| Broadway Metals | Former Metals Broker |
| Liberty Metals | |
| PAPER | |
| International Paper | Royal Paper Converting |
| ALL RECYCLABLES | |
| City of Phoenix | Coca Cola |
| Recycle 1 | Republic Services |
| SERDCO | Sonoran Waste Disposal |
| Buyer in the recovered materials business | |

Source: Authors

2.1 PLASTICS

In 1988, the Society of the Plastic Industry (SPI) established a classification system to help consumers and firms recycle and dispose of different types of plastic based on chemical composition. Seven distinct types of plastic have been identified as part of this classification. These are:

- SPI Code 1: Polyethylene Terephthalate (PET), often used for bottling water, soft drinks, juice, beer, and salad dressings; for microwaveable meal trays; and for detergent and cleaner containers.
- SPI Code 2: High Density Polyethylene (HDPE), typically used for plastic grocery bags; water and juice containers; bleach, detergent and shampoo bottles; and yogurt and margarine tubs.
- SPI Code 3: Polyvinyl Chloride (PVC), used in toys; clear food and non-food packaging; shower curtains; and wire and cable insulation.
- SPI Code 4: Low Density Polyethylene (LDPE), used to make dry-cleaning bags; plastic wraps; and coatings for paper milk cartons, among other things.
- SPI Code 5: Polypropylene (PP), typically used for food and medicine containers, and baby bottles.
- SPI Code 6: Polystyrene (PS) or Styrofoam, used for food containers; egg cartons; disposable cups; in-box packaging.
- SPI Code 7: All Other Plastics (O), which is a catch-all for any other type of plastic, including Polycarbonate (PC).

All seven codes are usually applied to plastic products to facilitate recycling.

2.1.1 Plastic Recycling Insights

- Logistically, it is more difficult to recycle plastics than paper/cardboard due to the value chain. That is, plastic recycling requires the coordination of multiple steps to close the loop.
- Recyclers also have to keep different types of plastic separate from one another. Flexibility in a recycled paper chain gives an economy of scale that simply doesn't exist in plastics.
- Most MRFs will pile and separately bale PET bottles and HDPE bottles, then collate SPI Codes 3-7 in a single bale. A few MRFs will also separate polypropylene, but it's rarely economic to do so.
- These bales are then sold to processors.
- A MRF's bales typically have 80-90% of the material that they are supposed to contain.
- Some processors buy mixed bales, usually in the hope of recovering additional PET and HDPE.
- Processors initially chop and wash PET and HDPE to remove contaminants, which incur costs.
- The recycled plastic resin is then sold on to manufacturers in either ½ inch flake or pellet form.

- Every time plastic is reheated, the physical properties shift, reducing the strength of the material, which can increase the amount of virgin (prime) resin needed in a blend. As a result, there are thermal heat benefits associated with the recycled flake, compared to recycled pellets.
- Pelletizing also adds approximately 8-10 cents a pound to the cost of the recycled resin.
- Table 5 offers plastic recycling insights by SPI code in the U.S. in 2015. In addition, a further 1.2 billion pounds of post-consumer film was recovered for recycling nationwide. This is excluded from Table 5 because the composition of recovered film bales varied by location. That is, the bales contained one or more of HDPE, LDPE, and LLDPE resins.²⁵

Table 6: U.S. Recovered Paper and Fiber Export Volume, Top 15 Destinations

| PLASTIC TYPE | POST-CONSUMER PLASTIC BOTTLE RECYCLING (Pounds) | NON-BOTTLE RIGID PLASTIC RECOVERED BY RESIN (Pounds) | TOTAL (Pounds) |
|---------------|---|--|----------------|
| SPI 1 - PET | 1,797,000,000 | 159,730,000 | 1,956,730,000 |
| SPI 2 - HDPE | 1,143,800,000 | 405,258,000 | 1,549,058,000 |
| SPI 3 - PVC | 1,100,000 | 16,666,000 | 17,766,000 |
| SPI 4 - LDPE | 3,300,000 | 91,090,000 | 94,390,000 |
| SPI 5 -PP | 31,800,000 | 5,110,540,000 | 5,142,340,000 |
| SPI 6 -PS | - | 20,987,000 | 20,987,000 |
| SPI 7 - Other | 5,200,000 | 116, 581,786 | 5,200,000 |

Sources: Moore Recycling Associates, (2016), (2017b)

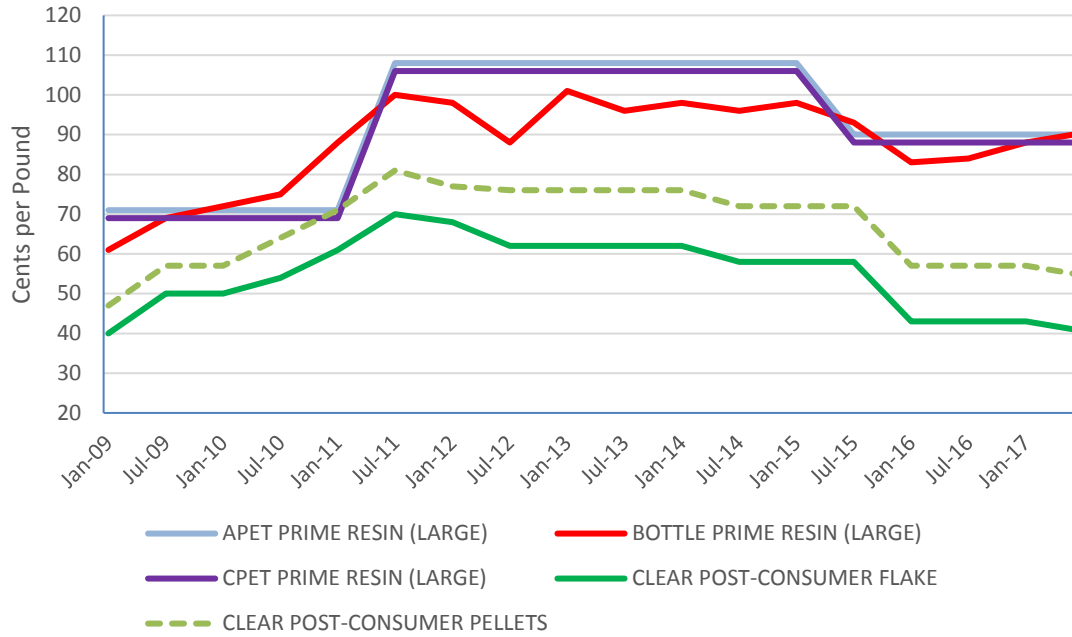
2.1.2 National Supply and Demand Considerations

- The demand for recycled plastic resin is highly correlated with the cost of oil. If the cost of oil falls, virgin (prime) plastic is cheaper than recycled plastic. One interviewee suggests that the cut-off point is \$65-\$75 per barrel.
- Virgin (prime) resin costs plummeted in 2015. Prior to that, recycled plastics had enjoyed an economic advantage.
- It currently costs approximately 50 cents per pound to wash and pelletize post-consumer PET.
- The traditional large volume markets to date have been for PET and HDPE. For all other types of plastic, a novel way needs to be found to mix the different types for manufacturers.

²⁵ Moore Recycling Associates, (2017a). 2015 Post-Consumer Plastic Bag & Film Recycling Report.

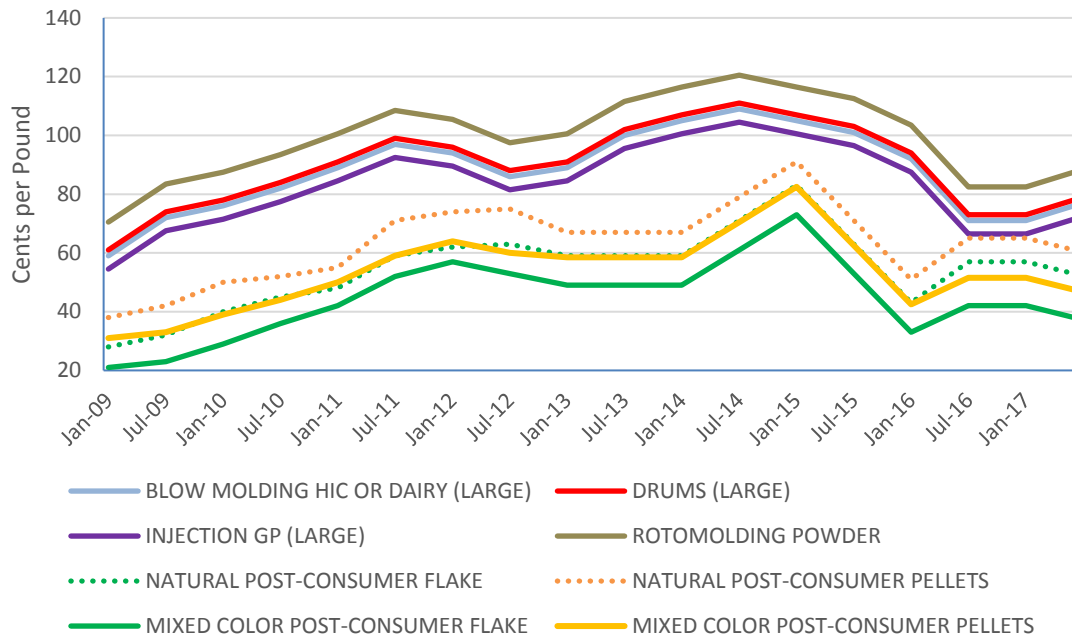
- Most plastic is recyclable by weight rather than number. Thousands of potato chip bags are therefore needed just to equal the weight of one or two plastic detergent jugs.
- A PET water bottle will on average contain 15% recycled content. Other plastic items could have a 25-30% recycled component.
- A processor can mix detergent and shampoo bottles, or mix compatible types of polyethylene; but the challenge is always getting enough volume of scale of material to make it logistically worthwhile and cost-effective.
- Some plastics re-enter the value chain as pallets or crates for shipping/transportation.
- Another alternative is to establish a depolymerized mixed plastic plant, which returns the recycled material to an oil refinery for fertilizers and kerosene.
- Consumer product companies often make a commitment to using recycled content, but that could change, now that virgin (prime) prices are lower than recycled resin prices.
- There is currently no economic reason to recycle all plastic resins. PET and polyethylene in particular are currently struggling against virgin (prime) pricing.
- When there is no demand for post-consumer resin, and a lack of incentives, manufacturers will choose virgin (prime) over recycled resin.
- In the absence of a cost advantage, recycled resin processors need to emphasize the sustainable credentials of their materials.
- Most plastic recyclers in the U.S. are operating on a small scale. This means that they have a particularly hard time when the price of virgin (prime) plastic drops, and can simply go out of business.
- The demand for recycled plastic flake is often regional.
- There is the potential to make money with plastic, but it is very difficult for recycled materials to compete.
- Figure 2 compares the cost of three types of prime PET resin with clear post-consumer pellets and post-consumer flake. This shows the price-competitiveness of clear post-consumer flake and post-consumer pellets compared to APET, CPET and bottle prime resin. The prices displayed for large prime resin in Figure 2 are lower than small prime resin alternatives.

Figure 2: Comparison of Select Prime PET Resins with Clear Post-Consumer Flake and Pellets



Source: Plastic News, (2017)

Figure 3: Comparison of Select Prime HDPE Resins with Post-Consumer Flake and Pellets



Source: Plastic News, (2017)

- Figure 3 compares the cost of four types of prime HDPE resin with clear post-consumer pellets and post-consumer flake. This shows the price-competitiveness of natural and mixed post-consumer flake and pellets compared to blow molding, drums, injection GP prime HDPE resin,²⁶ and rotomolding powder. The prices displayed for large prime resin are cheaper than small prime resin alternatives. There is also on average only a half cent difference between blow modeling HIC and blow molding dairy (the latter being the cheaper option). This explains their combined entry in Figure 3.

2.1.3 Manufacturing Using Recycled Plastic

- Manufacturers do not need different types of machinery to use virgin and recycled plastic resins, particularly if they are both pelletized. There is also no price differential in energy usage.
- However, some manufacturers need to include additional processes when they use recycled plastic, which adds to the cost of production. For example, a recycled plastic manufacturer might need to compensate for surface defects, use a toughening agent, or add additional pigment.
- Gradability is an issue, but this is dependent in part on the end usage.
- Manufacturers can compensate for the inclusion of recycled plastic pellets in their manufacturing via the use of virgin (prime) inputs renowned for their extra tough strength.
- Manufacturers frequently interchange between virgin (prime) and recycled plastic based on the availability of supply and price.
- Producing food packaging from recycled resin is more challenging, due to quality issues such as no contaminants and tight specifications on color to avoid discoloration.
- The greatest opportunities for recycled plastic are in less demanding applications such as buckets, garden furniture, less critical parts of a car, industrial applications, and non-aesthetic applications.

2.1.4 Examples of Processing Plants

- PetStar in Mexico is the world's largest food grade PET bottle-to-bottle recycling plant. The plant cost in excess of \$100 million, and is capable of processing 65,000 tons of PET a year. Through the use of advanced technologies, the PetStar plant allows six bottling firms to recycle 70% of the PET used by Mexican bottlers.

²⁶ Injection GP is a HDPE resin grade.

- A major PET recycling plant is also operational in Oregon. Costing \$10 - \$12 million and employing 50 people, the facility processes between 12 and 15 million pounds of plastic per year. Baled PET is collected from the six regional facilities in Portland, Eugene, Bend, Pendleton, Medford and Coos Bay. This material is then processed, washed and converted to PET flake for use in manufacturing, construction and packaging in Portland, Eugene, Bend, Pendleton, Medford and Coos Bay. ORPET plans to market these products to a variety of Northwest companies, providing a local supply for regional businesses and eliminating the carbon footprint associated with exporting. Oregon would like its recycled PET to stay entirely in state, but there are currently only a couple of local consumers. The recycled PET is therefore primarily exported out of state, into other parts of the domestic market.
- A pre-consumer plastic recycling plant in Arizona currently handles approximately 12,000 tons a year, 90% of which is sourced from Metro Phoenix/Maricopa County. A further 5% is sourced from other parts of Arizona, and 5% from outside the state. The plant currently shreds, grinds, densifies and bales PET, but will begin pelletizing in late June. Around 14 people work specifically within the plastics division, with a further 80+ in other parts of the firm. An additional 2-5 people could be added once the pelletization begins. The firm has already invested \$10 million to date in capital equipment to bale, shred, grind, and pelletize pre-consumer plastic. It estimates that 90% of its customers will be outside Arizona.

2.1.5 New Developments in Plastics

- One interviewee believes that the aggregation of multiple plastic materials into new feedstock will be the next big thing.
- Several new technologies are in development to facilitate increased lightweight recycling. This could entail designing packages that are more easily mechanically recyclable. It could also require the use of compatibilizer technology to enable different types of plastic to be recycled together.
- Attention should also be given to a MRF's sorting equipment, to enable them to more readily sort the likes of chip bags and cheese pouches.
- Most of the world's plastic waste is not available from MRFs. It's part of other products, such as automobiles. MBA Polymers therefore tries to mine complex streams of plastic. That is, it purchases at very little or no cost mixed plastics that used to be shipped to China, landfilled or incinerated for energy, and then reprocesses it as a pellet. Original equipment manufacturers (OEMs) require large quantities of plastic that are not readily available from smaller plastic

recyclers. MBA operates on a large-scale level in England (60 employees), Austria (70 - 80 employees) and China (100+ employees) to sell recycled plastic to large automotive and electronic manufacturers. MBA's material contains over 90% recycled content, supplemented by additives to get the right color, performance, and UV stabilization. The interviewee believes that Phoenix could potentially support an MBA-sized plant costing up to \$20 million. However, it will only be worthwhile to do so if the likes of Waste Management or Republic sign a long-term contract to guarantee a high level of supply.

- ByFusion has developed a mobile process to turn SPI 1 – SPI 5 and SPI 7 plastics into RePlast. This is a usable building block similar in size and shape to a typical CMU block.²⁷ The ByFusion converter can allegedly be taken throughout the U.S. on a flatbed truck or in a shipping container. The company also offers training for foremen. Transforming six of the seven types of plastic contained in the city of Phoenix's residential waste stream into green construction material could therefore be an economic development possibility for the city.

2.2 GLASS

Virgin glass is made by melting silica or sand with soda ash and limestone in 1700° centigrade furnaces. From a weight perspective, glass is one of the heaviest materials in the waste stream. Anything that reduces glass entering landfill is therefore seen as a good thing.

2.2.1 Glass Recycling Insights

- A glass recycler will purchase or acquire comingled recycled glass from MRFs.
- When they receive the recycled glass material, they will put it through a sizing screen, crush it, and then optically sort it into different types of glass (flint, emerald, and amber).
- It is a very capital-intensive process.
- Crushers and screens reduce the glass to 5/8' size for the likes of the container industry, or to a fine grind powder for fiberglass and specialty products customers. The fine grind material is also dried to insure proper material flow through the screening and silo storage process.
- Sorters are used to separate ceramic and stone contamination from good glass.

²⁷ Hedmond, Shane, (2016).

- Magnets and vacuum systems are used to remove ferrous and non-ferrous metals, paper, and organics from heavier glass fragments.
- The quality of glass supply is key, as it helps to drive down recycling costs in three ways:
 - The less the amount of trash mixed in with the recycled glass, the lower a recycling glass processor's disposal costs.
 - Manufacturing costs are lower for higher quality glass.
 - Less trash also results in higher throughput and less equipment maintenance.
- Glass recycling firms are often willing to pay more for cleaner glass because their costs are lowered by better supply. This can include the availability of a pricing matrix to help determine the value of the glass.
- Glass recycling processors will accept glass from municipal single sort collections, but this typically generates more trash. Source separated (glass only) collections can be more costly to a municipality, but the material is usually cleaner and therefore attracts a higher price from glass recyclers. Source-separated collections also typically lead to higher rates of glass recovery in a town or city.
- A few cities have removed glass recycling from their stream, and replaced it with recycling "hot spots" throughout their municipalities. This can potentially result in cleaner material, but the glass recycling volumes decrease dramatically, thereby increasing landfill costs for a city. The short-term hot spot approach is therefore not very effective from a recycling perspective.
- Glass that is crushed and ready to be remelted is called cullet.
- One ton of recycled glass is estimated to save:
 - 42 kWh of electricity;
 - 5 gallons of crude oil;
 - 714.3 BTU heat energy;
 - 2 cubic yards of landfill space; and
 - 7.5 pounds of air pollutants from being released.
- The Glass Packaging Institute suggests that glass bottles and jars are 100% infinitely recyclable.²⁸
- Processing center employment at a glass recycler can range from 8 to 25 people, depending on supply and demand, and the tonnage capacity of a plant.

²⁸ Glass Packaging Institute, (2017).

- In 2014, approximately half of the recycled cullet was used in bottle manufacture, 40% on insulation, and 10% in sandblast media or carpet applications. Bottle cullet is typically transported by truck, so processing facilities tend to be located within 300 miles of consumers. Insulation cullet is often transported by rail.²⁹

2.2.2 National Supply and Demand Considerations

- Glass recycling through curbside and drop-off programs in the U.S. has increased considerably in recent years.
- The price of recycled glass cullet increased by 40% between 2012 and 2015 due to demand for the product, but is now relatively stable.
- Enhanced relationships between recycled glass (cullet) processors and municipalities could lead to greater landfill avoidance.
- Some municipalities supply materials to a glass recycler for free. Others charge fees, thereby necessitating the need for a processing facility.
- The demand for recycled glass exceeds current supply in the U.S., because more glass needs to be recycled.
- Landfill rates in some states, including Arizona, are too low and have a negative impact on recycling. Some states have passed legislation insisting on bar/restaurant glass recycling. Minnesota and Wisconsin prohibit putting glass into landfills.
- Glass recycling is worth very little to the likes of Republic, Waste Management, and Recommunity. These waste management companies need to compare how much it will cost to pay someone else to take it, as opposed to landfilling it. For example, they might need to pay someone \$10 a ton to take it, or alternatively pay \$30 a ton to landfill the material. Some of the glass they collect will be sent to the likes of recycled glass processors. However, it can also be used as a road base between layers of rock, as daily cover in landfills, or in gas wells instead of rock.
- Glass has increased from an estimated 10% of Republic's waste stream 25 years ago to 20-25% of their waste stream today.
- In 2016, Coca Cola's Arizona plant sent more than 32,000 lbs. of glass to parallel products in California. This is due to the absence of recycled glass manufacturers in Arizona.

²⁹ McKenna, Lisa, (2014).

- The EPA in 2013 estimated that glass represented about 5% of municipal solid waste in the U.S., 34% of which was recycled.³⁰
- The current low prices for collected glass poses a challenge.
- In 2015-16, the glass container manufacturing industry purchased 2.4 million tons of recycled glass for remelting into new containers. Approximately 30% of the recycled glass remelted into new containers comes from single-stream programs.³¹

2.2.3 Manufacturing Impacts

- Recycled glass can constitute up to 95% of the raw materials used in the manufacture of glass.
- Glass manufacturers can use recycled glass to improve their sustainability and lower manufacturing costs.
- The only material used in greater volumes than cullet is sand.
- Raw materials like sand for the manufacturing of glass are often cheaper than recycled glass cullet. For example, the cost of sand can vary from \$40 to \$80 a ton, while cullet ranges from \$100 to \$150 a ton.
- However, manufacturers that use more recycled cullet benefit from both sustainability marketing value, and also substantial energy cost savings.
- Cullet can burn at a lower temperature and therefore emit less carbon dioxide. Less heat = less maintenance required on the furnace, thereby extending furnace life.
- Every 1,000 kg of waste glass recycled into new items saves an estimated 315 kg of carbon dioxide from being released into the atmosphere during the manufacture of new glass products.
- The Glass Packaging Institute estimates that energy costs drop about 2-3% for every 10% of cullet used in the manufacturing process. It also estimates one ton of carbon dioxide is saved for every 6 tons of recycled container glass used in the manufacturing process.
- Greater use of cullet also lowers the amount of water consumption required for glass manufacturing.
- Recycled glass content varies by industry:
 - Fiberglass could be 70% recycled glass (cullet). Ellis Corning set the industry standard.
 - Container glass uses could use 5-40% recycled cullet.

³⁰ Henricks, Mark, (2016).

³¹ Ibid

- Some products could be made from 100% cullet, but there can be strength issues or furnace implications.

2.2.4 Examples of Glass Recycling Plants

- Strategic Materials is the largest glass recycler in North America, operating from 50 locations, including Phoenix where it processes 50,000 tons a year. Approximately 73% of the Phoenix plant's recycled glass is currently sourced from Metro Phoenix/Maricopa County, and 23% sourced elsewhere in the state. The Phoenix plant accepts curbside single stream mixed glass recycling from Republic, Waste Management, and Recommunity, limited clean bottle supply where it's sourced separately, and some plate glass. All of the recycled material is then sold on to firms operating outside Arizona.
- In March 2017, Momentum opened an \$11 million glass recycling plant in Broomfield, CO, to process up to 80,000 tons of glass each year. The cullet will be delivered to a local bottle making plant in Windsor, supplying the Budweiser and MillerCoors breweries. An estimated 15% of the cullet will be sent to secondary markets for use in abrasives, large water filters, and concrete coatings.³²

2.2.5 New Developments in Glass

- Angel Fire, NM, is converting whole glass bottles into clean glass pebbles with rounded edges utilizing a small glass pulverizer, for local maintenance and upkeep of dirt roads.³³
- A New Zealand beer company, DB Export, has developed glass beer bottle crushing machines that remove the labels and silica dust and turn the glass into 200g of sand substitute within five seconds.³⁴

2.3 METAL

There are 2 kinds of scrap metal – obsolete scrap and production scrap. Phoenix is primarily an obsolete scrap city because it is predominantly sourced from automobiles, appliances, air conditioners, and other metallic objects that have ended their useful lives.

³² Anonymous, (2017).

³³ Nagawiecki, Tom, (2012).

³⁴ Hedmond, Shane, (2017).

There are at least three key stakeholders in the scrap metal logistics chain. These are:

- (a) The scrap metal broker that purchases metals from residents, and/or from peddlers or small one-or-two person firms who go around streets picking up goods on bulk trash days.
- (b) Scrap metal merchants/dealers.
- (c) Scrap metal shredders.

2.3.1 Metal Recycling Insights

- The margins for scrap metal brokers can be as small as 1c per pound, or a couple of dollars per ton; and the supplies are usually sourced locally.
- Most brokers are too small to be able to sell directly to metal manufacturers. They have to sell to shredders who alone then sell the recycled metal onto manufacturers, thanks to their greater access to volume.
- There are several scrap metal dealers in Phoenix. For example, there are 10-15 competitors within a 3-to-5 minute reach of Broadway Metals on W. Broadway Road (one of the firms interviewed); and Yelp lists 29 scrap metal dealers in the metro Phoenix area.
- The business model for scrap metal merchants is often focused on high volumes and low margins.
- Scrap metal dealers rarely interact directly with the general public to minimize the potential for handling stolen materials. Most of their supplies will be sourced from municipalities, manufacturers, demolition companies, and large organizations such as ASU.
- Scrap metal dealers will often initially try to clean up some materials themselves (e.g. removal of iron screws from aluminum window frames). They will also bale the metals, and shear cut them using a plasma-cutting machine. The metal pieces are then taken to a mill for melting down into bar or metal rod, for sale back to manufacturers.
- There are two large metal shredders in Arizona – Liberty and SA Recycling. All brokers and most scrap metal merchants sell to these two firms. They are publicly traded companies.
- The Phoenix population base is large enough to produce a pretty consistent and known amount of obsolete metal scrap.
- Liberty's metal feedstock originates from a variety of sources – automobile wrecking yards (the primary source); other scrap dealers in city and the state; industrial/commercial clients; municipalities such as the city of Phoenix; demolition waste (e.g. heavy beams, copper wire, etc.);

and copper mines. Liberty also purchases some metal materials from Waste Management's local MRFs and transfer stations.

- Scrap dealers and brokers (including automobile wreckers) account for up to 70% of Liberty's supply.
- In addition to the giant hammer mill, a shredder will require a sophisticated downstream system to separate their materials into ferrous metals, non-ferrous metals, and garbage (also known in the industry as fluff).
- In the State of Arizona, the shredding usually takes place at night, due to lower electricity rates.
- The scrap metal industry usually sources its materials locally.
- Aerospace and automobile industries are key customers of certain grades or alloys of scrap.
- However, the majority of scrap metal is shipped to China in empty containers.

2.3.2 National Supply and Demand Considerations

- The market for scrap metals is currently described as soft. It has declined in 2017, possibly due to a surplus of scrap metal. China often drives the market. For example, when the Chinese were building their 2008 Olympic stadium, it was as high as \$280-300 per ton. Whenever the Chinese reduce their propensity to buy, it creates a surplus in the west.
- There is no more consolidation in the scrap metal industry today than the mid-1990s.
- The price of recycled aluminum has ranged from \$1,000 to \$2,000 a ton over the last 15 years. Republic does not export aluminum. It is sold to U.S. aluminum can manufacturers.
- There are a couple of aluminum plants in Southern California, but it is difficult to ship the product there due to the California Redemption or Refund Value (CRV).³⁵
- Aluminum is resold back to the likes of Anheuser Bush for beer cans.
- In 2016, the city of Phoenix's North Transfer Station saved 575.66 tons of aluminum, 1,432.24 tons of ferrous metal and 2,072.47 tons of non-ferrous metal from landfill. The aluminum generated \$80,621 revenue; ferrous scrap \$21,986 revenue; and non-ferrous scrap \$23,184 revenue. All 3 therefore accounted for 10.15% of total revenue.
- Aurubis of Hamburg considered establishing a processing plant in Los Angeles around five years ago, but struggled to satisfy the environmental regulations.
- In reality, the US could not consume all of the scrap metal that it produces on an annual basis.

³⁵ The CRV is the amount paid to consumers when they recycle beverage containers at certified recycling centers in California.

Table 6: U.S. Scrap Metal Prices (May 19, 2017)

| METAL | WEST COAST US\$/LB | MID WEST US\$/LB | EAST COAST US\$/LB | SOUTH WEST US\$/LB |
|------------------|-----------------------|---------------------|-----------------------|-----------------------|
| Aluminum | 0.100 - 1.198 | 0.098 - 1.180 | 0.099 - \$1.192 | 0.090 - 1.188 |
| Brass | 1.198 - 1.776 | 1.18 - 1.75 | 1.192 - 1.768 | 1.188 - 1.766 |
| Copper | 0.233 - 2.536 | 0.230 - 2.536 | 0.232 - 2.536 | 0.223 - 2.536 |
| Nickel & Alloy | 3.106 – 4.639 | 3.06 – 4.57 | 3.091 – 4.616 | 3.096 – 4.629 |
| Ferro Molybdenum | 8.831 | 8.700 | 8.787 | 8.821 |
| Pure Tin | 8.100 | 7.980 | 8.060 | 8.000 |
| Stainless Steel | 0.320 – 1.634 | 0.315 – 1.610 | 0.318 – 1.626 | 0.310 – 1.624 |
| Steel | 203.000 - 314.650 | 200.000 - 310.000 | 202.000 - 313.100 | 202.000 - 313.650 |
| Zinc & Lead | 0.3555 – 0.711 | 0.350 – 0.700 | 0.354 – 0.707 | 0.345 – 0.376 |

Source: Scrap Register – Global Scrap Trading, (2017)

- Table 6 summarizes the current prices for select scrap metal types by U.S. region. The base metal prices for comparative purposes, as of June 16, 2017, are:
 - Aluminum \$0.84/lb.
 - Copper \$2.57/lb.
 - Lead \$0.95/lb.
 - Nickel \$4.04/lb.
 - Tin \$8.81/lb.
 - Zinc \$1.14/lb.³⁶

2.3.3 Manufacturing Impacts

- There is some potential for greater scrap metal processing in Arizona, but the state needs a stronger manufacturing base to justify any increase in available supply.
- Alcoa Inc. is the U.S.’s largest company involved in mining bauxite and fabricating it into aluminum. Alcoa operates on Chandler Boulevard and 56th Street, but is unable to consume all of the aluminum waste produced in the city.
- Sonoran Waste Disposal sells aluminum to Alcoa.
- There is an aluminum smelter in Phoenix (SAPA). They consume primary segregated alloys sourced from scrap dealers.

³⁶ Investment Mine, (2017).

- About two-thirds of Liberty's sorted shredded steel goes to a steel rebar manufacturer in Mesa - Commercial Metals – that has been smelting since September 2009. They require over 1,000 tons of clean recycled steel, free of debris; and the only way to guarantee this is to purchase from a large-volume shredder.
- Liberty is currently shipping steel as far as Arkansas on a monthly basis, as they have more than the local Arizona steel mill can consume.
- In 2016, Coca-Cola locally recycled 265,000 lbs. of aluminum.

2.3.4 Examples of Scrap Metal Recyclers

- Liberty opened in Phoenix in 2007 and has been shredding since 2009. The firm also shears, bales, reduces, and densifies materials. Their equipment is constantly maintained; but some of it is due for replacement. A significant amount of investment is required. For example, Liberty has invested approximately \$25 million to date in the shredder, loading equipment, and post-shredding sources. They currently employ 100 people who work around the clock; and handle approximately 20,000 tons of metals a month, or 250,000 tons of metals a year. This includes aluminum, copper, and brass that never goes through the shredder. Around 95% is sourced in-state. The breakdown of their sorted materials is as follows: 75% ferrous; 5% non-ferrous; 20% garbage/fluff.
- Liberty's fluff is taken by Waste Management for a fee and used as alternative daily cover in landfills – that is, used as a substitute for soil to cover municipal waste. The fluff consists of glass, several types of plastic, foam, and rubber. The shredded glass can range from the size of a dime to the size of a baseball. The interviewee suggests that very little can be done with the fluff from a recycling standpoint, despite its abundant supply nationwide.
- Liberty's non-ferrous shredded materials are primarily shipped via road in containers to Long Beach, then onto China, Thailand, Indonesia, Malaysia, Vietnam and India. Copper, brass, stainless steel, lead-acid batteries, and insulated wires are sent to California, Texas, Korea, or China.
- Liberty's local competitor - SA - has shredders in Tucson and Phoenix. Price is often the driving factor that will encourage someone to sell to Liberty rather than SA.
- Liberty can potentially handle up to 20% or 25% more scrap metal a year without any increase in its workforce or machinery.

- Broadway Metals in Phoenix currently handles 25-30 million pounds (15,000 tons) of non-ferrous metals a year. Their key customers are municipalities, manufacturers, demolition companies, and large organizations. They also handle large appliances from MRFS and electrical scraps; and even sources some scrap from outside the Valley – e.g. the Rocky Mountain region. The firm does not upgrade or process the scrap. It uses external shredders such as Liberty.

2.3.5 New Developments in Metal

- No new developments were noted during the interviews.

2.4 PAPER

Recycled paper can be made from mill broke, pre-consumer waste, or post-consumer waste. Mill broke refers to the scrap produced during the manufacture of paper. Pre-consumer waste refers to any paper discarded before it is used by a consumer. This study, though, focuses on post-consumer waste, which is paper discarded after consumer use, such as old corrugated containers, newspapers, magazines, and other printed papers.

2.4.1 Paper Recycling Insights

- A recycled mill is cheaper to establish than an integrated paper mill. This is because there are fewer processes, which in turns means less machinery. That is, a recycled paper mill simply requires a repulper, waste, and boiler machines. It also does not require the wood yard adjacent to a traditional mill.
- There is a potential energy differential associated with manufacturing from recycled paper fibers compared to manufacturing from wood/virgin materials. For example, 100% of the energy needed to manufacture from recycled materials at International Papers comes from utilities, compared to 70% of the energy used in integrated mills generated from renewable carbon-neutral biomass as a byproduct of pulping the virgin materials. This is partly offset by the fact that manufacturing from recycled materials requires less energy and water overall.
- A recycled mill will require approximately 1 million tons of recycled paper to operate a year.
- Typically, the higher the grade of paper, the lower the recycled contribution. For example, containerboard will contain 0-10% recycled material.

- Old corrugated containers can offer the greatest value, due to its high quality and limited contamination. BLK (pre-consumer waste from box plants) also has high value.
- Paper has an 80% recovery rate, and can be used up to seven times before the fibers lose their strength.
- The average recycled content of International Paper's North American corrugated packaging products is 37%, including 30% post-consumer fiber and 7% pre-consumer fiber.
- Supply sources determine mill location. Recyclable paper mills are usually near urban centers; integrated mills in more rural locations.
- A traditional paper mill will convert wood chips into paper and paperboard. International Paper's integrated mills also convert recovered fiber into paper and paperboard. Their recovered-fiber-only (recycled) mills produce linerboard and corrugating medium.
- The industry standard for toilet tissue and bathroom towels is 80% post-consumer or recycled content. However, both types of product can currently only use non-contaminated recycled papers.
- A deinking system is required to clean printed paper. This is an industrial process to remove printed ink from recycled paper fibers. Several processes are employed to make deinked pulp, most commonly flotation or washing. This deinking process requires a significant water supply and chemicals. Arizona's suitability for a deinking system is therefore open to question; and the absence of a local deinking system prevents in-state tissue manufacturers from using paper in the city of Phoenix waste stream.
- A deinking system on average costs around \$10 million, has a very long shelf life, and will only require minimal upgrades due to technology changes.
- At least 40 full-time people are needed to operate a deinking system.
- 80% of the cost of final production for bathroom tissue and towels is related to paper, primarily the pulp. The remaining 20% is the cost of the paper mill, including energy and water.

2.4.2 National Supply and Demand Considerations

- In the U.S., 65% of all paper products is currently recycled.
- The most common type of recycled paper is corrugated packaging (OCC) with a 91% recycled rate.
- The market for recovered fiber is strong and driven by economic forces rather than government mandates.

- The U.S. is currently a net exporter of recycled fibers, as there are not enough mills in the nation to repurpose the recycled paper.
- Recycled paper is the highest-volume U.S. containerized export.
- From 2000 until 2013, China rapidly expanded its paper-making production, and the new mills sourced significant supplies of U.S. recycled paper, particularly corrugated cardboard packaging.³⁷
- U.S. scrap paper exporters saw a 0.8% overall increase in export volumes in 2016, generated primarily from Canada, Mexico and the Pacific Rim (Japan, Vietnam, Taiwan, and Indonesia).
- U.S. recycled paper tends to have a higher content of virgin fiber than material from other countries in Europe and the Pacific Rim, because the material in the latter countries has been recycled multiple times.
- Republic Services and Waste Management ship 65-70% of their recycled paper material domestically. The rest goes to China, India, Vietnam, Venezuela, Thailand, Mexico, and Europe. Corrugated boxes are most likely to be exported (that is, boxes from the likes of Amazon, rather than breakfast cereal boxes).

Table 7: U.S. Recovered Paper and Fiber Export Volume, Top 15 Destinations

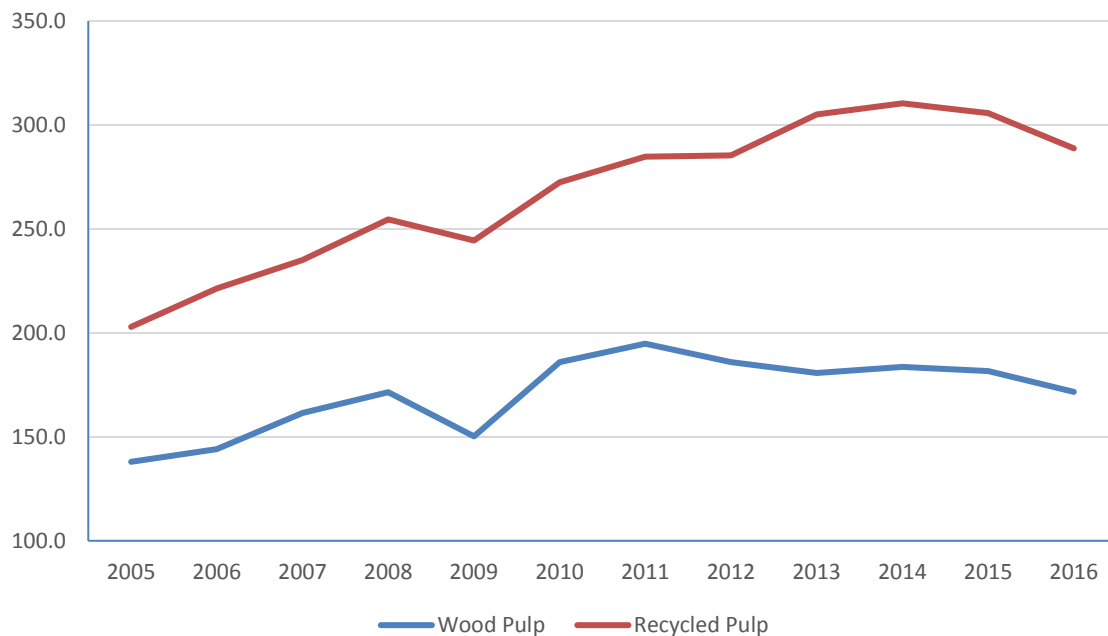
| COUNTRY | 2014 <i>Short Tons</i> | 2015 <i>Short Tons</i> | 2016 <i>Short Tons</i> | PERCENT CHANGE 2015-2016 |
|-------------|---------------------------|---------------------------|---------------------------|-----------------------------|
| China | 14,292,148 | 14,979,164 | 14,527,207 | -3.0% |
| India | 1,747,162 | 1,654,495 | 1,728,272 | 4.5% |
| Mexico | 1,321,855 | 1,298,741 | 1,646,529 | 26.8% |
| South Korea | 1,112,365 | 1,120,781 | 1,140,405 | 1.8% |
| Canada | 710,905 | 650,515 | 717,540 | 10.3% |
| Indonesia | 368,863 | 318,884 | 419,583 | 31.6% |
| Thailand | 202,426 | 308,477 | 324,618 | 5.2% |
| Taiwan | 257,226 | 191,092 | 281,739 | 47.4% |
| Vietnam | 74,237 | 111,118 | 133,807 | 20.4% |
| Italy | 89,894 | 112,536 | 102,700 | -8.7% |
| Japan | 51,910 | 84,342 | 101,228 | 20.0% |
| Netherlands | 80,373 | 90,650 | 88,467 | -2.4% |
| Colombia | 73,428 | 81,788 | 88,309 | 8.0% |
| Germany | 36,122 | 53,761 | 52,949 | -1.5% |
| Chile | 65,279 | 43,963 | 45,048 | 2.5% |

Source: RISI, (2016)

³⁷ Bonney, Joseph, (2015).

- Newsprint has been a large part of the waste stream over the last 10 - 12 years. For example, in 2005, Republic suggests that 18 million tons were recovered. Today, it is closer to 3 million tons.
- Newsprint in the Southwest will in all likelihood be exported via Long Beach. Mixed paper is also usually sent overseas.
- Demand for recycled corrugated fiber is currently very high, driven by the likes of Amazon and also Ali Baba in China. Mills do not have enough fiber to keep pace, so the market today is the highest it has been since 1995. This also in part offsets the previous 5 years' poor market conditions.
- Global wood pulp prices in 2015 were at their highest level for over 30 years, increasing the production costs for paper mills using virgin inputs. IBISWorld expects the price of wood pulp to increase 5.1% per year until 2019, reflected in a 3.2% annual increase in domestic paper prices.³⁸
- The U.S. paper and paperboard capacity declined 0.3% in 2015. The long-term trend decline per year since 2001 is 1.3%. Containerboard capacity reached an all-time high of 37.7 million tons, but U.S. capacity to produce newsprint and printing-writing papers continued to decline.³⁹

Figure 4: Producer Price Index by Commodity for Wood Pulp and Recycled Pulp



Source: Federal Reserve Bank of St Louis, (2017)

³⁸ Chiang, Jesse, (2016).

³⁹ American Forest & Paper Association, (2016).

- Figure 4 shows U.S. annual averages for Producer Price Index by Commodity for wood pulp and recycled paperboard, using 1982 as the index (100) year.⁴⁰ The figure shows a small, annual decline in the Producer Price Index since 2011 for wood pulp, and a much higher rate of growth for recycled paperboard. The cost of wood pulp in 2016 is 71.6% higher than the price in 1982.⁴¹ The cost of recycled paperboard in 2016 is 188.7% higher than the price in 1982.⁴²

2.4.3 Manufacturing Impacts

- The machinery used by bathroom tissue and towel manufacturers is the same for virgin and recycled pulp, but the process is different. The biggest difference is that recycled pulp needs to be cleaned and whitened using oxygen peroxide. Recycled tissue products also require more energy and water, depending on the efficiency of the system. On average, there is probably a 10% price differential.
- There is very little difference between the softness of virgin and recycled tissue paper. Even visually, the technology has advanced to ensure close similarities.

2.4.4 Examples of Paper Recycling Mills

- There is a large Clearwater plant in Las Vegas, NV, manufacturing bathroom tissue and towels that benefits from a complete system, including deinking. Clearwater also has large plants in Wisconsin and Georgia.
- International Papers (one of the biggest global players in the industry) has a presence in Tolleson and Yuma. However, they do not have a paper mill in Arizona, only box plants. Their combined workforce in the state is around 200 employees. Both Arizona plants convert containerboard into boxes, and that containerboard is likely to contain some recycled content, primarily supplied by their Springfield, OR, and Texas mills. Some of the latter recycled content is also purchased externally from other companies.
- The nearest domestic corrugated mills are in Pruitt, NM, or in Los Angeles and Ontario, CA.

⁴⁰ The price index for each year is non-seasonally adjusted for January 1.

⁴¹ U.S. Bureau of Labor Statistics, (2017a).

⁴² U.S. Bureau of Labor Statistics, (2017b).

2.4.5 New Developments in Paper

- The number of deinking projects established each year worldwide is decreasing, compared to 10 years ago. This is partly due to the discovery of quicker-growing trees. That is, the trees are simply replaced to produce new virgin fiber, particularly in Canada and Indonesia.

3.0 ESTIMATING POTENTIAL LOCAL IMPACT

The current section attempts to quantify the extent to which the four types of recycled and additionally recoverable materials from the city of Phoenix waste stream discussed in Section 2 could potentially add to economic activity in Maricopa County and expand circular economy practices. When the current study was originally commissioned, the objective of this section was to estimate the economic impact of prospective manufacturers interested in recycling/repurposing/reusing the city of Phoenix’s municipal waste materials as part of a circular economy. However, the stakeholder interviews implemented as part of Section 2 demonstrate that:

- (a) Most of the recycled materials in the state are currently shipped to domestic customers located either outside Arizona, or, more frequently overseas.
- (b) It would be difficult to attract circular economy manufacturers to Arizona without first ensuring that an appropriate supply of recycled material is not only readily available from the waste stream, but also already processed into a form appropriate for circular economy manufacturing within the state.

The revised purpose of Section 3 is to therefore estimate the gross maximum potential economic impact of up to four individual firms, three of which operate earlier within the value chain. These are:

- The economic impact of a post-consumer plastic flake or pellet processor.
- The economic impact of a recycled glass processor.
- The economic impact of a local metal shredder’s operations.
- The economic impact of a recycled box mill.

The inputs and assumptions from these models are based on Section 2’s stakeholder insights, U.S. Bureau of Labor Statistics data, and examples of comparator processing plants in other states.

Consistent with the first city of Phoenix study, Seidman’s economic impact analysis is gross in nature. That is, it assumes that the local processing of waste-diverted feedstock generates additional demand, rather than replace existing demand for “virgin” or prime inputs. The gross maximum economic impact estimates in the current section therefore take into account the capital and operational costs of

processing the recycled materials, but do not account for any corresponding fall in the demand for “virgin” or prime feedstock, or the cost of any incentives potentially offered by state and local governments to attract recycled processors to establish plants in Maricopa County.

3.1 ECONOMIC IMPACT ANALYSIS – CONCEPT AND METHOD

Economic impact analysis traces the full impact - direct, indirect and induced - of an economic activity on jobs and incomes in a local economy.

When a business decides to expand or relocate in the city of Phoenix, there is a resulting increase in capital expenditures as new buildings are constructed and/or old buildings are remodeled. Further, industry specific expenditures (capital equipment) may be required to ensure the facility is fit-for-purpose.⁴³ Coupled with this initial capital investment, there are on-going jobs created once the business begins operation. These are the *direct* impacts on the local economy from a new business locating within the city of Phoenix. These direct impacts are generally easy to understand and calculate.

However, there are additional second-order expenditures and jobs created as a result of the initial “injection” of expenditures and on-going jobs. For example, a person hired at a newly opened post-consumer plastic flake firm in the city of Phoenix represents a direct job. The income that this person spends in the local economy will in turn create revenues/income for a variety of different businesses. This creates *indirect* and *induced* effects associated with the initial direct expenditures.

These rounds of expenditures are not self-perpetuating in equal measure. They become smaller as more of the income/expenditures “leak” out of the local economy.⁴⁴ The cumulative impacts of these rounds of expenditures or “ripple effects” are known as the multiplier effect in economics. The extent of these ripple effects depend on numerous factors. In very simple terms, what matters is the size of the direct impact, where it occurs (that is, in which county and which sector of the economy), and the duration of the impacts. A full understanding of the total impact that a new business will have on the local economy is therefore rather more complex than just an extrapolation of direct impacts.

⁴³ There are also on-going (operations) capital expenditures throughout the lifetime of the business.

⁴⁴ For example, in the form of savings, payments on goods and services produced outside of the state, etc.

Sections 3.2 through 3.5 estimate the impact of four distinct firms working within the circular economy value chain either locating or expanding their operations in the metro Phoenix area.

The study makes use of an Arizona-specific version of the REMI regional forecasting model, updated at the Seidman Research Institute, to estimate the economic impact of each firm in Maricopa County and the State of Arizona.⁴⁵

REMI is an economic-demographic forecasting and simulation model developed by Regional Economic Models, Inc., and designed to forecast the impact of public policies and external events on an economy and its population. The REMI model is recognized by the business and academic community as the leading regional forecast/simulation tool available.

Unlike most other regional economic impact models, REMI is a dynamic model that produces integrated multi-year forecasts and accounts for dynamic feedbacks among its economic and demographic variables. The REMI model is also an "open" model in that it explicitly accounts for trade and migration flows in and out of the state.⁴⁶ REMI is especially useful when examining the economic impact associated with businesses expanding or relocating to a particular region, state or country. Through its dynamic modeling, REMI takes account of variations in the economic impact of a business as it moves from the establishment to operations phase, and also shows how estimates can vary through time for the project. These estimated impacts are the difference between the baseline economy and the baseline economy augmented with the new enterprise. As a result, the analysis measures the local economy, 2017 through 2022, *with* and *without* the existence of the new enterprise.

The use of a county level model also enables a more detailed disaggregation of results to occur, estimating the "leakage" of economic impacts into Arizona counties other than Maricopa County.

The method for estimating the macroeconomic impact involves four fundamental steps:

⁴⁵ This is a different type of economic model to the one used in the first study.

⁴⁶ A complete explanation of the model and discussion of the empirical estimation of the parameters/equations can be found at www.remi.com.

- 1. Prepare a baseline forecast for the state and county economies:** This Business As Usual (BAU) case forecasts the future path of the Maricopa County and State of Arizona economies based on a combination of an extrapolation of historic economic conditions and an exogenous forecast of relevant national economic variables.
- 2. Develop a policy scenario:** This policy scenario describes the *direct* impacts that a new business locating in the city of Phoenix will generate.
- 3. Compare the baseline and policy scenario forecasts.**
- 4. Produce the delta results:** Differences between the future values of each variable in the forecast results estimate the magnitude that a new business locating in the city of Phoenix could have on the state or county economies, relative to the baseline.

Three measures of gross maximum economic impact are offered at a state and county level for the study time horizon. These are:

- **Gross State Product (GSP):** This is the dollar value of all goods and services produced in Arizona for final demand/consumption. National level GSP is referred to as Gross Domestic Product (GDP). GSP can also be defined as the sum of employment compensation, proprietor income, property income, and indirect business taxes.
- **Employment:** This is the number of full-time and part-time employees needed to support the economic activity. It is expressed in terms of job years. A job year is equivalent to one person having a full-time job for exactly one year. Two measures of employment are offered: total employment and total private non-farm employment. The first measure include public sector (government) and farming jobs. The second measure excludes the public sector and farming jobs.
- **Real Disposable Personal Income:** This is a measure of the household income that is available to be spent after tax payments. Technically speaking, real disposable personal income is the sum of wage and salary disbursements, supplements to wages and salaries, proprietors' income, rental income of persons, personal dividend income, personal interest income, and personal current transfer receipts, less personal taxes and contributions for government social insurance.

3.2 GROSS MAXIMUM ECONOMIC IMPACT OF A RECYCLED PET PROCESSOR

The 2014 Waste Characterization Study estimates that 4,859.8 tons of PET is recycled in the city of Phoenix. This consists of 3,995.7 tons of PET bottles, and 864.1 tons of other PET packaging. The study also suggests that an additional 3,251.9 tons of PET bottles and 993.1 tons of other PET packaging are potentially recoverable from the city of Phoenix's municipal waste stream. This equates to 9,104.8 tons of recyclable PET, or 18.2 million pounds per year.

Seidman uses the ORPET plant in Oregon as a comparator in this study. The ORPET plant in Oregon currently employs 50 people to process up to 15 million pounds of PET per year. To err on the side of caution, the current analysis assumes that a similar number of employees in a hypothetical Arizona-based plant could manage the city of Phoenix's 18.2 million pounds of PET per year. Total capital expenditure for the Oregon plant (buildings and equipment) is at least \$10 million. The Bureau of Labor Statistics Quarterly Census of Employment and wages estimates the average weekly wage of a MRF employee in Arizona is \$792 per week (excluding benefits) in 2016.⁴⁷

When modeling the economic impact of any new business locating in Arizona, the effects can be broken down into two phases; the construction phase and the operation phase. Table 8 estimates the gross maximum economic impact of a PET post-consumer flake or pellet firm operating in the city of Phoenix using a REMI model. The analysis assumes that the construction takes place in 2017, followed by five years of full operations (2018-2022).

Using REMI, Table 8's results incorporate the gross maximum direct economic impacts associated with the establishment and operations of a PET post-consumer flake or pellet firm, as well as any potential gross maximum impacts indirect and induced that could occur due to the increased economic activity associated with the newly-established business. All of the gross maximum estimates presented in the Table are against the Business as Usual (BAU) case.⁴⁸

⁴⁷ U.S. Bureau of Labor Statistics, (2017c). Using a GDP deflator, this is equivalent to \$808 in 2017.

⁴⁸ If GSP is estimated to be x dollars higher than the baseline case, this means that it is x dollars higher than the GSP forecast for that given year if the new business had not located in Arizona.

Table 8: Gross Maximum Economic Impact of a PET Post-Consumer Flake or Pellet Firm⁴⁹

| COUNTRY | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | CUMUL. IMPACT 2017-2022 |
|---|-------|-------|-------|-------|-------|-------|-------------------------|
| Total Employment (Job Years) | | | | | | | |
| Arizona | 116 | 190 | 201 | 202 | 198 | 191 | NA |
| Maricopa County | 113 | 185 | 196 | 198 | 194 | 187 | NA |
| <i>County as % of State</i> | 97.6% | 97.8% | 97.8% | 97.9% | 98.0% | 98.1% | NA |
| Total Private Non-Farm Employment (Job Years) | | | | | | | |
| Arizona | 113 | 183 | 191 | 192 | 187 | 179 | NA |
| Maricopa County | 110 | 179 | 187 | 188 | 183 | 176 | NA |
| <i>County as % of State</i> | 97.7% | 97.8% | 97.9% | 98.0% | 98.1% | 98.2% | NA |
| Real Disposable Personal Income (Millions Fixed 2017 \$) | | | | | | | |
| Arizona | 5.8 | 9.4 | 10.2 | 10.6 | 10.7 | 10.6 | 57.2 |
| Maricopa County | 5.6 | 9.1 | 9.9 | 10.3 | 10.4 | 10.4 | 55.7 |
| <i>County as % of State</i> | 96.4% | 96.7% | 97.1% | 97.5% | 97.9% | 98.4% | 97.4% |
| Gross State Product (Millions Fixed 2017 \$) | | | | | | | |
| Arizona | 10.4 | 19.3 | 20.7 | 21.2 | 21.2 | 20.8 | 113.5 |
| Maricopa County | 10.2 | 19.0 | 20.3 | 20.9 | 20.8 | 20.6 | 111.8 |
| <i>County as % of State</i> | 98.1% | 98.4% | 98.5% | 98.5% | 98.6% | 98.6% | 98.5% |

Source: Authors' Calculations

Examining Table 8, Seidman estimates that Arizona-wide total employment could be up to 116 full-time (or equivalent) jobs higher relative to the baseline in 2017, including 113 jobs in the private sector.⁵⁰ GSP could be higher relative to the baseline by a gross maximum \$10.4 million (2017 \$), and real disposable personal income could be higher relative to the baseline by a gross maximum \$5.8 million (2017 \$). All of the 2017 impacts could occur as a result of the firm's capital expenditure. The vast majority of these positive gross maximum economic impacts could occur within Maricopa County (97.7% for total private non-farm employment, 96.4% for real disposable personal income, and 98.1% for GSP).

In 2018, the first year of operations, Seidman estimates that Arizona-wide total employment could be up to 190 full-time (or equivalent) jobs higher relative to the baseline for the year, including 183 jobs in the private sector.⁵¹ GSP could be higher relative to the baseline by a gross maximum \$19.3 million (2017 \$),

⁴⁹ Numbers may not tally exactly due to rounding.

⁵⁰ These are the gross maximum jobs associated with the project only in 2017.

⁵¹ These are the gross maximum jobs associated with the project only in 2018.

and real disposable personal income could be higher relative to the baseline by a gross maximum \$9.4 million (2017 \$). The vast majority of these positive gross maximum economic impacts could occur within Maricopa County (97.8% for total private non-farm employment, 96.7% for real disposable personal income, and 98.4% for GSP).

In 2022, the fifth year of operations, Seidman estimates that Arizona-wide total employment could be up to 191 full-time (or equivalent) jobs higher relative to the baseline for the year, including 179 jobs in the private sector.⁵² GSP could be higher relative to the baseline by a gross maximum \$20.8 million (2017 \$), and real disposable personal income could be higher relative to the baseline by a gross maximum \$10.6 million (2017 \$). The vast majority of these positive gross maximum economic impacts could again occur within Maricopa County (98.2% for total private non-farm employment, 98.4% for real disposable personal income, and 98.6% for GSP).

In aggregate terms, during the study period 2017-2022, GSP could be cumulatively higher by a gross maximum \$113.5 million (2017 \$), 98.5% of which could occur in Maricopa County. Real disposable personal income could be cumulatively higher by a gross maximum \$57.2 million (2017 \$), 97.4% of which could occur in Maricopa County. Seidman also estimates for every 1 job year of direct employment at the PET processing firm in Maricopa County during the six year study horizon, a gross maximum 3.1 additional job years of employment could be created elsewhere in the county. The top five private non-farm beneficiaries of the cumulative job years' employment could be:

- 33.1% Administrative and Waste Management Services
- 15.2% Construction
- 8.2% Retail Trade
- 6.2% Health Care and Social Assistance
- 5.9% Professional, Scientific, and Technical Services.

3.3 GROSS MAXIMUM ECONOMIC IMPACT OF A GLASS CULLET PROCESSOR

The 2014 Waste Characterization Study estimates that 9,527.1 tons of glass is recycled in the city of Phoenix as part of the residential blue recycling program. The study also suggests that an additional

⁵² These are the gross maximum jobs associated with the project only in 2022.

4,591.4 tons of recyclable glass is potentially recoverable from the city of Phoenix's municipal waste stream. This equates to 14,118.5 tons of recyclable glass per year, or 28.2 million pounds per year.

Arizona already has a glass cullet processor located on S. 19th Avenue in Phoenix. They currently employ 15 people at this facility, and handle 50,000 tons of recycled glass per year. 73% of this glass is sourced from metro Phoenix/Maricopa County, and 23% from other parts of Arizona. The firm to date has invested \$3 million in the Phoenix facility; and their cullet is only sold to customers outside the state. The average weekly wage for their Phoenix-based employees is \$897.

The current statewide annual economic impact of this firm's Arizona operations, 2017-2022, is estimated at:

- \$37.3 million cumulative contribution to GSP for the 5 year study horizon.
- An average 57 total private non-farm jobs each year.
- \$19.0 million cumulative contribution to real disposable personal income for the 5 year study horizon.

This is based on current operations, which handle 50,000 tons of glass from residential and non-residential sources primarily inside the State of Arizona. It excludes a \$3 million capital expenditure investment, as it occurred before 2017.

To enable the firm to process the additional 4,591.4 tons of recoverable glass from the city of Phoenix waste stream, management estimates that it will need an additional 5 employees and invest \$1.5 million in new equipment. Table 9 estimates the gross maximum economic impact of this firm additionally processing the additional 4,591.4 tons of recoverable glass using a REMI model. The analysis assumes that the capital investment takes place in 2017, with the additional 5 employees and processing commencing in 2018. All of the estimates presented in the Table are against the BAU case.⁵³

⁵³ The BAU case for glass assumes that the firm will continue to employ 15 people and process 50,000 tons of glass per year. Seidman's alternative scenario estimates the impact of an additional \$1.5 million investment in equipment in 2017, and an additional 5 direct employees per year 2018 through 2022.

Table 9: Gross Maximum Economic Impact of Increasing Glass Cullet Processing Capacity in the State of Arizona⁵⁴

| COUNTRY | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | CUMUL. IMPACT 2017-2022 |
|---|--------------|--------------|--------------|--------------|--------------|--------------|-------------------------|
| Total Employment (Job Years) | | | | | | | |
| Arizona | 8 | 19 | 20 | 21 | 20 | 20 | NA |
| Maricopa County | 8 | 18 | 20 | 20 | 20 | 19 | NA |
| <i>County as % of State</i> | <i>96.6%</i> | <i>97.7%</i> | <i>97.8%</i> | <i>97.8%</i> | <i>98.0%</i> | <i>98.1%</i> | <i>NA</i> |
| Total Private Non-Farm Employment (Job Years) | | | | | | | |
| Arizona | 8 | 18 | 19 | 20 | 19 | 18 | NA |
| Maricopa County | 8 | 18 | 19 | 19 | 19 | 18 | NA |
| <i>County as % of State</i> | <i>96.6%</i> | <i>97.8%</i> | <i>97.8%</i> | <i>97.9%</i> | <i>98.0%</i> | <i>98.1%</i> | <i>NA</i> |
| Real Disposable Personal Income (Millions Fixed 2017 \$) | | | | | | | |
| Arizona | 0.4 | 0.9 | 1.0 | 1.1 | 1.1 | 1.1 | 5.7 |
| Maricopa County | 0.4 | 0.9 | 1.0 | 1.1 | 1.1 | 1.1 | 5.6 |
| <i>County as % of State</i> | <i>95.2%</i> | <i>96.6%</i> | <i>96.9%</i> | <i>97.4%</i> | <i>97.8%</i> | <i>98.2%</i> | <i>97.2%</i> |
| Gross State Product (Millions Fixed 2017 \$) | | | | | | | |
| Arizona | 0.9 | 1.9 | 2.1 | 2.2 | 2.2 | 2.1 | 11.4 |
| Maricopa County | 0.9 | 1.9 | 2.1 | 2.1 | 2.1 | 2.1 | 11.2 |
| <i>County as % of State</i> | <i>97.4%</i> | <i>98.4%</i> | <i>98.4%</i> | <i>98.5%</i> | <i>98.5%</i> | <i>98.6%</i> | <i>98.4%</i> |

Source: Authors' Calculations

Examining Table 9, Seidman estimates that Arizona-wide total employment could be up to 8 full-time (or equivalent) jobs higher relative to existing operations in 2017 if the firm could process the 4,591.4 tons of glass additionally recoverable from the city of Phoenix waste stream.⁵⁵ GSP could be higher relative to existing operations by a gross maximum \$0.9 million (2017 \$), and real disposable personal income could be higher relative to existing operations by a gross maximum \$0.4 million (2017 \$). All of the incremental gross maximum impacts could occur as a result of the firm's \$1.5 million capital expenditure in new equipment to process the additionally recoverable glass. The vast majority of these positive incremental economic impacts could occur within Maricopa County (96.6% for total private non-farm employment, 95.2% for real disposable personal income, and 97.4% for GSP).

⁵⁴ Numbers may not tally exactly due to rounding.

⁵⁵ These are the gross maximum jobs associated with the new capital expenditure required by the project in 2017 alone.

In 2018, the first year of extended operations, Seidman estimates that Arizona-wide total employment could increase by up to 19 full-time (or equivalent) jobs higher relative to existing operations for the year, including 18 jobs in the private sector.⁵⁶ GSP could be higher relative to existing operations by a gross maximum \$1.9 million (2017 \$), and real disposable personal income could be higher relative to existing operations by a gross maximum \$0.9 million (2017 \$). The vast majority of these gross maximum positive incremental economic impacts could occur within Maricopa County (97.8% for total private non-farm employment, 96.6% for real disposable personal income, and 98.4% for GSP).

In 2022, the fifth year of operations, Seidman estimates that Arizona-wide total employment could be up to 20 full-time (or equivalent) jobs higher relative to the baseline of current operations for the year, including 18 jobs in the private sector.⁵⁷ GSP could be higher relative to existing operations by a gross maximum \$2.1 million (2017 \$), and real disposable personal income could be higher relative to existing operations by a gross maximum \$1.1 million (2017 \$). The vast majority of these gross maximum incremental positive economic impacts could occur within Maricopa County (98.1% for total private non-farm employment, 98.2% for real disposable personal income, and 98.6% for GSP).

In aggregate terms, during the study period 2017-2022, GSP could be cumulatively higher by a gross maximum \$11.4 million (2017 \$), 98.4% of which could occur in Maricopa County. Real disposable personal income could be cumulatively higher by a gross maximum \$5.7 million (2017 \$), 97.2% of which could occur in Maricopa County. Seidman also estimates for every 1 job year of additional direct employment at the recycled glass processing firm in Maricopa County during the six year study horizon, a gross maximum 3.0 additional job years of employment could be created elsewhere in the county. The top five private non-farm beneficiaries of the cumulative job years' employment could be:

- 33.6% Administrative and Waste Management Services
- 13.1% Construction
- 8.6% Retail Trade
- 6.3% Health Care and Social Assistance
- 5.9% Professional, Scientific, and Technical Services.

⁵⁶ These are the gross maximum jobs associated with the extended operations (5 additional direct employees) in 2018 alone.

⁵⁷ These are the gross maximum jobs associated with the extended operations (5 additional direct employees) in 2022 alone.

It is important to note that Table 9's gross maximum economic estimates and the distribution of employment impacts above are only for the incremental employees and equipment needed to handle the additionally recoverable glass from the city of Phoenix waste stream. They do not include the impact of existing operations.

3.4 GROSS MAXIMUM ECONOMIC IMPACT OF A SCRAP METAL SHREDDER

The 2014 Waste Characterization Study estimates that 1,043.3 tons of aluminum, 1,516.5 tons of tin and steel food cans, and 1,416 tons of other metals are recycled in the city of Phoenix. The study also suggests that an additional 1,026.7 tons of aluminum, 2,328.5 tons of tin and steel food cans, and 3,444.1 tons of other recyclable metals are potentially recoverable from the city of Phoenix's municipal waste stream. This equates to an additional 6,799.3 tons of potentially recyclable metal a year.

Section 2's interviews suggest there is already greater supply than demand for recycled aluminum in the state without the additionally recoverable 1,026.7 tons for that type of metal. Liberty Metals - one of two existing large-scale local metal shredders - is also able to manage at least 50,000 more tons of recycled metals per year without requiring any additional investment in equipment or employees. Only a small portion of Liberty's 250,000 tons of metals each year are sourced from municipal waste. As a result, there does not appear to be any immediate additional economic benefit available from the diversion of metals from the city of Phoenix waste stream. At best, it will simply help retain the presence of a metal shredder in the city which, based on an employment profile of 100 staff, is conservatively estimated to have the following statewide economic impact in 2017 alone:

- 361 job years Total Employment
- 351 job years Total Private Non-Farm Employment
- \$36.2 million contribution to GDP
- \$18.1 million contribution to Real Disposable Personal Income.⁵⁸

⁵⁸ These annual gross maximum economic impact estimates exclude any capital expenditure investment. They are based exclusively on employment.

The 1-year economic impact estimates above exclude any capital expenditure investments in 2017, and are therefore conservative. They are simply included for illustrative purposes, and predominantly occur in Maricopa County (in excess of 96.5%, dependent on the economic impact metric).

3.5 GROSS MAXIMUM ECONOMIC IMPACT OF A RECYCLED BOX MILL

The 2014 Waste Characterization Study estimates that 17,161.4 tons of plain OCC/Kraft paper is recycled in the city of Phoenix. The study also suggests that an additional 5,380.3 tons of plain OCC/Kraft paper is potentially recoverable from the city of Phoenix's municipal waste stream. This equates to a total of 22,541.7 tons of recyclable plain OCC/Kraft paper, or 45.1 million pounds per year, from the city of Phoenix waste stream.

Seidman uses Pratt Industries' corrugated box factory which opened in Beloit, WI, as a comparator in this study. This factory currently employs 140 people to produce 600 tons of 100% recycled boxes every day.⁵⁹ To err on the side of caution, Seidman assumes that this equates to 156,000 tons of recycled boxes manufactured a year, based on a 5-day week. Total capital expenditure for the Wisconsin plant (buildings and equipment) is \$60 million.

The Bureau of Labor Statistics Quarterly Census of Employment and wages estimates the average weekly wage of a MRF employee in Arizona is \$788 per week (excluding benefits) in 2015.⁶⁰

Table 10 estimates the gross maximum economic impact of a recycled corrugated box firm operating in the city of Phoenix using a REMI model. The analysis assumes that construction takes place in 2017, followed by five years of full operation (2018-2022).

Using REMI, Table 10's results incorporate the gross maximum direct economic impacts associated with the establishment and operations of a recycled corrugated box mill, as well as any potential gross maximum indirect and induced impacts that could occur due to the increased economic activity associated with the newly-established business. All of the gross maximum estimates presented in the Table are against the Business as Usual (BAU) case.⁶¹

⁵⁹ Pratt Industries, (2017).

⁶⁰ U.S. Bureau of Labor Statistics, (2017c).

⁶¹ The BAU case assumes that no recycled box mill currently exists in Arizona.

Table 10: Gross Maximum Economic Impact of a Recycled Corrugate Box Firm⁶²

| COUNTRY | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | CUMUL. IMPACT 2017-2022 |
|---|-------|-------|-------|-------|-------|-------|-------------------------|
| Total Employment (Job Years) | | | | | | | |
| Arizona | 637 | 668 | 692 | 688 | 670 | 644 | NA |
| Maricopa County | 621 | 649 | 672 | 668 | 651 | 626 | NA |
| <i>County as % of State</i> | 97.5% | 97.1% | 97.1% | 97.1% | 97.2% | 97.2% | NA |
| Total Private Non-Farm Employment (Job Years) | | | | | | | |
| Arizona | 620 | 640 | 658 | 650 | 630 | 604 | NA |
| Maricopa County | 605 | 622 | 639 | 632 | 613 | 588 | NA |
| <i>County as % of State</i> | 97.6% | 97.2% | 97.2% | 97.2% | 97.3% | 97.3% | NA |
| Real Disposable Personal Income (Millions Fixed 2017 \$) | | | | | | | |
| Arizona | 32.0 | 34.9 | 37.4 | 38.3 | 38.4 | 38.3 | 219.2 |
| Maricopa County | 30.8 | 33.6 | 36.1 | 37.1 | 37.3 | 37.3 | 212.1 |
| <i>County as % of State</i> | 96.3% | 96.3% | 96.5% | 96.8% | 97.1% | 97.3% | 96.7% |
| Gross State Product (Millions Fixed 2017 \$) | | | | | | | |
| Arizona | 58.0 | 72.2 | 76.1 | 77.4 | 77.2 | 76.5 | 437.4 |
| Maricopa County | 56.9 | 70.8 | 74.6 | 75.8 | 75.7 | 75.0 | 428.9 |
| <i>County as % of State</i> | 98.0% | 98.1% | 98.0% | 98.1% | 98.1% | 98.1% | 98.1% |

Source: Authors' Calculations

Examining Table 10, Seidman estimates that Arizona-wide total employment could be up to 637 full-time (or equivalent) jobs higher relative to the baseline in 2017, including 620 jobs in the private sector.⁶³ GSP could be higher relative to the baseline by a gross maximum \$58.0 million (2017 \$), and real disposable personal income could be higher relative to the baseline by a gross maximum \$32.0 million (2017 \$). All of the gross maximum impacts are assumed to occur as a result of the firm's capital expenditure. The vast majority of these positive economic impacts could occur within Maricopa County (97.6% for total private non-farm employment, 96.3% for real disposable personal income, and 98.0% for GSP).

In 2018, the first year of operations, Seidman estimates that Arizona-wide total employment could be up to 668 full-time (or equivalent) jobs higher relative to the baseline for the year, including 640 jobs in the private sector.⁶⁴ GSP could be higher relative to the baseline by a gross maximum \$72.2 million (2017 \$),

⁶² Numbers may not tally exactly due to rounding.

⁶³ These are gross maximum jobs associated with the project in 2017 alone.

⁶⁴ These are gross maximum jobs associated with the project in 2018 alone.

and real disposable personal income could be higher relative to the baseline by a gross maximum \$34.9 million (2017 \$). The vast majority of these positive economic impacts could occur within Maricopa County (97.2% for total private non-farm employment, 96.3% for real disposable personal income, and 98.1% for GSP).

In 2022, the fifth year of operations, Seidman estimates that Arizona-wide total employment could be up to 644 full-time (or equivalent) jobs higher relative to the baseline for the year, including 604 jobs in the private sector.⁶⁵ GSP could be higher relative to the baseline by a gross maximum \$76.5 million (2017 \$), and real disposable personal income could be higher relative to the baseline by a gross maximum \$38.3 million (2017 \$). The vast majority of these positive economic impacts could again occur within Maricopa County (97.3% for total private non-farm employment, 97.3% for real disposable personal income, and 98.1% for GSP).

In aggregate terms, during the study period 2017-2022, GSP could be cumulatively higher by a gross maximum \$437.4 million (2017 \$), 98.1% of which could occur in Maricopa County. Real disposable personal income could be cumulatively higher by a gross maximum \$219.2 million (2017 \$), 96.7% of which could occur in Maricopa County. Seidman also estimates for every 1 job year of direct employment at the recycled box mill in Maricopa County during the six year study horizon, a gross maximum 4.3 additional job years of employment could be created elsewhere in the county. The top five private non-farm beneficiaries of the cumulative job years' employment could be:

- 23.7% Manufacturing
- 16.4% Construction
- 8.8% Retail Trade
- 6.6% Professional, Scientific, and Technical Services.
- 6.5% Health Care and Social Assistance

It is important to note that the total amount of plain OCC/Kraft paper already recycled or additionally recoverable from the city of Phoenix waste stream represents less than 15% of the comparator plant's recycled pulp. This is a significant difference to the plastic flake/pellet processor, and the glass cullet

⁶⁵ These are gross maximum jobs associated with the project in 2022 alone.

processor. It also reinforces a common theme expressed by several interviewees – specifically, the need to adopt a multi-state approach to the development of a circular economy. The idea here is that the waste generated by Arizona alone is insufficient for the establishment of a recycled corrugated box operation. In short, economic viability is predicated on the sourcing of additional material from neighboring states.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The original purpose of this study was to quantify the extent to which the current recycled and additionally recoverable tons of plastic, glass, metal, and paper in the city of Phoenix municipal waste stream could meet the annual production needs of locally-based circular economy manufacturing firms. However, based on a series of 21 stakeholder interviews, the research team quickly realized that:

- (a) Most of the recycled materials in the state are currently shipped to domestic customers located either outside the State of Arizona, or, more frequently overseas.
- (b) Circular economy manufacturers will require some certainty that an appropriate supply of recycled material is available locally in an appropriate form for their operations.

The study has therefore estimated the gross maximum potential economic impact of up to four individual firms, three of which operate earlier within the circular economy value chain. These were:

- The economic impact of a post-consumer plastic flake or pellet processor.
- The economic impact of a recycled glass processor.
- The economic impact of a local metal shredder's operations.
- The economic impact of a recycled box mill.

Figure 5 offers a snapshot of key conclusions for each of the four materials examined. Sections 4.1 through 4.4 offer more detailed conclusions for each recycled material examined.

4.1 PLASTIC

One of the quickest potential opportunities for the city of Phoenix from a recycled plastic perspective could be to focus on PET.

The city of Phoenix already recycles 4,859.8 tons of PET, which could increase to 9,104.8 tons if all of the additional PET is diverted from the city's municipal waste stream.

Figure 5: Snapshot of Recommendations (excluding compostable materials)

| | |
|--|--|
| <p>PLASTIC (0.86% increase in recycling)</p> <p><i>Municipal Waste Recycled (2014): 11,548.3 tons (PET, HDPE & Other)</i> <i>Additional Amount Recoverable (2014): 11,782.4 tons (PET, HDPE & Other)</i></p> <p><i>Seidman Recommendation:</i> Establish a PET processing facility in the city of Phoenix</p> <p><i>Estimated Capital Expenditure Investment: \$10-\$12 million</i> <i>Estimated Direct Annual Employment at Facility: 50 jobs</i> <i>Total Estimated Volume of Recycled Materials: 9,100 tons (PET)</i></p> <p><i>Gross Maximum Total Contribution to GSP (2017-2022):</i> \$113.5 million – 98.5% in Maricopa County</p> | <p>GLASS (0.93% increase in recycling)</p> <p><i>Municipal Waste Recycled (2014): 9,527.1 tons</i> <i>Additional Amount Recoverable (2014): 4,591.4 tons</i></p> <p><i>Seidman Recommendation:</i> Extend current 50,000 ton cullet processing operation in the city of Phoenix</p> <p><i>Estimated Additional Capital Expenditure Investment: \$1.5 million</i> <i>Estimated Additional Direct Annual Employment at Facility: 5 jobs</i> <i>Total Estimated Volume of Recycled Materials: 55,000 tons</i></p> <p><i>Gross Maximum Total Additional Contribution to GSP (2017-2022):</i> \$11.4 million – 98.4% in Maricopa County</p> |
| <p>METALS (1.38% increase in recycling)</p> <p><i>Municipal Waste Recycled (2014): 3,975.8 tons (Aluminum, Cans & Other)</i> <i>Additional Recoverable (2014): 6,799.3 tons (Aluminum, Cans & Other)</i></p> <p><i>Seidman Recommendation:</i> Utilize existing scrap metal network in the city of Phoenix. Encourage existing manufacturers to expand their local operations, or attract new recycled metal manufacturers to the area</p> <p><i>Estimated Additional Capital Expenditure Investment: \$0 (processing)</i> <i>Estimated Additional Direct Annual Employment at Facility: 0 jobs (processing)</i></p> <p><i>Gross Maximum Total Additional Contribution to GSP (2017-2022):</i> \$0 million (processing)</p> | <p>PAPER (1.84% increase in recycling)</p> <p><i>Municipal Waste Recycled (2014): 53,447.7 tons (Newspaper, OCC & Other)</i> <i>Additional Recoverable (2014): 26,115.8 tons (Newspaper, OCC & Other)</i></p> <p><i>Seidman Recommendation:</i> Adopt a multi-state approach, in which newspaper is shipped out of state but OCC is processed in-state, subject to the availability of sufficient volume from neighboring states</p> <p><i>Estimated Capital Expenditure Investment: \$60 million</i> <i>Estimated Direct Annual Employment at Facility: 140 jobs</i> <i>Estimated Volume of Recycled Materials Needed: 156,000 tons (OCC)</i></p> <p><i>Gross Maximum Total Contribution to GSP (2017-2022):</i> \$437.4 million – 98.1% in Maricopa County</p> |

Source: Authors' Calculations

There are challenges with the recycling of plastic, in part because the demand for recycled plastic resin is correlated with the cost of crude oil. This means that when the cost of crude oil falls, virgin (prime) plastic resin is cheaper to purchase than its recycled counterpart. Furthermore, the demand for recycled plastic in the State of Arizona appears to be currently negligible. However, plastic manufacturers can interchange between virgin (prime) and recycled plastic based on the availability of price; and the ORPET facility in Oregon illustrates a potential roadmap for the city of Phoenix.

If a plant similar in size and output to ORPET is established in the city of Phoenix, the construction of this facility and five consecutive years' operations could cumulatively increase statewide GSP by a gross maximum \$113.5 million, and real disposable personal income by a gross maximum \$57.2 million. Approximately 50 people would also be directly employed at the plant during each year of operation. For every 1 job year of direct employment at the firm, up to 3.1 additional job years of employment could be created elsewhere in Maricopa County.

The establishment of a PET processing facility to handle Phoenix's recycled PET feedstock could increase total recycling in the city by 0.86%, based on the 2014 waste characterization study data.

PET is not the only form of plastic in the city of Phoenix municipal waste stream. An estimated 6,688.5 tons of HDPE and other types of plastic was recycled by single-family homes in 2014, with a further 7,537.4 tons additionally recoverable from the waste stream.⁶⁶ One potential solution could be to convert these other types of plastic waste into green construction material, using ByFusion's mobile process. Their process turns SPI 1 – SPI 5 and SPI 7 plastics into RePlast - a usable building block similar in size and shape to a typical CMU block.^{67 68} The technology is new, and the demand for green construction materials is outside the remit of this study; but this is a potential circular economy area worthy of further investigation.

If all of the additionally recoverable plastic is recycled, the city of Phoenix's total recycling rate could increase by 2.39%, based on the 2014 waste characterization study data.

⁶⁶ This excludes 65.9 tons of additionally recoverable compostable plastic.

⁶⁷ Hedmond, Shane, (2016).

⁶⁸ Please note: the current study assumes that SPI 1 (PET) will be managed by a new post-consumer PET processing facility.

4.2 GLASS

The city of Phoenix is already home to a recycled glass (cullet) processor that purchases some of its material from local MRFs. This firm currently employs 15 people and handles 50,000 tons of recycled glass per year at their \$3 million Phoenix facility. 73% of their glass is sourced from metro Phoenix/Maricopa County. Seidman therefore recommends that the city enter into discussions with Strategic Materials, with a view to their processing the additionally recoverable glass in the municipal waste stream.

To enable the firm to process 4,591.4 tons of the additionally recoverable glass from the city of Phoenix municipal waste stream, the firm estimates that it will need to employ an additional 5 people, and invest a further \$1.5 million in new equipment.

In aggregate terms, during the six-year study period, this could increase GSP in the State of Arizona by a gross maximum \$11.4 million. Real disposable personal income could increase by a gross maximum \$5.7 million over the 6 years. For every 1 job year of additional direct employment at the firm, Seidman also estimates that up to 3.0 job years of employment could be created elsewhere in Maricopa County. These gross maximum economic impacts are incremental positive impacts associated with an extension of the firm's current operations. They do not include the existing economic impact of the firm, which is estimated at \$37.3 million total contribution to GSP (2017-2022) based on existing operations alone.

The diversion of the additionally recoverable glass from Phoenix's municipal waste stream to the existing glass processing facility could increase total recycling in the city by 0.93%, based on the 2014 waste characterization study data.

Recycled glass cullet can constitute up to 95% of the raw materials used in the manufacture of glass products, and also offers significant energy savings to manufacturers. Waste management firms sometimes question the value of recycling glass, but it is one of the heaviest things in the municipal waste stream and there is a demand for the product, albeit currently at a national rather than local level. The quality of the glass supply, though, is key. A source-separated (glass only) system within the city of Phoenix could increase the value of, and recovery rate for, glass in the Valley, thereby offsetting the potential higher costs of such a collection strategy. Approximately one fourth of the Phoenix-based cullet

facility's current operating are disposal/landfill fees due to the waste delivered with their recycled glass material. Establishing a cleaner supply could dramatically reduce their costs and landfill volumes. This is another area the city could explore with Strategic Materials.

In 2014, approximately half of the recycled cullet in the U.S. was used in bottle manufacture, 40% on insulation, and 10% in sandblast media or carpet applications. Bottle cullet is typically transported by truck, so processing facilities tend to be located within 300 miles of consumers. Insulation cullet is often transported by rail.⁶⁹ If the city of Phoenix wishes to create a circular economy for glass, it could explore manufacturing opportunities in bottle manufacture, insulation, and sandblast or carpet to utilize its glass. All of the recycled glass is currently sold on to firms operating outside Arizona.

4.3 METAL

The scrap metal industry already has a significant footprint in the city of Phoenix. There are several scrap metal brokers and dealers, and two large-scale shredders. Looking further along the value chain, metro Phoenix is also home to an aluminum can manufacturer and a steel mill, both of which accept recycled metal inputs.

The 2014 waste characterization study suggests that there are an additional 6,799.3 tons of potentially recyclable metal a year in the city of Phoenix waste stream. This consists of 1,026.7 tons of aluminum, 2,328.5 tons of tin and steel food cans, and 3,444.1 tons of other recyclable metals.

An interview with one of the two large-scale shredders currently in operation in Phoenix suggests that they can accommodate over 50,000 tons of additional metal each year, without requiring any new investment in equipment or increasing its workforce. As a result, there appears to be negligible economic benefit accrued from processing the additionally recoverable metals in the city of Phoenix municipal waste stream.

To generate local economic benefits, the city could encourage existing manufacturers to expand their local operations, or attract new manufacturers to the Valley that utilize recycled metal. At present, the

⁶⁹ McKenna, Lisa, (2014).

city's supply of recycled metals is already greater than the demand from its aluminum can manufacturer (Alcoa) and steel rebar mill (Commercial Materials).

The diversion of the additionally recoverable metals from Phoenix's municipal waste stream to existing scrap metal processors could increase total recycling in the city by 1.38%, based on the 2014 waste characterization study data.

4.4 PAPER

Post-consumer paper-based waste includes old corrugated containers, newspapers, magazines, and other printed papers.

The city of Phoenix could find it difficult to attract a company capable of creating pulp from old newspapers, magazines, and other printed papers, as a water-intensive deinking system will be needed to remove printing ink from recycled paper fibers. Given the water challenges currently faced by the state, the prospect of establishing a \$10 million deinking (cleaning) system employing 40 or so people in the Valley is somewhat remote.

Furthermore, the amount of corrugated waste available from the city of Phoenix waste stream (currently recycled and additionally recoverable) is less than 15% of the fiber inputs required by a comparable corrugated box factory in Beloit, WI. It's doubtful that this shortfall in recycled corrugated fiber could be overcome through the utilization of a statewide as opposed to city of Phoenix municipal waste stream, because the city accounts for around 20% of the state's population. The future economic viability of a recycled corrugated box facility in the city could therefore be predicated on the sourcing of additional material from neighboring states.

If an appropriate volume of OCC could be sourced throughout the Southwest and a plant similar in size and output to Beloit, WI, is established in the city, the construction of this facility and five consecutive years' operations could cumulatively increase statewide GSP by a gross maximum \$437.4 million, and real disposable personal income by a gross maximum \$219.2 million. Approximately 140 people could also be directly employed at the facility during each year of operation.

A multi-state approach to the circular economy could result in reciprocal economic benefits within paper recycling. For example, the city could potentially ship its recycled newspaper, magazines, and printed materials to Nevada in return for the latter's OCC, given that a deinking plant already operates outside Las Vegas. This multi-state approach could take several years of discussions to come to fruition, and could even extend to other materials. Nevertheless, the city needs to think beyond its geographic limits and give due consideration to a multi-state approach if it wishes to foster a vibrant circular economy.

The diversion of the additionally recoverable OCC and newspaper feedstock from the Phoenix municipal waste stream, if an economic partnership could be established with other counties/states, could increase total recycling in the city by 1.84%, based on the 2014 waste characterization study data.

4.5 CITY OF PHOENIX WASTE STREAM IMPACTS

Purely from a waste reduction perspective, the study has suggested that the quickest wins for the city of Phoenix could relate to PET, glass, and metal.

In 2014, an estimated 15.94% (or 78,509 tons) of materials were recycled through the city's curbside programs (excluding contaminants). If a flake/pellet processing firm could be established to handle all of the city's PET, and the existing glass (cullet) processor and scrap metal shredder could consume the additionally recoverable materials in the waste stream, the city's total amount of curbside recycling could increase by more than 15,600 tons. This equates to a revised recycling rate of 19.11%.⁷⁰

Longer-term, if a multi-state supply can be agreed for a recycled corrugated box plant located in the city of Phoenix, this could result in a revised recycling rate of 20.21%.⁷¹

4.6 CITY OF PHOENIX GROSS MAXIMUM TOTAL ECONOMIC IMPACTS

Table 11 summarizes the gross maximum total economic impact of the new PET processor, and additional glass and metal recycling in the city of Phoenix, as outlined in this study:

⁷⁰ Please note: this is based on the 2014 waste characterization study data, and does not reflect any changes to the rate of recycling in the city of Phoenix since that time.

⁷¹ Please note: this is based on the 2014 waste characterization study data, and does not reflect any changes to the rate of recycling in the city of Phoenix since that time.

Table 11: Gross Maximum Economic Impact of PET Processing, and Enhanced Glass and Metal Recycling⁷²

| COUNTRY | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | CUMUL. IMPACT 2017-2022 |
|---|-------|-------|-------|-------|-------|-------|-------------------------|
| Total Employment (Job Years) | | | | | | | |
| Arizona | 125 | 208 | 221 | 223 | 219 | 210 | NA |
| Maricopa County | 122 | 204 | 216 | 219 | 214 | 207 | NA |
| <i>County as % of State</i> | 97.5% | 97.8% | 97.8% | 97.9% | 98.0% | 98.1% | NA |
| Total Private Non-Farm Employment (Job Years) | | | | | | | |
| Arizona | 121 | 201 | 211 | 211 | 206 | 198 | NA |
| Maricopa County | 118 | 196 | 206 | 207 | 202 | 194 | NA |
| <i>County as % of State</i> | 97.6% | 97.8% | 97.9% | 98.0% | 98.1% | 98.2% | NA |
| Real Disposable Personal Income (Millions Fixed 2017 \$) | | | | | | | |
| Arizona | 6.3 | 10.3 | 11.2 | 11.7 | 11.8 | 11.7 | 63.0 |
| Maricopa County | 6.0 | 10.0 | 10.9 | 11.4 | 11.5 | 11.5 | 61.3 |
| <i>County as % of State</i> | 96.3% | 96.7% | 97.1% | 97.5% | 97.9% | 98.4% | 97.4% |
| Gross State Product (Millions Fixed 2017 \$) | | | | | | | |
| Arizona | 11.3 | 21.2 | 22.8 | 23.4 | 23.3 | 23.0 | 124.9 |
| Maricopa County | 11.1 | 20.8 | 22.4 | 23.0 | 23.0 | 22.7 | 123.0 |
| <i>County as % of State</i> | 98.0% | 98.5% | 98.4% | 98.5% | 98.6% | 98.6% | 98.5% |

Source: Authors' Calculations

In aggregate terms, during the study period 2017-2022, GSP could be cumulatively higher by a gross maximum \$124.9 million (2017 \$), 98.5% of which could occur in Maricopa County. Real disposable personal income could be cumulatively higher by a gross maximum \$63.0 million (2017 \$), 97.4% of which will occur in Maricopa County. There could be an additional 55 people *directly* employed each year to handle the recycled materials. Seidman also estimates for every 1 job year of additional direct employment as a result of this waste diversion in Maricopa County during the six year study horizon, up to 3.1 additional job years of employment could be created elsewhere in the county.

It is important to note that Table 11's gross maximum economic estimates and the distribution of employment impacts do not take into account existing glass (cullet) processing or scrap metal shredding. They only take into account the incremental employees and equipment needed to handle the additionally

⁷² Numbers may not tally exactly due to rounding.

recoverable glass and metal from the city of Phoenix waste stream, along with the establishment and operation of a new post-consumer PET processing facility.

The gross maximum economic impact estimates listed in Table 11 should also not be added to the maximum gross estimates of Maricopa County's circular economy in 2014 previously calculated by Seidman for the city of Phoenix in fall 2016. This is because the two reports use different types of economic model. The 2014 maximum gross estimate uses a linear IMPLAN model best suited for a single analysis of a 12 month historical or current time horizon. The current study uses a more dynamic REMI model best suited for future multi-year forecasts.

Longer-term, if a multi-state supply can be agreed for a recycled corrugated box plant located in the city of Phoenix, this could increase the annual gross maximum economic impact estimates for PET, glass, and metals (combined) described in Table 11 by more than 300%.

4.6 RECOMMENDATIONS FOR FURTHER STUDY

The focus of this study has been on the city of Phoenix municipal waste stream collected curbside from single-family residential properties in blue and black containers. The study does not take into account the additional waste generated by multi-family properties, or the commercial and industrial sectors. Seidman therefore recommends further review of the feedstock for recycled plastic, glass, metal, and paper taking into account these additional sources.

Seidman also recommends widening the feedstock review to other parts of Arizona and its contiguous states, to validate the need for some form of multi-state approach to the circular economy on a single or multiple feedstock level. This could even extend to feedstock not examined as part of the current study, such as organics (food and green waste), or construction and demolition waste.

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