German and American Exchange on Zero Waste and Circular Economy Initiatives:

Analysis and Observations from 2024 McCloy Fellowship on Global Trends

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From extreme drought to extreme precipitation in the western United States to rising temperatures in the arctic and record drought in parts of Europe and Africa, climate change is expanding across the globe. A linear economy of production, consumption, and disposal of products and food is a significant contributor of climate change. Implementation of a circular economy is a fundamental step towards achieving climate targets since the products and food production and consumption equate to 45% of current emissions (Ellen MacArthur Foundation, 2021). Additionally, the disposal process for consumed food and products is a significant contributor to greenhouse gas emissions including transportation, landfill or incineration. Developing and implementing a successful circular economy and zero waste initiatives across the globe will be essential to combat the climate change global trend.

Germany and the United States have long histories of recycling using different approaches and making recent strides with circular economy and zero waste. For example, municipalities across Germany and the United States have aggressive goals to accelerate their carbon neutrality, zero waste and circular economy development before 2050. This report explores the development and implementation of local circular economy and zero waste initiatives in the cities of Bonn, Munich, Kiel and Berlin including the solid waste management structures, regulations, economics and lessons learned. Additionally, the report will compare the approaches taken by these German cities with those of the City of Phoenix, Arizona.

City of Phoenix

As the fifth largest city in the United States and encompassing 500 square miles (1,295 square kilometers), Phoenix is unique compared to other cities across the United States in that it not only provides weekly contained solid waste and single stream recycling collection services to 420,000 residential customers but it also owns two single stream Materials Recovery Facilities (MRF), two transfer stations, an industrial composting facility, and one open landfill that process all of the inbound recycling, organics and residual waste collected. In addition to the collection service, residents can drop off recyclables, yard waste, electronics, appliances and solid waste items at the city's two transfer stations located in the north and south areas of the City. Through a public/private partnership, Phoenix also offers a scheduled collection service for household hazardous waste materials. After decades of providing quarterly bulk trash collection, in September 2024, Phoenix began implementation of an appointment-based bulk trash collection program. With the new program model, Phoenix residents can schedule their bulky-waste collections online rather than waiting for quarterly bulk trash pickup during the dates assigned to their area. The goals of the new collection model include providing greater convenience to Phoenix residents to schedule bulk trash collection when they need it up to four times per year and preventing collection scheduling during the holidays. The City also hopes to realize long-term collection efficiencies by developing more targeted collection routes based on appointments instead of driving every street of the City four times per year.

Phoenix is a recycling pioneer beginning with the establishment of a voluntary recycling collection program in the early 1990s and development of its first city-owned Materials Recovery Facility (MRF) in 1995 and continuing with the second MRF in 2005. In the Fall 2024, Phoenix completed a comprehensive upgrade of its original 27th Avenue MRF to become state-of-the-art in its processing capabilities and capture rates. Phoenix's recycling program was established as a single stream system where residents place recyclables in one container for automated collection by the City and the City's MRFs are designed to mechanically sort the comingled recyclables into valuable commodities including aluminum, metal, plastics, cardboard, paper and glass.

Weekly curbside collection of residual waste, co-mingled recycling and yard waste in 90-gallon containers.

North Gateway Materials Recovery Facility

Since 2013, Phoenix has led the United States in establishing programs and projects focused on developing a local circular economy. One of the programs includes establishing the Resource Innovation Campus (RIC), a circular economy hub for public-private partnerships designated across 40 acres of land adjacent to the City's waste stream feedstocks at the 27th Avenue Transfer Station. The first successful project at the RIC was the construction of a state-of-the-art industrial scale compost facility capable of processing up to 55,000 tons of organics per year. Due to contamination concerns with the residential food waste stream, the majority of organics feeding the compost facility currently are from yard waste delivered to the City's transfer stations from Phoenix residents and local landscaping companies. The food waste delivered to the compost facility comes from select food waste sources including K-12 schools, Arizona State University, Phoenix Convention Center and City-sponsored zero waste events. The City's contracted compost facility operator, WeCare Denali, is also seeking out clean food waste sources they can collect directly for processing at the facility including food manufacturers and grocery store chains. The City partners with WeCare Denali to operate the City's compost facility including producing quality compost and marketing and selling the finished compost products. They also participate in the US Composting Council's Seal of Test Assurance Program and Organic Materials Review Institute certification processes to provide third party quality assurance of the finished compost.

Phoenix implemented mega zero waste events including in 2023, where Phoenix achieved 92.6 percent diversion from the downtown Phoenix Superbowl events, making it the greenest Superbowl in history. Phoenix repeated its zero waste event achievements in 2024 when it hosted events for the NCAA men's Basketball Final Four.

In both events, Phoenix strategically placed convenient collection containers around the downtown Phoenix venues and staffed the event to help with education and sortation. Despite this, achieving zero waste at both events required extensive hand sortation of the loads at the transfer station. Additionally, the majority of the tonnage came from the large compactors and roll-off bins at the convention center servicing the set-up and break down of the events.

Phoenix encounters many challenges with achieving its zero waste goals including customer behaviors around composting and recycling. Some residents do not believe items placed in the recycle bin are actually recycled whereas others think almost everything belongs in the recycle bin. Furthermore, with no Federal or State mandates for recycling, composting and zero waste, participation in Phoenix's programs is voluntary. Phoenix's zero waste team focuses on education and outreach to help residents learn how to recycle and compost correctly. Some of the most innovative tools they've implemented include the Recycle Right Wizard which is a search tool to help residents determine how to responsibly recycle or dispose of common household items. The tool also includes an interactive waste sorting game which has been used by schools. After Phoenix's implementation of the Recycle Right Wizard, Phoenix has partnered with surrounding cities to expand the tool to create a consistent messaging. The Zero Waste Team also engages with residents through community events and school presentations. The relationships they developed with some of Phoenix's schools led to a partnership with five schools to pilot a composting program in their cafeterias using grant funding from the United States Department of Agriculture. The programs were successfully implemented and many of the schools have opted to continue with the program after the conclusion of the grant funding. The 20,000 people per year that the Zero waste Team engages with includes conducting weekly tours of the City's North Gateway MRF that includes a viewing gallery where residents can see how the recycling is sorted into commodity bales from start to finish. The Zero Waste Team also posts virtual tours of the MRF and compost facility on Phoenix's website. Additionally, the Zero Waste Team manages a Green Business certification program that includes over 100 participating businesses that not only implement recycling or composting actions, but other sustainability efforts.

Phoenix's solid waste utility is limited in its reach with Phoenix's 1.6 million residents. By City Code, Phoenix's solid waste utility is limited to collecting only from single family households, complexes less than 30 units, condominiums, schools, non-profits and other city departments. Private solid waste companies provide collection service to Phoenix's multi-family complexes and commercial properties and often do not include recycling collection. To provide access to recycling for these residents, Phoenix places large roll-off bins at seven parks across the City for residents to drop off their recyclables. Phoenix currently relies on local businesses, community-based organizations and non-profits to provide reuse options to its residents through technology platforms, flea

markets and second-hand stores. Local businesses also provide subscription-based food waste collection service and dishwashing services for events.

Although there are no state or national mandates requiring circular economy or zero waste implementation, Phoenix's City Council is leading the charge for the City's circular economy development and solid waste diversion that were memorialized in the 2021 Climate Action Plan including goals for zero waste and carbon neutrality by 2050. Phoenix recognizes that the transportation of 130 loads of solid waste per day for over fifty miles one way to the City's landfill is a source of carbon emissions in addition to the emissions generated from landfill operations and gas production. From a global circular economy perspective, in 2015, Phoenix became the first municipality in the United States invited to join the Ellen MacArthur Foundation CE100 membership. More recently, Phoenix also joined the US Plastics Pact.

All of the solid waste programs and services provided by Phoenix's solid waste utility are funded by the service fees assessed to its customers. The solid waste utility charges a monthly service fee to its customers for the weekly collection and processing of their solid waste and recycling. The service fee also includes four on-demand bulk trash collections per year, one household hazardous waste collection per year and up to one free ton of waste disposal at the city's transfer stations per month. The standard curbside collection containers provided for solid waste and recycling is 90 gallons. For neighborhoods with alleys, every three or fewer residences share a 300 gallon solid waste container. The utility also provides voluntary options including a green organics collection bin for eligible residents that is an additional $5 per month and residents who request to reduce their solid waste container size from 90 gallons to 60 gallons can see a savings of $3 per month for services.

For customers that deliver solid waste directly to the city's transfer stations, the solid waste utility charges fees based on the tonnage and type of material delivered. To encourage diversion of residential waste from the landfill, the City does not charge a fee for recycling and they offer a discounted fee to landscaping companies that deliver clean yard waste loads for the compost facility.

<u>European Union and Germany Governance</u>

The governance around waste management, zero waste and circular economy is different in Germany. In general, the European Union provides framework directives for its member countries, including Germany that are reflected in associated laws that are passed by the German federal government. Enforcement of the German federal laws are established by the 16 federal states that include the city states of Berlin, Hamburg and Bremen. Specific to waste management, the European Union established frameworks and public procurement laws regarding recycling, zero waste and circular economy. This has recently translated into Germany's Circular Economy Act of 24 February 2012 and Packaging Act of 5 July 2017. The purpose of the Circular Economy Act is to promote circular economy in order to conserve natural resources and to ensure the protection of human health and the environment in the generation and management of waste (Federal Law Gazette, 2012). The law also prioritizes waste prevention and management measures in the order of avoidance, preparation for reuse and recycling, energy recovery, and elimination (Federal Law Gazette, 2012). In Germany, energy recovery includes waste incineration as there is a ban to landfill untreated residual waste. The only waste allowed in the landfill is hazardous waste, construction waste, mineral waste and the slag from waste incineration (BonnOrange, Waste Hierarchy, 2024).

Comparatively, the Packaging Act of 5 July 2017 provides requirements for product responsibility for packaging. The Act also includes targets for recovery and recycling of wood, plastics, metals, glass, paper and cardboard (Federal Ministry of Justice and Consumer Protection and the Federal Office of Justice, 2017). The law includes financial responsibility of producers for the collection, reuse, recovery, and recyclability of their products. This is considered the dual system in Germany where products are sorted and collected by customers commercially for

reuse or recycling in parallel to the dual collection at their homes. Common ways the dual system is seen commercially in Germany is with take-back systems at stores using deposits and drop-off containers. The most advanced technology used in stores are reverse vending machines where customers can return plastic and glass containers with eligible labels to the machine and receive money back or store credit. The machines can be programmed to detect and sort the eligible packaging based on their composition or what the store sells.

Applicable stores also provide drop off sites for used batteries to keep them out of the residual waste stream.

Another method used are recycle island collection points installed around German cities for the public to drop off their packaging items. Pictured are recycle islands with bins to collect clear, brown and green glass as well as used textiles.

Collection at the reverse kiosks and recycle islands is typically done by private recycling companies that operate recycling processing facilities. Examples of some of these companies include, but are not limited to, ALBA and Remondis.

Other businesses like cafes, restaurants and hotels provide return options for plastic and glass bottles they sell. Additionally, in alignment with German laws, these businesses provide reusable dishware options for the food and beverages they sell or provide, reducing their obligations under the Packaging Act. An example of the impact of Germany's regulations compared to those of the United States can be seen with food service at international hotel chains. Like in the United States, some of the lower cost international hotel chains provide complimentary breakfast buffets for their guests. In Germany, the international hotel chains use all reusable dishes, glasses and silverware at the breakfast buffets and either provide tray collection areas as pictured below or use staff. In contrast, the same hotel chains in the United States offer guests disposable plates, cups and plasticware for their complimentary breakfast buffets with limited or no reusable options.

In alignment with the federal laws, state laws generally specify the enforcement of the federal laws including the responsibilities of the public disposal company and associated reporting requirements including waste plans and balance sheets. The city statutes generally specify the solid waste collection and disposal services and fees as well as the organization and authorization of the public disposal company. Similar to Phoenix's solid waste utility, German public disposal companies rely on the service fees to fund all of their services and programs.

City of Bonn

The City of Bonn resides along the Rhine River in the federal state of North Rhine-Westphalia and was the capital of the Federal Republic of West Germany from 1949 until the reunification of Germany that resulted in the German capital returning to Berlin in 1991 and the German parliament's relocation to Berlin in 1999. Since then, Bonn is still considered a Federal and international city in Germany as the headquarters to the United Nations. The population of Bonn is over 320,000 people across the city's four districts and BonnOrange is a public disposal company responsible for the collection of waste generated in the City of Bonn and advising residents on waste avoidance and recycling (Bonn, 2024). BonnOrange runs a manual dual stream collection system where organics (brown bin), paper and cardboard (blue bin) and residual waste (grey bin) are collected separately. The collection is done with a team of four BonnOrange collection employees manually rolling each bin from their storage area to and from the collection truck. Because of this collection method, residual waste and organics are collected every 14 days and paper is collected monthly. The collection method and Germany's mandates dictate Bonn's service fee structure where collection fees for residual waste are higher compared to the paper and organics collection. For

residual waste, the larger the container and more frequent the collection, the higher the collection fees. The residual waste container sizes provided by BonnOrange range in size and associated fees with 40 liters being the smallest and 1100 liters being the largest. The intent for this fee structure is to financially incentivize recycling, composting and reuse. Furthermore, BonnOrange provides a discount on the service fees for residents that are composting at home (BonnOrange, Waste, Bins & Co., 2024) (BSR, NochMall- Everything But New. The BSR Second-Hand Goods Store, 2024). The following are pictures of the various container sizes for reference.

Containers ranging from 60 liters to 240 liters in size.

Containers sized at 660 liters and 1100 liters.

In addition to the service fee, BonnOrange also charges a transportation surcharge based on container size, with the larger containers having the highest fees. This is because of the manual nature of the collection method. Although BonnOrange advises residents about recycling their lightweight packaging material in the yellow containers, collection of these containers is done by a private company.

In addition to residential collection, BonnOrange operates two recycle centers for residents and businesses to drop off items for recycling. Similar to the service fee model, BonnOrange provides free drop off of recyclable items at the centers but charges fees for household waste, bulky waste, and construction and renovation wastes, with increases in the fees based on volume. BonnOrange also provides free drop off of household hazardous waste but charges fees for drop offs of commercial quantities of hazardous waste. Unlike Phoenix's transfer stations, BonnOrange's recycle centers are smaller and designed specifically for residents to easily separate their items for recycling with a separate container for each item accepted. The recycle center also separates items for recycling or disposal that Phoenix does not at its transfer stations including CDs, ink cartridges, natural cork, lighting, lithium-ion batteries and construction and renovation waste. In addition to the recycle centers, specific for garden waste, BonnOrange provides seasonal mobile drop off locations for garden waste and three year-round drop off sites including two of the city's cemeteries (BonnOrange, 2024).

As defined in Bonn's statute, BonnOrange is limited in their functions with the Rhineland Waste Management Corporation Association (REK) authorized by the City of Bonn to manage the sorting, treatment, storage, incineration and landfilling of the waste generated in Bonn (Bonn, 2024). With this, the items collected by BonnOrange directly from residents or at the Recycle Centers are delivered to REK's post-collection facilities or contractors. In the center of Bonn are the incineration plant, paper sortation facility and packaging recycling facility where Bonn's residual, paper and packaging waste is delivered respectively. Outside the city limits are three composting facilities that accept organics from the City of Bonn and neighboring cities. The Sankt Augustin facility recently opened in 2023 and contains state-of-the-art anaerobic digestion technology that can process around 60,000 tons of organics and 18,000 tons of green waste annually. The delivered organic material is shredded and screened before going through the fermentation process to produce biogas. The large sized overs are blended with the digestate produced from fermentation and composted.

In addition to collection services, BonnOrange provides extensive education and outreach to its customers about what items belong in each container and to promote reuse. In 2019, BonnOrange began an initiative with businesses to promote their offerings of reusable cups and free water. Within the first year, 153 businesses participated and were added to a map on BonnOrange's website to make it easy for residents to find. In 2024, BonnOrange relaunched the initiative to reengage with businesses and residents about reuse. This includes providing campaign logos for participating businesses to display and providing more resources to businesses about reuse and associated hygiene practices. To further encourage reuse, BonnOrange provides information on their website about local non-profits, community organizations or businesses that accept and sell secondhand items or borrowing schemes. Additionally, BonnOrange facilitates a non-commercial swap and give-away market on their website for residents to post their items. BonnOrange encourages residents to use these options before dropping off their bulky waste at the recycle center or requesting bulky waste collection (BonnOrange, Overview: Where to put the table, chair, armchair, etc.?, 2024). BonnOrange also provides links to local makerspace and repair cafes networks on their website. There are 16 repair cafes across Bonn and each location operates either weekly or monthly. The repair cafes are community gathering and social environments where volunteers help their neighbors repair items over food, coffee and conversation (Repair Cafes Bonn, 2024).

City of Kiel

Similar to Bonn's population, the City of Kiel's population is over 250,000 as of 2023 and it is divided into 18 districts and 30 neighborhoods. Kiel is the state capital of Schleswig-Holstein in northern Germany and is known as the sailing city given its location on the Kiel Fjord of the Baltic sea. In 2018, the Kiel City Council decided the state capital should become a zero waste city and in 2020 a 270 page zero waste concept was developed and approved by the City Council. The concept includes 107 zero waste-measures to achieve the following two main objectives:

1. The total amount of waste per capita per year in Kiel is to be reduced by an average of 15% by 2035.
2. Halve household and commercial waste (residual waste) by 2023 and reduce it to less than 50 kilgrams per capital per year in the long term (Kahl, 2024).

Kiel's zero waste efforts were recognized in 2023 when it became the first certified zero waste city in Germany by Zero Waste Europe. Implementation of the zero waste concept is ongoing with the City's Environmental Protection Department and public disposal company ABK leading the efforts. Like BonnOrange, ABK runs a manual dual stream collection system where organics (brown bin), paper and cardboard (blue bin) and residual waste (grey bin) are collected separately. The collection is done manually with four-person crews. Similar to BonnOrange, ABK charges the highest service fees for residual waste collection based on the sizes of the containers, with the smallest size being the least expensive. Residual solid waste is typically collected every 14 days. Service fees for the collection of the paper and organics bins are significantly less to encourage reuse and recycling. Collection of the paper bins occurs monthly whereas the organics bin collections are every 14 days. In addition to the service fee,

ABK assesses transportation surcharges if the containers are more than 15 meters from the collection truck. If the containers are more than 30 meters from the collection truck, the surcharge increases further. Similar to BonnOrange, ABK promotes the use of the yellow packaging containers but their collection is conducted by Remondis. Also similar to BonnOrange, ABK operates two recycle centers for residents to drop off and separate their items and they rely on third parties for the processing of the paper, organics and residual waste collected by residents. Starting January 1, 2025, ABK is no longer accepting residual waste loads at the recycle centers. The residual waste will only be collected in the grey containers. The intent is to increase separation of recyclables from the residual waste and reduce the risk of fires at the recycle centers (ABK Sauber,Kiel, 2024). Similar to BonnOrange, ABK charges fees for larger volumes or difficult to recycle/dispose of items like construction waste, treated woods, large tree trunks, insulation materials, green waste and tires (Kiel Waste Management Company, 2024). The recycle centers accept household hazardous waste and ABK also provides mobile collection points across the city to make the proper disposal of this waste as convenient as possible for residents. In addition to garden waste drop off areas at the recycle centers, in the Spring and Fall, ABK provides mobile drop off sites on designated days and locations for up to 1 cubic meter of garden waste at no charge (ABK Sauber, Kiel, 2024).

In addition to ABK's tasks, the City of Kiel has implemented a series of zero waste projects to help the city achieve its goals. Some examples include the Centre for Sustainability in downtown Kiel. The center provides information, resources, workshops and events around zero waste. The center includes an interactive refrigerator exhibit with advice on storage of foods to preserve them longer and reduce waste. The exhibit is portable for school and community events as well. Similar to BonnOrange, the City of Kiel is undertaking a reuse campaign for businesses to promote reusable packaging and Kiel is embarking on incorporating more reusables at their annual Kiel sailing (Kieler Woche) event. The initial approach focused on reusable cups in 2022 resulting in 1 million reusable cups used at the event. Another community event example was on September 14, 2024 when ABK hosted their first open house in seven years at their headquarters and recycling center. The open house was open to the public to see the collection vehicles and interact with the organizations involved with zero waste. The event included food and beverages using reusable dishes, glass bottles and silverware. ABK partnered with a local start-up company called Spülbar that provided mobile dishwashing service from a retrofitted conex box.

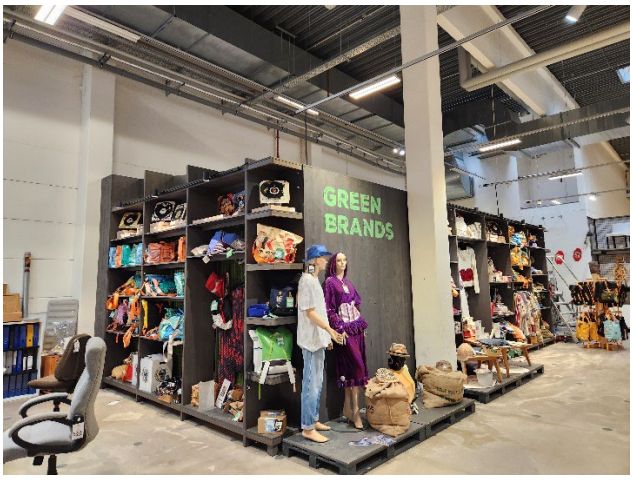
The City also established an excavated soil exchange including a public platform that has prevented 4,700 tons of soil from being disposed of. Lastly, Kiel Public Library implemented a Library of Things that currently includes 81 different items ranging from gaming consoles to gardening tools that patrons can check out like library books. The idea is to encourage borrowing items rather than purchasing new (Kahl, 2024).

City of Berlin

Like the cities of Bonn and Kiel, Berlin is taking innovative approaches to comply with the German Laws. Berlin is the German capital and is also a federal city-state like Hamburg and Bremen. Berlin is the most populous city in Germany with 3.87 million residents as of June 2023 (Office for Statistics Berlin-Brandenburg, 2023). Berlin's population is distributed across 12 borough administrations which serve as municipalities in Berlin's two-tiered political administrative structure (Chancellery, 2024). BSR and its subsidiary Berlin Recycles is the public disposal agency that conducts manual collections of organics, paper, and residual waste with four person-crews across all 12 boroughs of Berlin. Unlike BonnOrange and ABK, the lightweight packaging (yellow bins) are collected by BSR in some of the Boroughs. The bins in the other boroughs are collected by ALBA (BSR, BSR, 2024). Collection of organics, residual waste and recycling is every 14 days whereas collection of paper is monthly. Similar to BonnOrange and ABK, BSR charges high service fees for residual waste collection by container size and their service fees for organics, recycling and paper collection are significantly less to incentive diversion from the landfill. Like ABK, BSR charges transportation fees based on the distance of the containers from the collection vehicles. BSR operates 14 recycling centers across the City that are set-up similarly to those of ABK and

BonnOrange where residents drop-off and separate their items. Residents are not charged a fee to drop off most recyclable items but there are fees for old tires, residual waste, construction waste and household hazardous waste (BSR, 2024). As part of their education and outreach, BSR not only provides information on their website about what is acceptable at each recycle center, but they also include a virtual tour of their most modern Gradestraße recycling center and list the locations of all of the glass recycling containers along city roads for which they also service. Unlike BonnOrange and ABK, BSR and its subsidiaries operate post-collection sites including an incineration plant for residual waste and a biogas and compost facility for organic waste. Since BSR is involved in both the collection and post-collection of the waste streams, their education and outreach not only covers how to separate the waste but also what happens to organics, plastics, paper and glass after collection.

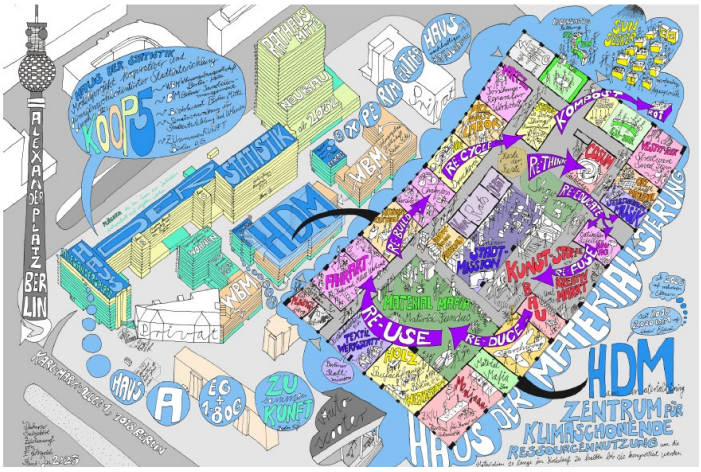
In addition to waste separation, BSR provides multiple options for waste avoidance including links to an online exchange and gift market and list of charities that accept items for donation. Regardless of these reuse options, BSR saw large quantities of items dropped off at the recycling centers that were still in good condition. Because of this and to comply with the Circular Economy Act, BSR began operating its own second-hand store called NochMall in 2020 in Berlin's Reinickendorf borough. NochMall includes household items, furniture, books, CDs, toys, and functional electronic items that are collected at three of BSR's recycling centers and delivered directly to the NochMall. NochMall also coordinates pick-up of items with residents. In addition to providing low-cost secondhand items, NochMall provides space for community gatherings around circular economy and reuse including a café area on the second floor, a weekly repair café, occasional workshops on reuse and upcycling, and monthly auction events for the most special items donated to NochMall (BSR, NochMall- Everything But New. The BSR Second-Hand Goods Store, 2024). The approach to the weekly Repair Café is similar to those in Bonn that rely on volunteers and focus on showing participants how to repair the items themselves in a social atmosphere. Below is a picture of the café area with a repair café session in the background.



NochMall also includes a Green Brands area for the sale of upcycled items produced by local designers. Although the area showcases circular economy entrepreneurs and products, given the time and costs to produce the upcycled items, their prices are significantly more expensive than the secondhand items in the store. This has created challenges for NochMall as the customer base for these items is different than those looking for low-cost second-hand items. Since NochMall opened, it has relied on BSR's funding in addition to the revenue from the sale of donated items to cover its operating costs, but it is looking for ways to become more self-sufficient.

In addition to NochMall another example of circular economy and reuse initiatives in Berlin is the House of Materialization near AlexanderPlatz in Berlin's Mitte Borough. The House of Materialization is a circular economy hub for start-ups and research and development initiatives including a reuse market for construction and creative items, bicycles made from used steel, Berlin City Mission second-hand store, and upcycled art installations. The

House of Materialization also houses a repair café along with sewing, upcycling and woodworking studios and workshops (House of Materialization, 2024).



Munich

Like Bonn, Kiel and Berlin, Munich is taking innovative approaches to zero waste and circular economy implementation. Munich is the capital of the German State of Bavaria with a population of over 1.6 million people as of November 2024 (Landeshauptstadt Munchen, 2024). AWM is the public disposal agency that conducts dual stream collection of residual waste, organic waste and paper/cardboard waste with four person crews across the 25 districts of Munich. Similar to the City of Kiel, in 2022, Munich's City Council approved a zero-waste concept that includes the following zero waste goals by 2035 (Company, 2024).

1. Reduce household waste by 15% per capita, per year, compared to 2019 baseline.
2. Reduce residual waste by 35% per capita per year, compared to 2019 baseline.
3. Raise awareness among Munich residents about zero waste.

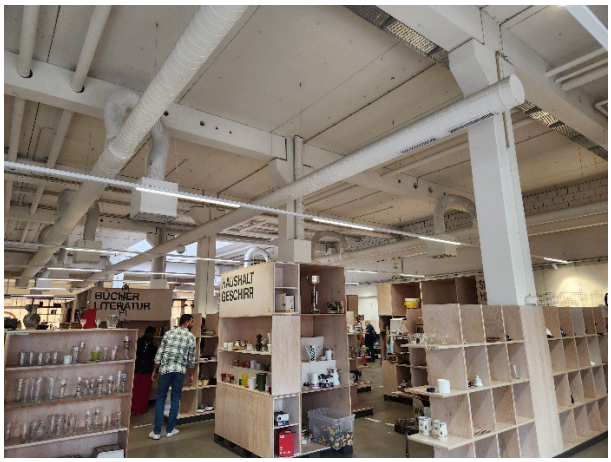
The plan includes additional measures in the categories of public administration, education, industry, commerce, construction and private individuals. One of these measures is to increase the recycling rate of household waste to 60% by 2035. As of 2023, Munich is boasting a 54.9% recycling rate (Company, 2024). Similar to BonnOrange, ABK and BSR, AWM charges higher fees based on the size of the residual waste containers and frequency of collection. AWM's residual waste containers range in size from 80 liters to 1,100 liters and frequency of collection options include weekly and every 14 days. Unlike BonnOrange, ABK and BSR, AWM does not charge additional fees for the paper and organics bins or for transportation (AWM, 2024). Similar to BonnOrange, ABK and BSR, AWM's frequency of collection is every 14 days for the paper and organics bins. Starting January 2025, AWM increased their residual waste service fees siting personnel costs, increased incineration costs, decline in paper and textile recycling revenue and a 15.69% inflation rate on other costs as the causes for the increases. Below is a chart from AWM's website describing the fee increases (AWM, 2024).

container size	fee so far per year	fee new per year	difference per year	difference per month
80 Liter	159,12 €	177,84 €	18,72 €	1,56 €
120 Liter	205,92 €	230,88 €	24,96 €	2,08 €
240 Liter	341,64 €	382,20 €	40,56 €	3,38 €
770 Liter	912,60 €	1.021,80 €	109,20 €	9,10 €
1.100 Liter	1.265,16 €	1.416,48 €	151,32 €	12,61 €

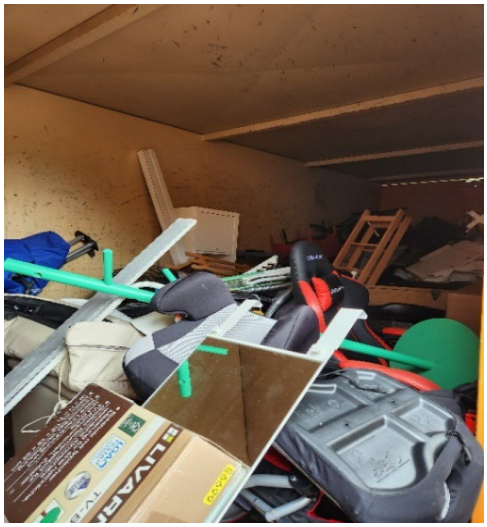
Source: https://www.awm-muenchen.de/muelltonnen-fuer-privathaushalte/muellgebuehren-2025

The residual waste AWM collects is delivered to Munich's North Combined Heat and Power Plant that is operated by Munich's municipal electrical utility where the material is incinerated. The incineration plant generates 9,873 MWh of electricity from the waste and 1,694,948 MWh generated district heating, supplying heat to approximately 150,000 households (Company, 2024). AWM operates 12 recycling centers for residents to drop off bulky waste and recycling items. AWM's website shows all of the locations of the recycling centers and what is accepted at each site. Like BSR, AWM's website also includes a map of the dual system recycle islands for residents to drop off glass and lightweight packaging for private companies to collect.

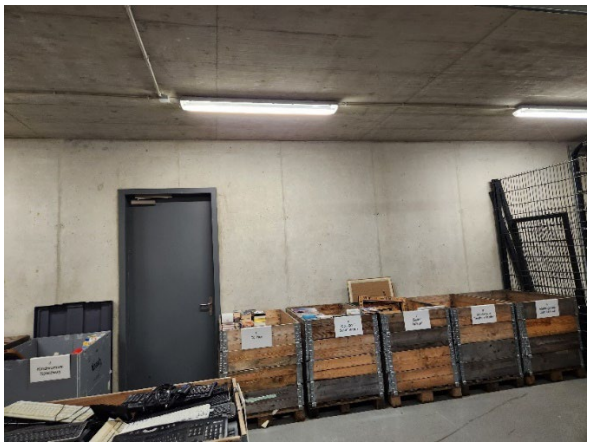
Like ABK, BonnOrange and BSR, some recyclable items are accepted at AWM's Recycling Centers without charge to residents and AWM charges fees for other items based on type and volume delivered including construction waste, household hazardous waste, garden waste, and bulky waste. AWM also charges a separate fee for the collection of bulky waste. Like ABK, AWM does not accept residual waste at the recycling centers. To reduce the disposal of bulky waste, like BSR, AWM operates their own secondhand store called Hall 2 located in the Pasing-Obermenzing district. Hall 2 consists of 1,000 square meters of space and sells items including furniture, books, CDs, sporting equipment, small appliances, electronics, toys, and household goods that are dropped off by residents at Hall 2 or one of the recycling centers.



As a solid waste focused company, AWM uses equipment like roll-off bins to transport the items collected at the recycling centers to Hall 2. Items can easily break if they are not placed with care inside the roll-off bin as pictured. AWM also uses wooden sortation boxes to collect smaller items at the recycling centers and transport to Hall 2.



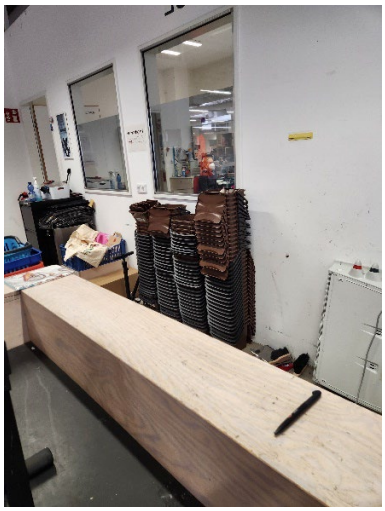
Roll-off bin challenges with Hall 2



Sortation boxes at a recycling center and Hall 2

Like BSR's secondhand store, AWM established their secondhand store to promote more reuse of items sent to the recycling centers that are still in working condition and promote the circular economy. AWM also conducts monthly auctions of unique items to increase participation. The House of Self-Employment organizes quarterly repair cafes at Hall 2 with volunteers to show participants how to repair their items. In addition to Hall 2, AWM includes a listing of other repair cafes across Munich on their website. They also provide information on their website about community and non-profit operated public bookcases and recycling cabinets for residents to informally share and exchange items instead of purchasing new (AWM, 2024). Additionally, AWM has information on their website about second-hand flea markets around the City.

In addition to being a secondhand store and repair café location, Hall 2 is a pick-up location for kitchen scrap bins and a sales location for bagged compost produced at AWM's dry fermentation and composting facility. Bagged compost is also sold at the recycling centers.



Similar to BSR and RSAG, AWM operates a dry fermentation plant called Erdenwerk Freimann that produces energy from processing organics through anaerobic digestion. The digestate from the process is then composted aerobically. The facility can process 18,000 tons of organics per year (Technologies, 2015). When the material has finished the composting process, it is moved to the sales area onsite where it is screened and mixed with other materials like peet and sand to make various compost blends based on the local market demand.

Similar to Phoenix's composting facility, the markets are regional and one of the primary markets of the true, unblended compost are agriculture and nurseries. AWM bagged compost also includes the label for Gütezeichen Kompost RAL which is a local third-party quality assurance program. This is similar to US Composting Council's Seal

of Test Assurance and Organic Materials Review Institute quality assurance programs that Phoenix's composting facility participates in. In 2022 AWM's fermentation plant generated 2,493 MWh of electricity and produced 4,878 tons of compost (Company, 2024).

Although AWM primarily provides collection and disposal service to the 830,000 private households across Munich, it also provides collection service to public institutions and some companies and hotels. AWM also does collection for large events including the annual Oktoberfest and Christmas markets. AWM provides the large event requirements based on the state and federal regulations including a ban on single-use items at events on city property, source separation of waste and recycling streams, and mandate that residual waste be disposed of by AWM (AWM, 2024). AWM provides resources for commercial and event customers including listings of third-party reuse systems and sorting and recycling companies.

During the 2024 Oktoberfest, implementation of the requirements were seen in a few different ways. The small food and beverage tents and booth use a deposit and ticket process to encourage return of reusable and plastic items. The tickets or tokens are provided with the food or beverage purchased and are used to confirm purchase of the items at the booth or area the items are returned. Typically the returned deposit was one or two euro per glass or bottle. At the large tents, all beverages and food are served with reusable dishes and glassware. The brewery staff at the large tents work to remove the beer steins swiftly from the tables once they're empty to wash and reuse them at the tent. Despite these efforts, some attendees leave the tents and attempt to leave the Oktoberfest with the steins before they're confiscated. During the 2024 Oktoberfest, 6.7 million people attended and 98,000 stolen steins were collected (Oktoberfest Munchen, 2024).

During Oktoberfest, AWM places 160 roll-off and compactor containers ranging in sizes from 20 to 35 cubic yards in designated areas across the venue for collection of the waste streams. For security, police officers guard the bins and there are no small bins around the venue for attendees to dispose of their residual waste. Because of this, not only are the bins emptied every night during Oktoberfest but AWM also does nightly street cleaning to remove any litter. From the time of set-up to dismantling of Oktoberfest, AWM collected a total of 1,198 tons of waste, of which 962 tons was residual waste, 100 tons was paper, cardboard and cartons, and 136 tons was mixed broken glass. (Fischer, 2024). The data is limited to what AWM collected and does not include the food waste and construction waste collected by private firms. The data also does not include scrap metal and electronic waste collected in separate waste streams as part of the dual system (Fischer, 2024).

To help its customers know how to properly separate their items, AWM conducts education and outreach campaigns including the use of diagrams and a fairytale story for children that explains what happens to the collected recyclables, organics, and residual waste. AWM also has a Waste Lexicon on their website that is similar to Phoenix's Recycle Wizard where residents can do a keyword search for results on proper recycling, reuse, or disposal of items.

Conclusion

Phoenix, Bonn, Kiel, Berlin and Munich all provide extensive education and outreach to residents about how to recycle properly and options to divert materials from the landfill or incinerator. Each of the municipal solid waste organizations also rely on the fees they charge their customers to cover the service costs for collecting and processing residual waste, recyclables and organics. Bonn, Kiel, Berlin and Munich all charge higher fees for larger residual waste containers and more frequent collection. Conversely, each city charges either reduced fees or no fees for collection of organics and paper waste. The fee structures used in Germany are similar to what the solid waste industry calls pay-as-you-throw where larger generators of waste pay more and diversion of waste from the landfill or incinerator is incentivized. Unlike Phoenix, weekly collection of the solid waste and recycle containers is not the standard service levels in Bonn, Kiel, Berlin or Munich due to the manual collection and space challenges. Additionally, Bonn, Kiel, Berlin and Munich's implementation of zero waste and circular economy initiatives are driven by the European Union and Federal regulations as is the participation by producers through Germany's dual system. To demonstrate compliance with the regulations, some of the municipal solid waste organizations expanded their service scopes to directly operate secondhand stores to reduce the amount of bulky waste going to the incinerators, rather than rely solely on charitable organizations to provide this service. The regulations and fees structures are effective tools for behavior change as demonstrated by Munich's 2023 recycle rate of 54% and create solid foundations as the cities attempt to achieve higher recycle rates.

In comparison, Phoenix's standard service is weekly collection of recycling and solid waste and participation in recycling and composting is voluntary with no federal and state mandates. Residents who fill their garbage containers each week pay the same as residents that roll out their solid waste container every two weeks. Like the German cities of Bonn, Kiel, Berlin and Munich, Phoenix understands that behavior change is important for the City to achieve its zero-waste goal by 2050 but given the voluntary nature of the zero waste and circular economy structure in the state of Arizona, cost-effective post-collection solutions will also be required to achieve Phoenix's zero waste and circular economy goals. There are clear differences and similarities in approaches to solid waste management, zero waste and circular economy implementation in the German cities of Bonn, Kiel, Berlin and Munich with that of the U.S city of Phoenix, Arizona. The key drivers for the different approaches include political will, producer responsibility, and individual behavior change. As the German and European Union model demonstrates, significant strides can be made with recycling, zero waste and circular economy implementation when federal and international policies standardize the requirements. It also provides an alternative approach for cities like Phoenix to consider.

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