HARD TO RECYCLE CHALLENGES, TRENDS, AND OPPORTUNITIES IN OUR REGION

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Contents

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1. Executive Summary

The current recycling system in Southwestern Pennsylvania troubled regional leaders due to environmental impact, lack of clarity, and governmental and personal expense. Americans have shown increased interest in environmentally conscious methods of recycling. For citizens who wish to make a contributable impact in protecting the environment, the most tangible method is through increased recycling efforts. However, in Pennsylvania and other areas of the United States, regions are poorly funded and recycling programs are largely dependent on local tax earnings which varies across county and city lines. Due to the capitalist mindset encapsulating the American environmental protective shift, many recycling programs are still limited to value-added programs which do not always include best practices according to environmental scientists.

For years, countries across the world have been buying and processing American recyclable materials, namely plastic. China used to be America's primary importer of American recyclable materials and waste. However, China enforced limitations on the types of materials it would accept from American waste management, referred to China's "Green Fence" established in 2013. As a result, many US recycling centers were forced to instead send these materials to American landfills, as there was no longer an overseas market. [1] This policy alone led to an 11 percent decline in export value of US plastic in the first half of 2013. Due to the loss of the market, American recycling centers and environmentalists shifted policy and methodology.

Again in 2017 China constricted its limitations on imported recyclable materials, almost completely closing the market to American waste. The United States began sending that material to other countries willing to accept it, including Malaysia and Vietnam. Despite their willingness to accept our trash, these countries mishandle 55% of all collected plastic waste, meaning it was dumped into landfills or illegally dumped elsewhere. This is not a solution; it is an extension of our own environmental problem.[2]

With no market for some of the most widely accepted to be recyclable materials such as glass, plastic, and rubber, the United States must look inward for a solution. Our region, and country, still support incredibly flawed and inefficient recycling systems that do not account for non-value-added options or true recycling objectives laid out in the circular economy theory.[3] Moving away from the mindset that disposable items are "waste" rather than "materials" with infinite alternative use opportunities will be a catalyst for changing behavior among local populations. However, much of the change necessary to successfully implement an environmentally focused recycling system must begin with investing in local infrastructure and following best practices that will optimize environmental sustainability rather than monetary value. Other countries have already implemented successful and dynamic recycling systems and infrastructure that places mutual responsibility on the government and the citizen. If they can do it, why shouldn't we?

2. Regional Structure & Problems

2.1 Pennsylvania's Current Structure for Hard to Recycle Materials

For years Pennsylvania has had difficulty streamlining its consistent recycling plan. Recycling has been an increasingly important albeit controversial topic among municipal bodies of governance due to the mutual burden it places on governments and citizens. In southwestern Pennsylvania municipalities have demonstrated increased frustration over the recycling of items known as hard to recycle materials. These items include a wide variety of materials ranging from tires fluorescent tubes ammunition and mattresses. All items our region and our nation seemed to have an overabundance. Each of the items has created specific and unique difficulties in the region due to the lack of recycling infrastructure and production regulations surrounding the initial manufacturing of such items. In combination with lack of waste management education our region has continued to confront this issue without sufficient resolution.[4]

A significant factor in the hard to recycle waste management is the overt lack of infrastructure targeting such materials. Currently southwestern Pennsylvania has around 18 municipal landfill facilities throughout the ten counties. Our region currently has the highest density of landfills per region in Pennsylvania. Comparatively, the southeast region surrounding Philadelphia has a similar number of landfills, however that region also contains the state's highest number of resource recovery facilities also known as waste to energy facilities.[5]

2.2 International Comparisons

We hope to summarize the similarities and differences of the policies by comparing the waste tire recycling policies of different countries and regions. We analyze the recycling systems, practices, and technologies of three regions in China, Japan, and Germany to compare with the current situation in Pennsylvania. By comparing our regional system to the systems and methods within these countries, we formulate policy recommendations that meet regional capacity limits and further reduce pollution generated during production. (Appendix A)

2.2.1 China model

For our analysis, we focus on the highly populated region of Shandong Province. This region was chosen as it shares various geographic and historical similarities with Pennsylvania, including holding historical political significance and proximity to the current capital.

In China, waste is recycled through incineration, landfill deposits, and recycling. The recycling industry most significantly involves three categories of disposed materials, including plastic, electronics, and paper. As of 2018, China's waste recycling industry was valued at 228.21 billion yuan (USD 34.77 billion), with a compound growth rate of 6.3% from 2014 to 2018. However,

China's recycling and processing industry has been greatly affected by China ‘s garbage classification policy.[6]

“Internet +” Model

Environmental companies use the “Internet +” model to promote the construction of a classified management system for garbage recycling. Residents can make an appointment to collect garbage through the community phone app. The commissioner is responsible for sorting and collecting while residents can gain points within the app as a reward for proper collection practice.

In June 2019, nine major departments including the Ministry of Housing and Urban-Rural Development, the National Development and Reform Commission, and the Ministry of Ecology and Environment jointly issued the "Notice on Comprehensively Carrying out Domestic Waste Classification in Cities Above the Prefecture Level." The requirement states that by 2020, 46 key cities must have established basic domestic waste classification and treatment systems. It also requires other prefecture-level cities to have achieved full coverage of domestic waste classification in public institutions. As a result, and at least one street has basically built a domestic waste classification demonstration area. China's garbage classification policy clarifies that household waste is divided into four categories: hazardous waste, kitchen waste, other waste, and recyclable waste. Among them, recyclable garbage includes five categories: wastepaper, plastic, glass, metal, and cloth. This policy has guided all regions to carrying out waste sorting in a comprehensive and orderly comprehensive, orderly manner which has driven market demand for waste sorting and has promoted the continuous expansion of the industry.

2.2.2 Japan model

Japan is the second country included in our international regional comparisons due to the similarities between Japanese prefectures and US states, such as total number of prefectures to states and population density. This similarity includes regional government responsibility over waste stream management and recycling initiatives which will be discussed furthered.

Tokyo Prefecture in Japan divides waste into three categories: general waste, industrial waste, and toxic & hazardous waste. Domestic waste belongs to general waste. At present, domestic garbage in Japan is mainly divided into combustible garbage, non-burnable garbage, bulk garbage, and resource garbage.[7]

Tokyo contains 23 special administrative regions. In order to dispose of waste more effectively, the 23 districts jointly built intermediate waste disposal facilities. Each district is responsible for the collection and transfer of garbage. Within the scope of the 23 districts, the disposal of garbage generated by residents does not need to pay separate disposal fees, and large-scale garbage can be

disposed of once a year for free. The remaining large-scale garbage disposal and garbage disposal generated by commercial activities need to pay a certain fee. After the combustible waste is collected, it will be directly sent to the waste incineration plant for incineration. After being collected, the non-combustible garbage will be sent to the garbage intermediate disposal center for intermediate disposal. After crushing and sorting, the volume of non-combustible garbage can be reduced and the recyclable materials in it can be recycled.[8]

2.2.3 Germany model

Germany was chosen for this comparative analysis due to similar government styles and ideology. Also, Germany is considered along with Japan and China to be an environmentally innovative nation. We believe Germany is another country that brings good insight into the changes Pennsylvania could adopt, such as multi-stream recycling practices.

Multi-Stream Recycling System

In the Germany multi-stream recycling system, Germans use various colored bins to classify their disposals including, black/gray, yellow, brown, blue, and white or green. Black/gray trash cans to store any garbage that cannot be recycled, corresponding to the dry garbage classification in Chinese garbage. Yellow trash cans are used to store packaging waste, including thin aluminum packaging waste, plastic packaging waste (including Lightweight plastic and various plastic packaging materials), metal containers, composite packaging materials. Brown trash cans are used to store organic garbage and other garbage that can be used to make organic compost, similar to wet garbage or kitchen waste in Chinese garbage classification, which also includes yard garbage. In addition, they use blue buckets to collect wastepaper, and white or green buckets to collect colorless and colored glass.[9] This multi-stream recycling method has proven successful in German cities as it places the responsibility of recycling in the hands of the citizen. This method holds individuals responsible for separating personal recyclable materials and thus reduces the cost of recycling for collection and sorting. Additionally, this system reduces material processing time which ultimately speeds along the process of returning that material to the market as a new product.

3. Case study

3.1 Tires

3.1.1 Pennsylvania's Current Structure and Problems with Tires

Southwestern Pennsylvania first established its modern recycling program in 1988 with the Municipal Waste Planning Recycling and Waste Reduction Act also known as Act 101 (henceforth, Act 101). Act 101 establishes the current requirements for municipalities to recycle and establish individual County recycling and waste management programs. It has made it possible for 79% of Pennsylvania residents to have access to 1,050 curbside pickup programs and 870 drop-off programs to account for the immense rural population. To manage landfill deposits, act 101 established a $2 per ton fee. Several organizations are currently targeting hard to recycle items such as glass, tires, and bulk items. The Pennsylvania Resource Council (PRC) has engaged local communities and dropped off initiatives that put the recycling responsibility in the hands of the citizens.[10]

Speaking with a PRC employee working to improve glass recycling Ashley DiGregorio, our group has learned these drop-off initiatives tend to see high user turnouts, though not the levels curbside pickup experiences. Many initial critiques of such programs include the incentive factor for the average person. The reason curbside sees such high numbers of participation is due to the lack of initiative and personal effort needed to engage. Conversely, drop-off requires high amounts of personal initiative and responsibility, which has traditionally hindered the promulgation of such programs. However, Ms. DiGregorio has confirmed that the glass drop-off programs in the region have been largely successful. She has assured us that many participants invite the idea of more frequent events.

Currently the Pennsylvania Department of Transportation (PennDOT) is the largest recipient of recycled tire materials. Tires can be recycled in various ways as whole tires, slit tires, shredded, or chopped tires, or as ground or crumb rubber products. predominantly scrap tires are used as tire derived fuels for power plants, cement plants, and industrial boilers.[11]

3.1.2 International Comparisons of Tires

According to the European Tire and Rubber Manufacturers Association, in 2016, the disposal rate of waste tires in Europe was as high as 95%. By June 2013, the tire recycling rate in Europe reached the highest level in history at 98%.

In Japan, Mitsubishi Corporation established a joint pilot project in 2000 to produce 0.4TPA (tissue plasminogen activator protein) nanomaterials from scrap tires.[12] It uses waste hydrocarbons to produce high-tech materials that can reduce emissions and increase energy efficiency. In addition,

this method can also reduce the cost of raw materials and achieve maximum resource efficiency. The advanced technology and experience of Japan and Germany for recycling waste tires are worth implementing in our own region.

In China, Shandong Kaiyuan Runfeng Environmental Protection Technology Company has built a 60,000-ton/year waste tire (rubber) thermal cracking production line, which has realized safe, environmentally friendly, and energy-saving production and operation conditions. Through thermal cracking of 1 ton of waste tires (rubber), approximately 0.35 tons of carbon black, 0.45 tons of waste rubber oil, 0.12 tons of steel wire and some combustible gases can be produced. It is safer and more environmentally friendly, saves energy, and has a good overall economy, which is in line with the development trend of the times.

3.2 Glass

As previously discussed, glass recycling has become a controversial issue in southwestern Pennsylvania. A notable case study is the South Hills. In 2019, the South Hills banned glass from its single stream recycling. This decision was made as a result of a new contract between the council of governments and a local hauling company. This contract did not include the recycling of glass due to the weight and contamination issues associated with glass. To address this issue, the South Hills needed to reallocate resources. As a direct result of this glass recycling ban, landfill fees began rising, thus directly impacting residents.

In our conversation with Ashley DiGregorio, the PRC does not foresee southwestern Pennsylvania continuing curbside glass collection. However, she insists that the focus in this region must be reallocated two infrastructures in solid waste management. This objective will not be easily met due to the high degree of variance in income among municipalities in our region. For example, high population areas with high median incomes will be able to afford to pay for better recycling programs and infrastructure via higher taxes. Conversely, low population and low-income areas will not be able to afford the same resources.[13]

In studying and analyzing regional problems with glass collection it appears wait and contamination concerns are the most impactful feet factors in organizing efficient glass recycling programs. Despite a relatively stable and valuable market for repurposing glass materials, without a functioning collection process this market will not see full optimization. The PRC has indicated data increase investment and drop off recycling programs that work with locally owned and operated haulers could spark local competition and thus fuel more efficient glass collection at the local level

3.3 E-Waste

Electronics waste is quickly becoming one of Pennsylvania's waste streams. Municipal authorities and waste haulers are responsible for sponsoring and operating drop-off events for electronic waste and equipment that are prohibited from landfills under the Covered Device Recycling Act, Act 108 of 2010.13

Beginning in 2013, the CDRA was amended to ban the disposal of any e-waste components from municipal landfills. However, the Act details that electronic items such as cell phones, computers, and televisions must be able to be recycled at local retailers that sell these items. The CDRA requires manufacturers to provide a recycling program for desktop computers, laptop computers, computer monitors, computer peripherals, and TVs sold in Pennsylvania.[14] Manufacturers must collect and properly recycle an equal amount to that they sell over a two-year period in pounds (lbs).[15]

In 2018, 56.5 million pounds of devices covered in the CDRA were recycled by 63 manufacturers. This was a reduction of 1.6 million pounds of recyclable e-waste from 2017 levels, meaning an estimated 70,351 pounds of covered materials were left unrecycled.16 According to the Pennsylvania Department of the Environmental Protection (DEP), this oversight was a direct result of manufacturers not following through with state-mandated recycling requirements. Negligent companies included Innovative DTV Solutions, Sears Holdings Management Corporation, and Yifang USA, Inc.

In Pennsylvania, there are some programs and one-time events where citizens can drop off waste electronics to ensure that it is recycled or disposed of appropriately. The program and event are mainly organized by county and operator or sponsor, the latter is usually a local municipality in which collection is performed. Some commercial waste collectors and/or municipalities also operate curb-side collection programs, in which electronics can be left to the curb to be picked up like regular trash.[16] (The municipalities in SW PA holding e-waste collection programs are listed in Appendix B)

4. Technologies

4.1 Mass Burning

Mass burn refers to the incineration of unsorted municipal waste in a Municipal Waste Combustor (MWC) or other incinerator designated to burn only waste from municipalities. In 2018, 34.6 million tons of MSW were combusted with energy recovery. Food made up the largest component of MSW combusted at approximately 22 percent.[17]

This waste management method avoids the expensive and unpleasant task of sorting through the garbage for unburnable materials. All waste received at the facility is shredded into small pieces and fed into the incinerator. Steam produced in the incinerator's boiler can be used to generate electricity or to heat nearby buildings. The residual ash and unburnable materials, representing about 10-20 percent of the original volume of waste, are taken to a landfill for disposal. Mass burn incineration also has several drawbacks. Since the waste is unsorted, it often generates more polluting emissions than sorted waste, and it is more likely to corrode burner grates and chimneys. The residual ash and unburned materials may be toxic and require special treatment.[18]

4.2 Refuse Derived Fuel

The concept of refuse-derived fuels (RDFs) is one that has the potential for addressing two of the most troubling environmental problems in the world at the same time: solid waste disposal and a source of energy. The term refuse derived fuel refers to any process or method by which waste materials are converted into a form in which they can be burned as a source of energy.[19]

The primary roadblock to the commercial development of RDFs is the economic cost of preparing such fuels. Given that most RDFs produced have only about half the energy value of a typical sample of industrial coal and given the relatively low price of coal, there is little economic incentive for municipalities to build energy systems based on refuse-derived fuels.

One of the fundamental problems in the development of refuse-derived fuels is obtaining the raw materials in a physical condition that will allow the extraction of combustible organic matter. The solid waste material entering most landfills consists of a complex mixture of substances. Some of these are combustible while others are not. Some have other commercial values while others have none. Plastics provide a convenient example that illustrates both aspects.[20]

4.3 Waste Pyrolysis

Pyrolysis is the heating of organic molecules without oxygen, to produce hydrocarbons (char) which have a high calorific value. Fuel produced by this process can be concentrated and stored. Organic waste may be used.[21]

The biggest problem of using pyrolysis is the difficulty to obtain the raw material. It's a method of disposal of whatever people must dispose of, but few people would make a fresh material to be decomposed. Thus, the quality of the outcome would be hard to control. Also, the mixture of raw materials makes it harder to widely use this technology. For example, when you get a mix of plastics still you will not be able to crack them all at the same temperature and your product will vary everyday as your feed mix keeps changing.

4.4 Technological Innovations for the Future

It looks like the mass burning can't be replaced by those advanced technologies because of its low cost, though the residual ash and unburnable materials still make an environmental burden. The necessity of sorting the raw materials for new technologies led to an increase in the cost, thereby reducing their commercial value and the possibility of popularization. Promoting the multi-stream waste collection and advocating the automatic garbage sorter can be good ways to ensure waste streams are "pure".

5. Recommendation

In order to address some harmful recycling trends in our region, our group plans to make calculated policy recommendations for regional policy makers.

Establish a Multi-Stream Recycling System

We believe through analyzing international protocols and procedures in addition to discussions with experts previously credited, that multi-stream recycling is the only efficient and effective method to recycle. Multi-stream recycling hastens the process of returning used materials back into the economy and begins the process for a circular economy.

Invest in Recycling Collection and Processing Infrastructure

Many of the issues we lay out in our report share common hindrances due to the lack of infrastructure in collection and processing. Through investment in better infrastructure for collection and processing, our regional recycling efforts will see increased efficiency, participation, and incentives. Lack of infrastructure is a result of lack of funding due to reallocation of funds to other worthy causes. However, we can no longer afford to ignore the building tire piles in our backyards or the building collections of glass in our basements.

Dedicate Task Forces in Financially Neglected Regions to Establish Uniform Recycling Protocols

In our report, we discuss how underfunded communities throughout our county are the first to lose recycling program funding and are often bearing the heaviest burden of misplaced materials or landfills. Redistribution of the county budget to account for these communities will not only benefit these underfinanced communities but will help streamline the future recycling system we hope Allegheny county is able to achieve. In recycling, the efforts of the few cannot outweigh the efforts of the majority, so we cannot forget those who need our attention the most.

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Appendix

Appendix A: International Comparisons

	Policies	Technologies	Output	Outcome
Southwestern Pennsylvania	Waste Tire Recycling Act, Act 190 of 1996	Shredders	Tire derived fuels Production of new products Asphalt pavements	Fuel creating toxic emissions Reduced asphalt cracking 1.5-2 times more expensive than regular asphalt
China: (Shandong Province)	Built safe, environmentally friendly and energy-saving production and operation conditions.	Built a 60,000-ton/year waste tire (rubber) thermal cracking production line	Ton of waste tires (rubber) Approximately 0.35 tons of carbon black,0.45 tons of waste rubber oil,0.12 tons of steel wire and Some combustible gases can be produced	Safer and more environmentally friendly Saves energy Has a good overall economy
Japan: (Mitsubishi Corporation)	A joint pilot project was established in 2000 to produce 0.4TPA nanomaterials	Use waste hydrocarbons	0.4TPA nanomaterials High-tech materials	Reduce emissions and increase Energy efficiency. reduce the cost of raw materials Achieve maximum resource efficiency.

Appendix B: Policies of Municipalities to deal with E-Waste

Municipality	Hauler	Electronic Waste Recycling
City of Pittsburgh	The city	● E-wastes are out for curbside pick-up, either trash OR recycling. ● No known free recycling options for televisions are available to residents of Pittsburgh. ● Need to pay to use one of the locally available drop-offs.
Ross Township	Waste Management	● Online schedule for home collection. ● Order a kit online and mail the electronic waste back.
Shaler Township	County Hauling*	● Online registration for complimentary Curbside Electronics
Wilkins Township	Republic Service*	● Call to arrange a free home collection

*According to the data sheet that Allison Walker offered, we summarized some of the municipalities' policies about e-waste collection. There are three main haulers for these municipalities: Waste Management, County Hauling and Republic. Each of them has their own policies about e-waste collection, so the different counties with the same hauler have the same way to deal with e-waste. In this way, we list 4 municipalities in the table.